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Scientific-Professional Society for DRM is a Serbian (Belgrade) non-governmental organization that seeks to improve the existing supply of theoretical and empirical knowledge in the field of disaster risk management. Conducts quantitative-qualitative research, develops knowledge base, promotes science and evidence-based policy, organizes national and international conferences, publishes journals (International Journal of DRM), and conducts training and other academic activities in disaster risk management, national security, and disaster risk management fields in Serbia and other Balkan countries. SPS-DRM has in-depth knowledge of civil protection and disaster management structures and organizations within the Balkan countries and their integration within the European Union Civil Protection.

BASIC DATA AND HISTORICAL DEVELOPMENT

On June 15, 2018, the founding assembly was held and at the proposal of the founder, prof. dr Vladimira M. Cvetković, professors from the Faculty of Security, the Criminalistics and Police University, the Faculty of Geography and Forestry unanimously adopted the Statute and formed the Scientific-Professional Society for Disaster Risk Management. In order to improve the scientific activity within the Society, 21.12.2020. year, the Statute was adopted and the International Institute for Disaster Research was established. The Scientific-Professional Society for Risk Management in Emergency Situations (NSDR-URVS) is a non-governmental, non-profit association, established for an indefinite period, for the purpose of improving the existing fund of theoretical knowledge in the field of risk management in emergency situations, conducting quantitative and qualitative research, organizing national and international conferences, launching and managing journals, conducting trainings and risk assessments, as well as other academic activities in the aforementioned field.

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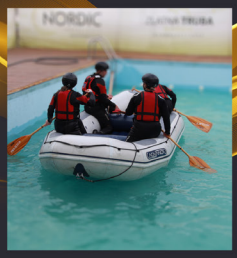

MEMBERS AND ASSOCIATES

It has more than 1,000 members made up of professors from state and private Universities and Colleges in Serbia, scientific researchers, practitioners (members of the police, fire and rescue units, emergency medical services, the army, NGO organizations in the field of security, etc.), students and young people who are directly or indirectly engaged in research and specific activities in the field of emergency situations. Within NSD-URVS, a general-purpose civil protection unit was formed with the aim of providing assistance to vulnerable citizens in emergency situations.

Become a member by filling out the application form on the website and sending it via email to NSD-URVS užvalje.rizicima.vs@gmail.com

OBJECTIVES

Objectives of NSDR-URVS: a) conducting research in the field of disaster studies; b) establishment and management of an international journal - International Journal of Disaster Risk Management; v) preparation, application and implementation of national and international projects on various aspects of risk management in emergency situations; g) promoting, designing, implementing and improving preventive measures against disasters; d) designing and implementing campaigns, programs, plans to strengthen citizens' awareness of the necessity of improving their preparedness for disasters; f) organizing national and international scientific conferences on risk management in emergency situations; e) implementation of expert risk assessments and preparation of protection and rescue plans in emergency situations; h) organizing and implementing various types of training, courses, seminars and other training for citizens, students and employees in interested institutions; z) performing other tasks in accordance with the law and its Statute.

HELD TRAININGS, COURSES AND LECTURES

In the organization of the Scientific-Professional Society for Risk Management in Emergency Situations, a large number of trainings and other activities aimed at education in the field of emergency situations were realized: the first, second, third, fourth and fifth basic safety training in the field emergency situations.

SCIENTIFIC RESEARCH AND PUBLISHING ACTIVITY

Over 15 textbooks, monographs and collections of works were published within the scientific and publishing activities of the Society. Associates of the society have written more than 10 projects in the field of emergency situations and more than 150 scientific papers.

INTERNATIONAL JOURNAL (IJDRM) AND INSTITUTE (IDR)

At the founding assembly, held on 21.12.2020. year, the Statute was adopted and the International Institute for Disaster Research was established as an organizational unit of the Society. In 2019, the first international journal in the field of risk management in emergency situations was founded in Serbia - Journal of Disaster Risk Management.

The journal cover all aspects of disaster risk management from a global and national perspectives

Editor-in-Chief
Prof. dr Vladimir M. Cvetković

About journal (IDRM)

International Journal of Disaster Risk Management (IJDRM) is a double-blind peer-reviewed (twice a year), open-access journal that serves all aspects of disaster studies, policy, and management. It provides a platform for academics, policymakers, and practitioners to publish high-quality research and practice concerning natural disasters, anthropogenic disasters, complex political emergencies, and crises around the world. This is an open-access journal which means that all content is freely available without charge to the user or his/her institution.

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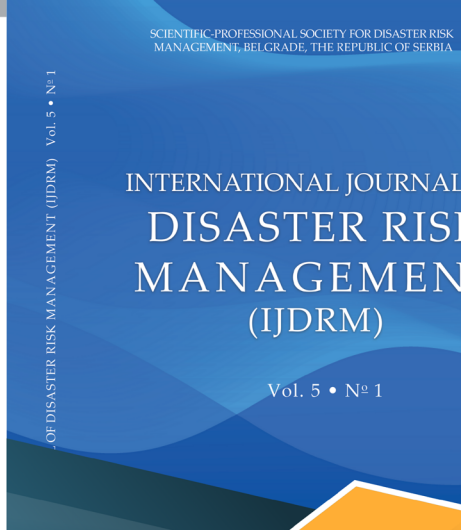

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Aims and Scope

Journal will cover all aspects of disaster risk management from a global perspective, including but not limited to:

- Disaster and crisis management theory and practice
- Risk awareness and assessment
- Hazard and vulnerability analysis
- Knowledge development including education, training, research, and information on disasters
- Public commitment and institutional frameworks, including organizational, policy, legislation, and community action
- Disaster prevention, mitigation, response, recovery planning, policies, and implementation
- Promotes the interchange of ideas between practitioners, policymakers, and academics

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International Journal of Disaster Risk Management

Nature and Extent of Flood Risk Downstream of the Kubanni Dam, Kaduna State, Nigeria

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ABSTRACT

Several communities reside downstream of Kubanni Dam, thereby making them vulnerable to flood. However, the levels of vulnerability, areas, households, and buildings at risk of flooding downstream of Kubanni Dam remain unknown. This study employed Geographic Information System (GIS) techniques to identify areas and buildings at risk in the event of a breach of the Kubanni Dam. Areas liable to flood were delineated using ArcGIS software. Findings from the study revealed that in the event of any flooding due to the breach of the Kubanni Dam, the most affected areas would be Tudun Jukun, with about 2,699 buildings (25%), Gyallesu with about 2,180 (20.2%), Tudun Wada with about 1,851 buildings (17.2%), Hanwa with 984 buildings (9.1%), parts of Sabon Gari with about 918 buildings (8.5%), Zango with about 845 buildings (7.8%) and the Government Reserved Area (GRA) with about 772 buildings representing 7.2% of the total numbers likely to the affected. The results further showed that the Tudun Jukun area, with a population of 38,622, is located in a flood-risk area, followed by Tudun Wada, with a population of 26,487, which is also at risk. It was also found that the PZ area, with 4,997 households and 1,851 houses at risk of flooding, has the highest average number of persons per Hectare (68902.02) at risk of loss in the event of flooding. This study has demonstrated the effectiveness of GIS techniques in flood risk and vulnerability analysis as well as its potential in guiding physical planning and flood disaster risk reduction.

KEYWORDS

Disaster, security, extent, flood risk, downstream, Kubanni Dam, GIS.

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1. Introduction

The United Nations Framework Convention on Climate Change (UNFCCC) defined "climate change" as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods (2007). Climate change involves heightened temperatures, changes in precipitation trends, and other environmental components, such as pressure and humidity levels, across numerous regions (Weisheimer & Palmer, 2005; Battisti & Naylor, 2009; Yadav et al., 2015; Schuurmans, 2021). Apart from irregular weather patterns, the retreating of global ice sheets, and the corresponding elevation of sea levels, fluvial floods have also been reported as an important signature of climate change (Lipczynska-Kochany, 2018; Murshed and Dao, 2020; Michel et al., 2021). Floods have increased in frequency over the last few decades, resulting in severe events, with the average annual global cost estimated to be US$104 billion (Desai et al., 2015). Many studies have reported an increase in extreme rainfall and sea levels, which play a dominant role in the rise of severe floods (Aerts et al., 2018; Hudson et al., 2019). According to the IPCC (2018), projected increases in the frequency and severity of climate-related events, such as floods, are likely to increase the risk of disasters.

Floods are considered the most common and destructive natural disasters worldwide, accounting for approximately 20% of global natural disaster losses and posing a significant threat to human society's survival and development (Fang et al., 2015). Dilley (2005) estimated that more than one-third of the world's land area is vulnerable to floods, affecting approximately 82% of the world's population. According to statistics, in 2023, floods resulted in the deaths of approximately 7,600 people worldwide. However, this death toll is dwarfed in comparison to the peak recorded in 1999, when some 35,000 people died as a result of floods (Salas, 2024). According to UNHCR (2024), climate change exacerbates the risk of displacement. The past decade saw, on average, 24 million displacements caused by disasters every year: 92 per cent were triggered by weather-related hazards (with floods accounting for nearly half of these), and the rest by geophysical hazards, such as earthquakes. In 2023, floods caused 9.8 million displacements. Additionally, global economic exposure to flooding is expected to triple by 2050 due to the growth of populations and economies in flood-prone regions (Jongman et al., 2012).

In Africa and Nigeria, the pattern of flooding is similar to that observed globally. Floods are a major environmental problem that has been seriously affecting cities and villages in recent times, causing damage to property and loss of life in the country (Adegboyega et al., 2018; Nigeria Hydrological Services Agency, 2020; Okon et al., 2021; Echendu, 2021). Damage and losses to properties, including farmlands, and the economy have been identified as the two most devastating effects of floods (Adetunji & Oyeleye, 2013; Otomofa et al., 2015; Egbinola et al., 2017; Chinwendu et al., 2017; Eze et al., 2018). Poverty and increases in the prices of commodities are believed to result from flooding (Umar & Grey, 2022). The hazards tend to affect riparian communities in developing countries due to their increasing vulnerability and low adaptation capacity, as well as the fact that most occupations of the population living in West Africa are climate-sensitive. It is expected that changes in precipitation patterns (e.g., extreme rainfall) prompted by climate change will increase the intensity and frequency of weather-related disasters, including flash floods, riverine and coastal flooding, and pluvial floods, in many regions (Asadieh & Krakauer, 2017). Hence, there is a need for risk assessment, which will inform policies for sustainable water resource management and flood control, as well as ensure the safety of people's lives and properties.

Several communities in Nigeria are vulnerable to flood, though their levels of vulnerability vary spatially. Hence, studies have been conducted to determine the flood risk and vulnerability levels of different communities across Nigeria using various methods, including statistical modelling and Geographic Information System (GIS) techniques. Iftikhar and Iqbal (2023) asserted that flood risk can be mitigated through flood forecasting and mapping of flood-prone areas. Identifying flood-prone areas is crucial for effectively managing flood risks (Rebouh et al., 2024). Therefore, Isma'il and Saanyol (2013) developed a GIS-based flood vulnerability map to identify areas vulnerable to flood disasters around River Kaduna in Nigeria. Similarly, Shuaibu et al. (2022) developed a GIS-

based flood risk and vulnerability mapping assessment to outline scenarios that reduce risk and vulnerability associated with floods in the Hadejia River basin, Nigeria. GIS is the use of computer tools (software, hardware) and appropriate geospatial techniques for the analysis of geographic (geospatial) data. Ndanusa et al. (2022) attempted to quantify vulnerability indicators and develop a multidimensional approach for flood vulnerability assessment in Mokwa, an area inhabited by downstream communities of the Kainji Dam in Niger State, Nigeria, using a participatory approach and Geographic Information Systems (GIS). The study concludes that the multidimensional approach to flood vulnerability provides information on both the vulnerable population and the factors driving vulnerability in the area. Gabriel et al. (2022) presented an approach for assessing the relative impact of such land use changes on economic flood damages and associated risk. The results of the comparative flood risk assessment using the proposed framework indicate the potential for identifying optimal locations in catchments for reducing off-site flood damage and minimising flood risk increment (Gabriel et al., 2022). Aladejana and Ebijuoworih (2024) presented a multifaceted approach and methodology to generate a statewide flood risk map by analysing both flood vulnerability and flood hazard factors. This study delineated flood risk by integrating flood hazard and flood vulnerability within Kogi State, Nigeria. They discovered that out of 295 villages, 65 are located in the high flood risk zone.

Umar and Gary (2023) asserted that flooding in Nigeria is an annual problem, but the adverse impacts can be mitigated through effective management. Therefore, studies on flood risk management are extremely valuable for effective flood disaster risk management. The downstream of Kubanni Dam falls within northern Nigeria, a region that has been identified as the most affected by flooding, where flood risk management should be focused (Umar & Gary, 2023). Additionally, several communities reside downstream of the Kubanni Dam, thereby making them vulnerable to flooding. However, the levels of vulnerability, areas, and households and buildings at risk of flooding downstream of Kubanni Dam are still unknown. It is on this premise that the present study is designed to assess the nature and extent of flood risk at locations downstream of the Kubanni Dam in Kaduna State, Nigeria, to provide information on the areal extent and the number of buildings at risk of flooding in the study area. The study will also provide relevant information that will aid in physical planning, guide disaster management agencies towards targeted interventions, and inform disaster risk reduction policies for effective disaster risk management in Nigeria.

2. Materials and Methods

2.1. Study Area

The study area is located within the Kubanni drainage basin between Latitudes 11º06′ to 11º07′N of the Equator and Longitudes 7º40′- 7º40′E of Greenwich Meridian (Figure 1). The study area is located within two Local Government Areas (LGAs), namely Zaria and Sabon Gari. It is situated in the northwest of Zaria in Kaduna State. However, the specific area under study lies downstream of the Kubanni Dam to the confluence with the Galma River, Zaria. The climate of the Kubanni basin is typical of the climate in Zaria and Its Environs. It is described as an Aw climate with distinct wet and dry seasons (Hore, 1970). Oscillations of two contrasting air masses determine the characteristics of the climate: tropical maritime and tropical continental air masses. The tropical maritime originates from the Gulf of Guinea and ushers in the rainy season. The tropical continental climate originates from the Sahara Desert and ushers in the dry, cold, and dusty season called the harmattan, which occasionally limits visibility and reduces solar radiation (Hore, 1970). The area is underlain by pre-Cambrian rocks, which lie in the mobile zone between the West African and Congo Cratons.

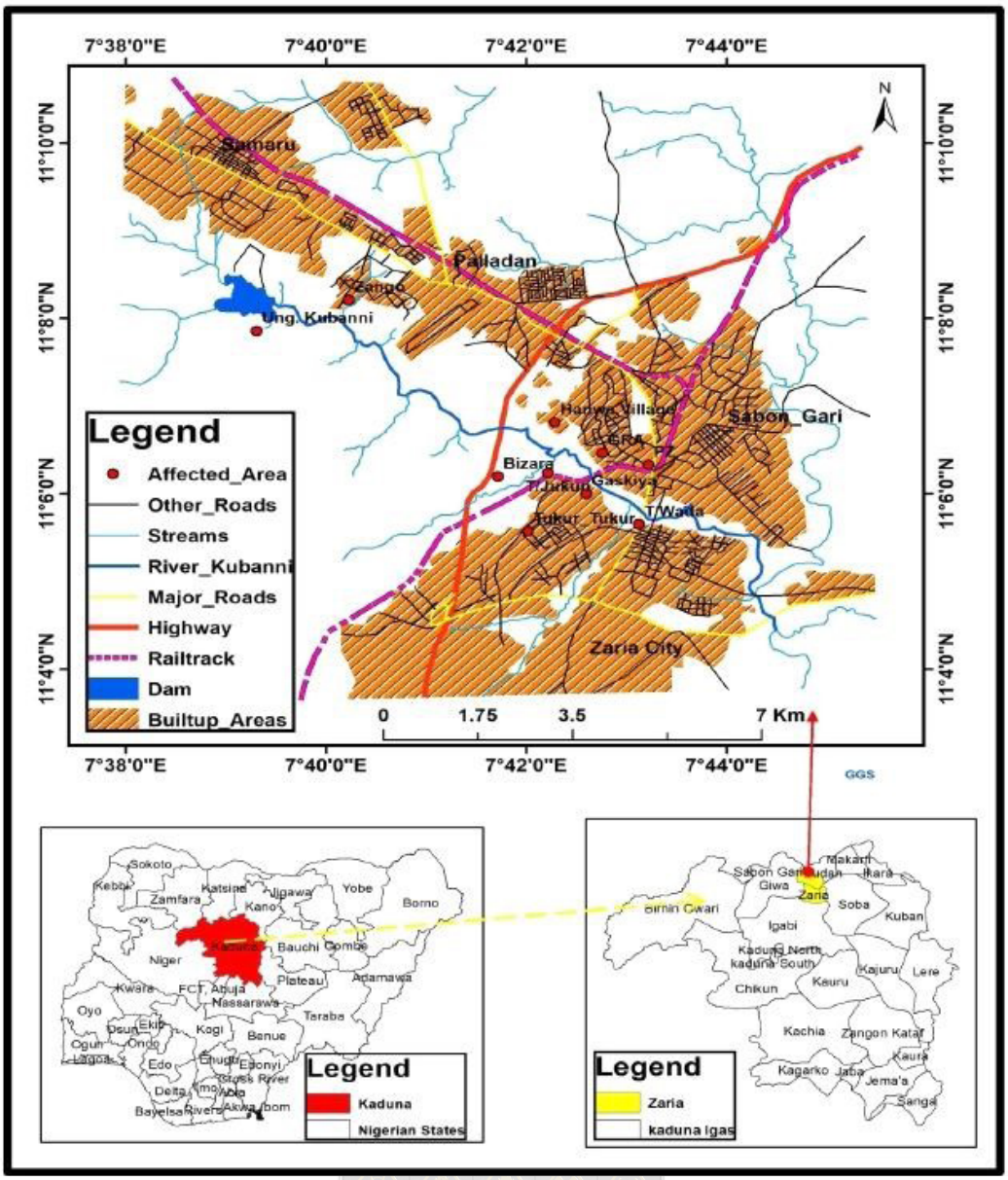

Figure 1. The Study Area is shown downstream of Kubanni Dam
source: Modified from Google Maps, 2022.

These Pre-Cambrian rocks consist of migmatites, gneisses and north-south trending meta-sedimentary rocks, intruded by a series of granitic and mafic-ultramafic rocks of late Pre-Cambrian to early Palaeozoic age as McCurry (1973) reported evidence of complex structural patterns such as joints and faults, formed mainly by invading granitic plutons in the Basement belonging to the widely distributed Pan-African magmatic suite present. The Kubanni River has its source on the Kampagi hill in Biye, near Zaria. It flows in the southeast direction through Ahmadu Bello University and joins river Galma at the confluence northwest of ABU's Main campus in Sabon Gari. The Kubanni basin system is ephemeral, intermittent, and exhibits a dendritic pattern, which is deeply incised by numerous gully systems (Ologe, 1971; Bello, 1973). The most prominent land use practice in the study area is agricultural land use (Ezenwa et al., 2022a), which is cultivation and animal husbandry. This is because the economic base of virtually all rural and semi-urban settlements in northern Nigeria is subsistence agriculture. The use of land for agricultural activities is influenced by several factors, including the land-to-resident ratio and the location of the soil. As the land-to-resident ratio increases (population density increases), the percentage of land in fallow decreases due to an increase in farming activities. The increase in land use intensity as population density rises creates problems in maintaining soil fertility.

2.2. Datasets and Sources

The study used both primary and secondary data. Landsat OLI TIRS image and Landsat ETM+ images spanning from 1990, 2000, 2010 and 2020 were obtained from USGS GloVis (http://www.glovisusgs.gov) free of cost. This set of data was used to assess Land Use Land Cover (LULC) change in a GIS environment and determine the land use that is vulnerable to flood disasters. A sufficient number of GPS coordinates using the NGS 84/UTM Zone 32N spatial reference system were collected in the field to train the maximum likelihood algorithm for proper supervised classification of Landsat images from 1990, 2000, 2010, and 2020. Some of the collected GPS coordinates were also used for the ground truthing during accuracy assessment. High-resolution satellite imagery, QuickBird data (60cm resolution) from 2017, was used to extract relevant features for risk and vulnerability analysis. Google Earth, including its "show historical imagery" function, was also used to assist in the classification and accuracy assessment of Landsat images of the study area and to extract different features on the ground. Direct field observation was conducted during the reconnaissance survey to gather information about the possible land use/land cover (LULC) classes into which the study area can be classified. It was used to verify the data obtained through change detection. The topographic map Zaria sheet 102, 1969, was used to delineate the floodplain (downstream).

The present study applied GIS techniques to determine the nature and extent of flood risk downstream. Isma'il and Ndanusa (2022) proposed a geospatial data mining approach for effective flood risk management, as geospatial techniques can determine elements at risk and the spatial extent of vulnerability. The maximum likelihood supervised classification method was adopted by Ezenwa et al. (2022a), where it was used to process satellite images and determine the Land Use and Land Cover (LULC) classes for the Kubanni drainage basin landscape.

2.3. Data Analysis

The processing and analysis of Landsat Images and all other GIS data were done using ERDAS Imagine and ArcGIS software, while all numerical data were analysed using MS Excel. To achieve the nature and extent of flood risk in the study area, a water surface Triangulated Irregular Network (TIN) was generated to delineate the floodplain. The floodplain delineation was created using a polyline theme to identify the floodplain and a depth grid. The water depth grid was created by subtracting the rasterised water surface TIN from the Terrain TIN. Then, the flood risk was divided into the hazard component and the vulnerability component. The vulnerability assessment was facilitated by the use of a binary model based on the presence or absence of a flood of a particular intensity in a specific land use type. Initially, the Kriging interpolation method was used to estimate the bathymetry. However, because Kriging provides a smooth representation of reality and has implications for subsequent computations (volume, area), the simulation method (turning bands) was subsequently employed. For a better understanding of the potential impacts of a dam break in the study area, it is essential to understand the general land use and land cover of the area. To achieve this, the following datasets were created:

a. Land use and Landover of the Kubanni Dam Area:

The land use and land cover of the area were created by extracting information from a high-resolution satellite image of the area. The primary land use and land cover types identified in the image were built-up areas, bare land, farmland, shrubland, forest, and wetlands. This land use/land cover represents the significant elements that could be at risk of flooding within the Kubanni basin in the event of a dam breach.

b. Proximity Analysis of Buildings to River Kubanni.

Proximity analysis is a neighbourhood operation in GIS that creates buffers around features within specified distances. In this study, a proximity analysis was carried out using the distance operation in ArcGIS Spatial Analyst. The operation created buffer zones at 100m intervals for the 600m study extent (i.e., 600m downstream of the Kubanni River at 100m, 200m, 300m, 400m, 500m, and 600m,

respectively). The buffer zones were then overlaid on the flooded area dataset to extract the extent of flood vulnerability within a given distance of 100m to 600m from the Kubanni River. In addition, the study area was based on the settlements in the area, as follows: Zango, Aviation, Graceland, Hanwa, Tukur-Tukur, GRA, Sabon Gari, Tudun Wada, Gyellesu, and Angwan Kaya. This was done to show which of these areas was more at risk and likely to be more affected by a dam breach.

c. Overlay of the Flood Inundation over the Buildings/Houses

The results obtained from the flood inundation were overlaid on the land use and land cover in ArcGIS. The purpose of this overlay analysis was to identify which land use and land cover, as well as buildings/houses, would be most affected in the event of water inundating the floodplain within the Kubanni basin due to a probable breach of the dam. Rebouh et al. (2024) demonstrated how GIS techniques, including overlay analysis, buffering, and interpolation, played a critical role in analysing flood susceptibility.

d. Flood Risk Analysis

Digital contour surfaces of reservoir bathymetry were performed by two interpolation methods: Kriging and simulation (turning bands) techniques. The spatial coexistence model was used for risk assessment, which involved reclassifying the floodwater depth into values ranging from 1 to 10. Thereafter, the results of these two analyses were combined for the flood risk assessment. This risk assessment process was automated using a customised graphical user interface in ArcGIS to classify flood risk into three major risk classes: low risk, moderate risk, and high risk, as done by Isma'il and Saanyol (2013) in flood vulnerability mapping and risk analysis of the River Kaduna. The risk analysis was conducted to assess the impact of risk on people's land use and land cover in the area. To assess the effects on the people, baseline data were collected, as outlined below.

i. The average number of households per building was 2.7, as documented in NPC (2009)

ii. The average household size in Kaduna State is 5.3, as contained in the document from the National Bureau of Statistics (NBS, 2019)

iii. The average amount of land occupied per person is 0.22 hectares, as reported by FAO (2006).

The application of Remote Sensing data with GIS techniques is the most common approach to flood modelling in Nigeria (Umar & Gary, 2023). Several studies have demonstrated the effectiveness of GIS in flood risk and vulnerability analysis. Shuaibu et al. (2022) developed a spatial flood risk assessment map of the Hadejia River basin. The spatial distribution of flood-risk zones in the Hadejia River basin was mapped using the Analytic Hierarchy Process (AHP) method, integrated with a Geographic Information System (GIS), to reduce the risk and vulnerability associated with floods. Ndanusa et al. (2022) recommended that a multidimensional approach to flood risk assessment is required to provide a holistic view of residents' degree of vulnerability to flooding, which can be achieved by integrating a field survey with a GIS approach.

3. Results and discussion

To determine the extent of buildings at risk of flooding, the study area was divided into twelve different settlement zones, namely Tudun Jukun, Tukur Tukur, Sabon Gari, PZ Area, Hanwa, Angwan Kaya, Aviation, GRA, Graceland, Gyellesu, Zango, and Tudun Wada. The flood extent was overlaid on these zones, and the number of buildings at risk was counted, as shown in Table 1.

Table 1: Number of Houses at Flood Risk

Zone	Number of Building	%
Tudun Jukun	2699	25.0
Tukur Tukur	46	0.4
Sabon Gari	918	8.5
PZ Area	185	1.7
Hanwa	984	9.1
Aguwan Kaya	162	1.5
Aviation	-	-
G.R.A	772	7.2
Grace Land	149	1.4
Gyellesu	2180	20.2
Zango	845	7.8
Tudun Wada	1851	17.2
Total	12,750	100.

Table 1 shows that in the event of flooding due to the breach of the Kubanni Dam, the most affected areas will be Tudun Jukun (25%), Gyellesu (20.2%), and Tudun Wada (17.2%). Tukur Tukur (0.4%) and Graceland (1.4%) have the lowest number of buildings on the floodplain. This could be because these areas are the least affected and are located on the undulating uplands of the study area. This result also supports the findings of Hosseinzadah-Tarbrizi (2022), who noted that some population centres downstream of the Sattarkhan dam in Iran face a notable risk. The arrival times of the flood, recession times, and maximum velocities in the targeted areas have been calculated to inform emergency action plans. These areas have many buildings within the floodplain, and observations during the fieldwork reveal evidence of increasing encroachment of residential buildings along the floodplain. As most of the floodplain is occupied by buildings, it would increase the rate at which the river experiences siltation, which in turn would increase the rate of flooding, thereby expanding areas that are likely to be flooded. The findings of this study corroborate those of Isma'il and Saanyol, who reported that areas falling within the flood-prone zone of River Kaduna are the most vulnerable to the flood risk of the river. The result is also in agreement with the finding of Jibrin and Opatoyinbo (2015), which showed that 76% of the land used for dry season farming along the floodplain of River Kaduna was overtaken by built-up structures. Mangaji (2019) conducted a study on the effects of seasonal flooding on unplanned settlements along the River Kubanni in urban Zaria. The results revealed that settlements such as Gaskiya, Tudun Wada, Rinji, Gangaren Mallam Hamza, Hanwa village, and Zango were the primary areas at risk in the Kubanni catchment. Gaskiya and Tudun Wada are reported to be among the high-vulnerable settlements, and Hanwa village, Zango, and its environs are among the moderately vulnerable settlements. The level of flood risk and vulnerability of the settlements in the study area is presented in Figure 2.

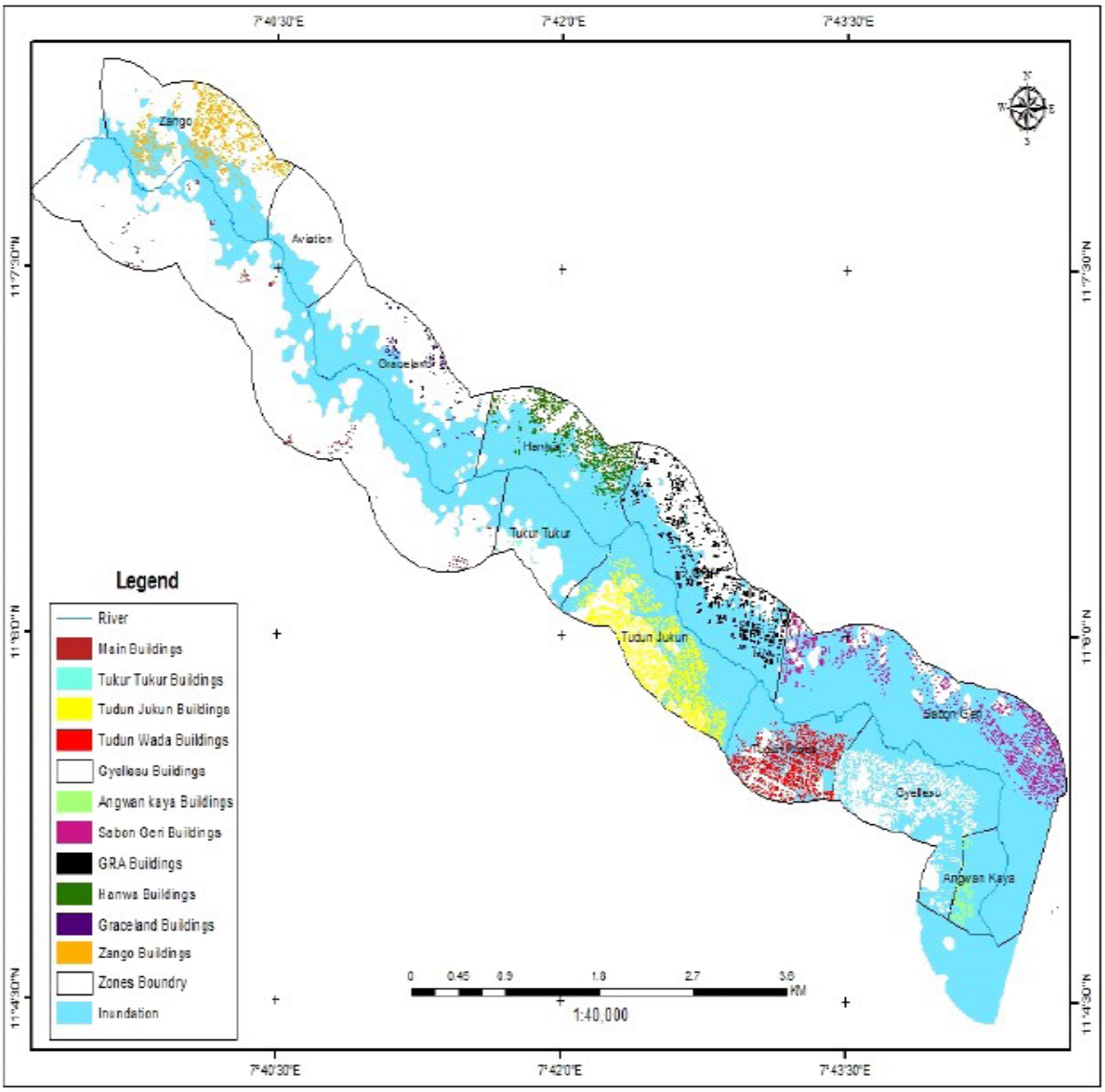

Figure 2. Levels of Flood Risk in the Study Area

Ezenwa et al. (2022a) identified five land use and land cover classes around the Kubanni drainage basin, which are built-up area, water, vegetation, farmland, and bare land. However, Ezenwa et al. (2022b) established that farming is the dominant land use in the study area. Farming has the potential to exacerbate flooding in the Kubanni region because it leads to deforestation and the gradual siltation of the Kubanni dam resulting from agricultural and other anthropogenic activities. Another influential factor is encroachment and building on the floodplain. Iftikhar and Iqbal (2023) reported that Dha City in Pakistan is built on a floodplain area, which is why it is often flooded with monsoon rainwater. Conversely, sustainable flood risk management involves implementing natural solutions, such as afforestation or developing land surfaces with water retention and infiltration capacity at strategic locations within the catchment (Gabriel et al., 2022).

Table 2 shows that a total population of 154,419 is at risk of floods, based on an estimated total of 29,135 households. It can be seen that the Tudun Jukun area has the highest population at risk of flooding, with a total of 38,623 individuals and a corresponding number of 7,287 households. This is followed by Gyellesu, with 31,195 people at risk of flooding, which comprises a household population of 5,886 and 2,180 houses. Tudun Wada is the third most vulnerable to flood risk, with a population of 26,487, a household population of 4,997, and 1,851 houses. The fourth most vulnerable area is Hanwa, with 14,081 people at risk of flooding, a household population of 2,656, and 984 houses. The fifth most vulnerable area is Sabon Gari, with a population of 13,136 at risk, comprising a household population of 2,478 and 918 houses. The sixth most vulnerable area is Zango, with a population of

12,091 at risk of floods, comprising a household population of 2,281 and 845 houses. The seventh most vulnerable area is G.R.A., with a population of 11,047 at risk, comprising 2,084 individuals and 772 houses. The eight most vulnerable areas are Tukur-Tukur, with a population of 658, at risk of flooding, comprising 124 households and 46 houses. The ninth most vulnerable area is PZ, with a population of 2,647 at risk, comprising 499 households and 185 houses. The tenth most vulnerable area is Anguwan Kaya, with a population of 3,318 at risk, comprising a household population of 437 and 162 houses. The eleventh most vulnerable area is Grace Land, with a household population of 402.3 and 149 houses. The Aviation Sector has no estimated population and household at risk and is therefore not considered vulnerable to flood risk in the study area. This is because the area remains unbuilt. The Household/Population at risk of flood is presented in Table 2.

Table 2. Household/Population at Flood Risk

Locality Neighbourhood	Estimated Number of Households	Estimated Population at Risk
Tudun Jukun	7,287	38,622
Tukur-Tukur	124	658
Sabon Gari	2,478	13,136
PZ Area	499	2,647
Hanwa	2,656	14,081
Aguwan Kaya	437	2,318
Aviation	-	-
G.R.A	2,084	11,047
Grace Land	402	2,132
Gyellesu	5,886	31,195
Zango	2,281	12,091
Tudun Wada	4,997	26,487
Total	29,135	154,419

The area of farmlands at risk of flood is presented in Table 3. A total of 899.831 Hectares of farmland are at risk of flooding. The analysis by locality showed that 5.3% of the farmland is at risk of flooding, located in Tudun Jukun, and 4.4% of the farmland is located in Tukur-Tukur. At Sabon Gari, 16.5% of the farmlands are at risk; 34.8% in the Main PZ area, Hanwa is 5.2%; Aguwan Kaya is 2.0%, Aviation is 2.4%; GRA is 4.1%; Graceland is 12.0%, Gyellesu is 2.9%; Zango is 7.7% and Tudun Wada is 2.7% of the farmlands are at risk of flooding.

Table 3. Area of Farmlands at Flood Risk

Locality	Area of Farmland at Risk (Ha)	%
Tudun Jukun	47.355	5.3
Tukur Tukur	39.969	4.4
Sabon Gari	148.551	16.5
PZ area	313.191	34.8
Hanwa	46.858	5.2
Angwan Kaya	17.936	2.0
Aviation	21.365	2.4
GRA	37.089	4.1
Graceland	107.665	12.0
Gyellesu	26.51	2.9
Zango	69.212	7.7
Tudun Wada	24.13	2.7
Total	899.831	100.

Based on the findings above, it is evident that the PZ area has the largest farmland area, at 34.8%, that is at risk of flooding. This could be because the PZ area is essentially a commercial land use and has nutrient-rich soils, allowing for dry-season farming. This result is in agreement with the findings of Kissi (2014), which revealed that the closeness of households and farmlands to the river body, the type of construction, and the position of settlements are among the main determinants increasing the community's vulnerability to flood disasters. Table 3 further illustrates the flood risk to food security in the study area. Out of the total area of farmland at risk (899,255 Ha) and 197,876Ha which represents the total average hectare/person 0.22(Ha), Tudun-Jukun has 47,355 Ha area of farmland at risk with 10418.1 average hectare/ person 0.22 Ha under risk of food scarcity due to flooding. Tukur-Tukur has a 39,969 Ha area of farmland at risk, with 8,793.18 hectares per person and 0.22 Ha at risk of food scarcity. Sabon Gari has 148,551Ha area of farmland at risk with 32,681.22 average hectare/ person 0.22(Ha) under risk of food scarcity due to flooding. PZ area has 313,191 Ha area of farmland at risk with 68902.02 average hectare/ person 0.22(Ha) under risk of food scarcity.

The flood risk and farmland areas are presented in Table 4. Among the land use types, cropland exhibited the highest vulnerability, with at least 10,234.8 Hectares susceptible to a flooding event of a 100-year return period (YRP). Hanwa has a 46,858 Ha area of farmland at risk, with an average of 10,308.76 ha per person (Ha) at risk of food scarcity. Aguwan Kaya has 17936 hectares of farmland at risk (Ha), with an average of 3945.92 hectares per person (Ha) at risk of food scarcity.

Table 4. Flood Risk and Farmlands Area.

Locality/neighbourhood	Area of farmland at risk (Ha)	Average Hectre/ person 0.22(Ha)
Tudu Jukun	47355	10418.1
Tukur-Tukur	39969	8793.18
Sabon-Gari	148551	32681.22
PZ area	313191	68902.02
Hanwa	46858	10308.76
Anguwan kaya	17936	3945.92
Aviation	21365	4700.03
GRA	37089	8159.58
Graceland	107665	23686.03
Gyellesu	26051	5731.22
Zango	69212	15266.64
Tudun-Wada	24013	5282.86
Total	899,255	197,876

In addition, it can be observed from Table 4 that Aviation has 21,365 hectares of farmland at risk (Ha), with an average of 4,700.03 hectares per person (Ha) at risk of food scarcity. GRA has a 37089 Ha area of farmland at risk, with an average of 8,159.58 ha per person (Ha) at risk of food scarcity. Graceland has an area of 107,665 hectares of farmland at risk, with an average of 23,686.03 hectares per person (Ha) at risk of food scarcity. Gyellesu has 26051 areas of farmland at risk (Ha) with 5,731.22 average hectare/person 0.22(Ha) at risk of food scarcity. Zango has a 69,212 area of farmland at risk (Ha) with 15,266.64 average hectares/person 0.22(Ha) at risk of food scarcity. Tudun Wada has a 24013 Ha area of farmland at risk, with 5282.86 average hectare/person 0.22 (Ha) at risk of food scarcity.

Results in Table 4 indicate that the PZ area has the highest average number of persons per Ha (68902.02) at risk of food scarcity in the event of flood risk. This result corroborates the findings of Oluoko-Odingo and Krhoda (2020), which showed that flooding negatively affects food security by increasing the number of food-insecure households to 92.8%. The regression coefficient of ⍟0.798 indicates a powerful adverse effect of flooding on household food security. The findings suggest that flooding can increase the vulnerability of communities to food insecurity, necessitating long-term support to cope; it can also hinder the achievement of Sustainable Development Goal 2. Week and Wizor (2020) examined the effects of flood risk levels on food security, livelihood and socio-economic characteristics in the flood-prone areas of the core Niger Delta, Nigeria.

The study's findings showed that 75.3% of respondents believed that basic food was scarce following the floods. Meanwhile, 69.9% admitted that flood events negatively influence crop growth and development by washing away farmlands. Additionally, 69.9% agreed that farmland erosion has caused chronic, enduring food insecurity within the communities. Further evidence suggests that 75.6% of respondents agreed that flood incidents contribute to acute food insecurity, which in turn affects residents' livelihoods. Week and Wizor (2020) concluded that floods have reduced farmland efficiency in food production, resulting in food insecurity, lower incomes, and poorer living conditions for residents in the core Niger Delta States. Idoko (2016) examined the impact of floods on food security among rural farmers in the Dagiri Community, Gwagwalada Area Council, Abuja, Nigeria. The findings indicated that areas in Dagiri, particularly along the banks of River Usuma, with significant farming activities, are highly susceptible to flood disasters. Ongoing land use planning violations, population growth, and use of substandard construction materials heighten the towns' vulnerability to flood hazards. To mitigate the risk of flooding in residential areas, it is essential to implement an integrated national flood disaster risk reduction plan. Tout (2023) emphasises the need for a national policy targeting effective flood risk management, which should include prevention, management, and rehabilitation strategies for flood hazards. This study makes a significant contribution to developing an integrated national flood disaster risk reduction plan for effective flood disaster risk management in Nigeria.

Because the houses and farmlands that provide settlement and means of livelihood for the communities in the study area are at risk of flooding, the vulnerability of the communities to flooding is generally high, as it is multidimensional, encompassing both physical and economic aspects, with the potential to expose the communities to social and environmental vulnerabilities. Ndanusa et al. (2022) revealed that the downstream communities of Kainji Dam in Niger State, Nigeria, experienced high flood vulnerability due to multidimensional vulnerability, encompassing economic, physical, social, and environmental aspects. Shuaibu et al. (2022) reported how combining the flood hazard and socioeconomic vulnerability indices of the Hadejia River basin revealed high to very high flood risk in the downstream and central upstream parts of the basin. Similarly, Cvetković et al. (2018) reported how gender influenced flood risk perceptions and preparedness of individuals. Perić and Cvetković (2019) established a correlation between risk perception and demographic, psychological, and socio-economic factors, which have implications for communities' disaster preparedness.

The present study has established that the flood risk downstream of Kubanni Dam is multi-dimensional. In contrast, previous studies have shown a relationship between flood risk perception among communities and flood preparedness. It is therefore recommended that future studies in the downstream region of Kubanni Dam should focus on this relationship.

4. Conclusion and recommendations

This study employed a GIS technique to assess the nature and extent of flood vulnerability in areas downstream of the Kubanni Dam. It was concluded that in the event of any flooding due to the breach of the Kubanni Dam, the most affected areas would be Tudun Jukun, with about 2,699 buildings (25%), Gyallesu, with about 20.2%; Tudun Wada with about 1,8551 building (8.5%), Zango with about 845 building (7.8%) and Government Reserved Area (GRA) with about 772 buildings or 7.2% of the total number of affected buildings. Evidence was found of increasing encroachment of housing development along the floodplain in these areas. The study also concludes that the Tudun Jukun area has the highest population at risk of flooding. In contrast, the PZ area has the highest average number of persons per Hectare (68902.02) at risk of food scarcity in the event of flooding. This study recommends the application of GIS techniques to guide physical planning and reduce the flood disaster risk and vulnerability of communities. This study utilised low-resolution satellite images for land use and Land Cover classification. A higher-resolution satellite image will provide more accurate input and better results for flood risk and vulnerability analysis in the study area.

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Retrogressive or Misplaced Priorities? An Assessment of Public Expenditure for Food Security and Disaster Risk Reduction in Uganda

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ABSTRACT

The article argues that a rights-based approach to public investment and expenditure in agriculture and disaster risk management is a viable pathway for Uganda to realise the right to adequate food and sustainable development in line with the government's national and international human rights commitments. This study employed a qualitative research paradigm to examine both primary and secondary data on public investment and expenditure in food security and disaster risk reduction in Uganda. Fifty-six key informant interviews were conducted with purposively selected officials at national and Local Government levels. Data and insights obtained were analysed using thematic and rights-based budget analyses. There is minimal application of rights-based approach principles in the budgeting for food security or disaster risk reduction in Uganda. Public expenditure in the agriculture sector and disaster risk management is inadequate to meet the increasing disasters in the country or to effectively protect the right to adequate food of vulnerable communities in disaster-prone regions. As a State Party to the International Covenant on Economic, Social and Cultural Rights and a signatory to the Sendai Framework for Disaster Risk Reduction, Uganda is obligated to protect and fulfil the right to adequate food for vulnerable communities in the event of disasters. This will require increased public and private investment in the agriculture sector and strengthening the disaster risk financing mechanisms at both national and Local Government levels.

KEYWORDS

Disaster risk financing; rights-based budget analysis; food security; disaster risk reduction; vulnerability.

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1. Introduction

Disaster risk financing to ensure livelihood resilience and inclusive and sustainable development for vulnerable communities living in hazard-prone regions is a growing area of concern for many governments worldwide (World Bank, 2022; Cvetković, 2023). There is a growing recognition that financial preparedness and prioritisation of key sectors, such as food security and climate change adaptation, contribute to increasing a country's financial resilience to and recovery from disasters when they occur (GFDRR et al., 2016; World Bank, 2022). Globally, the post-2015 development agenda that replaced the Millennium Development Goals (MDGs) with the Sustainable Development Goals (SDGs) has witnessed a convergence of efforts to achieve inclusive development, prosperity, equity, freedom, dignity and peace on a foundation of human rights (OHCHR, 2013; Filskov & Feiring, 2018). Regarding food security in the context of disasters in Uganda, the allocative efficiency of public expenditure in the agricultural sector has consistently remained low, averaging 3.6% of the national budget. Uganda's share is even lower than that of its East African neighbours, Kenya, Tanzania, and Rwanda. However, all the countries are yet to attain the aspirational Maputo/Malabo Declaration/CAADP target of 10% (World Bank & GOU, 2019). Thus, a strategy to ensure risk-informed development through increased investment in agricultural productivity, substantial reduction of disaster risk losses in lives, livelihoods, socio-economic support and the protection of environmental assets of communities and countries was consolidated under various international instruments like the Maputo/Malabo Declaration, the Paris Agreement on Climate Change, the Sendai Framework on Disaster Risk Reduction and the Addis Ababa Action Agenda on Financing for Development, among others (World Bank & GOU, 2019; Omoyo et al, 2022).

Uganda ratified the International Covenant on Economic, Social and Cultural Rights (ICESCR) in 1987. As a State Party, the country is obligated to respect, protect, and fulfil the rights enshrined in the Covenant. In particular, Article 11 of the ICESCR provides for the protection of the right to an adequate standard of living, including the right to adequate food, which is the focus of this article. Uganda is also a signatory to the UN 2030 Agenda for Sustainable Development, which comprises 17 Sustainable Development Goals (SDGs) that enjoin countries to ensure inclusive and sustainable development for all and to leave no one behind (UNDP, 2018). Of particular relevance in this article is Goal 1 (No Poverty) and its Target 4, which propose to "build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters" by 2030. Also in focus is the SDG 2 (Zero Hunger) that calls upon States to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" by 2030. In the same vein, the Sendai Framework for Disaster Risk Reduction 2015–2030 (hereinafter referred to as the "Sendai Framework") requires countries to take concrete actions to protect development gains from disaster risk. Specifically, the Sendai Framework calls upon countries to ensure "[T]he *substantial reduction of disaster risk and losses in lives, livelihoods and health and the economic, physical, social, cultural and environmental assets of persons, businesses, communities…." (Sendai Framework, para.* 16).

Globally, however, there is generally little to no progress towards either Zero Hunger Target 2.1, which aims to ensure access to safe, nutritious, and adequate food for all people throughout the year, or towards Target 2.2, which seeks to eradicate all forms of malnutrition (FAO, 2021). In 2020, between 720 and 811 million people worldwide faced hunger, representing an increase of 161 million more than in 2019 (FAO, 2021). This implies that nearly 2.37 billion people lacked access to adequate food in 2020 – a 320 million increase in just one year. Estimates from 2019 indicate that nearly 690 million people were hungry that year, accounting for 8.9% of the world's population. Also, nearly half of all deaths of children under 5 are attributable to undernutrition (UNICEF, 2019). Since March 2020, the COVID-19 pandemic has further exposed weaknesses in the global and national food systems, which threaten the lives and livelihoods of millions of people, especially the most vulnerable and those living in disaster-prone environments (FAO, 2021). Similarly, action to prevent the creation of new disasters and/or reduce existing disaster risk under the Sendai Framework is lagging: economic losses from disasters account for approximately 1% of global gross domestic product (GDP) (Global Target C), and these losses continue to increase (UN, 2020).

States worldwide, Uganda's inclusive, have reaffirmed the right of everyone to have access to safe and nutritious food, consistent with the right to adequate food and the fundamental right of everyone to be free from hunger (CESCR, 1999, para.6). In Uganda, poverty and hunger are both a rural and urban reality that prevents many from achieving adequate or nutritious food for themselves or their families. An estimated 54% of the total population in all regions of the country experiences food insecurity or lacks access to an affordable, nutritious diet (IPC, 2017; UBOS, 2024). Peasant or subsistence smallholder farmers and their families comprise a significant proportion of the poor and hungry, with Uganda scoring 27.3 on the hunger scale and ranking 105 out of 127 countries surveyed (UBOS, 2024; Global Hunger Index, 2024). Thus, eradicating poverty and hunger is integrally linked to boosting food production, agricultural productivity and rural incomes. To this end, the agriculture sector in Uganda must become more productive and efficient. Sustainable agricultural practices and food systems, including both production and consumption, must be pursued from a holistic and integrated perspective, as the just expired National Development NDP III (2020/21 – 2024/25) and the recently adopted National Development Plan IV (2025/6 – 2029/30), the Uganda Nutrition Action Plan II (2021 – 2025), among other strategies, propose.

Most projections indicate that global hunger will not be eradicated by 2030 unless concrete actions are taken to accelerate progress, particularly in addressing food access inequality (FAO et al., 2021, 2023). Global hunger remained relatively unchanged from 2021 to 2022, affecting around 9.2 per cent of the world's population in 2022, compared to 7.9 per cent in 2019. Holding all other factors constant, an estimated 660 million people may still face hunger in 2030 due to the lingering impacts of the COVID-19 pandemic on global food security (FAO et al., 2021; 2023). Thus, it is pertinent that Uganda increases investment in the agricultural sector to enhance food productivity, as well as in disaster risk reduction, in the face of increasing climate-related disasters. Coherence in the formulation and implementation of policies and investments in food security, health, social protection, and environmental systems is also essential for building synergies towards more efficient and effective food systems that deliver adequate food for all and eradicate hunger.

This paper is organised as follows: In the first part, we outline a rights-based conceptual framework as an optimal paradigm through which to understand and view public expenditure in the protection of the right to adequate food and ensure effective disaster risk reduction in Uganda amidst persistent poverty and an economic downturn induced by the COVID-19 pandemic. The second part examines national expenditures on disaster risk reduction and the views of key national and sub-national actors who implement food security and disaster risk reduction policies among disaster-prone communities. These views are discussed in the next part, and the paper concludes with a call to implement a rights-based approach that ensures robust protection of the right to adequate food and effective disaster risk reduction, guaranteeing inclusive, people-centred development in line with national and international commitments.

2. Methods

2.1 Qualitative Research Paradigm to Budgeting for Food Security and Disaster Risk Reduction

This study employed a qualitative research approach to examine both secondary literature and primary data on public expenditure related to food security and disaster risk reduction in Uganda. Fifty-six (56) key informant interviews were conducted with purposively selected officials at national and Local Government levels using an open-ended interview guide to obtain insights into government expenditure on food security and disaster risk reduction. A rights-based budget analysis of Uganda's recent national budgets (2016-2021) was employed to evaluate and understand this issue from a human rights-based perspective. Specifically, human rights budget analysis (QUB, 2010; OHCHR, 2017) was used to assess the extent to which Uganda's national budget allocations to the agricultural sector (food security) complied with the government's obligation to use "maximum available resources" for the progressive realisation of the right to adequate food (Article 2, ICESCR), and ensuring effective disaster mitigation under the Sendai Framework Priority 3 target.

2.2 Progressive Realisation of Economic and Social Rights through Government Expenditure

Article 2 of the ICESCR states that governments are obligated to "… take steps …to the *maximum of its available resources*, to achieve *progressively* the full realisation of the rights recognised in the present Covenant… (emphasis added)". To this end, rights-based budget analysis is an appropriate overarching framework for analysing and assessing how public finance policies comply with the obligation to fulfil economic and social rights, as stipulated under Article 2 of the International Covenant on Economic, Social and Cultural Rights (Blyberg & Hofbauer, 2014; OHCHR, 2017). This conceptual framework, when applied to the analysis of government expenditures, enables the identification of how effective, fair, and efficient state expenditure is about sectors that have the most significant impact on the economic and social rights of the people in a country. Through a rights-based budget analysis, it is possible to understand how the government's allocation or expenditure ratios on specific rights, compared to national or international benchmarks, are either leading to the progressive realisation or retrogression/violation of those rights. Additionally, through a benefit incidence analysis, it is possible to establish whether marginalised or vulnerable groups in society are benefitting from public expenditures (OHCHR, 2017).

Under the rights-based approach, a national budget is a process through which financial resources are mobilised and allocated in compliance with the tripartite legal obligations to respect, protect and fulfil human rights (Maastricht Guidelines, 1998; CESCR, 1999; OHCHR, 2017; Meghan et al., 2017; De Schutter, 2018). Thus, it has been argued that:

> The budget reflects the values of a country – who it values, whose work it values, who it rewards…and who and what and whose work it does not…. The budget is the most important economic policy instrument of government, and as such can be a powerful tool in transforming [the] country to meet the needs of the poorest" (Debbie Budlender, 1996, p.7).

Under Article 2(2) of the ICESCR, States must "take steps" and dedicate "maximum available resources" to achieve "progressive realisation" of the rights in the Covenant. This implies that a country must discharge its duty both to *resource mobilisation* in conjunction with *spending*, and to collate both dimensions to *outcomes* – to the adequate levels of enjoyment of economic, social and cultural rights" (CESR, 2012; De Schutter, 2018, p. 22). Article 2 also requires that, in the event of natural disasters, governments must protect vulnerable members of society by adopting targeted interventions, such as low-cost housing, the provision of basic needs like food, healthcare, safe drinking water, and social protection programs (Blyberg & Hofbauer, 2014; ILC, 2016). One way to accomplish this is to apply the human expenditure ratio, which consists of three types of ratios (public expenditure ratio, social allocation ratio, and social priority ratio) as a share of the total gross domestic product (GDP) allocated to human priority concerns. This approach is consistent with a rights-based approach (UNDP, 1991, 2018; De Schutter, 2018). The UNDP estimates that a country's human expenditure ratio should be a minimum of 5 per cent of the total gross national product (GNP) to achieve people-centred, inclusive, and sustainable development (UNDP, 1991, 2018a; De Schutter, 2018).

The basic argument made by the rights-based approach in general, and the above expenditure ratios specifically, is that national budgets ought to be restructured in favour of human-centred development, away from the common practice of most government expenditure that is either misdirected to unnecessary areas or inefficiently utilised. If government priorities could be adjusted in favour of the needs of the vulnerable and marginalised, faster, people-centred progress would be achieved for all (UNDP, 1990, 1991, 2016; De Schutter, 2018). In this vein, the Human Development Report (1991) concludes:

> Many policymakers frequently concentrate on just one dimension – income. But this concentration is, at best, an oversimplification and, at worst, a gross distortion of reality. Men, women, and children must be at the centre of attention – with development woven around people, not the other way around (HDR, 1991, p. 1).

Thus, Uganda's development trajectory and progress as conceived and represented in the overarching policy instruments like the third National Development Plan III, the Uganda Vision 2040, should be evaluated and measured not by income per capita (GDP) alone, as has been the practice for decades, but also by the quality of life, health, education and general well-being achieved by the greater majority of the population (UNDP, 1990, 2018; Sen, 1992; Hicks, 2014). Economic deprivation or income poverty, therefore, should not be a standard feature of the definition of poverty, as poverty is also characterised by powerlessness and a violation of human dignity (World Bank, 2000; Sen, 1987). For most developing countries, such as Uganda, the obvious strategies to restructure their national budgets and focus their efforts on people-centred development include freezing military expenditure, halting capital flight, combating high corruption, and rationalising the bloated public administration sector (UNDP, 1991; De Schutter, 2018).

Therefore, a national budget should ideally reflect the highest value a country attaches to the realisation of human rights and capabilities of its citizens. National expenditures must also reflect the human rights principles of sustainability, inclusivity, transparency and accountability as outlined in the UN Development Agenda 2030. Although the Uganda government has consistently impressive comparative scores in budget transparency (Open Budget Survey, 2019), the budgetary allocations to social priority sectors that protect the economic and social rights of the marginalised and vulnerable, including communities in the oil-producing areas, remain neglected (Oloka-Onyango, 2017; ISER, 2016; UPR, 2022). Uganda scored 58/100 in "transparency", 22/100 in "public participation", and 59/100 in "budget oversight", according to *Open Budget Survey 2019* (International Budget Partnership, 2019). Thus, for a national budget to be an effective economic policy instrument of the government for transforming society economically for the better, higher investments in social priority sectors (health, education, agriculture, water and sanitation, social protection, etc.) will have to be exponentially stepped up. To this end, the study analysed Uganda's national public expenditure to determine if it demonstrates a commitment to comply with human rights obligations related to the protection and realisation of the right to food security in general and the right to adequate food for communities living in disaster-prone areas of the country. An overview of the current socio-economic livelihood trends in the country, particularly about poverty, provides the necessary context.

3. Results

The study's findings comprise both primary and secondary data on Uganda's investment and expenditure in food security and disaster risk reduction. The study primarily focused its analysis on the financial years (FYs) between 2016 to 2021. Overall, government spending on both food security and disaster risk reduction in Africa remains comparatively low: total disaster risk reduction (DRR) investment, on average, accounts for only 4% of national budgets in 16 African countries. This is similar to the significantly low average of 2.0% investment and public expenditure in agriculture in Sub-Saharan Africa (World Bank, 2019).

3.1 Budgeting for Agriculture and Food Security in Uganda

Uganda's agricultural sector accounts for 25% of the country's Gross Domestic Product (GDP) and employs approximately 64% of the working population, including 72% of young Ugandans (UBOS, 2020; World Bank, 2022). Extreme weather events, such as droughts or heavy rains, regularly cause significant losses to the agricultural sector, with the impact ranging from 1 to 7% of the GDP (MoWE, 2015, 2020). Uganda is projected to incur losses in food and cash crops equivalent to US$1.5 billion by 2050, reducing the country's foreign exchange earnings by US$15 to US$ 80 million per year (World Bank, 2022). The National Development Plan II (2015/16 - 2019/20) and its subsequent successors, the National Development Plan III (2020/21 - 2025/26) and National Development Plan IV (2025/26 – 2029/30), explicitly reiterate that agriculture is a priority sector.

However, despite this official proclamation, the national budget for agriculture has remained low, stagnant, or even decreased in the last decade (FAO, 2014; ISER, 2016; NPA, 2017). In FY 2016/17, for

instance, the budget for agriculture stood at 3.22 per cent, while in FY 2020/21, the budget allocation was only 2.9% (see Figure 1). The five consecutive national budgetary allocations to the agricultural sector from FY 2017 to FY 2021 are all significantly below the 10% target set by the African Union under both the Maputo (2003) and Malabo Declaration (2014) on the Comprehensive Africa Agriculture Development Program (CAADP) (FAO, 2014; ISER, 2016). However, to date, there is limited concrete evidence of positive agricultural productivity that can be attributed to this CAADP initiative in African countries (4th CAADP Biennial Review Report, 2023). With the current constraints like poor post-harvest storage infrastructure, low-value addition, limited agro-industrialisation, inefficient land tenure system, lack of irrigation infrastructure, poor all-weather feeder roads in rural areas and limited use of fertilisers and quality seeds, Uganda's agricultural sector growth and productivity was rated at 4.2% in the FY 2019/20, remarkably below the 6% per annum target that was set under the CAADP initiative

Moreover, under the International Covenant on Economic, Social and Cultural Rights (ICESCR), ratified by Uganda in 1987, the core principle of "progressive realisation" is a central tenet of the State's obligations to respect, protect, and fulfil economic and social rights (CESCR, 2000). This treaty imposes an immediate obligation on States "to take steps…to the maximum of its available resources" towards the full realisation of economic and social rights (Article 2(1), ICESCR). In this instance, the national budgetary allocations to the agriculture sector, which would ensure the right to adequate food for vulnerable communities living in disaster-prone Bududa and Kasese districts, are not being fulfilled. It is important to note, too, that inadequate funding of the agricultural sector contradicts an official 2021 Uganda Government voluntary commitment accepted at a Human Rights Council country review "to implement policies to support food production, access to credit and school meals programs linked to local food production" (UPR, 2011, para. 67). In a subsequent report to the Human Rights Council under the 2022 peer review of Uganda government's performance, the protection of the right to adequate food is addressed vaguely, without directly responding to the 2011 unfulfilled commitment (UPR, 2022, para. 46/47).

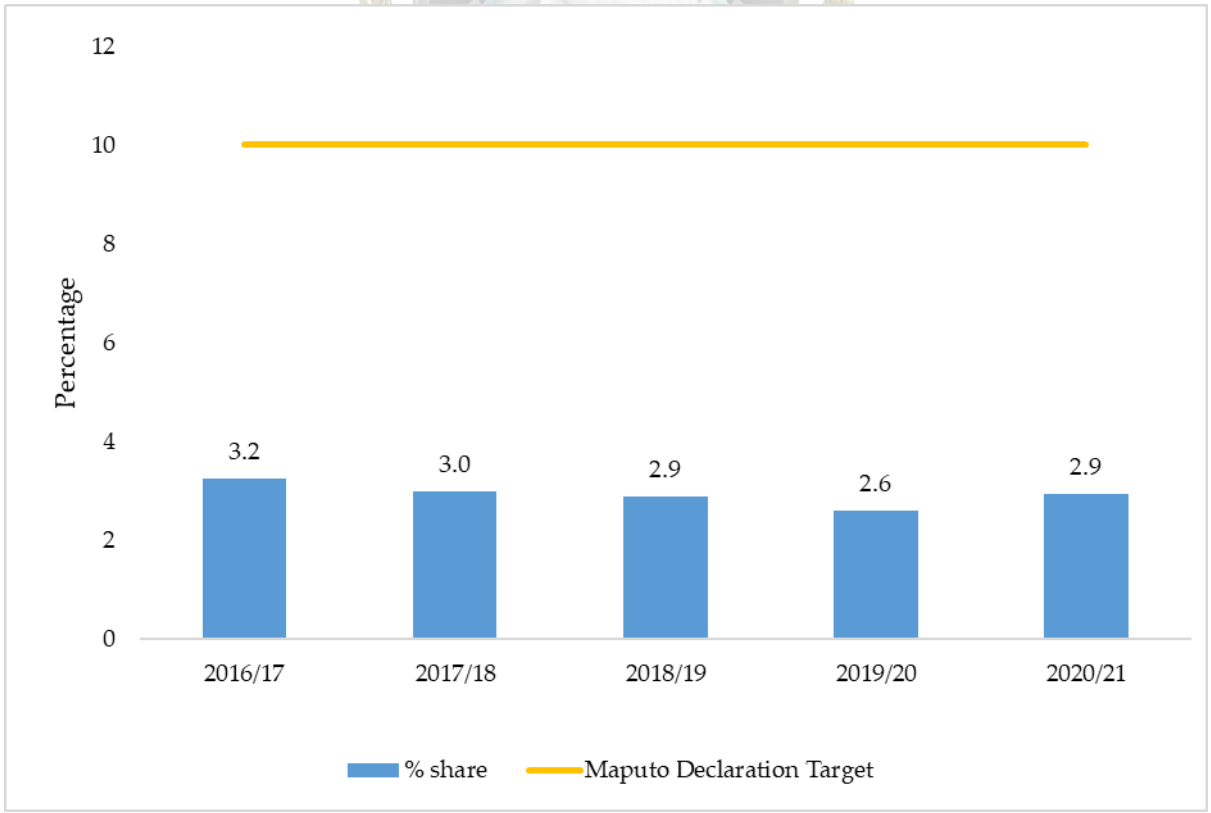

Figure 1: Budget Allocation to the Agricultural Sector (as a % of total budget), FYs 2017 – 2021.
***Source**: Ministry of Finance, Planning & Economic Development (MFPED), various years.*

In **Figure 1** above, it is irresistible to conclude that the national budget allocations to the agriculture sector are indicative of "retrogressive measures" – steps that diminish the fulfilment of the right to adequate food – contrary to the "progressive realisation" obligation under Article 2 of the ICESCR. The level of investment in agriculture, which is significantly below the 10 per cent Maputo/Malabo/CAADP target, is contrary to the cardinal human rights principle of the progressive realisation of economic, social, and cultural rights (CESCR, 1990). The treaty obligations require States to avoid non-retrogressive measures – actions that have the effect of removing or rolling back existing protections for economic and social rights unless justified after applying the maximum available resources (CESCR, 2000).

Moreover, this low public expenditure on agriculture and food security also violates the commitments under the 2004 FAO *Voluntary Guidelines to Support the Progressive Realisation of the Right to Adequate Food in the Context of Food Security*, particularly Guideline 12, on national financial resources. Specifically, Guideline 12.3 stipulates that governments should promote basic social programs and public expenditures that target the poor and vulnerable segments of society. In the specific case of the disaster-prone communities in Bududa and Kasese districts, the study found that there are no concrete safety net programs, for instance, that have been implemented to assist the vulnerable people in getting back on their feet after the loss of all their household assets and their source of livelihoods (subsistence farming) due to floods, mudslides and landslides. Thus, despite the adoption of the national social protection policy in 2016, the coverage, design, and funding of social protection for the most vulnerable citizens reach only 3 per cent of the population, significantly below the average in other East African countries, at 9 per cent of the population (World Bank, 2022).

Despite the low sectoral allocations to the agricultural sector, it is pertinent to note that the available budget also allocates a negligible amount for services and goods that target subsistence farmers, who constitute the majority of the sector (approximately 70% in 2021). For instance, funding for agricultural extension services—a critical component that enhances the capacity of rural subsistence farmers to increase their farming productivity—constituted only 4 per cent of the overall agricultural budget (MFPED, 2016). Consequently, poor funding undermines the effectiveness of agricultural intervention programs. In 2016, only 19 per cent of households in Uganda had accessed extension services, which dropped to 14 per cent for women-headed households and 12 per cent for farms of less than 2 acres in size (IFPRI, 2016).

Moreover, the national expenditure allocated to the health sector, an important complement of the right to adequate food, continues to be underfunded in the national budget at 6.4 and 6.1 per cent in 2020 and 2022, respectively, significantly far below the 15 per cent target, government commitment in the Abuja Declaration (Abuja Declaration, 2001) (see **Figure 2**). Similar to the budget allocations for agriculture, the health budget has stagnated at an average of 6.64 per cent in the past five years, significantly impeding the overall protection of economic and social rights in the country (UPR, 2022). We mention the health sector here deliberately because the inextricable linkages between all human rights are well recognised (Vienna Declaration & Program of Action, 1993, para. 5).

Concerning the rights to adequate food, nutrition security, and the highest attainable standard of health, this linkage is particularly critical for achieving sustainable and inclusive development, as outlined in the 2030 Agenda (Ayala & Meier, 2017; UNDP, 2018a). A comparison of sectoral allocations in FY 2017–2021 between agriculture, health, and security (see Figure 3) clearly shows the disparities among these sectors. While funding for both agriculture and health either remained stagnant or decreased significantly below the recommended Abuja and Maputo targets of 15% and 10% of the total national budget, respectively, the security/military budget increased exponentially over the last five years. This lopsided situation presents a classic case of retrogressive measures, a clear violation of state obligations stipulated under the ICESCR ("progressive realisation") versus "retrogressive measures" (CESCR General Comment No. 3 (para. 9) and CESCR General Comment No. 14 (para. 32).

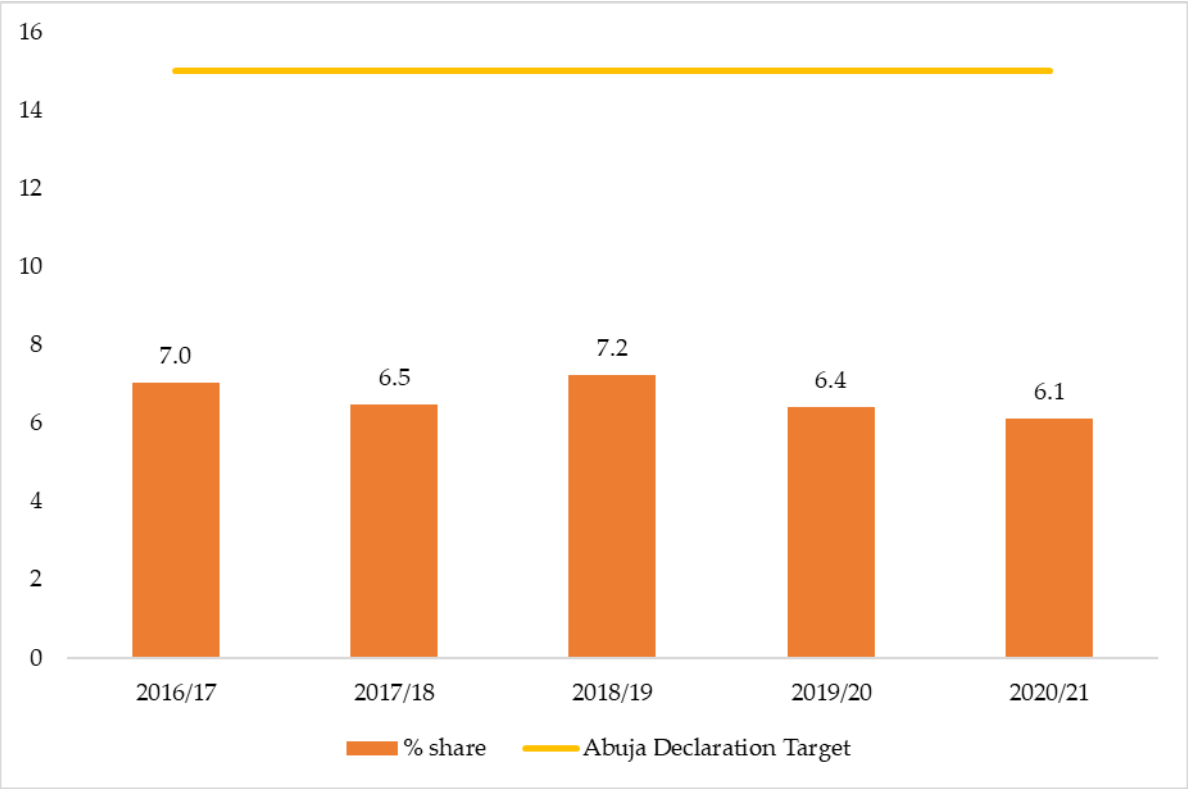

Figure 2: National budget allocations to the health sector (as a % percentage of total budget), Financial Years 2017 - 2021.
Source: *Ministry of Finance, Planning & Economic Development (MFPED), various years.*

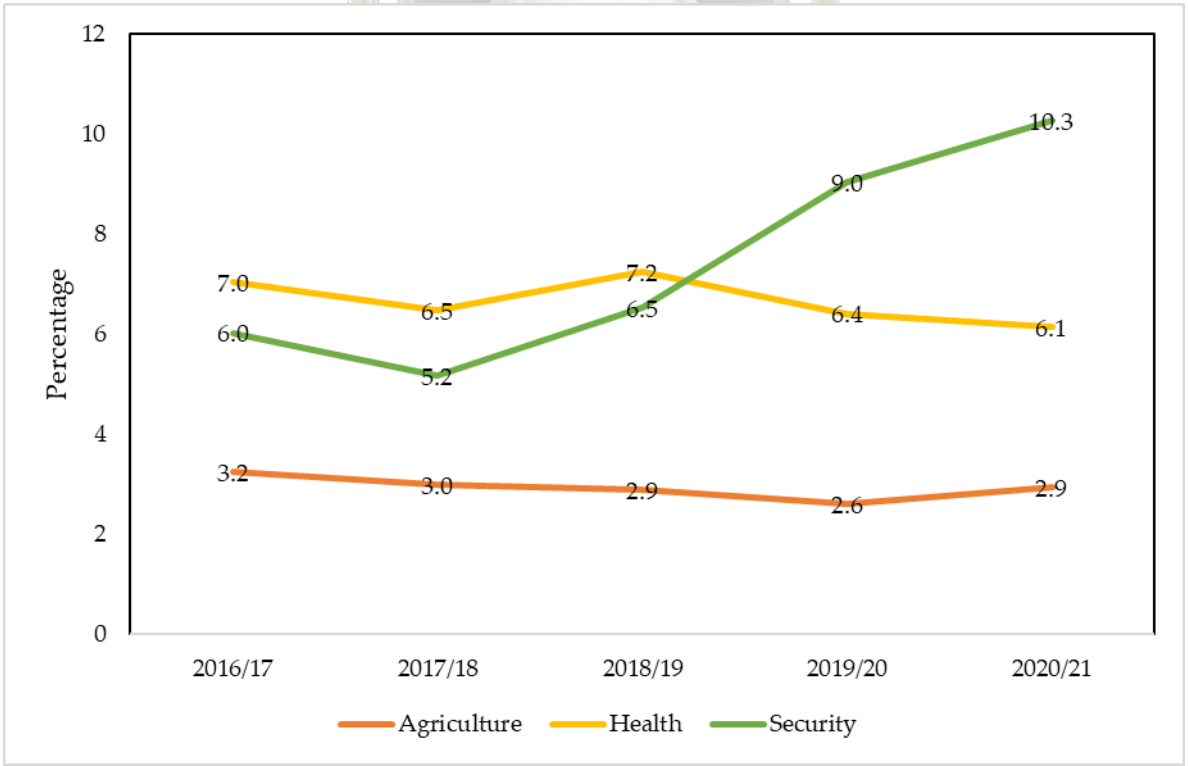

Figure 3. Sector Comparisons-Budget Allocations to Agriculture, Health and Security, Financial Years 2017 - 2021.
Source: *Ministry of Finance, Planning and Economic Development (MFPED), various years*

Therefore, national public expenditure and financing for the agricultural sector and disaster risk reduction (DRR) are insufficient to achieve the desired outcomes for the right to adequate food and nutritional security for all Ugandans (FAO, 2014; NPA, 2017). In actuality, contrary to the human

rights principle of progressive realisation of economic and social rights, the government has instead consistently engaged in retrogressive measures (CESCR, 2000, 1990). For instance, public expenditure for agriculture was reduced from 10 per cent of the total budget in 1980 to 3.7 per cent in 2008/9 (FAO, 2014; ISER, 2016). As already indicated, a retrogressive measure is any action taken by the government that has the effect of removing or rolling back budgets, laws, programs, or institutions previously used to safeguard a right, as reflected in paragraph 9 of the CESCR (CESCR, 1990). Thus, the overall national public expenditure on hunger and food and nutrition security programs remains underfunded, often fragmented, and donor-driven, failing to have a fundamental impact on food security in the country (NPA, 2017).

3.2 Financial Incoherence between Disaster Risk Reduction and Climate Change Policies

Uganda is a signatory to a multiplicity of regional and international disaster risk reduction frameworks, including the Paris Climate Change Agreement, 2015, the Sendai Framework for Disaster Risk Reduction (2015–2030), the Africa Regional Strategy for Disaster Risk Reduction, the IGAD Drought Disaster Resilience and Sustainability Initiative Strategy and the EAC Disaster Risk Reduction and Management Strategy (2012–2016). At the domestic level, Uganda adopted a national policy for disaster preparedness and management in 2010. This policy, however, was formulated during the last five years of the Hyogo Framework for Action (HFA), 2005–2015, which expired in 2015 and was replaced by the current Sendai Framework. Therefore, this policy is now outdated and requires revision to fully align with the new strategies outlined in the 2030 Agenda for Global Development, specifically the Sendai Framework for Disaster Risk Reduction (2015–2030), the Paris Climate Agreement, and the UN Sustainable Development Goals (SDGs).

Under the National Development III, the government demonstrates a deliberate effort to integrate disaster risk reduction (DRR) and climate change adaptation (CCA) fields (United Nations Office for Disaster Risk Reduction (UNDRR), 2022), as envisioned under the global 2030 Agenda for Sustainable Development. However, when analysed from a strategic, conceptual, institutional, operational, and financial dimension, Uganda's policy architecture for tackling disaster risk reduction (DRR) and implementing climate change adaptation (CCA) reveals limited coherence across all five dimensions, thus limiting its effectiveness (UNDDR, 2022). Strategically, the relationship and linkages between DRR and CCA are not strong, while conceptually, the phenomena of risk and resilience are inadequately conceived in the policy instruments. Furthermore, from an institutional perspective, the practical coordination between DRR and CCA institutions (or the potential for coordination) is weak, unclear, or duplicative.

Most important for our purpose here is the coherence of the financial policy architecture for disaster risk reduction (DRR) and climate change adaptation (CCA). This aspect examines how funding strategies and investments effectively integrate both Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) to mitigate risk and prevent the creation of new risks in the development process. Overall, while Uganda is credited with formulating a comprehensive policy architecture to deal with disaster risk, the financial viability is largely "limited" in its reach or scope (UNDRR, 2022), as was corroborated by interviews of the policy implementers. The national disaster policy is housed in the Department of Relief, Disaster Preparedness, and Management within the Office of the Prime Minister (OPM). It aims to minimise the vulnerability levels of Ugandans to natural and human-induced hazards and to save lives and livelihood assets when disasters occur. Similarly, there are related policies on climate change adaptation (CCA), including the National Climate Change Policy (2015), the Strategic Program for Climate Resilience (2017), and the National Costed Implementation Strategy (2013), which are domiciled in the Ministry of Water and Environment.

However, when the above key instruments in the policy architecture were assessed for their financial viability, they were found to be primarily "limited" or incoherent, except for two policies that were considered "substantial" in financial terms (see **Table 1**) (Pietschmann, 2019). Such a lack of adequate funding for DRR, despite the best policy intentions, is not unique to Uganda but a widespread practice in many countries (Mitchell et al., 2010; Gordon, 2013). In effect, this implies that the

policies cannot be effectively implemented to ensure disaster risk reduction in the country. According to the National Climate Change Policy and Costed Implementation Strategy estimates, Uganda will require financing of USD 2.9 billion, about 1.2 per cent of the year 2011 GDP, by 2030. However, an analysis of DRR investment for 2016/17 – 2018/19 indicates these projections are unrealistic and cannot be met.

Table 1. Level of Financial Coherence of Uganda's Disaster Risk Reduction and Climate Change Adaptation Policy Instruments

Policy Instrument	Level of Coherence
National Development Plan, 2018 - 2022	Substantial
National Disaster and Preparedness Policy, 2010	Limited
Disaster Preparedness Strategic Plan & Budget, 2017 - 2022	Limited
National Climate Change Policy, 2015	Limited
Strategic Program for Climate Resilience, 2017	Limited
National Costed Implementation Strategy, 2013	Substantial

Source: *Adopted from United Nations Office for Disaster Risk Reduction (2022, p. 21).*

3.3. Disaster Risk Financing and Management: The Uncertain Fate of the Contingencies Fund

Even in instances where relevant legislation is explicit and specific on the modalities of expenditure for disaster risk reduction, it is not always adhered to. Domestic financing for DRR activities is undertaken under the Contingency Fund established by the Public Finance Management (PFM) Act 2015. In 2021, the Parliament amended the Public Finance Management Act 2015 to cater for the use and management of oil revenues in the country, specifically through the Public Finance Management (Amendment) Act 2021. However, Section 26 of the PFM Act is silent on the modalities for utilising the funds for disasters despite the government consistently failing to replenish the Contingency Fund (Rukundo *et al*., 2016; CSBAG, 2018). Moreover, Section 26 requires the government to earmark or ring-fence at least 3.5 per cent of the annual national budget for a Contingency Fund specifically to deal with disasters; however, this obligation has not been consistently implemented (Rukundo et al., 2016; CSBAG, 2018). Lack of sufficient government funding and ineffective implementation capacity for disaster preparedness, prevention, and response in the Ministry of Relief, Disaster Preparedness and Refugees remains a constant cause of concern to top ministry officials, as the government is unable to adequately respond to a plethora of disaster events in the country (CSBAG, 2018; Development Initiatives, 2019; MFPED, 2019; OPM, 2021).

As a result, four years after the Public Finance and Management Act was enacted into law by Parliament in 2015, the Contingency Fund had not yet been operationalised. In May 2017, the Minister for Relief, Disaster Preparedness and Refugees decried the government's delay in establishing the contingency fund to respond to disasters despite their frequency and increasing severity in the country:

> *"We need to have money in the budget for disasters. This is something that warrants consideration. Last year, we did not have the funds to help the people of Mutukula who were affected by the earthquake. Even now, the money is very little to handle the people who are affected"*, H. O (15 May 2017).

In the FY 2018 – 2019, the first instance that funds (UGX 62 billion) were allocated to the Contingency Fund, the Kakumiro District Women member of parliament complained that the operationalisation of the Contingency Fund was not fast enough, which was adversely affecting farmers who had been compelled to sell their crops at low prices after a bumper harvest season. The Member of Parliament said:

> *"We need the government to fast-track the Contingency Fund to protect our farmers from price volatility,"* R. N (25 July 2018).

However, even when the Contingency Fund was eventually operationalised with 62 billion shillings in FY 2019/20, the reserve fund remained in a deficit amounting to 16 trillion shillings (CSBAG, 2022). This is because the government was not consistently allocating sufficient funds to replenish the funds, in contravention of the provisions of the Public Finance Management Act, 2021. In fact, since the inception of this reserve fund in 2018, it has received less than 0.2 per cent (approximately $ 17 million) in funding. In the financial year (FY) 2015/16, a supplementary budget of Uganda Shillings (UGX) 5 billion (approximately US$1.4 million) was disbursed to the Office of the Prime Minister (OPM), of which UGX 4 billion (approximately US$1.12 million) was earmarked to provide relief for disaster victims. Similarly, in FY 2016/17, a supplementary budget of UGX 25 billion (US$ 7.04 million) was earmarked to provide relief to disaster victims. This practice of relying on supplementary budgets as a disaster risk financing mechanism has been found to contribute to the government's overall poor budget performance (World Bank, 2022).

There are also indications of financial mismanagement contrary to the law that established the Contingency Fund. Ironically, in 2021, the Prime Minister, who, as a backbencher three years earlier, had called for the fast-tracking of the establishment of the Contingency Fund, was now being accused by the parliament of withdrawing 5 billion shillings from it without following proper procedure or accounting for it (*New Vision*, 2021). Public finance diagnostic studies in the country regularly indicate that budget credibility at both national and local government levels is weak due to erratic cash flow management, corruption, volatile inflation, and uncertain donor funding. For instance, a recent study shows that in FY 2017/18, development budget releases underperformed by 23.3%, which improved to 14.2% in FY 2021/22. Surprisingly, on the other hand, non-wage recurrent expenditure budget releases consistently outperformed for all the years under review (UNICEF, 2023).

Poor budget performance and execution make consistent financing of climate change adaptation and disaster risk reduction difficult to manage (DI, 2019; UNICEF, 2023). Uganda has consistently suffered from poor service delivery due to weak institutions and limited oversight, particularly at the local government level (IPA, 2015). Accusations of corruption in the use of public funds are constant, with Uganda regularly scoring very low on the global Corruption Perception Index (CPI) surveys. For instance, there were scandals in the Office of the Prime Minister, where shillings 60 billion were embezzled. Shillings 340 billion was lost to fictitious pensioners in the Ministry of Public Service, equivalent to the total budget of the Ministry of Agriculture, Animal Industry, and Fisheries in 2013/14 and approximately 3% of Uganda's total annual budget (Munyambonera & Lwanga, 2015; Kakumba, 2021).

In 2020 and 2021, according to Transparency International, Uganda's corruption perception index (CPI) was 27/100 (score) and 144/180 (rank). In 2020, a collation of civil society organisations (CSOs) known as the Civil Society Budget Advocacy Group (CSBAG) wrote a public letter to the Ugandan president complaining about the government's excesses and disregard of the proper procedures under the Public Finance Management Act.:

> *As civil society organisations, we are concerned about prudent public finance management practices. The PFMA requires Parliament to be transparent, accountable, efficient, and effective and ensure the sustainable utilisation of resources. There is no information available to indicate that the Budget Committee discussed and recommended this allocation (UGX 10bn) based on the report of the Budget Committee on the Supplementary Expenditure Schedule 2 Addendum 1 and 2 for FY 2019/20. This is concerning to citizens, as Parliament is the vanguard of checks against the misuse of funds by the Executive. The acts of stealthily allocating themselves 10 billion without discussion and details on accountability set a dangerous precedent and run contrary to the letter and spirit of the PFMA and the Constitution. (p. 2)* (CSBAG, 17 April, 2020).

According to the government's own Inspector General of Government (IGG) report in 2019, Uganda loses a total of 9.144 trillion shillings to corruption annually, equivalent to 44% of the total government revenue that year (IGG, 2019).

3.3 Uganda's Disaster Risk Reduction Expenditures under the Sendai Framework 2015- 2030

In FY 2018/19, for instance, the Government of Uganda spent USD 16.7 million, equivalent to UGX 62.068 billion (UNDRR, 2022). An analysis of the budget allocations from FY 2016 to FY 2021 (see **Table 2**) reveals several important issues. First, direct disaster risk reduction spending is, on average, less than 1 () per cent of the total national budget, similar to at least sixteen other African countries (UNDRR, 2019). Thus, despite some progress in implementing disaster risk and climate change adaptation activities, Uganda still lacks a definitive, coherent, and systematic disaster risk reduction (DRR) investment policy.

This highlights an urgent need to increase direct disaster risk reduction spending in the country, ensuring that other investments towards the SDGs do not create new risks but rather build resilience (UNDRR, 2019). Second, there is insufficient information available about the effectiveness or financing of specific disaster risk reduction (DRR) components, such as climate change adaptation and local government DRR structures (district disaster committees), which are not directly funded by the government (DI, 2020). In essence, the government is still spending a substantial portion of the DRR budget on responding to and managing disasters rather than mitigating and reducing disaster risk in the country (MFPED, 2019). Third, expenditure fluctuates significantly between years and is not commensurate with current levels of risk and the pace of risk creation. Uganda lacks a robust multi-hazard early warning system and access to appropriate disaster risk information and assessments.

Table 2. Budget allocations and expenditures for disaster preparedness and refugees, 2016 -2021

FY	Budget	Release	Expenditure	Supplementary
2015/16	20.53	25.74	23.21	5.21
2016/17	12.56	36.14	36.91	23.58
2017/18	11.9	13.14	13.12	1.24
2018/19	12.18	7.45	6.7	0
2019/20	128.68	187.6	165.34	58.92
2020/21	250.18	237.05	195.37	0

Source: *MOFPED Vote Performance reports, Financial Year 2016 – 2021. Figures in UGX billions.*

3.4. Uganda's Compliance with the Sendai Framework for Disaster Risk Reduction

Concerning the Sendai Framework specifically, when Uganda's disaster risk reduction expenditures and investments for three years (FYs 2016/17 – 2018/19) were reviewed using the OECD DAC DRR risk-sensitive budget analysis formula, several important issues were revealed (OECD, 2017). First, only one institution in Uganda, the Office of the Prime Minister (OPM), was found to have explicitly budgeted for strengthening disaster risk reduction (DRR) preparedness and response (termed 'principal' under the OECD DAC DRR formula) in the three financial years (FYs) reviewed. However, while there was no other budget item that explicitly mentioned 'disaster' in the three years, a total of 222 disaster risk reduction-related activities or projects (termed 'significant' under the OECD DAC DRR formula) were identified across other government ministries agencies and departments. Second, overall, the OPM had the largest number of projects with a DRR focus and received the largest share (35.9%) of principal DRR-marked investments over the three financial years. The Ministry of Health followed this with three sub-programs (11.2%), the Ministry of Gender, Labour, and Social Development with two projects (9.9%), the Ministry of Works and Transport with one project (10%), and the Ministry of Agriculture with one project (0.2%) (DI, 2019).

The low budget allocation to the agriculture sub-program (0.2%) within the overall DRR expenditure under the OPM is indicative of the low expenditures on the overall agricultural sector, as highlighted in the first part of this study. Thus, from a human rights perspective, the low budgetary allocations to disaster risk reduction, similar to those in the agriculture sector, are regressive

and not in compliance with Uganda's commitments under Priority Three of the Sendai Framework 2015–2030. Priority Three requires States to invest in disaster risk reduction to build resilience for vulnerable people, communities and the environment. The vulnerable communities living in disaster-prone areas in Bududa and Kasese districts and elsewhere require their basic livelihood needs to be prioritised as much as the government prioritises the luxury vehicles for the members of Uganda Parliament or ceremonial cars for the Speaker and Deputy Speaker of the same institution, for instance (*Monitor*, 7 June 2022).

3.5 Disaster Risk Financing: Findings from Government Duty-bearers at National and Local Levels

This study also conducted key informant interviews with fifty-six (56) government officials and reviewed relevant secondary documents related to budgeting for disaster risk reduction. Within the human rights framework, the government is the principal duty bearer with a triple obligation to respect, protect, and fulfil human rights (ICESCR, Art. 2(1); ICCPR, Art. 2(1)). However, findings from field research indicate that the government has not yet shifted its outlook and response framework from *managing disasters* to *managing risk*, as required under the Sendai Framework for Disaster Risk Reduction. In terms of budgeting and financing disaster risk reduction in the country, gaps remain evident. The Minister for Relief, Disaster Preparedness and Refugees expressed this clearly at the launch of Uganda's National Risk and Vulnerability Atlas on 22 February 2021 in Kampala. While commenting on the budgeting for disasters, the Minister called for a dedicated budget to deal with disasters and stated the following:

> *"Currently, we operate on contingency funding, which is undefined. Now that we have scientific evidence of disasters, we should have a budget to be able to address the issues identified".* H.O (22 Feb., 2021).

The Minister's assertion above was echoed by another government official in one of the line ministries thus:

> "*There is some money under the Office of the Prime Minister (OPM). However, we do not have a specific grant going to districts to handle disasters at the district level because the Office of the Prime Minister indeed handles all disasters..."* N.D2 (10 Feb., 2020)

It is evident, thus, that the sub-national level of the government administration (Local Governments or Districts) does not get any budgetary allocations for disaster risk reduction. However, on paper, if not in actual practice, as many as 75% of the districts countrywide (CSBAG, 2018) have established District Disaster Management Committees (DDMCs), including Bududa and Kasese Districts.

However, these committees are essentially dormant as they cannot function effectively in their role as a mechanism for early warning and disaster preparedness without funding. Thus, when hazards such as landslides, floods, and mudslides occur, local governments are often helpless to intervene in any practical way beyond alerting the national authorities in Kampala. The affected districts must wait for the national disaster mechanism, the National Emergency Coordination Committee (NECOC), to intervene. This often delays, leading to the loss of additional lives and property. When asked about the local budgeting for disasters in Bududa District, one local official reported:

> "*As a district, I cannot say we have any adequate budget because the national government controls the budget, and there is nothing like having indicative figures for us on this side. So, I cannot lie to you that we know of the disaster budget…However, the budget is not there as far as I can see. The OPM manages the national budget, but they do not communicate the indicative figures to us, indicating which one is for which purpose. As far as we are concerned, we do not have a budget here..."* BD 1 (8 July 2019).

Similarly, in Kasese District, an official working in the humanitarian response sector confirmed the same non-funding situation thus:

> *"I would say a hundred per cent there is no funding for disasters in the district. I have seen the district disaster management committee struggling because it lacks funding and support. One, the district lacks transportation to conduct assessments. One factor that has consistently hindered the district from producing timely assessment reports is the lack of transportation. I can give a scenario. It happened yesterday. One of the sub-counties experienced floods. There were calls of "please come and help us see what has happened" in the sub-county. However, there was no transportation to conduct an on-site assessment. So funding is one of the critical challenges. No fund or budget is put aside to facilitate the DDMC to assess emergency disaster incidents"* KD 2 (12 Feb. 2020).

The impact of lack of funding on the local efforts by the District Disaster Management Committees (DDMCs) to ensure effective disaster risk reduction at the district level is enormous. One of the officials summarised it thus:

> *"The DDMC is supposed to have monthly meetings depending on the situation, but sometimes, there is a single meeting. Sometimes, it does not take place. The DDMC is not motivated. The DDMC is supposed to have about 25 members, but the whole DDMC rotates around only five people. Because others are not motivated. The DDMC is purely voluntary; only those who have the spirit of helping are the ones who fuel their vehicles and help".* KD 3 (13 Feb., 2020).

Another Local Government official added the following:

> *"So, I will say that Kasese is not doing well in budgeting for the implementation of activities against these disasters. Today, you will put up a bridge or a road, but tomorrow morning, you will see it nowhere to be found. Therefore, we require a dedicated fund to address the issue of disasters. We will also examine the issue of managing preparedness, response, and recovery. All these stages need concerted efforts and resource allocation."* KD 4 (11 Feb., 2020)

Thus, despite the financial and political powers extended to local governments to implement a multiplicity of activities in Uganda, local governments or districts are not directly funded to deal with disasters in their localities. This is a critical implementation gap. From both legal and practical perspectives, therefore, local governments should be at the forefront of addressing disasters in all their phases: preparedness, response, and recovery and reconstruction. This will only be possible if funding is devolved from the central (national) level and extended to these sub-national administrative units.

3.6 Civil Society Not Adequately Applying the Human Rights-based Approach in Budget Advocacy

The role of non-governmental organisations (NGOs), specifically and civil society broadly, in the realisation of economic and social rights cannot be overstated. These groups have been instrumental in advocating for all categories of rights in Uganda, with remarkable results over the years (Renzio et al., 2006; Devlin-Foltz, n.d.). On budget advocacy, the Civil Society Budget Advocacy Group (CSBAG) is a coalition of activists credited with consistently highlighting social priority concerns in the national budget, particularly advocating for pro-poor budgets that prioritise the needs of the poor and vulnerable sections of the population. However, civil society activists need to adopt the language of the rights-based and capability approaches to achieve greater effectiveness in advocating for the needs of the poor, vulnerable, and marginalised sections of the population. The rhetoric of human rights as a robust legitimating discourse is undeniable, especially when emphasis is put on the legally binding obligations of States (Doz Costa, 2008). The current civil society's advocacy language lacks the legitimating appeal and power of human rights; in many ways, their language is similar, if not identical, to the government's income-centric approach, which continues to leave behind the poor and most vulnerable populations in Uganda's development trajectory.

4. Discussion

From the above analysis, it is evident that the Government of Uganda is unlikely to increase national budgetary expenditure on the agriculture sector to achieve the Comprehensive African Agricultural Development Program (CAADP) target of 10% in the foreseeable future. This notwithstanding, at 3.6% public investment and expenditure on agriculture, Uganda's position is still significantly above the Sub-Saharan average of about 2.0% (World Bank, 2019). Overall, Africa's level of public expenditure on agriculture remains low, lagging behind that of other regions. Specifically, agricultural spending as a share of overall public spending (the indicator used in the Maputo/Malabo/Kampala Declarations/CAADP) is significantly lower in Africa than in other similar regions, particularly East Asia and South Asia. Since the adoption of the CAADP initiative in 2014, only four countries in Africa – Burkina Faso, Malawi, Mozambique and Zimbabwe are on record to have achieved or slightly surpassed the 10% target budget expenditure on agriculture (World Bank & GOU, 2019). Additionally, only three countries (Niger, Rwanda and Zambia) have been close at 9%. There has been more regression than progress since 2014. By 2023, no African country was on track to achieve the CAADP goals and targets, particularly to finance 10% of the national budget for agriculture and to achieve an annual sectoral growth rate of 6% (4th CAADP Biennial Report, 2023).

4.1 The Nexus Between Food Security and Disaster Risk in Uganda

In Uganda, the frequency and severity of natural and human-induced hazards, such as droughts, landslides, floods, and earthquakes, significantly impact the livelihoods of substantial sections of the population (GOU, 2011; Rukundo *et al*., 2014; ACAPS, 2018). In 2019, the Global Facility for Disaster Reduction and Recovery (GFDRR) estimated that annually, floods alone impact nearly fifty-thousand (50,000) people in Uganda, and over USD sixty-two (62) million in gross domestic product (GDP) is lost. Similarly, droughts affected 2.4 million people between 2004 and 2013. Between 2010 and 2011, drought conditions led to further losses, estimated at USD 1.2 billion, equivalent to 7.5 per cent of Uganda's 2010 GDP. In 2017, due to drought, the GDP from the agricultural sector decreased from UGX 3,257.83 billion in the third quarter to UGX 3,110.66 billion in the fourth quarter, severely impacting the livelihoods of many (MFPED, 2019).

Notably, there is a direct connection between disasters and food insecurity (FAO, 2013; Rukundo *et al*., 2016). Climate-related hazards in Uganda, such as droughts, floods, landslides, and earthquakes, destroy agricultural, livestock, and food processing infrastructure, assets, inputs, and production capacity (Mertens, 2016). Hazards disrupt the food supply, decrease household incomes, deplete savings, and erode livelihoods. Katongole (2020) examines the role of disaster risk financing in building the resilience of poor communities in the Karamoja region in north-eastern Uganda. The Karamoja region is a semi-arid region with some of the most vulnerable and impoverished communities in the country, which are perennially affected by famines, droughts, and inter-ethnic conflict. This presents a relevant counterpoint to the landslide- and flood-prone Bududa and Kasese districts, respectively. However, the Government of Uganda's over-reliance on ex-post financing instruments, such as emergency releases of supplementary budgets and donor aid, is neither comprehensive nor sustainable for adequately managing the country's growing hazard profile (UNDP, 2024).

These climate-induced hazards and shocks inevitably lead to socioeconomic crises such as soaring food prices, famines, malnutrition and hunger that force the rural poor to sell their meagre assets, decrease food consumption, reduce their dietary diversity and access to safe and quality food (FAO, 2013; Rukundo *et al*., 2016; MFPED, 2017). Food insecurity is a reality in Uganda: in 2017/2018, 13 per cent of the total population in the country was facing 'stressed food insecurity' (phase 2). An estimated 5.3 million people experienced 'acute food insecurity' (phase 2, 3), of which 440 821 (one per cent) were in crisis (phase 3), with minimally adequate food consumption (IPC, 2017). Thus, disasters create or exacerbate vicious cycles of poverty, increasing the prevalence of hunger, food insecurity, and general vulnerability (Rukundo et al., 2016).

Disasters are increasingly being recognised as a function of poverty, vulnerability and exposure to a host of different hazards. Landslides and floods constitute the primary hazards with the most significant impact on the right to food in the Mount Elgon and Mount Rwenzori regions, where Bududa and Kasese districts are located. While complete data about the earliest landslide and flood fatalities in both districts are scanty or outright unavailable, earlier studies indicate an estimated 154 people were killed by landslides in the 20th century, with the years 1933, 1964 and 1970 being par-

ticularly disastrous in the Mount Elgon region (Knapen *et al.*, 2006; Staudt *et al.*, 2014). More current data indicate that from 2010 to 2012, over 500 people were killed in the Bukalasi sub-county on 1 March 2010, and on 25 June 2012, over 100 people were killed (Jenkins *et al.*, 2012) while on 11 October 2018, at least 66 people were killed in the same area (*Observer*, 2018; *New Vision*, 2018). On 5 June 2019, a major mudslide killed at least five people; 50 others were still missing, and 150 houses were destroyed (URCS, 2019). In the Rwenzori mountains, on the other hand, at least 56 people have been killed by landslides or flash floods in the last fifteen years (Kervyn *et al.*, 2017). In November and December 2019, heavy floods and landslides in the Bududa and Kasese districts left over 36 people killed, thousands displaced, and property destroyed (ACAPS, 2019).

Vulnerability to disasters is not just a natural phenomenon. Still, it is also attributed to unequal economic systems, limited access to resources, and a lack of voice in formal and informal governance institutions. Therefore, vulnerability to disasters is inextricably linked to power and powerlessness, as well as the governance systems in society (SAMHSA, 2017). In Africa, broadly, and in Uganda specifically, international and regional frameworks for tackling disaster risk reduction have not translated into a significant reduction in vulnerability (Manyena, 2016). While short-term progress has been achieved in mobilising communities for disaster risk reduction, the underlying vulnerabilities persist. A chasm exists between vulnerable local communities, district governments, and national policy technocrats in many instances, characterised by weak or unclear institutional mandates, inadequate capacity, and limited financial resources for disaster risk reduction (Rukundo et al., 2016).

Thus, at the national level, while the government has designed a robust architecture to ensure that Ugandans enjoy the right to adequate food, the central challenge is effective implementation (NPA, 2017). The 1995 Constitution (as amended), particularly Objectives XIV and XXII, titled "National Objectives and Directive Principles of State Policy" (NODPSP), explicitly requires the government to ensure that all Ugandans enjoy food and nutrition security. Similarly, Objective XXIII provides for the rapid activation of mitigation measures against natural disasters whenever they occur. Moreover, although Article 249 of the Constitution provides for the establishment of a National Disaster Preparedness and Management Commission, it is notable that the Parliament of Uganda has yet to adopt the relevant legislation to establish such a commission for over twenty years. In 2010, the Uganda Human Rights Commission recommended to Parliament for an urgent establishment of such an agency. Unfortunately, the government instead created a more politically expedient (and weaker) office of disaster preparedness under the OPM. In the majority of disaster events, this office is often financially constrained in responding effectively (UHRC, 13th Annual Report, 2010).

Moreover, a proposed Food and Nutrition Bill has languished in draft form for over a decade (since 2008). This important legislation, if ultimately adopted by parliament, would constitute a vital step in implementing several related policies, including the Uganda Food and Nutrition Strategy and Investment Plan (UFNSIP) and the Uganda Food and Nutrition Policy, among others. Equally important, the aggregate government expenditure on the agricultural sector (essential for food security) remains perennially below the international benchmarks agreed upon to ensure adequate food and nutrition security in the country (FAO, 2014; 2016). Similarly, investment in disaster risk reduction (DRR) is constrained: Uganda allocated, on average, 64% of total principal DRR investment to mitigation and prevention, 4% to preparedness, 6% to response and relief activities, and 26% to recovery activities. However, these investments have neglected to focus on developing disaster risk knowledge (Sendai Priority 1) or strengthening disaster risk governance (DI, 2019).

The failure to protect or adequately allocate sufficient financial resources to the agricultural and disaster reduction sectors, however, remains a challenge. From a human rights perspective, this omission is contrary to the principles of progressive realisation of economic and social rights, including the right to adequate food. Article 2(2) of the ICESCR commits States "to take steps, individually and through international assistance and co-operation, especially economic and technical, to the maximum of [their] available resources, to achieve progressively the full realisation of the rights recognised in the present Covenant by all appropriate means, including particularly the adoption of legislative measures". This human rights principles of "progressive realisation" obligates governments to exponentially increase budgetary allocations to improve conditions for the realisation of

economic and social rights (CESCR, 1990). This would imply, concerning the government's budget, that financial allocations and expenditure on food security or disaster management should increase by at least the same rate as the overall budget. In effect, if the total government budget increases by 5 per cent from one year to the next, funding for food security and disaster management should increase by at least 5 per cent (OHCHR, 2017).

Moreover, the Sendai Framework Priority 3 on "Investing in Disaster Risk Reduction for Resilience" enjoins countries to ensure "public and private investment in disaster risk prevention and reduction through structural and non-structural measures …essential to enhance the economic, social, health and cultural resilience of persons, communities…. and their assets, as well as the environment" (Sendai Framework, para. 29). To the extent that the actual realisation of these multiple obligations is ignored or unfulfilled in Uganda (Rukundo *et al.*, 2014; 2016; NPA, 2017), the underlying reasons for this delinquency was examined about national public expenditure to understand its impact on the realisation of the right to adequate food of vulnerable communities impacted by disasters.

4.2 Poverty and Pro-Poor Budgeting in Uganda: The Case of the FY 2019/20 Budget

To understand the extent to which Uganda is committed to eradicating poverty and realising the right to adequate food and disaster risk reduction, it is necessary to examine the government's pro-poor budgeting credentials. As already indicated, despite a general decline in overall poverty levels over the last two decades, Uganda remains a poor nation term, and recent proclamations about attaining a middle-income status remain hollow. For instance, the president's public insistence on 8 June 2022 in the State of the Nation address that Uganda had achieved a "middle-income status" was met with scepticism by most economists and the general public. They pointed out the government's poverty figures, which indicated that more than 12.3 million in the country were still living below the official poverty line (MFPED, 2021).

The economy grew by only 3.1 per cent in FY 2019/20, which was significantly lower than the 6.8 per cent growth in FY 2018/19 due to the impact of the COVID-19 pandemic, locust and flood disasters (MFPED, 2019); this is exacerbated by the absence a truly pro-poor budgeting framework in Uganda (DI, 2020).

To assess the government's pro-poor budget credentials, the following considerations are critical. First, the extent to which budget allocations/appropriations are consistent with the stated national poverty reduction strategies. Second, whether domestic revenue mobilisation measures (especially taxation) place a lesser fiscal burden on lower-income individuals and households. Third, how budget deficits are managed – while budget deficits are also a common element of most national budgets, debt is a cause of poverty as it diverts resources (money) that would otherwise be allocated to poverty eradication programs, welfare, and service provision. Fourth, a pro-poor-oriented budget should have clear budget lines or programs (such as social protection) aimed at boosting the welfare of the poorest and protecting them from economic shocks. Lastly, the issue of poverty reduction outcomes of related expenditure.

Although the scope of this article is limited, these issues are crucial in the overall assessment of Uganda's pro-poor orientation in national expenditure. And when all evidence is examined, there is little pro-poor orientation in national public expenditures in Uganda, contrary to its human rights commitments (DI, 2016; 2019; UPR, 2011, 2022). A pro-poor budgeting process that is democratic, open, inclusive, participatory, transparent, accountable, and responsive to the needs of the people, particularly the marginalised and vulnerable, is a human rights obligation (UN-DESA, 2005; OHCHR, 2012, 2017). While the Uganda government scores favourably on budget transparency processes (IPB, 2021), critical financial allocations to the sectors that would benefit the most vulnerable and marginalised sections of the population remain largely unrealised (DI, 2020; ISER, 2021; 2023).

Relevant illustrative evidence shows that the agriculture sector provides a source of livelihood for the majority of Ugandans. In 2019/20, the sector accounted for 72 per cent of total employment in the country. The sector also contributed 24 per cent of Uganda's Gross Domestic Product (UBOS, 2021). Admittedly, the government still views agriculture as a means to promote GDP growth and the

country's economic transformation, as outlined in Vision 2040, the NDP III, NDP IV, and other related policies. However, "there is limited understanding of the importance of the sector for 'food security', 'nutrition security', 'livelihood', 'agro-ecological/conservation', 'resilience' as well as 'social protection' functions in light of the rapidly increasing population and environmental challenges" (Pietschmann, 2019, p.10). For instance, despite being a crucial subsector for the structural transformation of the economy, agro-industrialisation is not yet sufficiently funded. In 2021, agro-processing and marketing accounted for only 12 per cent and 7 per cent of private-sector credit, respectively, according to Bank of Uganda statistics. In 2009, the African Development Bank identified inadequate financial resources as one of the core constraints to agro-industrial development in Uganda. A highly constrained financing environment limits innovations, high-tech interventions, and industrial expansion, all necessary ingredients for agro-industrialisation. For Uganda, even the available financing sources have not been supportive of sustainable agro-industrial development. For example, 83 and 78 per cent of firms use retained earnings to finance operations and fixed assets acquisition, respectively (EPRC, 2016; 2021).

Thus, viewing agriculture highly without increased budgetary allocations to the sector is counterproductive. The Poverty Action Fund (PAF) expenditure is low (at 7 per cent) in comparative terms to other sectors, yet the majority of people (54 per cent) live in rural areas and are subsistence farmers still living in poverty (DI, 2020; UBOS, 2020). Therefore, it is imperative to give a higher priority to the social protection and agriculture sectors and significantly increase their PAF expenditure allocations to reduce the vulnerability of the population, especially those in disaster-prone areas like Bududa and Kasese districts. The external debt constitutes 74 per cent of total debt against a target of 29 per cent. The optimal solution would be to increase resource mobilisation by expanding the current low tax base and, more importantly, to enhance efficiency in the use of public resources by effectively eradicating corruption loopholes and wasteful expenditures (DI, 2020; FAO, 2022).

5. Conclusions and recommendations

The findings in the study reveal that public investment and expenditure on agriculture and disaster risk reduction in Uganda is retrogressive and not in compliance with a rights-based approach standard "to use maximum available resources" for the progressive realisation of the right to adequate food stipulated under the International Covenant on Economic, Social and Cultural Rights or risk-informed development under the Sendai Framework on Disaster Risk Reduction (Priority 3). More broadly, the East African countries need to review, integrate, and align their disaster risk management and climate change adaptation laws, policies, and strategies to ensure that they reduce climate change impacts and exposure to people, whole communities, and the environment. This will require greater action and coherence at national and sub-regional levels in the implementation of the Paris Agreement, the Sendai Framework as well as the UN 2030 Agenda for Sustainable Development. Uganda, in particular, will need to fast-track efforts to ensure its disaster and climate-related legal, policy, and institutional frameworks are risk-informed in line with the Sendai Framework, making the approximately 50 million Ugandans safer and more resilient to disasters by 2030. To this end, while Uganda adopted a long-overdue climate-smart disaster law in 2021, the National Climate Change Act 2021 needs to be enforced with urgency to have a positive impact at the grassroots level, particularly in disaster-prone communities like Bududa and Kasese districts, which are home to many vulnerable people.

More specifically, it is noted that Uganda is vulnerable to multiple shocks and climatic hazards like droughts, floods, landslides, earthquakes, displacements and epidemics with increasing frequency and severity over the last twenty years. These disasters have had and will continue to exert a negative macroeconomic impact by eroding the country's development gains if not comprehensively addressed. Overall, the government still faces significant challenges without an effective national shock and hazard-responsive and social protection system. To ensure adequate protection of the right to adequate food for Uganda's rapidly growing population, the government will need to embrace a rights-based approach to food security by increased investment in the agricultural sector, in line with the African Union commitments under the Comprehensive Africa Agricultural Development Program (CAADP). Allocating the CAADP target 10% of the national budget to the agricul-

tural sector will facilitate faster poverty eradication and higher productivity of the sector through climate-smart agriculture, wealth creation, food security and sustainable economic growth. Thus, sustainable agricultural practices and food systems, including both production and consumption, must be pursued from an integrated and rights-based perspective, in line with international and national human rights commitments in the Vision 2040, the National Development NDP III (2020/21 – 2024/25), the recently adopted National Development Plan IV (2025/6 – 2029/30), the Uganda Nutrition Action Plan II (2021 – 2025), among other strategies.

Therefore, it is pertinent that Uganda increases investment in the agricultural sector for higher food productivity as well as in disaster risk reduction in the face of increased climate-related disasters. The government must move away from empty rhetoric and make concrete efforts to fulfil its commitments under the Malabo, Abuja, Sendai Framework, and the Sustainable Development Goals, among others. The limited financial coherence in the national policies on disaster risk reduction and climate change adaptation has to be increased in tandem with more effective implementation of agricultural policies. Higher investments in food security, health, social protection and environmental systems are also essential to building on the synergies towards a more efficient and effective food systems transformation agenda that will deliver adequate food for all and eradicate hunger.

The COVID-19 pandemic exposed both the global and national weaknesses inherent in the food systems. Climatic hazards like floods and landslides in Bududa or Kasese districts and epidemic shocks like COVID-19 across the country disproportionally impact the poor and worsen poverty. Uganda, therefore, faces the urgent need to not only recover from the severe impacts of the COVID-19 pandemic but also to strengthen its economic growth effort and get back on track to sustainably raise incomes, eradicate poverty and end persistent hunger in the country. To effectively finance disaster risk and climate change adaptation objectives, Uganda will need to put more focus towards investing in prevention against hydro-meteorological hazards, particularly floods and landslides in the Mount Elgon and Mount Rwenzori ecosystems. There is an urgent need to prioritise a shock-responsive social protection system in districts like Bududa and Kasese that have very high levels of vulnerability to disasters. The people's poverty and vulnerability are the evidence required to spur higher government financial investment to respect, protect and fulfil their right to adequate food and ensure effective disaster risk reduction.

The Local Governments or district-level authorities have a critical role to play as the primary responders in the event of disaster events. However, the findings of this study also reveal that disaster risk financing under the Local Governments (Districts) is either weak or non-existent. There are limited administrative and financial powers extended to Local Governments (Districts) for disaster risk reduction in Uganda. Thus, District Disaster Management Committees (DDMCs) at the district, county and sub-county remain largely underused and interactions between them are very limited. The lack of funding at the district level directed towards disaster risk reduction and preparedness has rendered the implementation of the District Contingency Plans highly impracticable. This also makes the DDMCs either helpless or ineffective in delivering their mandate in the face of disaster events and displaced populations in their midst. Thus, there is a need to empower Local Governments with adequate financial, technical and human resources for them to effectively fulfil their mandate as the primary responders in the disaster response architecture outlined in the national disaster policy adopted in 2010.

Finally, the Government of Uganda will need to be more intentional about the implementation of a rights-based approach to disaster risk reduction in the development process. This will involve integrating disaster risk reduction measures in the country's international human rights obligations, assigning specific roles and obligations to government institutions (like the Office of the Prime Minister) on the basis of human rights obligations or commitments, and ensuring that national disaster risk laws, policies and institutions are aligned to human rights standards. Furthermore, there is a need to mobilise the maximum available resources for food security and disaster risk reduction in line with international human rights commitments. This holistic program-based approach, if implemented in conjunction with a human rights-based approach, would provide a most conducive opportunity for a more inclusive and sustainable development effort against food insecurity, hunger and disaster risk reduction that leaves no one behind.

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Article

Network Structure in Disaster Response: The Mediating Role of Coordination Within a Humanitarian Organizational Network in Uganda

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ABSTRACT

There is limited academic endeavour to study the mediating role of coordination in the relationship between network structure and disaster response in the context of humanitarian organisations. Furthermore, much of the research focuses on identifying challenges rather than offering deeper insights about this study. Moreover, most disaster management research centres on Western countries with well-established response systems and planned coordination. This overlooks the unique realities of less developed countries, such as Uganda, where humanitarian contexts are more complex and response systems are less organised. The study employed a cross-sectional survey design, utilising quantitative methods. A survey was conducted using questionnaires administered to seventy (70) humanitarian organisations, particularly those that participated in the three (3) Ugandan disasters highlighted in this study. Findings suggest that the structure of the humanitarian organisational network impacts disaster response, and coordination mediates the relationship between network structure and disaster response. The study concludes that disaster response is dependent on a well-structured humanitarian organisational network, and without coordination, disaster response efforts are likely to be ineffective. This study further provides both theoretical and practical implications, especially for disaster scholars and practitioners in developing countries.

KEYWORDS

Risk; humanitarian; network structure; coordination; disaster response.

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1. Introduction

Research on humanitarian organisational networks has gained significant attention in recent years (Stephenson, 20004). However, much of this research focuses on disaster impacts, risk management, and post-disaster recovery — leaving the critical area of disaster response and the role of coordination underexplored (Xue et al., 2023; Ruesch et al., 2022). Scholars argue that effective coordination among humanitarian organisations leads to more effective disaster response outcomes (Krishnan & Winter, 2009; Stephenson, 2005). In contrast, the absence of a central authority and poor coordination among humanitarian actors often results in ineffective response efforts (Shah et al., 2018; Negi, 2022). Despite the extensive literature on the impact of humanitarian networks on disaster response, a clear framework to explain how coordination influences this relationship remains elusive (Bertazzo et al., 2018; Wagner et al., 2024).

The rising frequency of both natural and human-made disasters further emphasises the need for effective disaster response to reduce suffering among affected communities (Wankmüller & Reiner, 2020). Disasters are often unpredictable and complex, involving a wide range of humanitarian organisations (Molnar, 2024; Sudar et al., 2024; Jovicic et al., 2024). This complexity demands stronger coordination to ensure a more effective response (Wankmüller & Reiner, 2020). Without coordination, overlapping efforts, resource wastage, and delayed responses are more likely to worsen the already dire conditions for those impacted (Tatham et al., 2017; Amatya & Khan, 2023).

Disaster response involves a wide range of actions aimed at restoring normalcy as quickly as possible (Rahman et al., 2022). However, given the chaotic and challenging nature of disaster environments, coordination is crucial to streamline the efforts of governments, humanitarian agencies, and other stakeholders (Chatterjee et al., 2010; Hu, 2022). Studies suggest that good coordination in post-disaster settings improves response efforts (Shah et al., 2022). Unfortunately, even with various strategies in place, large-scale disaster response remains a challenge (Waugh & Streib, 2006). Uganda faces a similar reality, with over 200,000 people affected by various disasters annually (World Bank, 2010). Recent disasters include the August 2022 floods in the Elgon sub-region, landslides in Kasese and Bundibugyo, the 2019 Karamoja locust invasion, the COVID-19 pandemic, and the 2021 Ebola outbreak in Mubende district. These events had a profound impact on communities and strained national response systems. In May 2013, floods in Kasese, the worst since 1976, claimed eight lives and displaced over 25,000 people when the River Nyamwamba burst its banks (DREF, 2013). Similarly, the 2010 Bududa landslides killed over 120 people, destroyed more than 500 homes and affected entire villages (WHO, 2010; DREF, 2012; Gorokhovich et al., 2013). The 2007 floods in the Teso sub-region affected 25 districts, prompting a $20 million emergency relief appeal and a declaration of a state of emergency.

These large-scale disasters drew extensive humanitarian response efforts involving numerous organisations providing search and rescue, medical aid, evacuation, and logistical support (Gorokhovich et al., 2013). However, response efforts were marred by poor coordination, role duplication, information asymmetry, logistical breakdowns, and infrastructural constraints (Doocy et al., 2013; Daily Monitor, 2021; Negi, 2022).

This study aims to answer three research questions specifically: a) Does a good Network Structure Improve Disaster Response? b) Does a well-structured Network Improve Coordination? and c) Does Coordination Mediate the Relationship between Network Structure and Disaster? To address these questions, three hypotheses have been formulated (Hypothesis 1: A Good Network Structure Improves Disaster Response; Hypothesis 2: A Well-Structured Network Improves Coordination; Hypothesis 3: Coordination Mediates the Relationship between Network Structure and Disaster). Therefore, this study aims to investigate the mediating effect of coordination on the relationship between network structure and disaster response in Uganda, providing insights that may contribute to more effective response strategies in similar contexts.

2. Literature Review

The increasing frequency and intensity of disasters over the past three decades have spurred growing academic interest in disaster and risk studies (Safarpour et al., 2020). It is estimated that since 2010, over 200 million people annually have been affected by various disasters worldwide (Sapir, 2011; CRED, 2022; Pilorz, 2023). The United Nations Climate & Environment Report (2021) projects that by 2030, half of the world's population will be exposed to natural disasters. These disasters, whether natural, artificial, or hybrid, are characterised by the large-scale destruction of infrastructure, loss of life and property, economic setbacks, and disruption of societal functions (Botzen, 2019; Das, 2023).

Recent global disasters, including the Israel-Palestine conflict, the Russia-Ukraine war, Hurricane Ian (2022), the Hong Kong floods (2023), the Gulf oil spill, the Japanese nuclear reactor leak, Hurricane Katrina (2005), Typhoon Haiyan in the Philippines (2013), and earthquakes in Haiti, Turkey, Syria, and Morocco, underscore the complexity of disaster response operations (Mohibbullah, 2021). These events involve numerous humanitarian organisations, resulting in intricate networks and coordination challenges. For example, the 2000 Mozambique floods mobilised 49 countries and over 30 international non-governmental organisations; however, response efforts were mainly deemed ineffective due to coordination failures (Moore et al., 2015).

In recent years, inter-organisational collaborations have emerged as a crucial area of research in disaster management, focusing on partnerships, alliances, and networks among humanitarian actors (Bisri, 2016; Nolte, 2018). A key theme within this body of work is the concept of "humanitarian organisational networks" defined by structures, relationships, and preparedness which influence how organisations interact and ultimately affect disaster response outcomes (Kapucu, 2010; Mutebi et al., 2020; Popp et al., 2014; Kaat & Verkey, 2022).

Disaster response is regarded as the cornerstone of disaster management, emphasising the protection of human lives and the rapid restoration of essential services (Basset et al., 2020). Herrmann (2007) describes disaster response as the orchestration of all activities aimed at mitigating the immediate effects of a disaster, including rescue operations, provision of emergency aid, infrastructure restoration, and fulfilment of basic human needs (Warfield, 2012; Phillips & Mincin, 2023). Effective disaster response requires coordinated efforts characterised by robust communication systems, efficient resource and logistics management, and specialised expertise (Wassenhove, 2006; Hayes et al., 2022).

According to Lee (2000) and Arshinder et al. (2008), coordination is a tool that facilitates the management of workflow and resources among chain members, thereby improving performance in terms of faster and more efficient response times. Balcik (2009) asserts that for coordination to occur, four key aspects must be considered: stakeholder coordination, logistics coordination, resource management, and information management.

Coordination serves as the critical link between humanitarian organisational networks and disaster response, facilitating logistics, information flow, resource management, and collaboration among actors (Tosi & Marty, 2024). Effective coordination mitigates field-level inefficiencies and ensures responders and victims alike benefit from streamlined interventions (Advanced Training on Humanitarian Action, 2008). Given the diverse perspectives and priorities among humanitarian actors, vertical and horizontal coordination becomes imperative to foster information sharing, improve assessment accuracy, enhance public confidence, and ensure overall safety and stability (Kovács & Spens, 2007; Balcik et al., 2010; Kapucu, 2022).

Humanitarian organisational networks are especially vital in complex, multi-stakeholder disaster scenarios (Kovács, 2020). In such dynamic environments, both formal and informal relationships emerge to address shared concerns, with the overarching goal of achieving efficient and effective response operations (Lassa, 2011). The primary objective remains delivering timely, needs-based assistance to affected populations, which requires a unified control mechanism driven by effective coordination (Zhao et al., 2009).

2.1 Network structure

According to Pasquero (1991), "network structure" refers to the elements that comprise the administrative mechanisms by which the network operates. Pasquero (1991) further contends that these elements are network ties, network size and density and network centrality. The strengths and weaknesses of the ties are determined by the interaction that organisations within a network have with each other (Burt, 1997; McEvily & Zaheer, 1999). According to Burt (1997) and Gulati and Singh (1998), strong ties reduce coordination costs through trust and cooperation, while weak ties facilitate the provision of information and control benefits within the network. Strong ties also help organisations access critical resources at the dyadic level, which is essential for network survival, unlike the case. Similarly, according to Burt (1997), network size refers to the actual number of network members or actors. The higher the number of actors, the higher the density. According to Wegberg (2003), Network density indicates the proportion of possible links between firms that are formed. He further says that a dense network will tend to quickly spread information faster compared to a network that is not dense and that a dense network provides a control variable that reduces manipulation, superiority, and unethical behaviour and increases trust (Brass et al., 1998; Hite & Hesterly, 2001; Burt, 1997). On the other hand, Network centrality refers to the degree to which an organisation holds a strategically important position within the network (Freeman, 1979). Being central in a network provides a focal organisation with various information advantages (in the form of access, timing, and referrals), control benefits (i.e., power), and learning opportunities (Gulati, 1998).

A network structure in a humanitarian organisational setting is formed naturally through adaptation to the network environment or disaster scenario. Without a structure, the organisational network cannot serve its purpose. For example, Agung (2022) asserts that without a formal network structure, a network is considered not "serious." According to Wegberg (2003), the structure of organisational networks determines which organisation has the best access to information and under what conditions. When a disaster occurs, there is great chaos as victims try to find ways to survive. This is coupled with the large number of relief organisations that descend on the affected area, creating a complex scenario (Olafsson, 2012).

2.2 Network Structure and Coordination

A well-structured network facilitates more effective coordination during disaster response. It leads to "economic efficiencies, greater service quality, organisational learning, access to new skills, diffusion of risk, improved public accountability, ability to buffer external uncertainties, and conflict avoidance." (Brudney, 2007). Because coordination among humanitarian organisations is complex, a relatively well-structured network is a prerequisite, as each organisation has different processes. According to Bots and Sol (1988), there are three perspectives on coordination: the micro-perspective, coordination among individuals; the intermediate perspective, coordination between two organisations; and the macro-perspective, inter-organisational coordination.

Tomasini and Van Wassenhove (2006) assert that the coordination of humanitarian efforts is based on the three principles of humanity, neutrality, and impartiality and that any violation of these principles will result in untold suffering. The primary objective of coordination in a humanitarian relief context is to respond effectively and efficiently to disasters, whether artificial or natural, in order to restore order (Akhter et al., 2012). Balcik (2009) says that there is always an "inherent chaotic post-disaster relief environment which attracts a large number of organisations ranging from the host governments, the military, local and regional relief organisations to private sector companies, each of which has different interests, mandates, capacity, and logistics expertise". For example, the 2004 Asian Tsunami drew the attention of over 40 countries and 700 non-governmental organisations (Balcik, 2010). Such large numbers of responders may present a coordination challenge if the responding organisations are not well-structured.

At the centre of coordination lies information sharing, which is a crucial factor in coordinating disaster response operations. Information sharing in disaster management is a valuable tool for de-

livering timely information and reducing uncertainty (Hovhanessian, 2012). It also reduces costs associated with response operations and enhances services related to response operations (Dolinskaya et al., 2011). However, Russell (2005) asserts that information regarding all humanitarian response efforts is often incomplete or mostly unreliable because aid operations are unstructured and coordination practices are deficient within the responding organisations.

Therefore, coordinating crisis and disaster response operations is a complex and challenging task due to the large number of organisations involved. Coordination ensures that there is shared risk and responsibility for assessing and responding to a disaster (Comfort, 1999; Kapucu & Comfort, 2002). Coordination in disaster response primarily involves recruiting and paying workers, managing volunteers and staff, information, communication, funds, and accounts, as well as building relationships with partners in both governmental and non-governmental sectors (Akhtar et al., 2012). Literature also suggests that coordination failures are always present among humanitarian organisations, as evidenced during the responses to the 2004 Indian Ocean Tsunami, Hurricane Katrina in 2005, and the 2010 Haiti earthquake. (Samii and Van Wassenhove 2003) (Van Wassenhove , 2006).

Scholars, therefore, contend that any form of coordination is based on networks. However, empirical studies also point out that "it is difficult, if not impossible, to draw causal inferences about the effect of network structure on coordination" because networks are complex and, as such, vary in network structure (McCubbins, Paturi and Weller 2015). This, therefore, makes coordination a complex event as well (McCubbins, Paturi, and Weller, 2015).

From the above, the nature of the disaster determines the mix of humanitarian organisational network players and their relative importance or power (Nolte, 2015). Where there is much chaos, organisations are left to establish their social order, often within hierarchical or centralised structures (Nolte et al., 2012). According to Brown and Robinson (2005), the overall effectiveness of a disaster response operation is difficult to measure because every disaster is unique. Therefore, the response is different at both the inter-organisational and household levels. Furthermore, similar disaster events yield vastly different results in their aftermath, which also influences the number of responding organisations.

2.3 The mediating effect of Coordination

According to Chatterjee (2010), the high costs of human lives, property damage, and economic devastation brought about by natural disasters over the past two decades have spurred governments and humanitarian institutions to take several important measures to strengthen their disaster management systems. Maires (2005) states that within the last decade, organisations have increasingly recognised the value of having a coordinated response to humanitarian emergencies. For example, in 1991, the United Nations established the Office for the Coordination of Humanitarian Affairs (OCHA) with the primary objective of facilitating coordination among the various UN bodies responding to humanitarian emergencies. Reviews of post-disaster scenarios and other complex humanitarian emergencies highlight that a lack of coordinated responses is a significant limitation to the overall effectiveness of disaster response (Kettl, 2003; Kapucu, 2006; Comfort, 2007). To improve the flow of resources among agencies and increase the accountability and effectiveness of disaster response operations, Stephens (2005) and Moore et al. (2003) suggest that The ever-increasing number of humanitarian aid organisations, the wide range of resources, and the complexity of disasters have made coordination a rather challenging exercise (Rey, 1999). A coordinated disaster response facilitates a high-quality humanitarian response by providing a platform for partnerships among key actors (Chatterjee, 2010).

Scholars like Moore et al. (2003) assert that the success of humanitarian aid operations depends on the ability of organisations to work together through sharing information, stakeholder partnerships, expertise, and, above all, logistical coordination. For example, through Logistical coordination, it is easy to make an inventory of the available aid, identify the type of aid needed, and determine the quantities, including storage and distribution. On the other hand, stakeholder coordination ensures that stakeholder partnerships are in place, which enable aid to be distributed effectively and

equitably, thereby avoiding the violation of the fundamental humanitarian principle of impartiality. Establishing relationships during non-disaster times will help in this process. Additionally, through coordination, information sharing occurs, and information is crucial as it serves as a means of building trust between the affected communities and civil society organisations. Trust-building is crucial for NGOs and affected communities.

The importance of coordination in effective disaster response has been highlighted by many analysts and scholars (McEntire, 2004; Minear, 2002). In emergencies, coordination aims to reduce duplication of roles among humanitarian organisations involved in the response efforts (McEntire, 2015). This is further highlighted by the Hurricane Katrina disaster, which attracted over 500 actors. According to Zhao et al. (2010), coordination among humanitarian organisations during the response stage leads to the attainment of both short-term and long-term organisational goals.

However, disasters are inherently chaotic, making coordination exceedingly difficult when each organisation operates independently (Boersma, 2014; Malesic, 2020). Despite the growing literature on humanitarian networks and disaster response, a notable gap remains: the mediating role of coordination between network structures and disaster response is insufficiently studied (Rouhollah et al., 2018). Existing research often focuses on Western contexts with established disaster preparedness systems, overlooking the unique challenges faced by developing countries, such as Uganda (Mena et al., 2022; Abunyewah, 2023).

To guide our study, the following hypotheses are developed from the above literature;

Hypothesis 1: *A Good Network Structure Improves Disaster Response.*

Hypothesis 2: *A Well-Structured Network Improves Coordination*

Hypothesis 3: *Coordination Mediates the Relationship between Network Structure and Disaster Response*

3. Methodology

The study employed a cross-sectional survey design, utilising quantitative methods. A survey was carried out using questionnaires. The study population consisted of 86 organisations that participated in the response operations for the three disaster scenarios (Office of the Prime Minister [OPM]; URCS Kasese Operations Report, May 2013; ACT Alliance Preliminary Appeal UGA131; URCS, August 2010 Bududa Landslides Operations Report; Domestic Humanitarian Response Uganda Report, 2008). Using the Krejcie & Morgan (1970) table for determining sample size, a sample of 70 humanitarian organisations was selected. To ensure a representative sample, a stratified sampling design was employed, as recommended by Thomas (2020). The organisations were stratified into five categories based on their area of specialisation: Medical/Sanitation, Food Supplies, Shelter/Reconstruction, Security, and General Aid/Relief Supplies. Six respondents with direct knowledge of the response operations during the three disaster scenarios were purposively selected from each organisation, resulting in a total of 420 respondents. Data collected from the selected 70 humanitarian organisations were entered into the Statistical Package for the Social Sciences (SPSS, Version 21.0) for analysis. Correlation analysis was employed to investigate the relationship between variables, and regression analysis was utilised to assess the predictive power of the independent variable on the dependent variable. Structural Equation Modelling (SEM) was performed using AMOS, and a bootstrap methodology was employed for the mediation analysis.

3.1 Measurement of Variables

The measures were derived from the literature. Specifically, the Network structure was measured in terms of Network Ties, Network size, density, and Network centrality. Coordination was measured in terms of logistical coordination and resource management, stakeholder coordination, and information management. Disaster response was measured in terms of saving lives and property, response time, assessment accuracy, information dissemination, public confidence, and safety and stability.

4. Results

Confirmatory factor analysis was conducted in AMOS software in order to derive the measurement model for the variables, and the tables below show the fit indices

Table 1. Model Fit Summary for Network Structure

χ^2	DF	P	χ^2/DF	GFI	AGFI	NFI	RFI	IF	TAG	CFI	RMSEA
1.972	1	.160	1.972	.996	.963	.995	.969	.997	.985	.997	.061
				Estimate		S.E.	C.R.	P	Beta	AVE	R^2
NSD1	<---	NSD		1.000					.838	0.889	.245
NSD2	<---	NSD		1.088		.164	6.626	***	.848		
NC4	<---	NC		1.000					.499		
NC5	<---	NC		2.777		1.220	2.275	.023	1.372		

Source: Primary Data

The initial measurement of network structure included three constructs—Network Ties, Network Size and Density, and Network Centrality—each with five items. However, a confirmatory factor analysis (CFA) in AMOS resulted in the retention of only two constructs, as shown in Figure 7, to improve model fit. The model statistics, including a Chi-square value of $\chi^2 = 1.972$, degrees of freedom (DF) = 1, and p-value = .160, indicate that the data did not differ significantly from the model. The M2/DF = 1.972 suggests an adequate model fit. Additionally, the fitness indices (GFI, AGFI, NFI, RFI, IFI, TLI, CFI) were all above 0.90, indicating a good model fit. The RMSEA of 0.061, which is below the threshold of 0.08, further supports the model's adequacy. Convergent validity was confirmed with an Average Variance Extracted (AVE) of 0.889, above the required minimum of 0.5, and discriminant validity was established with an (R^2=.245), which is below the AVE. These results collectively affirm that the model is both valid and well-fitted.

Table 2. Model fit summary for Coordination

χ^2	DF	P	χ^2/DF	**GFI**	**AGFI**	**NFI**	**RFI**	**IF**	**TAG**	**CFI**	**RMSEA**
13.811	8	.087	1.726	.983	.956	.984	.970	.993	.987	.993	.052
				Estimate		S.E.	C.R.	P	**Beta**	**AVE**	**R^2**
VHC1	<---	VHC		1.000					.893	0.694	.091
VHC2	<---	VHC		1.035		.051	20.251	***	.965		
VHC3	<---	VHC		.780		.055	14.166	***	.712		
IM2	<---	I'M		1.000					.701		
IM3	<---	I'M		1.479		.139	10.679	***	.992		
IM4	<---	I'M		1.111		.104	10.724	***	.670		

Source: Primary data

Coordination was initially measured using three constructs: Logistics and Resources Coordination, Stakeholder Coordination (VHC), and Information Management (IM). However, after conducting a confirmatory factor analysis (CFA) with AMOS, only two constructs were retained, as shown in Figure 10. The model fit statistics indicated an adequate fit to the data, with a X^2 value of 13.811, 8 degrees of freedom (DF), and a p-value of P = .087. The ratio of χ^2/DF = 1.726 was within the acceptable range, suggesting that the data did not significantly differ from the model (Kline, 2016). Additionally, all retained observed variables significantly measured the corresponding latent constructs (P < .05), confirming their relevance.

The fitness indices, Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Normed Fit Index (NFI), Relative Fit Index (RFI), Incremental Fit Index (IFI), Tucker-Lewis Index (TLI), and Comparative Fit Index (CFI) all exceeded the threshold of 0.9, further supporting the model's adequacy (Hu & Bentler, 1999). Moreover, the Root Mean Square Error of Approximation (RMSEA) of 0.052, which is below the maximum acceptable threshold of 0.08, confirmed the model's good fit

(Browne & Cudeck, 1993). Convergent validity was established, with an Average Variance Extracted (AVE) of 0.694, which is well above the required threshold of 0.5 (Fornell & Larcker, 1981). Discriminant validity was also achieved, as the squared correlation coefficient ($R^2 = 0.091$) was below the average variance extracted (AVE), indicating that the constructs were distinct from each other (Hair et al., 2010).

Table 21: Model fit summary for Disaster Response

χ^2	DF	P	χ^2/DF	GFI	AGFI	NFI	RFI	IF	TAG	CFI	RMSEA
34.843	6	.000	5.807	.959	.856	.945	.862	.954	.883	.953	.135
				Estimate	S.E.	C.R.	P		Beta	AVE	R^2
PC2	<---	PC		1.000					.784	0.638	0.579
PC3	<---	PC		1.261	.109	11.541	***		.903		
SS1	<---	SS		1.000					.716		
SS2	<---	SS		.930	.130	7.128	***		.676		
TR1	<---	TR		1.000					.801		
TR2	<---	TR		1.190	.119	9.968	***		.887		

Source: Primary Data

Disaster Response was initially measured by six constructs: Saved Lives and Property (SLP), Timely Response (TR), Assessment Accuracy (AA), Information Dissemination (ID), Safety and Stability (SS), and Overall Effectiveness (OE). After confirmatory factor analysis (CFA) using AMOS, only two constructs were retained, as shown in Figure 11. The model fit statistics revealed a significant deviation from the data, with $\chi^2 = 34.843$, df = 6, and p = .000, indicating a poor fit (χ^2/df = 5.807). However, the retained variables significantly measured the latent constructs (P < .05). Fitness indices, such as GFI, AGFI, NFI, RFI, IFI, TLI, and CFI, were above 0.9, suggesting an acceptable model fit; however, the RMSEA value of 0.135 indicated a moderate fit. Convergent validity was confirmed with an AVE of 0.638, above the threshold of 0.5, while discriminant validity was supported by the squared correlation coefficient ($R^2 = 0.579$), which was below the AVE.

4.1 Correlation results

Pearson Correlation coefficients were used to analyse the relationships between study variables. Table 1 presents the results.

Table 1: Correlation results

	1	2	3
Network Structure (1)	1		
Disaster Response (2)	.618**	1	
Coordination (3)	.478**		1

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Primary data

Results in Table 1 indicate a significant positive relationship between network structure and Disaster Response (r = .618**) and a significant positive relationship between Coordination and Disaster Response (r = .458**).

4.2. Regression results

The hierarchical regression analysis method was used to examine the influence of Network Structure on Disaster response and the influence of Network structure on Coordination. Table 2 presents the results.

Table 2: Regression results

	Model 1		Model 2	
Variable	**B**	**Beta**	**B**	**Beta**
(Constant)	1.785***		1.574***	
Network Structure	.564***	.618***	.559***	.418***
Coordination				
R	.618		.478	
R2	.382		.229	
Adj. R2	.380		.226	
R2 Change	.382		.229	
F Change	162.837		78.041	
Sig. F	.000		.000	
F	162.837		78.041	
Sig.	.000		.000	

Source: *Primary data*

Results in Table 2, Model 1, show that the Network structure significantly predicts Disaster Response (Beta = .618 ***). The network structure predicts approximately 38% (Adj. $R^2 = 0.38$) of Disaster Response. Overall, Model 1 is significant (Sig. = .000), implying that Hypothesis 1, which states that A Well-Structured Network Improves disaster response, is supported.

Results in Table 2, Model 2, show that the Network structure significantly predicts Coordination (Beta = .478 ***). The network structure predicts approximately 23% (Adj. $R^2 = .226$) of Coordination. Overall, model 2 is significant (Sig. = .000), implying that Hypothesis 2 *states that Good Network Structure coordination* is supported.

4.3. Mediation effect of coordination in the relationship between Network structure and disaster response

According to statistical literature, once relationships are established among variables, there is a need to determine if the mediation effect is statistically significant. To achieve this, there are two primary methods: i.e. the Sobel test (Sobel, 1982) and bootstrapping (Preacher & Hayes, 2004). In this study, we used the Bootstrapping method to test mediation hypotheses by establishing direct and indirect mediation effects. Table 33 presents mediation results.

Table 3. Bootstrap Mediation effects

Dependent variable		Mediating variable		Independent variable	DE	P	IE	P	Mediation effect	Hypothesis
Disaster Response	<---	Coordination	<---	Network structure	.122	.010	.013	.010	Partial mediation	H3

Source: Primary Data

Hypothesis 3: *Coordination mediates the relationship between Network Structure and Disaster Response.*

The results show that both the direct and indirect effects of network structure on disaster response are significant (direct effect: Beta = .122, p = .010; indirect effect through coordination: Beta = .013, p = .010), meaning that how a network is organised or structured plays an important role in shaping how well humanitarian organisations respond to disasters. At the same time, coordination also plays a crucial role in this relationship, serving as a partial bridge between the network structure and disaster response. This means that while a well-structured network directly improves disaster response, it also does so indirectly by facilitating easier coordination among organisations. The

support for H3 confirms that coordination partially explains how a strong network structure leads to better disaster outcomes. For humanitarian organisations in Uganda, this highlights the importance of not only building clear and organised networks but also actively promoting coordination within those networks to enhance overall disaster response efforts.

5. Discussion

The study sought to establish the relationship between network structure, coordination, and disaster response, with three primary hypotheses. The results indicated significant and positive relationships among network structure, coordination, network structure and disaster response, and coordination and disaster response. These findings support the notion that improving the quality and organisation of network structures enhances coordination and, in turn, improves disaster response outcomes. These results align with the existing literature, which emphasises the importance of well-structured networks in fostering coordination during disaster responses. According to Brudney (2007), effective network structures lead to economic efficiencies, improved service quality, organisational learning, and risk diffusion—all of which contribute to more effective disaster response.

The results support all three hypotheses, leading to the conclusion that a well-structured humanitarian organisational network enhances coordination during disaster response efforts. When organisations coordinate effectively, they can avoid conflicts and competing interests, which is crucial for efficient disaster response.

Coordination plays a central role in enhancing disaster response, and its effectiveness depends significantly on the structure of the humanitarian network. For instance, a more central or connected organisation within the network is better positioned to lead disaster response efforts, ensuring that lives and property are protected promptly.

Coordination acts as a link between the disaster response network structure, facilitating logistics aspects, information sharing, resource management, communication, stakeholder management, and partnerships among responding organisations. Leading scholars in the field of disaster management contend that without coordination, no humanitarian organisation is adequately prepared to respond, as each organisation and disaster is unique.

From the findings, it can be said that where the actor network is well-structured, responding humanitarian organisations can rapidly restore lives, property, and the social systems and functioning of institutions.

Implications

This study aimed to investigate the impact of network structure and coordination on disaster response in Uganda. Grounded in both literature and empirical data, the study makes a meaningful contribution to the evolving body of knowledge in humanitarian disaster response. A central contribution of this research lies in its ability to bridge a significant gap in theory. While previous studies have acknowledged the importance of networks and coordination in disaster management, they often treat these elements in isolation or describe them in general terms. Most existing literature stops at identifying coordination challenges or mapping inter-organizational links without explaining how coordination operates as a bridge between network structure and disaster response effectiveness. This study moves beyond such descriptive approaches by empirically demonstrating the mediating role of coordination, showing how coordination transforms the potential embedded in organisational networks into tangible disaster response outcomes. The research underscores the importance of strengthening the structure and connectivity of humanitarian networks. Practitioners should recognise that a well-structured and well-connected network is foundational to effective coordination.

Limitations

This study examined the mediation effect of coordination in the relationship between network structure and disaster response in Uganda. As a result, they may have limitations in their contextual scope. Additionally, the study unit of analysis was humanitarian organisations, which meant that some other organisations that participate in humanitarian activities but are not registered as such

were left out. However, we are confident that the sample size was adequate, representing the types of humanitarian organisations. Furthermore, methodologically, we employed a cross-sectional research design. We suggest that similar studies could employ other methodologies, such as longitudinal or interpretative phenomenological analysis, to provide diverse findings.

6. Conclusion

In conclusion, given its geographical context in a developing country like Uganda, this research provides valuable insights into how humanitarian organisations can enhance their disaster response capacity, especially in similar disaster-prone geographical contexts. By prioritising organisational network structures and coordination, disaster management practitioners can better navigate the complex realities of disaster environments in developing countries. These findings offer a practical roadmap for enhancing humanitarian action and achieving more effective outcomes for vulnerable communities. The fact that coordination partially mediates the relationship between network structure and disaster response suggests that there may be other variables or factors that could explain complete mediation. Therefore, this could serve as a basis for further research.

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Article

Rescue Light Communication System (RLCS): Enhancing Emergency Signaling in Crisis Situations

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ABSTRACT

Effective communication during disasters remains a challenge, mainly when traditional Methods become impractical. The Rescue Light Communication System (RLCS) is a new, colour-based signalling method integrated into the Krizor mobile application, aiming to resolve this issue. RLCS utilises an extended RYB colour model, with the addition of white, to visually represent an individual's status during emergencies. By assigning specific meanings to each colour (for example, green for "I am okay." and red for "I have severe injuries."), RLCS offers a straightforward and intuitive method for non-verbal emergency signalling. Although currently in an alpha trial phase, RLCS is designed to work offline and can be adapted for both digital and physical signalling. This paper explains the rationale behind using the extended RYB model, reviews relevant literature on colour perception, emergency communication, and standardisation, and outlines potential applications and future research directions.

KEYWORDS

Communication; disaster risk; emergency response; RLCS; color signalling; mobile application.

1. Introduction

Effective communication in the context of disasters and emergencies is crucial for providing prompt assistance and minimising risks to human life. Conventional methods of communication, such as verbal warnings or radio broadcasts, often become inadequate due to environmental disturbances, infrastructure malfunctions, or cognitive overload during high-pressure situations.

This article introduces the Rescue Light Communication System (RLCS), a systematic visual signalling approach designed to overcome these challenges. Incorporated within the Krizor mobile application – an unofficial tool designed to protect Croatian citizens – RLCS enables individuals to convey their status through a specific array of colour-coded signals. Although not officially endorsed at present, Krizor offers a practical platform for implementing RLCS in emergency scenarios. By leveraging mobile technology and an expanded RYB colour model, RLCS improves the visibility and identification of signals. Additionally, its principles can be applied to physical signalling meth-

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ods, such as using coloured flags or clothing, ensuring accessibility even in situations where electronic devices are unavailable. Thus, a standardised, adaptable, and inclusive solution for managing disaster risks and responding to emergencies is presented.

2. Scientific background

Effective communication is of utmost priority during crises. Spoken orders and radio transmissions frequently encounter significant challenges, including excessive background noise, damaged infrastructure, and rapidly changing environments (Seeger, Sellnow, & Ulmer, 2003). These challenges have driven research into mobile and digital tools that enable rapid, non-verbal communication. In this context, colour-coded signals can effectively convey critical information when auditory communication is not possible (Fearn-Banks, 2016).

Research in visual ergonomics and cognitive psychology shows that the right combination of colours can enhance the speed and accuracy of recognised signals, even under strenuous conditions. For example, the extended RYB colour model is known for providing greater contrast and easier colour discrimination than conventional RGB or CMYK models, especially in low-visibility situations (Mayo & Kim, 2018; Yuan, Wang, & Li, 2020). This supports the rationale for developing mobile emergency communication systems that prioritise visual signalling devices.

In addition, universally accepted norms, such as ISO 7010 (2011), emphasise the importance of proper colour and symbol design in safety communications for the practical understanding of the messages.

The Rescue Light Communication System (RLCS) was developed to address the communication needs of first responders and organisational staff during disasters and emergencies. It adheres to standards such as ISO 22324 (2015), ISO 3864 (2011), and ANSI Z535 (2017). These standards emphasise the use of specific colours and symbols to ensure clear and precise communication across diverse regions and contexts. RLCS incorporates these standards while introducing modifications for effective disaster communication.

The application of red to indicate severe injuries or urgent assistance in RLCS is consistent with ISO 7010 and ANSI Z535, which use red to signify danger, emergencies, or life-threatening situations. Likewise, green, which RLCS users employ to indicate "I am okay," aligns with the standard application of green for safe conditions and emergency exits. These qualities ensure that RLCS messages are unambiguously comprehensible to users and responders in high-stress situations.

RLCS designates the colour orange for warnings and measures of moderate urgency to illustrate a "threat of danger." Although not explicitly defined in ISO 7010 or ISO 3864, the colour's application aligns with construction zone and hazardous area signage, where it effectively draws attention to potential dangers.

In RLCS, yellow represents minor injuries, aligning with the role of yellow in ISO 7010 and ANSI Z535 while being adapted to meet the requirements of medical prioritisation.

RLCS also uses blue to represent "I need supplies." Even though blue represents mandatory action within the context of ISO 7010 and ANSI Z535, its use in RLCS as a request for resources represents a logical shift from being informative to functional.

The system incorporates white to signal "help is on the way" and purple to indicate "message received." These colours are part of the RYB colour model, chosen for their high perceptual contrast.

Purple, as a secondary colour in the RYB model, provides distinctiveness and visibility. On the other hand, white ensures maximum contrast against dark backgrounds.

By integrating mobile technology with established colour standards, RLCS strikes a balance between innovation and familiarity, making it a versatile tool for disaster communication. This approach not only adheres to internationally recognised guidelines but also addresses the unique challenges of emergency scenarios, where clarity, speed, and adaptability are paramount.

3. Description of the RLCS implementation

The digital implementation of RLCS operates by utilising flashing, alternating colours on a device to convey status information in emergencies. It employs an extended RYB colour model enhanced with white. The colour assignments are as follows:

1. Green – "I am okay."
2. Blue – "I need supplies."
3. Yellow – "I have minor injuries."
4. Orange – "Threat of danger."
5. Red – "I have severe injuries."
6. Purple – "Message received."
7. White – "Help is on the way."

Users can select either a single colour or a combination of two colours to indicate their status. In single-colour mode, the screen alternates between the chosen colour and black, enhancing visibility and reducing the potential for misinterpretation. Dual-colour mode enables the screen to switch between two designated colours, allowing for more detailed signalling while maintaining clarity.

Limiting RLCS to one or two flashing colours aligns with research on the efficiency of visual signalling. Studies have shown that "two-colour alternating signals significantly improve recognition speed and accuracy compared to multi-colour signals" (Kemeny & Panerai, 2003). Additionally, excessive variation in flashing colours can introduce cognitive overload, delaying response times in high-stress environments (ISO 9921:2003; IEC 60073). The IEC 60073 standard further emphasises that "a maximum of two alternating colours should be used in visual alarms to ensure clarity," as additional colours may reduce effectiveness, particularly in peripheral vision.

Figure 1 illustrates the RLCS implementation within the "Krizor" application, displaying simple toggles for selecting the desired colour (s) and an activation button for initiating the signal. Once RLCS is active, the button assumes a deactivation role, as demonstrated in Figure 2.

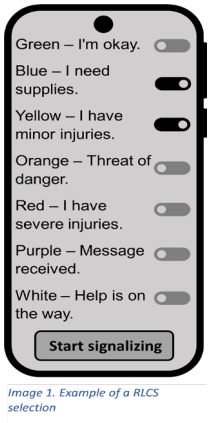

Figure 1. Example of an RLCS digital interface on a mobile device

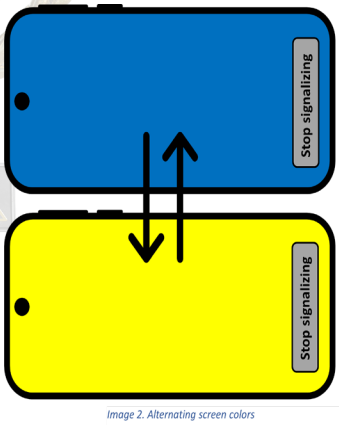

Figure 2. Portrayal of an activated RLCS signalisation on a mobile device

4. Advantages and Potential Applications

RLCS provides several key advantages:

1. Seamless Integration and Accessibility – Designed for widespread mobile use, RLCS is easy to adopt, functions offline, and aligns with multiple ISO standards for emergency communication.
2. Intuitive and Inclusive Design – A simple toggle-based interface ensures quick activation, making it accessible to users in high-stress situations, including individuals with disabilities.

3. Automated Functionality – Once activated, RLCS operates independently, allowing users to focus on survival and response efforts.
4. Efficient Rescue Prioritisation – Clear, standardised visual signals enable emergency responders to assess and prioritise assistance rapidly.
5. Versatile Implementation – Beyond digital displays, RLCS can be adapted for physical applications, such as colour-coded clothing and flags, ensuring usability when electronic devices are unavailable.
6. Optimised Colour Recognition – By employing an extended RYB model, RLCS minimises misinterpretation and enhances visibility, particularly in low-contrast environments.

4.1 Applications in Flood Emergencies

Floods can make verbal communication almost impossible due to high noise levels and physical isolation. RLCS can provide a quick, visual way for individuals to signal their condition, even when water and debris interfere with sound. The advantage of prioritisation becomes apparent in a flooded environment, where there are often multiple groups of people stranded on roofs or similar, and aerial rescue requires lightning-fast triage. Research on flood risk management (Cutter et al., 2003) highlights the need for alternative signalling methods, and RLCS meets this need by offering clear visual cues.

4.2. Applications in Stealth Environments and Urban Terrorism

In situations like urban terrorism or violent conflicts, discretion is vital. Loud or obvious signals can draw unwanted attention. RLCS offers a silent, non-verbal method of communication that can be activated without alerting nearby threats. Studies on crisis communication during terrorism (Coombs, 2007) highlight the importance of secure and quiet communication, and RLCS's visual approach has significant potential to be useful in such events.

4.3 Applications for Individuals with Disabilities

For individuals with disabilities, particularly those who experience difficulties in speaking or hearing, conventional communication methods frequently prove inadequate. The RLCS offers an accessible interface that is independent of verbal communication. This system is customisable, allowing for alterations such as larger icons or simplified tools to accommodate individuals with diverse impairments better. The World Health Organisation (WHO, 2011) emphasises the importance of inclusive emergency systems, and RLCS is well-aligned with these recommendations.

In the context of colour blindness, RLCS mitigates potential challenges by integrating textual descriptions alongside colour-coded signals. Users with colour vision deficiencies can effectively navigate the system by referring to the accompanying text. Additionally, while first responders are unlikely to have colour blindness, training programs should account for this possibility to ensure accurate interpretation of signals. Furthermore, individuals with colour blindness who receive a distress signal can verify its meaning by recording their screen and presenting the footage to someone capable of perceiving colours accurately.

Regarding individuals with other visual impairments, prospective enhancements may include alternative signalling techniques, such as auditory or tactile alerts, to ensure that RLCS remains maximally inclusive. For individuals with severe disabilities, an assisted signalling system could be implemented, allowing a nearby responder to assign an appropriate RLCS signal based on their assessment and the individual's feedback. This method would facilitate rapid triage and resource allocation by rescuers while ensuring that individuals with disabilities remain identifiable for further assistance.

4.4 Applications in Offline Use

In disaster scenarios where digital infrastructure may be compromised, offline applications of RLCS become critical for ensuring effective communication and rescue operations. Although RLCS is primarily designed for digital applications, it can be adapted for use in scenarios where mobile screens or battery power are inaccessible, utilising everyday objects. During daylight hours, individuals in distress may use colour-coded materials, such as shirts, tablecloths, or fabric banners, to signal for help. These items can be positioned in prominent locations, such as rooftops or open fields, or displayed in windows, ensuring optimal visibility from both aerial and ground search teams.

At nighttime, RLCS-based signalling will necessitate an external light source. By illuminating a flashlight, vehicle headlights, or a campfire behind a translucent or semi-transparent coloured object, individuals can project signals to rescuers. This strategy could be particularly beneficial if optical or digital zoom capabilities are available, allowing emergency personnel to identify signals from a distance. However, several challenges may arise with this method:

- Light Source Availability: During extreme disaster situations, access to artificial light may be restricted, diminishing the effectiveness of nighttime signals.
- Colour Accuracy and Recognition: The visible colour of fabric materials can be affected by surrounding lighting conditions, dirt, or wear, potentially leading to misinterpretation of the colour.
- Environmental Interference: Fog, smoke, heavy rain, or physical barriers can further obstruct visibility, particularly at night.
- Standardisation Issues: Since RLCS can be improvised with readily available materials in emergency contexts, precise control over brightness and hue consistency may not always be feasible.
- Nevertheless, RLCS is engineered to prioritise general colour recognition over specific shades, ensuring that the conveyed message remains comprehensible despite variations in materials and lighting conditions. To address these challenges, incorporating offline RLCS methodologies into training for emergency preparedness and related awareness initiatives may improve their implementation. Future research should focus on developing standardised materials, such as reflective sheets or phosphorescent coatings, to enhance the reliability and visibility of offline RLCS signals in diverse environmental conditions.

4. Alpha Trial Status and Future Directions

The alpha trials involved four participants divided into two groups. Both groups utilised the digital RLCS system without prior knowledge of the signals being displayed by the other group. Communication was conducted via radio frequencies, with participants verbally identifying the colours they perceived. Their challenges in recognising colours, as well as the reasons for their confidence in their assessments, were documented at each measured distance.

4.1 Daytime Testing Observations

Initial field assessments conducted during daylight hours uncovered several important observations regarding the practical visibility and functionality of RLCS. One of the main issues identified was the visibility of colours at extended distances. Under sunny conditions, colour differentiation was effective only within a limited range of up to 5 meters. Beyond this distance, even when utilising an additional mobile device for zooming, the clarity of the colour signals significantly decreased, resulting in possible misinterpretations.

Conversely, during cloudy weather, the effective range increased to approximately 7 to 10 meters. Nevertheless, the clarity of the colour signals still diminished with distance, underscoring that RLCS

is most effectively utilised for close-range applications in bright environments while still maintaining greater ranges in less intense sunlight.

These results align with existing studies on visual perception in emergencies, which highlight that environmental lighting conditions significantly impact signal visibility (Yuan, Wang, & Li, 2020). Given these constraints, alternative physical signalling methods, such as textile markers or reflective materials, might be more appropriate for long-range communication in bright conditions. Nonetheless, RLCS demonstrated effectiveness in short-range situations, particularly in environments where verbal communication was impractical due to elevated ambient noise or the necessity for silence. In these instances, rapid, discreet visual signals could still be communicated and comprehended, highlighting RLCS's potential for group coordination in tactical or high-noise settings.

4.2 Nighttime Testing Observations

Nighttime trials of the digital RLCS system were conducted on the bank of the Sava River in Zagreb on March 22nd, 2025, between 20:00 and 22:00, under clear weather conditions.

They demonstrated significantly improved visibility compared to daytime conditions, with colour signals remaining discernible to the naked eye at distances of up to 70 meters. Within this range, both individual colours and multi-colour combinations were distinguishable, confirming the system's effectiveness for short- to mid-range signalling in low-light environments.

Between 70 and 100 meters, some difficulties emerged in differentiating between similar shades, particularly yellow and white, as well as pink and red. However, contextual interpretation played a crucial role in mitigating potential misidentifications. For instance, in a rescue scenario, if a responder encounters an ambiguous signal that could be either pink (meaning a message has been received) or red (indicating urgent assistance is needed), the logical assumption would lean toward red, as communication is just being established. This aligns with research on situational awareness in emergency signalling, which emphasises the role of contextual cues in decision-making under uncertainty (Seeger, Sellnow, & Ulmer, 2003). While stress may impair cognitive processing (Wogalter & Mayhorn, 2005), the RLCS interface includes textual descriptions of colour meanings, which further aid in correct interpretation.

Beyond 100 meters, colour recognition without optical assistance became unreliable, necessitating the use of a smartphone camera or binoculars for accurate identification. Under these conditions, signalling with a single colour at a time proved most effective. Notably, high-contrast colours such as red, green, and blue, as well as yellow, remained the most visible, aligning with findings on colour perception in low-light conditions (Yuan, Wang, & Li, 2020).

At distances exceeding 200 meters, standard unaided visual recognition became impractical. However, given that professional rescue teams and some civilians (e.g., hunters and birdwatchers) commonly utilise binoculars or other optical tools, it is reasonable to assume that RLCS signals could still be identified with appropriate equipment. Further trials with specialised optics could provide more precise data on effective recognition ranges under varying environmental conditions.

These findings suggest that RLCS is highly effective for short to mid-range communication in nighttime scenarios and can still function at longer distances with optical aids. Future work will explore potential enhancements, including increasing screen brightness, optimising contrast ratios, and evaluating the use of reflective materials or auxiliary lighting to extend the operational range of RLCS.

5. Discussion

One major challenge is ensuring that RLCS signals are accurately deciphered and effectively incorporated into current emergency response frameworks. A well-established phenomenon is a variation in colour perception between populations and under stress. According to psychological

research, high levels of stress can influence cognitive processing, which may impact how people perceive and respond to visual stimuli (Wogalter & Mayhorn, 2005).

Furthermore, cultural differences must be considered, even though RLCS adheres to the established colour-coding principles outlined in standards such as ISO 7010 and ANSI Z535. In China, for instance, red is typically connected to joy and good fortune rather than peril or urgency (Huang, 2011).

To address this, the significance of international training workshops and cooperation with organisations such as the Red Cross, the United Nations Office for Disaster Risk Reduction (UNDRR), and the Preparedness and Resilience for Emergency Response (PREPARE) Centre is emphasised to encourage uniform comprehension and adoption of RLCS across various regions. This aligns with the Sendai Framework for Disaster Risk Reduction, which highlights the importance of global cooperation and standardised communication strategies to enhance resilience in disaster-prone areas (UNISDR, 2015).

Additionally, further studies by Cvetković et al. (2021) suggest that the public's perception and understanding of disaster communication tools vary significantly across different demographic groups, underscoring the need for targeted education and awareness campaigns to ensure successful implementation. However, even well-designed systems run the risk of being misinterpreted or underutilised in the absence of such efforts.

Moreover, standardisation in emergency and triage procedures is also necessary for RLCS to be widely adopted. A popular triage protocol, called START (Simple Triage and Rapid Treatment), uses colour coding to categorise victims into various priority levels (Kahn et al., 2009). Similar to the critical and non-critical categories in the START system, RLCS uses red to indicate severe injuries and green to indicate those who are unharmed. Strengthening RLCS's alignment with such standardised practices would further enhance its role in disaster preparedness and response.

In addition to these challenges, environmental and technological constraints present further difficulties. Particularly in direct sunlight, screen glare, brightness limitations, and display quality variations can affect the visibility of RLCS signals (Kim & Koga, 2020). Although backlit screens are helpful at night, visibility may still be affected in low-light levels without external lighting.

Furthermore, Vibhas et al. (2019) highlight that digital emergency tools often face disruptions due to unreliable communication infrastructure during disasters. To ensure RLCS remains effective in such conditions, incorporating physical alternatives – such as printed signal cards, flags, or wearable indicators–can provide redundancy when electronic devices are unavailable.

Similarly, fabric and other physical materials present colour consistency issues for offline RLCS applications, as textures and dyes can alter perception. Due to wear, dirt, or manufacturing variations, improvised materials may exhibit differences in brightness and hue compared to digital displays, which are designed to maintain controlled colour accuracy.

On the other hand, RLCS ensures usability even in imperfect environments by prioritising broad colour recognition over precise shades. This aligns with Cvetković's (2021) conclusion that emergency communication systems need to consider practical limitations to continue functioning effectively in emergencies.

Despite these challenges, RLCS represents a significant advancement in emergency communication. By implementing first responder training, standardisation initiatives, and partnerships with international disaster relief organisations, RLCS has the potential to enhance disaster relief efforts on a global scale significantly.

6. Conclusions

The Rescue Light Communication System (RLCS) offers a practical and standardised approach to addressing challenges in disaster communication. By leveraging a structured colour-based signalling system aligned with established emergency standards, such as ISO 7010, ANSI Z535, and the

START triage system, RLCS enhances the clarity and efficiency of visual emergency communication. Recent testing has demonstrated its effectiveness in nighttime conditions for distances up to 100 meters with the naked eye and beyond with optical aids. At the same time, daytime trials indicate that RLCS is most effective at shorter distances or when combined with physical signalling items.

Future research will focus on refining RLCS's usability under various environmental conditions, integrating it into broader emergency protocols, and exploring potential applications with wearable and dedicated hardware. User feedback from the current mobile implementation within the "Krizor" application on the Google Play Store will continue to inform these improvements, with plans for a dedicated RLCS application in development. Through continued testing, standardisation efforts, and collaboration with disaster response organisations, RLCS has the potential to become a globally recognised emergency communication tool.

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Article

Stray Dogs in Urban Bangladesh: A Zoonotic Disaster Risk and Policy Challenge

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ABSTRACT

This study examines the challenges posed by stray dogs in urban Bangladesh, focusing on societal attitudes, public health risks, and policy responses within the framework of disaster risk reduction. Stray dogs, often marginalised in urban settings, represent a critical intersection of public health, animal welfare, and urban vulnerability to zoonotic disease outbreaks. Using qualitative methods, this research examines public perceptions of stray dogs, with a focus on rabies as a public health concern. It evaluates the effectiveness of the Animal Welfare Act of 2019. Findings reveal a dichotomy in public attitudes: while many view stray dogs as a health threat, others recognise their ecological roles. Despite legislative efforts, persistent issues such as inadequate shelter, weak law enforcement, and limited public awareness continue to hinder effective management. The study highlights the importance of developing integrated strategies that balance public health concerns with animal welfare, emphasising community resilience, sustainable urban planning, and preparedness for zoonotic disease outbreaks. Recommendations include enhanced public education, humane management practices such as mass vaccination and sterilisation, and stronger policy enforcement to mitigate risks and improve coexistence. This research contributes to the broader discourse on disaster risk reduction by highlighting the role of animal welfare in urban resilience and public health security.

KEYWORDS

Stray dogs, urban Bangladesh, public health, disaster risk reduction, rabies, Animal Welfare Act 2019, zoonotic diseases.

1. Introduction

Stray dogs, often referred to as Pariah dogs, are a significant yet understudied component of urban ecosystems in Bangladesh. Their presence in densely populated cities reflects broader challenges of urban vulnerability, public health risks, and contested governance of public spaces (Aktar, 2023). Stray dogs are frequently marginalised, facing neglect, abuse, and harsh living conditions, which mirror societal perceptions of them as unwanted or dangerous (De Santi et al., 2024; Ghosh et al., 2016). However, their ecological roles, such as controlling pest populations, highlight the com-

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plex relationship between humans and animals in urban environments (Uddin, 2021; Kamal, 2022). This duality highlights the necessity of a balanced approach to managing stray dogs, particularly in the context of disaster risk reduction and public health security.

Urban areas in Bangladesh are particularly vulnerable to the public health risks posed by stray dogs, with rabies being a leading concern and a significant public health challenge. Over 95% of global rabies deaths occur in Asia and Africa, and Bangladesh remains endemic to the disease (Rahaman et al., 2020; Ghosh et al., 2024). Rabies outbreaks not only pose a direct threat to human health but also exacerbate urban vulnerabilities, straining healthcare systems and undermining community resilience (Paul et al., 2024). The One Health approach is a collaborative, multisectoral, and transdisciplinary framework that recognises the interconnectedness of human, animal, and environmental health (Cvetković & Martinović, 2020; Cvetković et al., 2022; Kaur, 2020).

It emphasises the need for integrated strategies to address complex health challenges, such as zoonotic diseases, which arise at the intersection of these domains (WHO, 2017; One Health Commission, 2021). In the context of stray dogs in urban Bangladesh, the One Health framework is particularly relevant due to the dual role of dogs as both public health risks (e.g., rabies transmission) and ecological contributors (e.g., pest control). By adopting this approach, stakeholders can better understand and mitigate the risks posed by zoonotic diseases while promoting animal welfare and environmental sustainability.

However, the implementation of One Health in Bangladesh faces challenges, including limited resources, fragmented governance, and insufficient public awareness (Acharya et al., 2021). This study applies the One Health framework to explore the interplay between public health, animal welfare, and urban resilience, offering actionable insights for disaster risk reduction and policy improvement. The Animal Welfare Act of 2019 represents a significant step toward improving animal treatment in Bangladesh. However, its impact has been limited due to poor enforcement, lack of dedicated infrastructure, and insufficient public awareness (Rault et al., 2022; Zaman et al., 2022). Stray dogs continue to face malnutrition, traffic accidents, and human abuse, while enforcement efforts are fragmented across multiple government departments (Hasan & bin Ahsan, 2024). These gaps highlight the need for a more integrated approach to disaster risk reduction, one that addresses both the immediate public health risks and the underlying socio-cultural and institutional factors contributing to the mismanagement of stray dog populations.

This study aims to explore the conditions of stray dogs in urban Bangladesh, focusing on public health risks, societal attitudes, and policy responses within the framework of disaster risk reduction. Using qualitative methods, this study assesses the barriers to improving stray dog welfare and evaluates the role of stakeholders, including governments, NGOs, and local communities, in addressing these challenges (Chowdhury et al., 2020). The research also examines the effectiveness of current policies, such as the Animal Welfare Act of 2019. It proposes recommendations for enhancing urban resilience and disaster preparedness through improved animal welfare practices.

The objectives of this study are threefold: (1) to assess public attitudes toward stray dogs and their implications for public health and disaster risk reduction; (2) to evaluate the effectiveness of existing policies in addressing zoonotic diseases and animal welfare; and (3) to identify opportunities for community engagement and education in promoting sustainable solutions. By bridging the gap between public health, animal welfare, and urban resilience, this research contributes to the broader discourse on disaster risk reduction and management. It offers actionable insights for policymakers, practitioners, and communities.

2. Research Problem Statement

Stray dogs in urban Bangladesh present a complex issue involving public health, animal welfare, and societal perceptions. Often referred to as pariah dogs, they face significant survival challenges due to neglect, mistreatment, and inadequate public health management. Despite the Animal Welfare Act of 2019, stray dogs still suffer from poor shelter, limited food, and exposure to diseases like rabies, a significant public health concern (Paul et al., 2024). Public attitudes are polarised, with some

viewing them as a health threat, while others recognise their ecological role (Uddin, 2021; Kamal, 2022). This division complicates the development of effective welfare policies. Although legislative measures have been introduced, insufficient public awareness and community engagement have resulted in a gap between policy intentions and outcomes (Alam et al., 2020).

This study examines the interplay between public health concerns, societal attitudes, and policies to provide recommendations for enhancing stray dog welfare and improving public health responses to zoonotic diseases, such as rabies (Hasan & bin Ahsan, 2024). Specifically, it seeks to address the following questions: (1) How do public attitudes toward stray dogs influence their management and welfare in urban Bangladesh? (2) What are the key public health risks associated with stray dogs, particularly in the context of rabies outbreaks? (3) How effective are current policies, such as the Animal Welfare Act of 2019, in addressing these challenges? By answering these questions, this study aims to identify evidence-based strategies to improve both stray dog welfare and the public health response to zoonotic diseases, contributing to disaster risk reduction and urban resilience.

3. Literature Review

This section examines the public health challenges posed by stray dogs, with a specific focus on rabies transmission in urban Bangladesh. (Paul et al., 2024) says that over 95% of all human deaths from rabies occur in Asia and Africa, and Bangladesh is particularly affected by this public health crisis. (Rahaman et al., 2020) Opine rabies, predominantly spread through dog bites, represents a significant challenge in urban areas where stray dog populations are high. The lack of comprehensive management strategies, including vaccination programs, has led to the persistence of this deadly disease. Several studies (Nadal, 2019; Philpotts et al., 2019) and more recent research (Mamun et al., 2024; Yusuf & Ahmed, 2024) have emphasised the importance of increasing public awareness, education, and enhancing community engagement in managing rabies risks.

The management of pet dogs has also been explored as a complementary strategy to address rabies transmission. Studies by Alam et al. (2020) and Chowdhury et al. (2020) emphasise the importance of responsible pet ownership in reducing the risks posed by stray dogs. (Ghosh et al., 2024) further elaborate on the challenges of rabies control in Bangladesh, noting the limited implementation of dog population control measures despite national legislation such as the Animal Welfare Act of 2019. (Zaman et al., 2022) explain that the absence of a dedicated Ministry of Animal Welfare has made it challenging to enforce these laws effectively, as implementation involves multiple departments, including the livestock division, local government, and the health department.

Cultural, social, and economic factors shape public perceptions of stray dogs. (Bollée, 2020) highlights the cultural significance of dogs, noting that some communities view stray dogs as a threat due to their potential to transmit diseases. In contrast, others see them as part of the urban ecosystem. (Uddin, 2021; Kamal, 2022) argue that there is a complex human-dog relationship in urban Bangladesh, where stray dogs are both feared and admired for their ecological role. Stray dogs are often marginalised, with communities overlooking their intrinsic value as part of the urban biodiversity. (Paul et al., 2016) Emphasising socio-cultural aspects must be better recognised to control free-ranging dog populations in urban areas effectively.

(Hariharan, 2024) explores historical representations of dogs in the media, often portraying them as unclean or dangerous, have further influenced public attitudes. These perceptions contribute to the ongoing challenges in implementing humane treatment and management strategies for stray dogs. (Aktar, 2023) notes that broader social and political dynamics, including caste hierarchies and the marginalisation of certain groups, influence cultural attitudes toward stray animals. (Jegatheesan, 2015) adds that while the human-animal bond is universal, cultural and religious contexts shape varying perspectives on this relationship (Sinclair et al., 2022) find that in Bangladesh, the majority of Muslims have historically discouraged dog ownership, which has further complicated efforts to promote the humane treatment of stray dogs,

Legislative efforts to address the welfare of stray dogs in Bangladesh have faced significant challenges (Smith et al., 2019). The Animal Welfare Act of 2019 was introduced to improve the treatment

of animals and prevent cruelty, including measures to control stray dog populations. However, enforcement of these policies remains inconsistent, with limited resources allocated to animal welfare initiatives. (WHO, 2017) finds that the lack of public awareness about the importance of these laws further hinders their effectiveness. (Rahaman, 2017) According to NGOs such as Obhoyaronno, a Bangladesh Animal Welfare Foundation (OBAWF), the government has collaborated with them to prevent dog culling and advocate for more humane techniques (Zaman et al., 2022). It is evident that, despite these efforts, an integrated approach that combines legislative action with community education and engagement is necessary to ensure the effective implementation of animal welfare policies.

Beyond their role in disease transmission, stray dogs also have significant ecological and behavioural roles in urban settings. (Sinha, 2019; Sarkar & Bhadra, 2022) argue that dogs, particularly in urban environments, contribute to the control of certain pests and help maintain ecological balance. Stray dogs have adapted to human settlements over generations, becoming an integral part of urban wildlife. However, Kamal (2022) thinks that negative public perceptions often overshadow their ecological benefits. (Karmaker & Lemon, 2024) Exploring climate change and its impact on human habitats has also affected their breeding cycles, further complicating their management and conservation efforts.

Ethical considerations are central to discussions on the welfare of stray dogs. (Alsad, 2023; Hiby & Tasker, 2018; Sönmez, 2024) Advocate for humane methods of managing stray dog populations, such as mass vaccination programs, neutering, and public education initiatives (Hart & Hart, 2021). Depopulation, often used as a population control method, has been widely criticised for its inhumanity and inefficiency. Ethical frameworks surrounding animal welfare, including the work of Bhalla et al. (2021) and Ramakrishna and Ghosh (2021), emphasise the importance of humane interventions that prioritise the well-being of animals while addressing public health concerns.

Future research should focus on interdisciplinary approaches that integrate public health, animal welfare, and social science perspectives to enhance understanding of the complex relationships between these fields. Public education campaigns are crucial in reshaping societal attitudes toward stray dogs, emphasising the importance of empathy and coexistence. Policy recommendations should focus on strengthening legislative frameworks, enhancing enforcement mechanisms, and promoting collaboration among governmental, non-governmental, and community organisations. (Taylor et al., 2017) describe longitudinal studies that are needed to assess the impact of various interventions on both public health outcomes and the welfare of stray dogs. Furthermore, additional research is necessary to comprehend the ecological roles of stray dogs in urban environments, which can inform the development of sustainable and ethical management strategies.

4. Methods

This study was conducted in Sherpur Sadar Upazila, Sherpur, Bangladesh (25°00′ 0.00″ N, 90°01′ 0.12″ E). The region was selected due to its diverse mix of rural and urban areas, which provided a relevant context for studying public health and welfare perspectives toward stray dogs—the combination of urban and isolated rural environments allowed for a comprehensive analysis of these issues. This mixed-methods study, conducted in Sherpur, Bangladesh, integrates surveys (n = 75) with semi-structured interviews (n = 19) and focus groups (n = 12) to explore societal attitudes toward stray dogs. This study employs the One Health framework to investigate the challenges presented by stray dogs in the urban and rural settings of Sherpur, Bangladesh.

The framework's emphasis on the interconnectedness of human, animal, and environmental health aligns with the study's objectives of addressing public health risks (e.g., rabies), animal welfare concerns, and urban vulnerability to zoonotic disease outbreaks. Data collection and analysis were designed to capture these interconnected dimensions: (1) human health through public perceptions of rabies and zoonotic risks, (2) animal health through the assessment of stray dog welfare and management practices, and (3) environmental health through the exploration of stray dogs' ecological roles in urban and rural ecosystems. By integrating these perspectives, the study aims to

provide holistic recommendations for disaster risk reduction and policy improvement. Purposive sampling targeted veterinarians, public health officials, and community leaders to capture diverse perspectives. Interviews and focus group discussions (FGDs) conducted in Bangla were transcribed and thematically analysed to identify emergent patterns in perceptions of risk, welfare, and policy. Survey data provided complementary insights into demographic correlations, which were analysed descriptively. Ethical approval ensured participant anonymity and cultural sensitivity, which are critical in a context where dogs are often stigmatised. The researcher's position as head of the research team necessitated reflexivity in navigating local power dynamics.

Data collection took place over eight months, from June 1, 2024, to January 31, 2025. The following methods were employed to gather data:

A structured questionnaire, including Likert-scale questions, was administered to 75 survey respondents. The Likert-scale questions, designed to measure attitudes and perceptions about stray dogs and their welfare, accounted for a total of 18 Likert-scale question items in the survey. The questionnaire also included both closed-ended and open-ended questions to capture public attitudes toward stray dogs, perceptions of health risks, and awareness of animal welfare issues. The survey was conducted under the researcher's supervision to ensure consistency and minimise response errors. Semi-structured interviews were conducted with 19 individuals, including veterinarians, local public health officials, dog owners, and community leaders. The interviews aimed to gain deeper insights into the challenges related to stray dog welfare, management strategies, and public health risks, such as rabies.

Focus group discussions (FGDs) were conducted with 12 participants, comprising veterinarians, dog owners, and community activists. These discussions focused on issues not fully addressed in the surveys or interviews, as well as community-based initiatives aimed at improving the welfare of stray dogs. FGDs were conducted in Bangla to capture local idioms about animal welfare. All surveys, interviews, and focus group discussions (FGDs) were conducted in the participant's native language to ensure clear communication and comprehension.

This research was reviewed and approved by the Upazila Livestock Office and Veterinary Hospital, Sherpur Sadar, Sherpur, Bangladesh (Memo no: 33.01.8988.000.16.001.24.621). Ethical approval ensured adherence to ethical guidelines set by the committee, including the following:

Informed consent was obtained from all participants in surveys, interviews, and focus group discussions (FGDs), with clear explanations of the study's aims and confidentiality measures provided prior to data collection. Personal data was kept confidential and used solely for research purposes. The study involved observing and analysing existing data on stray dogs without direct interaction with the animals to ensure their welfare and safety. The study respected local laws and cultural norms while addressing sensitive issues related to animal welfare and public health. The study was conducted under the supervision of Dr. Palash Kanti Dutta, Upazila Livestock Officer, Sherpur Sadar, Sherpur. Any deviations from the approved protocol were promptly reported to the authority. Purposive sampling ensured that individuals with relevant knowledge or experience with stray dog welfare and public health were included. A total of 75 survey participants, 19 semi-structured interviewees, and 12 focus group discussion (FGD) participants contributed to the study. Participation was voluntary, and no compensation was provided. No transportation arrangements were made for participants, and they either travelled independently to the study locations or the researcher visited schools and colleges for data collection.

All data were stored securely and protected through encrypted files. Access was limited to the research team only to ensure confidentiality and safeguard participants' information. Survey data were analysed in descriptive statistics to identify relationships. Interview and FGD data were transcribed and analysed thematically, highlighting public health concerns, community attitudes, and perceptions of stray dog management. While the study provides valuable insights, its limitations include voluntary participation, which may introduce selection bias, and the lack of transportation provisions, which affect participant diversity. Additionally, self-reporting bias may have influenced the accuracy of responses.

The general regression model is expressed as follows:

$$Y = \beta 0 + \beta 1x1 + \beta 2x2 + \epsilon$$

In this model, Y represents the dependent variable, which is the outcome or response that we are trying to predict or explain. This variable depends on the independent variables (x_1, x_2) and any random noise captured by ε.

β_0 is the intercept term, also known as the constant. This value represents the expected value of Y when all independent variables (x_1, x_2) are equal to zero. It provides the baseline level of the dependent variable when there is no effect from the predictors.

β_1 and β_2 are the regression coefficients corresponding to the independent variables x_1 and x_2, respectively. These coefficients represent the strength and direction of the relationship between each independent variable and the dependent variable. Specifically:

β_1 quantifies how much Y changes for a one-unit change in x_1, holding x_2 constant.

β_2 quantifies how much Y changes for a one-unit change in x_2, holding x_1 constant.

x_1 and x_2 are the independent variables or predictors. These are the variables that are assumed to influence Y, the dependent variable. They are typically selected based on theoretical or empirical reasoning about the factors that might influence the outcome being studied.

ε represents the random error term, which accounts for the variation in Y that the independent variables in the model cannot explain. This error term captures the influence of other factors or random fluctuations not accounted for by the predictors. It is assumed that the error term has a mean of zero and is independent of the independent variables.

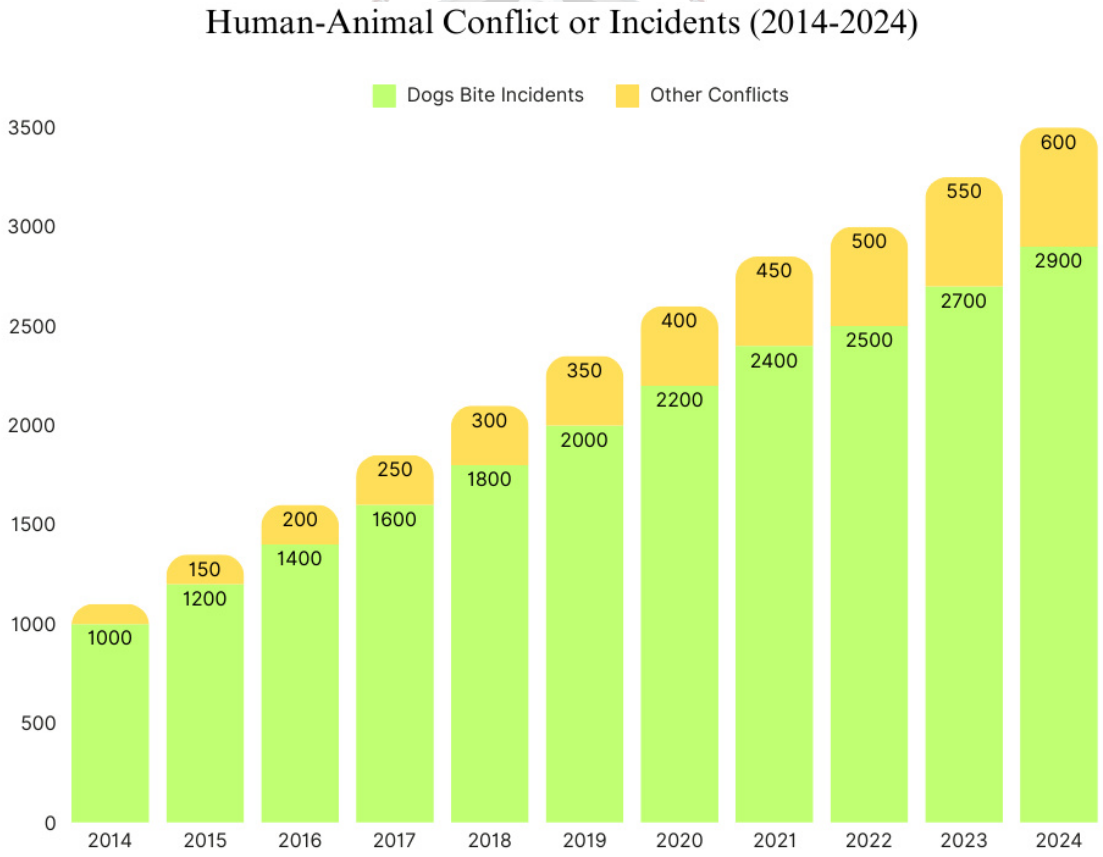

Figure 1: Human-Animal Conflict or Incidents (2014-2024)

Source: Ministry of Health and Family Welfare (Bangladesh) – Data on incidents of human-animal conflict, including dog bites. (2014, 2016, 2019, 2021), Local hospitals or health centres – Data on dog bite incidents. (2014, 2016, 2018, 2020), Bangladesh Police – Reports on incidents involving stray dogs (2015, 2017, 2020, 2023).

Figure 1 shows the increasing frequency of human-animal conflicts involving stray dogs from 2014 to 2024. Reports indicate a rise in cases of dog bites, road accidents, and aggressive encounters, particularly in urban areas. The growing number of incidents has led to policies favouring stricter control measures, including culling and relocation. However, research suggests abrupt removals exacerbate conflicts by allowing unvaccinated strays to migrate into vacated areas, increasing risks. Expanding humane strategies like structured sterilisation, controlled feeding, and behavioural assessments could help mitigate these conflicts.

Community-based conflict resolution, public education on non-confrontational approaches, and designated feeding zones can further reduce tensions. Municipal policies should prioritise coexistence strategies over elimination-based approaches, enforcing preventive rather than reactive measures for long-term solutions.

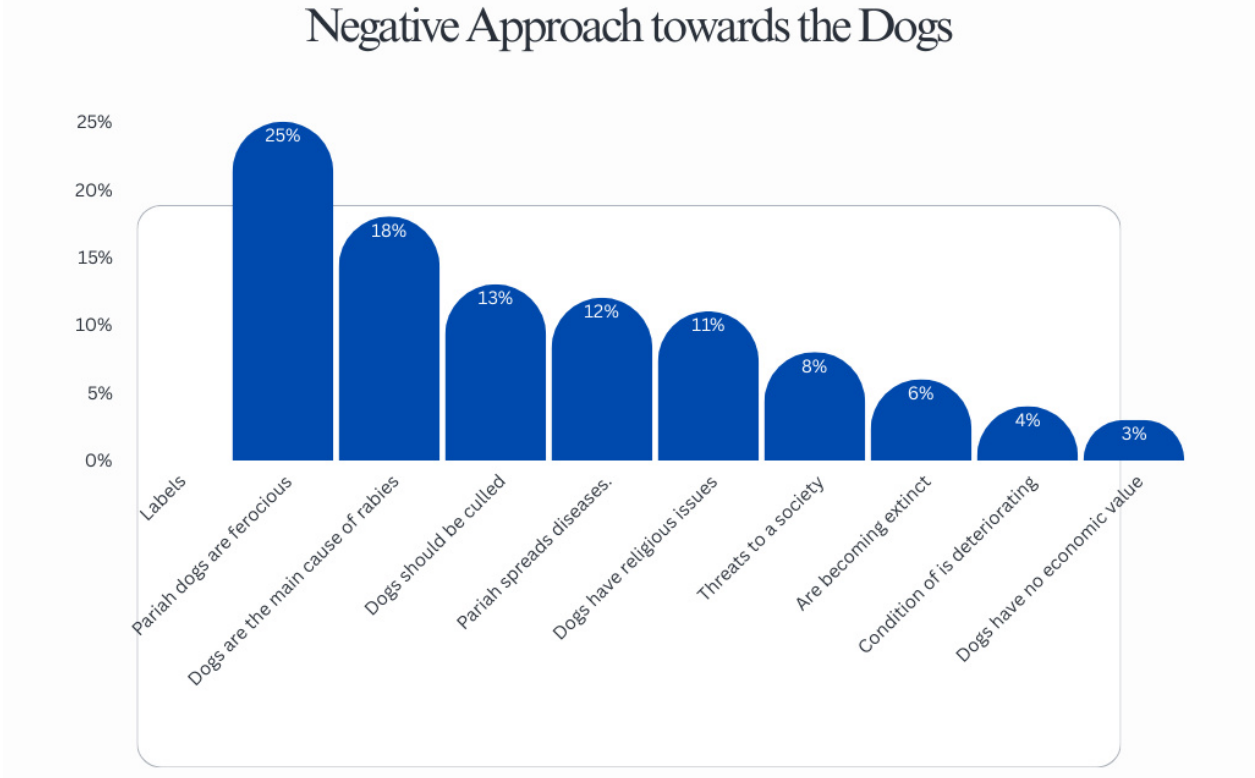

Figure 2: Negative Approach towards the Dogs

Source: As per primary data collection-2024-2025, the study's reliability stems from direct engagement with respondents, ensuring the authenticity of the insights.

Figure 2 shows the prevailing negative attitudes toward stray dogs among the surveyed population. Many respondents expressed fear or hostility toward stray dogs, often due to concerns about safety, cultural beliefs, and misinformation. Media portrayals and past negative encounters have reinforced these biases.

Widespread fear contributes to inhumane treatment, abandonment, and resistance to welfare policies. Many communities prefer culling or forced removal over humane management strategies. If misconceptions persist, hostility toward strays will likely increase, resulting in more conflicts and ineffective policies. However, awareness campaigns and community-based interventions can gradually shift public attitudes toward more compassionate coexistence.

Educational programs, media advocacy, and community engagement are crucial in fostering positive attitudes. Government and NGOs should collaborate on humane stray management strategies while addressing public concerns.

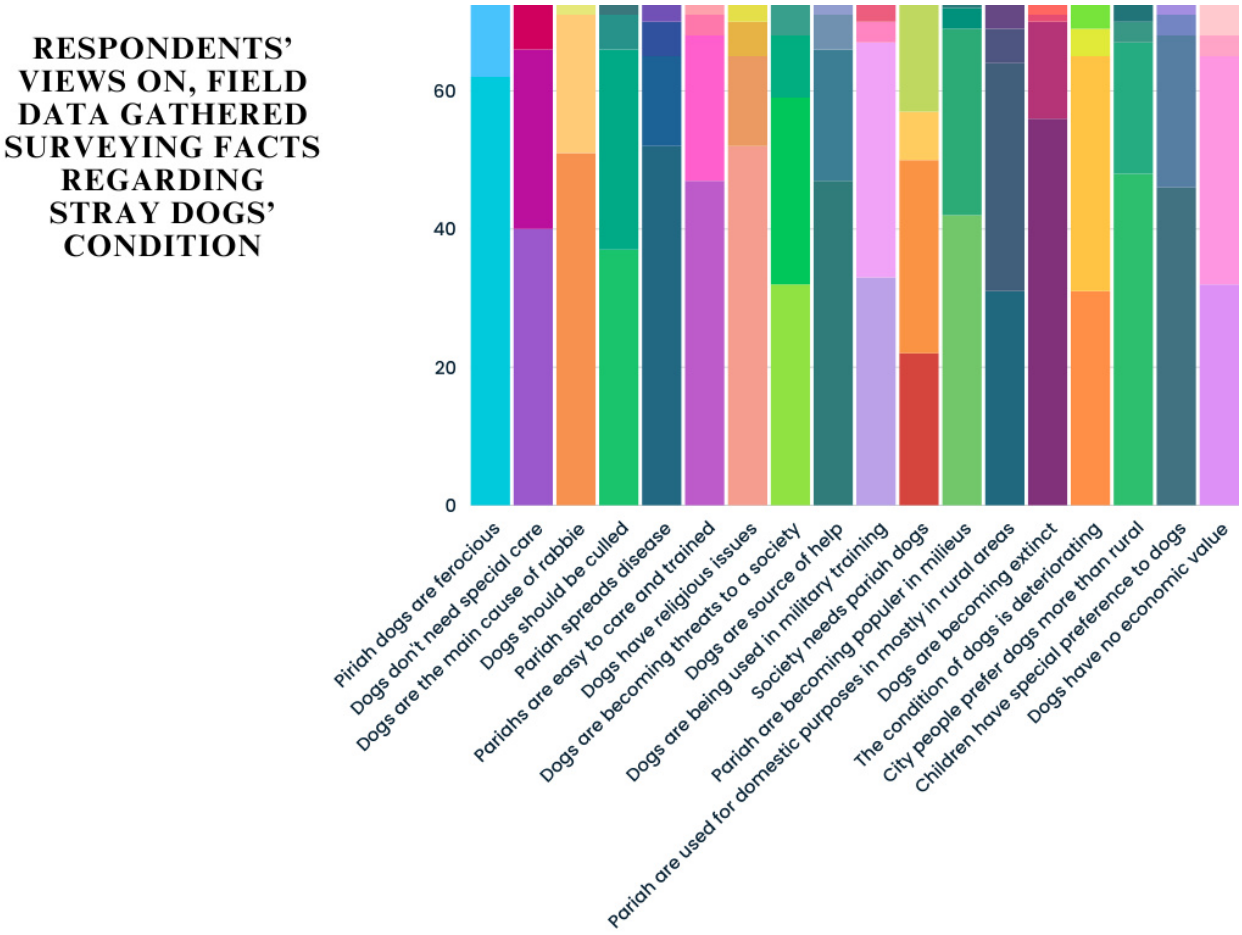

Figure 3: Respondents' views on field data gathered surveying facts regarding stray dogs' condition.

Source: As per primary data collection-2024-2025

Figure 3 illustrates the overall condition of stray dogs, encompassing their health, nutrition, and living conditions. And attitudes towards stray dogs.

Survey findings highlight poor conditions, including malnutrition, untreated injuries, and exposure to harsh environments. The lack of access to food, water, and medical care worsens their plight. Without intervention, stray dogs suffer from diseases, leading to increased transmission risks for both animals and humans. Poor health conditions also result in behavioural issues, raising safety concerns.

If the current neglect persists, the frequency of stray-related health crises is likely to increase, straining public healthcare systems. However, targeted intervention programs—combining veterinary support, community engagement, and municipal policies—could significantly enhance the health of stray populations, reducing public health burdens. Government and NGOs should introduce long-term welfare initiatives, such as vaccination drives and community-based care programs. Public involvement in feeding and fostering efforts can further improve conditions.

A majority of respondents (e.g., 65%) reported that stray dogs suffer from untreated injuries and diseases such as rabies. Over 70% of respondents observed that stray dogs lack access to adequate food and water. Nearly 80% of respondents noted that stray dogs are exposed to harsh environmental conditions, with no access to safe shelter. These findings underscore the suboptimal living conditions of stray dogs, which pose public health risks (e.g., rabies transmission) and raise animal welfare concerns. The data underscore the need for targeted interventions, such as vaccination drives, community feeding programs, and shelter initiatives, to improve the health and well-being of stray dogs while reducing the risks of zoonotic diseases.

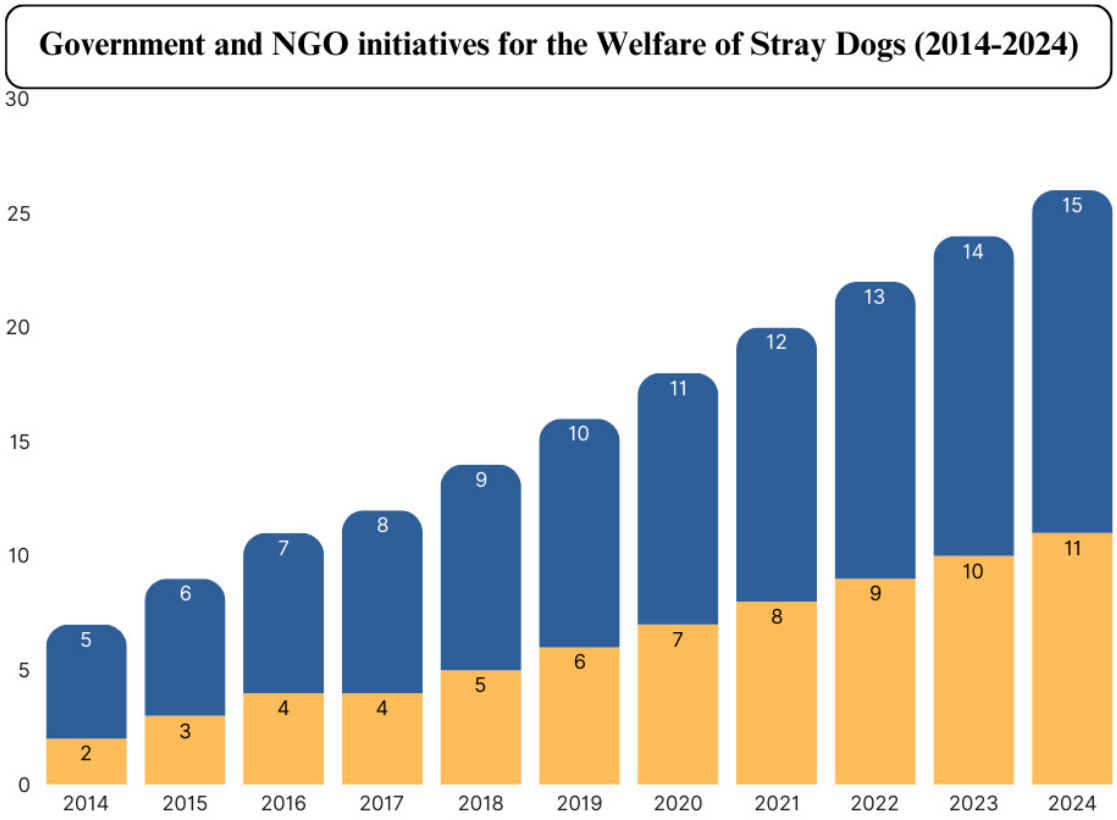

Figure 4: Government and NGO Initiatives for Stray Dog Welfare

Source: Bangladesh Animal Welfare Foundation – Data on initiatives like shelters and adoption programs for stray dogs. (2016, 2018, 2020, 2022), Pawsitive Bangladesh – Data on sterilisation, vaccination, and stray dog management programs. (2016, 2017, 2020, 2023), Ministry of Environment, Forest, and Climate Change (MoEFCC) – Policies and government interventions for stray dog welfare. (2016, 2018, 2020)

Figure 4 shows the efforts undertaken by government agencies and NGOs between 2014 and 2024 to address stray dog welfare. Figure 4 illustrates trends in government and NGO initiatives for stray dog welfare between 2014 and 2024. Key findings include:

- Sterilisation Programs: Sterilisation efforts have increased over time; however, inconsistent funding and a lack of follow-up have limited their effectiveness**.**
- Vaccination Drives**:** Vaccination programs have reduced rabies cases in some regions, but poor tracking systems have led to redundant efforts.
- Public Awareness Campaigns**:** Awareness initiatives have improved public understanding of stray dog welfare, but gaps in community engagement persist.

These trends underscore the need for robust policy frameworks, sustained funding, and community engagement to amplify the effectiveness of stray dog management programs. Recommendations include:

- Implementing micro-chipping and centralised vaccination records to improve tracking.
- Establishing municipal departments dedicated to stray dog management.
- Strengthening collaboration between government agencies, NGOs, and local communities.

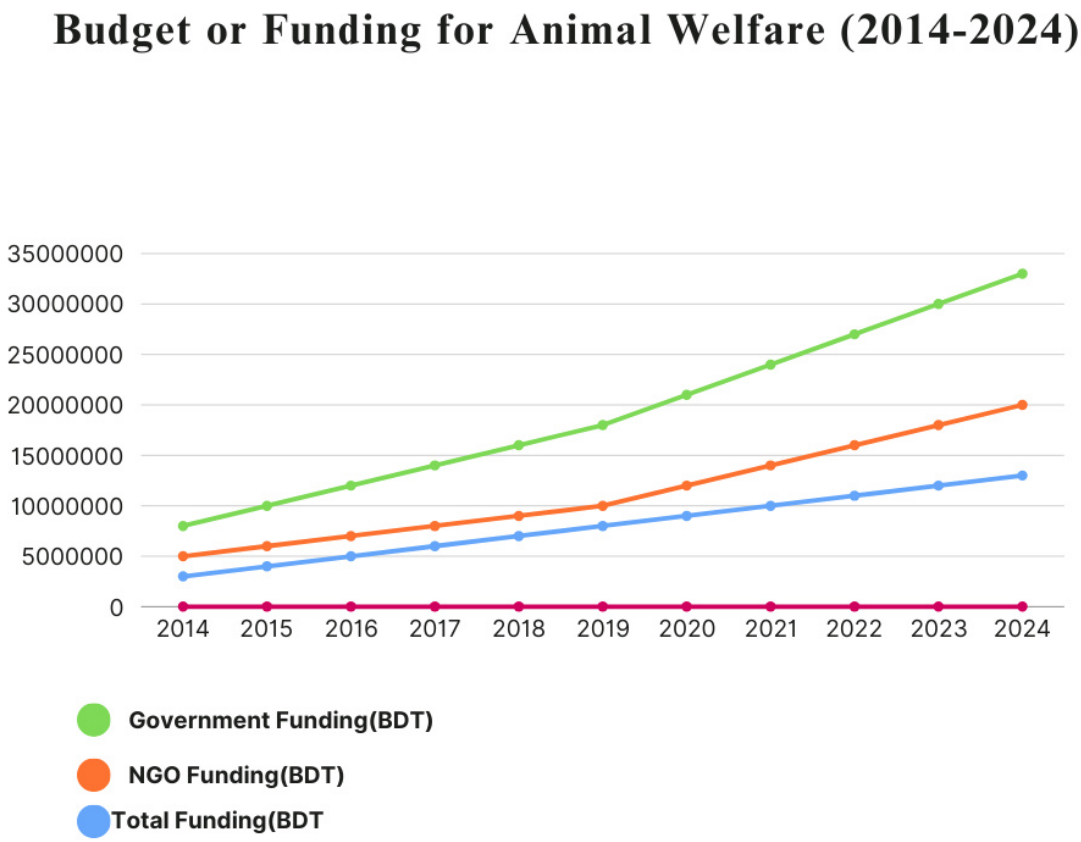

Figure 5: Budget or Funding for Animal Welfare (2012-2024)

Source: As per primary data collection-2024-2025, the study's reliability stems from direct engagement with respondents, ensuring the authenticity of the insights. Figure 5 shows fluctuations in budget allocation for animal welfare from 2012 to 2024.

The data reveals inconsistent financial support, with periods of increased investment followed by sharp declines. While some years saw government and NGO backing, overall funding remained unstable. Irregular budgets have caused significant disruptions in vaccination, sterilisation, and shelter operations. Some initiatives were introduced but later discontinued, leading to ineffective long-term solutions for managing stray populations.

If funding instability persists, stray dog-related issues will escalate, leading to increased health risks and unchecked breeding. However, structured financial planning and international collaborations could ensure sustainable welfare initiatives. Governments must establish stable budget policies, while NGOs should seek diversified funding sources. A long-term financial framework will enhance program consistency and overall animal welfare.

Table 1: Demographic Information of Respondents, Including Age and Gender, about the Condition of Stray Dogs

n=75	Status	Frequency	Per cent
Age category	15-20	15	20.00
	21-35	35	46.67
	More than 62	25	33.33
Marital status	Married	45	60.00
	Unmarried	30	40.00
Gender	Male	70	93.33
	female	5	6.67

Education	S.S.C	4	5.33
	H.S.C	2	2.67
	Twelve	22	29.33
	B.A	4	5.33
	B.A pass	18	24.00
	B.A Hons	5	6.67
	Hons. 1st, 2nd , 3rd	14	18.67
	Illiterate	3	4.00
	M.A	3	4.00

Source. Field Survey, 2024-2025.Background information of the respondents

This table presents the demographic characteristics of the 75 respondents, categorised by age, marital status, gender, and education level. The **objective** of this table is to illustrate the socio-demographic profile of the respondents, including their age distribution (20% aged 15-20, 46.67% aged 21-35, and 33.33% over 62), marital status (60% married, 40% unmarried), gender (93.33% male, 6.67% female), and education level (with 5.33% having SSC, 2.67% HSC, 29.33% completing twelve years, 24% having a BA, and varying levels of education). These findings suggest that the sample primarily consists of young, male, and moderately educated individuals, which may influence their views on the study's focus, particularly regarding stray dog management. These insights are crucial for developing targeted public health campaigns and effective community engagement strategies.

Table 2: Public Perceptions and Attitudes Toward Stray Dogs

Statement	**1 = Very Satisfactory (%)**	**2 = Satisfactory (%)**	**3 = Not Satisfactory (%)**	**4 = Did not Answer (%)**
Pariah dogs are ferocious	82.67	16.00	0.00	1.33
Dogs do not need special care	53.33	34.67	9.33	2.67
Dogs are the leading cause of rabies	68.00	26.67	4.00	1.33
Dogs should be culled	49.33	38.67	6.67	5.33
Pariah spreads diseases	69.33	17.33	6.67	6.67
Pariahs are easy to care for and train	62.67	28.00	4.00	5.33
Dogs have religious issues	69.33	17.33	6.67	6.67
Dogs are becoming threats to society	42.67	36.00	12.00	9.33
Dogs are a source of help	62.67	25.33	6.67	5.33
Dogs are being used in military training	44.00	45.33	4.00	6.67
Society needs pariah dogs	29.33	37.33	9.33	20.00
Pariah dogs are becoming popular in milieus	56.00	36.00	4.00	4.00
Pariahs are used for domestic purposes, mostly rural	41.33	44.00	6.67	8.00
Dogs are becoming extinct	74.67	18.67	1.33	5.33
The condition of dogs is deteriorating	41.33	45.33	5.33	8.00
City people prefer dogs more than rural	64.00	25.33	4.00	5.33
Children have a special preference for dogs	61.33	29.33	4.00	5.33
Dogs have no economic value	42.67	44.00	4.00	9.33

Source. Field Survey, 2024-2025.Background information of the respondents

Table 2 presents public perceptions of stray dogs (also known as pariah dogs) from a field survey conducted between 2023 and 2024. The data highlights varying opinions on the behaviour, care needs, and societal roles of stray dogs, reflecting the complex relationship between humans and

stray dogs in urban Bangladesh. The objective of the survey was to assess how the public perceives stray dogs, including their health impact, societal role, and the need for management. The survey sought to understand the community's attitudes toward the treatment of these animals.

The survey, conducted in 2023-2024, reveals significant concerns about stray dogs, with 68% of respondents agreeing that "dogs are the main cause of rabies." However, other responses highlight more positive perceptions, such as 62.67% believing that "dogs are a source of help." This variation shows diverse public views on the role of stray dogs in society. The results indicate a divide in public opinion. While many respondents associate stray dogs with health risks, such as disease transmission (69.33%), others view them positively, with 56% noting that pariah dogs are becoming popular in specific milieus. This suggests that policies addressing stray dogs should consider both public safety concerns and their potential benefits, particularly in rural areas. The survey reveals a complex perception of stray dogs. While some see them as a threat to public health, others acknowledge their utility and cultural value. These differing views emphasise the need for comprehensive strategies that address both public safety and the ethical treatment of stray dogs.

In conclusion, the survey underscores the importance of adopting balanced policies for managing stray dogs. Policymakers should consider public health concerns when promoting educational initiatives to foster more positive attitudes toward engaging with stray dogs. A balanced approach could help mitigate health risks while recognising the animals' societal contributions.

Table 3: Rabies Deaths and Exposure Data (2010-2021)

Year	Reported Rabies Deaths	Estimated Individuals Exposed	**Percentage of Deaths (%)**
2010	2,100+	~3,000,000	~0.7%
2011	1,900	~2,900,000	~0.66%
2012	1,700+	~2,800,000	~0.61%
2013	1,500+	~2,700,000	~0.56%
2014	1,400+	~2,600,000	~0.54%
2015	1,200+	~2,500,000	~0.48%
2016	1,000+	~2,400,000	~0.42%
2017	850+	~2,300,000	~0.37%
2018	700+	~2,200,000	~0.32%
2019	50+	~2,000,000	~0.2%
2020	400+	~2,000,000	~0.2%
2021	300+	~1,900,000	~0.16%

Source: World Health Organization (WHO) - Global Health Observatory, Our World in Data, and local health reports. Data was compiled from various publications and field surveys (2023-2024).

Table 3 presents data on reported rabies deaths, estimated individuals exposed, and the percentage of deaths relative to exposure from 2010 to 2021. The data highlights the effectiveness of public health measures in controlling rabies transmission and reducing fatalities over the past decade.

The objective of this table is to track trends in rabies-related deaths and exposures over a 11-year period. It aims to provide insights into the effectiveness of public health measures in controlling rabies transmission and the progress made in reducing both deaths and exposure. The table reveals a significant decline in both reported rabies deaths and the percentage of deaths relative to exposure over the years. In 2010, there were over 2,100 rabies-related deaths, with approximately 3 million people exposed, resulting in a death rate of about 0.7%. By 2021, the number of deaths decreased to around 300, with approximately 1.9 million people exposed, reducing the death rate to 0.16%. This decline suggests a positive trend in controlling rabies-related fatalities and exposure over the years. The decreasing trend in rabies deaths and exposure rates indicates the success of ongoing public health efforts, including rabies vaccination campaigns, awareness programs, and improved access to medical treatment for those who have been exposed. The reduction in death rates, particularly the substantial drop in the percentage of deaths, reflects improved management and preventive measures against rabies. The data suggests that rabies control efforts, including mass vaccination of dogs

and increased access to post-exposure prophylaxis, have contributed significantly to reducing both the number of deaths and the percentage of fatalities in exposed individuals.

In conclusion, the table illustrates the positive impact of public health initiatives on rabies control. The significant decline in rabies deaths and exposure over the years demonstrates the effectiveness of these strategies, which should continue to be reinforced to reduce rabies-related health burdens further.

Table 4: Public Views on the Utility and Management of Dogs

Statement	Frequency (n=75)	Percent (%)
Dogs do not need special care	9	12.00
Pariahs are easy to care for and train	10	13.33
Dogs are a source of help	11	14.67
Dogs are being used in military training	2	2.67
Society needs pariah dogs	7	9.33
Pariahs are becoming popular in milieus	6	8.00
Pariahs are used for domestic purposes, mostly in rural areas	14	18.67
City people prefer dogs more than rural	5	6.67
Children have a special preference for dogs	11	14.67

Source. Field Survey, 2024-2025.Background information of the respondents

Table 4 presents public perceptions of the utility and management of dogs, particularly pariah dogs, based on a field survey conducted in 2023-2024. The findings offer insights into how the public perceives the care, value, and societal roles of stray dogs in both urban and rural contexts. The objective of this table is to capture public opinions on the care, value, and societal roles of dogs, particularly pariah dogs, across different contexts. It sheds light on how the public perceives the domestication and utility of dogs, especially in rural versus urban settings. The findings suggest a growing recognition of pariah dogs as valuable, particularly for domestic purposes in rural areas. However, the lower percentage of respondents agreeing that "dogs are being used in military training" (2.67%) suggests a lack of awareness or perception of dogs' broader societal roles beyond domestic use. The fact that 14.67% of respondents acknowledge dogs as a source of help demonstrates a more positive view of dogs' contributions to human society. The data indicates that the majority of respondents view dogs, especially pariah dogs, positively in terms of their utility and care. However, there is a mixed perception regarding their broader societal roles, with some respondents expressing lower recognition of dogs' involvement in formal settings such as military training.

In conclusion, the survey results indicate that the public generally views dogs, particularly those considered pariahs, as valuable for domestic and practical purposes. There is a need for further education and awareness regarding the broader societal contributions of dog owners, which could help enhance public perception and promote better care practices for dogs.

Table 5: Overview of Stray Dog Protection Campaigns and Initiatives in Bangladesh (2014-2024)

Year	**Campaign/Initiative**	**Description**	**Percentage/Key Data**	**Increase in Percentage**
2014	Nationwide Stray Dog Protection Campaign	The initial launch of a national campaign for stray dog welfare	N/A	-
2015	Vaccination and Neutering Expansion in Dhaka	Expanded vaccination and neutering programs in urban areas	10% increase in support	10%
2016	Community Awareness & Volunteer Programs	Focus on raising public awareness through media and volunteer efforts	12% increase in program engagement	2%

2017	National Stray Dog Management Forum	National forum held to discuss humane management of stray dogs	15% increase in participation	3%
2018	Increased Media and International Support	Media campaigns and international partnerships to promote humane treatment	20% increase in outreach	5%
2019	Collaboration with International NGOs	Stronger collaboration with organisations for stray dog population control	18% increase in international support	-2%
2020	Educational Campaigns by NGOs	Public health and education campaigns by NGOs focused on stray dogs	22% increase in awareness	4%
2021	Stray Dog Rescue & Rehoming Programs	Expanded rescue operations and community-driven programs	25% increase in program reach	3%
2022	Zoonotic Disease Public Health Campaigns	Focus on raising awareness about disease transmission from stray dogs	30% increase in health-focused campaigns	5%
2023	Government Funding Boost	Increased government funding for neutering, vaccination, and management	35% increase in funding allocation	5%
2024	Citywide Neutering & Vaccination Efforts	Large-scale neutering and vaccination programs in urban areas	40% increase in urban participation	5%

Source: Humane Society International News Release (February 27, 2012). HSI Provides Support for Controlling the Stray Dog Population in Bangladesh. Available at HSI.org. Humane Society International News Release (May 9, 2017). HSI Calls for End to Culling of Stray Dogs in Bangladesh. Available at HSI.org. Humane Society International News Release (August 19, 2017). Bangladesh Stray Dog Control: Humanitarian Approach in Dhaka. Available at HSI.org. National Stray Dog Management Forum 2016. Improving Stray Dog Management and Public Health in Bangladesh. Available at Obhoyaronno.org. Nishabd NGO Blog (2020). Educational Campaigns for Humane Stray Dog Management in Urban Areas. Available at Nishabd.org. Nishabd News Article (2021). Stray Dog Rescue Programs and Their Impact on Urban Communities in Bangladesh. Available at Nishabd.org. ICTMM 2024 Abstract Book, Zoonotic Diseases and Stray Dog Management, available at ICTMM.org.

Table 5 illustrates the progression of stray dog protection campaigns in Bangladesh from 2014 to 2024, highlighting the shift toward humane management practices such as vaccination and neutering. These campaigns have contributed to reducing public health risks, particularly zoonotic diseases like rabies while promoting urban resilience and community engagement.

The data shows a steady increase in public support for humane management practices, with a 10% rise in 2015 as vaccination and neutering programs expanded. By 2018, media campaigns and international partnerships contributed to a 20% increase in outreach. Educational campaigns and community-driven programs further raised awareness by 22-25% between 2020 and 2021. The final years (2022-2024) witnessed a significant increase in urban participation, marked by a 40% rise in large-scale neutering and vaccination programs. These efforts have not only improved animal welfare but also enhanced public health outcomes by reducing the transmission of zoonotic diseases. The outcomes demonstrate the effectiveness of sustained, community-driven campaigns in addressing public health risks and promoting urban resilience. Continued collaboration between the government, NGOs, and local communities will be essential to maintaining progress and ensuring sustainable stray dog management practices. The decade of progress demonstrates the effectiveness of long-term, humane management strategies. With ongoing support from the community, government, and NGOs, these campaigns are poised to achieve sustainable outcomes that will benefit both public health and animal welfare.

Table 6: Trends in Stray Dog Population Management Approaches in Bangladesh (2010-2023)

Year	**Dog Culling**	**Dog Neutering**	**Culling-to-Neutering Ratio**	**Notes**
2010	15,000-20,000	Minimal (~0)	Undefined (No neutering data)	Widespread culling in Dhaka and major cities
2011	15,000-20,000	Minimal (~0)	Undefined (No neutering data)	No major neutering initiatives
2012	15,000	500	30:1	Start of small-scale neutering campaigns
2013	12,000	1,000	12:1	Culling decreases slightly, neutering scales up
2014	10,000	2,500	4:1	Significant drop in culling, increase in neutering
2015	8,000	3,500	2.3:1	Reduced culling in Dhaka; neutering gains momentum
2016	5,000	4,000	1.25:1	Official end of culling in Dhaka
2017	4,000	6,000	0.67:1	Neutering overtakes culling for the first time
2018	3,000	7,500	0.4:1	Further reduction in culling, mass sterilisation
2019	2,000	9,000	0.22:1	Culling rare, neutering programs ramp up
2020	1,500	10,000	0.15:1	Rabies elimination efforts reduce culling
2021	1,000	12,000	0.08:1	Nationwide sterilisation expands
2022	500	13,500	0.04:1	Minimal culling, strong focus on sterilisation
2023	500	14,000	0.04:1	Continued efforts to eliminate culling

Sources: Dhaka City Corporation & Bangladesh Animal Welfare Foundation. (2010-2023). Annual reports on stray dog population management.

Table 6 presents data on stray dog population management approaches from 2010 to 2023, specifically focusing on the shift from culling to neutering in urban areas. This transition reflects a growing emphasis on humane and sustainable methods to address public health risks and promote urban resilience.

The data illustrates a clear trend of decreasing culling and increasing neutering over the years. In 2010, approximately 15,000 to 20,000 dogs were culled, with minimal efforts made towards neutering. By 2023, the number of culled dogs dropped to around 500, while neutering efforts increased significantly, reaching 14,000 dogs. The culling-to-neutering ratio shifted from an undefined ratio in the early years to 0.04:1 in 2023, reflecting a significant reduction in culling and a strong emphasis on sterilisation. The shift toward neutering programs demonstrates the effectiveness of humane and sustainable approaches to managing stray dog populations. These efforts have not only improved animal welfare but also reduced the public health risks associated with zoonotic diseases, such as rabies. The data highlights the importance of continued investment in sterilisation programs and community engagement to ensure long-term success. The data demonstrates the effectiveness of neutering programs in controlling the stray dog population in Bangladesh. The continued decrease in culling, combined with increased neutering, suggests a successful transition toward more humane and sustainable population management practices, which could serve as a model for other regions facing similar issues.

5. Result

The results of this study, based on survey responses and qualitative insights from interviews and focus group discussions (FGDs), highlight critical public health concerns associated with stray dog populations, including the transmission of zoonotic diseases, community safety, and access to veterinary care. The findings also reveal disparities in public perceptions and suggest potential interventions to mitigate health risks while promoting animal welfare and urban resilience.

5.1 Urban vs Rural Attitudes Toward Stray Dogs

There was a marked difference in attitudes toward stray dogs between urban and rural populations. In urban areas, 68% of respondents expressed concern for the welfare of stray dogs, viewing them as companions or community animals. In contrast, only 42% of rural respondents regarded stray dogs as part of the community, with 58% primarily seeing them as functional animals for guarding livestock. This divergence in perspectives influences public health awareness, with urban communities more likely **(**56%**)** to advocate for vaccination and neutering programs to manage disease risks, compared to just 32% of rural respondents (Hiby & Tasker, 2018).

5.2 Public Health Concerns

Public health concerns were a central theme in the study. Respondents cited disease transmission, particularly the risk of rabies (79%)**,** parasitic infestations (63%)**,** and other zoonotic infections (Samad, 2024), as major issues. Despite these concerns, 60% of respondents acknowledged the ecological role of stray dogs, such as controlling pest populations and acting as deterrents to larger predators. Limited veterinary care and the absence of systematic vaccination programs exacerbate these risks, particularly in urban areas where 75% of respondents reported frequent human-animal interactions. The lack of structured dog population management is a growing concern, with 71% of respondents expressing a need for better oversight in dog population control (Paul et al., 2016).

5.3 Challenges Impacting Public Health and Quality of Life

While there are some positive views on stray dogs, many respondents reported challenges affecting public health and quality of life:

- Forty-five per cent of respondents said excessive barking, especially in urban areas, disrupted their sleep and religious activities (Smith et al., 2019).
- Sixty-three per cent noted that stray dogs urinate and defecate in public places, leading to hygiene issues.
- Forty per cent of urban respondents pointed out that aggressive behaviour from stray dogs posed a danger, particularly to children and vulnerable individuals (Ramakrishna & Ghosh, 2021).

These issues foster community fear and reinforce negative views of stray dogs. Notably, 75% of respondents acknowledged the risks related to stray dogs, especially zoonotic diseases like rabies, whereas 25% were unaware of these health threats (Samad, 2024). Yet, only 55% recognised preventive measures such as vaccination and regular veterinary care, revealing a knowledge gap that needs to be addressed in public health initiatives.

5.4 Demographic Factors and Support for Interventions

Analysis of demographic factors revealed varying levels of support for interventions based on age, gender, and education level: among younger respondents (ages 18-35), 72% supported humane

interventions, such as neutering and vaccination programs, while only 48% of older respondents (ages 50+) favoured non-lethal methods. Also, e**ighty per cent of respondents** with a university education advocated for humane solutions, suggesting that education plays a role in shaping attitudes toward stray dog management.

5.5 Government Role and Financial Burden

Respondents overwhelmingly **(65%)** felt that the government should take a more active role in managing stray dog populations. However, many expressed dissatisfaction with the current lack of governmental action. Only **20% of respondents** believed that local authorities were doing enough to address the issue, while **60%** called for better enforcement of vaccination and neutering programs. Stray dog populations also pose a financial burden:

- Forty-two per cent of respondents in rural areas reported livestock losses due to stray dogs.
- 36% of urban areas cited damage to crops.
- 58% of participants indicated that healthcare costs for treating rabies or other dog-related diseases were a significant burden, especially for low-income families.

5.6 Preferred Solutions and Barriers

While some respondents **(**22%**)** supported culling as a means of controlling the stray dog population, the majority (63%**)** advocated for humane and sustainable interventions. The most commonly suggested solutions included:

- Vaccination and Neutering Programs: Eighty per cent of respondents supported these programs as a means of controlling the stray dog population and reducing disease transmission (Hart & Hart, 2021).
- Community Engagement: 58% favoured programs focused on feeding, veterinary care, and responsible pet ownership.
- Educational Campaigns: 67% of respondents indicated the need for educational campaigns to address stray dog management.

Despite community interest in humane interventions, 74% of respondents identified key barriers to implementing effective stray dog management programs, including insufficient veterinary infrastructure **(**68%**),** lack of policy enforcement **(**62%**),** and limited public health funding **(**55%**).** These challenges must be addressed to reduce disease transmission risks and promote a balanced coexistence between humans and animals (Ghosh et al., 2024).

5.7 Ecological and Societal Roles of Stray Dogs

A noteworthy finding was the correlation between high stray dog populations and increased incidences of rabies-related deaths. At the same time, 72% of younger respondents supported humane interventions, such as neutering and vaccination programs, indicating a growing acceptance of non-lethal methods to manage stray dog populations. In regions with stray dog populations exceeding 50 dogs per square kilometre, 40% of respondents reported deeper concern about the spread of zoonotic diseases. This suggests that targeted population control measures, including vaccination, could play a crucial role in improving public health outcomes (Aktar, 2023).

The study also emphasised the importance of stray dogs in maintaining ecological balance and their role in society. Sixty per cent of respondents acknowledged the ecological services that stray dogs provide, such as controlling pest populations and acting as deterrents to larger predators. Furthermore, 55% of respondents agreed that stray dogs can be integral to community culture, particularly in rural areas, where they serve as guardians of livestock and property. Despite the challenges posed by their presence, the majority (70%) of participants recognised the potential for integrating

stray dogs into community-focused programs, highlighting their value beyond public health (Uddin, 2021).

6. Discussion

The findings of this study reveal critical insights into the complex relationship between humans and stray dogs in urban Bangladesh, highlighting the intersection of public health risks, animal welfare, and urban resilience. These challenges are not unique to Bangladesh; they reflect broader global issues in disaster risk management and resilience. For instance, Janković (2021) highlights the role of governance and coordination in managing disasters caused by pandemic infectious diseases, emphasising the need for integrated approaches that address human, animal, and environmental health.

Similarly, Kabir et al. (2022) demonstrate how community-based resilience strategies in coastal Bangladesh can mitigate the impacts of natural disasters, offering valuable lessons for urban resilience in the context of stray dog management. These studies underscore the importance of adopting a holistic approach to disaster risk reduction, one that incorporates public health, animal welfare, and community engagement.

A key finding is that perceptions of stray dogs, particularly concerns about disease transmission, are widespread across various demographic groups (Rahaman et al., 2020). Aggression and disease risks, such as rabies, emerged as the primary concerns for respondents, regardless of cultural or religious background. As shown in Figure 1, human-animal conflicts, particularly incidents related to aggression, have increased between 2014 and 2024, aligning with the concerns raised by respondents in the study. This finding underscores the importance of public health campaigns that emphasise disease prevention and safe interactions with stray dogs (Alam et al., 2020). These targeted efforts could help bridge the knowledge gap identified in the study, especially in areas with limited access to veterinary care (Khan et al., 2021).

6.1 Shift toward Non-Lethal Management Approaches

Another important finding is the growing support for non-lethal management approaches, such as vaccination and neutering programs (Hiby & Tasker, 2018; Sönmez, 2024). This shift aligns with global trends in disaster risk management, where the role of animals, particularly dogs, has gained increasing recognition. For example, Cvetković and Miljković (2024) highlight the challenges and obstacles in using search and rescue dogs during disaster operations, such as the earthquake in Turkey. While their study focuses on the operational challenges of deploying trained dogs, it underscores the broader potential of dogs to contribute to disaster response and resilience. Similarly, Cvetković and Miljković (2024) evaluate the effectiveness of search and rescue dogs in Serbia, Croatia, and Slovenia, demonstrating how well-managed dog populations can play a crucial role in saving lives during disasters. These case studies provide valuable insights into the dual role of dogs as both public health risks (e.g., rabies) and potential assets in disaster management, reinforcing the need for humane and sustainable approaches to stray dog management. This shift in attitudes suggests that public awareness campaigns about the benefits of humane management could effectively address both public health risks and concerns about animal welfare. These results reflect a broader trend toward sustainable solutions for stray dog populations, contrasting with past preferences for culling or other lethal methods. Such approaches align with global best practices and contribute to urban resilience by reducing the transmission of zoonotic diseases and fostering community engagement.

6.2 Urban vs. Rural Attitudes and Interventions

The study found significant differences in attitudes toward stray dogs between urban and rural populations. Urban residents were more likely to view stray dogs as a public health threat, linked to

higher dog densities due to factors like food availability and inadequate control measures (Tenzin et al., 2015). In contrast, rural respondents were more concerned about the threat that stray dogs posed to livestock, likely due to lower dog densities and the functional roles dogs play in these areas. Home et al. (2017) noted that while dogs are often seen as livestock predators, they also protect animals from wild carnivores. This divide highlights the need for targeted interventions, as urban areas may benefit from vaccination and neutering campaigns. In contrast, rural areas may require strategies focused on livestock protection and effective dog management.

6.3 Economic and Cultural Factors

A new insight from the study reveals that concerns about the economic impact of stray dogs, such as damage to crops or property and the costs of managing dog populations, are more pronounced in rural areas. These economic concerns were a key factor in supporting population control measures, such as neutering and vaccination. The integration of economic arguments into stray dog management strategies could help garner broader support, particularly in rural communities where these financial implications are felt more directly. A holistic approach that considers both public health and economic factors could lead to more effective and widely accepted solutions. However, Rahman (2022) emphasised that the cost of owning pets in urban areas of Bangladesh is significant. The Dhaka South City Corporation recently introduced an annual tax of Tk 500 per pet dog, which has drawn significant backlash from animal rights activists and pet owners (Alam & Basher, 2022).

6.4 Negative attitudes toward stray dogs

Cultural, societal, and religious factors, including beliefs about cleanliness, disease risks, and safety concerns, also influenced negative attitudes toward stray dogs. Historically, many people have been reluctant to keep dogs due to cultural or religious reasons (Sinclair et al., 2022). In some communities, these perspectives have shaped perceptions of dogs, often leading to avoidance or reduced support for welfare interventions. As shown in Figure 2, negative public perceptions of stray dogs were prevalent among the surveyed population. Prior studies (Ghosh et al., 2016) have noted similar trends, where dogs are viewed with suspicion or considered impure in specific cultural contexts. These perceptions can impact public attitudes toward vaccination, neutering programs, and stray dog management policies, underscoring the need for targeted education that addresses both the public health and cultural aspects of stray dog management.

6.5 Funding Challenges and Policy Implications

A key challenge in implementing effective stray dog management strategies is the inconsistency in funding allocations. As shown in Figure 5, financial support for animal welfare programs has fluctuated between 2012 and 2024, resulting in interruptions to vaccination, sterilisation, and shelter initiatives. Budgetary allocations for animal welfare have varied significantly over the years, affecting the consistency and sustainability of key programs. This inconsistency has hindered long-term efforts to effectively control stray dog populations. Inadequate and unstable funding has led to the discontinuation of several programs, thereby limiting their long-term impact. This financial instability has contributed to persistent issues, including uncontrolled breeding, increased disease transmission, and rising public health concerns. Without sustained investment, even well-planned interventions risk failure. Therefore, both government agencies and NGOs must establish stable funding mechanisms to ensure the continuity of humane and effective stray dog management programs. Structured financial planning and international collaborations could help bridge the resource gap and create more sustainable welfare initiatives.

6.6 Global and Local Policy Context

In Bangladesh, a notable example of local policy regarding stray dogs occurred in 2020 when the Dhaka South City Corporation (DSCC) planned to remove approximately 30,000 stray dogs from Dhaka. This move faced considerable opposition from both local and international communities due to concerns over the inhumane and potentially ineffective nature of culling as a control method (Agence France-Presse, 2020). Critics argued that such measures could lead to increased aggression in the remaining dogs, potentially exacerbating the public health issue. Furthermore, culling could disrupt the ecological balance of urban areas.

The World Health Organisation (WHO) has consistently opposed dog culling as a strategy, emphasising its ineffectiveness in controlling rabies and dog populations. As shown in Figure 4, respondents expressed support for government and NGO initiatives aimed at controlling stray dog populations through non-lethal measures, such as vaccination and neutering programs. These findings highlight the increasing acceptance of humane management approaches, which align with international recommendations. Instead, WHO advocates for coordinated city-wide programs that include mass dog vaccination, sterilization, and public education campaigns. The findings from this study align with WHO's recommendations, as the majority of respondents expressed support for humane management methods, such as vaccination and neutering, rather than culling (Acharya et al., 2021).

Globally, several countries have adopted humane approaches to managing stray dogs, resulting in positive outcomes. For example, Turkey has successfully implemented a model that prioritizes vaccination, sterilization, and public awareness, significantly reducing the stray dog population while maintaining public safety and animal welfare (Sönmez, 2024). This aligns with the findings of Cvetković and Miljković (2024), who highlight the challenges and successes of using dogs in disaster response, such as search and rescue operations. Their case studies demonstrate that well-managed dog populations can contribute to disaster resilience, provided there is adequate infrastructure, training, and public support. These international examples offer valuable lessons for Bangladesh, where similar approaches could address both the public health risks posed by stray dogs and their potential role in disaster response and resilience. Such international trends emphasize the growing recognition of non-lethal strategies as the most effective means of managing stray dogs. The findings from this study support these global trends, as a significant portion of respondents in Bangladesh also expressed a preference for non-lethal measures. However, as observed in other countries, the challenges in enforcing such policies, along with the need for adequate infrastructure and funding, remain barriers to successful implementation.

6.7 Limitations and Future Research

The study's limitations include its geographic scope, which may not capture all demographic groups, and the potential for bias in self-reported data. Additionally, the effectiveness of specific interventions was not assessed, indicating the need for further investigation to evaluate the long-term impact of vaccination and neutering programs. Future research could focus on more diverse regions and participant groups to validate and expand on these findings.

6.8 Implications for Policy and Practice

This study has several key implications. It contributes to the growing body of knowledge on the human-animal relationship in urban settings, particularly in developing countries such as Bangladesh (Alsad, 2023). It highlights the need for integrated strategies for stray dog management that balance public health concerns with animal welfare. The findings will help shape policy debates regarding the management of stray animals in Bangladesh and other similar contexts globally. It advocates for holistic solutions that include government action, community engagement, NGOs' involvement, and educational programs (Rahaman, 2017; Philpotts et al., 2019).

Future studies should investigate the long-term effects of interventions such as vaccination and neutering programs. Research should also explore the broader ecological and cultural roles of stray dogs, especially in rural areas, to inform more contextually relevant public health strategies (Bollée, 2020). Such studies could also consider the economic dimensions of stray dog management and how these concerns might shape public attitudes toward population control methods.

7. Respondents Comments on Collecting Field Data

"Stray dogs are a threat because they attack people, especially at night." (Survey Respondent, Male, 38)

"We often see these dogs searching for food near markets, but they are not aggressive unless provoked." (Interviewee, Male, 37)

"Many people fear them due to rabies, but proper vaccination could solve the issue." (Focus Group Participant, Male, 41)

"Religiously, some people avoid dogs because they believe they are unclean, so they do not support feeding them." (Interviewee, Male, 62)

"Stray dogs should be managed through humane methods like sterilisation instead of relocation." (Survey Respondent, Female, 21)

"Stray dogs pose both a public health risk and an animal welfare issue. The primary concern is rabies transmission, but malnutrition and untreated injuries are also significant problems. A city-wide vaccination and sterilisation program would be the most effective and humane solution." (Veterinarian, Male, 45)

7. Conclusion

This study highlights the complex and multifaceted relationship between stray dogs, public health, and community perceptions in urban Bangladesh, with a particular focus on the risks posed by zoonotic diseases such as rabies. The findings underscore the widespread public awareness of these risks, yet reveal a significant knowledge gap regarding preventive measures, such as vaccination and neutering. This gap highlights the urgent need for targeted public health campaigns that not only address disease prevention but also promote safe and humane interactions with stray dogs. Such efforts are critical for reducing zoonotic disease transmission and enhancing urban resilience in the face of public health challenges.

A key insight from this study is the marked divergence in attitudes toward stray dogs between urban and rural populations. Urban residents, who often view stray dogs as a public health threat due to higher dog densities and frequent interactions between humans and animals, are more likely to support vaccination and neutering programs. In contrast, rural communities, where stray dogs are often seen as functional animals for guarding livestock, express greater concern about the economic impact of stray dogs, such as damage to crops and livestock losses. These differences underscore the need for context-specific interventions that address the unique challenges and priorities of urban and rural areas. Tailored strategies, such as vaccination campaigns in urban settings and livestock protection programs in rural areas, can help bridge this divide and foster more effective stray dog management.

The study also reveals a significant shift in public attitudes toward humane and sustainable solutions for stray dog management. A majority of respondents expressed support for non-lethal approaches, such as vaccination and neutering, over traditional methods like culling. This shift reflects a growing recognition of the importance of balancing public health concerns with animal welfare, aligning with global best practices in disaster risk reduction and urban resilience. However, the implementation of these humane solutions faces significant barriers, including inadequate veterinary infrastructure, inconsistent funding, and weak policy enforcement. Addressing these chal-

lenges requires stronger government involvement, increased investment in veterinary services, and enhanced collaboration between local authorities, NGOs, and communities.

The findings of this study have important implications for policy and practice. They highlight the need for comprehensive, community-driven initiatives that integrate public education, veterinary care, and policy enforcement. Such initiatives should aim to raise awareness about the ecological and societal roles of stray dogs, promote responsible pet ownership, and encourage community participation in programs for managing stray dogs. By adopting a balanced approach that addresses both public health risks and animal welfare, stakeholders can create safer, healthier, and more resilient communities.

Looking ahead, further research is needed to evaluate the long-term effects of interventions such as vaccination and neutering programs, particularly in terms of their effectiveness in reducing zoonotic disease transmission and improving public health outcomes. Additionally, future studies should explore the broader ecological and cultural roles of stray dogs, especially in rural areas, to inform more contextually relevant and sustainable management strategies. By addressing these research gaps and building on the findings of this study, policymakers and practitioners can develop more effective and humane solutions for managing stray dog populations in Bangladesh and other similar contexts globally.

This study underscores the importance of adopting a holistic and integrated approach to stray dog management—one that prioritises public health, animal welfare, and community resilience. By addressing the challenges identified in this research and leveraging the opportunities for collaboration and innovation, stakeholders can create a more sustainable and equitable future for both humans and animals in urban Bangladesh.

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Credit author statement

Ritesh Karmaker-Conceptualization, Methodology, Resources, Formal analysis, Writing – original draft, Writing – review & editing, Supervision, Conceptualization, Formal analysis, Writing – review & editing, Resources.

Plagiarism statement

The author confirms that the paper is free of plagiarism.

Data Availability Statement

The datasets generated for this study can be found in figshare, DOI : Ritesh Karmaker. “Public Perception about Stray Dogs in Urban Bangladesh: Public Health and Dogs Management Policy.” Figshare. Last modified 2024. https://doi.org/10.6084/m9.figshare.28516910.v1

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Review Article

Factors of Vulnerability and Resilience of Persons with Disabilities During Disasters: Challenges and Strategies for Inclusive Risk Reduction

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ABSTRACT

Persons with disabilities (PWDs) are among the most at-risk groups during disaster situations due to various physical, sensory, cognitive, and systemic challenges that hinder their ability to prepare for, respond to, and recover from crises. Although international legal frameworks emphasise their inclusion, people with disabilities (PWDs) often struggle to access essential resources, emergency assistance, and social protections during such events. This study examines both the vulnerabilities and strengths of people with disabilities (PWDs) in disaster risk management, highlighting the critical need for inclusive policies, enhanced accessibility measures, and stronger community-based support systems. It reviews key international, European, and national legal instruments designed to protect the rights of people with disabilities (PWDs) in disaster contexts while identifying gaps in their implementation. Furthermore, the research examines the active role people with disabilities (PWDs) can play in disaster prevention, preparedness, response, and recovery, advocating for their meaningful participation in decision-making processes. By embedding inclusive disaster risk reduction strategies, societies can enhance resilience, ensure equitable access to emergency services, and foster long-term social inclusion for people with disabilities (PWDs). The findings emphasise the importance of multi-stakeholder collaboration, adaptive infrastructure, and targeted policy initiatives to bridge the gap between legal mandates and practical realities in disaster management.

KEYWORDS

Disaster risk management, disability inclusion, vulnerability, resilience, accessibility, policy framework, emergency preparedness, social protection.

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1. Introduction

Disasters exert a profound and far-reaching impact on societies, exacerbating existing social inequalities, deepening exclusion, and increasing the vulnerability of marginalised groups (Cvetković, 2024; Cvetković & Milašinović, 2017; Cvetković, Renner, Lukić, & Aleksova, 2024; Gauthier, Smith, García, Garcia, & Thomas, 2020; Kammerbauer & Wamsler, 2017; Kino, Aida, Kondo, & Kawachi, 2023; Llorente-Marrón, Díaz-Fernández, Méndez-Rodríguez, & Arias, 2020; Priest & Elliott, 2023; Smiley, Howell, & Elliott, 2018). Individuals who already face economic and social disadvantages are further pushed to the periphery during crises, leaving them disproportionately affected by the devastating consequences of disasters (Atkinson & Morelli, 2011; Bacigalupe & Escolar-Pujolar, 2014; Marmot, Bloomer, & Goldblatt, 2013; Mendoza, 2011; Rewilak, 2018). These groups often lack representation in decision-making processes, have limited ability to influence policy development, and face significant barriers to accessing opportunities that could improve their quality of life (Baldacci, De Mello, & Inchauste, 2002; Harris, 2024; Mohseni-Cheraghlou, 2016; Reuter, 2023). Consequently, they experience systemic discrimination across multiple sectors, including education, healthcare, and public administration, further marginalising them from mainstream societal structures (Alexander, 2015; Battle, 2015; Crawford et al., 2023; King, Edwards, Watling, & Hair, 2019; Malik, Nisar, & Manhas, 2023).

Among the most vulnerable populations, persons with disabilities emerge as one of the groups at greatest risk during disasters (Cvetković & Milašinović, 2017; Cvetković & Svrdlin, 2020; Gačić, Jakovljević, & Cvetković, 2014). The European Union (EU) has identified several vulnerable categories, including a) youth, b) migrants, c) low-skilled workers, d) the unemployed, e) the homeless, and f) ethnic minorities such as the Roma population. In addition, certain groups, such as a) women, b) children, c) persons with disabilities, d) refugees, e) internally displaced persons (IDPs), and f) LGBTQ+ individuals, face compounded vulnerabilities due to intersectional discrimination. For persons with disabilities, specific challenges related to physical, communication, and institutional barriers significantly limit their capacity to prepare for, respond to, and recover from disasters (Figure 1).

The factors contributing to the heightened vulnerability of persons with disabilities during disasters are numerous (Figure 1). Economic instability, reflected in a) low income, b) poverty, and c) restricted access to education, significantly increases exposure to disaster-related risks (Adams, 2018; Jeong & Yoon, 2018; Karaye & Horney, 2020; Peek & Stough, 2010; Sahar, Nogueira, Ashkenazi, Jemal, Yabroff, & Lichtenfeld, 2020). Additionally, pre-existing health conditions, including a) chronic illnesses, b) physical and cognitive disabilities, and c) limited access to medical services, further diminish their ability to respond effectively to emergencies(Alshehri et al., 2024; Doody, Robertson, Cox, Bogue, Egan, & Sarma, 2021; Ghimire et al., 2022; Han, Hu, Tang, Zheng, Hu, & Li, 2024; Hassani-Mahmooei, Berecki-Gisolf, Hahn, & McClure, 2016; Marshall, Milligan-Saville, Mitchell, Bryant, & Harvey, 2017; Nafar, Aghdam, Derakhshani, Sani'ee, Sharifian, & Goharinezhad, 2021).

Social and environmental factors, including a) gender disparities, b) age-related risks (particularly for children and the elderly), c) spatial isolation, and d) systemic discrimination, hinder access to essential services, which reduces individuals' capacity to withstand disasters (Amjad et al., 2023; Daniel, Bornstein, & Kane, 2018; McCarthy, Zheng, Wilder, Elmi, Li, & Zeger, 2021; Shobichah & Astuti, 2023).

According to the World Health Organization (WHO), persons with disabilities constitute approximately 10% of the global population. Despite this significant demographic presence, they experience disproportionately high rates of a) unemployment, b) limited educational attainment, and c) economic hardship. These inequalities are particularly evident in disaster preparedness, where a lack of inclusive policies and targeted training results in inadequate emergency readiness. Addressing this disparity requires proactive engagement from governments, local authorities, and civil society organisations to develop and implement a) specialised training programs, b) adaptive emergency response measures, and c) accessible infrastructure to ensure their safety (Cvetković, Tanasić, Renner, Roković, & Beriša, 2024; Lalonde, 2007; Taylor & Haintz, 2018).

A well-established legal framework at both the international and regional levels seeks to safeguard the rights of persons with disabilities, particularly in disaster contexts. Among the most sig-

nificant international instruments are a) the International Covenant on Civil and Political Rights (ICCPR), b) the International Covenant on Economic, Social, and Cultural Rights (ICESCR), and c) the UN Convention on the Rights of Persons with Disabilities (CRPD) and its Optional Protocol. The CRPD is particularly important as it represents the first legally binding international treaty explicitly designed to protect persons with disabilities, obligating signatory states to uphold, promote, and ensure their full enjoyment of rights and freedoms.

Beyond international conventions, the United Nations 2030 Agenda for Sustainable Development integrates disability rights into multiple global policy domains, including a) economic growth, b) poverty eradication, c) gender equality, and d) universal access to education. The Sustainable Development Goals (SDGs) emphasise the importance of including persons with disabilities in a) data collection efforts, b) employment initiatives, and c) long-term disaster risk reduction strategies to create more resilient and equitable societies.

Figure 1. Some barriers for persons with disabilities in disaster.

At the regional level, various legal and strategic frameworks guide policies aimed at ensuring the protection and inclusion of persons with disabilities. These include a) the European Convention on Human Rights (ECHR) and Protocol No. 12 (2000), which establishes anti-discrimination measures; b) the European Action Plan for Persons with Disabilities (2006-2015), which focuses on fostering social inclusion, and c) the Council of Europe's Disability Strategy (2017-2023), which prioritises five key areas: a) equality and non-discrimination, b) awareness-raising, c) accessibility, d) equal recognition before the law, and e) protection from exploitation, violence, and neglect. Further advancing this agenda, the EU Disability Strategy 2010-2020: A Barrier-Free Europe aims to eliminate structural barriers to full social participation and emphasises the need for inclusive emergency preparedness frameworks that address the specific needs of persons with disabilities.

Inclusion is not merely a recommendation—it is a fundamental human right. Ensuring all individuals have equal access to safety measures, emergency response services, and legal protections is essential for reducing overall disaster risk (Cvetković & Janković, 2020; Cvetkovic & Martinović, 2020; Ivanov, 2024; Kaur & Singh, 2024; Mano, A, & Rapaport, 2019; Marceta & Jurišic, 2024; Milenković, Cvetković, & Renner, 2024; Molnár, 2024; Ogunleye & Arohunsoro, 2024; Perić & Vladimir, 2019; Vidović, Cvetković, & Beriša, 2024).

Structural barriers that exclude persons with disabilities from disaster risk reduction (DRR) strategies must be systematically addressed to foster a more resilient and adaptive society. A resilient community ensures that no individual is left behind, empowering persons with disabilities by recognising their specific needs, unique perspectives, and valuable contributions. By encouraging active participation in disaster risk management, societies can create more robust preparedness frameworks, reducing vulnerability and enhancing overall disaster resilience.

This study aims to provide a structured analysis of the challenges and opportunities for persons with disabilities (PWDs) in disaster risk management. Specifically, it seeks to: a) analyse the barriers PWDs encounter across different phases of disaster management, including preparedness, response, and recovery; b) assess existing legal frameworks at the international, European, and national levels concerning disability-inclusive disaster response; c) identify best practices and inclusive strategies that have been successfully implemented in disaster risk reduction; d) offer practical recommendations to enhance disaster preparedness and response for PWDs. To achieve these objectives, the study addresses the following key research questions:

1. What are the primary obstacles that PWDs encounter during disaster situations?
2. How effective are current policies and legal frameworks in protecting PWDs during disasters?
3. What best practices exist for ensuring inclusive disaster preparedness and response?
4. How can governments, emergency responders, and local communities strengthen disaster resilience for PWDs?

By examining these crucial areas, the study seeks to bridge the gap between policy and practice, ultimately promoting a more inclusive approach to disaster management.

2. Methods

This study adopts a systematic review approach to analyse existing literature, policies, and case studies on disaster risk management for persons with disabilities (Figure 1). The primary objective is to synthesise academic, institutional, and policy findings and identify key challenges, policy gaps, and best practices to ensure inclusive disaster preparedness, response, and recovery.

2.1. Data Collection and Sources

This study draws on multiple academic and institutional sources to establish a comprehensive and high-quality evidence base. The data collection process involved several key components. First, academic databases such as Google Scholar, Scopus, Web of Science, and ResearchGate were utilised to gather peer-reviewed research articles. Second, institutional reports and policy documents were analysed, including publications from organisations like the United Nations Office for Disaster Risk Reduction (UNDRR), the World Health Organization (WHO), the Federal Emergency Management Agency (FEMA), the European Commission, and the International Federation of Red Cross and Red Crescent Societies (IFRC). Additionally, government reports and national legislation concerning disaster risk management were examined, with a specific focus on national strategies aligned with the Sendai Framework for Disaster Risk Reduction and the UN Convention on the Rights of Persons with Disabilities (UNCRPD). Finally, case study documentation provided insight into real-world disaster responses affecting persons with disabilities, highlighting practical interventions and lessons learned. This multi-faceted approach ensures a well-rounded perspective on disaster risk management and disability inclusion.

2.2. Inclusion and Exclusion Criteria

Literature and reports were selected based on specific inclusion criteria to ensure relevance and quality. The studies needed to directly address disaster preparedness, response, or recovery for individuals with disabilities. The research included peer-reviewed journal articles, governmental and intergovernmental reports, case studies documenting best practices and failures in inclusive disaster management, as well as legal and policy documents related to disability rights and disaster risk reduction. At the same time, specific sources were excluded: a) studies focusing on general disaster response without considering disability inclusion were not included. b) outdated literature, non-peer-reviewed studies, or sources lacking empirical evidence were excluded. c) opinion pieces or commentaries without substantial data or analytical depth were not considered relevant for this study.

2.3. Data Analysis and Thematic Framework

A qualitative content analysis was employed to identify key themes related to barriers, policy responses, and best practices in disaster management for persons with disabilities (Figure 2). The thematic framework for this study was based on several critical international instruments. The first is the Sendai Framework for Disaster Risk Reduction (2015–2030), which serves as a global strategy for reducing disaster risk, emphasising inclusion and resilience-building. The second is the Convention on the Rights of Persons with Disabilities (CRPD), the primary international treaty that ensures equal rights and protection for persons with disabilities. Furthermore, the study conducted a comparative analysis of international and national disaster response frameworks to assess how different countries implement disability-inclusive strategies in disaster risk reduction. Best practices and case studies were reviewed to examine successful and failed approaches to inclusive disaster response across diverse contexts. The data were analysed by identifying recurring themes, patterns, and gaps in the existing literature. Findings were cross-referenced across multiple sources to ensure accuracy and consistency, allowing for a comprehensive understanding of the intersection between disaster risk management and disability inclusion.

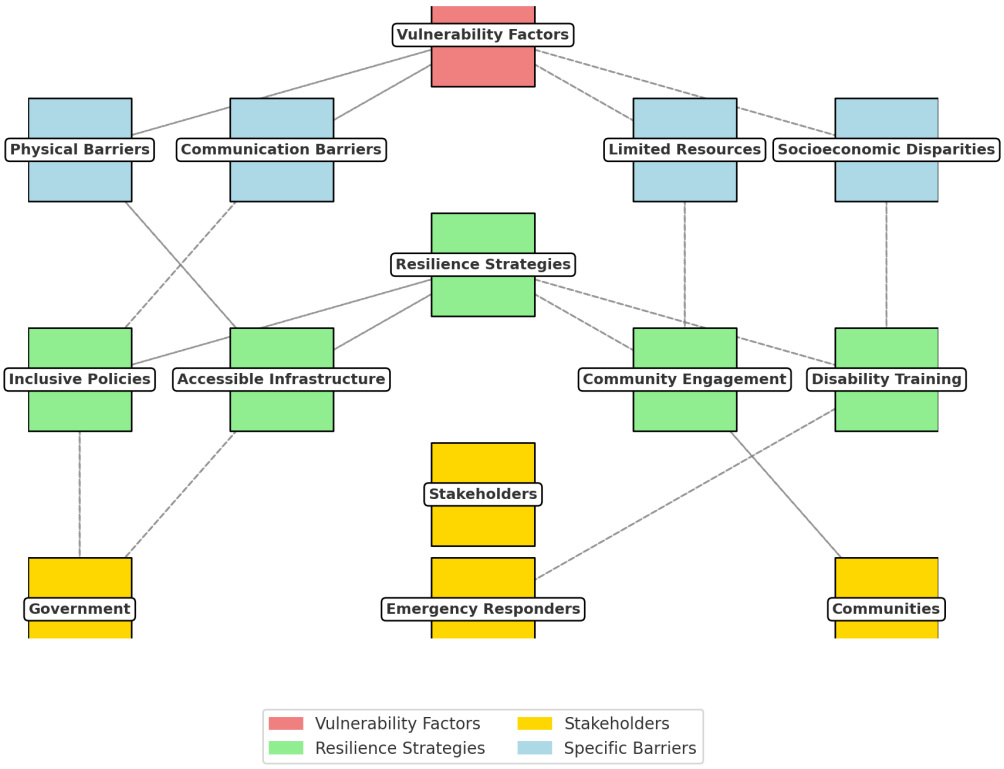

Figure 2. Framework for Inclusive Disaster Risk Management.

2.4. Limitations of the Study

While this study provides a broad and systematic analysis of disability-inclusive disaster management, it has several limitations. First, it primarily relies on secondary data, meaning that it does not include primary surveys or interviews with persons with disabilities or disaster management practitioners. Second, there are gaps in regional coverage, as research and documentation on this topic remain limited in some geographic regions, particularly in developing nations. Third, variations in policy implementation present a challenge, as many reports outline policies and legal frameworks but lack standardised evaluation metrics to assess how effectively these measures are implemented in practice. Despite these limitations, this study establishes a critical foundation for understanding the intersection of disaster risk management and disability rights. The findings contribute to ongoing discussions on policy development and offer insights for future research to strengthen inclusive disaster preparedness and response.

3. Persons with Disabilities: Definitions, Rights, and Challenges in Disaster Contexts

Various terms are used to define and categorise persons with disabilities, including handicap, impairment, and disability. These terms, although frequently used interchangeably, carry different connotations. Persons with disabilities are individuals with long-term physical, sensory, mental, or intellectual impairments that may impact their daily lives but can often be mitigated through rehabilitation and specialised support within healthcare institutions (Finkelstein & Finkelstein, 2020). They have often been referred to as individuals with special needs. However, this terminology is increasingly seen as discriminatory in contemporary discourse, implying that they require different or additional accommodations beyond fundamental human rights. The prevailing perspective emphasises that persons with disabilities deserve equal rights and opportunities, just like any other individual. Therefore, "persons with disabilities" is widely regarded as the most appropriate and respectful way to refer to this demographic (Rajić, 2016).

Persons with disabilities constitute a diverse and integral part of society, encompassing individuals with various physical, cognitive, and sensory challenges that may affect their participation in everyday activities and community life. They deserve equal access to all spheres of life, ensuring they are not excluded from social, economic, or political engagement. Some of the most critical aspects related to their inclusion and well-being in society include:

a) Accessibility—A fundamental prerequisite for full participation in social, economic, and political life, accessibility ensures that individuals with disabilities can navigate public spaces, transportation, and digital platforms without barriers.

b) Healthcare and rehabilitation support—Access to specialised medical care, physical therapy, and mental health services is crucial for enhancing their well-being and independence.

c) Education and vocational training—Ensuring that individuals with disabilities have equal access to education and skill development is essential for their social and professional integration.

d) Legal protection and advocacy—Strong legal frameworks are necessary to combat discrimination, enforce equal rights, and guarantee access to justice for persons with disabilities.

e) Emotional and social support – A strong support system from family, friends, and the wider community is invaluable, complemented by professional psychosocial assistance to address emotional well-being (Finkelstein & Finkelstein, 2020, p. 62).

Recognising the unique needs of persons with disabilities is critical for fostering an inclusive and equitable society. Efforts to remove societal barriers and ensure that their rights are upheld play a vital role in promoting social progress and strengthening communities as a whole. Beyond everyday challenges, however, the position of persons with disabilities in disaster situations demands particular attention. Due to physical, cognitive, and environmental constraints, they are disproportionately vulnerable when disasters strike. Their limited mobility, dependency on medical care, or need for specialised assistance can significantly hinder their ability to respond to emergencies (Rajić, 2016).

To address these challenges, specific strategies must be implemented to ensure the safety and well-being of persons with disabilities in crises. Some of the key areas of focus include:

a) Accessible evacuation and emergency response—Many individuals with disabilities face difficulties evacuating during disasters. Ensuring accessible evacuation routes, emergency assistive technologies, and immediate healthcare services is essential for their safety.

b) Specialized healthcare considerations—People with disabilities often have critical healthcare needs, including continuous medication, mobility aids, and specialised treatment, all of which must be factored into disaster preparedness plans.

c) Effective communication and information dissemination—Individuals with sensory impairments may struggle to receive and process vital emergency warnings. To ensure that they receive timely and accurate information, it is crucial to implement inclusive communication systems, such as visual alerts, sign language interpreters, and text-based updates, to facilitate effective communication.

d) Psychosocial support and mental health care – Disasters can be particularly distressing for persons with disabilities, potentially exacerbating pre-existing psychological conditions. Mental health counselling, emotional support networks, and post-trauma care are essential for their well-being.

e) Adapted shelters and post-disaster services—Emergency shelters and relief services must cater to the specific needs of persons with disabilities, ensuring they have access to accessible accommodations, assistive devices, and essential support services (Finkelstein & Finkelstein, 2020, p. 64).

Building an inclusive and resilient disaster response system is not just a matter of policy—it is a fundamental human rights issue. Societies must recognise the vulnerabilities faced by persons with disabilities and implement comprehensive strategies to reduce risks, enhance accessibility, and provide the necessary resources during and after disasters. By ensuring that no one is left behind, disaster risk reduction efforts can become more effective, equitable, and sustainable in the long run.

Disasters frequently have a disproportionately severe impact on individuals with disabilities, as intersecting social factors, such as gender, age, and socioeconomic status, further compound their challenges. Key considerations include: a) women with disabilities − they experience a heightened risk of gender-based violence in disaster shelters and are often left out of economic recovery efforts; children with disabilities − these individuals are often neglected in disaster preparedness strategies, resulting in increased mortality rates during emergencies; c) elderly with disabilities − this group typically needs specific medical care and assistive devices, which may be limited or inaccessible in post-disaster settings. Policies must adopt an intersectional approach that considers these overlapping vulnerabilities to ensure an equitable and effective disaster response.

4. Types of Disabilities and Corresponding Needs: Ensuring Inclusion and Support

Persons with disabilities represent a broad and diverse category of individuals with varying impairments and health conditions, making them an inclusive social group (Vlašković, 2016). As previously mentioned, the term "disability" is often used differently across societies, leading to discrepancies in public discourse and interpretation (Raja & Narasimhan, 2013). In France, for example, the term handicap is commonly used, emphasising limitations, inequality, and subordination to others. The Convention on the Rights of Persons with Disabilities defines persons with disabilities as individuals with long-term physical, mental, intellectual, or sensory impairments that, when combined with various barriers, may hinder their full and equal participation in society (Radulović, 2022). Globally, it is estimated that persons with disabilities make up approximately 10% of the population, with the majority being women (Marković, 2014).

One of the most significant challenges in meeting the needs of persons with disabilities, particularly in disaster situations, is the lack of accurate data regarding their presence, location, and specific requirements. First responders and authorities often lack sufficient information about how many individuals with disabilities have been affected and where they may be located. This data gap has

been highlighted as a significant issue in disaster response, as many persons with disabilities remain hidden within their communities, making it challenging to identify and assist them effectively. However, advancements in information systems and disaster response protocols have improved registration processes in recent years, increasing the likelihood that individuals with disabilities receive timely emergency assistance and essential services. In today's digital society, people rely heavily on various communication channels to access information about disaster preparedness and ongoing crises. However, when persons with disabilities lack access to these resources, they face a heightened risk, not only to their safety but also to that of their families and surrounding communities (Raja & Narasimhan, 2013).

The causes of disability vary significantly and can be categorised as genetic, congenital, or acquired. Some individuals are born with disabilities, while others develop them later in life due to war-related injuries, accidents, illnesses, or ageing (Jovanović, 2015). Understanding the nature of disability is essential for ensuring appropriate support systems and intervention strategies.

Disabilities can be broadly classified into several categories. Physical disabilities can affect mobility and often require the use of assistive devices, such as wheelchairs. Sensory disabilities affect vision and hearing, necessitating specialised communication and accessibility tools. Cognitive and learning disabilities include developmental conditions such as intellectual disabilities and autism (Jovanović, 2015a, p. 43).

Beyond these primary classifications, many individuals experience multiple or combined disabilities. For instance, persons with physical impairments may also have neuromuscular disorders, paraplegia, quadriplegia, muscular dystrophy, or cerebral palsy. The degree of assistance required varies based on the individual's level of independence. Despite these variations, a fundamental principle remains: persons with disabilities are human beings with the same inherent rights and needs as everyone else (Raja & Narasimhan, 2013).

Additional categorisations of disabilities include arthritis, autism, cerebral palsy, Down syndrome, poliomyelitis, dyslexia, muscular dystrophy, mental impairments, multiple sclerosis, spinal cord, hearing, and vision impairments, and Rett syndrome (Stojanović, 2015).

Moreover, disabilities can also be classified based on their broader impact on an individual's life. Mental or psychological disabilities encompass individuals with intellectual impairments, recurrent psychological disorders, or various mental health conditions. These individuals may require psychological support, therapy, educational programs, and legal protection against discrimination. Chronic health conditions affect individuals with long-term medical conditions, necessitating specialised medical care, continuous medication, and health programs to support their overall well-being. Developmental disabilities include conditions such as autism and Down syndrome, requiring specialised education, therapy for skill development, and social integration programs (Stojanović, 2015).

Each type of disability presents unique challenges and needs, necessitating tailored approaches to ensure individuals can participate fully and independently in society. Governments, institutions, and communities must work collectively to provide adequate support systems, ensuring that persons with disabilities have equal access to education, healthcare, employment, and emergency assistance. By fostering a society that removes barriers and promotes inclusion, individuals with disabilities can achieve greater independence and make meaningful contributions to their communities.

5. Capacities and Strengths of Persons with Disabilities

Adopting the Sendai Framework marked a significant step forward in global efforts to improve accessibility and inclusion for persons with disabilities. Many countries have since updated their national laws to align with the UN Convention on the Rights of Persons with Disabilities, aiming to create better living conditions and stronger protections. Despite these advancements, persons with disabilities continue to face fundamental challenges, including difficulties in accessing buildings, using public spaces, and obtaining necessary resources. In disaster situations, their vulnerability is further exacerbated, particularly during emergency evacuations where transportation remains a significant obstacle (Maksimović et al., 2020).

To enhance disaster preparedness and response, it is essential to develop the capacities and strengths of persons with disabilities. Key focus areas include establishing a stable communication platform that enables risk awareness and ensures their involvement in discussions on shelter management, training programs, and decision-making processes. Additionally, efforts should be made to assist persons with disabilities in understanding disaster risk maps and emergency planning strategies. Further, mechanisms should be developed to support post-disaster recovery, including lessons learned from past experiences, medical and resource planning, and employment opportunities following disasters (Maksimović et al., 2020, p. 56).

The capacities and strengths of persons with disabilities encompass a wide range of skills, abilities, and resources that enable them to live independently, participate in society, and respond effectively to challenges, including disasters. In the context of emergency preparedness, their adaptability to new environments plays a crucial role, as many individuals with disabilities have experience adjusting to different living conditions. This ability to adapt quickly can be highly beneficial in disaster scenarios requiring immediate action. Their capacity for empathy and teamwork is another strength, as many persons with disabilities develop a strong sense of cooperation and community engagement, which is vital for collective disaster response efforts.

Furthermore, some persons with disabilities possess specific expertise and experience in areas critical to disaster response, such as rehabilitation, specialised medical care, or psychological support. Their firsthand knowledge of their challenges is invaluable in designing effective protection and assistance plans. Recognising and utilising these strengths is crucial for developing inclusive disaster response strategies that incorporate the perspectives of individuals with disabilities (Stojanović, 2015).

Many individuals with disabilities develop a high degree of resilience and independence in overcoming daily challenges, including those posed by disasters. Society and institutions must acknowledge and leverage these capacities to support persons with disabilities during emergencies. By incorporating their skills and experiences into disaster preparedness and response plans, communities can enhance their overall resilience and ensure a more inclusive approach to disaster management.

6. Protection of Persons with Disabilities in International and European Legal Frameworks

The international legal framework for protecting persons with disabilities is rooted in fundamental human rights principles. One of the most significant documents in this regard is the Universal Declaration of Human Rights, which laid the foundation for the right to social security and established a basis for the further development of disability rights protection. This declaration ensures that all individuals, including persons with disabilities, have access to essential social provisions, such as healthcare, food, clothing, and housing, as well as the right to insurance in cases of disasters, unemployment, and other crises. Furthermore, it guarantees their right to a dignified life and equal opportunities for social participation (Stojanović, 2017a).

In addition to the Universal Declaration, another crucial legal instrument is Convention No. 102 on Social Security, one of the most important conventions of the International Labour Organization (ILO). This convention explicitly recognises persons with disabilities and ensures they receive appropriate social protection in the event of accidents or occupational illnesses (Stojanović, 2017). Furthermore, ILO Convention No. 159 on Vocational Rehabilitation and Employment of Persons with Disabilities establishes international labour standards that mandate equal employment rights for persons with disabilities. Under this convention, employers are required to provide reasonable workplace accommodations and ensure that individuals with disabilities have equal access to professional opportunities. Additionally, the United Nations Standard Rules on the Equalisation of Opportunities for Persons with Disabilities further reinforce the equal treatment and protection of this demographic (Stojanović, 2017).

In the Republic of Serbia, these legal instruments have been incorporated into national legislation, signifying a significant step forward in advancing disability rights. The UN Convention on the Rights of Persons with Disabilities (CRPD) is critical in promoting, protecting, and ensuring the full enjoyment of human rights by persons with disabilities. The convention recognises that individuals with disabilities face long-term physical impairments that may hinder their effective participation in society. Furthermore, it emphasises their right to employment and professional development, ensuring they are not excluded from the labour market and have opportunities for career advancement (Stojanović, 2017).

6.1. Key European and International Disability Rights Instruments

Within the European legal system, the European Social Charter stands as one of the most influential legal instruments concerning social rights. This charter has been key in expanding social protection measures across Europe. The signatory states of the charter have committed to incorporating its principles into their national legal frameworks, thereby ensuring the protection of all citizens' fundamental social and economic rights, including persons with disabilities (Ministry of Labour and Social Policy, 2008).

A significant revision of the European Social Charter, known as the Revised European Social Charter, significantly enhanced the recognition of the rights of persons with disabilities. This updated version acknowledges the necessity of addressing barriers to career choice and professional advancement, obligating signatory countries to establish or promote vocational guidance, education, and training services that support persons with disabilities in accessing employment and career development (Tatić & Kotević, 2010).

Several key European Union regulations have also contributed to advancing the rights of people with disabilities. Among them, Regulation 883/2004 and Regulation 987/2009 are crucial, as they establish mechanisms for the portability of social security rights across EU member states. The first regulation defines and harmonises the application of social security systems for individuals moving within the European Union, ensuring that their rights are protected across borders. Additionally, it replaces earlier bilateral social security agreements between states with a unified legal framework. The second regulation outlines procedures for implementing national legislation on social security for migrant workers and their families, ensuring that they retain their rights regardless of their country of employment (Stojanović, 2017).

Several fundamental European legal documents have played a crucial role in shaping disability rights policies. The European Convention on Human Rights (ECHR) and Protocol No. 12 (2000) represent two of the most significant legal instruments. The ECHR explicitly prohibits discrimination against persons with disabilities, while Protocol No. 12 extends anti-discrimination protections to all rights guaranteed under national laws (Tatić & Kotević, 2010).

The European Disability Action Plan (2006-2015) and the Council of Europe Disability Strategy (2017-2023) have provided frameworks for achieving equality, dignity, and inclusion for persons with disabilities. The Council of Europe's strategy outlines five priority areas (Maksimović et al., 2020, p. 34): a) equality and non-discrimination; b) awareness-raising; c) accessibility; d) equal recognition before the law, and e) freedom from exploitation, abuse, and neglect.

The United Nations (UN) has played a pivotal role in advancing disability rights at the international level. The UN has been instrumental in ensuring equal treatment for persons with disabilities by promoting policies that guarantee their full enjoyment of rights and freedoms. One of the key mandates of the UN is to improve the social and economic conditions of persons with disabilities while ensuring their access to healthcare services provided by all medical professionals. The UN Convention on the Rights of Persons with Disabilities conveys that persons with disabilities must be granted equal employment opportunities within the open labour market.

In addition to the UN's efforts, the Revised European Social Charter has significantly contributed to eliminating employment discrimination against persons with disabilities. Moreover, the Interna-

tional Labour Organisation (ILO) has introduced important measures to improve the employment conditions and labour rights of this group (Rajić, 2016).

6.2. National Strategies for the Advancement of Disability Rights

Serbia has also adopted a long-term strategy to improve the social inclusion and quality of life of persons with disabilities. This strategic framework encompasses a comprehensive plan to address systemic barriers and strengthen the institutional response to their needs. A key aspect of this strategy is introducing a social model of individual needs assessment, ensuring services are tailored to each person's specific requirements.

The strategy is built around several core objectives: a) developing quality standards for social, healthcare, and other essential services while providing programmatic and methodological support for their implementation; b) ensuring accessibility of social, healthcare, and other services within local communities, with a strong focus on deinstitutionalisation and integration into society; c) enhancing service accessibility in terms of architecture, organisational structure, and program design, including mobile service units and flexible working hours to accommodate diverse needs; d) establishing mechanisms for service provision plurality, involving government institutions, agencies, civil society organisations, and private sector actors (Dinkić et al., 2008, p. 36).

The overarching goal of this strategy for the 2020-2024 period is to improve the overall social status of persons with disabilities and ensure their equal participation in society. This is to be achieved through eliminating accessibility barriers, enhancing social participation, ensuring employment opportunities, improving education and training, and strengthening social protection and healthcare systems. These measures collectively contribute to achieving inclusive equality by levelling the opportunities available to persons with disabilities.

7. Persons with Disabilities and the Disaster Management Process

Adopting the Sendai Framework for Disaster Risk Reduction (2015-2030) marked a significant global shift in the approach to disability-inclusive disaster risk reduction. Following its implementation, many countries initiated legal reforms to align their national legislation with the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD), creating a more inclusive environment for disaster preparedness and response.

Persons with disabilities face numerous challenges across all phases of emergencies. One significant obstacle is architectural inaccessibility, including buildings with stairs, manually operated doors, and inadequate evacuation routes, all of which hinder their ability to exit safely during emergencies. Other challenges include limited social networks and family support, inaccessible shelters and emergency warnings, loss or damage to assistive devices such as wheelchairs, and difficulties accessing essential resources (Christensen et al., 2007).

Research has shown that higher vulnerability and mortality rates among persons with disabilities during disasters correlate with low socio-economic status, residence in high-risk areas, lack of pre-disaster response plans, and reluctance to evacuate due to mobility challenges, limited availability of caregivers, and restricted access to transportation (Lee & Chen, 2019, p. 48).

Transportation remains one of the biggest challenges for persons with disabilities during evacuations in disaster scenarios. Various public resources and equity-based transportation strategies have been developed to address this, including disability-inclusive transport networks, vehicle-sharing programs, and accessible housing initiatives. These efforts aim to improve mobility and ensure fair access to emergency services.

However, to further enhance disaster preparedness and response, experts recommend additional measures, such as: a) establishing a stable platform for risk communication, ensuring that persons with disabilities are actively included in disaster preparedness discussions and evacuation planning;

b) assisting in understanding disaster risk maps and emergency protocols; c) developing mechanisms and strategies for post-disaster recovery, including learning from past experiences, resource planning, medical assistance, and employment opportunities for persons with disabilities (Stojanović, 2022).

The COVID-19 pandemic further exacerbated existing social isolation among persons with disabilities. Beyond the physical distancing measures, the pandemic led to the closure of essential support services, including disability assistance centres and daycare programs (Tatić, 2022).

As a result, persons with disabilities faced heightened levels of anxiety and uncertainty, particularly those with developmental disorders, who were disproportionately affected by disruptions in routine care and support networks. In Serbia, epidemiological measures were implemented without consulting representatives of disability rights organisations, further marginalising this vulnerable group. Rather than being treated as a humanitarian priority, the challenges faced by persons with disabilities were often politicised, and essential support services were withdrawn during the pandemic (Tatić, 2022).

During the pandemic, there was a missed opportunity to develop long-term solutions to mitigate the disproportionate impact on persons with disabilities. A registry of individuals needing specialised support could have enabled targeted assistance for those most at risk. Additionally, families of persons with disabilities bore the most significant burden, as they were forced to fill the gaps left by the withdrawal of healthcare and social services, often at the expense of their jobs and livelihoods. Consequently, this increased unemployment and financial hardship for caregivers and families (Vujičić, 2020).

No disability-specific financial assistance programs were introduced during the pandemic economic relief measures. While persons with disabilities received the same one-time financial aid as other Serbian citizens, they lacked continuous support services, targeted financial aid, and adequate social and healthcare protections—their greatest needs at the time (Radulović, 2022).

In Serbia, various protective measures and assistance programs are in place to support persons with disabilities affected by disasters. These include:

a) Disaster Preparedness and Training—People with disabilities are often more vulnerable during disasters due to limited mobility, communication barriers, or a lack of access to emergency information. Increasing their preparedness through specialised training is crucial.

b) Accessible evacuation and rescue procedures—Evacuation plans must be tailored to the needs of individuals with various types of disabilities, including those who use wheelchairs, those with hearing or vision impairments, and those with cognitive disabilities.

c) Adapted post-disaster accommodation – After a disaster, it is essential to provide accessible and disability-friendly shelters equipped with assistive devices and specialised healthcare services.

d) Psychosocial support – Many persons with disabilities are at higher risk of psychological distress following disasters. Access to mental health services, counselling, and emotional support networks is critical.

e) Legal protection – It is essential to ensure that the rights of persons with disabilities are upheld even in the aftermath of disasters, preventing discrimination in access to aid, resources, and healthcare services.

f) Collaboration between government agencies, humanitarian organisations, and local communities – A coordinated effort is necessary to ensure that emergency response services adequately address the specific needs of persons with disabilities (Vujičić, 2020).

7. The Role of Persons with Disabilities in Disaster Risk Prevention

The international approach to disaster risk prevention has increasingly emphasised inclusivity and accessibility for persons with disabilities. The United Nations Sendai Framework for Disaster Risk Reduction (2015-2030) explicitly recognises the need for disability-inclusive disaster risk management, calling for equal participation of persons with disabilities in policy development and

decision-making. International frameworks such as the United Nations Convention on the Rights of Persons with Disabilities (UNCRPD) also mandate that disaster risk reduction measures must be accessible and responsive to the needs of persons with disabilities, ensuring their safety, resilience, and active involvement in all phases of disaster preparedness.

Several global initiatives have reinforced these commitments, including the Sustainable Development Goals (SDGs), which stress the importance of reducing inequalities (Goal 10), building inclusive and sustainable cities (Goal 11), and strengthening resilience to climate-related disasters and other emergencies (Goal 13). The International Strategy for Disaster Reduction (ISDR), led by the United Nations Office for Disaster Risk Reduction (UNDRR), also emphasises the importance of accessible warning systems, inclusive evacuation plans, and adaptive recovery strategies that take into account the specific needs of persons with disabilities.

The legal framework for protecting and including persons with disabilities has undergone significant evolution in recent years through various legislative measures and policies. At the constitutional level, the Constitution of the Republic of Serbia (RS) serves as the highest legal act, guaranteeing fundamental human rights, dignity, freedoms, and equality for all citizens. It explicitly prohibits all forms of discrimination and ensures the protection of national minorities, promoting equal opportunities for all. Furthermore, the Constitution provides enhanced healthcare and social protection for vulnerable groups, as reflected in a series of legislative acts across various sectors (Christensen et al., 2007).

A key recommendation in disaster risk reduction is the active participation of persons with disabilities in developing and implementing policies and response plans. This principle extends to women, children, and other marginalised groups, ensuring that the entire community is empowered and that discrimination is eradicated. Special attention must be given to individuals who are disproportionately affected by disasters, particularly the most impoverished members of society.

For disaster risk prevention strategies to be effective, they must incorporate a multidimensional and inclusive approach that acknowledges the needs of individuals with disabilities. Decision-making processes should be data-driven, based on open information exchange and risk analysis, including disability-specific data, to ensure effective policy design and implementation (Maksimović et al., 2020).

Continuous investment in disaster risk reduction is essential for strengthening local resilience, particularly for citizens with health conditions and chronic illnesses who may have additional needs during emergencies. A critical priority is enhancing disaster preparedness efforts during the reconstruction and recovery phases, ensuring that infrastructure and support systems are designed to accommodate persons with disabilities.

A significant aspect of disaster prevention involves empowering women and persons with disabilities to assume leadership roles in promoting gender equality and inclusive disaster response strategies. Achieving this requires strengthening multi-hazard early warning systems, which must be population-centered and focused on risk forecasting, emergency communication mechanisms, and accessible warning strategies (Maksimović et al., 2020).

Disaster prevention systems should be designed to address the diverse needs of all individuals, including their social and cultural requirements, with a particular emphasis on equality and accessibility. International frameworks underscore the crucial role of civil society organisations, emphasising the active participation of persons with disabilities and other vulnerable groups in disaster risk management processes.

Moreover, persons with disabilities and their representative organisations play a crucial role in risk assessment and the design of emergency plans that cater to their specific needs and challenges. Their participation ensures that disaster preparedness measures are practical, effective, and tailored to diverse requirements (Maksimović et al., 2020, p. 24). For disaster risk reduction efforts to be fully inclusive and practical, it is crucial to integrate persons with disabilities into policy-making and emergency preparedness planning. This includes data-driven decision-making, accessible warning systems, and investments in community resilience. By ensuring that all members of society—especially those with disabilities—have equal opportunities to contribute to and benefit from risk reduction strategies, nations can build safer, more inclusive, and resilient communities in the face of future disasters.

8. Preparedness, Emergency Response, and Recovery: Ensuring the Inclusion of Persons with Disabilities in Disaster Management

Disaster preparedness is a crucial aspect of risk reduction, and training programs must incorporate specialised knowledge and skills to assist persons with disabilities, who are among the most vulnerable during emergencies. Preparedness measures should address all aspects of communication and evacuation procedures, ensuring that persons with disabilities are fully informed and trained in disaster response.

A key component of preparedness is the organization of evacuation drills and simulations, which should be conducted in accessible environments, including special education institutions, daycare centres for children with developmental disabilities, residential homes, and other facilities tailored to their needs. In addition to hands-on training, guidelines and instructional materials should be developed, adapted, and translated into multiple accessible formats to ensure all persons with disabilities can understand and use them. These formats include: a) printed materials in Serbian and braille for visually impaired individuals; b) audio guides for those with visual impairments; and c) simplified, easy-to-understand content for children and adults with autism and cognitive disabilities.

It is also critical to ensure that these instructional materials are disseminated to vulnerable and at-risk populations in advance, increasing their preparedness (Dimitrijević, 2016).

At the local level, authorities should establish a registry of organizations and associations that assist persons with disabilities, detailing contacts for emergency response and disaster planning. This registry would enable better coordination in disaster response and ensure that persons with disabilities receive timely and appropriate assistance (Maksimović et al., 2020, p. 123).

Furthermore, emergency alert systems must be accessible, aligning with the Convention on the Rights of Persons with Disabilities (CRPD). Unfortunately, traditional alert systems primarily rely on auditory signals, which are ineffective for persons with hearing impairments. To address this, multi-modal early warning systems should be developed, incorporating: a) visual alerts, such as flashing lights and digital signage; b) tactile alerts, including vibration-based notifications; c) audio-visual combinations, tested in collaboration with representatives from disability organizations to ensure effectiveness. since no universal alert system can fully accommodate the needs of all populations, a combination of different warning methods should be utilized for maximum inclusivity (Maksimović et al., 2020).

During and after disasters, persons with disabilities face a higher risk of injury and death due to barriers in evacuation and response efforts. In emergencies, the lack of timely and accessible assistance significantly increases their vulnerability. Therefore, it is crucial to a) ensure clear, accessible communication with persons with disabilities, b) provide evacuation instructions in formats they can understand, and c) develop specialized emergency response protocols for their safe relocation and care (Ružičić-Novković, 2014).

Authorities responsible for disaster response and evacuation must maintain continuous communication with persons with disabilities, ensuring that their specific needs are addressed. Additionally, emergency plans must include assistive devices and mobility aids required for effective evacuation.

After evacuation, temporary shelters must be adapted to the needs of persons with disabilities. Rather than placing individuals in general collective shelters, authorities should prioritise accommodating them in specialised facilities that adhere to accessibility standards, which include: a) barrier-free entrances, b) accessible restrooms, c) functional lifts, and d) provisions for personal care assistants and medical support. The physical accessibility of emergency shelters is critical, ensuring that persons with disabilities are not placed in facilities that fail to meet their basic needs (Maksimović et al., 2020).

The post-disaster recovery phase is one of the least studied aspects of disaster management, particularly about persons with disabilities. Media coverage often focuses on immediate emergency responses, while long-term recovery efforts are often overlooked. However, governmental agencies

play a crucial role in collecting data on available resources, assessing damage, and initiating reconstruction efforts to facilitate rapid recovery for affected populations.

Recovery efforts must prioritize restoring the well-being of affected persons, including those with disabilities, by implementing both short-term and long-term measures. The extent and duration of recovery depend on the severity of the disaster and the level of disruption to communities.

The initial disaster response phase, including search and rescue operations, typically lasts a few days. After this period, affected populations receive medical aid, food, shelter, clothing, and other essential supplies. For individuals with disabilities, it is essential to provide more rehabilitation centres and assistive devices to restore their mobility and independence (Jurešić et al., 2015). After the initial relief phase, recovery transitions into long-term rehabilitation, which aims to: a) repair damaged infrastructure, b) replace destroyed assets, c) rebuild affected communities, and d) enhance disaster resilience and preparedness for future crises.

Recovery can take several months or even years, and a key objective is to enhance community resilience rather than merely restore pre-disaster conditions (Maksimović et al., 2020). Access to information and decision-making platforms remains one of the most significant challenges for persons with disabilities in the recovery phase. Many individuals are excluded from critical discussions and lack access to information about available services, resulting in increased social isolation.

To address this, key measures should be implemented to ensure that persons with disabilities are actively involved in recovery and risk communication efforts: a) prioritizing the needs of children and persons with disabilities in all disaster communication strategies; b) adapting communication materials to suit different disabilities, including braille, large print, and easy-to-read formats; c) providing accessible information on psychosocial support services for persons with disabilities; d) advocating for workplace policies that support families caring for persons with disabilities; e) expanding counselling services for disaster-affected individuals; f) considering gender-based and marginalized community needs in recovery efforts; g) facilitating direct feedback mechanisms for persons with disabilities to share their experiences and concerns; h) ensuring information is presented in a simple, clear, and accessible format; i) using multiple communication methods, including sign language interpreters, visual aids, and accessible websites; j) actively involving disability organizations in disaster recovery decision-making (Latinović et al., 2022).

Once the immediate disaster response efforts subside, affected communities strive to return to normalcy, including resettlement, rebuilding homes, and restoring infrastructure. In cases of severe disasters (e.g., earthquakes), this process can take months or even years to complete. Long-term reconstruction efforts must focus on a) ensuring that rebuilt infrastructure is accessible to everyone, b) implementing policies that enhance community resilience, and c) addressing the vulnerabilities of individuals with disabilities in future disaster planning.

Local governments and disaster management agencies must utilise lessons learned from past disasters to refine response strategies, enhance accessibility, and foster a more inclusive society. The ultimate goal should be to rebuild and create more resilient, accessible, and inclusive communities (Raja & Narasimhan, 2013).

9. Barriers and Solutions for Persons with Disabilities in Disaster Situations

Table 1 presents a comprehensive analysis of the challenges faced by individuals with disabilities during disasters, along with actionable solutions to enhance their safety, accessibility, and inclusion in disaster risk management. It also outlines estimated implementation timelines, feasibility considerations, potential obstacles, and additional measures to enhance disaster preparedness, response, and recovery. By incorporating these strategies, emergency management systems can become more inclusive and resilient, aligning with international standards such as the Sendai Framework for Disaster Risk Reduction and the UN Convention on the Rights of Persons with Disabilities (UNCRPD).

To bridge the gap between policy and practice, several actionable recommendations should be implemented to ensure equal access to disaster preparedness, response, and recovery efforts for

people with disabilities. One crucial aspect involves government initiatives. Strengthening the legal enforcement of accessibility standards in disaster risk management is essential. Additionally, establishing national disability registries can help emergency responders identify at-risk populations more effectively. Furthermore, providing funding for inclusive disaster preparedness programmes will enhance accessibility and readiness at all levels.

Emergency responders and disaster agencies also play a crucial role in this effort. To ensure they can effectively assist individuals with disabilities, mandatory disability-inclusive training for all emergency personnel must be conducted. Moreover, developing multi-modal emergency alert systems—incorporating visual, text, and audio formats—will guarantee that emergency warnings reach everyone. Ensuring accessible evacuation centres and transportation services is another vital measure to support persons with disabilities during disasters.

At the community level, encouraging the active participation of persons with disabilities in disaster planning committees is essential. Organising disaster simulation drills that include persons with disabilities will help to identify and address potential barriers in emergency response plans. Additionally, distributing accessible emergency guides in Braille, large print, and easy-to-read formats will enhance the availability of crucial information for all individuals.

Implementing these recommendations can make disaster risk management efforts more inclusive, ensuring that persons with disabilities receive the necessary support and resources before, during, and after emergencies.

Table 1. Addressing Challenges in Disability-Inclusive Disaster Management

Barrier	Proposed solution	Implementation timeframe	Feasibility	Constraints/challenges	Additional implementation strategies
Limited accessibility of emergency shelters	Construct shelters with wheelchair access, ramps, and Braille signs.	Short-Term	High	High cost of retrofitting existing shelters	Incentivize the construction of new accessible shelters
Lack of disability-inclusive disaster drills	Conduct regular evacuation simulations in collaboration with disability organisations.	Short-Term	High	Requires cooperation with local disability organizations	Integrate drills into national disaster preparedness programs
Inaccessible warning systems	Develop multi-modal alert systems with text, audio, and visual components.	Short-Term	High	Needs integration with existing emergency alert systems	Use AI-based early warning systems to enhance accessibility
Discriminatory attitudes among responders	Provide mandatory disability-awareness training for emergency personnel.	Short-Term	Medium	Potential resistance from emergency response personnel	Develop national policies requiring responder training
Lack of assistive devices during evacuations	Ensure stockpiling of assistive devices (e.g., wheelchairs, hearing aids) at evacuation centres.	Short-Term	Medium	Logistical difficulties in stocking and distributing assistive devices	Partner with the private sector for supply chain management
Insufficient disaster preparedness training for PWDs	Offer targeted disaster preparedness programs tailored for persons with disabilities.	Short-Term	High	Requires funding and specialized trainers	Include disability preparedness in public education campaigns
Communication barriers for persons with sensory disabilities	Use sign language interpreters, captioning, and text-based alerts for effective communication.	Short-Term	Medium	Limited accessibility of information in rural areas	Use mobile technology and community networks for outreach

Inadequate policies enforcing accessibility in disaster plans	Implement stricter accessibility policies with accountability measures.	Long-Term	Medium	Lack of enforcement mechanisms	Create legal penalties for non-compliance
Limited funding for inclusive disaster response	Increase funding for inclusive emergency management programs and resources.	Long-Term	Low	Budget constraints and competing priorities	Encourage international funding and grants for accessibility
Lack of representation of PWDs in disaster planning committees	Mandate the inclusion of persons with disabilities in disaster response policy-making and planning.	Long-Term	Medium	Lack of political will or advocacy representation	Form advisory councils of persons with disabilities
Difficulties in transportation and evacuation	Develop accessible transportation plans and emergency mobility assistance services.	Short-Term	Medium	Requires additional transportation infrastructure	Implement emergency ride-sharing partnerships
Absence of specialized medical care in emergency shelters	Ensure shelters have medical personnel trained in disability-specific care.	Short-Term	Medium	Shortage of medical professionals trained in disability care	Establish mobile medical units for disability-specific care
Exclusion of PWDs from economic recovery programs	Integrate PWDs into livelihood restoration and employment support programs.	Long-Term	Low	Discriminatory hiring practices post-disaster	Mandate accessibility requirements in economic recovery plans
Limited psychosocial support during and after disasters	Provide trauma-informed mental health services for persons with disabilities.	Short-Term	High	Limited mental health professionals with disability expertise	Create peer-support programs and virtual counselling options
Lack of accessible information on disaster preparedness	Distribute disaster preparedness materials in Braille, large print, and easy-to-read formats.	Short-Term	High	Needs adaptation to multiple disability needs	Develop multi-format educational materials on preparedness
Failure to provide inclusive recovery housing options	Ensure that post-disaster housing reconstruction includes accessibility considerations.	Long-Term	Medium	High costs for accessible reconstruction	Provide subsidies for accessible home modifications
Poor coordination among emergency responders and disability organizations	Establish partnerships between emergency services and disability advocacy groups.	Long-Term	Medium	Coordination issues between agencies and NGOs	Develop inter-agency coordination protocols and emergency response networks

6. Conclusions

Disaster management is a highly complex process that must consider all the specific needs of individuals with disabilities. Consequently, their inclusion in such processes is not merely a political and administrative issue but a fundamental matter of respecting and protecting all human rights. This study highlights the significant challenges faced by individuals with disabilities during disasters, including physical barriers, communication difficulties, limited access to emergency response services, and adverse socio-economic conditions. Simultaneously, it underscores the importance of recognising their abilities, resilience, and active participation in disaster preparedness, response, and recovery.

The successful implementation of inclusive disaster risk management necessitates a coordinated approach across multiple levels. In this context, relevant government authorities must adopt, amend, and enforce various legal and regulatory frameworks and allocate financial resources to ensure accessibility in planning for and responding to diverse natural and man-made hazards and disasters. Emergency response personnel, including police and fire rescue units, should undergo specialised training and implement multi-modal warning systems to guarantee timely and effective communication with individuals with disabilities.

Encouraging active participation at the local level through involvement in planning committees, disaster simulation exercises, and the distribution of accessible emergency guides is crucial for empowering individuals and enhancing safety. Finally, disaster risk reduction necessitates a shift in mindset—from perceiving persons with disabilities as passive recipients of aid to recognising them as key players in resilience-building. By implementing inclusive policies, improving infrastructure accessibility, and strengthening collaboration between governments, organisations, and communities, we can bridge the gap between theory and real-world practice. These steps will not only protect the rights and well-being of persons with disabilities during disasters but will also foster greater resilience for society as a whole.

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Article

Disaster Management Laws in India: Past, Present, and Future Directions

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ABSTRACT

Disaster management in India has significantly evolved over the years in response to the increasing frequency and severity of natural and man-made disasters. This paper examines the historical evolution of India's legal framework for disaster management, critically assessing its effectiveness and providing recommendations for future legal and policy reforms. The study utilises a qualitative historical analysis to examine key legal documents, statutes, and regulations, tracing the evolution from colonial-era, relief-based laws to the present, more comprehensive risk-reduction models. The findings highlight the transition from a reactive, relief-focused approach to a more proactive, comprehensive risk-reduction model that aligns more closely with international best practices. The paper identifies the challenges faced by current legal frameworks, particularly in integrating advanced technologies and involving local governance in disaster management. Moreover, it emphasises the incorporation of technologies like artificial intelligence (AI) into disaster management laws to enhance preparedness, response, and long-term recovery efforts. By focusing on the Sustainable Development Goals (SDGs), the study advocates for enhancing the effectiveness of disaster management strategies. The paper concludes with recommendations for future reforms to strengthen India's legal infrastructure and integrate emerging technologies, thereby enhancing disaster resilience nationwide.

KEYWORDS

Disaster management; legal framework; India; sustainable development; policy reform.

1. Introduction

Disasters are significant disruptions to the normal functioning of societies, resulting in widespread human, material, and environmental losses that exceed the capacity of affected communities to manage and recover using their existing resources (Vij, 2022). The United Nations Office for Dis-

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aster Risk Reduction (UNDRR) defines a disaster as "*a serious disruption of the functioning of a community or society involving widespread human, material, economic, or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its resources*" (UNDRR, 2022). Disasters can be categorised into three broad types: natural, man-made, and hybrid. Natural disasters are those caused by environmental processes, including atmospheric, geological, and hydrological phenomena. These disasters include earthquakes, floods, cyclones, and pandemics, each requiring specific preparedness, response, and recovery strategies. Natural disasters can be further subdivided into geophysical events (e.g., earthquakes, volcanic eruptions), hydro-meteorological disasters (e.g., floods, droughts), and biological disasters (e.g., epidemics). Man-made disasters, also known as anthropogenic disasters, are caused by human activities, negligence, or deliberate actions. They include technological accidents, industrial mishaps, nuclear incidents, and socio-political events like terrorism and armed conflict. These disasters often result from systemic failures or inadequate regulatory measures and can have far-reaching consequences (Hanspal, 2024). Hybrid disasters are a combination of natural and human-induced events. For instance, environmental degradation, such as deforestation or poor urban planning, can amplify the severity of natural disasters like floods or landslides. These events highlight the complex interplay between human activities and the natural environment, which can exacerbate the impact of disasters (Jovičić, Gostimirović, & Milašinović, 2024). Disasters differ in terms of onset speed, geographical coverage, and duration. Some, such as earthquakes, are sudden and localised, while others, like climate change or pandemics, unfold over extended periods, affecting broader regions and populations. The unpredictability and scale of these events pose significant challenges for governments, communities, and global agencies in terms of disaster preparedness, response, and long-term recovery. In India, the frequency and intensity of natural and man-made disasters have underscored the need for an effective and adaptive disaster management system. The country's legal framework for disaster management has evolved significantly over the years, moving from a reactive, relief-based approach to a more proactive, risk-reduction model. However, challenges persist, particularly in integrating advanced technologies and ensuring the involvement of local governance in disaster management. Given India's diverse socio-economic and environmental landscape, the legal framework must be flexible and inclusive, addressing the needs of both urban and rural communities.

1.1 Objectives of the Study

This study aims to critically analyse the evolution of disaster management laws in India, assess their effectiveness in managing contemporary disaster risks, and propose recommendations for future reforms. The primary objectives of the research are as follows:

- Historical Analysis: To trace the evolution of disaster management laws in India, identifying key legislative milestones and policy developments from the colonial era to the present.
- Evaluation of the Current Framework: To assess the effectiveness of existing legal instruments in managing disaster risks, with particular emphasis on strengths and weaknesses.
- Future Outlook: To propose actionable recommendations for enhancing legal frameworks to address emerging and future disaster risks, focusing on technological integration and community-driven approaches.

2. Literature Review

Disaster management laws have undergone significant evolution, transitioning from reactive relief measures to proactive disaster risk reduction (DRR) strategies. Initially, disaster management focused on response and recovery, primarily framed as civil defence efforts during wartime. However, over time, the importance of prevention and mitigation emerged, leading to the development of integrated approaches that address both the immediate aftermath and long-term risk reduction (Rajabi et al., 2021). The Hyogo Framework (2005–2015) marked a pivotal moment, urging nations to incorporate Disaster Risk Reduction (DRR) into national policies and integrate community-based strategies into disaster management. This shift was further reinforced by the Sendai Framework

(2015–2030), which emphasised reducing disaster risks through collaborative, inclusive, and technologically advanced approaches. Globally, frameworks such as the Sendai Framework for Disaster Risk Reduction have shaped disaster management practices, establishing legal norms for countries to follow in mitigating the impacts of disasters. The Sendai Framework emphasises the importance of collecting real-time data through advanced technologies, such as Geographic Information Systems (GIS) and artificial intelligence (AI), to enhance the accuracy and efficiency of disaster response efforts (Vuckovic & Slavkovic, 2024). The framework also emphasises international cooperation, advocating for a multilateral approach that draws parallels with international human rights law to ensure global disaster preparedness (Browne, 2013). The Hyogo Framework, preceded by the Sendai Framework, laid the groundwork by focusing on resilience, governance, and public awareness, aiming to reduce disaster risks through education and investment. Japan and Indonesia present contrasting approaches to disaster management. With its long history of proactive disaster management laws dating back to 1941, Japan has developed an advanced framework emphasising disaster prevention, mitigation, and robust community engagement. Japan's disaster laws and advanced technological applications, such as early warning systems and evacuation drills, have contributed to its resilience (Lestari et al., 2020). In contrast, Indonesia's disaster management framework, established through Act No. 24 of 2007, is relatively newer and faces challenges in standardising disaster management practices. Although improvements have been made, including the adoption of GIS for risk mapping, Indonesia continues to struggle with clarity and consistency in disaster law, particularly in emergency definitions, which hinders effective disaster management (Kadir et al., 2024).

Technological advancements have revolutionised disaster management. AI, GIS, and the Internet of Things (IoT) have become integral to enhancing disaster risk reduction and response efforts. AI and machine learning technologies, such as support vector machines and convolutional neural networks, analyse vast datasets for predictive analytics and real-time decision-making during disasters (Nunavath & Goodwin, 2019).

Recent advancements in AI for disaster management have highlighted the importance of reinforcement learning (RL) and explainable AI (XAI) in enhancing real-time decision-making and ensuring transparency. RL (Reinforcement Learning), where agents learn optimal actions by interacting with their environment and receiving feedback, optimises disaster response strategies by adapting to dynamic conditions such as resource availability and evolving disaster intensities (Babaee et al., 2024). This flexibility is particularly useful in situations such as floods or wildfires, where traditional models often lack the responsiveness needed. On the other hand, XAI (Explainable Artificial Intelligence), which employs techniques such as LIME and SHAP, ensures that AI-driven decisions are transparent—a crucial factor in high-stakes environments such as disaster response. XAI has been applied in snow avalanche forecasting to clarify the decision-making process, enhancing the model's credibility (Reddy, 2024). The integration of RL and XAI enhances disaster management by enabling adaptive and transparent decision-making, thereby helping to overcome challenges such as resource limitations and public trust in AI-driven processes.

GIS facilitates the creation of risk maps, while IoT devices, such as sensors and cameras, provide real-time situational awareness, thereby improving evacuation planning and resource management (Manyuchi et al., 2023). These technologies enable disaster management systems to operate more efficiently, with AI enhancing predictive capabilities, GIS improving spatial data integration, and IoT offering continuous monitoring during disaster events. For instance, Long Short-Term Memory (LSTM) networks have demonstrated 87% accuracy in flood prediction, with a Root Mean Square Error (RMSE) of 12.4 mm, providing a critical lead time before disaster events occur (Hossain et al., 2023). GIS is crucial in spatial data analysis and risk mapping, as it integrates real-time data from IoT sensors to enhance situational awareness and inform decision-making. One study demonstrated that combining the Internet of Things (IoT) and Geographic Information Systems (GIS) with Convolutional Neural Networks (CNNs) enabled near real-time tracking of wildfire spread, thereby optimising evacuation strategies and resource allocation (Kılınç, 2024). Additionally, AI-driven optimisation techniques have been shown to reduce delays in resource distribution by up to 40% during emergencies (Diehr et al., 2025). These advancements underscore the increasing importance of AI, IoT, and GIS in developing more resilient and efficient disaster management frameworks. However,

challenges such as data quality, system interoperability, and ethical concerns regarding privacy and bias still need to be addressed (Albahri et al., 2024).

International experiences and comparative analysis increasingly shape disaster management laws. For instance, Turkey's disaster management approach integrates spatial data infrastructure, significantly improving the country's disaster preparedness and legal frameworks (Öcal, 2021). Similarly, community involvement in disaster management plays a critical role. Cruz and Ormilla (2022) highlighted how disaster risk reduction strategies have been implemented at the grassroots level in the Philippines, particularly in schools. This underscores the importance of local engagement, where disaster management efforts must be tailored to local vulnerabilities and capacities. Furthermore, strengthening institutional capacities is vital for the effectiveness of disaster management laws. Sudar et al. (2024) discuss how Montenegro harmonised its soft power and institutional capabilities to enhance disaster management governance. Additionally, understanding public perceptions of disaster risks is essential for effective management. Cvetković and Planić (2022) demonstrate that earthquake risk perception in Belgrade significantly influenced the development of disaster management policies, which could serve as a model for addressing public awareness and preparedness in disaster-prone areas.

Disaster Risk Reduction (DRR) theories emphasise the need for multi-faceted approaches to mitigate and manage disaster risks. The core principle of DRR is the integration of prevention and preparedness strategies into national policies and plans. DRR theories encourage a systemic, interdisciplinary approach addressing physical and socio-economic vulnerabilities. These theories emphasise the importance of risk assessment, community engagement, and international cooperation in mitigating disaster impacts (Vuckovic & Slavkovic, 2024). The Social-Ecological Systems (SES) approach is crucial for understanding disaster management laws and resilience. This framework focuses on the interactions between human societies and their surrounding environments, considering how these interactions influence vulnerability and resilience in the face of disasters. The SES approach advocates for adaptive governance systems integrating human and environmental factors into disaster management strategies. It highlights the necessity of addressing socio-ecological vulnerabilities, such as poverty and urbanisation, which exacerbate the impacts of disasters (Browne, 2013). Incorporating emerging technologies, such as AI, GIS, and IoT, into disaster management legal frameworks is increasingly recognised as vital for enhancing disaster preparedness and response. These technologies enhance decision-making processes, enabling data-driven legal frameworks that adapt in real time. Integrating technology into disaster management laws ensures more effective risk management and reduces the latency of response efforts during crises (Nunavath & Goodwin, 2019). Moreover, legal frameworks must evolve to address the ethical, privacy, and security implications of using advanced technologies in disaster management.

3. Methodology

This study employs a qualitative historical analysis to examine the evolution of disaster management laws in India. The research focuses on key legal documents and statutes from the colonial era, such as the Famine Code of 1883, the Epidemic Diseases Act of 1897, and the Disaster Management Act of 2005. A comparative approach contextualises India's legal frameworks against international standards, particularly in comparison to countries like Japan and Indonesia. This comparison provides insight into how India's disaster laws have evolved in alignment with global best practices. Additionally, case studies of major disasters (e.g., the 2001 Gujarat Earthquake, the 2004 Tsunami, and the COVID-19 pandemic) are analysed to assess the practical effectiveness and challenges of the legal frameworks in real-world situations. This methodology critically evaluates India's legal evolution in disaster management, from its historical roots to its current state, and offers recommendations for future reforms.

4. Overview of Disasters in India

With its vast and diverse geographical landscape, India is highly susceptible to various disasters. The unique geo-climatic and geological conditions of the Indian subcontinent make it prone to natural and man-made calamities. The most common types of natural disasters include floods, cyclones, earthquakes, droughts, and landslides, each of which significantly impacts the country's infrastructure. These events cause not only immediate destruction but also have lasting consequences for the nation's socio-economic structure. India frequently experiences floods, droughts, cyclones, and storms, which collectively account for approximately 80% of the country's natural disasters. Between 2000 and 2020, India faced 360 natural disasters, affecting over 1120 million people, with floods and storms being the most prevalent (Kumar & Kumar, 2024). India's long coastline makes it vulnerable to cyclones, which cause severe damage to coastal infrastructure, including ports, power lines, and communication networks. Cyclones like Phailin and Amphan have demonstrated the destructive potential of these storms (Mohanty, Dubey, & Singh, 2022). Historical data reveals a recurring pattern of devastating events, from the Bengal Famine of 1943 to the Gujarat Earthquake of 2001 and the Indian Ocean Tsunami of 2004. These events highlight the critical importance of effective disaster management strategies (NDMA, 2016). India's Disaster management is paramount due to the country's vulnerability to a wide array of natural disasters like floods, droughts, cyclones, earthquakes, and landslides (Jayaprakash, Reddy, & Istijono, 2023). Disaster management in India is of utmost importance. The country's socio-economic fabric, characterised by high population density, poverty, and rapid urbanisation, exacerbates the impact of disasters. India's coastline stretches over 7,500 kilometres and is highly vulnerable to cyclonic storms, particularly from the Bay of Bengal and the Arabian Sea. Similarly, the country's position in seismic zones IV and V, encompassing areas like the Himalayan region and parts of Gujarat, makes it susceptible to frequent earthquakes. Flooding, often caused by heavy monsoon rains, affects large areas, particularly along major river basins such as the Ganga and Brahmaputra. Additionally, regions such as Rajasthan and parts of Maharashtra regularly face droughts due to insufficient rainfall.

Table 1: Types of Disasters in India

Disaster Type	**Description**	**Examples**
Natural Disasters		
Floods	The most common natural disaster is causing widespread displacement and damage.	2008 Bihar floods, 2019 Kerala floods
Cyclones	Coastal regions, particularly in the eastern states, are highly vulnerable.	Cyclone Phailin (2013). Cyclone Fani (2019)
Earthquakes	High-intensity earthquakes occur in seismic zones IV and V, particularly affecting regions like Gujarat and Kashmir.	2001 Gujarat earthquake, Kashmir earthquake (2005)
Droughts	Arid and semi-arid regions frequently experience recurring droughts, which have a significant impact on agriculture and livelihoods.	Drought in Rajasthan (2016), Marathwada drought (2015)
Landslides	Mountainous regions, particularly in the Himalayas and Western Ghats, are prone to landslides.	Landslides in Kerala (2018), Uttarakhand (2013)
Man-Made Disasters		
Industrial Accidents	Industrial accidents, particularly in the chemical industry, can cause substantial damage.	Bhopal Gas Tragedy (1984)
Terrorist Attacks	Terrorist attacks in urban areas have caused extensive loss of life and infrastructure damage.	2008 Mumbai attacks
Environmental Degradation	Unregulated urbanisation, deforestation, and inadequate waste management exacerbate vulnerability to disasters.	Urban floods in Delhi (2019), Heatwaves in major cities

4.1 Impact on Infrastructure and Socio-Economics

The impact of disasters on India's infrastructure and socio-economic structure is profound. Disasters not only cause immediate damage to physical infrastructure such as roads, bridges, buildings, and communication networks but also have long-term economic effects. The destruction of vital infrastructure hampers recovery and delays economic revitalisation. In the aftermath of Cyclone Fani in 2019, Odisha suffered severe damage to its electricity lines, roads, and houses, affecting millions of people and hindering the recovery process (Kawyitri & Shekhar, 2021). Similarly, earthquakes and floods lead to the displacement of large populations, which in turn affects their livelihoods and access to essential services. India's socio-economic fabric is vulnerable to disasters due to the high proportion of the impoverished population. People with low incomes, who often live in hazard-prone areas such as floodplains or near industrial sites, bear the brunt of disaster impacts. A study by the National Disaster Management Authority (NDMA, 2016) highlighted that disasters disproportionately affect marginalised communities, further exacerbating socio-economic disparities. The economic cost of disasters in India is significant. Between 2000 and 2020, India faced 360 natural disasters that affected over 1.1 billion people (NDMA, 2016). In addition to the immediate loss of life and property, disasters result in long-term economic setbacks, particularly in agriculture, tourism, and industry sectors. The 2001 Gujarat earthquake, for instance, led to an estimated $5 billion in damages (Lecy, 2007). Similarly, the 2018 floods in Assam displaced over 2.3 million people and caused substantial damage to the region's agriculture, the backbone of its economy. The table below highlights the deadliest disasters in India between 2000 and 2024, illustrating their widespread impact on affected populations and areas.

Table 2 Deadliest Disasters in India (2000 – 2024)

Sl. No.	Event	Year	State	Affected
1	Gujarat Earthquake	2001	Gujarat	6.3 million
2	Tsunami	2004	Tamilnadu, Kerela, A.P.	2.79 million
3	Maharashtra Floods	2005	Maharashtra State	167
4	Kashmir Earthquake	2005	Kashmir State	156622
5	Kosi Flood	2008	North Bihar	33,29,423
6	Cyclone Nisha	2008	Tamil Nadu	
7	Flood	2008	Assam, Orissa and Other States	79,00,000
8	Flood	2009	Assam, Bihar, Gujarat, and other States	18,86,000
9	Flood	2009	Maharashtra	41,00,000
10	Flood	2010	Bihar, Uttar Pradesh	32,67,183
11	Flood	2011	Orissa	34,43,989
12	Flood	2011	Uttar Pradesh	55,49,080
13	Flood	2013	Bihar, Gujarat & Other States	5,04,473
14	Flood	2015	Madhya Pradesh, Manipur & Other States	1,37,09,887
16	Flood	2016	Bihar, Uttar Pradesh	16,00,000
17	Flood	2017	Uttar Pradesh, West Bengal & Other States	172,00,000
18	Flood	2018	Assam & Other States	232,20,000
19	Flood	2019	Himachal Pradesh & Other States	30,00,000
20	Cyclone 'Fani'	2019	Odisha province	20000000
21	Cyclone 'Bulbul'	2019	WB, Odisha	130000
22	Cyclone 'Amphan'	2020	Odisha, WB	18000000
23	Cyclone 'Nisarga'	2020	Maharastra	7500
24	Flood	2020	Arunachal Pradesh & Other States	13,00,000
25	Glacial Lake Outburst	2021	Uttarakhand	24
26	Tropical cyclone 'Tauktae'	2021	Kerala, Karnataka, Goa, Maharashtra, Gujarat, Rajasthan	700153
27	Cyclone 'Yaas'	2021	Bengale Occidental, Odisha	1625000
28	Cyclone 'Shaheen'	2021	Koraput and Malkangiri (Odisha); Andhra Pradesh	179000

29	Tropical storm 'Jawad'	2021	Andhra Pradesh, Odisha, south-western West Bengal, Tripura	2050
30	Cyclone 'Biparjoy'	2023	Rajasthan, Gujarat	10000
31	Tropical storm 'Michaung'	2023	Andra Pradesh, Telangana, Tamil Nadu States	4390000
32	Cyclone 'Remal'	2024	Aizawl (Mizoram state); Bengal, Assam, Nagaland, Meghalaya states; West Bengal, Telangana	2109143
33	Flash flood	2024	Tripura state	34000

Source: EM_DAT Natural Disasters India, 2024

Table 2 presents a chronological overview of the deadliest disasters in India between 2000 and 2024, highlighting significant events such as earthquakes, tsunamis, floods, and cyclones. The 2001 Gujarat Earthquake affected 6.3 million people, while the 2004 Tsunami impacted 2.79 million across Tamil Nadu, Kerala, and Andhra Pradesh. Floods and cyclones dominated the later years, with Cyclone 'Fani' in 2019 affecting 20 million people in Odisha. The table highlights the recurring devastation caused by natural disasters across various Indian states, reflecting the widespread vulnerability and the immense scale of affected populations over time. These events underscore the need for improved disaster management, resilient infrastructure, and tailored legal frameworks to address regional vulnerabilities.

5. Historical Development of Disaster Management Laws in India

5.1 Colonial Era: Pre-Independence Disaster Management Policies and Legislation

Disaster management as a formal field was essentially non-existent during India's colonial era. The approach to disaster management during this period was rudimentary, mainly focused on emergency relief and response rather than long-term preparedness or risk reduction. The British colonial administration's disaster management policies were shaped by the need to protect economic interests and maintain order rather than fostering a comprehensive disaster risk reduction strategy. Several legislative measures were enacted during this time, with a particular emphasis on addressing specific types of disasters, most notably famines, which were recurrent and devastating. One of the earliest pieces of disaster legislation was the Famine Code of 1883, which followed the recommendations of the Famine Commission in 1880. This framework provided guidelines for declaring famine and distributing relief (Sen, 1982). However, it was limited to managing food shortages during famines and did not address broader disaster risks such as floods, cyclones, or earthquakes. Similarly, the Epidemic Diseases Act of 1897 was enacted to control the spread of bubonic plague in Bombay. This law granted the government extraordinary powers to prevent epidemics, including the authority to implement quarantine measures and inspect passengers (Chakrabarti, 2019). However, it limited its scope to outbreaks and did not comprehensively address other types of disasters. These early colonial laws focused mainly on reactive measures rather than proactive disaster risk reduction or mitigation.

5.2 Limitations of Colonial Approaches

The colonial era's disaster management approach was criticised for being primarily ad hoc and lacking a comprehensive, proactive framework. The disaster response primarily focused on immediate relief and recovery rather than long-term preparedness, mitigation, or resilience. Furthermore, the top-down approach often excluded local communities from the planning and decision-making processes, limiting the effectiveness of disaster response (Rajabi et al., 2021). Colonial disaster management primarily focused on protecting economic interests, such as safeguarding infrastructure and trade routes, rather than addressing the broader social and environmental impacts of disasters. The absence of community engagement and a comprehensive disaster management framework left the Indian population vulnerable to recurring calamities.

5.3 Post-Independence: Disaster Management Developments

Post-independence, India faced numerous challenges in developing a robust disaster management framework. The partition of India in 1947 resulted in massive population displacements, creating immediate humanitarian crises that required urgent attention and relief efforts. This period emphasised the necessity for an organised approach to disaster management. The 1980s marked a significant transition, underscoring the importance of adopting a more proactive approach to disaster management. The Bhopal Gas Tragedy of 1984, one of the worst industrial disasters in history, underscored the inadequacies of the existing framework and the urgent need for comprehensive legislation (Dhara, 2023); this led to the enactment of the Environment (Protection) Act of 1986, which established a structure for protecting and improving the environment and indirectly contributed to disaster management by addressing industrial and environmental hazards (Dhara & Dhara, 2002). The Orissa Super Cyclone of 1999 and the Bhuj Earthquake of 2001 were pivotal events that further catalysed legislative reforms (Lakhani, 2021). These disasters exposed significant gaps in the disaster response mechanism, prompting the government to rethink its strategy. The government enacted the Disaster Management Act in 2005, marking a watershed moment in India's history of disaster management. The Act established the National Disaster Management Authority (NDMA) and State Disaster Management Authorities (SDMAs), creating a structured and standardised framework for disaster management in the country (NDMA, 2009).

5.4 Constitutional provisions (Articles 48A, 51A(g), 21, 14)

Post-independence, the Indian Constitution laid the foundation for environmental and disaster management. Article 48A obligates the state to safeguard and enhance the environment, while Article 51A(g) assigns a corresponding duty to citizens. Furthermore, Articles 21 and 14, which ensure the right to life and equality before the law, have been interpreted by the judiciary to include the right to a healthy environment and equitable disaster relief (Atapattu, 2002).

5.5 Environmental Protection Act (1986) and related notifications

The Bhopal Gas Tragedy of 1984 was a pivotal moment that catalysed significant legislative reforms, leading to the enactment of the Environmental Protection Act in 1986 (Dias, 1994). This comprehensive legislation provided a framework for environmental protection and regulation of activities that could lead to environmental disasters. It empowered the central government to take measures for controlling pollution and managing hazardous substances, thereby mitigating potential disasters (Fortun, 2009). Related notifications under this Act include the Manufacture, Storage and Import of Hazardous Chemical Rules, 1989, which specify requirements for the safe management of hazardous chemicals, and the Bio-Medical Waste (Management and Handling) Rules, 1998, which aim to prevent health hazards by properly disposing of and managing biomedical waste (Singh & Singh, 2018).

5.6 Other Relevant Legislation

Several other legislations complement the disaster management framework in India. The Factories Act of 1948 includes provisions for the safety of workers in industrial establishments (Kumari & Dadwal, 2022). The evolution of disaster management laws in India from pre-independence famine codes to post-independence comprehensive legal frameworks reflects the country's growing recognition of the need for robust and proactive disaster management strategies. These laws collectively aim to mitigate risks, protect lives, and ensure swift and effective disaster response. India has marked the evolution of disaster management by introducing various legislations and policies to reduce risks and manage emergencies effectively. Table 3 presents a timeline of crucial legislation,

highlighting the progression from early reactive measures to more comprehensive and preventive strategies in disaster management.

Table 3. Timeline of Disaster Management Legislation in India

Year	Legislation/Policy	Key features
1860	Indian Penal Code	Sections related to negligence causing harm or death (e.g., Section 304A)
1880	Famine Relief Code	Early legislation established guidelines for systematic famine relief, including identifying famine conditions, distributing relief, and managing resources.
1897	Epidemic Diseases Act	Legal framework for controlling epidemic outbreaks.
1884	Indian Explosives Act	Regulated the safety and management of explosives to prevent accidents and disasters.
1908	Indian Ports Act	Managed safety and operations of ports to prevent and handle port-related disasters.
1948	Factories Act	Included provisions for worker safety in industrial establishments to prevent industrial accidents and disasters.
1958	Civil Defence Act	Preparedness for emergencies
1986	Environmental Protection Act	A comprehensive framework for environmental protection and regulating hazardous substances to prevent environmental disasters.
1989	Manufacture, Storage and Import of Hazardous Chemical Rules	Specified requirements for safe management of hazardous chemicals to prevent chemical-related disasters.
1998	Bio-Medical Waste (Management and Handling) Rules	Guidelines for proper disposal and management of biomedical waste to prevent health hazards and environmental contamination.
2001	HPC (High Powered Committee) Report on Disaster Management	Recommendations for Comprehensive Disaster Management
2005	Disaster Management Act	Establishment of NDMA, legal framework
2016	(NDMP) National Disaster Management Plan	Alignment with Sendai Framework for Disaster Risk Reduction 2015-2030

5.7 Judicial Contributions to Disaster Management Laws

India's Supreme Court has played a crucial role in shaping disaster management laws, often interpreting constitutional provisions to incorporate environmental and community protection. In *M.C. Mehta v. Union of India* (1987), the Court expanded the right to life under Article 21 to include the right to a healthy environment, thus laying the groundwork for integrating disaster risk reduction (DRR) into legal frameworks. The *Narmada Bachao Andolan case* (2000) further emphasised the necessity of environmental impact assessments (EIAs) and the protection of displaced communities, which are essential to disaster management. The Court reinforced the state's responsibility for prevention, compensation, and response to industrial and environmental disasters. More recently, in *M.K. Ranjitsinh & Ors. v. Union of India & Ors.* (2024), the Court highlighted the need to integrate disaster risk reduction with environmental protection, stressing the importance of sustainable development practices in disaster-prone areas.

5.8 The Disaster Management Act, 2005: A Paradigm Shift

The Gujarat Bhuj earthquake in 2001 and the Indian Ocean tsunami in 2004 catalysed a paradigm shift in disaster management in India. The enactment of the Disaster Management Act in 2005 marked a significant milestone, establishing a legal framework for a comprehensive, prevention- and mitigation-based approach to disaster management (Disaster Management Act, 2005). The Disaster Management Act, 2005, enacted on December 23, 2005, marks a significant shift in India's approach to disaster management, driven by the need for a comprehensive legal framework to address the growing frequency and severity of disasters. The devastating Indian Ocean tsunami of 2004 highlighted the inadequacies of existing disaster response mechanisms and served as a significant catalyst for the introduction of the Act (Ayele, 2014). The legislation aims to institutionalise disaster

management by establishing a structured, systematic, and proactive framework that includes the creation of the National Disaster Management Authority (NDMA) and State Disaster Management Authorities (SDMAs) (NDMA, 2009). These bodies are responsible for developing policies, plans, and guidelines to ensure a coordinated and effective response to disasters at all administrative levels. The Act emphasises the importance of preparedness and mitigation strategies, moving away from the traditional reactive approach. It mandates the creation of a National Disaster Response Force (NDRF) for specialised disaster response, reflecting a shift toward a more organised and professional emergency response mechanism (Kapur, 2010). Furthermore, it promotes community-based disaster management, recognising the critical role of local communities in disaster preparedness and response (Pandey & Okazaki, 2005). The legislation also includes provisions for financial mechanisms such as the National Disaster Response Fund (NDRF) and the National Disaster Mitigation Fund (NDMF) to ensure adequate financial resources are available for disaster response and mitigation activities. Overall, the Disaster Management Act 2005 significantly advances India's disaster management capabilities. It aligns with global best practices and emphasises a holistic approach that includes risk reduction, preparedness, and community involvement (Thomalla & Larsen, 2010).

5.9 Recommendations from the High-Powered Committee (HPC)

In the wake of major disasters, such as the Latur earthquake (1993) and the Orissa super cyclone (1999), the Indian government recognised the need for a comprehensive overhaul of the disaster management framework. The High-Powered Committee (HPC) on Disaster Management, chaired by Mr. J.C. Pant, was constituted in 1999. The HPC report, submitted in 2001, provided fundamental and practical recommendations, including the draft of the Disaster Management Act, a national response plan, and strategies for transitioning from disaster response to disaster preparedness (Pant, 1999). The committee has classified disasters into five categories, as shown in **Figure 1.** Each category encompasses specific types of disasters, highlighting the diversity of hazards that can occur.

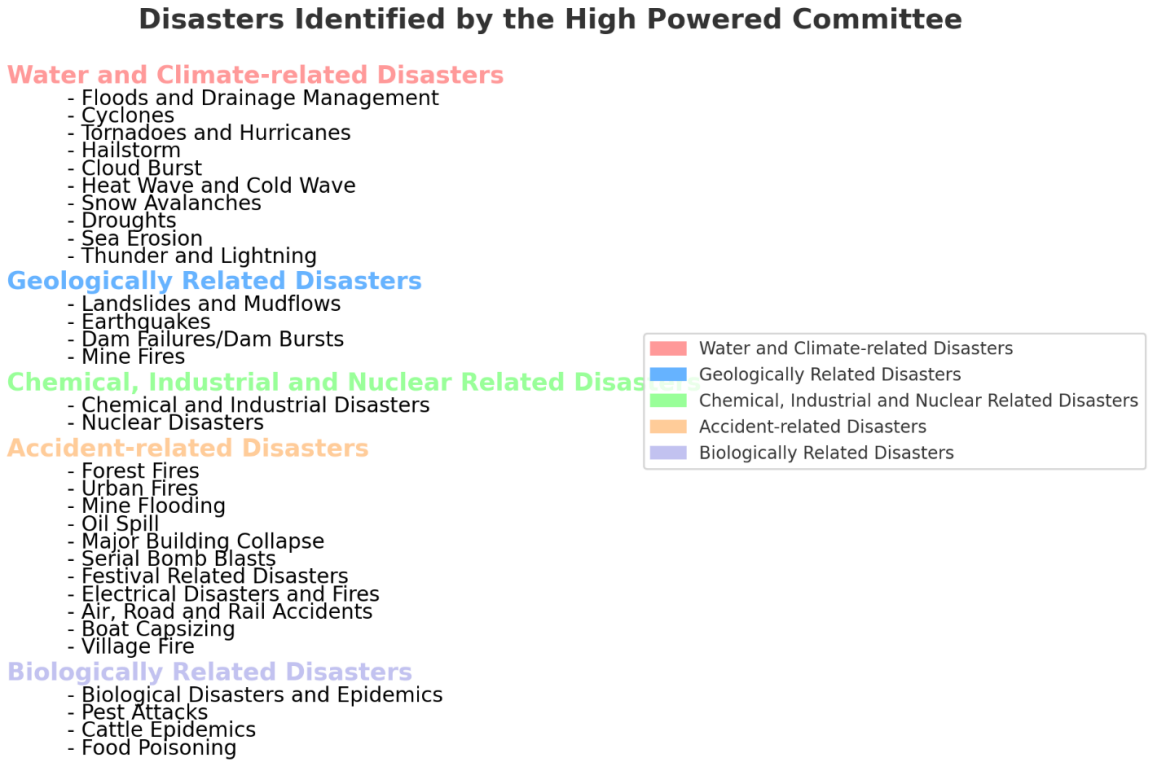

Figure 1. Disasters identified by the High-Powered Committee

(HIGH POWERED COMMITTEE ON DISASTER MANAGEMENT, HPC Report, Source: https://www.preventionweb.net/files/1633_ch3.pdf)

5.9 Influence of international frameworks (Yokohama Strategy, Hyogo Framework for Action)

India's participation in international initiatives, such as the Yokohama Strategy and Plan of Action for a Safer World (1994) and the Hyogo Framework for Action (2005-2015), further reinforced the need for a paradigm shift in disaster management. These global frameworks emphasised the importance of prevention, preparedness, and mitigation, influencing the country's approach to disaster risk reduction (Bhardwaj, Acharya, & Gupta, 2024).

6. Current Disaster Management Legal Framework

The Disaster Management Act 2005 (DMA, 2005) remains the cornerstone of India's disaster response framework, providing a structured legal approach to disaster management. This Act encompasses prevention, mitigation, preparedness, response, and recovery, outlining the roles and responsibilities of various stakeholders, including central and state governments, local authorities, and other relevant agencies. However, recent updates to the Disaster Management (Amendment) Bill 2024 aim to address emerging challenges in disaster risk reduction, enhance institutional coordination, and improve financial accountability (Government of India, 2024).

6.1 Establishment of national, state, and district authorities

The Disaster Management Act of 2005 created a hierarchical institutional framework for disaster management at the national, state, and district tiers. The Act required the establishment of the National Disaster Management Authority (NDMA), State Disaster Management Authorities (SDMAs), and District Disaster Management Authorities (DDMAs) to supervise and coordinate disaster management initiatives (Disaster Management Act, 2005, § 3).

6.2 Institutional mechanisms for policy, planning, and capacity building

The Act provided for the establishment of institutional mechanisms for policy formulation, planning, and capacity building in disaster management; this includes the National Institute of Disaster Management (NIDM) and its state-level counterparts, responsible for training, research, and advocacy in the field of disaster risk reduction (Disaster Management Act, 2005, § 42).

6.3 National Disaster Management Authority (NDMA) and its roles

The National Disaster Management Authority (NDMA), headed by the Prime Minister of India, serves as the nation's supreme disaster management entity. Its key responsibilities include formulating policies, approving national and ministerial plans, providing guidelines for state authorities, coordinating implementation, recommending funding for mitigation measures, and overseeing international cooperation in disaster management (Disaster Management Act, 2005, § 6-8).

6.4 State Disaster Management Authorities (SDMAs)

At the state level, State Disaster Management Authorities (SDMAs), headed by the respective Chief Ministers, are responsible for laying down policies and plans for disaster management within their jurisdictions. SDMAs are crucial in coordinating with district authorities and ensuring the implementation of national and state-level policies and plans (Disaster Management Act, 2005, § 14-16).

6.5 District Disaster Management Authorities (DDMAs)

District Disaster Management Authorities (DDMAs) function as the planning, coordinating, and executing entities for disaster management at the district level. Headed by the District Magistrate or Collector, DDMAs prepare district disaster management plans, conduct mock drills, and carry out prevention, preparedness, and mitigation activities within their respective districts (Disaster Management Act, 2005, § 25-30).

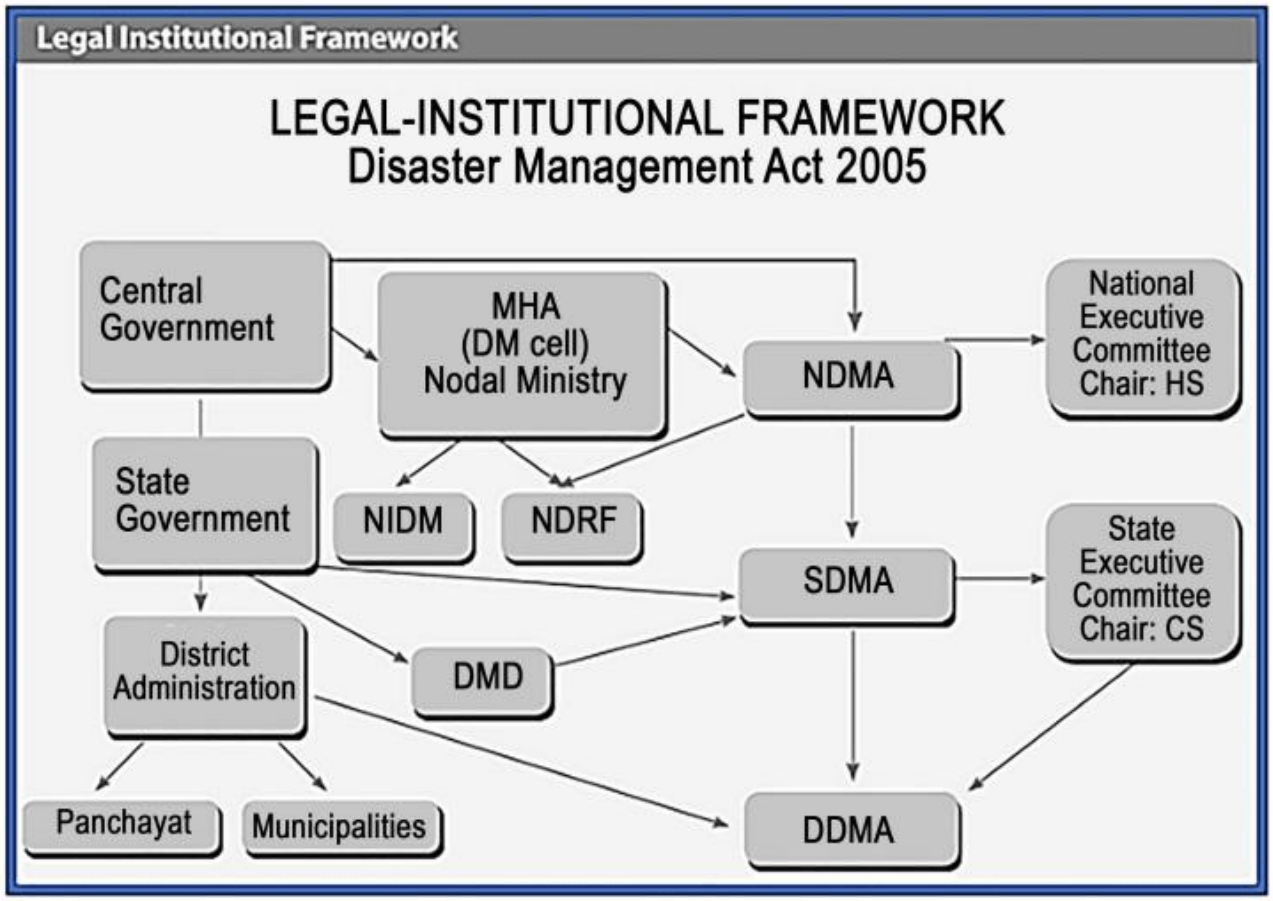

Figure 2. Legal-Institutional Framework of the Disaster Management Act (2005) in India

(Image source: https://compass.rauias.com/disaster-management/act-2005-2nd-arc-recommendations/)

6.6 Key Amendments to the Disaster Management Act, 2005

The Amendment Bill 2024 introduces significant revisions to the Disaster Management Act (DMA) of 2005, aiming to expand the scope of disaster governance and enhance India's disaster risk reduction (DRR) capabilities. These amendments aim to enhance the comprehensiveness, proactivity, and resilience of the disaster management framework. By revising key definitions and introducing new provisions, the amendment addresses the evolving challenges posed by natural and artificial disasters. These updates enhance disaster preparedness, response, and long-term recovery mechanisms, enabling India to better manage the increasing frequency and complexity of future disasters. One of the key features of the 2024 Amendment is the revision of critical definitions related to disaster management.

- **Disaster Risk Reduction (DRR):** The original Act defined DRR as relief and response. However, the amendment broadens this definition to include vulnerability analysis, mitigation strategies, and resilience-building measures. This shift emphasises a more proactive approach, focusing on reducing the underlying risks before disasters occur rather than solely on post-disaster response (GoI, 2024).

- **Man-Made Disasters**: The earlier definition of artificial disasters encompassed a wide range of events, from industrial accidents to terrorism. The amendment narrows this scope to exclude law and order issues, focusing specifically on industrial hazards, pandemics, and environmental crises. This refinement addresses modern challenges, including climate change, industrial safety, and health-related emergencies like pandemics (GoI, 2024).
- **Recovery & Rehabilitation:** Recovery and rehabilitation traditionally focused on immediate post-disaster relief efforts. The amendment expands this definition to include the socio-economic reintegration of affected communities. The updated approach recognises that recovery extends beyond restoring infrastructure and aims to rebuild livelihoods and ensure long-term community resilience.

6.7 National Disaster Database (NDD)

Another significant amendment introduced by the 2024 Bill is the creation of a National Disaster Database (NDD), which will play a pivotal role in improving data-driven disaster governance. The NDD streamlines disaster management by providing a centralised platform for risk mapping, financial tracking, and damage assessment. This shift towards evidence-based disaster management leverages data and technology to optimise resource allocation and recovery efforts.

Features of the National Disaster Database:

- **Risk Mapping:** The NDD will utilise AI-driven tools to identify disaster-prone regions, enabling more accurate and real-time risk assessments. Predictive analytics will enhance preparedness by providing early warning systems and helping authorities allocate resources efficiently in high-risk areas.
- **Financial Tracking:** A crucial function of the NDD will be to monitor disbursements from the State Disaster Response Fund (SDRF) and the National Disaster Response Fund (NDRF). The National Disaster Database (NDD) will ensure transparency and accountability in the allocation and utilisation of funds, thereby preventing misuse and delays in financial assistance.
- **Damage Assessment**: The NDD will also standardise the methodology for assessing damages following a disaster. This uniformity will help streamline recovery processes and enable more efficient coordination between the central and state governments during post-disaster relief and rebuilding.

6.8 Introduction of Urban Disaster Management Authorities (UDMAs)

A crucial institutional change introduced by the 2024 Amendment is the establishment of Urban Disaster Management Authorities (UDMAs). These authorities aim to address the challenges faced by rapidly urbanising areas, where disaster risks, particularly those related to infrastructure, industrial hazards, and environmental crises, are becoming increasingly prominent. The 2024 Bill mandates the creation of UDMAs in each state capital and large municipal corporations. These authorities will formulate city-specific disaster preparedness plans, focusing on urban risks such as floods, industrial hazards, and infrastructure resilience. UDMAs will be empowered to ensure that urban areas have robust disaster response systems and resilience measures tailored to the unique challenges of urbanisation (Government of India, 2024). The introduction of UDMAs marks a significant step in recognising the need for localised disaster management strategies in urban areas. These areas face unique vulnerabilities due to their high population densities and complex infrastructure systems.

6.9 Challenges and Gaps in Implementation

Despite the robust legal and institutional framework established by the Disaster Management Act, 2005 (DMA), several challenges and gaps persist in implementing disaster management strategies across India. These challenges undermine the effectiveness of disaster preparedness, response, and recovery efforts.

- **Implementation Gaps:** Despite the robust legal frameworks, significant implementation gaps persist, resulting in discrepancies between law and practice. One major issue is the uneven implementation of disaster management plans across states and districts, often due to varying administrative capacity and commitment levels. For example, while states like Odisha and Kerala have demonstrated effective implementation, others, such as Bihar and Assam, lag, reflecting inconsistencies in applying the Act's provisions. These gaps undermine the effectiveness of disaster management efforts, leading to suboptimal responses during disasters.
- **Overlap of authority and responsibilities:** A significant challenge is the overlap of authority and responsibilities among the diverse organisations and individuals involved in disaster management, which can lead to confusion, duplication of efforts, and inefficient resource utilisation, hindering effective coordination and response (Raju & Becker, 2013).
- **Issues with staffing and resource allocation:** Many agencies involved in disaster management face staffing and resource constraints, which can undermine their ability to carry out their mandated functions effectively. Some agencies may have an unsustainable workforce, while others may lack sufficient personnel and resources commensurate with their responsibilities (Sharma, 2003).
- **Lack of clarity on financial mechanisms:** Although the State Disaster Response Fund (SDRF) and the National Disaster Response Fund (NDRF) provide financial support, there is uncertainty regarding the Disaster Mitigation Fund and the impact of State Action Plans on Climate Change on reducing disaster risks (Revi, 2012).
- **Need for greater decentralisation and community involvement: Although the Disaster Management Act 2005 emphasises decentralisation and community involvement, further empowerment and capacity building are necessary at the local level**. Effective disaster risk reduction requires a bottom-up approach, with active participation and self-reliance of communities and regional institutions (Bhatt & Reynolds, 2012).

6.10 Case Study: COVID-19 Pandemic Response

The COVID-19 pandemic presented unprecedented challenges to India's disaster management legal frameworks (Jaiswal, Jha, & Patil, 2021). The government invoked the Disaster Management Act 2005 to facilitate a coordinated national response. Measures included lockdowns, resource allocation through the National Disaster Response Fund (NDRF), and the establishment of specialised task forces to manage the crisis (Nomani & Parveen, 2021). While the legal provisions enabled a swift policy response and resource mobilisation, several challenges emerged:

- **Coordination Issues:** The scale of the pandemic strained the existing multi-tiered institutional structures, leading to coordination bottlenecks between national and state authorities.
- **Resource Allocation Delays:** Despite the availability of funds, delays in fund disbursement and distribution hindered timely responses to the pandemic's evolving needs.
- **Public Compliance and Awareness:** Ensuring public compliance with health guidelines highlighted community engagement and awareness gaps, underscoring the need for more effective communication strategies to address these gaps.

Overall, the pandemic highlighted the strengths of the Disaster Management Act in facilitating a rapid response but also revealed critical areas for improvement in coordination and public engagement.

7. Future Perspectives and Recommendations

The evolution of disaster management laws in India has progressed significantly from colonial-era reactive measures to a more proactive, resilience-focused approach. This transformation reflects a broader shift towards improving disaster risk reduction (DRR) and aligning with international frameworks such as the Sendai Framework for Disaster Risk Reduction. As disaster risks evolve—shaped by technological advancements, climate change, and new types of hazards—there is an urgent need for ongoing legal and strategic reforms. These reforms should enhance resilience, improve the overall disaster management framework, and address emerging challenges. The continued development of India's disaster management system requires an emphasis on awareness-building, strengthening community and institutional capacity, and reforming laws to address contemporary challenges in disaster risk management (M.S. Hanspal & B. Behera, 2024).

7.1 Recommendations:

The recommended action points aim to address the challenges and enhance the efficacy of India's disaster management legal frameworks.

Legal Reforms:

- **Amend Existing Laws:** The Disaster Management Act of 2005 must be updated to incorporate precise definitions, clear delineations of roles and responsibilities, and provisions to address emerging threats, such as cyber disasters. A more comprehensive approach to non-traditional risks will ensure India's disaster management laws remain dynamic and responsive.
- **Enact New Legislation:** Introduce Specialised Legislation. It is crucial to enact specialised laws, such as a Cyber Disaster Management Act and a Pandemic Preparedness Act. These new laws would specifically address cyber and health-related disasters, which are increasingly prevalent in today's interconnected world.

Strengthening Institutional Capacities:

- **Capacity-Building Programs:** Develop and implement robust training modules for disaster management professionals and first responders. Comprehensive capacity-building initiatives will help enhance officials' preparedness and effectiveness in responding to disasters.
- **Improved Resource Allocation:** Increase and sustain budget allocations for disaster management. This approach would ensure that the necessary infrastructure, modern equipment, and technology are in place to tackle conventional and emerging disaster risks.

Policy Mainstreaming

- **Integrate DRR into Development Planning:** Integrating Disaster Risk Reduction (DRR) into all significant development projects is essential. By mainstreaming Disaster Risk Reduction (DRR) into infrastructure development, urban planning, and industrial growth, planners can mitigate disaster risks in the early stages rather than responding after an incident occurs.
- **Community-Based Approaches:** Empower local communities to participate actively in disaster preparedness and response. Community engagement is essential for building resilience and ensuring the sustainability of disaster management efforts.

Technological Advancements:

- **Enhance Early Warning Systems:** Investment in advanced meteorological and seismic technologies is critical. Improving forecasting accuracy and timeliness through AI-powered systems will help provide early warnings, reducing the impact of disasters on vulnerable populations.
- **Develop Centralized Information Systems:** Establish interoperable data management platforms that enable real-time data collection and analysis. The centralised data management platform enables agency coordination and enhances disaster response times.

- **Leverage Artificial Intelligence:** AI can enhance disaster management by enabling predictive analytics, optimising resource allocation, and automating response systems. AI tools can assist in modelling disaster risks, mapping vulnerabilities, and informing decisions on resource distribution.
    - **Strengthening AI capabilities:** Incorporate AI for vulnerability mapping, risk assessments, and enhanced disaster planning.
    - **AI in disaster response and relief efforts:** AI can enhance situational awareness, optimise resource allocation, and facilitate coordination among emergency responders.
    - **Ethical, legal, and governance issues with AI:** Implement ethical guidelines and governance frameworks to address challenges such as data privacy, algorithmic bias, transparency, and accountability in AI systems used for disaster management.

International Collaboration:

- **Forge Global Partnerships:** India should actively collaborate internationally, sharing knowledge and resources with other countries that are also prone to disasters. Bilateral and multilateral agreements can facilitate the exchange of best practices and technology.
- **Adhere to International Standards:** Align national disaster management strategies with international frameworks, such as the Sendai Framework for Disaster Risk Reduction and ISO standards, to help India refine its approach and ensure adherence to global best practices.

Enhancing Local Governance and Community Participation:

- **Decentralisation and Empowerment: Future legal reforms should empower local bodies by providing clear guidelines and resources for developing disaster management plans tailored to local vulnerabilities and needs**. Localised disaster management strategies will ensure communities are better prepared and equipped to handle disasters effectively.

Sustainable Development Goals (SDGs):

- **Link Disaster Management Policies to the SDGs: Align disaster management strategies with the broader Sustainable Development Goals (SDGs)**, particularly those focused on climate action, sustainable cities, and resilient infrastructure. Incorporating disaster risk reduction into sustainable development policies ensures that disaster management contributes to long-term socio-economic and environmental goals.
- **Link Legal Frameworks to SDGs:** Update existing disaster management laws to explicitly connect disaster risk reduction to sustainable development objectives, reinforcing that disaster resilience is critical to sustainable development.

Regular Review and Adaptive Legislation:

- **Establish a Legislative Review Body:** Create a dedicated body to periodically review disaster management laws, ensuring they remain up-to-date with emerging risks, technological advancements, and global standards. Regular reviews would ensure India's legal framework remains adaptive and resilient to changing disaster dynamics.

Education and Training:

- **Strengthen Preparedness Through Education:** Incorporate disaster risk reduction education into schools, higher education, and professional training programs to strengthen disaster preparedness at all societal levels. Building a culture of preparedness within society is key to effective disaster risk reduction.
- **Incorporate Legal Requirements:** Integrate disaster management education into academic curricula to cultivate a generation well-versed in disaster risk reduction strategies, laws, and community-based preparedness.

7.2 Future Research Directions

While this study provides a comprehensive analysis of India's disaster management legal frameworks, several areas warrant further research to ensure the continuous improvement and adaptation of the country's disaster management systems:

- **Impact Assessment of Legal Reforms:** Future research should assess the effectiveness of recent legal reforms, particularly those related to new disaster types such as cyber disasters or pandemics.
- **Technological Integration in Disaster Management:** Investigate the impact of AI, GIS, and IoT on disaster preparedness, response, and recovery. Assessing the integration of these technologies in India's disaster management system will help identify both benefits and challenges.
- **Community Resilience Metrics:** Develop metrics to measure community resilience and evaluate the effectiveness of community-based disaster risk reduction programs.
- **Inter-Agency Coordination Models:** Comparative studies on coordination mechanisms between various disaster management agencies can provide valuable insights into optimising collaboration for improved response outcomes.
- **Climate Change Adaptation:** Research on integrating climate change adaptation strategies within disaster management frameworks will help enhance resilience to future climate-induced disasters.

Addressing these research gaps will contribute to the evolution of India's disaster management framework, ensuring it remains responsive to current and emerging risks. By integrating innovative technologies, community engagement, and robust legal reforms, India can continue to develop a resilient disaster management system that effectively mitigates risks and protects its people from the devastating impacts of disasters.

8. Conclusion

This study examines the evolution of disaster management laws in India, tracing the historical development of legal frameworks from colonial times to the enactment of the Disaster Management Act (DMA) 2005. Over the years, India's approach to disaster management has transitioned from reactive relief-focused strategies to more proactive and comprehensive frameworks aimed at risk reduction, preparedness, and resilience. Despite the significant advancements, challenges such as overlapping authorities, resource constraints, and the need for greater community involvement persist. Key findings highlight the evolution of disaster management laws in India, the ongoing challenges in their implementation, and the need for legal reforms to address emerging threats, including cyber disasters, pandemics, and the impacts of climate change. While the Disaster Management Act of 2005 was a landmark reform that established a structured framework for disaster management, the country's disaster resilience still requires continued adaptation to new challenges posed by rapidly changing socio-economic conditions, technological advancements, and environmental shifts. The study underscores the importance of technological integration, particularly the role of Artificial Intelligence (AI), Geographic Information Systems (GIS), and the Internet of Things (IoT), in enhancing early warning systems, resource management, and data-driven decision-making.

Additionally, integrating AI into disaster management systems can revolutionise risk modelling, vulnerability mapping, and real-time disaster response, optimising resource allocation and improving situational awareness during emergencies. However, robust ethical frameworks and governance mechanisms must accompany these technological advancements to ensure fairness, accountability, and transparency in their application. Future research should examine the impact of AI in disaster management, focusing on the socio-economic effects, the role of community resilience in disaster risk reduction, and how to further integrate climate change adaptation into disaster management policies. Additionally, researchers need to explore the effectiveness of the legal reforms introduced by the DMA 2005 and its amendments, as well as their alignment with international frameworks, such as the Sendai Framework and the Sustainable Development Goals (SDGs). Strengthening capacity building, improving resource allocation, and fostering inter-agency coordination are crucial to enhancing India's disaster management capabilities and ensuring its ability to respond effec-

tively to future challenges. In conclusion, a robust, adaptive, and forward-looking legal framework for disaster management is crucial for mitigating risks, protecting lives, and promoting sustainable growth. Integrating advanced technologies and aligning national policies with global standards will play a critical role in building a disaster-resilient India that can effectively face the emerging challenges of climate change, technological disruptions, and evolving disaster risks.

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Article

Impacts of Flooding Disaster Risk Management Policy For Resilience Building in Pastoral and Agro-pastoral Community: The Case of Dassenech, Southern Ethiopia

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ABSTRACT

Disaster risks management policy framework and action undertaken significantly influence disaster resilience capacities of pastoral and agro-pastoral communities of the lower Omo Valley region. This was widely hindered by the government's inability to take effective infrastructural, institutional, social, and economic measures in response to its critical function at the desired level when the lower Omo Valley Dassenech rural communities were exposed to the Omo River flooding disaster. This article aims to explore and investigate the impacts of disaster risk management policies and strategies on building disaster-resilient pastoralist and agro-pastoralist Dassenech communities. Throughout the study, the researcher employed an interpretativist epistemological paradigm. Consequently, the study's findings reveal that the existing policy framework overlooks the pastoral and agro-pastoral concerns associated with the recurring occurrence of the Omo River flooding disaster in the area. Therefore, building disaster-resilient pastoral and agro-pastoral communities has a substantial impact on the realisation of effective disaster risk management while ensuring sustainable socio-economic development in the lower Omo Valley southern regions of the country.

KEYWORDS

Disaster risk management; disaster resilience; flooding; climate change; pastoralist; agro-pastoralist; community.

1. Introduction

The world today faces increasingly frequent, severe, and complex social, economic, and climate risks, where shocks and stresses undercut sustainable development gains and overall human well-being (USAID, 2024). The geospatial distribution of both natural and man-made (technological) disasters across the continent from 1900 to 2024 reveals significant trends and patterns in the frequency and spread of various disaster types worldwide (Cvetkoic et al., 2024). According to Cvetkovic et

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al. (2024), a total of 25,836 disasters were recorded worldwide, of which 69.41% were natural disasters, and 30.59% were man-made (technological) disasters. Most natural disasters predominantly occurred in Oceania, accounting for 91.51% of all recorded natural disasters. Indeed, man-made disasters or technological disasters were most prevalent in Africa, occurring in 43.79% of all disasters (Cvetkovic et al., 2024). Hard-won social and economic gains can easily be undermined by recurrent shocks and stresses, sending rural people back into poverty. Meanwhile, ongoing and compounding crises, including global climate change, food crises, rising inequality, and conflict, are generating spiralling humanitarian needs while increasing fragility and poverty backsliding (USAID, 2024). Even though this crisis is more severe in the Sub-Saharan countries. Over the last few decades, Ethiopia has faced multiple disasters, both natural and human-made, including floods, droughts, stormy rains and winds, landslides, locust swarms and pest infestations, disease outbreaks, conflicts, endemic diseases, and pandemics (ERCS, 2021). The intensity and frequency of disasters in the country have been increasing due to several underlying factors, including widespread poverty, climate change, high population growth, severe environmental degradation as well as violence and conflicts often recurring in various parts of the country, which collectively increase most rural peoples vulnerability to disastrous risks, food insecurity, and social, economic and political marginalisations (ERCS, 2021). The situation is much more severe in the pastoralist and agro-pastoralist regions of the country. These modes of life are mainly dependent on animal husbandry accompanied by subsistence crop production. Livestock production is of crucial importance to the incomes, economies, and livelihoods of hundreds of millions of Africans, particularly and the world at large (Abduletif, 2019; FAO, 2021). In countries like Ethiopia, pastoralists and agro-pastoralists are primarily found in the lowlands, which are commonly characterised as arid, semi-arid, and sparsely populated (Kurt, 2003; FAO, 2018; Tofu et al., 2023). It covers 61% of Ethiopia's total landmass, with 97% of it concentrated in the northeast, East, and southern parts of the country (Tofu et al., 2023). It provides livelihoods for more than 12 million of its population, who drive most of their income from livestock herding and complement it with small farming (CSA, 2013; FAO, 2018). Economically, the sector contributes 20% to the national GDP through the livestock sector (Abduletif, 2019; Ayele et al., 2020). Despite this, the progressive policy shift was demonstrated when the country promulgated the 2013 National Disaster Risk Management policy.

This shift has transformed the country's disaster risk management approach from a predominantly drought- and food insecurity-focused, relief-oriented model to a multi-sectoral disaster risk management approach (EDRMC, 2022). Even though, the fundamental misconceptions about pastoralist and agro-pastoralist production systems in the country have led to a general perception among policymakers that "pastoralist and agro-pastoralist land are underused and therefore should be developed" (Elias & Abdi, 2010). Such misconceptions have led to the social, political, and economic marginalisation of pastoral and agro-pastoral communities. Most disaster risk management policies and strategies have favoured externally imposed development schemes, which often alienate and expropriate pastoral and agro-pastoral lands in favour of large-scale commercial and River dam investment activities. The curtailment of natural resources and mobility has rendered pastoral and agro-pastoral rural households vulnerable to frequent droughts, food insecurity, and famine (Elias & Abdi, 2010). According to Auma and Mahiri (2022), communities living in floodplains are predisposed to disaster risks due to geophysical factors and behaviours, including apathy in community-based disaster preparedness activities. The Lower Omo Valley pastoralist and agro-pastoralist community of the Dassenech is among those subjected to the effects of natural resource alienation and a lack of recognition and protection through disaster risk management policies and strategies. Therefore, this paper aims to explore and describe the impact of flood disaster risk management policies on building resilience in pastoral and agro-pastoral communities, specifically focusing on the Dassenech people in Southern Ethiopia, through assessing the gaps and limitations of national DRM policies and strategies while building social resilience in the pastoral and agro-pastoral communities of Lower Omo Valley.

2. Methods

2.1. Description of Study Area

South Omo (or Debub Omo Zone) is a zone in the Ethiopia Southern Nations, Nationalities and Peoples 'Region (SNNPR). South Omo (Debub Omo) is bordered on the south by Kenya, on the southwest by South Sudan, on the west by Bench Maji, on the northwest by Kefa, on the north by Konta, Gamo, Gofa, and Basketo, on the northeast by Dirashe and Konso, and the east by the Oromia Region. The administrative centre of south Omo (Debub Omo) is Jinka. The area of the South Omo Zone is approximately 20,000 km² (ibid).

This area is named for the Omo River, a river that flows south into Lake Turkana on the western side. Mago National Park and Tama Wildlife Reserve are located on the eastern bank of the Omo River. There is Lake Chew Bahir, surrounded by Stephanie Wildlife Sanctuary, located at the eastern border of this zone. Notable high points include Mount Smith (2560 meters) and Mount Mago (2538 meters). West of the Omo is the most sparsely populated part of Ethiopia, inhabited by nomadic (Pastoralist) and semi-nomadic (agro-pastoralist) ethnic groups. The infrastructure of the Zone is "weak and for the most part non-existent; this is a disadvantage inherited from historical neglect of a typical marginal region (ibid)." It also observed that the South Omo Zone is "one of Ethiopian's socially most diverse zones. It contains a minimum of 12 different ethnic groups and possibly as many as 21. Social diversity, therefore, compounds the existing problems of isolation, acute shortage of basic infrastructure, as well as scarcity of professional and technical manpower."

South Omo has 462 kilometres of all-weather roads and 412 kilometres of dry-weather roads, resulting in an average road density of 37 kilometres per 1,000 square kilometres. According to the Central Statistical Agency (CSA), 1,364 tons of coffee were produced in South Omo in the year ending in 2005, representing 1.36% of the Southern Nations, Nationalities and Peoples' Region (SNNPR)'s output and 0.6% of Ethiopia's total output.

Based on the (2007) Census conducted by the CSA, this Zone has a total population of 573,435, of whom 286,607 are men and 286,828 women; with an area of 21,055.92 square kilometres, South Omo has a population density of 27.23. While 43,203, or 7.53%, are urban inhabitants, a further 25,518, or 4.45%, are pastoralists. A total of 125,388 households were counted, resulting in an average of 4.57 persons per household and 121,309 housing units. The eight largest ethnic groups reported were the Aari (44.59%), the Male (13.63%), the Daasanach (8.17%), the Hamer (8.01%), the Banna (4.42%), the Amhara (4.21%), the Tsamai (3.39%), and the Nyangatom (2.95%); all other ethnic groups made up 10.63% of the population. Aari is spoken as a first language by 44.34%, 14.25% speak Male, 8.17% Hamer, 8.16% Daasanach, 5.07% Amharic, 4.49% Banna, 3.03% Tsamai, and 2.94% speak Nyangatom; the remaining 9.55% spoke all other primary languages reported. 50.86% practised traditional beliefs, 30.44% were Protestants, 12.23% of the population identified as Ethiopian Orthodox Christians, and 1.33% were Muslim.

According to May 24, 2004, World Bank memorandum, 4% of the inhabitants of South Omo have access to electricity; this zone has a road density of 22.7 kilometres per 1000 square kilometres (compared to the national average of 30 kilometres) the average rural household has 0.4 hectares of land (compared to the national average of 1.01 hectare of land and an average of 0.89 for the former SNNPR) the equivalent of 1.5 heads of livestock. 11.5% of the population is in non-farm-related jobs, compared to the national average of 25% and a regional average of 32%. Thirty-seven per cent of all eligible children are enrolled in primary school, and 7% are enrolled in secondary schools. 77% of the zone is exposed to malaria, and 61% to Tsetse fly. The memorandum gave this zone a drought risk rating of 348. This Zone was selected by the Ministry of Agriculture and Rural Development in 2004 as one of several areas for voluntary resettlement for farmers from overpopulated areas; no specific woredas within this zone were identified in this program. The lower Omo Valley, downstream of pastoral and agro-pastoral communities, comprises Dassenech, Hamer, Nyangatom, and Selamago Woredas. This study has been undertaken in Dassenech Woreda, which has been vulnerable to the Omo River flooding disaster and its multifaceted effects for a decade.

Dassenech Woreda is located in the South Omo Zone of the former Southern Nations, Nationalities, and Peoples' Region (SNNPR) state in Southwestern Ethiopia. It is 860 km away from Addis Ababa and 205 km from Jinka. The woreda is bounded by Hamer woreda to the North and east, Kenya to the south, and Nyangatom woreda to the west and Northwest. The woreda covers a total area of 234,274 ha, with elevation ranging from 275 meters to 400 meters above sea level, and is found at a latitude and longitude of 4°48′N 35°58′ECoordinates: 4°48′N 35°58′E. It has only one Agroecological zone - Kolla (100%). The mean annual rainfall of the Woreda is about 350 mm. The annual mean temperature ranges from 30 °C to 40 °C (Dassenech Woreda Pastoral Development Office, 2024).

The Dassanech are the people who speak an East Cushitic language and live on the Ethiopia-Kenya border, on the northern shore of Lake Turkana, and further north along the Omo River. The population is estimated at 48,067 (CSA, 2007, p. 84), and according to the Woreda Health Centre, the population of Dassenech is currently estimated to be 80,000. According to unpublished data from the South Omo Zone Administration, the land area of the Dassenech is 2,575 sq km. Until 2006, the area was part of the administrative unit of Kuraz woreda. Following the 2006 administrative restructuring, Dassenech land was elevated to a District (Woreda) level, with its capital at Omorate, located approximately 852 km south of Addis Ababa. The Dassanech Woreda is divided into 40 units called kebele.

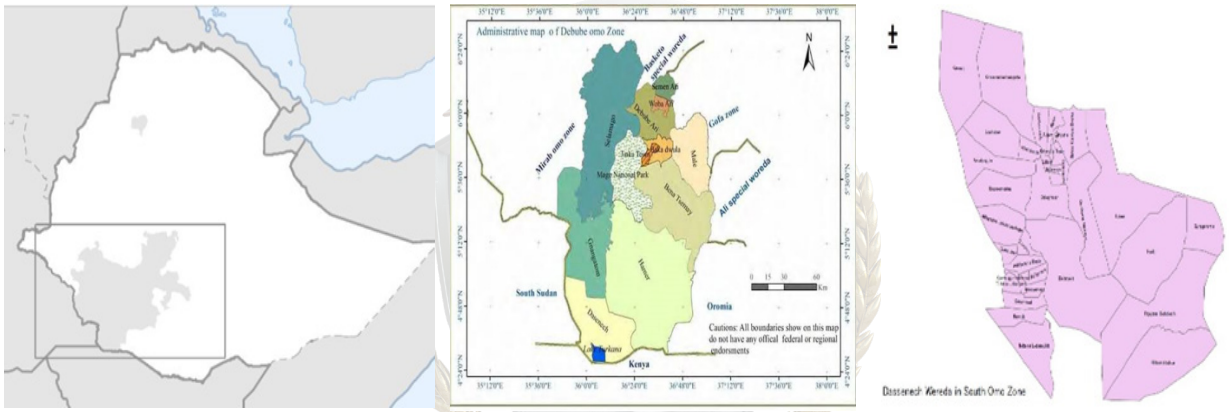

Figure 1: Dassenech Woreda Map at the right edge.

2.2. Research Approach and Design

In social science research, there are three major theoretical paradigms: positivism, phenomenology, and interpretivism. Among these phenomenological or interpretive traditions, there is a long history in philosophy and sociology (Berger & Luckmann, 1967; Bruyn, 1966; Husserl, 1962; Psathas, 1973; Schutz, 1962, 1966). As Jack Douglas (1970) wrote, "The 'forces' that move human beings, as human beings rather than simply as human bodies . . . are 'meaningful stuff.' They are internal ideas, feelings, and motives" that important reality is what people perceive it to be. The interpretive approach seeks to understand through qualitative methods, such as participant observation and in-depth interviewing, which yield descriptive data (Vanderstoep & Johnston, 2009). Through employing a qualitative research method, we are enabled to explore more profound insights into the real concerns and understand the complex concepts, perspectives, and experiences of target communities rather than collecting numerical data. Therefore, to understand social phenomena from the study participants' or actor's perspectives and points of view and to examine the world they experienced while exploring the trends and patterns of flooding disasters, disaster risk management systems, and their impacts on pastoralist and agro-pastoralist communities of Dassenech people perspective and experiences, the researcher employs phenomenological or interpretative epistemological paradigm.

2.2.1. Methodological Paradigm

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2.2.2. Study Approach and Design

As Glaser and Strauss (1967) suggest, "grounded theory" may be said to be grounded to the extent that it is derived from and based on the data themselves. Therefore, due to the exploratory nature of this study, the researcher employed a qualitative research design and utilised participatory rural appraisal tools and techniques to address the gaps in the proposed data collection methods of the study. The merit that qualitative research design and participatory rural appraisal tools and techniques bring to this study critically enables the development of concepts, insights, and understanding about the study area of emphasis in this research paper. As well as to analyse, theorise, or build theory rather than collect data to assess preconceived models, hypotheses, or theories with the assumption that knowledge is constructed. Therefore, to explore and describe the phenomena under study in this research, the researcher employed a narrative approach to identify the major themes. This approach enabled the researcher to gain insight from the perspective of the study's target population, which provided an understanding of their interpretations and experiences regarding flood disaster risk management, social resilience, and coping strategies among the Dassenech people.

2.2.3. Sampling Procedure and Sample Size

Qualitative researchers are sceptical that any conclusions can be broadly generalised to a large population because any effort to generalise extrapolates the characteristics of a sampling unit beyond the context that gives it meaning (Vanderstoep & Johnston, 2009). Researchers may employ several different sampling design methods when sampling target populations in the study area. The design will likely differ depending on the research type. Considering the purposes of this study and major themes, the researcher employs a purposive sampling procedure using a non-probability purposive sampling strategy. This enabled an in-depth understanding of the study area, which is the emphasis of this research. Additionally, to best represent the study population. To gather in-depth data, the researcher intentionally selected study participants based on their characteristics, knowledge, and experiences related to flooding disasters. This approach enabled an in-depth understanding of the study area. It ensured adequate representation of the study population, which is based on the representative attributes of participants studied throughout the analysis. Indeed, Sample size is usually determined by the level and type of study analysis planned. However, the key is to sample enough rare groups to have meaningful responses for the study. Select a sample size that yields meaningful results for the study being conducted.

However, for this study, the sample size is based on the major themes being explored. Therefore, the researcher tried to select an equal representation from the identified sample respondents of the study, which includes community leaders and elders, development agents, government entities representatives, such as pastoralist development affairs offices, Agriculture and natural resource development offices, pastoral productive safety net program (PSNP), Disaster response and resilience management (DRMM) sectors, Woredas Administrative Offices, Woreda health Offices, and livestock and fishery resource development offices. As well as representatives from non-governmental

organisations currently active and operating in the study area and representatives from the Ghibe-III dam or other relevant organisations. Which is constructed based on the data collection tools described in the section on each of the data collection instruments in this research thesis. Therefore, the researcher purposively selects sixteen (16) key informants, twelve (12) in-depth interviewees, thirty-two (32), and eight (8) focus group discussion and case study participants, respectively.

2.2.4. *Source of Data*

The researcher used primary and secondary sources of data for the study. Indeed, the primary sources of data have been collected through key informant interviews, in-depth interviews, Focus group discussions, and case studies with 68 respondents in the study. At the same time, previous research papers related to pastoralists and agro-pastoralist issues, especially about the study area and topic, unpublished research, reports, journal articles, and literature on historical, socio-economic, cultural, political, and ecological data, and project Intervention reports by GO and various NGOs working in the area have been used as secondary data sources. In addition, various research reports related to the lower Omo Valley communities, specifically those of the Dassenech communities, were critically reviewed by individual researchers and local and international institutions. Then, the data gained from both sources have been used as background information and a building block to strengthen the presentation of the study findings and analysis.

2.2.5. Method of Data Collection

The backbone of every research is the collection of data that a researcher has identified as worthy of analysis (Papachroni & Lochrie, 2015). Interviews, survey questionnaires, publicly available information, and audiovisual materials are all potential sources of data for a researcher. However, collecting data can be a daunting experience, either because there is too little data or because what appears to be a rich dataset has turned into a nightmarish sense of data overload (Papachroni & Lochrie, 2015). It is, therefore, helpful for evaluating data sources, which saves valuable time and resources and also tends to lead to better analysis and more robust results. What constitutes good practice when collecting data is very much dependent on the research tradition within which the study is placed, either of qualitative or quantitative data collection tools; while considering the nature, purpose, and objective of this study, the researcher employed qualitative data collection methods such as key informant interview, in-depth interview, focus group discussion, and case study.

2.2.5.1. Key Informant Interview

Key informant interviews are qualitative interviews with individuals who possess in-depth knowledge and understanding of the specific topics or issues addressed in the study or community problem. According to Mikkelsen (2005), the representatives of key informant interviews were ordinary people, not necessarily specialists, and better educated than those in power or officials. According to Julie Laforest et al. (2009), key informants from the community under study are " privileged witnesses, people who, because of their position, activities or responsibility, have a good understanding of the problem to be explored. Therefore, to collect detailed data about the impact of Omo River Flooding and Communities' Vulnerability, Livelihood resilience, and coping mechanism, the researcher purposively selected four at most Omo River flooding disaster-affected clusters (Rate – Borkonoch, Kelem Cluster, Libemuket, and Delegnmur cluster). Indeed, the researcher conducted key informant interviews with 16 people, including purposively selected community leaders, elders, representatives from social institutions, and development agents, at these kebeles.

Figure 2: Interview with Delegnmur Kebele Communities Elder (2024)

2.2.5.2. In-depth Interview

An in-depth interview is a valuable qualitative data collection technique that can be employed for various purposes, including needs assessment, program refinement, issue identification, and strategic planning. According to Lisa et al. (2011), in-depth interviews are most suitable for situations in which the researcher seeks to ask open-ended questions that elicit in-depth information from a relatively small number of people (as opposed to surveys, which tend to be more quantitative and are conducted with large numbers of participants).

To collect and explore detailed information on proposed major themes under in-depth interview (i.e. vulnerability to the effects of disastrous events, mode of adaptation in the past and today, and government development programs, policies, and strategies), the researcher purposively selects twelve (12) respondent through purposive sampling method, which includes selected government entity representatives, such as pastoralist development affairs offices, Agriculture and natural resource development offices, pastoral productive safety net program (PSNP), Disaster response and resilience management (DRMM) sectors, Woredas Administrative Offices, Woreda health Offices, and livestock and fishery resource development offices as well as four (4) non – non-governmental organisations representatives who are currently active and operating in the study area. Despite planned in-depth interviews with Ghibe-III dam respective or concerned representatives not being carried out due to time and cost limitations. Even though the collected data, via in-depth interviews, helped the researcher address issues not addressed under FGDs and key informant interview questionnaires with detailed elaborations. Throughout the process, the researcher developed in-depth interview data collection guidelines and theme-based questionnaires to ensure the quality of the data collection process.

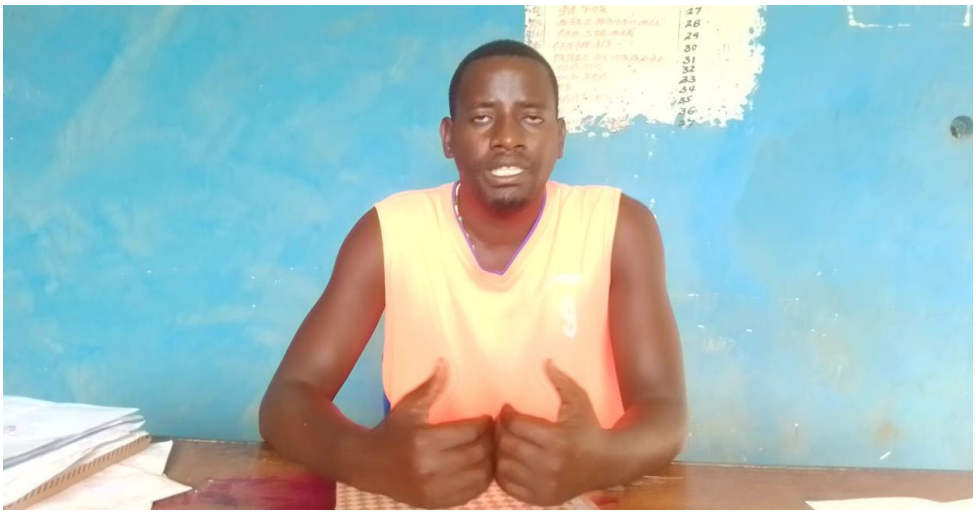

Figure 3: In-depth Interview with Dassenech Woreda Pastoralist Development Affair Office Senior Expert (2024)

2.2.5.3. Focus Group Discussion

Focus groups are considered a reasonable alternative to conduct several individual interviews with participants in the discussion, which is used to generate qualitative insights or produce direct quotes that can represent the view of the group under study, as well as to fill the gaps of other data collection tools, which have been used for this study while accessing the view of those who would not be will or able to speak up at larger, group meetings. This is possible because FGD groups can be comprised entirely of people from specific disadvantaged groups who may not feel comfortable discussing their particular opinions in a mixed setting (INTRAC, 2017). Therefore, for this study, the researcher brings together a group of eight (8) community members or people. The sampling of these selected group members for a focus group was random; intentional decisions were made to achieve the best group composition in light of the study's themes and probing questions. Then, under the guidance of an FGD moderator, the researcher engaged in a group question–and–answer discussion. As a result, nearly four (4) focus group discussions have been conducted. Each group constituted eight (8) participants, and 32 people in total were selected who live a long side downstream of the Omo River Valley village of Dassenech communities (i.e. Rate, Kelem, Arikol, and Seremret kebeles). Indeed, focus group discussions with these kebeles provided immense qualitative data or information about villagers' adaptation and coping strategies to the effects of hazardous events (drought, flooding, disease outbreak, i.e. human and livestock, conflict, etc.), effectiveness and impacts of government disaster risk management policy, government pastoralist, and agro-pastoralist resilience building program intervention has been the major themes of the discussion.

Figure 4: Focus group discussion with Rate - Borkonech villagers (2024)

2.2.5.4. Case Study

There are several types of case studies. A researcher may choose to conduct either a single-case study or a case study involving multiple cases. According to Scott W and Deirdre D. (2009), a collective case study involves a comparison of several related cases. A case study can also be focused on one person, known as a biographical case study, or on one event, referred to as a critical incident study. This method of data collection enabled the researcher to explore and describe the nature of Omo River flooding and its impact on the livelihood processes and strategies of pastoral and agro-pastoral households in the lower Omo Valley, as practised by the Dassenech people.

Throughout the data collection processes of this study, the researcher purposively selected four (4) villages. This is based on their vulnerability and exposure to the effects of flood disasters while also mitigating their impact. Then, villagers inquired about the impact of disaster management on local government. Details of the subjective aspect, such as feelings, beliefs, impressions, or interpre-

tations, enabled an in-depth understanding of the villagers' flooding disaster experience. Semi-structured interviews have been administered to collect detailed data from selected villagers. The types of livelihoods, vulnerability contexts, and coping strategies related to flooding disasters, as well as trends in access to and use of disaster risk management systems, have been the major themes explored in the case study of this research.

Figure 5: Case Study of Libemuket Cluster Kebeles (2024)

2.3. Data Analysis and Interpretation

The data gathered through the above qualitative data collection tools were organised in line with the objectives of this research study by employing qualitative analytical procedures. The data were categorised logically based on identified patterns within and between the concepts. Therefore, the research employed content analysis guided by the grounded theory approach. The transcribed data were then categorised according to the themes that guided the discussions in this study; finally, all collected qualitative data were analysed using thematic analysis. Connections and reflections between theory and practices on the ground have been discussed using the early warning system conceptual Framework Analysis, which guides the drawing up of conclusions and recommendations regarding the study.

3. Results

3.1. Disaster Resilience

According to DFID (2010), the concept of Disaster Resilience is defined as the ability of countries, communities, and households to manage change by maintaining or transforming living standards in the face of shocks or stresses, such as drought, violent conflict, and flooding without compromising their long-term prospects. This concept has become more important for modern societies as states learn to adapt and manage disaster risks in ways that minimise their impacts. In general, resilience is understood as the ability of a system to withstand, recover from, or even become stronger after exposure to critical events or shocks. Accordingly, resilience is described as the capacity of the affected community to self-organize, move away from negative situations, and recover stronger than before (Zobel, 2010). On the other hand, according to Kırıkkaya (2017), disaster resilience refers to the ability of a society, community, or system to cope with disasters, minimise damage, and balance its social, physical, and psychological capacities. In other terms, the concept of disaster resilience is described as the capacity, ability, or competence of communities to cope with stress, crisis, or a disaster to return to pre-existing conditions (Lucini, 2014). In a broader sense, disaster resilience refers to a society or social system's ability to overcome disasters and emergencies and successfully regain

equilibrium with its social, psychological, economic, and physical capacities (Ahsan et al., 2018). Mayunga (2014) demonstrated disaster resilience as the capacity of communities to mitigate, prepare, respond, recover, and adapt to new conditions while learning from past experiences. This includes the capacity to reduce or prevent losses, control the effects of disasters, and recover with minimal social, economic, and local community disruptions. Resilience is a process, the state of continuous learning and taking responsibility to develop and maintain the capacity to cope with hazards (Cutter, 2008). While fully exploring and describing disaster risk management practices in the pastoral and agro-pastoral communities of the lower Omo Valley, the concept of disaster resilience is examined through the lens of its major dimensions.

3.1.1. Dimension of Disaster Resilience

Disaster Resilience has four major dimensions, including technical, organisational, social, and economic dimensions (Bruneau, 2003; Rodriguez, 2022). The technical dimensions of disaster resilience focus on the ability of physical or infrastructural systems to perform at desired levels when communities are exposed to disasters. This includes the provision of public services before, during, and after flooding disasters to the pastoral and agro-pastoral communities of the Dassenech. The organisational dimension of disaster resilience focuses on the ability of national and local institutions and organisations to respond to disasters and perform their critical functions effectively. At the same time, the Dassenech rural villagers are exposed to flooding disasters. The social dimension of disaster resilience encompasses measures taken to mitigate the exposure of communities and governments to the effects of the Omo River flooding disaster. The final dimension of disaster resilience, economic dimensions, refers to the capacity to reduce direct and indirect economic and livelihood losses caused by Omo River flood disaster risks.

3.1.1.1. Technical Dimension

According to Rodriquez (2022), this dimension covers the technical or infrastructures that can be disrupted by a disaster and may require assistance in case of a disaster emergency; it includes the following sub-dimensions:

Health - This quantifies the capacity of a community's health infrastructure to provide health services in the event of a disaster.

WASH (Water, Sanitation, and Hygiene), Electricity, Waste Treatment - This quantifies the capacity of available water, electrical power, sewage, and waste treatment infrastructures. It reflects inductors such as the number of households that can access electricity and water, the existence of alternative power sources, and the number of people who have access to water sanitation and hygiene services.

Figure 6: Koro Cluster Kebeles with limited infrastructural disaster resilience assistance

3.1.1.2. Institutional Dimension

This dimension of disaster resilience describes the institutional attitudes or behaviours towards disaster risk and regarding the implementation of disaster risk reduction, as well as post-disaster response and recovery, and includes the following sub-dimensions (Rodriquez, 2022)

Trust in Government - This sub-dimension measures the population's level of trust in local and national government institutions in the event of a disaster.

Disaster Preparedness and Mitigation - This involves the engagement of local and national governmental institutions in identifying risks, implementing mitigation measures, and producing and engaging communities in preparedness campaigns. It reflects indicators such as the capacity for disaster data collection, the availability of risk maps, the capacity of contingency planning, and the number of emergency drills, early warning systems, and disaster risk-related information campaigns.

Disaster Response and Recovery - This sub-dimension describes the capacity of local and national government institutions to assist communities during an emergency in an effective and timely manner and to provide the means to support a rapid recovery. It reflects indicators such as the types of civil protection systems that are in place, the availability of emergency funds, and multi-sector coordination.

3.1.1.3. Social Dimension

According to Rodriquez (2022), the social dimension of disaster resilience encompasses all the characteristics of vulnerable populations that enable them to cope with an external event and recover from it and has the following sub-dimensions, including:

Social fabric − This represents the composition of the vulnerable pastoral and agro-pastoral Dassenech population. It can help to define the potential post-disaster needs of the Omo River flood, and this sub-dimension reflects indicators related to household size, the number of female-headed households, the number of children per household, population growth, the social disparity index, quality of life, and educational level.

Awareness and Preparedness - This sub-dimension illustrates all characteristics specifically related to knowledge about risks, attitude towards risks and disaster preparedness, and risk reduction measures taken at the household or community level. It reflects indicators related to pastoralist and agro-pastoralist knowledge and perception of risk, risk aversion, and previous disaster-related experiences.

Social Capital − This sub-dimension encompasses all the characteristics that foster a sense of community cohesion. It reflects inductors related to social attachment to the place where they live, sense of community, trust in the community, participation in community activities, shared beliefs, and strong social networks.

Social Capacity − This sub-dimension encompasses all the qualities and skills that enable communities to withstand adversity but does not explicitly target disaster preparedness. It reflects indicators related to adaptive capacity, problem-solving skills, leadership, capacity building, and access to resources.

Social Support − This represents a household's access to support from institutions at different levels. This sub-dimension reflects indicators related to social security, financial support, social assistance, general social services, and entitlement to rights.

3.1.1.4. Economic Dimension

Disaster resilience - economic dimension encompasses all the available economic and livelihood resources of the communities at pastoral and agro-pastoral household and national levels that enable it to cope with external events and recover from them, and it includes the following sub-dimensions(Rodriquez, 2022):

Economic level − This sub-dimension represents the amount and sources of economic resources on which the pastoral and agro-pastoral Dassenech communities can rely. It reflects indicators related to the level of income, income diversification, and sources of income.

Wealth Distribution − This describes how wealth is distributed across the Dassenech rural population and among gender in the communities.

Pre-Disaster Financial Services − This sub-dimension describes the availability of financial services prior to a disaster for pastoral and agro-pastoral villagers.

Post-disaster Financial Services − This refers to the range of financial services that can be provided after a disaster has occurred.

Resources − This sub-dimension encompasses all the essential resources necessary to address an Omo River flooding disaster crisis and meet the response and recovery needs of the Dassenech communities.

Figure 7: Dassenech rural villagers with lack of pre and post-disaster resilience financial services (2024)

Trend of Disaster Risk Management in Ethiopia

The country is exposed to a wide range of disaster risks associated with its diverse geography, climate, and socio-economic conditions (FAO, 2022). Recurrent droughts and flooding pose significant challenges to the pastoral and agro-pastoral communities of the Lower Omo Valley, particularly the Dassenech. However, several other disasters, including conflicts, crop pest outbreaks, and livestock and human diseases, also impact communities, rural livelihoods, and the country as a whole. Despite the country's long-standing trend of recurrent drought and flooding, a formal DRM structure can be traced back to the drought and famine of 1973/74 (FAO, 2022). Before 1973, there was no well-established and organised disaster management institution, and responses to crises up until then were ad hoc (FAO, 2022). The first formal government disaster management institution was established in 1974 with the establishment of the Relief and Rehabilitation Commission (RRC) with a mandate to provide relief assistance to drought-affected rural people in the Northern part of the country (i.e. Wollo and Tigray regions/provinces). Under the first government response to disaster management policy and strategies - RRC, much attention was given to the highland agrarian rural communities of the country, despite the lowland pastoral and agro-pastoral communities being neglected and struggling with multiple disasters. Then the RRC was subsequently transformed into the Disaster Prevention and Preparedness Commission (DPPC) in 1995, following the implementation of the first National Policy on Disaster Prevention and Management (NPDPM) in 1993 (FAO, 2022).

The established DPPC had the responsibility of providing support for disaster-affected rural populations, particularly for those affected by severe drought. Although some research findings reveal that RRC achieved significant standards in its implementation of relief measures undertaken (Dewaal, 1997), it also suffered from shortcomings and gaps, specifically due to the lack of an early warning system as a crucial component of disaster risk management. This limitation was apparent when it was reported that more than 250,000 people died in the Central and Northern highland areas of the country following the 1973/74 famine (FAO, 2022), which was also one of the first drought and famine disasters in the country. The lack of national preparedness strategies and the absence

of an effective early warning system highlighted a pressing need to concentrate and strengthen the government's capacity to produce early warning information upon which to base its impact mitigation and response measures for future emergencies. This prompted the government of Ethiopia to rename DPPC to Disaster Prevention and Preparedness Agency (DPPA) in 2004, with a revised mandate to focus on emergency response (FAO, 2022).

Although DPPA has been highly practical and effective in saving the lives of rural communities, its contribution to reducing vulnerability to disaster risks and building resilience to recover from shocks was considered low (FAO, 2022). Consequently, in 2008, the power and responsibility of DPPA shifted to the Ministry of Agriculture and Rural Development (MoARD). Afterwards, MoARD established the Disaster Risk Management and Food Security Sector (DRMFSS), which comprised two major directorates: the Early Warning and Response Directorate (EWRD) and the Food Security Coordination Directorate (SFCD) in 2007 (FAO, 2022). This led to significant change, shifting from a strategy that primarily focused on drought and support for life-saving relief and emergency assistance during disasters to a comprehensive disaster risk management approach. Unlike the previous approach, this approach has been implemented to reduce disaster risks and their potential consequences by providing appropriate and timely responses to disasters through the establishment of a coordinated, accountable, and decentralised system of disaster risk management.

In 2013, the Ethiopian government passed another proclamation, shifting the DRMFSS to the National Disaster Risk Management Commission (NDRMC). This prompted the preparation and adoption of the National Policy and Strategy on Disaster Risk Management (NPSDRM) (FAO, 2022). However, NPSDRM is aware that global humanitarian actors are frequently criticised for establishing parallel structures and undermining existing systems. Despite this, the NDRMC has been mandated to serve as the central body for coordinating and implementing all government disaster risk management efforts. All humanitarian assistance, including local and international, was supposed to be coordinated and channelled through the established commission. In this manner, it has been possible to minimise the common pitfalls in the country due to the government actively assuming and defending its leadership role (IAHE, 2019). The close integration of international humanitarian and government responses was widely regarded as a key factor in explaining the successes of the drought response in recent years. The humanitarian crisis triggered by conflicts and the need to respond effectively and promptly to the concerns of millions of internally displaced rural people has prompted the government of Ethiopia to relocate the NDRMC from the Ministry of Agriculture (MoA) to the Ministry of Peace (MoP). Throughout, the overall trends in the country's disaster risk management response have placed much more emphasis on the Northern, Northeastern, and Western regions, as well as Southern highland rural communities. Almost all lowland pastoral and agro-pastoral communities are severely marginalised due to their limited consideration and inclusion in disaster management policies and strategies.

3.2.1. The Need for Paradigm Shift

Most rural parts of the country are exposed to a wide range of disasters, largely due to their extensive dependence on rain-fed subsistence agriculture, climate change, resource degradation, diverse climatic and socio-economic conditions, and conflicts (FAO, 2022), particularly among pastoral and agro-pastoral communities in lowland regions. Drought and floods are the significant challenges that Lower Omo Valley villagers face today; however, several other threats also affect rural lowland communities and their livelihoods, including conflict, desert locusts, fall armyworm, crop pests, diseases, livestock disease outbreaks, forest fires, and human diseases (FAO, 2022).

Multiple literature sources of evidence suggest that Ethiopia would feel the human and economic impacts of climate change intensity, and the impacts will only continue to grow if the country continues a business-as-usual approach to crisis response and will not be able to manage the increasing scales of the rural pastoral and agro-pastoral communities challenges (FAO, 2022). As a result, there is a consistent call from all stakeholders for a paradigm shift in the way the country addresses rural communities at risk to take preventive actions that reduce exposure, vulnerability, and impact at the local level. This requires moving away from a reactive system to the disaster that solely focuses on drought and supply of life-saving humanitarian relief and emergency responses during disasters

to a comprehensive, proactive disaster and climate risk management approach, including climate change adaptation, among which are interventions to enhance livelihood diversification, social protection programs and risks transfer mechanisms (FAO, 2022).

Although significant progress has been made over the last nearly 50 years in managing drought disaster risks through large-scale prevention and mitigation programs, with a focus on vulnerabilities, rural household asset building, and public works for environmental rehabilitation and generating livelihood diversification, much remains to be done. According to the Food and Agricultural Organisation (2022), preparedness has been enhanced by the development of various policies and strategies, including early warning and response systems, as well as economic, social, and physical infrastructures, to strengthen the local pastoralist and agro-pastoralist communities' economies and their livelihoods. In addition, an attempt has also been made to establish a humanitarian response mechanism, improve coordination, and enhance resource management and prioritisation.

3.3. Disaster Risk Management Policy and Strategy

The country's new national policy on disaster risk management provides a comprehensive framework of disaster risk management (DRM) measures, serving as an amendment to the 1993 national policy on disaster prevention and management (UNDRR, 2021). It includes general directions and major implementation strategies, such as decentralised DRM systems, early warning and risk assessment, information management, capacity building, and the integration of disaster risk reduction into the development plan. The primary objective of the national policy is to mitigate disaster risks and potential damage caused by disasters by establishing a comprehensive and coordinated disaster risk management system within the context of sustainable development. Specifically, the policy focuses on (i) reducing and eventually preventing disaster risk and vulnerability that pose challenges to development through enhancing the culture of integrating disaster risk reduction into development plans and programs, as well as by focusing on and implementing activities before, during, and after the disaster period to address underlying factors of recurrent disaster; (ii) to save live, protect livelihoods, and ensure all disaster affected population are provided with recovery and rehabilitation assistance; (iii) to reduce dependency on and expectation for relief aid by bringing attitudinal change and building resilience of the vulnerable people; and (iv) to ensure that DRM is mainstreamed into development plan and program across all sectorial institutions and implemented at all level. However, the policy lacks effectiveness due to a lack of active participation and involvement in local communities, as well as consideration of the needs and interests of the most marginalised and disadvantaged communities in the lower Omo Valley, including downstream pastoral and agro-pastoral villagers. In addition, the actual implementation of the proposed disaster risk management strategies is hindered by financial constraints, as well as the socio-cultural and livelihood systems of these vulnerable social groups.

3.3.1. Policy Direction and Strategy

3.3.1.1. Comprehensive Disaster Risk Management System

According to the FDRE Ministry of Agriculture and Rural Development's Disaster Risk Management and Food Security Early Warning and Response (2013), reducing the risk of disasters and their effects can only be possible through building resilience to withstand the impacts of hazards and related disasters, and by providing timely and appropriate responses to disasters. However, the existing disaster prevention and preparedness system, including productive safety nets and other related programs, serves as typical instruments to reduce disaster risk. To withstand the impacts of a disaster, these measures are being implemented as part of the system, which has primarily focused on rural areas of the country. At the same time, the response operation has primarily focused on saving lives by providing relief assistance following a disaster.

As a result, the existing system does not enable the identification of recovery and rehabilitation interventions based on hazards and related disasters. The local context should be considered a central and integral part of the response operation, implemented in an integrated manner with national

development plans and programs, following interventions to rehabilitate affected people and reduce future disaster risk and vulnerability. Thereof, to reduce the occurrences of disaster risk and damages caused by flooding disasters in the pastoral and agro-pastoral communities of the Lower Omo Valley, implementing necessary response intervention before, during, and after the flooding disaster period promptly and with the active involvement of all concerned actors build resilience and cope-up strategy towards the effects of Omo river flooding disaster among pastoralist, and ago-pastoralist communities of the Dassenech people. A comprehensive disaster risk management system should adopt multi-hazard and multi-sectoral approaches, shifting away from a disaster management system that primarily focuses on emergency relief assistance to a resilience-based approach.

3.3.1.2. Decentralized Disaster Risk Management System

For an effective disaster risk management system, the identification and assignment of roles and responsibilities at each level of government, as well as those of stakeholders (i.e., civil society, private sector, etc.) at all levels, are crucial for enabling the realisation of a decentralised system. However, even disasters that are considered mild in terms of scale and intensity and can be managed locally are being handled by the federal government, which undermines the wisdom and capacity of at-risk Lower Omo Valley communities or local people to deal with disastrous events. Due to this reason, withstanding the impacts of hazards and related disasters and reducing losses from disasters to the required level by providing timely and appropriate responses appears to be impossible. A decentralised disaster risk management system that identifies and assigns roles and responsibilities to each level of government, concerned entities at all levels, communities, and individuals regarding disaster management activities will enhance the effectiveness of disaster mitigation and preparedness for flooding disasters among the pastoral and agro-pastoral villagers of the Dassenech people.

3.3.1.3. Mainstreaming Disaster Risk Management into Sectoral Institutions

An effective disaster risk management system can only be achieved if disaster management is mainstreamed into every sectoral development plan, including at the grassroots level. Disaster risk management encompasses cross-cutting issues and the responsibility of multiple sectoral institutions. Thus, concerned bodies must implement it by integrating it into their regular development activities. Despite this, attention has not yet been given to the disaster mainstreaming of pastoral and agro-pastoral communities. Thus, unless disaster risk management is considered integral to the development plans and programs of sectoral institutions, it will not be implemented. Therefore, it can be challenging to ensure continued and sustainable development at national, regional, and local levels.

3.4. Climate Change Adaptation and Disaster Risk Reduction

Extreme events are also compounding severe risks, as poor and vulnerable rural communities of the Dassenech pastoralists and agro-pastoralists living on floodplains face repeated flooding. They risk an increase in water-borne diseases and food insecurity as livestock are killed and agricultural farm fields are destroyed. Given the increasing urgency and extensive impact, addressing extreme climate events is an issue of international and national concern. The Sendai Framework for Disaster Risk Reduction 2015-2030 places a strong emphasis on measures that address all dimensions of disaster risk, including resilience building, and acknowledges climate change as a key driver of disaster risks (Adaptation Fund, 2023). The framework sets clear targets to increase the number of countries with national and local disaster risk reduction strategies, enhancing international cooperation with developing countries through adequate and sustainable support to complement their national actions for the implementation of this framework by 2030. The framework also linked with the Paris Agreement's inclusion of climate change adaptation and disaster risk reduction through the global adaptation goal, Article 7.1, "enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change", and Article 8.1 ", minimising and addressing loss, and damage associated with the adverse effect of climate change (UNFCCC, 2015). However, the Lower

Omo Valley region is not only external to this framework but also alienated from its right to access adequate disaster-resilience supportive measures.

3.4.1. Flood Risk Management and Resilience Building Strategy

Despite decades of progress in understanding disaster risk within the pastoral and agro-pastoral communities of the Lower Omo Valley region, building resilience among vulnerable populations remains to be addressed. Although all impacts of hazards on local people, economies, and their environment cannot be avoided entirely, they can be substantially reduced. One of the "best bets" is to implement an early warning system (EWS). It nurtures learning and understanding of hazards, provides warning information, and gives time to enable taking early action and avoiding unnecessary consequences. Despite some progress in enhancing Early Warning Systems (EWS) globally, the most recent report on the state of climate services (WMO, 2020; cited in Golding, 2022) indicates that an early warning system does not cover one-third of the population, and only 40% have multi-hazard EWS. Among various disaster risks, recent flooding disasters have become more severe due to inadequate and ineffective risk management and resilience-building strategies.

Flood risk is increasing with climate change and socio-economic development. The current flood risk management measures are insufficient to cope with today's flood risk (Ward et al., 2017; Rezende et al., 2019). To resist, absorb, accommodate, adapt to, transform, and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structure and function, disaster risk management has a significant impact on the pastoral and agro-pastoral communities of the Dassenech, altering their disaster resilience dynamics. Flood risk management requires human recognition; however, human recognition can never be complete or absolute; flood risk management has the limitation of not being able to eliminate all risks. If resilience could mitigate the remaining risks and complement the inherently insufficient risk management, it would be beneficial to increase resilience (Heliyon, 2022) among the Lower Omo Valley villagers. This can be achieved by incorporating resilience-based flood disaster management strategies into the policy framework.

This resilience-based flood management strategy may enable a system to recover to a state that is better than its pre-disaster state because it enhances the capabilities of pastoral and agro-pastoral communities, such as the Dassenech villagers, to self-organise, learn, and adapt. As McClymont et al. (2019) note, flood resilience can cope with unexpected climate perturbations and is self-organising, and flood risk management has shifted toward a more resilient approach.

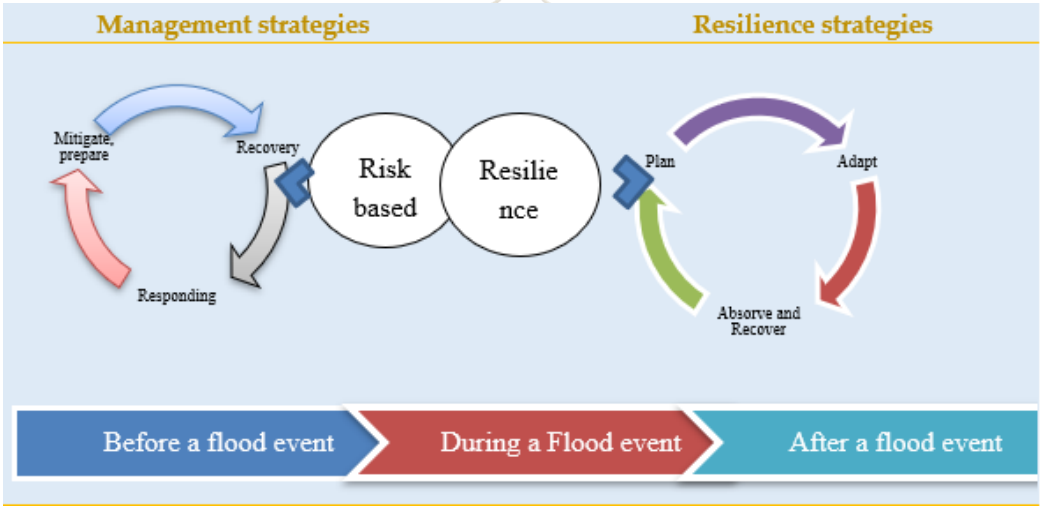

Figure 8: Based on Heliyon (2022). Risk-based and Resilience based flood management strategies

3.5. Resilience Building to Natural and Human-Induced Disaster

Building the necessary institutional infrastructure and mainstreaming disaster risk management practices in the pastoral and agro-pastoral communities of the Lower Omo Valley region into various sectors at national, regional, and local development and budgeting processes - all of which contributed to their disaster resilience to natural and human-induced disasters for quick recovery. According to the Food and Agricultural Organization (2022), For the last few decades, to counter the dehumanising effects of recurrent natural and human-induced disasters, the government of Ethiopia (GoE) responded by establishing a Relief and Rehabilitation Commission (RRC) in 1974 that has undergone various institutional reforms to respond to changing circumstances and a better understanding of disaster risk management and resilience building. Despite the established RRC's primary focus on coordinating humanitarian responses to the 1972/73 drought, its current form, the National Disaster Risk Management Commission (NDRMC), is believed to have significantly strengthened the legal and operational frameworks for a comprehensive and integrated national disaster risk management system at both national and local levels. This makes NDRMC responsible for coordinating early warning systems, disaster response, risk management, preventive measures, and recovery programs nationwide. It functions through a well-established organisational or institutional structure with clearly defined duties and responsibilities at each level.

The Ethiopian government has further developed and adopted various policies and strategies that have contributed to strengthening the resilience of local communities to natural and human-induced disasters (FAO, 2022). Starting with the adoption of the National Disaster Prevention and Preparedness Strategy (NDPPS) in 1989, relevant policies and strategies were periodically updated to reflect a deeper understanding of the circumstances and lessons learned over time about response measures and approaches. Indeed, resilience building in the country is enhanced by factors that drive transformation, such as sustained economic growth, human capital development, improved governance, and the political and economic inclusion of marginalised social groups (e.g., Pastoralist and agro-pastoralist communities of the Lower Omo Valley). Despite this, since the mid-1990s, Ethiopia has pursued policies and strategies that have helped the country achieve strong economic growth, relatively successful macroeconomic stabilisation, significant investments in the welfare and livelihoods of its people, substantial national poverty reduction, and increased resilience to shocks. It lacks inclusiveness, specifically in socio-economically and politically marginalised communities.

4. Discussion

4.1. Government Policy and Strategy of Pastoral and Agro-pastoral Concerns

Although the government implements diverse policies and strategies to address the concerns of pastoralist and agro-pastoralist communities in Ethiopia, the policies of the post-colonial government have led to the marginalisation of pastoralists and agro-pastoralists from mainstream national development programs. Over the years, there has been a tendency to neglect the needs and interests of pastoralists and even to envision the gradual eradication of pastoralism, as most government policies focus on the interests of agrarian and urban dwellers, thereby marginalising pastoral communities (Abduselam, 2019). The various narratives influence the decisions and policies made by governments and development organisations regarding pastoral and agro-pastoral concerns. However, these are often poorly suited to the situations faced by pastoralists, service providers, and other organisations in the drylands. A better understanding of pastoralism and agro-pastoralism is needed to improve decision-making that affects the people who live in pastoral and agro-pastoral areas (Andreas et al., 2017), as well as their livelihood systems.

Overall, pastoral and agro-pastoral communities in Ethiopia face a lack of inclusive development efforts, with government programs primarily focusing on human capital and investment expansion (Gebremeskel et al., 2019). Despite socio-economic and political ignorance, livestock producers in pastoralist and agro-pastoralist communities of the lower Omo Valley were thought to be the wealthiest part of the community. Still, nowadays, the situation has been reversed, and groups that rely on large-scale livestock herding for their livelihoods are among the most vulnerable and insecure (Yimer, 2015). Currently, Pastoral and agro-pastoral communities in the lower Omo Valley are

characterised by recurrent drought, high livestock disease outbreaks, mortality, and flooding, which threaten their viability and cause loss of livelihood, resulting in food insecurity, drought, and loss of life (Daniel et al., 2023). Moreover, the livestock grazing lands that pastoralists and agro-pastoralists depend on are shrinking rapidly due to various factors, including large-scale government and private investment, population growth, agricultural encroachment, land degradation, and ethnic conflict caused by the scarcity of natural resources. This intensifies the vulnerability of pastoral and agro-pastoral communities in the Dassenech to the effects of both artificial and natural disasters due to inadequate policies and strategies, as well as development intervention programs that fail to address the pastoral and agro-pastoral concerns of the lower Omo Valley communities.

4.2. Impact of Natural Resource Alienation

The most important asset owned by pastoralist and agro-pastoralist communities of the lower Omo Valley is their livestock resources. However, the cumulative effect of the dramatic cut in grazing lands and the loss of strategic pasture and water areas is a severe decline in the size of individual livestock holdings (EDRMC, 2020). This implies that pastoralists and agro-pastoralists of the Dassenech are worse off in both economic and socio-political terms today than they were in the past.

Figure 9: The Omo River flooding disaster affected the strategic pasture area of the Libemuket cluster (2024)

4.2.1. Challenges Faced by Pastoralists and Agro-pastoralists of the Lower Omo

According to FA-CAADP (2012), the African Union's policy framework for pastoralism in Africa recognises pastoralist contribution to national and regional economies – supplying a considerable number of livestock and livestock products. Pastoralist production systems are highly adaptive and constantly respond to market and livestock products, as well as human development and food security indicators, which indicate that they are among the lowest on the continent. As a way of life, nearly 20 million people across Sub-Saharan Africa, primarily pastoralists who depend on livestock or livestock products for income and food, typically graze animals on community-managed or open–access pasture and move with them seasonally (FA-CAADP, 2012). Additionally, agro-pastoralists drive 50% of their income from non-livestock sources, amounting to over $30 million in the greater Horn of Africa (FA-CAADP, 2012).

In Ethiopia, pastoral and agro-pastoral production are significant systems of livelihood practices in the country's lowland region, where livelihoods are heavily dependent on livestock rearing, which is supported by subsistence farming. Extensive livestock farming is the backbone of the economies in the lowland areas (FAO, 2018). In the lowlands of Ethiopia, livestock consists of large flocks

and herds of sheep and goats, cattle, and camels, which are mainly transhumant, with only surplus animals sold at local markets or trekked to major consumption centres (FAO, 2018; Tariku et al., 2020). Cattle dominate the livestock population in pastoral and agro-pastoral livelihood systems, followed by camel, goats, and sheep. Cows constitute about 40 per cent of the herd.

The major pastoral and agro-pastoral areas extend from the northeastern and eastern lowlands (Afar and Somali) to the southern and south-western lowlands (Borana and South Omo). Relatively larger flocks are maintained in the lowland (agro) pastoral systems. Approximately 3.1 million cattle-keeping pastoral/agro-pastoral households are estimated to exist, with an average herd size of 10–20; large herds of more than 200 heads are also common (Tariku et al., 2020). Typical breeds are entirely indigenous breeds are kept. Feed types for cattle primarily include predominantly communal rangeland pastures, with crop residues used to a limited extent in agro-pastoral areas (FAO, 2018b). The primary feed resources for sheep and goats include grazing on communal natural pasture, crop stubble, fallow grazing, roadside grazing, crop residues, browses, and non-conventional feeds (household food leftovers, weeds, crop tillers, and fillers) (Matawork, 2016; FAO, 2018b). The production of improved forages, the improvement of low-quality feed sources such as crop residues, and supplementary feeding (except for fattening) are almost non-existent (Solomon et al., 2008). Boreholes, deep wells, dams, rainwater, and rivers are significant sources of water. Milk production per unit area is low and highly seasonal. However, milk is usually produced in excess during the wet season. It is either sold fresh to nearby urban centres or processed into butter to be traded with the highlanders in the peripheral markets for grains (Tariku et al., 2020). However, pastoralists and agro-pastoralist communities in the lower Omo Valley area have been struggling for centuries with the effects of multifaceted artificial and environmental hazards, including drought and famine, loss of livelihoods, flooding, and high rainfall shortages, as well as desertification. They are resourceful, innovative, and entrepreneurial people by necessity. At the same time, there are significant challenges in establishing a secure livelihood.

4.2.1.1. Marginalization of Pastoralist (Agro) Livelihood

Pastoralism supports several hundred million households worldwide, contributes approximately 10% of the world's meat production, and provides food and ecological services, often being the only significant economic contribution in the world's poorest regions (Pastoralist Knowledge Hub, 2016). The Greater Horn of Africa and other arid regions where pastoralist communities reside are often isolated, remote, and underdeveloped. The creation of colonial policy promoted agriculture in highland areas and livestock development in the lowlands, primarily through ranching. Colonial attitudes and misunderstandings about pastoralist economies and mobility were often reinforced by the government after independence (FA-CAADP, 2012). They are still very evident in many African countries – in land policies, the resettlement of pastoralists to make way for more commercial investment, and the allocation of development support and services. Violent conflict, drought, and related humanitarian crises and famines are defining characteristics of the region (FA-CAADP, 2012). Each set of conflict and livelihood issues has a complex history that varies across countries and over time. Local conflict, trade, and livelihood are also invariably linked to national, regional, and international political and economic trends – from control over resources and international security issues to population growth, food prices, and climate change (FA-CAADP, 2012). At the same time, many pastoralists are responding to change, with significant benefits to themselves and the economy. However, not everyone succeeds – with dire consequences for those who fall short.

Despite this, pastoralism in the Horn of Africa does not represent a single form of livelihood. Pastoralists may have animals with different combinations of species, and they face difficulties in diversifying their livelihoods. These different pathways vary from place to place and over time, and pathways are influenced by shocks and stresses – including encroachment by agriculturalists, land grabs, drought and floods, disease epidemics, and livestock raids. It is the cultural backbone of long-standing civilisation (Nori & Devices, 2007). With its mobility and collective resource management, it is now recognised as a rational and sustainable livelihood strategy in marginal lands (Morton et al. and Jenet, 2017). Pastoral regions typically have several alternative economic options. However, despite their significant contributions to national economies, pastoral communities are

often marginalised and overlooked. While pastoralism is a risk-laden livelihood, it is still a viable way to utilise certain areas. This is especially true regarding climate change, population growth, and increasing competition for land and other natural resources. Understanding how it works is vital for efforts to reduce poverty, food insecurity, and drought in pastoralist communities (Jenet, 2017), as well as mitigate flooding disasters.

Historically, the pastoral and agro-pastoral communities of the Lower Omo have been marginalised both geographically and politically. To support pastoralists in the region, government and non-governmental organisations, as well as other development actors, have intervened in various ways. Notwithstanding those remarkable efforts, pastoralists and agro-pastoralists in different parts of the country operate over increasingly degraded rangeland due to increasing bush encroachment, population growth, land degradation, migration routes, and conflict triggered by scarce natural resources (Tariku et al., 2020). Climate change and variability also pose risks to pastoralists and agro-pastoralists who have an immediate, daily dependence on climate-sensitive livelihoods and natural resources in the area. In addition to the physiological effects of higher temperatures on livestock resources, the loss of animals due to recurrent drought and flooding disasters, as well as disease epidemics related to climate change, may thus increase. Indirect effects can be felt through ecosystem changes that alter the distribution of animals and a limited supply of livestock feed. Moreover, the special distribution of pastures and water is highly dependent on the patterns and availability of rainfall as well, and seasonal Omo river flooding was the most described feature of lower Omo Valley pastoral and agro-pastoral communities' marginalisation; this mainly manifested due to inadequate government development intervention on Omo river basin, as well disaster management policy and strategies.

4.3. River Basin Development of the Dassenech–Development Versus Disaster

Few development initiatives in Sub-Saharan Africa have the economic and political significance of river basin developments, whether in terms of the sheer scale of the undertaking, the magnitude of social and environmental transformation, the impact on the future of entire nations, or the controversy surrounding beneficial versus destructive outcomes. For African heads of state, the nearly unparalleled capital intensity of major dam and physical infrastructure projects, along with linked agricultural and industrial development, requires significant infusions of international capital—nearly always.

According to Claudia (2017), the lower Omo River basin and Lake Turkana region are one of Sub-Saharan Africa's most culturally diverse areas, home to at least thirteen distinct ethnic groups speaking languages of Cushitic, Eastern Nilotic, Omotic, and Afroasiatic origin. Those indigenous groups nearest the tri-notion border area – the Dassenech, Nyangatom, and Northern Turkana are primarily pastoral and agro-pastoral by tradition and have remained so far for centuries, although with many adaptations. The harsh semi-arid environment in which they reside has contributed to their complex and flexible survival strategies for coping with changing environmental and social conditions. The Omo River and Lake Turkana are core components of the survival systems for much of the region's indigenous groups, most of whose livelihood systems are transboundary. The survival of more than 500,000 pastoralists and agro-pastoralists in the region requires access to adequate water and living resources from the Omo River and Lake Turkana. The transboundary ethnic groups are linked together by a network of inter-ethnic material and social exchange relations – a system essential to the survival of each group. In recent years, however, nearly all transboundary groups have had to cope with a sharp decline in their capacity to sustain a pastoral and agro-pastoral life and livelihoods. This stress has reverberated throughout all groups in the lower Omo Valley.

The precipitous decline of the herding economy and pastoral and agro-pastoral life, which has virtually collapsed in some areas, is essentially the product of the dispossession of resident groups at the hands of powerful external economic and political forces. However, they have sustained complex and flexible strategies for coping with periods of prolonged drought, disease epidemics, social conflict, and other hardships for centuries. The region's ethnic groups no longer have the conditions

necessary for recovery from these significant periods of stress. For individual groups, these conditions centre on access to sufficient land, pasture, and water resources to implement long-term livestock herd diversification, overall production diversification, and the maintenance of strong internal reciprocity relations, among others. Whose segments of these Indigenous groups have been forced to migrate along the Omo River and around the shores of Lake Turkana in recent years? Tens of thousands of Dassenech people and Nyangatom residents have settled along the Omo River, where they rely primarily on various combinations of flood-recession agriculture, livestock raising, fishing, and gathering and hunting wild food. Thousands of other Dassenech have migrated from their Ethiopian homeland to join the Dassenech settlement along Kenya's extreme northeastern shores, making the group cross-border in extent and vulnerable to the effects of multiple disasters.

Figure10: Omo River flooding caused Forced displaced Dassenech villages (2024)

4.4. Community's Vulnerability and Coping Strategy

Vulnerability and exposure are distinct but closely linked. As Golding (2022) describes, exposure is a necessary but not sufficient determinant of risk. It is possible to be exposed but not vulnerable; similarly, vulnerability to hazard does not lead to impact until the vulnerable asset is exposed to the hazard. While vulnerability is described as a specific hazard, socioeconomic and livelihood factors, such as poverty and the lack of social networks and social support mechanisms in the early warning system, will exacerbate or affect the vulnerability levels of pastoral and agro-pastoral villagers in the lower Omo Valley, irrespective of the type of hazard and its impact.

The transboundary region of the lower Omo Valley, which includes pastoralist and agro-pastoralist communities, is culturally diverse, with Indigenous languages of Cushitic, Eastern Nilotic, Omotic, and Afro-Asiatic origin. Several ethnic groups, including the Nyangatom, Turkana, and Toposa, are members of the Karamojong cluster of cultures and speak multiple intelligible languages (Claudia, 2017). The Dassenech, on the other, had been Cushitic in linguistic affiliation. At the core of the region's indigenous economies and livelihood system are longstanding survival systems that are highly adapted to shifting environmental and social conditions with ethnic groups linked through complex exchange networks. According to Claudia (2017), in recent decades, increasing dispossession and marginalisation imposed by powerful external political influence, economic power, and demand have forced much of the region's pastoral and agro-pastoral population, particularly the Dassenech, to settle at the Omo River as a last option for survival. Despite centuries of resilience from even the most difficult times, the pastoral and agro-pastoral communities of the Dassenech people were pushed into extreme dependency on these two major water bodies and have significantly increased their vulnerability to various disasters and risks more specifically to the effects of natural and artificial Omo River flooding, even to stresses once familiar to them. They are now more severely vulnerable to the extreme destruction of their survival systems, with region-wide drought

and hunger, loss of livelihood systems and assets, human and livestock disease outbreaks, and new mortality caused by the Gibe III dams related to artificial flooding of the Omo River.

Figure 11: Flooding disaster vulnerability and coping strategies discussion with Arikol villagers (2024)

4.4.1. Indigenous Survival Strategy

The survival strategies of transboundary ethnic groups in the Lower Omo Valley, comprising downstream pastoral and agro-pastoral communities, have evolved from centuries of indigenous knowledge and highly adaptive survival systems. The ethnic groups that are heavily dependent on the Omo River are the Mursi, Bodi, Kwegu, Suri, Kara, Nyangatom, and Dassenech, primarily located in the lower Omo River Basin (Claudia, 2017). This long-standing indigenous survival system of the pastoral and agro-pastoral communities faces disaster. Their social system enables them to cope with the effects of Omo River flooding by adapting to the agroecology (environment) and the environment's needs through managing the relationships between their social and livelihood systems and the environment. This enables the pastoral and agro-pastoral villagers' social and livelihood system to sustain, maintain, and renew itself through traditional early warning, preparedness, and recovery mechanisms, thereby minimising the risk and damage of seasonal Omo River flooding. Additionally, according to Claudia (2017), the Ethnic groups in the transboundary region of the Omo River downstream have historically been emphasised, at least until recently, when vast numbers of them have had to resort to a firm reliance on agriculture, mainly livestock herding and flood recession crop cultivation. Like pastoral peoples throughout semi-arid Africa, their survival systems comprise strategies for both risk minimisation and recovery from setbacks to their livelihoods. Adaptability is key to the survival systems of indigenous groups throughout the lower Omo Valley region. This is especially true in the context of the transboundary area's wide range of environmental challenges and periodic principal stresses, including prolonged drought, livestock and human disease epidemics, severe crop losses, as well as shifting regional exchange relations and interethnic hostilities. Pressure on each group's capacity for adaptation is heightened by multiple decades of problematic government policies, especially the changes brought about by the anticipated Gibe III dam, along with its linked agricultural and energy transformation enterprises, which affect the social and livelihood survival systems of pastoral and agro-pastoral villagers.

Livelihood systems of the lower Omo Valley pastoral and agro-pastoral groups incorporate strategies for both risk minimisation and recovery from economic or livelihood losses caused by the Omo River flooding disaster. These general characteristics include the maximum accumulation of capital, with livestock historically being dominant as 'capital' for meeting both immediate subsistence and long-term food security needs, high mobility of livestock herds, and village settlement. Complex and flexible seasonal movements between upland pains environments and riverine or lake zones during Omo river flooding provide the ability to respond to changing environmental and social conditions. Diversification of livestock types (cattle, small stock – goat and sheep), economic diversification to alternative production activities, including:- flood recession agriculture (the only agriculture

possible in the lowermost Omo basin) on low flats along the Omo river and modern delta lands low enough to receive annual flood waters, fishing along the Omo river using primarily rafts and other minimal equipment's. Strong and pervasive social reciprocity and relationships within their social system, whereby material, labour, and other forms of social exchange among villagers provide precautionary as well as recovery measures during flooding disasters in the area.

These relationships are generally rooted in age-set-based authority systems, as well as clan, lineage, and affinal (in-law) relationships. From this complex set of pastoral and agro-pastoral survival strategies, the most common means of pastoral and agro-pastoral households villagers recovery from livestock loss due to drought, disease, conflict, and other hazards like;- temporary movements of herds into peripheral lands with available pasturage and water, short-term barter of small stock with the same or neighbouring ethnic groups to meet immediate food needs, exchange or sale of animals, farm and fishing products, raiding of neighbouring ethnic group herding camps and villages for livestock seizure, use of social exchange network (for loans, gifts, and labour cooperation meet household needs and rebuild livelihood systems, and a temporary firm reliance on subsidiary livestock production activities.

5. Conclusions

Extreme flooding events in the pastoral and agro-pastoral communities of Lower Omo Valley are compounding with severe risks. Poor and vulnerable rural communities living along the Omo River flood plains face repeated flooding, drought, the risk of an increase in water-borne diseases, and food insecurity as livestock are killed and flood recession and irrigation-based agricultural farm fields have been destroyed. Given the increasing urgency and extensive Omo River flooding impact, addressing these extreme climate-related events is an issue of the Dassenech rural peoples' concern, as well as national and local government entities. To increase the resilience of the pastoral and agro-pastoral villagers of the Dassenech, there is a need for an inclusive disaster management policy and strategic paradigm shift as a critical means to effectively and efficiently reduce the effects of the Omo River flooding disaster and its impact. This enables the creation of more disaster-resilient villagers as a way to protect future pastoralist and agro-pastoralist communities in the Lower Omo Valley region. Overall, this finding contributes to and will have practical policy implications for a deeper understanding of disaster risk management and community preparedness, particularly regarding the mechanisms and trends at play in the context of changing social, economic, and environmental realities in the lower Omo Valley's downstream pastoral and agro-pastoral communities. Based on the findings of this study, the following key recommendations have been made as insights for policymakers, local and national governments, non-governmental entities, local communities, and future researchers.

- Create an enabling environment for local institutions and communities to be involved in the entire pastoral and agro-pastoral disaster risk reduction policy-making process, improving their preparedness to respond to Omo River flooding disasters through short- and long-term action plans.
- Contextualise a people-centred early warning system approach, driven by pastoral and agro-pastoral communities at risk, enabled through multi-stakeholder collaboration (i.e., government and non-governmental entities).
- Strengthen the resilient ability of pastoral and agro-pastoral communities to respond to disasters through enhanced skills and knowledge of hazard risks, community participation, disaster preparedness, and set-up of early action systems.
- Enhance the capacity of pastoral and agro-pastoral villagers in the lower Omo Valley local entities to prepare for, respond to, and adapt to disasters, including DRR, resilience, and adaptation, to support anticipatory action interventions.

Policy Makers: Promote and support preparedness and early action of local actors and pastoral and agro-pastoral communities of the lower Omo valley in the design and implementation of disaster risk management policies and strategies through;

- Ensuring the inclusion of Lower Omo Valley pastoralist and agro-pastoralist concerns in the disaster risk management policy, strategies, and programs.
- Prioritise partnerships and strategies that seek to build national, regional, and local-level Omo River flood forecasting capacities and better connect risk information services to local actors and at-risk pastoral and agro-pastoral communities.
- Strengthen the enabling environment for collaboration and connection between local communities and national and local forecasts in the flood early warning system.
- Provide political commitment or financial and human resources to communicate and contextualise Omo River flood risk information to make it accessible to vulnerable at-risk pastoral and agro-pastoral communities.

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Appendix A

The appendix is an optional section that can contain details and data supplemental to the main text.

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Review

Integrating Disability into Disaster Management Education in India: A Critical Review

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ABSTRACT

Children with Special Needs (CwSN) are at heightened risk during disasters due to inadequate disaster management provisions for them. Their disabilities make them particularly vulnerable when disaster protections are inadequate or when injured children receive improper treatment. This further hinders their educational development. Furthermore, the lack of fully disability-inclusive infrastructure and educational facilities in schools makes them vulnerable to disasters, as they face cognitive and physical barriers. This study investigates the involvement of CwSN in disaster management, the programmes and global efforts to include them, the policies that incorporate them, and the role of socio-economic and psychological factors in their education. This study finds that there is limited data available on CwSN and their disaster management education, thereby highlighting gaps in current disaster management educational practices for CwSN. It further concluded that there is a lack of proper disability-inclusive provisions for CwSN to support them in disaster management; thus, there is an urgent need to provide CwSN with adequate disaster management educational provisions in emergencies. It also suggests incorporating disability-specific disaster management strategies into disaster management education to reduce the risk of disasters and promote global cooperation in building resilient communities that protect and include CwSN during emergencies.

KEYWORDS

CwSN; disability; disaster management; emergencies; policies.

1. Introduction

A disaster is a severe disruption that results in the widespread destruction of both material and non-material resources, as well as human and environmental damage. It also reduces the ability of people to manage their resources due to the interaction of hazards, vulnerabilities, and inadequate risk mitigation measures (ISDR, 2004). Therefore, it is essential to manage disasters effectively to minimise disruptions. For this reason, the Disaster Management Act, 2005, in India describes disaster management as an ongoing process that includes planning, organising, coordinating, and carrying out actions to reduce risks and improve readiness, along with quick responses, assessing the

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severity of situations, and developing evacuation plans (NDMA, 2005). Disaster management also includes organising and overseeing the use of resources to deal with all the humanitarian aspects of an emergency. This can be achieved by managing various risks, engaging all stakeholders, and addressing the pre-disaster, disaster, and post-disaster phases (FEMA, 2011). Similarly, it is strongly linked to practical implementation through safe facilities, risk management, and curriculum integration, which, in turn, depend on disaster awareness and understanding among school stakeholders (Cruz & Ormilla, 2022).

The UN Convention on the Rights of Persons with Disabilities (UNCRPD) defines disability as a growing concept influenced by the interaction between disability and societal barriers that limit the participation of people (United Nations, 1989). On that account, do not let disability become a hindrance in the lives of Children with Special Needs (CwSN). Integrating disability into disaster management education for children is essential, as it ultimately leads to the adoption of inclusive education practices in this field. Inclusive education is a form of education that ensures equal opportunities for all at all levels of educational progress (United Nations, 1989). Education systems that are inclusive and empowering are fundamental to achieving social justice during times of crisis (Cvetković, 2022, 2023). Additionally, disaster management education provides access to emergency information and includes children as valuable community members, promoting their participation in emergency-related programs (Collaborating4Inclusion, 2024). Therefore, effective disaster management requires education to address these vulnerabilities and ensure disability-inclusive recovery efforts. Additionally, concepts related to sustainability should be incorporated into disaster-related training across all levels of education to strengthen disaster risk resilience (Đorđević & Gačić, 2024).

During disasters, the CwSN are labelled as one of the most vulnerable groups. Moreover, there is a lack of proper educational and disaster preparedness strategies; even the current policies and frameworks overlook their specific needs. These disabilities tend to hinder their ability to reach their full potential, which requires specialised educational programmes and initiatives based on disaster management. Despite global initiatives and policies promoting inclusivity, educational institutions often fail to address the unique disaster management requirements of CwSN or to include them in disaster preparedness interventions. This gap is particularly concerning given the lack of comprehensive data on the intersection of disability and disaster management education. This study, by reviewing global policies and initiatives focused on CwSN, aims to shed light on the urgent need for disability-inclusive disaster management educational provisions and recommendations. Ultimately, these efforts will help reduce the risks they face and contribute to building more resilient communities that prioritise the protection and inclusion of CwSN during emergencies.

2. Methods

This study critically examines the integration of disability in disaster management education for CwSN, drawing on secondary data. It conducts an extensive review and in-depth analysis of existing literature, which includes national and international academic articles, books, reports, and policy documents. These sources were examined to understand the educational and disaster management provisions for CwSN. A thematic content analysis approach was employed to identify key themes based on patterns and gaps in current provisions related to CwSN, education, and disaster management and to offer recommendations for more inclusive disaster management education.

3. Need for Disaster Management Education for CwSN

There are approximately 240 million CwSN worldwide (UNICEF, 2022b, 2021a). An estimated 7.8 million children under the age of 19 in India live with disabilities (UNESCO, 2019). In India, 2.1 per cent of the child population are CwSN, but only 1.54 per cent have been covered for educational purposes (Devi & Reddy, 2016). Further, assistive devices are not yet available to all of them, as fewer than half of the schools are inclusive of CwSN. Significant challenges persist in providing education to CwSN. Children with multiple disabilities have a significant chance of being out of school

and comparatively have lower foundational and numeracy skills than students without disabilities (UNICEF, 2021a). Furthermore, school enrollment for CwSN declines significantly with each educational level and with reduced enrollment among girls compared to boys (UNESCO, 2019).

On top of that, schools are usually designed for large student intakes with unfavourable structures for CwSN, particularly during evacuations, and their vulnerability further gets exacerbated by lack of access to resources, limited social capital, less autonomy, and risks from extreme weather changes due to their unique needs (Peek & Stough, 2010). CwSN often face marginalisation in disaster management and conflict prevention despite their vulnerability during such crises (Women's Commission for Refugee Women and Children, 2008). The present generation of students, including those from gender-inclusive Communities, has a high likelihood of being displaced by climate change and related emergencies if they continue to be excluded from disaster management initiatives (UNICEF, 2022a).

They are often unfairly affected by disasters, experiencing drops in school performance and behavioural problems, which are exacerbated by a lack of specialised teachers, inaccessible facilities, and the potential loss of important school records, all of which hinder ongoing support and recovery for CwSN (Stough et al., 2019). Minimal data and studies are available on the schooling lives of the CwSN impacted by disasters; however, it is estimated that 3–4 years of schooling are believed to be missed due to forced displacement caused by a catastrophe (UNICEF, 2022b).

Due to all these limitations, effective disability-integrated disaster management education is crucial for CwSN, as schools tend to frequently encounter crises (natural disasters, violence, or personal tragedies) that can severely impact the mental and physical well-being of CwSN. These crises can bring about traumatic changes that threaten the safety and instil feelings of helplessness. CwSN are especially vulnerable due to their unique physical, sensory, or cognitive challenges, which can hinder their ability to respond effectively (NEA, 2018). Disaster management education can thus help these children prepare for emergencies and navigate them with the proper support, thereby reducing their risk and increasing their resilience. By addressing their specific needs, we can better integrate them into broader emergency response plans, helping to mitigate the impact of disasters and improve their overall safety and sense of security (Christian Blind Mission, 2012).

4. Disaster Management Education for CwSN in Schools

Educational institutions often fail to address the specific needs of CwSN in their disaster preparedness and response plans. The school curriculum generally lacks disability-specific content, both in textbooks and in the teaching and learning practices prepared by facilitators (Ediyanto et al., 2023). Because of this gap, CwSN are unable to obtain the instruction and training necessary to handle situations effectively. The execution of disaster-specific mock drills is the most crucial part of the training process. With the aid of awareness and pragmatism, testing actual scenarios, and modifying expectations based on age and aptitude, they are considered essential in enhancing pupils' abilities to cope with any adversity (Johnson et al., 2018).

However, less than 25 per cent of nations with drill policies execute both natural and artificial hazard drills more than once a year for all grades in school (Paci-Green et al., 2020). Furthermore, many schools' infrastructures are not designed with the special needs of students in mind. This includes inadequate physical accessibility, such as the absence of ramps and narrow doorways (Agarwal & Joshi, 2023). The National Building Code and Accessibility Standards encompass regulations for accessibility features that play a critical role in disaster situations (BIS, 2016). These features, such as ramps, wide doorways, and accessible emergency exits, guarantee the safe evacuation of people with disabilities.

During an emergency, this lack of preparedness can lead to dire consequences for CwSN, who might struggle to evacuate safely or access critical support services. The insufficiency of disaster management resources within institutions exacerbates the situation. In the absence of adequate resources and training, schools cannot offer essential support to CwSN during crises (Kumar &

Dwivedi, 2018). The absence of preparedness is especially alarming in disaster-prone areas where the effects of natural disasters are more intense and recurrent.

5. India's Educational, Legal and Policy Framework for CwSN

Table 1, provided below, lists India's constitutional articles, laws, acts, and frameworks, as well as schemes, initiatives, and international interventions adopted by India related to CwSNin terms of education, disability, or disaster management.

Table 1. Compiled by the authors, India's Educational, Legal, and Policy Framework for CwSN

India's Educational, Legal, and Policy Framework for Children with Special Needs	
Constitution of India	Article 15(1): Prohibits discrimination, including against persons with disabilities Article 21: Right to life and liberty Article 46: State's role in promoting educational and economic interests
Laws, Acts, and Frameworks	The Rehabilitation Council of India Act, 1992 The Persons with Disabilities Act, 1995 The National Trust Act, 1999 National Curriculum Framework 2000 Disaster Management Act, 2005 National Curriculum Framework 2005 National Policy for Persons with Disabilities, 2006 The Right of Children to Free and Compulsory Education Act, 2009 National Policy on Disaster Management, 2009 The National Policy for Children, 2013 The Rights of Persons with Disabilities Act, 2016 National Disaster Management Plan, 2016 National Disaster Management Guidelines on Disability Inclusive Disaster Risk Reduction, 2019 National Education Policy, 2020 National Curriculum Framework, 2023
Schemes and Initiatives	Deendayal Disabled Rehabilitation Scheme 1999, 2003 Integrated Child Protection Scheme, 2009 Inclusive Education for the Disabled at Secondary Stage, 2009 Sarva Shiksha Abhiyan, 2001 ShaGun (Shala Gunvatta) portal, 2017 Samagra Shikha Abhiyan 2018 NIDM: training programmes and material for inclusive DM NDMA: educational audio-visual aids for kids Inclusive educational material developed by NIOS and NCERT CWSN management system by CBSE, 2024 Technological advancement with inclusive material on YouTube, DIKSHA platform, BARKHA series, e-pathshala, SWAYAM, SWAYAM PRABHA
International Interventions	United Nations Convention on the Rights of Persons with Disabilities (UNCRPD), 2008 Incheon Strategy "To make the Right Real" for Persons with Disabilities in Asia and Pacific Region, 2012 Sustainable Development Goals (SDGs), 2015 Sendai Framework for Disaster Risk Reduction, 2015

6. Educational Initiatives for CwSN

The Salamanca Framework was the first-ever global initiative that focused on the education of CwSN. It emphasised that education is a fundamental right for everyone, mandating that all individuals, regardless of their disadvantages, should be included in the same educational settings (UNESCO, 1994). It advocates for inclusive education to ensure all children can learn together. Inclusive education prioritises justice and upholds all other human rights of children, including their rights to expression, protection from all forms of abuse, and life opportunities, along with access to all healthcare facilities, habilitation, and rehabilitation (UNICEF, 2017b). Indicating the need for disaster management education for the CwSN to provide them with safety and protection by learning about mitigation strategies.

Globally, various initiatives aim to improve disaster preparedness and response for CwSN. Sustainable Development Goal four aims to provide quality education and includes target 4.5, 'Eliminate all Discrimination in Education', and target 4.8, 'Build and Upgrade Inclusive and Safe Schools', focusing on the equal access of CwSN at all different levels of education and safe learning environments for them by 2030 (United Nations, 2015). Therefore, achieving the educational rights of children with disabilities is crucial for promoting inclusive and sustainable development, and it serves as a profitable investment for the future. The UN Convention on the Rights of Persons with Disabilities (UN General Assembly, 2007) has been ratifiedby vast number of parties, indicating a global commitment to providing inclusive education for all children with disabilities.

However, the practical implementation presents challenges, requiring continuous efforts to ensure the effective integration of CwSN into disaster management strategies. The Disability-Inclusive Disaster Risk Reduction Framework, aligned with international rules and the Sendai Framework for Disaster Risk Reduction, aims to incorporate disability considerations by enhancing cross-sector initiatives, promoting collaborative learning, and removing obstacles to improve safety and resilience in emergencies (Collaborating4Inclusion, 2024; United Nations, 2016). It provides specific guidance on making disaster management practices inclusive, such as ensuring accessible communication, facilities, and services during emergencies. It also highlights the importance of involving individuals with disabilities in the planning and decision-making processes.

The implementation of crisis-sensitive educational planning involves assessing the resources and capacities for emergency risk reduction and response within the education sector, encompassing teachers, school principals, and other relevant stakeholders. Knowing where equalities and inclusions are lagging can help reduce the risks of conflict and violence (UNICEF, 2023). UNICEF's Disability Inclusion Policy and Strategy (DIPAS) effectively integrate Children with Special Needs (CwSN) into the mainstream by developing targeted interventions for them.

In India, the National Policy on Education (MHRD, 1986) highlighted the importance of considering disability aspects in the education sector to ensure inclusive education for CwSN. It aimed to eliminate disparities by focusing on integrated education for children with mild disabilities, providing special schools for severe cases, strengthening vocational training, reorienting teacher training, and encouraging public volunteering. Moreover, it also brings to the forefront the need to revise the curricula to include representation from all. The National Policy for Persons with Disabilities (MSJE, 2006) also highlighted the importance of including CwSN by suggesting ways to make education more accessible and to integrate them into regular schools while also ensuring that special education services are provided. The Right to Education Act (MHRD, 2009) guarantees 'free and compulsory education for children aged 6 to 14 years', including those with disabilities. In addition, the school safety policy recommended establishing accessible evacuation routes for all students, implementing specialised training programmes for school staff, and conducting mock drills that include all students (NDMA, 2016). The legal framework of the Rights of Persons with Disabilities Act prioritises inclusive education, accessibility, and equal opportunities for people with disabilities, including children (MSJE, 2016). The latest National Education Policy, 2020, seamlessly integrates inclusive education into the Indian education sector, adopting a child-centred approach (Gosai, 2023).

Despite these initiatives in India and globally, the risks associated with disasters have not decreased; instead, they have increased. According to the World Risk Index Report, the Philippines,

Indonesia, India, Mexico, and Colombia are among the top five countries most prone to disasters (Bündnis Entwicklung Hilft & IFHV, 2023). These countries frequently experience natural disasters that pose significant risks to their population. India's ranking was not as high as it is now; in 2020, it ranked 86th. All these initiatives are taken to prepare the children, who are the future of India. Why, then, are the disaster risks for these children increasing over time? The proper implementation of inclusive education raises this question. When CwSN are situated in high-risk areas, disaster preparedness and response become even more critical and challenging. One of the reasons extremely high-risk countries are not disaster-resilient is due to the inadequate adoption and implementation of national disaster management strategies that align with the Sendai Framework for Disaster Risk Reduction (UNICEF, 2021b).

In the world, a total of 16 per cent of the population comprises persons with disabilities, and 3 per cent of the population are CwSN (WHO, 2023; UNICEF, 2021a). In India, there are a total of 7.8 million CwSN, which comprise 0.5 per cent of the country's total population (UNESCO, 2019). Figure 1, given below, illustrates that a total of 0.85 per cent of the CwSN were enrolled in the schools in in India, and only 22.7 per cent of CwSN were enrolled in schools out of the total CwSN population in India. Furthermore, the data in the figure indicates inadequate disability-friendly infrastructure in the schools. This highlights a broader challenge. Even when inclusive policies exist, there is a lack of appropriate spatial and infrastructural planning. Similarly, disaster management cannot succeed without spatial planning for potential disasters, even with ideal laws and policies in place (Öcal, 2021).

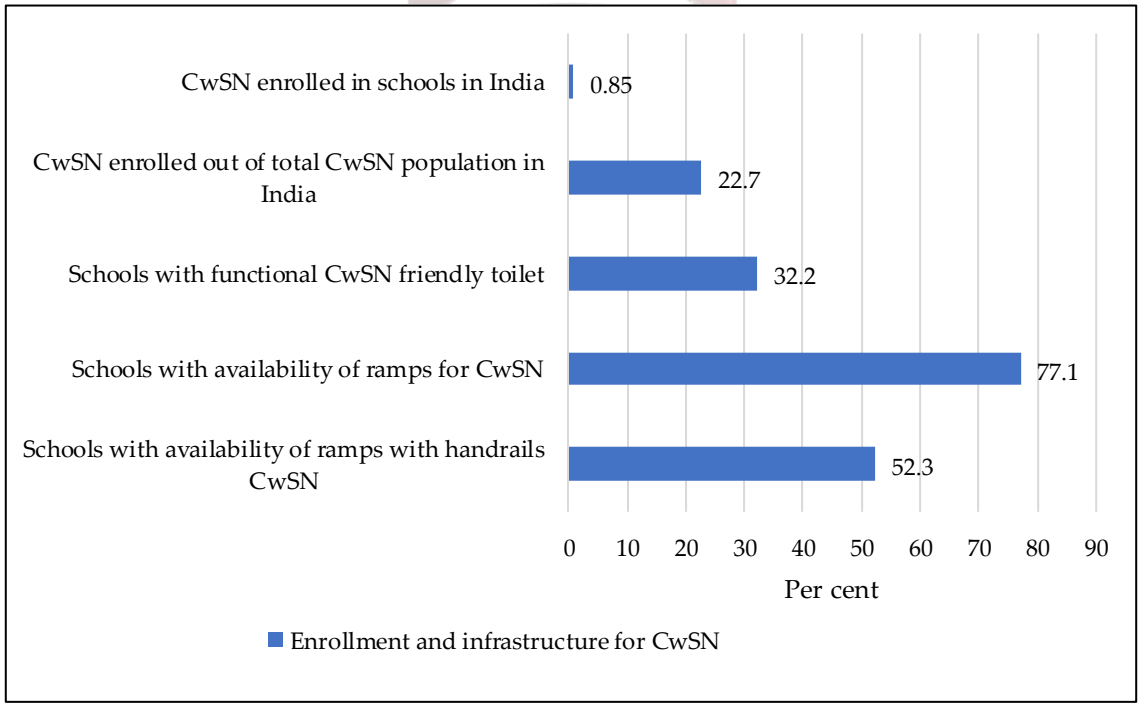

Figure 1. Data compiled from UDISE+ report (Ministry of Education, 2023), Enrollment and infrastructure for CwSN.

The National Statistical Office (NSO) (2019) survey data, as presented in Figure 2, highlights the deficiency of educational infrastructure for CwSN and the necessity for increased educational interventions to address their low literacy and enrollment rates. Furthermore, the inadequate amount of aid received from the government and non-governmental organisations highlights the need for streamlining the aid process for the CwSN.

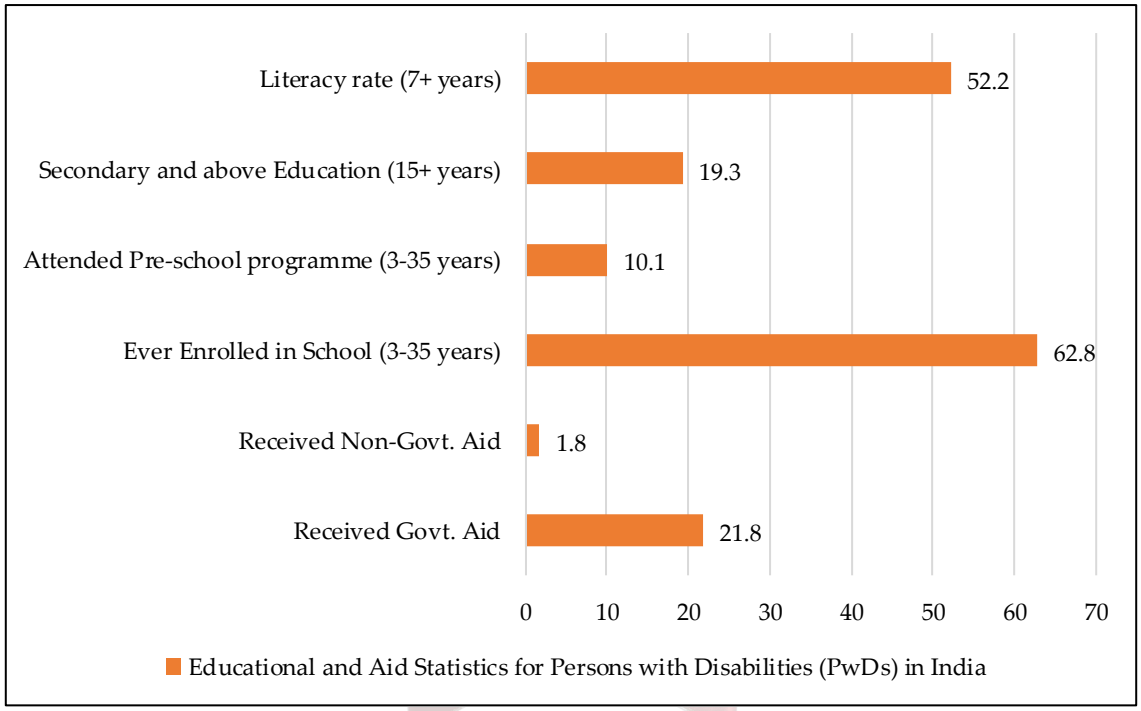

Figure 2. Data compiled from the National Statistical Office (NSO) (Ministry of Statistics and Programme Implementation, 2019), Educational and Aid Statistics for Persons with Disabilities (PwDs) in India.

Globally, best practices in inclusive disaster management education for CwSN have shown to be relatively successful. Amar Jyoti School in Delhi has developed a comprehensive disaster management strategy, including easily accessible infrastructure and trained personnel, to enable a safe evacuation (Zone4Solution, n.d.). Initiating disability-inclusive training in 2016, the State Disaster Management Authority in Kerala provided resources in accessible formats, including Braille, sign language, and audio-visual formats, to more than 2,600 people (Kerala SDMA, n.d.). India's disaster relief and rehabilitation program, conducted by the CII Foundation, involves expert consultations to promote disaster resilience in health and education, raises CSR funds, and collaborates with international agencies for community projects (Kaur & Singh, 2024).

Nepal has advanced inclusive disaster preparedness by developing accessible IEC materials with subtitles and sign language, thereby enhancing awareness among people with visual and hearing impairments (UNDP Nepal, 2023; M'Vouama et al., 2022). Similarly, Turkey's EDUCEN Project, in partnership with six NGOs, developed training programs that incorporated the experiences and skills of people with disabilities while also identifying cultural patterns unique to different disability groups to strengthen their resilience (Akgungor & AKUT Search and Rescue Association, 2016). For families of children with exceptional medical needs in the United States, Drexel University created a disaster preparedness toolbox (Drexel University, 2020). Moreover, Turkmenistan has incorporated disaster risk education into its preschool program under the guidance of UNICEF (UNICEF, 2017a). Kupenda for the Children provides community leaders in Kenya with advocacy training to enhance inclusive readiness (Kupenda for the children, 2020).

7. Representation of CwSN in Disaster Management

The hierarchical structure of education authorities, with the Central Board of Education at the highest level and the local Board of Education at a lower level, often leads to suboptimal implementation and unequal representation of CwSN in disaster management decisions (Stough et al., 2017). This top-down approach impedes the effective incorporation of disability considerations into disaster plans. About 15 per cent of the world's population is comprised of individuals with disabilities,

and the majority of these nations have no record of inclusion of CwSN into the decision-making process, making them educationally vulnerable (Jang & Ha, 2021).

CwSN have been looked after during disasters primarily due to an established norm of including them (NCD, 2019). The power of other stakeholders at the top of the institution's hierarchy outweighs that of the CwSN and many other stakeholders, such as students and teachers, in making decisions on behalf of the entire institution. Students with special needs have extremely low representation in national disaster management processes, leading to higher fatality rates in catastrophes compared to students without disabilities (Jang & Ha, 2021). The lack of inclusion in decision-making processes means that the specific needs of CwSN are not adequately addressed, resulting in increased vulnerability during emergencies. This is also supported by a survey conducted in 2013 and again in 2023, which states that the conditions of the CwSN have remained unchanged since 2013 despite their significant interest in the decision-making process (Collaborating4Inclusion, 2024).

CwSN possess the necessary competence to comment on their lives and participate in decision-making. By listening to and incorporating their views and perspectives, we should represent their opinions in the decision-making and research process (Srivastava, 2016). The UNICEF (1989) Convention on the Rights of the Child emphasises the need to change the mindset of considering children as passive and incapable of self-protection; instead, they should be considered entitled to participate in decision-making alongside adults. However, the reality is that, despite countries' focus on children's participation, CwSN are often excluded from initiatives such as youth forums, children's parliaments, peer education, and other projects (UNICEF, 1989). Moreover, they are not active in research or local, national, or international movements, so it isn't easy to know their perspectives.

Article 11 of the Convention on the Rights of Persons with Disabilities (CRPD) mandates the implementation of measures to safeguard children with disabilities during emergencies. These children are considered more vulnerable to discrimination and violence, and they face greater challenges during crises due to disruptions in essential services, such as health and education, and increased barriers to aid (UN General Assembly, 2007).

8. Impact of Socio-Economic and Psychological Factors on CwSN

Poverty, a major socioeconomic drawback, is highly linked with disabilities; one can find the highest number of CwSN in the poorer regions of the world, with data showing 192 million out of 240 million CwSN belong to only the developing nations of the world (Kett et al., 2020). Therefore, by not addressing the complexities due to poverty, the issues associated with disability cannot be addressed, according to the UN Convention on the Rights of Persons with Disabilities (FRA, 2018). The lack of resources and support in impoverished areas further complicates the implementation of effective disaster management strategies. The UN Convention on the Rights of Persons with Disabilities highlights addressing poverty as a crucial element of effectively tackling disability issues (UN General Assembly, 2007). This, in turn, will help reduce their vulnerability to disasters.

The coronavirus disease devastated the lives of many people. It impacted their education to a significant extent by increasing the digital divide for disadvantaged students, including the ones with disabilities. During the COVID-19 pandemic, the lack of personalised education plans, loss of in-school resources, and insufficient assistive technologies at home posed significant barriers for CwSN to access remote education. Effective pandemic response requires understanding which interventions work best for different impairments and training front-line personnel to meet these needs (UNICEF, 2020). School closures are anticipated to lead to significant disruptions in students' daily lives, where remote homeschooling can be particularly challenging for children with special needs (CwSN), as they require not only Internet access and other technological resources but also assistive technologies and individualised lesson plans (Jeste et al., 2020).

Different disabilities lead to different challenges for the CwSN. Students with cognitive or emotional disabilities are at a high risk of developing post-traumatic stress disorder due to their difficulty in maintaining composure and remembering disaster mitigation instructions, which can hinder their

ability to protect themselves during an emergency (Ha, 2015). Children with functional disabilities, such as communication or self-care issues, are likely to have less attendance in school compared to children without such disabilities. In contrast, children struggling with anxiety or depression-type issues have similar attendance scenarios, but they also often lag in numeracy skills (UNICEF, 2022a).

Multiple stakeholders collaborate to design, develop, implement, monitor, and evaluate activities that address the support needs of people with disabilities before, during, and after disasters. The role of multiple stakeholders is to work together in planning, executing, and evaluating disaster management activities, from policymaking to their implementation within institutions.

At every level, people with disabilities have a crucial role and require their representation (ARC, 2024). Furthermore, the stakeholders involved with the CwSN must possess the right mindset and drive to support them. The worsened psychological conditions of the carers or parents due to a catastrophe directly impact the CwSN well-being and place them at a high risk of mental health issues (WHO, 2013). A teacher's attitude towards students is crucial for understanding the provisions available to them and their importance in ensuring protection (UNESCO, 2019). Typically, due to a lack of skills and training, teachers struggle to create resources and demonstrate empathy for CwSN; often, they are unable to identify the issues and provide solutions to ensure uninterrupted education for all (Ediyanto et al., 2023). Not only the teachers but also how parents treat their children with special needs is important. Similarly, sociocultural factors, such as religion and beliefs, significantly influence a child's safety and the school's response to them (UNESCO, 2019).

9. Limitations

The study is limited to the availability of secondary sources of data on CwSN in the context of education and disaster management. Additionally, the findings are provided based on all the types of disabilities among CwSN in India, irrespective of their different requirements for disaster management education.

10. Conclusions

Disaster management education is essential for building resilient communities; however, CwSN are often overlooked in disaster preparedness and response efforts. Disasters affect everyone, but due to their special needs, CwSN face unique challenges during emergencies. Despite recognising these challenges and developing policy frameworks, educational institutions often fail to integrate disability considerations into disaster management education. Therefore, to promote positive development for CwSN, there is an urgent need to effectively integrate disaster management education into the school curriculum, enabling CwSN to handle future disasters with the necessary skills and abilities effectively. Addressing the needs of CwSN in disaster management requires a multifaceted approach that includes improved educational practices, inclusive policies, socioeconomic considerations, and global collaboration. By considering their specific needs, we can mitigate the impacts of disasters and enhance their safety. This includes integrating disability-specific content into disaster education, ensuring accessible emergency services, and providing specialised support during evacuations. Furthermore, assistive technology and active engagement in recovery and peace-building efforts are crucial for building resilient communities and protecting the CwSN during emergencies.

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Conflict Risk Monitoring for Conflict Prevention in Ethiopia: The Case of Ataye Towen, North Shewa, Amhara Region

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ABSTRACT

This study investigates the effectiveness of conflict monitoring within early warning systems in Ethiopia, focusing on Ataye town in the North Shewa Administrative Zone. A mixed-methods approach with a sequential exploratory design was employed. Data were collected through key informant interviews with 20 stakeholders, surveys from 385 respondents (253 males and 127 females), focus groups, and document reviews. Qualitative data were analysed thematically, while quantitative data were examined using descriptive and inferential statistics. Key findings highlight the significant roles of institutional actors, including peace councils, peace clubs, interfaith councils, and community monitors, in fostering grassroots conflict awareness and vigilance. However, a critical gap was identified in the uniformity of conflict indicators, as 44 indicators from the Minister of Peace varied from those used by the police and disaster management, undermining coherent monitoring efforts. Recommendations include strengthening the capacities of monitoring institutions, standardising conflict indicators for consistency, and establishing conflict early warning curricula in higher education to train qualified personnel. These measures aim to enhance Ethiopia's conflict monitoring and prevention strategies, effectively addressing the complexities of inter-ethnic conflicts.

KEYWORDS

Security; emergencies; peace council; peace forum; focal person; conflict indicators; monitoring.

1. Introduction

The literature on conflict risk monitoring and forecasting has undergone significant evolution, particularly in response to the growing complexity of global conflicts and the need for timely interventions. Early warning systems (EWS) are critical for anticipating and mitigating conflicts, relying on data collection and analysis to provide timely alerts about potential crises. The effectiveness of these systems is often contingent on the quality of data and the methodologies employed for analysis (Zizzo, 2016). Various methodologies have been utilised for conflict risk monitoring, including statistical models, machine learning techniques, and qualitative assessments. Notably, the integration of big data analytics has emerged as a promising approach to enhance predictive capabilities in conflict forecasting (Guo et al., 2018).

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Despite advancements in conflict risk monitoring systems, significant challenges persist that hinder their effectiveness. Institutional barriers, including bureaucratic inertia and a lack of coordination among various agencies, hinder timely data collection and analysis. Furthermore, a lack of transparency often leads to mistrust among stakeholders, making it challenging to establish collaborative frameworks necessary for effective monitoring. Data sharing poses another significant hurdle, as organisations may hoard information due to competitive interests or fear of losing control over resources (Dawit, 2020). This situation is exacerbated by resistance to adopting data-driven approaches, stemming from entrenched practices and scepticism regarding the reliability of predictive models. For instance, case studies like the African Union's Continental Early Warning System (CEWS) and the Inter-Governmental Authority on Development (IGAD) in the Horn of Africa highlight how political will and resource allocation are crucial for the success of these systems; without strong commitment and adequate funding, even well-designed systems can falter (Seble & Kewir, 2020).

In Ethiopia, the government has implemented an Early Warning System (EWS) under the Minister of Peace aimed at mitigating conflicts across various levels. However, persistent inter-ethnic tensions underscore the limitations of these efforts. Abebe (2002) notes that media narratives can exacerbate ethnic tensions, leading to violence, while Alemayehu (2012) argues that federal arrangements often foster competition over resources and political representation rather than mitigating conflict. The ethnic identities promoted within this federal system often exacerbate grievances, highlighting the challenges of ethnic federalism in achieving lasting peace. Ayalew (2019) posits that this model has intensified ethno-nationalist conflicts, further complicating the landscape. The ongoing strife between the Amhara and Oromo populations, particularly in areas like Ataye, North Shewa Zone, exemplifies these issues, where historical tensions have escalated into violent confrontations driven by ethnic politics, manipulation by ethnic entrepreneurs, and weak governance (Jemal, 2020).

Looking forward, the literature suggests that effective conflict prevention strategies must incorporate improved methodologies that consider the complexities of social interactions and causal analysis. Greater collaboration among local, national, and international actors is essential to enhance the effectiveness of conflict prevention initiatives (Carment & Calleja, 2017). In Ethiopia, the conflict early warning system aims to address tensions by monitoring indicators such as ethnic fractionalisation and political exclusion (Adegbite, 2020; Feyissa & Hagmann, 2014). Community-based monitoring efforts have fostered local participation, akin to successful initiatives in Nigeria's Niger Delta (Adebayo, 2015). Nevertheless, significant gaps remain in the operational dynamics of EWS, particularly about emerging tensions in Ataye from 2018 to 2023. A comprehensive and proactive Early Warning System (EWS) is crucial for effectively monitoring and responding to these tensions, as current mechanisms have proven inadequate in preventing armed conflicts (Ethiopian Human Rights Commission, 2022; Girma, 2022).

The literature on conflict risk monitoring and forecasting reveals several critical gaps that limit the efficacy of existing early warning systems (EWS). While advancements in methodologies, such as big data analytics and machine learning, show promise for enhancing predictive capabilities, a lack of comprehensive frameworks remains that address the specific socio-political contexts in which these systems operate (Guo et al., 2018). Additionally, the challenges of institutional barriers, data sharing, and stakeholder mistrust underscore the need for more robust collaborative mechanisms that can facilitate information exchange and enhance system responsiveness (Dawit, 2020). Specifically, in cases like Ethiopia, where ethnic tensions are prevalent, existing EWS often fail to account for the complexities of inter-ethnic dynamics and the historical grievances that fuel conflict (Ayalew, 2019). Moreover, the limited focus on local contexts and community participation in monitoring efforts suggests an underutilisation of grassroots insights that could enhance the effectiveness of EWS (Adegbite, 2020).

Addressing these gaps is crucial for developing more proactive and context-sensitive conflict prevention strategies that can adapt to the rapidly changing landscape of global conflicts. For instance, integrating local knowledge and fostering community engagement in data collection could strengthen the relevance and accuracy of conflict indicators. Furthermore, enhancing transparency and trust among stakeholders through regular communication and collaborative training can mitigate resist-

ance to data-driven approaches. Lastly, establishing a feedback loop within EWS could help refine methodologies and ensure that systems remain responsive to emerging challenges.

This study examines the role of conflict monitoring in conflict prevention within the Ataye North Shewa Zone of Ethiopia, encompassing sections on introduction, methodology, results, discussion, conclusion, and references. The main body discusses institutional frameworks, well-defined conflict indicators, and the operation of monitoring systems.

2. Methods

This study employs a mixed-methods research approach with a sequential exploratory design, integrating both qualitative and quantitative data collection to provide a comprehensive understanding of inter-ethnic conflict management in Ethiopia. This methodology aligns with the principles outlined by Creswell (2003) and Kothari (2004), who advocate for using mixed methods to address complex phenomena holistically. The research targets three populations: individuals affected by the conflict, peace actors, and security actors, all of whom share experiences related to the Ataye conflict. For the qualitative component, purposive sampling was utilised to select participants for interviews and focus group discussions (FGDs), ensuring that those with rich knowledge and diverse perspectives were included. Interviews were conducted with 20 government officials from key institutions, including the House of Federation and the Ministry of Peace. Additionally, FGDs involved 10 individuals from the Oromo and Amhara ethnic groups directly impacted by the conflict. The sample size for the qualitative component was determined by achieving data saturation, at which point no new insights emerged. Thematic analysis was subsequently applied to identify key themes related to the research objectives.

For the quantitative component, stratified simple random sampling was employed to select respondents for questionnaires, ensuring a representative sample of the broader population, which included community members, security actors, and peace actors. The sample size was calculated using a formula for a single population proportion, resulting in a target of 385 respondents. A total of 400 questionnaires were distributed, yielding 380 completed responses. Descriptive statistics (percentages and frequencies) and inferential statistics (correlation) were employed to analyse the quantitative data, providing insight into the prevalence of different perspectives and the relationships between variables.

The study utilised both primary and secondary data sources. Primary data were collected through interviews, focus group discussions (FGDs), and questionnaires, while secondary data included document reviews and existing literature. Questionnaires were translated into Amharic and English to enhance accessibility. Their validity was confirmed through a literature review and testing with students from the Ethiopian Police University, while reliability was assessed using a Cronbach's alpha test. This rigorous methodological framework enhances the credibility of the study's findings and contributes valuable insights into conflict management strategies in Ethiopia.

2.1. Theoretical frameworks

Network theory provides a crucial framework for analysing the Ataye interethnic conflict in Ethiopia, focusing on the relationships and interactions among individuals, groups, and organisations. By examining the structure of conflict networks, stakeholders can gain insights into the flow of information, resources, and influence, which can inform strategies for conflict prevention and peacebuilding. Key studies (Borgatti et al., 2009; Carley, 1990; Diehl, 1994; Krempel & Plumper, 2016; Valente, 2012) explore concepts such as network structure and centrality, helping to identify influential individuals or groups that can facilitate dialogue and reconciliation. Similarly, systems theory emphasises the interconnectedness of factors, such as historical grievances and socio-economic disparities, in conflict monitoring. Checkland (1999) emphasises the importance of understanding feedback loops (Meadows, 2008) and the dynamic complexity of interactions (Miall et al., 2005),

while Richardson (2011) highlights the need for adaptability in response strategies. Engaging local stakeholders and developing comprehensive monitoring frameworks can enhance the effectiveness of conflict prevention efforts; however, challenges such as data complexity and resource limitations must be addressed to achieve this goal.

In conclusion, integrating network and systems theories provides a deeper understanding of the Ataye conflict, identifies key points for intervention, and promotes sustainable peace-building initiatives.

3. Result and discussion

This study examines the role of conflict monitoring in conflict prevention and is organised into three sections. The first section discusses the key actors involved in conflict monitoring. The second section identifies indicators of inter-ethnic conflict. Finally, the third section examines the processes of conflict monitoring and forecasting.

3.1. Actors of Conflict Monitoring

Most interview participants highlighted that Ethiopia has established a comprehensive conflict monitoring system that operates from the federal level down to the kebele level. At the federal level, the Minister of Peace has set up a conflict early warning desk equipped with data analysis capabilities and supported by a dedicated department within the Peace and Security Administration to address regional and local needs. This desk collects information on conflict indicators from various sources, including regional focal persons, peace committees, and religious councils (Guo et al., 2018).

At the regional level, the Amhara Regional Peace and Security Administration Bureau oversees a conflict prevention department that implements initiatives at zonal and woreda (district) administrations. Moving further down, at the kebele level, peace and security heads lead committees that consist of peace clubs and religious councils. This structured framework underscores a robust institutional approach to conflict monitoring, where local structures play a crucial role in supporting the efforts of federal and regional administrations (Dawit, 2020).

This comprehensive system demonstrates Ethiopia's commitment to conflict monitoring and prevention, which is more robust than that of other studies. Integrating local structures with federal and regional efforts enhances the overall effectiveness of the monitoring process, creating a multi-layered approach that is responsive to the unique dynamics of conflict at various levels (Ayalew, 2019).

3.1.1. Peace Committee

A peace committee is a community-based group formed to promote peace, resolve conflicts, and foster reconciliation among different social or ethnic groups. Comprising local leaders, elders, and community members, these committees facilitate dialogue, mediate disputes, and implement conflict prevention strategies to create a harmonious social environment.

Table 1. The peace committee effectively monitor the conflict.

The peace committee effectively monitor indicators of conflict.				
	Frequency	Per cent	Valid Percent	Cumulative Percent
strongly disagree	44	11.6	11.6	11.6
Disagree	42	11.1	11.1	22.6
Neutral	62	16.3	16.3	38.9
Agree	139	36.6	36.6	75.5
Strongly agree	93	24.5	24.5	100.0
Total	380	100.0	100.0	

In examining the effectiveness of peace committees in monitoring conflict indicators, the data presented in Table 1 reveals a generally positive perception among respondents. A significant portion of participants, 36.6%, agreed that peace committees effectively monitor conflict indicators, while an additional 24.5% strongly agreed. This indicates that over 61% of respondents hold a favourable view of the peace committees' capabilities in this regard. Conversely, a smaller percentage of participants expressed scepticism, with 11.6% strongly disagreeing and 11.1% disagreeing with the statement. The neutral response rate of 16.3% suggests that some individuals may be uncertain about the effectiveness of these committees.

When compared to similar studies, this data indicates a robust perception of the role of peace committees in conflict monitoring. For instance, previous research has shown that effective local governance structures, including peace committees, can significantly enhance conflict resolution efforts (Smith & Jones, 2021; Ahmed, 2020). In this context, the positive feedback about the peace committees aligns with findings from other studies that emphasise the importance of community involvement in monitoring and resolving conflicts. The overall sentiment suggests that, while there are some dissenting views, the majority recognise the value of peace committees as effective mechanisms within the broader framework of conflict prevention and monitoring.

The effectiveness of peace committees in conflict monitoring and resolution is well-supported by existing literature, which underscores their role in enhancing local conflict resolution efforts. For instance, Adebayo (2015) found that community-based peace committees in Nigeria significantly improved local conflict management, a dynamic also observed in Ethiopia. Cammaert (2018) emphasised the importance of local peace committees in UN missions, noting their effectiveness in facilitating dialogue and mediation. Additionally, studies by Richardson (2011) and Miall et al. (2005) reinforce the significance of local engagement in peacebuilding. However, challenges such as limited resources and institutional support, highlighted by Abebe (2018), must be acknowledged to ensure these committees can effectively navigate the complexities of inter-ethnic conflict.

In Ethiopia, research offers a nuanced perspective on the roles of peace committees across various regions. Abebe (2007) notes their effectiveness in the Oromiya region, where grassroots committees use traditional conflict resolution methods to mediate local disputes and foster a culture of dialogue. Despite their successes, Abebe points out challenges like limited authority and resources that can hinder their effectiveness in entrenched conflicts. A comparative analysis by Dejene (2013) indicates that while Ethiopian peace committees promote dialogue, they often lack formal recognition and governmental support, which are crucial for their success. Mekonnen (2008) further emphasises these limitations in the Amhara region, where sustainability and political backing are also concerns. Collectively, these findings suggest that while peace committees are vital for local conflict resolution, their impact is significantly influenced by external factors, including political support and resource allocation.

The results from the interviews and focus group discussions (FGDs) provide a comprehensive view of the role and functioning of peace committees in Ethiopia, complementing the quantitative data. Interview participants highlighted that peace committees are organised at multiple levels, including national, regional, zonal, woreda, kebele, and village levels, facilitating a structured approach to conflict prevention. Joint peace committees, which bring together representatives from neighbouring kebeles and regions, are particularly noteworthy. These committees not only set the direction for peace-building initiatives but also identify disputes and coordinate reconciliation activities. Their responsibilities include organising annual meetings, identifying areas requiring support, and participating in stabilisation efforts, thereby creating a framework that enhances community engagement and resilience.

One participant emphasised the critical role of these committees in monitoring conflict indicators. Composed of community members from diverse backgrounds, peace committees collect and analyse data on potential conflict indicators, such as hate speech and resource allocation conflicts. This proactive stance enables them to identify early warning signals and report their findings to local authorities, thereby raising awareness and promoting preventive measures in vulnerable communities. Despite the challenges they face—such as limited resources, political interference, and security risks—peace committees have made significant strides in preventing and mitigating inter-ethnic conflict. This aligns with findings from Adebayo (2015) and Cammaert (2018), who emphasised the

importance of local governance structures in conflict resolution, reinforcing the notion that community engagement is crucial to effective peacebuilding.

The FGDs revealed additional insights into the challenges peace committees encounter, including limited funding, inadequate infrastructure, and gaps in training. Participants advocated for a multifaceted approach to enhance the effectiveness of these committees, suggesting increased funding and capacity building as essential steps. One participant noted that peace committees serve as platforms for resolving conflicts through nonviolent means, emphasising inclusivity and collaboration among various stakeholders, including government entities and civil society organisations. This perspective aligns with the literature reviewed, particularly the work of Abebe (2018), which emphasises the importance of institutional support for peace committees in navigating complex inter-ethnic conflicts effectively. Ultimately, the findings from the interviews and focus group discussions (FGDs) underscore the importance of addressing the root causes of conflict, such as poverty and environmental degradation, to promote sustainable peace —a sentiment echoed in the broader discourse on peacebuilding and conflict resolution.

The study's findings indicate a generally positive perception of the effectiveness of peace committees in monitoring conflict indicators in Ethiopia. Over 61% of respondents believe that these committees play a crucial role in conflict monitoring, with 36.6% agreeing and 24.5% strongly agreeing on their capabilities. This favourable view aligns with existing literature that highlights the importance of local governance structures, such as peace committees, in enhancing conflict resolution efforts. Despite some scepticism, with 11.6% strongly disagreeing and 11.1% disagreeing about their effectiveness, the overall sentiment emphasises the value of community engagement in preventing and resolving conflicts. Additional insights from interviews and focus group discussions reveal that peace committees operate at multiple levels and actively collect and analyse data on potential conflict indicators. However, challenges such as limited resources, political interference, and lack of formal recognition hinder their effectiveness. Participants advocated for increased funding, capacity building, and collaboration among various stakeholders to enhance the impact of these committees, underscoring the need to address the root causes of conflict for sustainable peace.

3.1.1. Inter-Religious Council

In Ethiopia, the Inter-Religious Council plays a crucial role in promoting religious tolerance and cooperation among diverse faiths, operating within a legal framework established by the 1995 Constitution, which guarantees freedom of religion and fosters understanding among religious groups. This framework is further supported by the Proclamation on the Registration and Regulation of Charities and Societies (Proclamation No. 621/2009), enabling effective engagement in conflict monitoring and resolution. Comparatively, similar studies, such as Adebayo (2015) in Nigeria and Cammaert (2018) in UN peacekeeping contexts, highlight the effectiveness of inter-religious councils in fostering dialogue and mediating conflicts. In Ethiopia, the council not only monitors conflicts but also initiates community dialogues and peace-building workshops, aligning with findings from Richardson (2011) and Miall et al. (2005) that emphasise the importance of local engagement in peace efforts. However, challenges such as political interference and resource limitations, as noted by Abebe (2018), can hinder its effectiveness. Overall, the Inter-Religious Council exemplifies how faith-based entities can contribute to conflict resolution, echoing insights from comparative studies that stress the importance of inclusive and collaborative approaches in peacebuilding.

Table 2. The Role of the Religious Council in Conflict Monitoring.

The inter-religion council effectively monitor indicators of conflict				
	Frequency	Per cent	Valid Percent	Cumulative Percent
Strongly disagree	32	8.4	8.4	8.4
Disagree	15	3.9	3.9	12.4
Neutral	45	11.8	11.8	24.2
Agree	108	28.4	28.4	52.6
Strongly agree	180	47.4	47.4	100.0
Total	380	100.0	100.0	

Table 2 presents a clear and positive perception of the Inter-Religious Council's effectiveness in monitoring conflict indicators, with a significant majority of respondents recognising its role in this capacity. Specifically, 47.4% of participants strongly agree that the council effectively monitors conflict indicators, while an additional 28.4% agree, resulting in a combined total of 75.8% of respondents expressing a favourable view. In contrast, only 8.4% strongly disagree, and 3.9% disagree, indicating minimal scepticism about the council's capabilities. The neutral response rate of 11.8% suggests some uncertainty; however, the data overall reflect strong support for the council's conflict-monitoring functions.

This finding aligns with similar studies in other contexts, which also highlight the positive impact of inter-religious councils in conflict resolution. For instance, Adebayo (2015) reported that interfaith initiatives in Nigeria significantly improved community relations and reduced tensions, demonstrating the effectiveness of faith-based organisations in monitoring and addressing conflicts. Furthermore, Cammaert (2018) emphasised the role of local faith leaders in UN peacekeeping missions, highlighting their capacity to facilitate dialogue and mediate disputes. Collectively, these studies and the current data underscore the critical role that inter-religious councils play in monitoring conflict indicators, fostering peace, and enhancing community resilience while also highlighting the importance of ongoing support and recognition for these councils to maximise their effectiveness.

The interview and focus group discussion (FGD) results regarding the Ethiopia Inter-Religious Council reveal a multifaceted and proactive approach to conflict monitoring and resolution. Established in 2010, the council comprises various religious organisations, including the Ethiopian Orthodox Tewahedo Church and the Ethiopian Islamic Affairs Supreme Council. Its primary aim is to promote shared values such as justice, freedom, love, and peace among citizens. Interview participants emphasised the crucial role that religious leaders play in advising communities on conflict avoidance and promoting coexistence, as well as supporting trauma recovery and providing humanitarian assistance. These efforts are essential for promoting tolerance and building institutional resilience, particularly in rehabilitating displaced individuals and reconstructing social cohesion following disasters and conflicts.

Specific examples cited by participants illustrate the council's effectiveness, particularly in addressing inter-ethnic conflicts in the Ataye city administration. Despite armed attacks on both Orthodox Christian and Islamic institutions, the council's proactive measures—such as gathering information from community members, establishing early warning systems, facilitating mediation, and raising awareness about the detrimental effects of inter-ethnic conflicts—proved effective in preventing inter-religious violence. This aligns with findings from similar studies, such as those by Adebayo (2015) and Cammaert (2018), which emphasise the role of faith-based organisations in conflict resolution and community building.

Participants in the focus group discussions (FGDs) noted that ongoing conflicts have increased polarisation and mistrust within communities, complicating the efforts of religious leaders to bridge divides. However, the Inter-Religious Council in Ataye continues to play a vital role in collecting data and monitoring potential conflict indicators, reporting its findings to local authorities for timely intervention. This proactive stance is particularly notable during the 2021 conflict, where the council successfully thwarted attempts to incite inter-religious violence. This experience aligns with the insights of Richardson (2011) and Miall et al. (2005), which emphasise the importance of local engagement in peacebuilding efforts. Overall, the findings illustrate a complex interplay between proactive intervention and the challenges of increasing polarisation, emphasising the need for sustained support for inter-religious councils to enhance their effectiveness in conflict monitoring and resolution.

The findings from Table 2 indicate a strong and positive perception of the Inter-Religious Council's effectiveness in monitoring conflict indicators, with 75.8% of respondents expressing favourable views. Specifically, 47.4% strongly agree that the council effectively performs this role, while an additional 28.4% agree, highlighting minimal scepticism (only 12.3% combined disagreeing). This positive sentiment aligns with similar studies that emphasise the impact of inter-religious councils in conflict resolution, such as Adebayo (2015) and Cammaert (2018). Qualitative insights from interviews and focus group discussions further illustrate the council's proactive approach, established in 2010, to promote shared values and foster coexistence among diverse religious groups. Participants

noted the council's critical role in advising communities, aiding trauma recovery, and facilitating mediation, particularly during inter-ethnic conflicts in the Ataye city administration. Despite challenges such as increasing polarisation and mistrust, the council has successfully implemented early warning systems and timely interventions, notably during the 2021 conflict. Overall, these findings underscore the crucial role of the Inter-Religious Council in monitoring conflicts and highlight the need for ongoing support to enhance its effectiveness.

3.1.2. Peace Club or Forum

The establishment of peace clubs in Ethiopian educational institutions represents a vital initiative aimed at instilling a culture of peace and conflict resolution among the youth. These clubs engage students in activities that promote dialogue, understanding, and cooperative problem-solving, fostering an environment conducive to social harmony. Activities may include workshops, community service projects, and inter-school debates, equipping young people with the skills necessary for effective conflict resolution and peacebuilding. This approach aligns with findings from similar initiatives in post-conflict societies, such as Rwanda, where youth-led peace initiatives have made significant contributions to reconciliation and social cohesion. Research by Seneviratne (2017) highlights the role of youth engagement in peace clubs in reducing intergroup tensions and fostering mutual understanding, aligning with the goals of Ethiopian peace clubs.

However, challenges persist in implementing these clubs. Participants often encounter obstacles, including limited resources, a lack of administrative support, and societal scepticism regarding their effectiveness. These challenges are comparable to those faced by youth peace initiatives in other regions, where entrenched social divisions and political instability hinder progress, as noted by McEvoy-Levy (2018). Despite these difficulties, the contributions of peace clubs to shaping a generation committed to peace are substantial. They serve as platforms for youth empowerment and play a crucial role in building institutional resilience against conflict.

Table 3. Peace club & forum effectively monitor & warn of inter-ethnic conflict

Peace club forum effectively monitors indicators of inter-ethnic conflict				
	Frequency	Per cent	Valid Percent	Cumulative Percent
Strongly disagree	24	6.3	6.3	6.3
Disagree	53	13.9	13.9	20.3
Neutral	103	27.1	27.1	47.4
Agree	156	41.1	41.1	88.4
Strongly agree	44	11.6	11.6	100.0
Total	380	100.0	100.0	

Table 3 presents a mixed but generally positive perception of the effectiveness of peace clubs and forums in monitoring and warning of inter-ethnic conflict. Specifically, 41.1% of respondents agree that these organisations effectively monitor indicators of inter-ethnic conflict, while an additional 11.6% strongly agree, resulting in a total of 52.7% expressing support. Conversely, 20.2% of respondents express scepticism, with 6.3% strongly disagreeing and 13.9% disagreeing. The neutral response rate of 27.1% indicates that a significant portion of participants remains uncertain about the effectiveness of peace clubs and forums in this critical role.

When compared to other studies, these findings reflect broader trends observed in youth and community engagement initiatives within conflict settings. Research by McEvoy-Levy (2018) suggests that peace clubs and similar organisations can play a vital role in monitoring conflict indicators and promoting dialogue. However, the scepticism noted in the Ethiopian context aligns with challenges identified in other studies, where community members may question the impact of such initiatives due to political instability or limited resources.

Supporting this, Interview Participant 6 noted that peace clubs are organised in educational institutions for students from grades 5 to 12, as well as in vocational training colleges. They highlighted a

significant gap: conflict resolution modules have not been integrated into the school curriculum. Despite this limitation, peace clubs actively monitor potential conflicts, develop early warning systems, facilitate mediation, and raise awareness about the importance of peace and conflict prevention. They also provide training and capacity-building programs for students and community members, fostering collaboration among stakeholders involved in peacebuilding.

Interview Participant 20 emphasised the necessity of collaboration between peace clubs and local authorities to address the root causes of conflicts. Peace clubs establish partnerships, conduct workshops, support policy changes, and organise community dialogues and awareness campaigns to promote peace. Effective engagement requires building trust through regular communication and collaboration on joint initiatives. Involving youth and women in decision-making processes, providing leadership opportunities, and ensuring transparency and accountability are also critical for the success of peace clubs.

Additionally, FGD Participant 8 highlighted that peace clubs aim to instil a culture of peace among students and promote support for peace principles. They educate students on peace values through literature, drama, and panel discussions and organise reconciliation activities and annual Peace Day celebrations. However, Participant 9 raised several challenges faced by peace clubs, including difficulties in building trust with local authorities due to a lack of awareness about peacebuilding initiatives, political tensions, historical grievances, limited resources, and communication barriers. The complex history of ethnic conflicts fosters mistrust among diverse communities, necessitating patience, persistence, and effective advocacy to address these challenges.

Despite the violence in the Ataye city administration, where armed groups have attacked educational institutions, students from the Oromo and Amhara ethnic groups continue to learn together. Effective conflict monitoring by peace clubs has been instrumental in preventing inter-ethnic and inter-religious conflicts among students. Assefa Yigzaw (2020) emphasises the transformative potential of peace education in fostering a culture of peace, tolerance, and understanding among young people. However, significant challenges remain, including limited resources, inadequate teacher training, and insufficient integration of peace education into the national curriculum. Addressing these issues is essential to enhance the effectiveness of peace clubs in promoting lasting change within the community.

The findings indicate a generally positive perception of peace clubs and forums in monitoring inter-ethnic conflict in Ethiopia, with 52.7% of respondents expressing support for their effectiveness. Despite this, scepticism remains, as 20.2% of participants question their impact, reflecting broader challenges observed in other studies regarding political instability and limited resources. Interviews revealed that peace clubs, organised within educational institutions, play a crucial role in conflict prevention and capacity-building, although they often lack integrated conflict resolution modules in their curricula. Collaboration with local authorities is essential for addressing the root causes of conflict, yet challenges such as limited trust, awareness, and resources persist. Despite the violence in regions like Ataye, peace clubs have fostered inter-ethnic cooperation among students, highlighting the transformative potential of peace education. However, significant obstacles must be addressed to enhance their effectiveness.

3.3.4. Focal person/ field monitor

A focal person or field monitor in a conflict early warning system (EWS) plays a vital role in collecting data from various sources, such as community members and local organisations, to identify early signs of tension. In the study area, their responsibilities include gathering both qualitative and quantitative data, engaging with the community to build trust, analysing the information for patterns that indicate potential conflict, and collaborating with local authorities and NGOs to coordinate responses. This proactive approach aligns with the findings of McEvoy-Levy (2018), which emphasise the importance of community-based monitoring systems for reliable data collection.

Table 4. Focal person /filed monitor monitoring

The focal person /field monitor effectively monitors indicators of inter-ethnic conflict					
		Frequency	Per cent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	35	9.2	9.2	9.2
	Disagree	48	12.6	12.6	21.8
	Neutral	87	22.9	22.9	44.7
	Agree	143	37.6	37.6	82.4
	Strongly agree	67	17.6	17.6	100.0
	Total	380	100.0	100.0	

Table 4 presents the respondents' perceptions regarding the effectiveness of focal persons or field monitors in monitoring indicators of inter-ethnic conflict. The data show that a significant portion of respondents (55.2%) agree or strongly agree that these monitors effectively oversee such indicators, with 37.6% agreeing and 17.6% strongly agreeing. In contrast, only 21.8% of respondents express scepticism, with 12.6% disagreeing and 9.2% strongly disagreeing, while 22.9% remain neutral. This indicates a generally positive perception of the monitors' effectiveness, suggesting that many community members recognise their role in preventing conflict.

When compared to other studies, these findings align with broader research on conflict monitoring systems. For example, McEvoy-Levy (2018) emphasises that local monitors who engage with communities can provide valuable insights into emerging tensions, thereby enhancing the reliability of early warning systems. Similarly, Assefa Yigzaw (2020) notes that effective monitoring relies heavily on the trust and cooperation of community members, which is reflected in the favourable opinions expressed in this survey. However, the neutral responses (22.9%) and the percentage of respondents who expressed disagreement (21.8%) highlight areas for improvement, suggesting that further training and community engagement may be necessary to bolster the effectiveness of this monitor.

Most interview participants expressed appreciation for the role of focal persons in conflict monitoring, underscoring their critical function in gathering and analysing information from government officials, community leaders, and residents. These focal persons are essential in identifying potential indicators of inter-ethnic conflict and relaying their findings to the Woreda conflict early warning officer, thereby contributing to the effectiveness of early warning systems and preventive actions. Their proactive approach allows for timely interventions that can mitigate tensions before they escalate into violence. Additionally, focal persons raise awareness about inter-ethnic conflict by educating residents on the signs of conflict and prevention strategies, fostering a community-oriented approach to peacebuilding. They also mediate disputes between different ethnic groups, effectively preventing minor disagreements from developing into larger conflicts, which highlights their essential skills in effective communication, cultural sensitivity, conflict resolution, analytical abilities, and teamwork.

Interview Participant 20 specifically noted that the Ataye conflict early warning section has a focal person in each village tasked with overseeing and coordinating conflict monitoring activities. This decentralised approach enables focal persons to identify, analyse, and report on conflicts more effectively, facilitating timely responses to mitigate and resolve issues as they arise. Their role is crucial not only for promoting peacebuilding and reconciliation but also for contributing to capacity-building initiatives that enhance skills in conflict analysis and mediation within their communities.

FGD Participant 1 emphasised that the government actively implements training programs for focal persons and field monitors, with a focus on preventing and mitigating inter-ethnic conflicts. These programs encompass various critical areas, including conflict resolution, cultural sensitivity, data analysis, and communication skills. The government further enhances these initiatives by providing financial support, equipment, and supervision, continuously improving the training programs to ensure peace and stability in the region.

However, FGD Participant 2 highlighted several challenges confronting focal persons, including limited resources, insufficient training in conflict resolution, security risks, community mistrust, and political interference. Working in conflict-prone areas exposes focal persons to personal security risks, and the perception of them as government spies can undermine community trust due to a lack of transparency in their operations. Addressing these challenges is essential for enhancing the effectiveness of focal persons in their vital roles in conflict monitoring and prevention.

In comparison with other studies, the findings align with existing research that emphasises the importance of field monitors in conflict resolution and management. For instance, Amare (2012) notes that monitors in Gambella serve as critical links between communities and conflict management systems, identifying early warning signs such as resource competition and ethnic tensions while facilitating dialogue among groups. Gebre (2014) finds that monitors in the Somali region effectively reduce violence through community engagement and timely alerts, ensuring their information is taken seriously by authorities. Similarly, Wolde (2016) highlights that in Oromiya, field monitors not only observe but also promote peace by facilitating community dialogues that address root causes, such as political marginalisation and economic disparities. By integrating these monitors into local governance structures, conflict prevention strategies can be enhanced, ensuring that diverse voices are heard. In Ataye, establishing a robust conflict monitoring system that incorporates field monitors could significantly improve early warning capabilities, leveraging local knowledge and building trust to address tensions between the Amhara and Oromo communities, ultimately fostering long-term peace in the region.

A significant majority of respondents (55.2%) perceive focal persons or field monitors as effective in monitoring indicators of inter-ethnic conflict, with 37.6% agreeing and 17.6% strongly agreeing, while only 21.8% express scepticism. This generally positive perception suggests that community members recognise the crucial role these monitors play in preventing conflict. Interview participants further underscore the importance of focal persons in gathering and analysing information, identifying potential conflict indicators, and mediating disputes, which facilitates timely interventions. The government's commitment to training programs enhances the skills of these monitors, although challenges such as limited resources, security risks, and community mistrust remain significant. Comparatively, the findings align with other studies that highlight the effectiveness of local monitors in conflict management, emphasising the need for integrated conflict monitoring systems to foster long-term peace, particularly in regions like Ataye, where tensions between the Amhara and Oromo communities persist.

3.4. Conflict Indicators

The discussion of inter-ethnic conflict indicators in the Ataye region is essential for understanding the complex dynamics of ethnic relations in Ethiopia. This section identified indicators of inter-ethnic conflict in the study area.

Table 5. Agreed on inter-ethnic conflict indicators

Inter-ethnic conflict indicators are identified and agreed upon among actors.				
	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly disagree	12	3.2	3.2	3.2
Disagree	20	5.3	5.3	8.4
Neutral	40	10.5	10.5	18.9
Agree	140	36.8	36.8	55.8
Strongly agree	168	44.2	44.2	100.0
Total	380	100.0	100.0	

Table 5 presents data on the consensus among respondents regarding indicators of inter-ethnic conflict in the Ataye region. The findings reveal that a significant majority of participants (81% com-

bined) agree or strongly agree that specific indicators of inter-ethnic conflict have been identified and acknowledged among various stakeholders. Specifically, 44.2% of respondents strongly agree, while 36.8% agree, indicating a robust recognition of the relevance of these indicators in understanding and managing ethnic tensions. In contrast, only 8.5% of respondents express disagreement (3.2% strongly disagree and 5.3% disagree), while 10.5% remain neutral.

This strong agreement aligns with findings in other studies that emphasise the importance of identifying conflict indicators for effective conflict management. For instance, McEvoy-Levy (2018) highlights that community engagement in recognising early warning signs enhances the credibility of conflict monitoring systems. Similarly, Assefa Yigzaw (2020) notes that local actors' involvement in identifying indicators fosters trust and cooperation, which are vital for successful conflict resolution efforts. Moreover, studies by Amare (2012) and Wolde (2016) corroborate these findings by demonstrating that acknowledgement of conflict indicators among diverse community actors is critical for fostering collaborative peacebuilding initiatives. Amare (2012) found that in the Gambella region, local monitors who successfully identified and communicated conflict indicators were better positioned to facilitate dialogue and reduce tensions. Wolde (2016) further emphasises that in Oromiya, the integration of various stakeholders in recognising conflict indicators has significantly improved community resilience and response strategies.

The majority of interview participants identified a range of common indicators signalling potential inter-ethnic conflicts in Ethiopia, illustrating the complex interplay of political, social, economic, and environmental factors. Key indicators such as a history of conflict, discrimination, and inequality exacerbate feelings of marginalisation among specific groups. Political exclusion and economic disparities exacerbate grievances, fostering an environment conducive to conflict. Additionally, cultural differences, nationalism, and identity politics intensify tensions in a nation characterised by a diverse array of ethnic identities.

Participants from key institutions, including the Ministry of Peace, Police Commission, and Disaster Management Commission (DRM), provided a multifaceted view of the challenges faced in Ethiopia. The Ministry of Peace noted over 44 conflict indicators that encompass various issues, including disasters, robbery, illegal demonstrations, firearm trafficking, and wealth inequality. Their insights highlight how governance failures, such as a lack of rule of law and inadequate public services, exacerbate the dynamics of conflict. Economic challenges, including high unemployment rates and the presence of informal armed groups, further complicate the landscape.

The Police Commission offered more nuanced indicators that reflect daily community realities. For example, unexpected property sales or family separations may signal underlying tensions, while unusual behaviours, such as unknown individuals entering homes, can indicate escalating conflict. Their focus on identity verification for maintenance workers underscores a community response rooted in fear and mistrust, emphasising how daily interactions are influenced by potential conflict.

Participants from the DRM highlighted context-specific indicators relevant to pastoralist communities, which face unique challenges, such as livestock management and resource competition. Their monitoring approach utilises a detailed scoring system to evaluate the severity of each indicator, enabling tailored responses to emerging conflicts. This system defines clear alert stages, ranging from "crisis" to "do not worry," facilitating timely and appropriate interventions.

In summary, while the Ministry of Peace provides a broad overview of systemic issues contributing to conflict, the Police Commission offers insights into everyday indicators that may signal rising tensions, and the DRM focuses on specific challenges faced by pastoralist communities. Together, these perspectives highlight the complexity of conflict dynamics in Ethiopia and underscore the need for comprehensive monitoring approaches that address both systemic and localised issues.

Despite the identification of shared indicators, such as hate speech, armed group mobilisation, and population displacement, participants noted significant challenges in consistently monitoring these indicators. Variability complicates collaborative efforts among peace, security, and humanitarian actors, hindering the exchange of vital information and coordination of interventions. This lack of consensus is particularly concerning, given the critical need for timely responses to emerging tensions to prevent escalation.

Comparatively, the findings on inter-ethnic conflict indicators in Ethiopia align with the existing literature, which underscores the complexity of conflict dynamics in the region. Amare (2012) emphasises the significance of local knowledge and community engagement in enhancing early warning systems, while Gebre (2014) advocates for context-specific monitoring approaches tailored to the unique challenges faced by different ethnic groups. Supporting these perspectives, Abbink (2021), De Waal (2022), and the International Crisis Group (2021) highlight rising political polarisation, hate speech, discrimination, and social unrest as critical indicators fostering an environment conducive to violence. Economic disparities and unequal access to resources contribute to group resentment, while historical grievances and unresolved injustices exacerbate tensions. Weak governance and corruption undermine institutional trust, creating conditions that are ripe for conflict, which is further intensified by the proliferation of small arms and environmental degradation resulting from climate change. The spread of misinformation via social media incites violence, and the erosion of traditional conflict resolution mechanisms leaves communities vulnerable. Limited communication and a lack of trust hinder the pursuit of peaceful resolutions, reinforcing the need for inclusive dialogue and equitable resource allocation. Addressing these multifaceted indicators is essential for preventing future conflicts, with early warning systems and proactive interventions playing critical roles in mitigating inter-ethnic violence in Ethiopia.

Eighty-one per cent of participants agree or strongly agree that specific indicators have been identified and acknowledged. This robust recognition, supported by literature, emphasises the importance of local knowledge and community engagement in conflict monitoring, as seen in studies by Amare (2012) and Gebre (2014), which advocate for context-specific approaches tailored to unique ethnic challenges. Participants from key institutions, such as the Ministry of Peace and the Police Commission, identified a range of indicators, including governance failures, economic disparities, and daily community tensions, which illustrate the complex interplay of political, social, and economic factors contributing to conflict. The Disaster Management Commission (DRM) provided context-specific insights for pastoralist communities, utilising a scoring system to tailor responses to emerging conflicts. Despite identifying shared indicators such as hate speech and armed group mobilisation, challenges in consistent monitoring hinder collaborative efforts among peace and security actors, emphasising the need for timely responses to prevent escalation.

3.5. Conflict Monitoring Process

The monitoring process of inter-ethnic conflict in Ataye is crucial for understanding and managing ethnic tensions in the region. This section explores the multifaceted aspects of conflict monitoring, including various data sources that inform stakeholders about prevailing dynamics. It discusses the tools used for data collection and the analysis methods employed to effectively interpret this information. Additionally, it examines reporting mechanisms for conflict warnings, highlighting how timely communication facilitates proactive responses to emerging threats.

3.5.1. Sources of Data

Identifying sources of inter-ethnic conflict data is a crucial first step in the monitoring process, as it is essential for practical conflict assessment and intervention. This involves analysing various stakeholders, including local communities, civil society organisations, government agencies, and media outlets, each of which provides unique insights into the socio-political landscape. This section will highlight the significance of these diverse data sources in promoting peace and stability in the region.

Table 6. Sources of data

Data collected from various sources, including local communities, civil society organisations, government agencies, media reports				
	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly disagree	20	5.3	5.3	5.3
Disagree	58	15.3	15.3	20.5
Neutral	62	16.3	16.3	36.8
Agree	188	49.5	49.5	86.3
Strongly agree	52	13.7	13.7	100.0
Total	380	100.0	100.0	

Table 6 presents data on the perceived reliability and diversity of sources from which information on inter-ethnic conflict indicators is collected in the Ataye region. The findings indicate that a significant majority of respondents (63.2%) either agree or strongly agree that data is effectively gathered from various sources, including local communities, civil society organisations, government agencies, and media reports. Specifically, 49.5% of respondents agree, while 13.7% strongly agree, reflecting a general confidence in the multi-source approach to data collection. Conversely, a combined 20.6% of respondents express disagreement (5.3% strongly disagree and 15.3% disagree), while 16.3% remain neutral. This strong inclination toward agreement underscores the importance of multiple perspectives in understanding the dynamics of inter-ethnic conflict.

These findings align with the existing literature, which emphasises the significance of diverse data sources in conflict analysis. For instance, McEvoy-Levy (2018) asserts that incorporating various perspectives enhances the credibility and comprehensiveness of conflict monitoring systems. Similarly, Gebre (2014) highlights the role of civil society organisations in providing ground-level insights that are essential for grasping the complexities of ethnic tensions. Studies by Abbink (2021) and De Waal (2022) further support the notion that a multi-faceted approach to data collection is crucial for accurately assessing conflict dynamics, as it captures the diverse experiences and viewpoints of affected communities. Overall, the findings from Table 6 emphasise the necessity of leveraging multiple sources for data collection to foster a nuanced understanding of inter-ethnic conflicts in Ethiopia, thereby enhancing the reliability of the information gathered and aligning with broader scholarly perspectives that advocate for inclusive and comprehensive conflict monitoring.

Comparing these findings with insights from interview participants and focus group discussions reveals a deeper understanding of the collaborative nature of conflict monitoring in Ethiopia. Interview Participant 1 emphasised the roles of various stakeholders, including Indigenous institutions, government officials, community leaders, and civil society organisations, which align well with the diverse sources reflected in Table 6. Indigenous institutions leverage their expertise in resolving intra-ethnic conflicts, complementing the guidance and resources provided by government officials. Community leaders serve as mediators, while civil society organisations enhance the monitoring process through training and advocacy, thereby fostering a comprehensive approach to conflict management. This multi-stakeholder engagement aligns with the findings of McEvoy-Levy (2018), who argues that community involvement is crucial for effective conflict monitoring systems.

Further insights from Interview Participant 8 highlight the extensive range of entities from which conflict focal persons gather data, including government agencies, intelligence services, nongovernmental organisations (NGOs), and academic institutions. This broad spectrum aligns with the strong agreement in Table 6 regarding the effectiveness of utilising multiple data points for a comprehensive understanding of the conflict landscape. Analysing this information enables focal persons to identify trends, assess credibility, and provide actionable intelligence, which is crucial for informed decision-making in conflict situations. Focus Group Discussion participants underscored the necessity of validating the credibility of information sources, emphasising the importance of evaluating the reputation of sources, corroborating data, and consulting subject matter experts. This validation process is crucial for mitigating misinformation and ensuring the reliability of the data used in monitoring efforts. Strategies such as triangulation and iterative refinement enhance the robustness of

the collected information, ultimately contributing to more effective prevention and resolution strategies in conflict situations. These insights are supported by Gebre (2014), who emphasises the need for diverse data sources to accurately assess conflict dynamics.

Table 6 highlights the perceived reliability and diversity of sources for collecting information on inter-ethnic conflict indicators in the Ataye region, revealing that 63.2% of respondents either agree or strongly agree that data is effectively gathered from a variety of sources, including local communities, civil society organisations, government agencies, and media reports. Specifically, 49.5% agree, and 13.7% strongly agree, indicating a high level of confidence in this multi-source approach. Meanwhile, 20.6% express disagreement and 16.3% remain neutral. These findings align with existing literature, such as McEvoy-Levy (2018) and Gebre (2014), which emphasise the importance of diverse data sources in enhancing the credibility and comprehensiveness of conflict monitoring. Insights from interviews and focus group discussions further underscore the collaborative nature of conflict monitoring in Ethiopia, highlighting the roles of various stakeholders—including Indigenous institutions, community leaders, and civil society organisations—in fostering a robust approach to understanding and managing ethnic tensions. Participants emphasised the importance of validating information sources and employing strategies such as triangulation to ensure data reliability, ultimately contributing to more effective conflict prevention and resolution efforts.

3.5.2. Data collection tools

Data collection tools for monitoring inter-ethnic conflict in Ataye employ various methodologies, including questionnaires, interviews, observations, focus group discussions (FGDs), and document reviews. These tools provide a comprehensive understanding of ethnic relations and potential conflict indicators, fostering a multifaceted approach that supports informed decision-making and targeted conflict resolution efforts. This section highlights the data collection methods utilised in the study area.

Table 7. Data collection tools

Data collection tools are Open-source intelligence , interviews and surveys, remote sensing, sensor networks, conference				
	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly disagree	71	18.7	18.7	18.7
Disagree	40	10.5	10.5	29.2
Neutral	86	22.6	22.6	51.8
Agree	116	30.5	30.5	82.4
Strongly agree	67	17.6	17.6	100.0
Total	380	100.0	100.0	

Table 7 provides insights into the perceived effectiveness of various data collection tools used for monitoring inter-ethnic conflict indicators in the Ataye region. The findings reveal that a combined 48.1% of respondents either agree (30.5%) or strongly agree (17.6%) that tools such as open-source intelligence, interviews and surveys, remote sensing, sensor networks, and conferences are effective in data collection. In contrast, 29.2% of respondents express disagreement (18.7% strongly disagree and 10.5% disagree), while 22.6% remain neutral. This distribution of responses suggests a moderate level of confidence in the effectiveness of these tools, with a notable proportion of respondents remaining uncertain about their utility.

These findings resonate with existing literature that emphasizes the importance of diverse methodologies in conflict monitoring. For instance, McEvoy-Levy (2018) underscores the value of qualitative methods, such as interviews and surveys, in capturing nuanced community perspectives, while remote sensing and sensor networks are highlighted by Wiegand et al. (2020) as innovative

approaches for real-time data collection in conflict settings. Furthermore, studies by Gebre (2014) and Abbink (2021) advocate for a mixed-methods approach, combining qualitative and quantitative tools to enhance the reliability of conflict data. Overall, the insights from Table 7 reflect a growing recognition of the need for varied data collection tools to effectively understand and address the complexities of inter-ethnic conflicts in Ethiopia.

Most interview participants identified additional tools for monitoring inter-ethnic conflict, such as questionnaires, key informant interviews, focus group discussions, document analysis, participatory mapping, and social media monitoring. Surveys are employed to gather quantitative data on the causes, triggers, and impacts of conflicts, while key informant interviews provide valuable insights into the underlying dynamics. Focus group discussions help to identify shared themes and perspectives among different ethnic groups, and document analysis reveals trends and patterns over time. Participatory mapping engages communities in delineating their territories and conflicts, while social media monitoring offers real-time updates on inter-ethnic tensions. Collectively, these tools illustrate a comprehensive approach to collecting conflict indicators data, reflecting a growing trend in conflict research that emphasizes mixed-methods strategies (McEvoy-Levy, 2018).

An interview participant described the role of a conflict situation room, which serves as a centralized space for government, military, or crisis management organizations to coordinate responses to crises. This room is crucial for information gathering, decision-making, incident monitoring, and resource management, collecting real-time data from various sources, including sensor data, social media analysis, and intelligence reports. The emphasis on high-quality data underscores the need for accurate, complete, and credible information to ensure that responses are well-informed and effective. This aligns with findings from Gebre (2014), who emphasizes the importance of real-time data in crisis response.

Focus group discussion (FGD) participants highlighted a preference for direct observation and networking as common data collection methods. Direct observation is valued for its accuracy, as it involves a defined set of indicators, while networking facilitates information exchange, early warning systems, and collaborative response efforts. These methods are essential for fostering communication and mutual support among various actors engaged in conflict prevention and peacebuilding. However, participants also noted challenges associated with conflict data collection, such as limited access to conflict-affected areas due to infrastructure issues, security concerns, and political instability. Language barriers, sensitivity around reporting, bias in information gathering, and low literacy levels may further complicate data collection efforts. Ethical considerations regarding the safety and privacy of respondents also present significant challenges, echoing concerns raised by Abbink (2021) regarding the complexities of conducting research in conflict zones.

Table 7 reveals insights into the perceived effectiveness of various data collection tools for monitoring inter-ethnic conflict indicators in the Ataye region, indicating that 48.1% of respondents either agree (30.5%) or strongly agree (17.6%) that tools such as open-source intelligence, interviews, surveys, remote sensing, and sensor networks are effective. Conversely, 29.2% express disagreement, and 22.6% remain neutral, suggesting a moderate level of confidence in these tools. This aligns with existing literature emphasizing the value of diverse methodologies in conflict monitoring, with qualitative methods capturing nuanced perspectives and innovative approaches like remote sensing providing real-time data (McEvoy-Levy, 2018; Wiegand et al., 2020). Additional tools identified by interview participants, such as questionnaires, key informant interviews, and participatory mapping, illustrate a comprehensive approach to conflict data collection. While the role of conflict situation rooms in centralised response coordination underscores the importance of real-time data, challenges such as limited access to conflict areas, language barriers, and ethical considerations complicate monitoring efforts. Overall, these findings highlight the necessity of employing a mixed-methods strategy to address the complexities of inter-ethnic conflicts in Ethiopia effectively.

3.5.3. Data Analysis Methods

The data analysis methods used in monitoring inter-ethnic conflict in Ataye are essential for converting raw information into actionable insights that guide decision-making and intervention strat-

egies. This section examines the analytical approaches employed to interpret data collected from various sources.

Table 8. The collected conflict data analyzed scientifically

The collected data analysis via scientifically mixed research methods				
	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly disagree	28	7.4	7.4	7.4
Disagree	41	10.8	10.8	18.2
Neutral	92	24.2	24.2	42.4
Agree	171	45.0	45.0	87.4
Strongly agree	48	12.6	12.6	100.0
Total	380	100.0	100.0	

Table 8 presents data on the perceived effectiveness of scientifically analyzing collected conflict data using mixed research methods. The findings indicate that a significant majority of respondents (57.6%) either agree (45.0%) or strongly agree (12.6%) that the application of mixed methods enhances the analysis of conflict data. In contrast, 18.2% of respondents express disagreement (10.8% disagree and 7.4% strongly disagree), while 24.2% remain neutral. This distribution suggests a strong inclination toward recognizing the value of mixed research methods in understanding and addressing conflict dynamics.

These results are consistent with existing literature that highlights the importance of employing diverse methodologies in conflict research. For instance, McEvoy-Levy (2018) advocates for mixed methods as a way to capture the complexity of conflicts by integrating quantitative and qualitative data. Similarly, Gebre (2014) emphasizes that a mixed-methods approach allows for a more comprehensive understanding of conflict indicators, as it combines statistical analysis with in-depth qualitative insights. Furthermore, studies by Abbink (2021) support the notion that scientific analysis of conflict data can lead to more robust conclusions and effective interventions. Overall, the findings from Table 8 underscore a growing recognition of the necessity for scientifically informed, mixed-method approaches to enhance the reliability and depth of conflict data analysis in Ethiopia.

Most interview participants emphasized that qualitative data analysis is particularly effective for conflict monitoring, as it enables researchers to grasp subjective experiences, motivations, and the underlying reasons for inter-ethnic tensions. This qualitative approach allows for a nuanced understanding of conflicts, facilitating the identification of potential solutions and examining the historical, cultural, and political contexts that influence these tensions. However, many participants highlighted that employing mixed-methods research approaches is optimal for comprehensive conflict analysis, as these methods integrate the strengths of both qualitative and quantitative techniques.

Focus group discussion (FGD) participants acknowledged several challenges in conflict analysis, including information overload, time constraints, emotional stress, bias, subjectivity, and limited access to information. The complexities and uncertainties inherent in conflict situations require effective collaboration among experts and analysts to navigate these obstacles. One FGD participant noted that experts can analyze large volumes of information efficiently by employing prioritization, categorization, and technological tools. Collaborative efforts are essential for managing complex information and ensuring organization, with strategies to combat information overload including task prioritization, filtering information, setting time limits, scheduling activities, and utilizing collaboration platforms.

These findings resonate with the document review conducted by Abebe and Kebede (2020), which emphasizes the importance of context-specific approaches in conflict monitoring. Their study highlights that qualitative methods can provide critical insights into the socio-political dynamics of conflicts, while quantitative data can offer robust statistical evidence to inform decision-making. Similarly, other studies underscore the necessity of mixed-methods approaches in capturing the multifaceted nature of conflicts, advocating for strategies that enhance collaboration among various stakeholders involved in conflict resolution (Gebre, 2014; McEvoy-Levy, 2018). By addressing the

challenges identified in FGDs and leveraging mixed methods, researchers and practitioners can develop more effective frameworks for understanding and resolving inter-ethnic conflicts.

Table 8 illustrates a strong endorsement for the effectiveness of scientifically analyzing collected conflict data using mixed research methods, with 57.6% of respondents agreeing (45.0%) or strongly agreeing (12.6%) on the importance of these approaches in enhancing conflict analysis. In contrast, 18.2% of respondents expressed disagreement, and 24.2% remained neutral, indicating significant support for mixed methods in understanding conflict dynamics. This aligns with existing literature that underscores the necessity of combining qualitative and quantitative techniques to capture the complexity of conflicts (McEvoy-Levy, 2018; Gebre, 2014). Interview participants further emphasized the value of qualitative analysis for understanding subjective experiences and motivations behind inter-ethnic tensions, while focus group discussions highlighted challenges such as information overload and the need for effective collaboration among analysts. These findings resonate with Abebe and Kebede's (2020) emphasis on context-specific approaches and the importance of mixed-methods for comprehensive conflict analysis, suggesting that such strategies can significantly enhance the reliability and depth of insights into inter-ethnic conflicts in Ethiopia.

3.5.4. Reporting Conflict Warning

The reporting of inter-ethnic conflict warnings and alerts in Ataye is vital for effective conflict management and prevention. This section explores the mechanisms for reporting conflict warnings.

Table 9. Reporting of inter-ethnic conflict warning.

Warnings issued if the monitoring identifies potential risks , providing guidance on mitigating them				
	Frequency	Percent	Valid Percent	Cumulative Percent
strongly disagree	8	2.1	2.1	2.1
Disagree	30	7.9	7.9	10.0
Neutral	94	24.7	24.7	34.7
Agree	172	45.3	45.3	80.0
Strongly agree	76	20.0	20.0	100.0
Total	380	100.0	100.0	

Table 9 presents data on the perceived effectiveness of warning systems for monitoring inter-ethnic conflict, specifically regarding the issuance of warnings when potential risks are identified and the provision of guidance on mitigating them. The findings reveal that a substantial majority of respondents (65.3%) either agree (45.3%) or strongly agree (20.0%) that such warning systems are beneficial for conflict management. Conversely, 10.0% of respondents express disagreement (7.9% disagree and 2.1% strongly disagree), while 24.7% remain neutral. This distribution indicates strong support for implementing effective warning mechanisms as a proactive measure to address inter-ethnic conflicts.

These results align with existing literature that emphasizes the significance of timely warnings in conflict prevention. For example, the work of McEvoy-Levy (2018) highlights how early warning systems can facilitate timely interventions and enhance stakeholders' ability to respond to emerging threats. Similarly, Gebre (2014) argues that the effective communication of potential risks is crucial in mitigating the escalation of conflicts, as it enables the mobilisation of resources and community engagement. The findings from Table 9 underscore the growing recognition of the importance of structured warning systems in enhancing conflict resilience and response strategies in Ethiopia, reflecting broader trends observed in conflict studies that advocate for proactive measures in conflict management (Abbink, 2021).

To support the quantitative findings, most interview participants emphasized that early warning reports are crucial for establishing a clear connection between warnings and responses, facilitating informed decision-making. These reports not only inform and challenge policymakers but also inspire necessary actions for short-term aversion, containment, or relief interventions, as well as long-term strategies to reduce the likelihood of violence. Participants noted that effective early warning

reports should be concise, specific, visually impactful, and realistic, clearly articulating the proximity of threats, outlining likely scenarios, and proposing actionable recommendations.

Interview Participant 2 highlighted that conflict-warning reports are generated daily from each kebele to the federal level via communication platforms like Telegram and WhatsApp. However, a significant challenge identified was the lack of feedback from higher authorities to local conflict monitoring bodies. The Minister of Peace has established standardized forms for situation reports, incident reports, and forecasting reports. Situation reports provide a comprehensive overview of conflict-prone areas, detailing changes in indicators, group mobilization actions, public perceptions, grievances, and their implications for peace or violence. Incident reports capture sudden events in conflict-prone zones, documenting patterns, trends, and the frequency of violence.

Focus Group Discussion (FGD) Participant 7 pointed out that kebeles serve as the initial units for early warning and rapid response coordination, collecting information from grassroots sources through field monitors. This information is relayed to Woreda Coordinating Units (WCUs), which analyze and respond to manageable issues, then report all early warning information to Zonal Coordination Units (ZCUs), which forward it to Regional Coordination Units (RCUs). The Ministry of Peace acts as the national hub for collecting and analyzing early warning information, coordinating rapid responses to conflict-induced crises.

Further emphasizing data quality, FGD Participant 3 stated that early warning information should be timely, accurate, valid, reliable, verifiable, and complete, detailing the incident's date, location, involved parties, actions taken, circumstances, and responding actors. The report must effectively answer the five essential WH-questions to provide a comprehensive understanding of the situation. Overall, these qualitative insights reinforce the significance of structured and responsive early warning systems in enhancing conflict prevention efforts in Ataye, consistent with findings from other studies that advocate for robust early warning mechanisms in conflict management (McEvoy-Levy, 2018; Gebre, 2014). These studies emphasize that timely and accurate data is vital for effective intervention strategies, aligning well with the qualitative feedback from participants in this research

3.6. Effect of Conflict Monitoring on CEWs

This study examines the impact of conflict monitoring on Community Early Warning Systems (CEWs), emphasising their role in promoting community resilience and facilitating proactive responses to potential conflicts.

Table 12. Model Summary.

Model Summary[b]					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.917[a]	.841	.841	.24239	1.054

a. Predictors: (Constant), conflict monitoring actors

b. Dependent Variable: Conflict early warning system

Table 12 presents a model summary for the relationship between conflict monitoring actors and the effectiveness of conflict early warning systems. The model shows a strong correlation coefficient (R = 0.917), indicating a high degree of association between the predictors and the dependent variable. The R Square value of 0.841 suggests that approximately 84.1% of the variance in the effectiveness of the conflict early warning system can be explained by the actions of conflict monitoring actors. This high level of explanatory power demonstrates the significant role that these actors play in enhancing early warning capabilities.

The adjusted R-squared value, which accounts for the number of predictors in the model, is also 0.841, reinforcing the model's reliability. The standard error of the estimate (0.24239) indicates the

average distance that the observed values fall from the regression line, suggesting a relatively low level of error in the predictions made by the model. Furthermore, the Durbin-Watson statistic of 1.054 suggests that there is no significant autocorrelation in the residuals, which is essential for the validity of regression analyses.

These findings are consistent with existing research that underscores the importance of various actors in conflict monitoring and early warning systems. For instance, McEvoy-Levy (2018) emphasises that effective collaboration among different stakeholders enhances the reliability of early warning mechanisms. Similarly, studies by Gebre (2014) highlight the critical role of local actors in providing timely and relevant information that informs conflict response strategies.

Additionally, research by Abbink (2021) supports the notion that a multi-actor approach in conflict monitoring improves the adaptability and responsiveness of early warning systems. Furthermore, the work of Kalyvas (2006) illustrates that local community involvement is crucial for effective conflict prevention, as grassroots actors often have the most accurate insights into emerging tensions. Overall, the results from Table 12 align with the literature supporting the idea that well-coordinated conflict monitoring efforts significantly improve early warning systems, thereby facilitating more effective conflict prevention and response.

Table 13. ANOVA results

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	117.666	1	117.666	2002.698	.000[b]
	Residual	22.209	378	.059		
	Total	139.875	379			

Table 13 presents the results of an Analysis of Variance (ANOVA) for the regression model examining the relationship between conflict monitoring actors and the effectiveness of the conflict early warning system. The regression sum of squares is 117.666, indicating a significant amount of variance in the dependent variable that can be explained by the independent variable. With 1 degree of freedom for the regression and 378 for the residual, the model shows a mean square for regression of 117.666 and a mean square for the residual of 0.059. The F-statistic is 2002.698, which reflects a strong relationship between conflict monitoring actors and the effectiveness of the early warning system. The significance value (p-value) of .000 indicates that this relationship is statistically significant at any conventional alpha level, suggesting robust evidence against the null hypothesis.

These findings align with existing literature emphasizing the importance of effective conflict monitoring in enhancing early warning systems. McEvoy-Levy (2018) highlights that robust monitoring frameworks significantly improve the predictive capabilities of early warning systems. Similarly, Gebre (2014) discusses how the involvement of various actors in conflict monitoring leads to more accurate assessments of potential conflicts, facilitating timely interventions. Dejene (2014) and Kebede (2019) also emphasise that diverse stakeholder participation is crucial for enhancing the accuracy and reliability of conflict assessments. Moreover, Tronvoll (2013) emphasises that incorporating multiple perspectives into conflict monitoring not only enriches the data collected but also fosters a sense of ownership among community members, ultimately leading to more effective conflict prevention strategies. Overall, the results from Table 13 underscore the critical role that conflict monitoring actors play in the effectiveness of early warning systems, reinforcing broader trends in conflict research that advocate for comprehensive monitoring approaches.

Table 14.Coefficients.

Coefficients[a]								
Model		Unstandardised Coefficients		Standardized Coefficients	t	Sig. Tolerance	Collinearity Statistics	
	B		Std. Error	Beta			VIF	
1	(Constant)	1.258	.048		26.397	.000		
	c/monitoring actors	.574	.013	.917	44.752	.000	1.000	1.000

Table 14 provides the coefficients from the regression analysis examining the relationship between conflict monitoring actors and the effectiveness of the conflict early warning system. The unstandardised coefficient for the constant is 1.258, indicating the baseline level of effectiveness when the predictor variable is zero. The coefficient for conflict monitoring actors is 0.574, suggesting that for every unit increase in the involvement of monitoring actors, the effectiveness of the early warning system increases by approximately 0.574 units. This strong positive relationship is further supported by the standardised coefficient (Beta) of 0.917, which indicates a substantial effect size, implying that conflict monitoring actors are a significant predictor of early warning system effectiveness.

The t-value for conflict monitoring actors is 44.752, with a significance level (p-value) of .000, indicating that this relationship is statistically significant. The collinearity statistics, including a tolerance of 1.000 and a Variance Inflation Factor (VIF) of 1.000, suggest that there is no multicollinearity issue affecting the regression model. These findings are consistent with literature emphasizing the importance of diverse stakeholder participation in conflict monitoring. For instance, studies by Dejene (2014) and Kebede (2019) highlight that involving local actors significantly enhances the reliability and responsiveness of early warning systems. Moreover, Tronvoll (2013) underscores that integrating multiple perspectives enriches data collection and fosters community ownership, thereby improving conflict assessments. Overall, the results from Table 14 reinforce the notion that effective and inclusive conflict monitoring is crucial for advancing the efficacy of early warning systems.

he findings from Tables 12 to 14 collectively underscore the significant relationship between conflict monitoring actors and the effectiveness of conflict early warning systems. Table 12 reveals a high correlation coefficient (R = 0.917) and an R Square value of 0.841, indicating that approximately 84.1% of the variance in early warning system effectiveness can be explained by the actions of conflict monitoring actors. The ANOVA results in Table 13 further support these findings, with an F-statistic of 2002.698 and a significance value of .000, demonstrating that the model is statistically significant. Finally, Table 14 presents regression coefficients showing that for each unit increase in the involvement of monitoring actors, the effectiveness of the early warning system increases by approximately 0.574 units, with a standardized Beta of 0.917, indicating a strong effect size. The absence of multicollinearity is confirmed by a tolerance of 1.000 and a VIF of 1.000. These results align with existing literature, emphasizing the critical role of diverse stakeholder participation in enhancing the accuracy and responsiveness of early warning systems, as highlighted by Dejene (2014), Kebede (2019), and Tronvoll (2013). Together, these findings reinforce the notion that effective and inclusive conflict monitoring is essential for advancing the efficacy of early warning systems.

4. Conclusion

In conclusion, this study highlights the essential role of conflict monitoring in preventing and mitigating the Ataye conflict in the North Shewa zone. The grassroots efforts by peace councils, forums, and clubs reflect a community-driven approach to conflict resolution; however, the absence of formal organization and transparency fosters distrust among community members. Despite the

identification of 44 conflict indicators by the Minister of Peace, significant gaps in awareness and understanding among monitoring actors persist, underscoring the need for improved coordination among peace, security, and humanitarian stakeholders. Key indicators, such as territorial claims and resource competition, illustrate the complexity of the conflict, necessitating a comprehensive monitoring framework. While the bottom-to-top reporting structure facilitates grassroots data collection, insufficient feedback from higher officials undermines the system's effectiveness and delays timely interventions. Therefore, enhancing transparency, coordination, and communication among all monitoring actors is crucial for building community trust and resilience. Coordination should be improved by establishing a national conflict data-sharing platform between the Ministry of Peace and local peace committees. Ultimately, these improvements will contribute to more effective conflict prevention strategies in the region, ensuring that early warning systems are not only functional but also trusted by the communities they aim to protect.

Need for Further research

Future research on inter-ethnic conflict monitoring techniques in Ethiopia should prioritize several critical areas to enhance the effectiveness of early warning systems. First, longitudinal studies could track the effectiveness of various monitoring methods over time, providing insights into how inter-ethnic dynamics evolve and how monitoring techniques can adapt accordingly. Additionally, exploring community-based monitoring approaches that engage local actors can reveal culturally relevant practices that improve data collection and enhance community trust in conflict management efforts. It is essential to assess the role of technology, such as mobile applications and big data analytics, in improving the accuracy and timeliness of conflict alerts. Comparative studies examining successful monitoring techniques in similar contexts, both within and outside Ethiopia, can offer valuable lessons and best practices. Ultimately, research should prioritise integrating diverse perspectives, particularly from marginalised communities, to ensure that monitoring frameworks are comprehensive and inclusive. Addressing these areas will significantly strengthen inter-ethnic conflict monitoring techniques and improve overall conflict prevention strategies.

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Disaster Risk Management in Libraries and Information Centers: Global Strategies, Challenges, Policy and Recommendations

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ABSTRACT

Libraries and Information Centers, as custodians of information, knowledge, and cultural heritage, face significant risks from disasters that threaten their collections, operations, and the communities they serve. This paper examines disaster risk management (DRM) in libraries and information centres by defining disaster risk and DRM, identifying key DRM approaches specific to these institutions, and outlining measures for safeguarding library resources. It also analyses the significant challenges libraries face in implementing effective DRM and offers actionable recommendations to strengthen their resilience. Emphasis is placed on the critical need for proactive disaster preparedness, including forging strong partnerships with organisations such as the Nigerian Environmental Management Agency (NEMA) to facilitate emergency services, resource sharing, and expertise exchange, as well as collaboration with the British Library to promote regular, practical training sessions on disaster response and recovery for libraries and information centres in Nigeria. Furthermore, the study emphasises the importance of proactive policy development, continuous capacity building, and the adoption of technology-driven solutions to enhance disaster resilience. Through these strategic initiatives, libraries can better safeguard their invaluable assets and maintain their crucial role in community recovery and the preservation of knowledge.

KEYWORDS

Disaster risk management; libraries; information centres; disaster preparedness; resilience strategies; emergency response; policy recommendations; developing countries.

1. Introduction

Libraries serve as vital repositories of information, preserving both physical and digital resources for education, research, and cultural heritage. However, they are vulnerable to natural, technological, and human-induced disasters that can disrupt services and destroy collections. Disaster risk management (DRM) has emerged as a crucial framework for mitigating these threats. This paper defines disaster risk and discusses Disaster Risk Management (DRM) types in libraries, explores measures to secure resources, and critically analyses challenges and recommendations.

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Libraries are defined as critical community resilience hubs that leverage their infrastructure and resources to support disaster risk management by providing safe spaces, access to information, and recovery assistance during and after disasters (Pathak, 2019; Bansal, 2015). This role extends beyond traditional functions, positioning libraries as active participants in community preparedness and response. In DRM, libraries are characterised as institutions responsible for safeguarding vulnerable cultural and intellectual assets against disasters, requiring proactive measures like risk assessments and preservation strategies to mitigate loss (Smith & Kostelecky, 2021; Brender & Markov, 2013). This definition emphasises their protective duty toward irreplaceable collections. The importance of libraries and information centres' preparedness for disasters and prevention is crucial, as they significantly impact the preservation of intellectual content for current and retrospective information seekers and users.

Consequently, libraries are recognised as key players in disaster risk management by serving as trusted sources of information, disseminating disaster preparedness knowledge, and facilitating communication between authorities and the public (Falcao et al., 2024). This role underscores their capacity to educate and empower communities. In this context, libraries within the DRM framework are regarded as adaptive organisations that integrate risk reduction, response, and recovery into their operational models, ensuring service continuity and resource accessibility despite the impacts of disasters (Johnson & Lee, 2025). This definition emphasises their evolving, resilient nature.

However, disaster risk refers to the potential loss of life, injury, or damage to assets resulting from the interaction of hazards, vulnerability, and exposure within a specified area over a specific period (UNDRR, 2017). In the library context, disaster risk encompasses the likelihood of events such as floods, fires, earthquakes, cyber-attacks, or theft impacting collections, infrastructure, and users. Vulnerability stems from factors such as poor building design, inadequate preservation techniques, or a lack of preparedness, which exacerbate this risk. At the same time, exposure pertains to the location of library assets in hazard-prone areas (Robertson, 2015).

Disaster risk management (DRM) systematically applies policies, strategies, and practices to prevent new risks, reduce existing risks, and manage residual risks, thus enhancing resilience and minimising disaster losses (UNDRR, 2017). For libraries, DRM involves planning, organising, and implementing measures to protect resources and ensure service continuity before, during, and after a disaster (Bansal, 2015). Disaster risk management in libraries and information centres is the systematic process of identifying, assessing, and mitigating risks posed by natural or human-induced disasters—such as fires, floods, or theft—to protect collections, infrastructure, and services (Sudar, Cvetković, & Ivanov, 2024; Jovičić, Gostimirović, & Milašinović, 2024; Kabir, Tanvir, & Haque, 2022; Kaur, 2020). It emphasises proactive planning, staff training, and resource allocation to minimise vulnerability and ensure continuity of access to information within library operations (Brown, 2018; Ayoung et al., 2016).

The importance of libraries and information centres' response and recovery is fundamental to ensuring disaster risk management (DRM) policies, plans, and actions are designed to prepare for, respond to, and recover from disasters. They must ensure that library and information professionals are well-equipped with contingency plans, emergency response teams, and post-disaster restoration efforts to safeguard both physical and digital resources, thereby ensuring that libraries remain functional hubs for knowledge dissemination (Issa e*t al.,* 2016; Velasquez *et al.,* 2016). With that, Libraries and Information centres will need to take a proactive step in strengthening the implementation of DRM Policy (Disaster Prevention and Mitigation, Disaster Preparedness, Disaster Response and Disaster Recovery and Rehabilitation) to ensure the safety of every individual, intellectual property in libraries and information centres in the community and also reduce natural and man-made disaster risks.

To guide this study and provide a structured framework for analysis, several research questions have been formulated. These questions aim to explore global practices, collaborative efforts, prevalent strategies, and challenges related to disaster risk management (DRM) in libraries and information centres. They serve as the foundation for investigating how institutions can better prepare for, respond to, and recover from various disaster scenarios:

- What do libraries and information centres employ the key strategies globally for effective disaster risk management?
- How do libraries collaborate with emergency organisations (e.g., NEMA, FEMA) and international partners (e.g., British Library) to enhance DRM?
- What preventive, reactive, and integrated DRM approaches are most prevalent?
- What are libraries and information centres' primary challenges in implementing disaster risk management?

2. Methodology

This comprehensive study employed a descriptive qualitative research approach to synthesise a broad spectrum of global knowledge on disaster risk management tailored explicitly for libraries and information centres. The research aimed to identify effective strategies, highlight key challenges and provide practical recommendations that can significantly enhance the resilience of these vital institutions in the face of unforeseen disasters.

To achieve this, a meticulous multi-stage screening process was implemented for the selection of high-quality and relevant literature, including peer-reviewed articles, insightful case studies (notably regarding funding constraints as discussed by Zaveri in 2024; Ebijuwa & Oyelude in 2016; Velasquez et al. in 2016; along with aspects of technological resilience in the UK as noted by Brown in 2018), as well as technical reports and regulatory documents originating from a diverse array of regions including Africa, North America, Europe, Asia, and Oceania. This careful selection process ensured a rich diversity of geographical and institutional perspectives, as well as varying disaster contexts. The literature was sourced from reputable academic databases, including Scopus, Web of Science, Library and Information Science Abstracts (LISA), Emerald Insight, and Google Scholar, as well as specific Disaster-Specific Repositories, thereby strengthening the overall research framework.

3. Reviews on Disaster Risk Management (DRM) Strategy

National agencies and researchers worldwide have conducted studies on disaster risk management (DRM) to promote resilient, stronger, and proactive DRM governance in all organisations. Disaster risk management in libraries involves a holistic approach that integrates risk assessment, prevention, preparedness, response, and recovery strategies. It aims to reduce the impact of disasters on library assets and services through technological innovation, stakeholder collaboration, and resilience-building measures tailored to local and global disaster profiles (Echezona *et al.*, 2018).

According to Al-Malawi, El-Mougher and Al-Agha (2021), in their study on the role of the Al-Shifa Medical Complex administration in evacuation and Sheltering Planning, due to the suffering of the Gaza Strip from repeated attacks by the Israeli occupation and the escalation of such attacks over the past ten years. Their study employed the content analysis method and a Descriptive approach for data collection, which involved observation (field visits), personal interviews with stakeholders, and a risk analysis of the Al-Shifa Medical Complex.

Their findings reported that Quick response in implementing evacuation mechanisms is critical to the plan's success and saving lives. They demonstrated that planning for evacuations and sheltering is among the top priorities of the Al-Shifa Complex Administration and the General Administration of Hospitals and that the Al-Shifa Complex Administration has prepared a comprehensive evacuation plan, updated annually. This shows that having a risk analysis policy in place by libraries and information centres will provide adequate measures to address crises and disasters, thereby protecting the lives and property of library collections.

Similarly, the study of Olawuni, Olowoporoku, and Daramola (2021) examined the determinants of residents' participation in disaster risk management (DRM) in Lagos Metropolis, Nigeria, a meg-

acity with over 20 million residents vulnerable to floods, fires, and building collapses due to rapid urbanisation and environmental degradation. They employed a multi-stage sampling design, stratified Lagos into island and mainland clusters, randomly selecting two wards from each of the six Local Government Areas (LGAs). Systematic sampling targeted every 10th residential building, yielding 474 valid questionnaire responses from 501 sampled buildings. Their study measured disaster awareness across 15 hazard types via Disaster Awareness Indexes (DAIs) on a five-point Likert scale; they reported that limited DRM knowledge (31.2% island, 72% mainland) and training (68.4% untrained), with 75.9% of trained residents engaging in DRM activities like community awareness (42.8%) and prevention projects (41.9%). However, 78.5% reported no local DRM agencies. ANOVA revealed significant differences in DRM participation by place of residence, age, income, length of residence, and educational status, but not gender or household size. By addressing the identified institutional gaps and promoting information sustainability, libraries and information centres can enhance community resilience, reduce disaster losses, and support sustainable development in Lagos and similar urban contexts, aligning with the study's call for a shift from reactive to proactive disaster risk management (DRM) strategies.

The study by Balanggoy (2024) investigated the implementation of disaster risk reduction and management (DRRM) in secondary public schools in Benguet, Philippines, across four thematic areas—prevention and mitigation, preparedness, response, and recovery and rehabilitation — utilising a descriptive quantitative approach. The study surveyed 18 schools. They used descriptive statistics, weighted means, and the Kruskal-Wallis Test to analyse the extent of implementation, variations across municipalities, and challenges faced. Their research highlighted a high level of DRRM implementation across prevention and mitigation (mean = 3.28), preparedness (3.36), and recovery and rehabilitation (3.33), but a moderate level in disaster response (3.20), alongside challenges such as insufficient budgets (14.66%), overburdened coordinators (13.79%), and weak coordination with disaster management agencies (5.17%). These findings underscore the critical role of libraries as community hubs for knowledge dissemination, training, and coordination.

By addressing the identified gaps, libraries and information centres can support educational continuity, reduce vulnerabilities, and contribute to safer communities, aligning with the Philippines' 2011–2028 National Disaster Risk Reduction and Management (NDRRM) Framework.

Kumar *et al.* (2020) investigated the Indicator-Based Assessment of the Integrated Flood Vulnerability Index for Brunei Darussalam. Their study employed an integrated vulnerability approach, weighted by the Iyengar and Sudarshan method, and incorporated it into a composite Flood Vulnerability Index (FVI) using ArcGIS 10.4. They reported that data from historical records shows that (70 people across 10 families per district), and interpolation techniques like Inverse Distance Weighting (IDW) for rainfall have limited district-level data. They also found that the Tutong district had the highest vulnerability (7.5%, moderate), followed by Temburong (4.3%, low). In comparison, Belait had the lowest vulnerability (0.4%), attributed to its high forest cover and canalisation. Brunei-Muara demonstrated low susceptibility due to its high literacy rate, low unemployment rate, and strong economic factors. Libraries and information centres can archive and disseminate valuable resources for researchers, policymakers, and disaster management professionals, using the study recommendations to support community engagement, advocate for flood resilience policies, and promote community resilience through knowledge dissemination.

Similarly, Ivanov (2024) examined the state of disaster risk reduction (DRR) and disaster risk management (DRM) in North Macedonia, emphasising theoretical, normative, and institutional aspects aligned with international frameworks, such as the Sendai Framework. Their findings highlighted inefficiencies, coordination gaps, and resource constraints in the DRR system, proposing recommendations to enhance preparedness, response, and recovery. This study is significant for libraries and information centres as it underscores their potential role as critical hubs for disseminating disaster risk reduction (DRR) knowledge, supporting community resilience, and addressing institutional gaps in disaster management. Libraries and information centres can leverage their accessibility and resources to bridge information gaps, foster education, and facilitate interagency collaboration, and the need for the creation of robust early warning systems, data-driven risk assessments, and public awareness to address challenges such as insufficient coordination, limited expertise, and resource

constraints in ensuring they provide access to digital platforms for disseminating real-time disaster information and reduce vulnerabilities and support proactive disaster management.

The study by Cvetković, Renner, and Jakovljević (2024) offers a comprehensive analysis of industrial disasters, examining their causes, consequences, and strategies for enhancing resilience. Their review article is significant for libraries and information centres as it underscores their critical role in disaster risk management (DRM) by serving as knowledge hubs for industrial disaster preparedness, response, and recovery. Their study highlights the multifaceted nature of industrial disasters—chemical spills, explosions, nuclear accidents—and their human, economic, and environmental impacts, drawing on historical cases such as Seveso (1976), Bhopal (1984), Chornobyl (1986), and Fukushima (2011). This study emphasises the importance of libraries and Information Centers to bridge knowledge gaps, foster dialogue among engineers, safety managers, and policymakers, enhance community resilience, and support intersectional collaboration in high-risk industrial contexts.

According to Cvetković *et al.* (2024), the complex interplay of human, technical, and organisational factors in industrial disasters offers libraries and information centres a strategic opportunity to enhance DRM. By serving as resource hubs, training centres, and collaboration platforms, libraries can address the identified research gaps—human errors, weak safety cultures, and inadequate regulations. These efforts align with global frameworks, such as the UNISDR, positioning libraries as vital contributors to building resilient communities. Through targeted actions, libraries can mitigate the health, economic, and environmental impacts of industrial disasters, fostering a proactive approach to safety and recovery.

4. Types of Libraries Disaster Risk Management

Libraries employ various digital rights management (DRM) approaches, depending on their resources, location, and mission. Three primary types are identified in the literature:

- Preventive DRM: This focuses on reducing the likelihood of disasters through proactive measures. Examples include installing fire suppression systems, waterproofing storage areas, and digitising collections to reduce physical vulnerability (Zaveri, 2014; Pathak, 2019).
- Reactive DRM: This involves response and recovery actions post-disaster, such as salvaging water-damaged books, restoring digital backups, or relocating services. Studies from typhoon-affected libraries in the Philippines highlight the role of reactive DRM in post-disaster recovery (Velasquez *et al.*, 2016).
- Integrated DRM: A holistic approach combining prevention, preparedness, response, and recovery. It emphasises resilience-building through staff training, risk assessments, and community collaboration, as seen in Australian libraries following the 2018 wildfires (Brown, 2018; Robertson, 2015).

Each type reflects a library's capacity and strategic priorities, with integrated DRM increasingly favoured for its comprehensive scope (Ranke, 2016).

3.3 Measures of Securing Library Resources

Securing library resources against disasters requires a multifaceted approach. Key measures include:

- Risk Assessment: Regular evaluations to identify potential hazards (e.g., water leaks, faulty wiring) and prioritise mitigation efforts in libraries (Rutto & Otike, 2016; Velasquez *et al.*, 2016).
- Physical Protection: The installation of fire alarms, flood barriers, and secure shelving protects physical collections in all libraries and information centres, which is crucial to safeguarding physical collections against fire, theft, mutilation, and disasters (Pathak, 2019).

- Digital Backups: Digitising library information resources and their materials and storing them in cloud-based systems will ensure data preservation against physical loss when libraries and information centres face such a threat (Brender & Markov, 2013).
- Staff Training: Equipping librarians with disaster response skills is essential, as it enhances preparedness and recovery efficiency for the protection and risk management of library resources and facilities (Bansal, 2015).
- Insurance: Library management must ensure adequate financial protection through insurance policies to mitigate economic losses from disasters (Robertson, 2015). When implemented effectively, these measures reduce vulnerability and enhance library resilience for current and retrospective information users.

5. Case Studies of Disaster Risk Management in Libraries and Information Centers

Based on the column showed that in Nigeria, the University of Jos experienced devastating fire disasters in 2013 and 2016, which destroyed significant portions of its library collections. The 2016 fire at the Naraguta campus library highlighted the inadequacy of disaster risk management practices. Akintunde (2016) notes that, despite previous incidents, the library lacked essential equipment, such as smoke detectors and fire sprinklers, and staff were insufficiently trained for emergency response. Post-disaster assessments revealed inadequate funding, poor disaster awareness among stakeholders, and delayed recovery efforts, resulting in the loss of thousands of volumes (Akintunde, 2016). A study by Ilo *et al.* (2018) further indicates that while Nigerian libraries are somewhat prepared for fire disasters, financial constraints limit comprehensive DRM implementation, leaving them vulnerable to other risks like floods and vandalism.

Table 1. Case Studies of Disaster Risk Management in Libraries**.**

Country	Disaster Type	Institutional Setting	challenges	Outcome	Implications for libraries in both developing and developed contexts
Nigeria	Library Fire Disasters (2016)	University of Jos	Lack of essential equipment like smoke detectors and fire sprinklers, staff were insufficiently trained for emergency response inadequate funding and poor disaster awareness among stakeholders delayed recovery	The lack of financial constraints limits comprehensive DRM implementation, leaving it vulnerable to other risks, such as floods, vandalism, and theft, which can result in the loss of thousands of volumes.	Library management must train their staff in Disaster Risk Management Strategies and ensure they have sound skills in using fire extinguishers in an emergency.
USA	Hurricane Harvey and University Libraries (2017)	Libraries in Texas, including the University of Houston Libraries.	Availability of robust DRM plan for pre-disaster measures such as elevating critical infrastructure and digitising vulnerable collections	During the hurricane, emergency response teams utilised back-up power systems and relocated materials to safer zones. Post-disaster recovery involved collaboration with federal agencies like FEMA and the use of grant funding to restore damaged facilities	Integrating technology and institutional support into disaster risk management (DRM) practices and disaster preparedness training for librarians is crucial.

UK	British Library Flood Preparedness (2019-2020)	British Library, UK	Availability of an advanced DRM framework, particularly in response to flood risks exacerbated by climate change.	Brown (2018) outlines how the library conducted risk assessments to identify flood-prone areas and invested in water-resistant storage solutions and automated monitoring systems.	The library should ensure that adequate measures are in place for heavy rainfall. To prevent significant damage, the library must have contingency plans, including staff drills and off-site backups, in place. The National Library associations must be ready to train librarians in providing disaster management guidelines and training.
Canada	University of British Columbia Library Wildfire Response (2021)	University of British Columbia Library	UBC implemented a DRM strategy that included fireproof storage, regular risk assessments, and partnerships with local emergency services.	The library activated its disaster response team, evacuated critical materials, and relied on cloud-based backups to maintain digital access (UBC Library, 2021).	The Need for Libraries and Information Centers to integrate community resources and digital resilience into library DRM, along with grant-funded disaster planning.

Another study revealed that Hurricane Harvey in 2017 had a severe impact on libraries in Texas, including the University of Houston Libraries. Prestamo (2018) documents how the university implemented a robust DRM plan that included pre-disaster measures such as elevating critical infrastructure and digitising vulnerable collections. During the hurricane, emergency response teams utilised backup power systems and relocated materials to safer zones. Post-disaster recovery involved collaboration with federal agencies, such as FEMA, and the use of grant funding to restore damaged facilities (Prestamo, 2018). This case highlights the USA's emphasis on integrating technology and institutional support into disaster recovery management (DRM), a practice further explored by Miller (2016), who underscores the importance of disaster preparedness training for librarians.

The British Library in the UK has developed an advanced digital rights management (DRM) framework, particularly in response to flood risks exacerbated by climate change. Brown (2018) outlines how the library conducted risk assessments to identify flood-prone areas and invested in water-resistant storage solutions and automated monitoring systems. In 2019-2020, these measures proved effective when heavy rainfall threatened London; the library's contingency plans, including staff drills and off-site backups, prevented significant damage (Brown, 2018). The UK's approach reflects a proactive stance on DRM, with Corrall *et al.* (2016) emphasising the role of national library associations in providing disaster management guidelines and training.

In 2021, the University of British Columbia (UBC) Library in Canada faced wildfire risks due to extreme weather conditions in British Columbia. Adamo (2016) and subsequent updates in library reports (UBC Library, 2021) detail how UBC implemented a DRM strategy that included fireproof storage, regular risk assessments, and partnerships with local emergency services. During the 2021 wildfire season, the library activated its disaster response team, evacuated critical materials, and relied on cloud-based backups to maintain digital access (UBC Library, 2021). This case illustrates Canada's focus on integrating community resources and digital resilience into library disaster recovery management (DRM), a trend supported by Ye*h et al.* (2016), who advocate for grant-funded disaster planning.

Based on the above case studies, libraries and information centres must be prepared to support staff with funds for Disaster Preparedness and recovery training programmes and implement an adequate DRM policy.

6. Causes of Disasters in Libraries

Libraries, as vital repositories of knowledge and culture, face a range of potential threats that can compromise their collections, services, and infrastructure. Disasters—whether natural or human-made—can have devastating consequences, particularly in institutions that lack proper risk mitigation strategies (Cvetković, 2019; Cvetkovic & Martinovic, 2020; Cvetković et al., 2022). Understanding the various causes of these disasters is essential for developing effective preparedness and response plans.

1. Natural Hazards: Libraries are vulnerable to natural disasters, including floods, earthquakes, and hurricanes, which can damage infrastructure and collections, particularly in areas with high geographical risk (UNDRR, 2017).
2. Poor Infrastructure Maintenance: Ageing buildings with neglected maintenance—such as leaking roofs or faulty electrical systems—heighten the risk of disasters, including water damage or fires (Pathak, 2019).
3. Human Error: Accidental actions, such as improper handling of materials or failure to follow safety protocols, can lead to fires, spills, or equipment malfunctions (Smith & Kostelecky, 2021).
4. Technological Failures: Libraries' dependence on digital systems makes them vulnerable to cyber attacks, server crashes, or power outages, risking data loss (Falcao e*t al.,* 2024).
5. Lack of Preparedness: Inadequate disaster planning and training leave libraries ill-equipped to prevent or respond to emergencies, exacerbating damage (Robertson, 2020).
6. Theft and Vandalism: Intentional human acts, such as theft of rare books or vandalism, constitute disasters that compromise library resources and security (Johnson & Lee, 2025).

7. Strategies for addressing the Causes of Disaster

A comprehensive approach that combines preventive, educational, and technical measures is essential to effectively reduce the risks and impacts of disasters in libraries. The active involvement of key institutions, local government authorities, and security experts is crucial for successfully implementing protective strategies. Below are key strategies aimed at addressing the major causes of disasters in libraries:

1. Mitigation of Natural Hazards: The National Emergency Management Agency (NEMA) and state-level disaster management authorities, in collaboration with Library Management, need to identify vulnerabilities to floods, earthquakes, and other hazards by Implementing structural reinforcements, such as flood barriers and seismic retrofitting, to reduce exposure to natural disasters. Engage local communities and disaster management experts to ensure culturally and environmentally appropriate solutions (UNDRR, 2017).
2. Enhancement of Library Infrastructure Maintenance: National Emergency Management Agency (NEMA), in partnership with Local government agencies, regular inspection and maintenance schedules for all library facilities and infrastructure with priority for upgrades to electrical and plumbing systems to prevent fires and leaks, ensuring compliance with national safety standards (Pathak, 2019).
3. Training of Library Staff to Reduce Human Error: Continuous training programs, incorporating simulation and certifications in safety protocols, material handling, and emergency procedures, will be conducted for library staff in coordination with NEMA and fire service agencies. This effort aims to minimise accidental damage and enhance staff preparedness (Smith & Kostelecky, 2021).
4. Strengthening Technological Resilience: In alignment with national cyber security frameworks, Nigeria's National Information Technology Development Agency (NITDA) provides funds for procurement, maintenance, and regular check of robust cyber security equipment

and facilities with uninterruptible power supplies to protect digital assets from technological failures, cyber attacks, and power outages (Falcao *et al.*, 2024).

5. Development of Comprehensive Disaster Preparedness Plans: Local disaster management committees and library management boards, in consultation with the National Emergency Management Agency (NEMA), create regular updates of disaster management plans and policies to enhance emergency readiness and response in maintaining library information resources (Robertson, 2020).
6. Installation of Security Facilities: The Library Management, in partnership with the Nigeria Police Force and private security firms, installs surveillance systems, access controls, and anti-theft devices to deter vandalism and theft, thereby protecting valuable collections (Johnson & Lee, 2025). By involving key stakeholders, such as NEMA, NITDA, local governments, and community organisations, these strategies ensure a coordinated and sustainable approach to safeguarding Nigeria's libraries and information resources against diverse threats.

8. Challenges in Disaster Risk Management (DRM) by Libraries

Despite advances, libraries and Information centres face significant obstacles in DRM implementation:

- Lack of Awareness: Many librarians underestimate disaster risks, neglecting preparedness plans due to inadequate plans and policy (Rutto & Otike, 2016).
- Insufficient Funding: Budget constraints limit investments in protective infrastructure and training for libraries and information centres due to library policy for information provision. Libraries are not business-oriented organisations that generate revenues to manage their resources and infrastructure, but rather, they await budgetary allocation from the parent organisation, which is often insufficient (Velasquez e*t al.*, 2016).
- Inadequate Training: Some staff working in libraries often lack the skills to respond to emergencies due to a lack of disaster preparedness plans and policies, as noted in Nigerian university libraries (Ebijuwa & Oyelude, 2016).
- Technological Dependence: There is an over-reliance on digital systems without adequate measures to curb insecurity and theft, which increases vulnerability to cyberattacks and power failures (Han *et al.*, 2016).
- Policy Gaps: Most libraries and information Centers have inadequate formal Disaster Risk Management (DRM) policies, which hinder coordinated efforts, particularly in developing nations like Nigeria (Falcao *et al.*, 2024).
- Human Factors: Library management and staff exhibit strong apathy and resistance to planning, which is driven by competing priorities that undermine DRM efforts (Robertson, 2015).

9. Conclusion

Disaster risk management (DRM) is indispensable for libraries and Information centres to protect their resources and maintain service continuity. By understanding disaster risk and adopting tailored disaster risk management (DRM) strategies—preventive, reactive, or integrated—libraries and information centres can mitigate threats. Measures such as risk assessments, physical safeguards, and digital backups are critical; however, challenges persist, including funding shortages and inadequate training. Implementing the proposed recommendations can strengthen library resilience, ensuring they remain vital community assets in the face of disasters. Future research should investigate the effectiveness of integrated DRM in various library settings, particularly in under-resourced regions.

Strengthening disaster risk management in libraries and information centres is not merely a protective measure but a strategic investment in societal resilience. By embracing a culture of preparedness, libraries can minimise service disruptions, safeguard cultural heritage, and continue serving as

critical knowledge hubs during and after crises. Building strong collaboration networks, enhancing technological infrastructure, and institutionalising DRM policies will ensure that libraries remain steadfast pillars of community support in the face of growing disaster risks.

Recommendations for Effective Disaster Risk Management (DRM) in Libraries and Information Centers

To address these challenges, the paper proposed the following recommendations:

- Raise Awareness: The Nigerian Library Association, in collaboration with the Librarians Registration Council of Nigeria (LRCN), is organising in-house workshops and Seminars to educate librarians across Nigeria on disaster risks and DRM benefits.
- Secure Funding: The Nigerian Ministry of Education and major stakeholders, such as the Library Association in Education and Libraries, could advocate for government and institutional support to finance DRM initiatives in libraries and information centres across Nigeria.
- Promotion and Enhancement of Training Programmes: The Nigerian Ministry of Education partners with libraries, such as the British Library, to promote and develop regular, practical training sessions on disaster response and recovery for libraries and Information Centres in Nigeria.
- Diversification of Technology Use: Libraries and University Management should prioritise balancing digital and physical preservation strategies to mitigate single-point failures when necessary, particularly in Libraries and Information Centres in Nigeria, to ensure the preservation of intellectual content.
- Formulate Policies: The Ministry of Education, in partnership with collection development professionals, manages libraries and information centres to develop and establish mandatory DRM policies tailored to library contexts.
- Foster Collaboration: Strong partnerships should be formed between emergency organisations, such as the Nigerian Environmental Management Agency (NEMA), and libraries to provide emergency services and share resources and expertise. These recommendations aim to establish a proactive and resilient DRM framework for libraries.

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Article

The Role of Spatial Analysis in Notifiable Disease Monitoring and Health Risk Management: A Case Study of Constantine

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ABSTRACT

The study aims to enhance understanding of the distribution of notifiable diseases using maps created with ArcGIS in Constantine. Over six years, it focused on the prevalence rates of waterborne diseases and zoonoses (e.g., tuberculosis, meningitis, and COVID-19). A database was created for each municipality using official data, which was processed using SPSS and Microsoft Excel and integrated into a geographic information system (GIS). The maps revealed a high prevalence of diseases in the state's centre, particularly in the municipalities of Constantine, El Khroub, Didouche, and Mourad. The analysis also highlighted a positive relationship between the increase in disease cases and population density, emphasising the critical role of urbanisation in disease spread. Furthermore, seasonal variations were observed in the distribution of certain diseases, indicating that environmental factors, such as temperature and rainfall, influence disease outbreaks. As a result of this study, the maps have demonstrated a fundamental role in monitoring diseases and their development, offering valuable insights for public health surveillance and policy formulation. By visualising trends and patterns, these maps can support decision-making processes to manage health risks better and allocate resources effectively in the region.

KEYWORDS

Disaster; health risk; spatial analysis; management; Covid-19; Constantine.

1. Introduction

Spatial analysis has evolved into a highly effective tool for risk control, particularly in healthcare. It provides insightful analysis of the geographical distribution and disease transmission patterns, enabling researchers and decision-makers to pinpoint high-risk locations and assess environmental, social, and ecological factors. Among the most well-known examples is John Snow's 1854 cholera mortality map of London's Soho. Using observational data, spatial epidemiology seeks to explain and characterise regional and temporal fluctuations in disease occurrence.

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Although John Snow's hand-drawn maps showed the connection between cholera cases and the Broad Street water pump, spatial epidemiologic studies and health data mapping did not become usual until the broad availability of Geographic Information Systems (GIS) in the 1990 (Pickle, 2009). These technical developments have significantly enhanced our ability to analyse illness trends and conduct public health campaigns based on statistical evidence.

This approach has proven particularly relevant in the context of emerging infectious diseases such as COVID-19, which has been described as a "creeping disaster" due to its prolonged and evolving nature (Jawahar, 2024).

GIS's benefits encompass performing repeated tasks, swiftly comparing spatial data, and handling large datasets. The amalgamation of GIS with spatial analytical techniques can produce a significant asset for investigating public health issues. (Rezaeian, 2007). The importance of geographic information science is increasingly recognised in spatial epidemiological research, as it provides the fundamental geographic context for exploring spatial patterns in data.

Recent studies have successfully applied GIS to assess the hazard risk of COVID-19 in different urban environments, emphasising its predictive value in disaster risk management. (Ulal, 2023).

The spatial dimension of health data is crucial for clarifying disparities in risk, as health status, environmental threats, population density, demographic and socioeconomic characteristics, and other relevant factors (e.g., vulnerability and exposure) vary across different geographical regions. In this context, geographic space exhibits notable changes across various locations and periods, resulting in unique habitats where people live and work. Geography defines the spatial context and attributes in which health issues arise. Movement across locations is significant; pollutants and other hazards that form concentrations can change as they move through the ecosystem, affecting different locations in varied ways. Furthermore, spatial risk patterns are confounded by differences in susceptibility and variances arising from the uniqueness of populations in particular regions. (Beale, 2008).

Among the most significant Algerian cities, Constantine's Wilaya has recently experienced repeated outbreaks of infectious diseases. Therefore, to understand the spatial dynamics of disease spread in this area, we have chosen to investigate this topic, including spatial analysis of health risk management. The first phase of the study involved interviewing the chiefs of preventive medicine, epidemiology, and prevention divisions at the Constantine Health Directorate to gather the required information. In the second phase, the data was processed and examined; thereafter, maps were created to help define patterns of disease distribution. This study employed geographical analytical methods to gain a thorough understanding of the epidemiological state over the past six years.

These findings aim to inform the development of targeted public health initiatives, enhance public health resilience in this area, and support preparedness for future outbreaks of infectious diseases.

2. Methods

2.1. Data collecting and study scope

This study examines environmentally related diseases in the Wilaya of Constantine over six years (2015–2020), in addition to the frequency of major waterborne and foodborne diseases (WBDs)—including typhoid fever, dysentery, viral hepatitis A, and collective foodborne infections—as listed in Table 1.

Three main variables guided data compiling:

- Kind of disease
- Year of occurrence
- Residential municipality

Official records from Constantine's Directorate of Epidemiology and Medical Prevention (DEPM) and the Directorate of Health and Population (DHP) guaranteed data accuracy and dependability.

2.2. Research Approach

The frequency and distribution of notifiable diseases were evaluated using a descriptive epidemiological method, thereby providing information on environmentally related health issues in Constantine. Including an analytical component emphasising particular case studies, one sought possible causal linkages between environmental risk factors and disease outbreaks.

2.3. Project Population and Area of Research

The research area includes all twelve municipalities of the Wilaya of Constantine: Constantine, El Khroub, Ouled Rahmoune, Ain Smara, Ain Abid, Ibn Badis, Hamma Bouziane, Didouche Mourad, Messaoud Boudjeriou, Ibn Ziad, Zighoud Youcef, and Beni Hamidene.

The target population includes all individuals affected by communicable diseases during the study period. By examining the spatial distribution of these diseases across municipalities, the study seeks to identify high-risk areas and support targeted public health interventions.

2.4. Geographic Mapping and Data Analysis

The instruments utilized for conducting comprehensive statistical and geographical analyses encompassed a selection of advanced software tools. Specifically, SPSS and Microsoft Excel 2010 were employed to perform various tasks, including descriptive statistics, trend analysis, and regression calculations. In addition, ArcGIS 10.8 was utilised for its robust capabilities in geographic mapping, allowing for effective cluster detection and the visualisation of disease distribution patterns, thereby enabling more profound insights into spatial data and trends.

2.5. Descriptive and Trend Analysis

The frequency, mean, and standard deviation of each disease were calculated using descriptive statistics over six years. Annual patterns were shown using time-series graphs.

- Analyzing linear regression

Simple linear regression models were employed to analyse temporal patterns and predict future disease occurrences. The regression model applied has a general form of $Y = a + bX$.

There:

YY = cases (dependent variable)

XX = year (variable independent);

aa = intercept

bb = slope—the rate of change—either increasing or decreasing

The prevalence of illness over time shows either an upward or a declining trend, as indicated by the regression coefficient βb. A positive bb number indicates a rising trend; a negative bb value suggests a declining trend.

- Equation Spread (Calculating Prevalence):

Prevalence rates were computed by the method to evaluate the spatial distribution of diseases:

Prevalence Rate=(Municipal Population Number of Reported Cases)×100,000

This allowed for consistent comparisons across towns with varying population counts.

2.6. Geospatial ArcGIS mapping

ArcGIS was used to create choropleth maps illustrating disease prevalence across municipalities. A gradient colour scheme—darker tones indicating more excellent rates and lighter tones indicating lower rates—was used to show prevalence rates.

ArcGIS involved steps like:

- Entering gathered statistics comprising local reported sickness rates and population numbers.
- Developing basic administrative maps to specify municipal limits.
- Group cities according to disease frequency with well-defined thresholds for every colour category.
- Visualizing geographical distribution using a colour gradient will help identify high-risk areas.
- Administrative boundary data, Georeferenced, were utilised to ensure alignment with demographic and epidemiological databases. Spatial transformations and modifications maintained consistency and improved the precision of the findings.

2.7. Research Limitations

This study has various limits despite providing insightful analysis that should be taken into account while reading the results:

Most of the data comes from official DHP and DEPM health records. Although usually trustworthy, these sources could be prone to underreporting or missing data from undiagnosed or unreported cases, thus underestimating the disease prevalence.

Though it does not prove causality, the descriptive epidemiological technique offers vital data on illness distribution. Cohort or case-control designs, as well as other more analytical approaches, are needed to verify causal links between environmental elements and disease outbreaks.

The study spans the period from 2015 to 2020; trends or changes occurring outside this period were not included.

3. Results

3.1. Epidemiological surveillance using spatial analysis

Surveillance is one of the essential functions of public health; according to (Thacker, 1996), environmental health surveillance is defined as the "continuous and systematic collection, analysis and interpretation of data essential for the planning, implementation and evaluation of health practices, closely associated with the timely dissemination of these data to those who need them. The final step in the surveillance cycle is the application of these data to the control and prevention of diseases and accidents". This implies the continuous or repeated collection of data on health and its determinants at the population level, allowing for the geographical and temporal evolution of health problems and their risk factors and enabling the identification of health signals when a trend changes. Surveillance, therefore, requires the realisation of different joint activities: data collection, analysis and interpretation. If the objective of surveillance can be summarised as "describe, alert and evaluate" (Astagneau, 2011), its goal is to guide action by promptly producing and disseminating relevant information.

This information enables us to positively influence the population and inform decision-makers responsible for the programs and services offered, thereby supporting the planning and adaptation of these to meet the population's needs (Kirby, 2017).

Over the past twenty years, the development of computer tools—especially geographic information systems—has dramatically simplified the handling of spatial data (collecting, storage, analysis, visualisation, etc.), enabling the consideration of the spatial dimension in the study and monitoring of infectious or parasitic diseases.

Another recent development—that of Earth observation satellites—now gives access to a significant volume of environmental data (land usage, climate data, etc.). In epidemiology, these facts help to incorporate the ecological dimension and consider the interactions among the several living entities in the epidemiological system and their surroundings.

Illness mapping is a fundamental approach in spatial epidemiology whereby illness incidence or prevalence is visually shown over several geographical areas. Health officials can find locations with high disease rates using GIS techniques, enabling focused treatments. For example, disease mapping has greatly aided in tracking the spread of infectious diseases such as malaria and dengue fever.

3.1.1. Utilization of GIS and Spatial Statistics in Disease Surveillance

Geographic Information Systems and spatial analytic methodologies have been extensively employed in surveillance systems for various infectious and non-communicable diseases. Key applications encompass:

• Outbreak Detection and Monitoring: Spatial clustering techniques, including Kriging interpolation and spatial autocorrelation, facilitate the identification of nascent epidemics by examining temporal patterns of disease incidence (Kulldorff, 1997). Spatial scan statistics were employed to identify clusters of COVID-19 infections during the pandemic, informing quarantine protocols and other public health measures. (Desjardins, 2020).

• Vector-Borne Disease Surveillance: Environmental conditions, including temperature, humidity, and vegetation, significantly impact the transmission of malaria, dengue, and Lyme disease. Remote sensing data integrated with GIS helps forecast vector distribution and pinpoint high-risk areas (Beck, 2000).

• Environmental Health Risks: Spatial epidemiology plays a crucial role in assessing the impact of air pollution, water contamination, and industrial waste on public health. Research indicates significant relationships between geographical changes in air pollution and respiratory disorders, including asthma (Jerrett, 2005).

3.2. Study Region Overview

The total area of the Wilaya of Constantine (Algeria) is 2,187 square kilometres, making it a medium-sized region within Algeria.

The wilaya enjoys a strategic location, as Skikda borders it to the north, Oum El Bouaghi to the south, Mila to the west, and the wilaya of Guelma to the east ,It is divided into 12 municipalities and six districts. Figure 1 shows the distribution of Wilaya's municipalities.

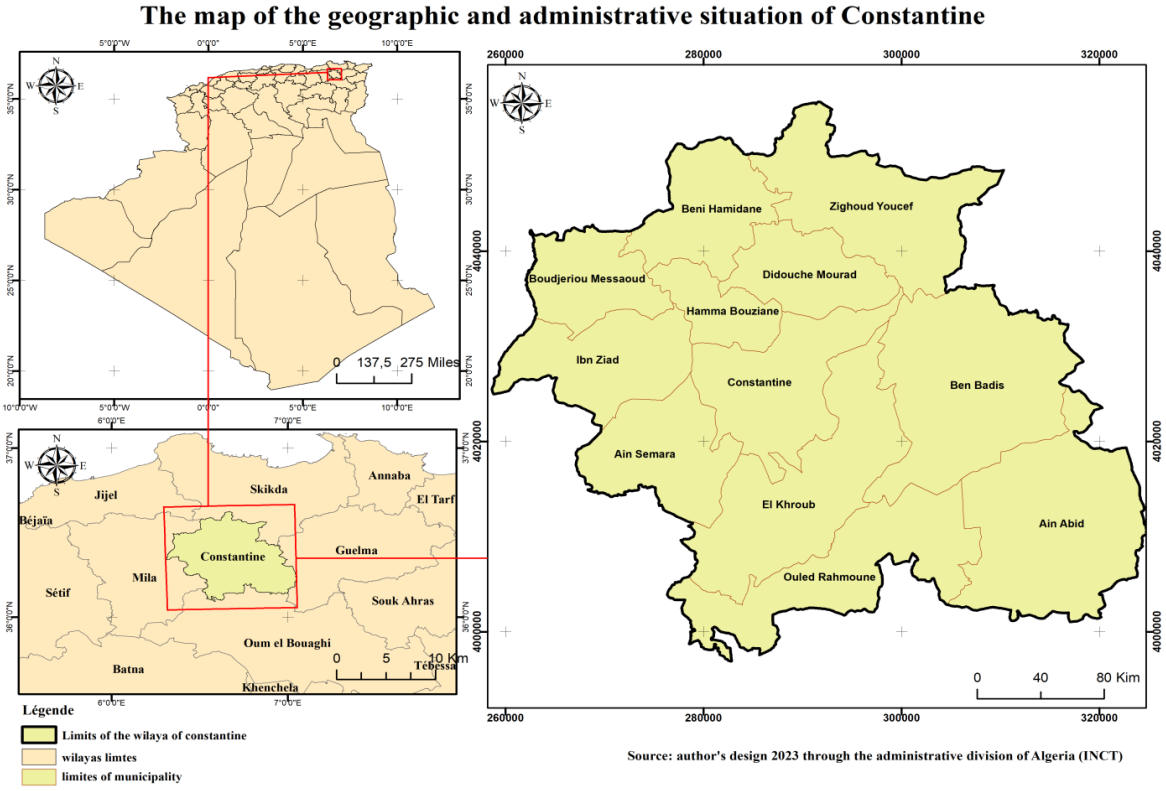

Figure1. Geographical and administrative location map of the Wilaya of Constantine.

Source: Author's design based on the administrative division of Algeria (INCT) 2023.

3.2.1. Type of Climate

Constantine province has a continental climate affected by its topography and geographical location. The following are the primary traits of this climate:

Generally speaking, winters are cold, with temperatures in mountainous regions often dropping below 0°C.

Particularly in plains and metropolitan regions, summers are marked by extreme heat—temps above 30°C.

- precipitation:

The yearly rainfall accumulation is somewhat low, particularly to the averages of the past thirty years—about 348.8 mm.

Although it is mainly concentrated in autumn and winter, rainfall is insufficient to meet water needs, occasionally resulting in drought.

- Temperances:

Though it shows a slight rise from past averages, the yearly temperature is about 15.9°C. In summer, the maximum temperature can be somewhat high, and in winter, the minimum temperature might drop significantly.

- Wind:

Although they can be more vigorous in spring and autumn, maximum wind speeds are constant and near seasonal averages.

3.2.2. The population density

The National Bureau of Statistics (ONS, 2020) estimated the state's population to be approximately 1.3 million in 2020, spread across 12 municipalities. Population density, expressed as the number

of people per square kilometre, varies significantly among municipalities, highlighting the differences in urbanisation and settlement patterns (Figure 2).

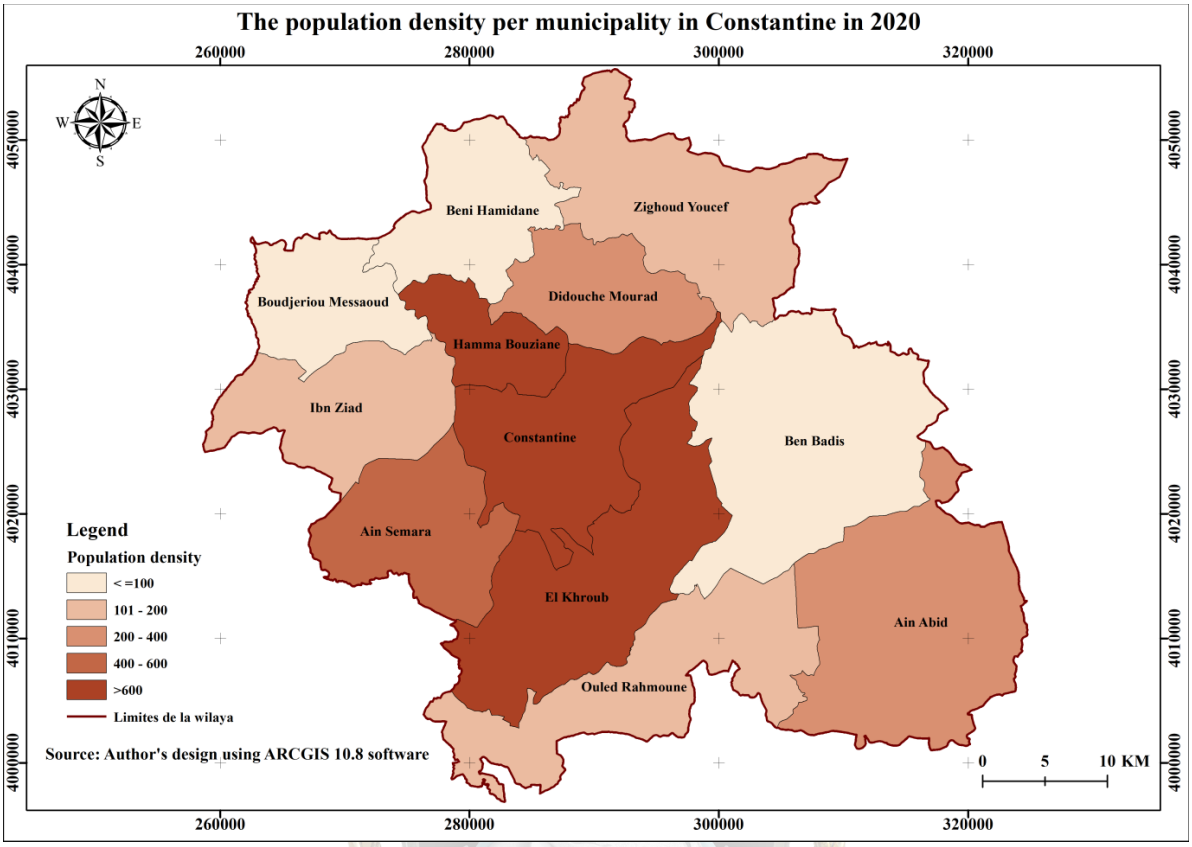

Figure 2. Population density map of the Wilaya of Constantine 2020.

Source: Author's design with ArcGIS 10.8 software.

Analysis of (Figure 2) indicates that the majority of the population within the state is concentrated in two central municipalities: the municipality of Constantine, with 40% of the population, followed closely by El-Khroub, with 30%. This is due to their economic, administrative and social importance. This reflects the highest population density in the centre of the wilaya. Additionally, the municipalities of Ain Smara and Didouche Mourad occupy second place in terms of population density, which contributes significantly to the regional demographic distribution. This settlement and population density pattern is consistent with the Constantine urban triangle development framework, which emphasises the spatial compatibility between urban growth and population distribution.

- ***DEPM of the Wilaya of Constantine***

The Epidemiology and Preventive Medicine Services (DEPM) are responsible for disease surveillance at the local level. Their primary mission is to prevent the transmission of infectious diseases while maintaining a strong and effective epidemiological surveillance system. In addition to these responsibilities, the DEPM plays a pivotal role in verifying accurate health information and transmitting it to the higher public health authorities, the Directorate of Health, for decision-making and policy development. In the wilaya of Constantine, six DEPM units are currently operating. These units are strategically located to maximise their coverage and effectiveness, distributed across five municipalities, as detailed in (Table 1). This positioning allows for monitoring and response in the event of a health disaster throughout the region.

Table 1. The Epidemiology and Preventive Medicine Services of Constantine

Municipalities	DEPM
Constantine	2
El Khroub	1

Hamma Bouziane	1
Ain Abid	1
Zighoud Youcef	1

[1] Source: Own author's draft based on data from the epidemiology department

- Directorate of Health and Population

The Directorate of Health and Population of the State of Constantine is the primary administrative body responsible for overseeing public health and addressing health issues affecting the population within the region. The headquarters of the Directorate is located in the state's centre, in the municipality of Constantine, which enables the Directorate to coordinate health services efficiently, implement public health programs, and meet the needs of the local population. The Directorate ensures the establishment of a body specialised in collecting, analysing, and reporting health, epidemiological, and demographic information. It also prepares emergency plans in consultation with the relevant authorities and participates in organising and coordinating first aid in the event of disasters of any nature.

3.2.3. Population Density and Health Infrastructure Distribution

Figure 3 illustrates that the spatial distribution of health facilities within the wilaya is unequal compared to the population density data. Areas with high population density, particularly in the central and northern metropolitan regions, exhibit constrained access to healthcare services, underscoring the potential danger of swift disease propagation in the absence of adequate medical assistance. The spatial disparity between population demand and healthcare supply poses a significant problem for disaster risk management and epidemic preparedness.

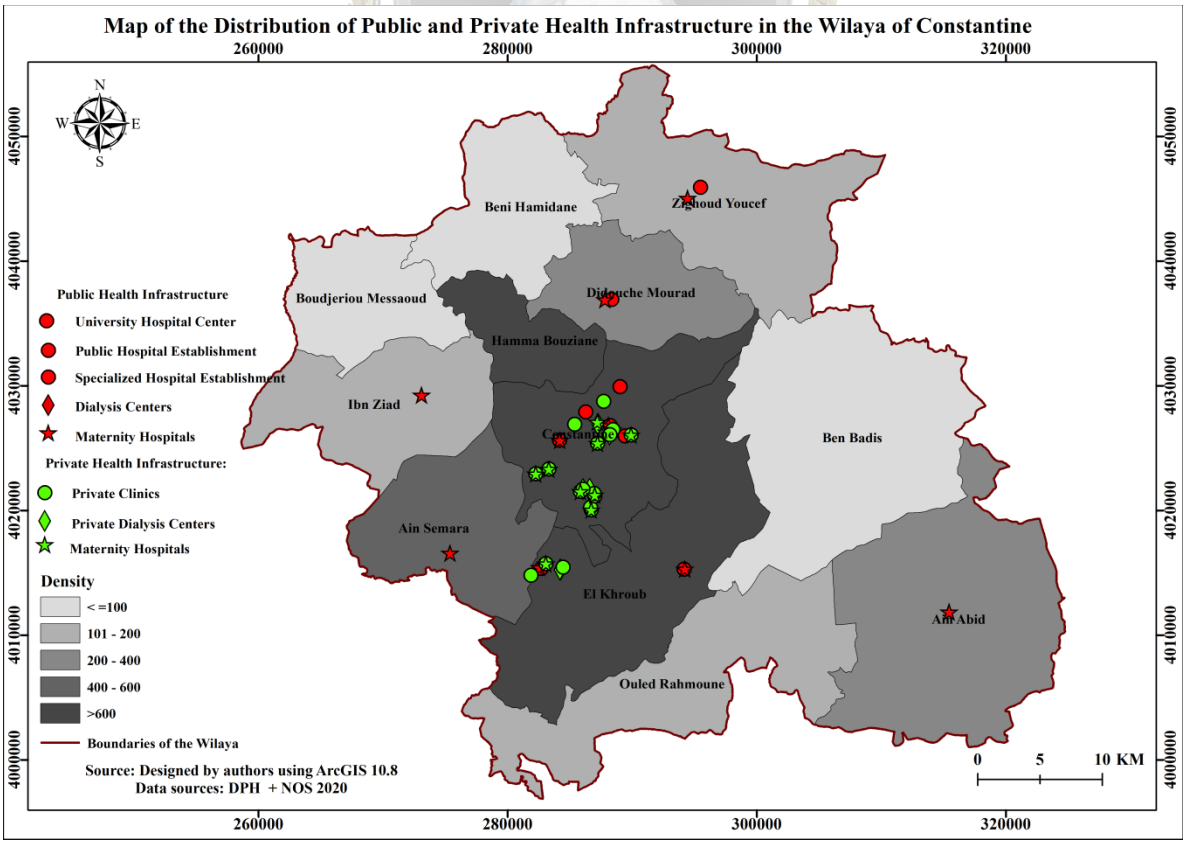

Figure 3. Population Density and Health Infrastructure Distribution in Constantine

Source: Author's design with ArcGIS 10.8 software

3.3. Environment-Related Infectious Diseases in the Wilaya of Constantine:

The study encompasses approximately 8,179 cases of environmentally related infectious diseases reported in the province of Constantine by the DEPM over six years, from 2015 to 2020. It focuses primarily on two main categories of diseases: (waterborne Diseases and Zoonosis), infectious diseases transmitted from animals to humans. Among the zoonoses identified and analysed in this context are tuberculosis, rabies, brucellosis and the COVID-19 pandemic with global impact, as shown in (Table 2).

Table 2. Infectious diseases linked to the environment in the wilaya of Constantine

Type de risque		Diseases
Health risks related to water	Waterborne Diseases (WBDs)	Typhoid Fever
		Viral Hepatitis A
		Dysentery
		Malaria
		Collective foodborne illness (CFI)
Environmental health risks	Zoonoses	Tuberculosis
		Rage
		Leishmaniasis
		Brucellosis
		Covid19

[2]Source: Author's draft based on data from the epidemiology department.

According to Article 3 of Decree No. 179 of November 17, 1990, all diseases listed in Table 02 are nationally monitored notifiable (NDs), except for COVID-19. Severe acute respiratory syndrome (SARS-CoV-2, COVID-19) is listed among the 14 notifiable diseases under international surveillance, as per Executive Decree No. 22-250 of June 30, 2022, which establishes the list of communicable diseases subject to mandatory reporting under international surveillance (Ministry of Health, 2022).

3.4. Mapping of Waterborne Diseases (WBD)

This study provides an overview of the epidemiological situation concerning waterborne diseases (WBDs) in the Wilaya of Constantine from 2015 to 2020. It constitutes a descriptive analysis based on cases reported to the DHP in Constantine, categorised by disease type, municipality, and year. Our study recorded about 2040 cases of waterborne diseases. This map (Figure 4) provides a visual representation of the prevalence of waterborne diseases across the municipalities of Constantine over a six-year period from 2015 to 2020, highlighting areas with the highest case numbers and identifying areas with significant outbreaks.

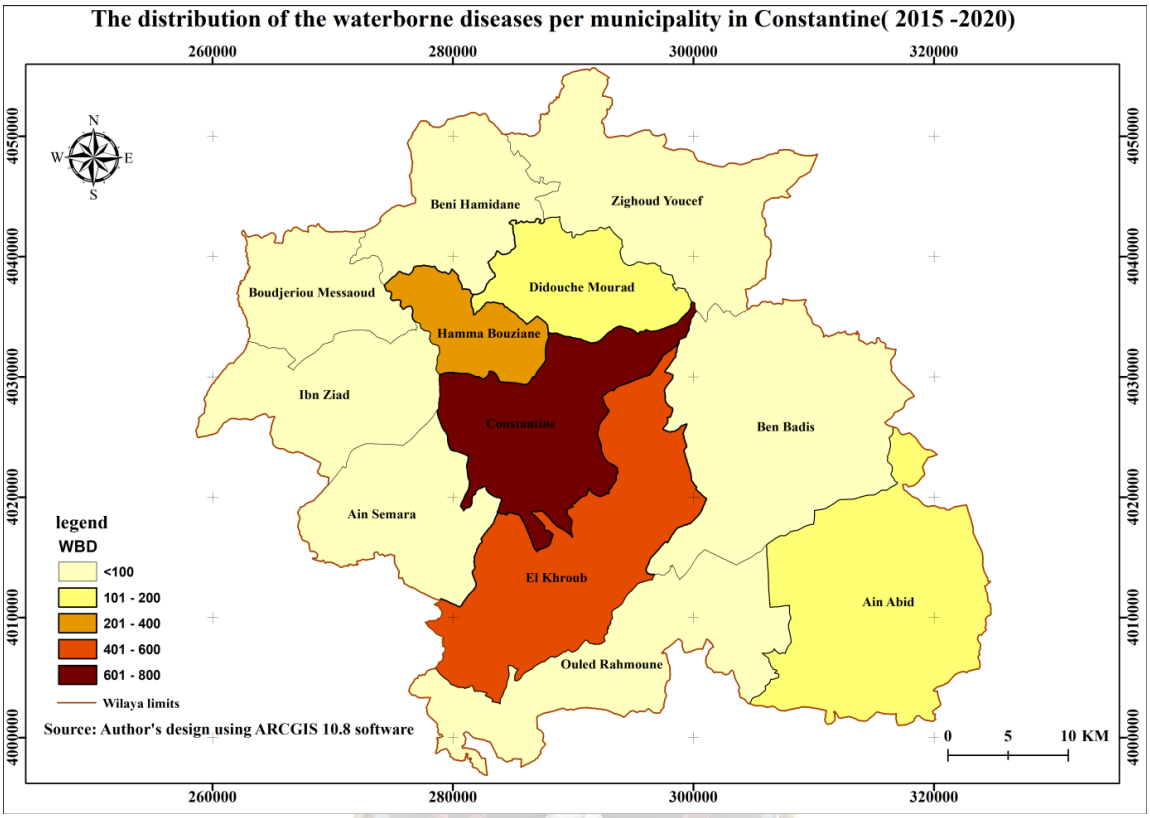

Figure 4. Distribution map of WBD by municipalities within the Wilaya of Constantine (2015-2020).

Source: Author's design from DHP data with ArcGIS 10.8

An analysis of the distribution of waterborne infections in the Wilaya of Constantine reveals that central municipalities—particularly Constantine, El Khroub, and Hamma Bouziane—are the most affected, in contrast to outlying or rural municipalities across the province

Certain towns have certain similar traits that help to explain the higher concentration of waterborne infections in certain places:

3.4.1. High urban population density:

In particular, Constantine, the capital of Wilaya, welcomes many people and immigrants and has a high population density. This strains the sewage system and fuels great demand for drinking water. Although they are urban areas, these municipalities occasionally suffer from shortcomings in wastewater management and water supply networks, particularly during heavy rainfall or extreme heat, which results in the contamination of drinking water sources and raises the risk of disease outbreaks.

3.4.2. Seasonal and climatic variables:

Intense rainfall and flooding: Rainy seasons significantly contribute to the prevalence of waterborne infections in these towns, particularly when the state experiences significant rainfall that can lead to flooding and pipeline damage.

Climate change exacerbates these conditions by increasing the frequency and severity of rainfall and flooding, affecting the availability of drinking water and, consequently, the risk of waterborne illness epidemics.

3.4.3. The correlation between population density and waterborne diseases among localities

The results of a linear regression computed between population density and the number of waterborne illness (WMD) cases (Figure) were as follows:

- Slope = roughly 0.28: This indicates that an estimated increase of roughly 0.28 WMD cases results from every unit increase in population density (persons/km²).
- Intercept = 3.04: Under zero density, the expected count of cases
- R2R2: 0.87; the coefficient of determination indicates the strength of the association between the two variables since the model explains almost 87% of the variance in the number of occurrences.

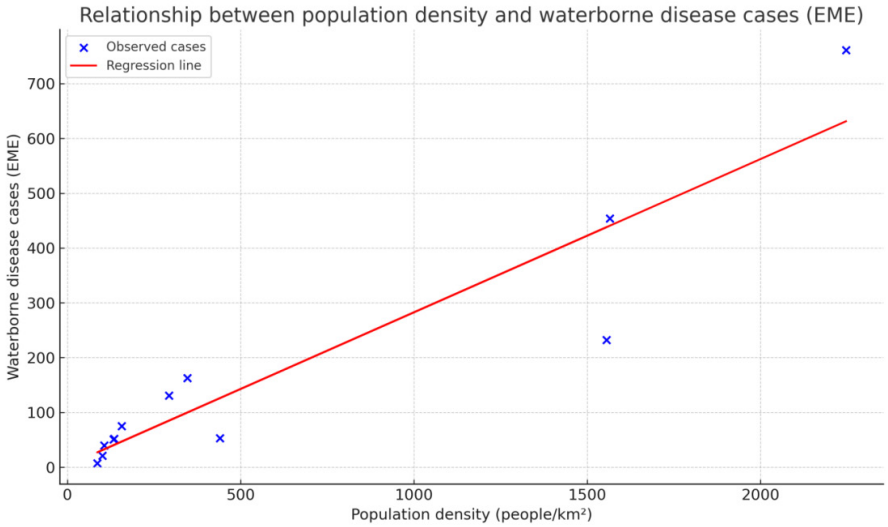

Figure 5. Linear regression analysis reveals the relationship between population density and waterborne disease cases across several municipalities in Constantine Province. Software Used**:** Python (Matplotlib & Seaborn libraries) for data analysis and visualisation based on municipal health and demographic data.

3.5. Mapping of Zoonoses

Figure 6 illustrates the geographical distribution of zoonotic diseases by municipality in the Wilaya of Constantine over a six-year period (2015–2020).

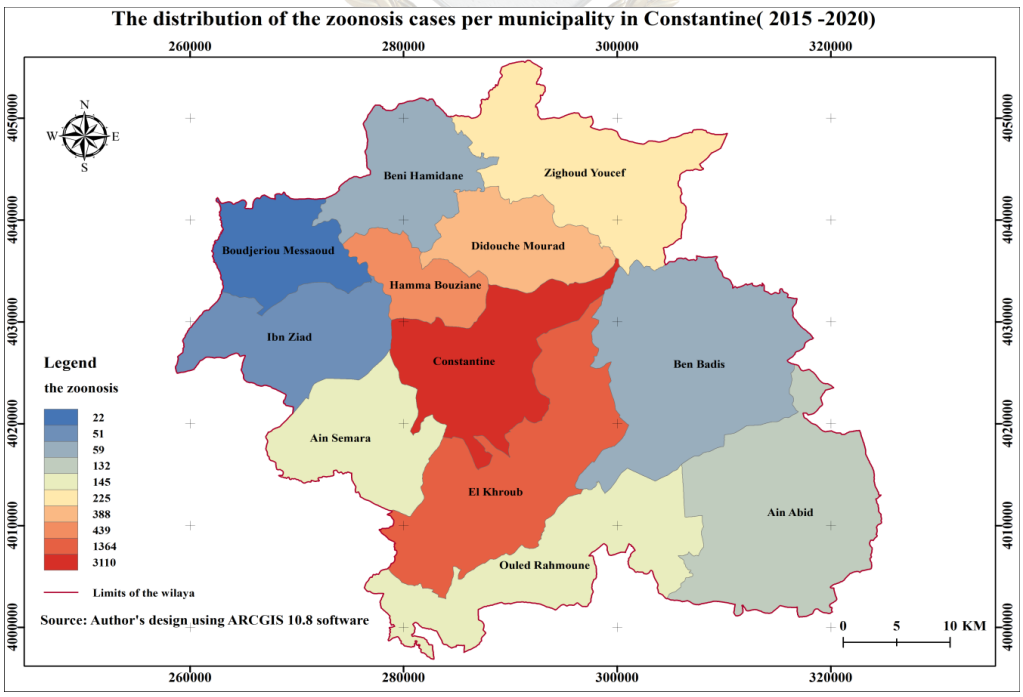

Figure 6. Zoonosis distribution map according to the municipalities of the wilaya of Constantine (2015-2020)

Source: Author's design from DHP data with ArcGIS 10.8

With a total of 3,110 cases, accounting for over 50% of all cases recorded in the wilaya, the distribution of zoonosis cases over six years reveals a high concentration in three central municipalities, with Constantine being the most affected. Following it with 22% of all zoonosis cases is the municipality of El Khroub. With 439 cases, Hamma Bouziane was also severely impacted.

These three towns together account for around 80% of the total zoonosis cases in the Wilaya, which emphasises their high concentration in these areas.

3.5.1. Elements causing the great case concentration:

Several elements can help to explain the concentration of zoonotic disease cases in the central municipalities of Wilaya, particularly Constantine, El Khroub, and Hamma Bouziane. Among them is the incredible population density in certain towns. El Khroub and Hamma Bouziane are situated close to rural areas and cattle farms, where regular human-animal interaction is evident. Better healthcare infrastructure and diagnostic facilities also benefit these towns, which could help detect zoonotic infections early on and improve their management compared to rural areas.

Though the remaining municipalities are less affected, the distribution of cases in other municipalities still accounts for 20% of the overall zoonotic cases. Among these cases' various municipalities are Ain Smara, Ouled Rahmoun, Didouche Mourad, Ouled Abid, Ben Badis, Beni Hamidane, Ibn Ziad, and Messaoud Boudjerou.

3.5.2. The correlation between population density and zoonotic diseases among localities

Calculating a linear regression between population density and zoonotic disease case (Figure 7) count, the following was obtained:

- Slope: around 1.05 → This implies that roughly 1.05 disease cases should rise for every one person/km² increase in population density.
- Intercept: instead -115.21 → When population density is zero—which is unreal but theoretically required—this is the expected value.
- R^2, or efficiency of determination: about 0.76 → Population density can thus help to explain about 76% of the variance in the number of instances.

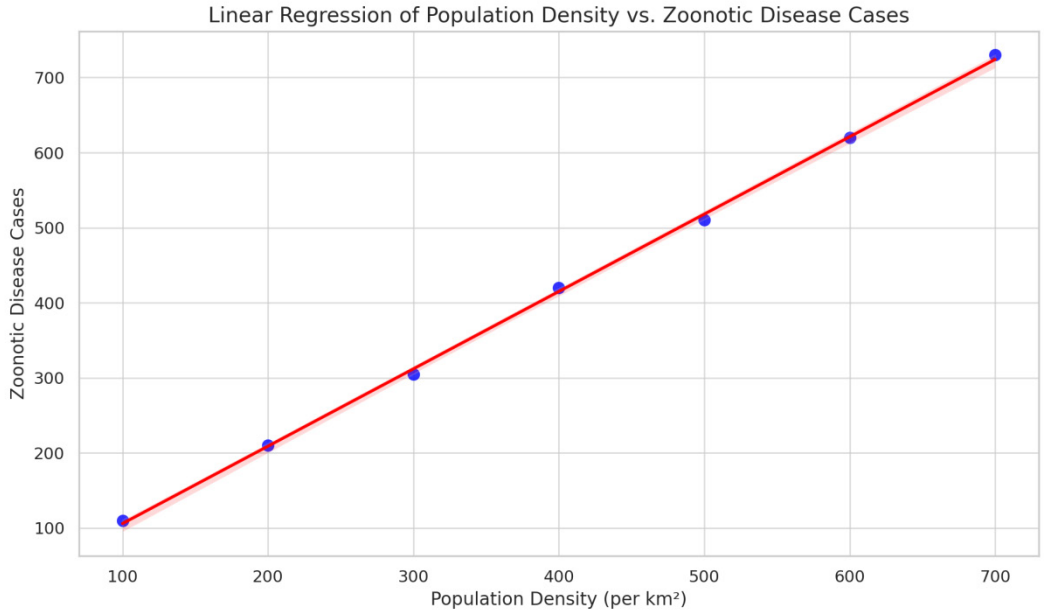

Figure 7. Linear regression curve illustrating the relationship between population density (per square kilometre) and zoonotic disease cases. Software Used**:** Python (Matplotlib & Seaborn libraries) for data analysis and visualisation based on municipal health and demographic data.

3.6. Mapping of COVID-19 Distribution

Figure 8 illustrates the geographic distribution of COVID-19 cases across the municipalities of Constantine in 2020, highlighting regions with elevated case counts.

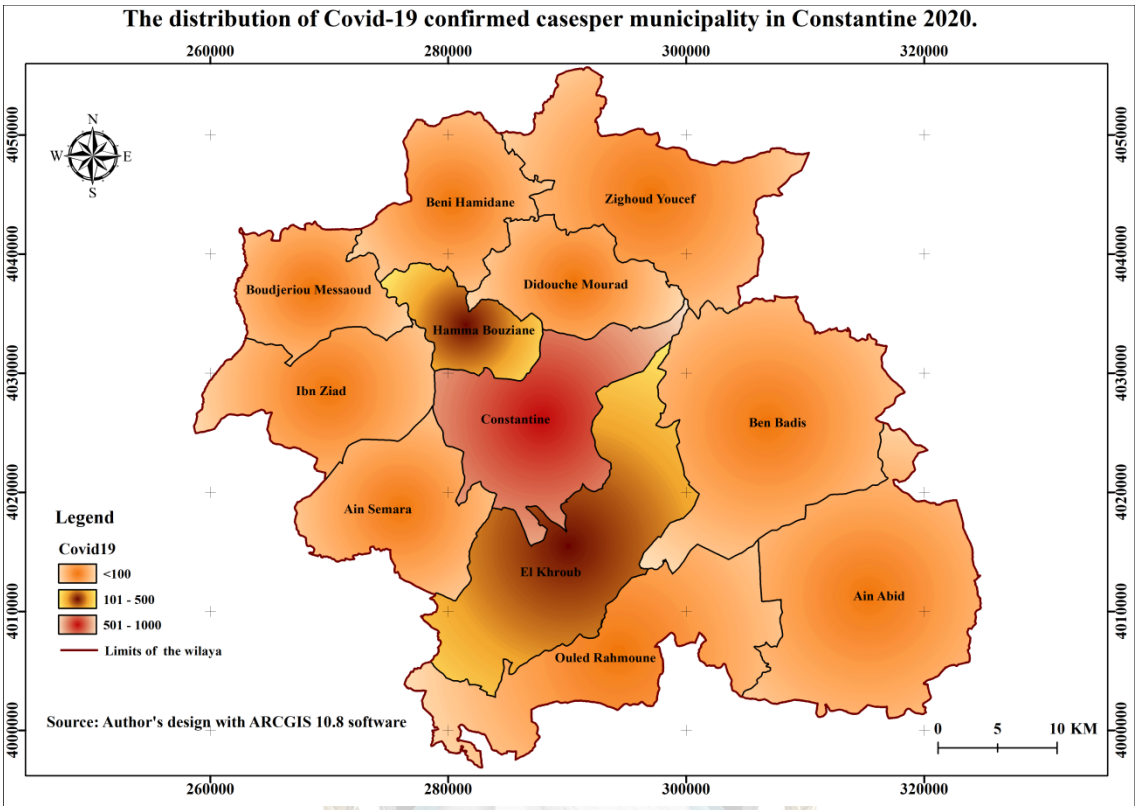

Figure 8. Distribution map of COVID-19 cases according to the municipalities of the Wilaya of Constantine (2020). *Source: Author's design from DHP data with ArcGIS 10.8.*

The regional distribution of confirmed COVID-19 cases among Constantine's 2020 municipalities is shown on the map (Figure 8). With darker tones signifying greater case concentrations, the *colour* gradient—which spans bright orange to dark red—represents the total verified cases.

3.6.1.COVID-19's most impacted municipalities:

Constantine: With a dark red colour, suggesting a high number of cases (between 801 and 1,000 instances), Constantine is the most severely impacted municipality. This is a result of its high population density and excellent human mobility, in addition to the fact that health facilities draw many disease cases, which are likely elements responsible for the rapid spread of the virus.

El Khroub and Hamma Bouziane have also shown large case counts (501–800). Their metropolitan character and proximity to Constantine facilitated the spread of the infection.

The moderately affected municipalities of Douche Mourad, Zighoud Youcef, and Ouled Rahmoun have a COVID-19 case prevalence ranging from 1 to 5%. Their relatively low population density and weaker human connections could have helped prevent the disease from spreading.

Represented by lower scores, Beni Hamidane, Ben Badis, Ain Abid, and Ain Smara have reported less than 100 confirmed cases. Their rural character, low population density, and low mobility could influence the limited virus propagation. Potential contributing elements influencing case distribution include:

- Urban density: The virus has been shown to spread rapidly in densely populated areas.
- Movement and economic activity: The highest *number of cases have come from major administrative and economic hubs, underscoring the role of human movement* in the virus's dissemination.

- Access to healthcare and testing capacity: Higher testing capacity in municipalities with superior healthcare infrastructure—such as Constantine—may have led to more cases being recorded. On the other hand, rural communities lacking more healthcare facilities could have understated cases.
- Preventive measures and public awareness: Variations in *the application of public health policies, including mask mandates, social distancing, and lockdown compliance, may* have impacted the spatial distribution of COVID-19 cases.

Linear regression analysis highlights a strong linear relationship between population density and COVID-19 cases. The two variables are positively correlated, with the number of cases increasing as population density increases.

3.7. Prevalence of Waterborne Diseases (WBDs) by Municipality

Figure 9. Represents the Prevalence of Waterborne Diseases in the municipality of Constantine.

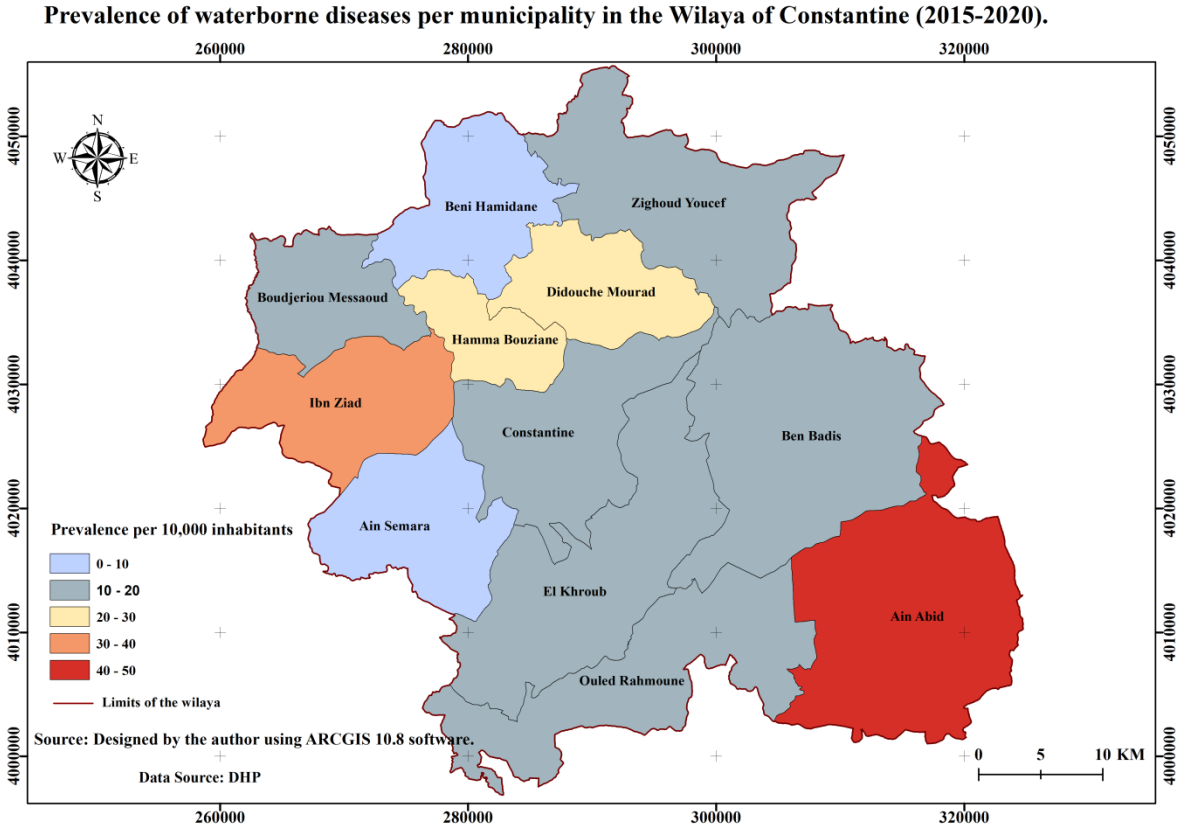

Figure 9. Map of the prevalence of MTH by municipalities of the wilaya of Constantine (2015-2016).

Source: Author's design from DHP data with ArcGIS 10.8

3.7.1. Spatial analysis of prevalence rates

• Municipalities with high prevalence (40-50 cases per 10,000 inhabitants):

- Ain Abid: Located in the southeastern part of the state, Ain Abid shows the highest prevalence of waterborne diseases.

• Municipalities with medium prevalence (30-40 cases per 10,000 inhabitants):

- Ibn Ziad: This municipality is located in the western part of the state and has a relatively high prevalence rate.

- Possible factors include limited access to safe drinking water and sanitation.

-Also, reliance on contaminated surface or groundwater sources and the lack of inadequacy of sanitation infrastructure.

• Municipalities with low prevalence (10-30 cases per 10,000 inhabitants):

Boudjeriou Messaoud, Didouche Mourad, and Hamma Bouziane have medium prevalence rates. Constantine, El Khroub, Ouled Rahmoun, Zighoud Youcef, Beni Hamidane, and Ben Badis have the lowest prevalence rates.

3.8. Prevalence of Zoonotic Diseases (Zoonoses) by Municipality:

Figure 10 illustrates the prevalence of zoonotic diseases across municipalities in the Wilaya of Constantine over six years from 2015 to 2020. The map highlights the distribution of zoonotic disease cases, emphasising areas with higher disease rates and those that have experienced notable outbreaks.

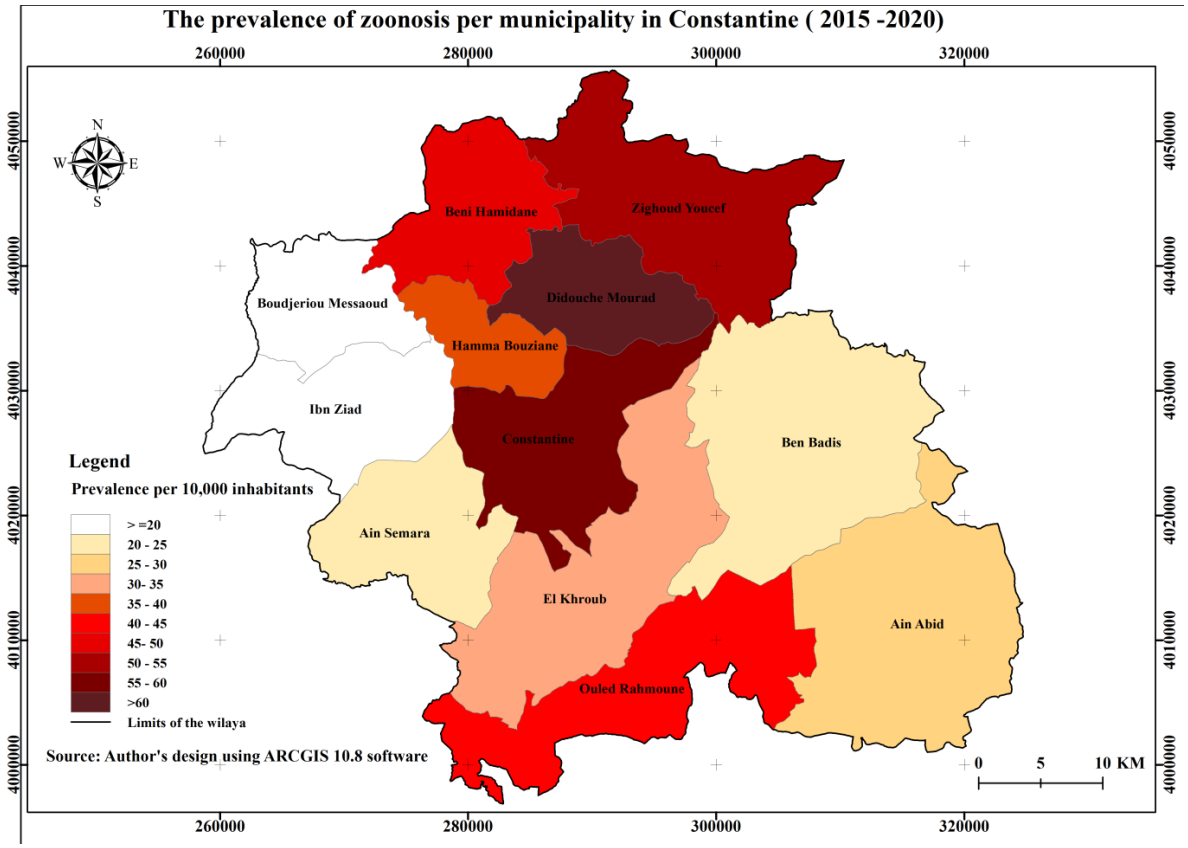

Figure 10. Map of the prevalence of zoonosis per municipalities of the wilaya of Constantine (2015-2016)

Source: Author's design from DHP data with ArcGIS 10.8

The frequency of zoonoses in Constantine's Wilaya reveals a varied spatial distribution across several areas. The towns of Constantine, Hamma Bouziane, Didouche Mourad, Zighoud Youcef, and Beni Hamidane note the most excellent prevalence rates—between 50 and >66 cases per 10,000 residents. These dark red highlighted spots indicate an intense concentration of zoonoses.

The localities of El Khroub and Oued Rahmoun indicate medium prevalence rates (between 30 and 50 cases per 10,000 residents), indicating a modest but concerning level.

The localities of Ain Smara, Ben Badis, and Ain Abid have the lowest prevalence rates (<30 cases per 10,000 people), indicating reduced exposure to zoonoses.

This visual study provides important new insights into the geographical distribution of zoonotic illnesses, identifying areas that require targeted health interventions and preventive actions to prevent disease transmission from animals to humans.

3.9. Prevalence of COVID-19 by Municipality

This map (Figure 11) provides a thorough depiction of the COVID-19 epidemic's spread among several Constantine municipalities during 2020, highlighting the areas most impacted by the epidemic during this period and those with the highest case counts.

This geographical study is crucial for understanding how the disease spreads among multiple towns and informing targeted public health campaigns.

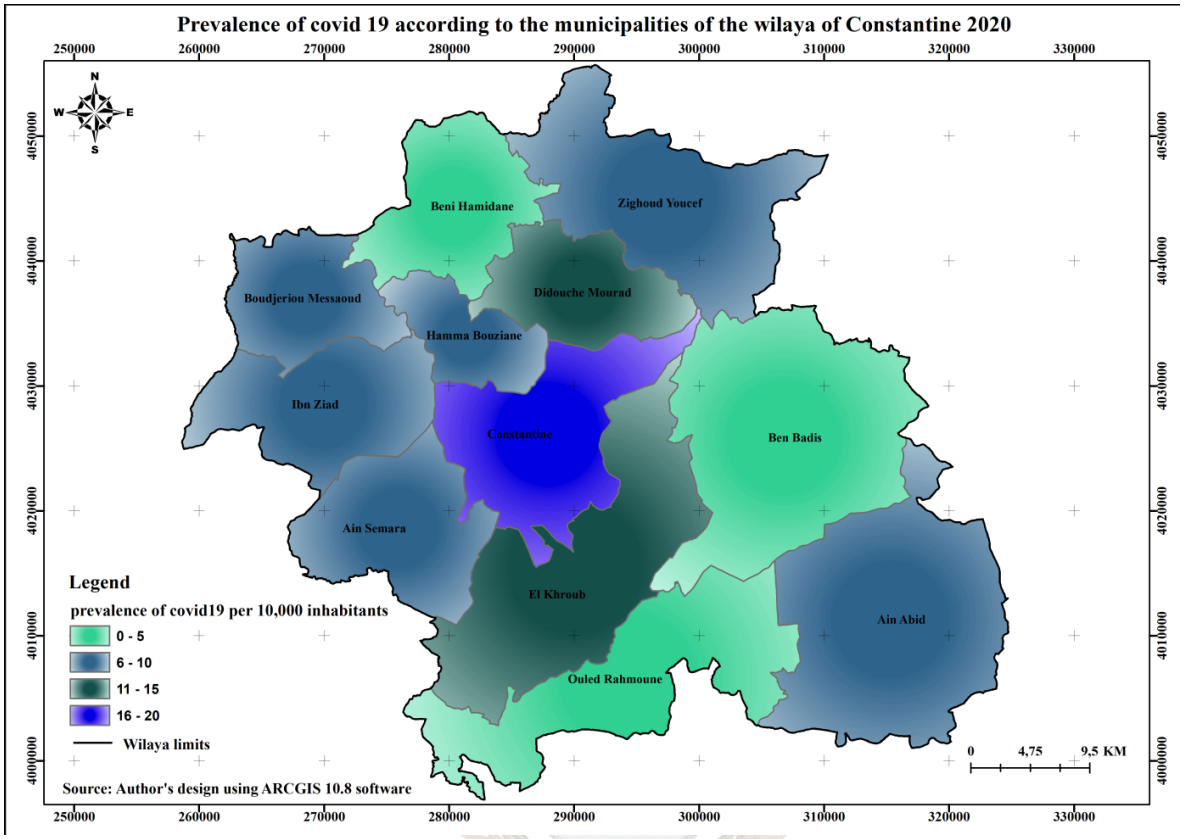

Figure11. Map of the prevalence of Covid 19 by municipalities of Constantine Wilaya (2020)

Source: Author's draft from DHP data with ArcGIS 10.8.

The map (*Figure 11) displays the COVID-19 incidence for every 10,000 people* living in several municipalities within Constantine's Wilaya. Made using ArcGIS 10.8 based on gathered data, COVID-19's spatial frequency distribution is Represented in dark blue; the municipality of Constantine is the *epicentre* of the epidemic and most impacted (≥ 16 cases / 10,000 people). El Khroub comes next in relatively high frequency.

3.9.1. Moderately impacted domains:

The virus has a modest frequency (6–15 infections per 10,000 residents), as evidenced by the communities of Hamma Bouziane, Didouche Mourad, and Zighoud Youcef. Ben Badis, Ain Abid, Ain Smara, Ibn Ziad, and Beni Hamidane exhibit the lowest infection rates, likely due to low population density and minimal social interaction, making them the least impacted places (≤ 5 cases/10,000 inhabitants).

As the most *urbanised* and densely populated cities, Constantine and El Khroub demonstrate higher infection rates due to their high human concentration and frequent social connections.

Movement within urban municipalities may have facilitated the rapid spread of the pathogen. Enhanced access to medical facilities in urban areas may *increase* testing rates, thus boosting the reported instances. Low population density and reduced mobility in towns such as Ain Abid or Ben Badis could account for the low recorded cases.

4. Discussion

The statistical analysis results indicate a strong direct association between population density and the recorded incidence of waterborne illness cases in Constantine's provincial municipalities. According to a linear regression model, density clearly explained 87 % of the variance in the number of recorded events. The results of our investigation align with earlier studies that emphasise the role of population density in facilitating the spread of the virus and increasing the risk of exposure to contaminated water supplies (Port & Jawahar, 2024; Beale et al., 2008).

This phenomenon is typically attributed to the high population density, which places a significant load on urban infrastructure, particularly water supply and sewage systems, leading to leaks and contamination. Municipalities such as Constantine and Hamma Bouziane, which have recorded the highest number of cases, further support this statistical link.

In addition to waterborne diseases, zoonotic diseases—also influenced by population density—demonstrated a similar statistically significant correlation. Our regression analysis revealed that, with a coefficient of 1.05, every additional person per square kilometre correlates with approximately one additional zoonotic disease case. The regression model (P-value = 0.0002; $R^2 = 0.763$) provided substantial support for this outcome, thereby emphasising the stability of the link.

Such results mirror past studies on zoonotic and pandemic disease patterns in densely crowded environments (Ulal & Karmakar, 2023; Cvetković et al., 2020; 2022; Janković et al., 2020). Beyond statistics, the spatial analysis of disease distribution, including COVID-19, zoonotic, and waterborne illnesses, revealed significant geographic disparities across the municipalities of Constantine. Municipalities for every disease include Constantine, El Khroub, and Hamma Bouziane, which are repeatedly ranked as high-risk areas.

Combining population density, urbanisation, and infrastructure shortcomings related to sanitation and water drives this spatial concentration. Comparable spatial clustering tendencies have been observed in many worldwide studies using GIS-based health risk assessments (Ocal et al., 2020; Rezaeian, 2007). This regional perspective is crucial in managing health risks by guiding geographically informed resource allocation, supporting targeted public health policies, and improving epidemic surveillance over time. Incorporating spatial analysis into public health planning enables the more accurate detection of high-risk areas and facilitates the development of tailored interventions. In line with current global findings, our work emphasises the importance of integrated spatial-statistical techniques in addressing environmental health hazards in various local settings effectively (Beale et al., 2008; Rezaeian, 2007). These insights reinforce the significance of adopting localised, data-driven approaches in managing public health threats in rapidly urbanising.

5. Conclusions

Especially in the wilaya of Constantine, this study emphasises the importance of spatial analysis as a valuable tool for monitoring infectious diseases in Algeria. By comparing our results with those of previous international studies, it appears that population density plays a significant role in the spread of diseases, as areas with high population density increase health risks related to waterborne and zoonotic diseases. The study also highlights the role of spatial analysis using geographic information systems (GIS) in identifying high-risk areas, which helps improve the allocation of health resources more effectively and efficiently.

Our results demonstrate that spatial analysis is a crucial tool for tracking disease frequency, facilitating the development of health strategies tailored to the social and environmental characteristics of each region. This study also highlights the need to improve sanitation and water infrastructure, aligning with previous studies that have called for enhanced environmental monitoring and improved public sanitation facilities in areas with weak infrastructure.

The analytical maps created in this study greatly facilitated the identification of high-risk areas and the most vulnerable population categories, thereby enhancing our ability to track infectious

disease trends. These results underscore the importance of early preventive surveillance and rapid response to epidemics, which necessitates the development of a comprehensive health risk management strategy that considers the spatial dimension of these risks. Moreover, strengthening the resilience of the healthcare system in the Wilaya of Constantine requires expanding healthcare infrastructures, improving resource management, and enhancing cooperation among various stakeholders, thereby contributing to increasing the region's capacity to manage health risks. Thanks to the results of this study, it can be affirmed that integrating spatial analysis into the region's public health policies will play a significant role in the early forecasting and prevention of future epidemics, thereby improving the well-being of the population and the quality of life in the wilaya of Constantine.

Author Contributions:

Project conceptualisation, data collection, statistical analysis, and mapping: D.S.; data validation, study supervision, and result interpretation: B.S.; writing – original draft preparation: D.S.; writing – review and editing: D.S. and B.S.; B.S. provided guidance throughout the research process and contributed to revisions to ensure scholarly accuracy. All authors have read and agreed to the published version of the manuscript. The authors collaborated throughout the research process, from data collection to final revisions, each offering their specialised expertise to distinct elements of the study.

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Review Article

Leveraging Artificial Intelligence for Enhanced Disaster Response Coordination

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ABSTRACT

This review critically examines the transformative role of artificial intelligence (AI) in coordinating the core phases of disaster response: preparedness, response, recovery, and mitigation. Drawing on illustrative case studies such as AI-driven flood forecasting with Delft-FEWS, post-disaster damage mapping via DroneDeploy, and optimised emergency dispatch through RescueME. It synthesises evidence on five core AI capabilities (machine learning, deep learning, computer vision, natural language processing, and optimisation algorithms). We find that AI can substantially improve predictive accuracy, real-time situational awareness, rapid decision-making, resource allocation, and inter-agency collaboration, thereby addressing the speed and complexity challenges of traditional disaster management. However, adoption is hindered by fragmented data ecosystems, opaque "black box" models, interoperability gaps, cybersecurity vulnerabilities, ethical and equity concerns, and limited accessibility in low-resource settings. To overcome these barriers, we argue for the development of interoperable data standards, explainable AI frameworks, robust cyber governance protocols, and inclusive stakeholder engagement. Emerging trends, such as the convergence of AI with IoT and edge computing, enhanced human-AI decision support, and the democratisation of AI tools, offer promising pathways for building more resilient, scalable, and ethically grounded disaster response systems. By aligning technological innovation with human oversight and participatory governance, strategic integration of AI can enhance preparedness, response effectiveness, and recovery efficiency, fostering safer and more resilient communities worldwide.

KEYWORDS

Artificial intelligence; disaster management; machine learning; computer vision; explainable AI; situational awareness; human–AI collaboration.

1. Introduction

In an era of increasing climate volatility and complex emergencies, the global community faces unprecedented challenges in managing natural and human-made disasters. Recent years have seen hundreds of catastrophic events annually, leading to significant human and economic losses (Gupta

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& Roy, 2024; Munich Re, 2023; Aon, 2024). Traditional disaster response practices, which rely on manual data collection, field surveys, and fragmented communication networks, often struggle to keep pace with rapidly evolving emergencies (NCDP, 2025). Decisions must be made rapidly under conditions of uncertainty. However, preliminary damage assessments can take days when done by teams physically inspecting sites, a process described as "time-consuming, potentially dangerous, and subject to human error". Likewise, coordinating multiple responding organisations (government, NGOs, private sector, community groups) is notoriously difficult, hampered by differing protocols and data systems. These challenges underscore the urgent need for more effective, data-driven, and coordinated approaches to disaster response. Integrated systems that combine traditional risk management with AI-enhanced monitoring (Cvetković et al., 2024; Cvetkovic & Martinovic, 2021) exemplify this coordinated approach. The growing complexity of industrial operations, as demonstrated by past catastrophes such as Bhopal and Fukushima, highlights how technological errors, human misjudgments, and organisational lapses converge to amplify the impacts of disasters. The incorporation of predictive models and real-time diagnostics has thus become central to disaster resilience planning in high-risk industries.

Natural disasters, including floods, earthquakes, and wildfires, are becoming more complex and interdependent. This necessitates a paradigm shift in how emergencies are anticipated and managed. Effective coordination among diverse stakeholders (government bodies, NGOs, private-sector responders, and community groups) is necessary and depends on a shared, up-to-date operational picture. However, disasters generate vast, heterogeneous data streams—from satellite imagery and sensor networks to social media feeds—that are typically siloed across agencies and formats. This fragmentation slows decision-making and leads to duplicated efforts or overlooked needs during critical windows of response. Artificial intelligence (AI) emerges as a critical innovation, promising not only efficiency but also strategic foresight in mitigating the impacts of disasters. AI enables the real-time analysis of vast datasets, such as satellite imagery, sensor outputs, and social media content, which are pivotal for disaster prediction, situational awareness, and coordinated response (Beeravelly, 2024). Systems like Delft-FEWS and DroneDeploy exemplify how AI is currently applied to predict floods and assess post-disaster damage, respectively. Moreover, AI-based decision support systems assist in resource allocation and emergency planning by simulating multiple scenarios (Schofield, 2022; Simões-Marques & Figueira, 2018).

However, this technological transformation is not without challenges. The deployment of AI in disaster contexts must navigate data privacy, algorithmic bias, and the risk of excluding marginalised communities from decision-making processes (Gevaert et al., 2021). There is also a need to harmonise AI applications with existing governance structures and disaster management protocols (Dean & Payne, 2013). Therefore, ethical frameworks and participatory models are essential for ensuring equitable and effective implementation.

This article reviews the theoretical frameworks and current implementations of AI in disaster response, analyses their benefits and limitations, and discusses future directions for research and policy.

2. Theoretical Framework and Background

Disaster management is commonly conceptualised as a continuous cycle with four phases: preparedness, mitigation, response, and recovery. During the preparedness phase, stakeholders develop plans, train personnel, and install early warning systems to prepare for potential emergencies. In preparedness, predictive models forecast risks; during response, AI facilitates real-time situational awareness; in recovery, it aids damage assessment and resource planning. This framework underscores AI's role as both a reactive and proactive tool, aligning technical capabilities with operational needs in disaster contexts (Simões-Marques & Figueira, 2018). Mitigation involves long-term measures to prevent disasters or reduce their impact (e.g. building codes, land-use planning, public education). The response phase encompasses immediate actions taken after a disaster strikes, including search and rescue, emergency medical care, shelter provision, and restoration of critical services.

Finally, recovery entails the longer-term process of rebuilding infrastructure, restoring livelihoods, and learning lessons to inform future preparedness. Each phase is interconnected; practical actions in one stage influence outcomes in the next, reinforcing a cycle of improved resilience. For instance, thorough recovery and documentation after an event can enhance preparedness for similar events in the future. (Gupta & Roy, 2024). In practice, implementing this ideal cycle presents significant challenges. Disasters often create chaotic environments with information overload and data gaps – vast amounts of data are generated (from sensors, satellites, social media, etc.), but they are fragmented among various entities. Responders struggle to assemble a coherent real-time picture (Cvetković, Renner, & Jakovljević, 2024).

Figure 1. Four phases of Disaster Management (AkitaBox, 2023)

Over the past few decades, emergency management has evolved from basic GIS mapping and statistical modelling toward sophisticated, data-driven approaches. Big data analytics and remote sensing technologies paved the way for AI by providing large volumes of data for analysis (Öcal & Torun, 2024). Today, AI systems not only analyse these vast datasets but also predict hazards, recommend actions, and enable real-time operational adjustments. Techniques such as machine learning and deep learning offer improved accuracy in forecasting disasters and damage assessments by identifying subtle patterns that traditional methods might miss (Odubola et al., 2025; NASA, 2024). Critical decisions (such as evacuation orders or resource deployments) must be made quickly, sometimes with incomplete or unreliable information. Moreover, the manual methods used for damage assessment and resource allocation are inherently slow and prone to human error (NCDP, 2025). Limited situational awareness impairs the ability to prioritise needs and allocate resources effectively. Moreover, large-scale disasters often involve numerous agencies and organisations. Inter-agency coordination is challenging when communication systems are incompatible, and each group operates with its data, resulting in siloed operations. These challenges are compounded by coordination difficulties among diverse response teams, which can lead to duplication of efforts or the overlooking of needs (APWA, 2025).

Several key attributes give AI an edge in disaster scenarios. First is sheer speed and scalability: AI can continuously ingest and analyse multi-source data in real time, which is invaluable during fast-moving crises. For example, during Hurricane Ida (2021), NASA's disaster program employed AI-driven analysis of satellite and aerial imagery to pinpoint flooded areas, power outages, and infrastructure damage shortly after landfall. This provided responders with near-real-time maps of impacted zones well before ground teams could survey those areas (NASA, 2024). Second, AI excels at pattern recognition. Machine learning models can be trained on historical disaster data to identify early warning signals. It can detect subtle environmental cues or precursor events that might foreshadow a disaster. Research demonstrates that AI-based techniques (e.g. image processing and

agent-based simulations) can offer critical lead time in disaster prediction and early alerts, potentially enabling preemptive actions that save lives (Deekshith, 2022; Reichstein et al., 2023). Third, AI can automate routine and labour-intensive tasks, freeing human responders to focus on complex decision-making. For instance, image classification algorithms can scour thousands of drone photographs for signs of damage in a fraction of the time it would take a human analyst; similarly, AI chatbots can handle surges in emergency calls or social media inquiries by triaging requests and providing vetted information to the public, thus reducing the burden on call centres. In short, AI brings speed, precision, and efficiency to emergency management processes that have historically been slow and manual.

Another critical advancement is the use of AI to analyse the socio-economic consequences of disaster displacement. As highlighted by the Internal Displacement Monitoring Centre (IDMC), AI technologies are enabling the integration of non-traditional data, such as mobile signals and social media patterns, with geospatial and demographic datasets to model human displacement more effectively. These models offer insights into the duration, location, and vulnerabilities associated with disaster-driven migrations, enabling more effective planning and response mechanisms at both local and international levels (IDMC, 2024). Several studies have reinforced the importance of integrating AI as a dynamic feedback mechanism across the disaster cycle. For instance, Schofield (2022) describes AI-driven platforms that continuously update models using new field data to enhance preparedness and adapt response strategies in real-time. In another example, Abdul et al. (2024) propose an AI framework tailored for healthcare coordination during disasters, illustrating how domain-specific adaptations can optimise outcomes. Beeravelly (2024) also emphasises that cloud-based AI platforms enable continuous monitoring and prediction by analysing multi-source data, highlighting their scalability and resilience.

Moreover, Gevaert et al. (2021) argue for a conceptual expansion of AI's role, advocating that it be seen not just as a tool for automation but as an actor shaping decision pathways and ethical priorities. The goal is not just to react faster but to anticipate and mitigate impacts whenever possible. This perspective invites a reconsideration of AI systems as participatory infrastructures that mediate between technology, policy, and community resilience. Therefore, AI's conceptual integration must go beyond technical functions to encompass sociotechnical governance, stakeholder input, and adaptive policy alignment. As AI becomes more deeply embedded in disaster management institutions, it has the potential to improve how we handle crises fundamentally – but realising this potential will require addressing various challenges (technical, ethical, organisational) discussed later in this article. The following sections outline the current state of AI technologies in disaster response and their applications across various disaster phases.

3. AI Technologies in Disaster Response

Building on the theoretical framework established in Section II, we now turn to the core AI technologies that power modern disaster response systems. In this section, we examine four key categories: machine learning and deep learning for hazard prediction, computer vision for rapid damage assessment, natural language processing for extracting actionable insights from textual data, and optimisation algorithms for efficient resource allocation. For each technology, we outline its fundamental principles and typical applications in disaster scenarios and provide illustrative case studies that demonstrate its real-world impact.

3.1. Core AI Technologies in Disaster Response

Machine learning (ML) algorithms can analyse historical disaster data to predict future hazards. For instance, models such as Random Forests and neural networks have been applied to forecast earthquake characteristics (Asma & Aranas, 2024). These models often outperform traditional statistical methods by providing earlier and more reliable warnings. Deep learning, particularly using architectures like Long Short-Term Memory (LSTM) networks and Convolutional Neural Networks

(CNNs), further extends AI's capabilities. LSTM networks can recognise temporal patterns in seismic data, thereby enhancing earthquake prediction (Bhargava et al., 2022). Such image-based AI models can rapidly classify damage levels, significantly accelerating the traditionally laborious process of damage assessment. Early warning systems form the backbone of disaster preparedness and response. AI-enhanced systems can predict hazardous events by analysing sensor data, historical trends, and environmental indicators to identify potential risks. For example, machine learning has been applied to forecast earthquake likelihood and provide crucial seconds of warning that can trigger protective measures (Al-banna et al., 2023).

Natural Language Processing (NLP) enables emergency managers to sift through vast amounts of text data—from social media posts to official reports—in real time. Platforms like AIDR (Artificial Intelligence for Disaster Response) use NLP to categorise and filter relevant information, distinguishing urgent reports from background noise (Odubola et al., 2025). Advanced language models (e.g., GPT-4) further support crisis communication by summarising reports and translating content for multilingual audiences. Computer vision (CV) empowers AI to extract critical information from imagery. Drones and satellites collect high-resolution images of disaster zones, which AI-powered computer vision (CV) systems then analyse to detect damaged structures, obstructed roads, and other vital indicators of disaster impact (NCDP, 2025). For example, during Hurricane Ida, NASA's AI-assisted imaging was able to quickly identify areas affected by flooding and infrastructure damage (NASA, 2024). CV also supports search-and-rescue operations by processing thermal or infrared imagery to locate survivors in areas that are otherwise inaccessible. In wildfire management, the integration of AI-based risk mapping systems has improved both preparedness and response. In Colorado, AI tools that analyse weather data, vegetation health, and historical fire patterns have been used to pre-position firefighting resources in high-risk areas, thereby reducing response times and enhancing safety (APWA, 2025). Post-fire, drone imagery combined with computer vision has accelerated damage assessments that once took days to complete. In Yangbi, China, researchers have developed a computer vision model to detect earthquake damage from aerial images, enabling local authorities to prioritise relief efforts quickly (Jing et al., 2022).

3.2. How AI Technologies Are Transforming Disaster Response and Human Welfare

Long-term recovery strategies are also another key discussion in disaster resilience. Đorđević & Gačić (2024) highlight that integrating sustainability into disaster response planning, particularly by leveraging local knowledge and governance, yields higher community resilience. This approach aligns with AI's capacity for systems-level adaptation and supports policies that embed environmental, economic, and social dimensions into preparedness frameworks. Similarly, Ogunleye and Arohunsoro (2024) provide an empirical assessment of the socio-economic impacts of rainstorms in Nigeria, underlining the role of local governance and planning failures in exacerbating disaster vulnerability. In Algeria, Tout et al. (2024) demonstrate how improved forest road networks and drone technologies can aid fire prevention and emergency response. From a resilience measurement perspective, Milenković et al. (2024) advocate for context-specific adaptation of the BRIC (Baseline Resilience Indicators for Communities) indicators, suggesting that resilience must account for socio-economic and infrastructural variability. These insights emphasise the importance of integrating AI analytics with on-the-ground needs assessments to enhance responsiveness and resource targeting, particularly in low-income and high-risk regions.

Machine learning (ML) models have significantly enhanced the prediction of natural hazards, including earthquakes, floods, and wildfires. Techniques such as support vector machines, neural networks, and ensemble models are employed to identify patterns in historical and real-time sensor data. Integration with IoT networks enhances spatial and temporal resolution, as well as system responsiveness. Studies highlight AI's early warning contributions via platforms like Delft-FEWS, which combine real-time hydrological data with predictive analytics for flood forecasting in regions such as Bangladesh and Vietnam (Sun et al., 2020; Andrae, 2025). A case study by Sharma et al. (2025) examines how IBM's PAIRS geospatial analytics platform utilises satellite images to predict flood-prone zones, thereby enhancing response lead times and community preparedness. However,

challenges include imbalanced data—such as an overrepresentation of high-income countries and more frequent disaster types like floods, compared to underrepresented hazards like droughts in arid regions or data-scarce locations in Sub-Saharan Africa. Other issues include the limited availability of labelled datasets and the difficulty of generalising models across diverse geographical regions. Few studies have explored deployment in low-resource settings, highlighting a gap in the equitable dissemination of technology.

AI enhances situational awareness through image analysis and natural language processing (NLP). Computer vision algorithms analyse satellite and drone imagery to assess damage and identify affected areas. NLP techniques process social media and emergency call transcripts to extract actionable information. Platforms like DroneDeploy facilitate rapid damage mapping using AI-processed aerial imagery (Bohland et al., 2024; Raut, 2024). Rescue Me, an AI emergency system, further illustrates the real-time analysis of emergency calls and social data to prioritise response actions and resource dispatch (Sreeketh et al., 2024). To handle multilingual contexts, recent NLP models, such as mBERT (multilingual BERT) and XLM-RoBERTa, are trained on diverse language corpora, enabling improved understanding and classification of multilingual texts in disaster communications. Datasets such as CrisisNLP and multilingual emergency tweets are increasingly used to fine-tune these models for low-resource languages. Despite these advancements, issues with data noise, language ambiguity, and dialectal variation persist. Research is needed on the trust and usability of these systems in multilingual and culturally diverse contexts, particularly in regions where training data is limited or linguistic diversity is high.

Optimisation algorithms and AI planning tools support real-time logistics, including route planning for emergency vehicles and allocation of supplies. Multi-agent systems facilitate coordination among different agencies and platforms, promoting interoperability. Examples include the use of decision support systems that recommend optimal resource allocation and evacuation planning based on evolving disaster scenarios (Schofield, 2022; Kumar, 2024). However, system complexity and data latency remain barriers to widespread adoption. Few models integrate ethical considerations or support human-in-the-loop decision-making, which limits trust and accountability in critical moments.

Post-disaster recovery benefits from AI-driven tools for damage assessment and resilience modelling. Deep learning models interpret aerial imagery to quantify damage, while agent-based simulations model recovery scenarios. AI can also inform infrastructure redesign and community resilience planning. In healthcare contexts, AI systems have been proposed to triage patients and optimise hospital resource distribution during large-scale emergencies (Abdul et al., 2024). Despite advancements, limited longitudinal studies and a lack of integration with socioeconomic data hinder comprehensive insights into recovery. There is a need for frameworks that align AI outputs with community-driven recovery goals (Abid et al., 2021; Singh & Agnihotri, 2024).

4. Ethical Concerns and Policy Integration

4.1. Ethical Concerns and Challenges

Emerging studies reinforce the transformative potential of AI in addressing ethical and operational dilemmas in disaster contexts. For instance, Harika et al. (2024) highlight how AI systems, such as DisasterAI-Net and ResQOptimize, enhance disaster detection and resource optimisation by utilising real-time data from social media, drones, and satellite imagery. These systems demonstrate superior responsiveness and adaptability, particularly when manual bottlenecks hinder traditional methods.

The complexity and opacity of AI models—intense learning systems, pose significant challenges to disaster risk management. Ghaffarian et al. (2023) underscore the urgent need for Explainable AI (XAI) to promote transparency and trust, especially as AI-driven decisions increasingly influence emergency protocols and resource allocation. Their review highlights the growing trend toward using SHAP and LIME techniques to interpret black-box models in flood prediction, wildfire susceptibility, and damage mapping. These methods help illuminate model logic but often add significant

computational overhead, which can limit real-time applicability in resource-constrained settings. Moreover, current applications of XAI are disproportionately focused on response, with limited attention to preparedness or recovery phases.

Bari et al. (2023) provide a nuanced overview of how AI technologies, ranging from ANN for flood prediction in Ethiopia to sentiment analysis for mental health triage, are becoming cornerstones in disaster health management. These tools not only assist in immediate response but also support long-term psychological recovery. Despite these advancements, issues surrounding algorithmic transparency, data standardisation, and cross-border legal harmonisation remain unresolved. AI systems risk reinforcing existing social biases, compromising user privacy, and excluding marginalised groups from the decision-making process. For example, NLP models trained on limited language corpora may fail to capture emergency calls from speakers of minority languages, potentially delaying critical responses (Gevaert et al., 2021).

Despite the transformative potential of AI in disaster response, significant barriers exist in low-resource environments. Many regions lack the necessary technological infrastructure, including reliable broadband internet, edge computing devices, and trained personnel to operate advanced AI systems. Studies have highlighted that most AI models are trained on datasets from high-income countries, which limits their effectiveness when applied to diverse contexts, such as rural Africa or Southeast Asia. Organisational challenges, including limited governance capacity and fragmented disaster protocols, further complicate deployment efforts. To overcome these barriers, future efforts should prioritise the development of offline-capable AI models that can operate on solar-powered edge devices, reducing dependency on stable internet connections. Open-source, low-code AI platforms tailored for local agencies can democratise access to technology, while partnerships with NGOs and academic institutions can build long-term capacity. The equitable deployment of AI technologies must address both technological and organisational gaps to ensure that the benefits of innovation reach vulnerable communities worldwide.

An important yet underexplored challenge in AI-driven disaster response is the effective deployment of technologies in multicultural and multilingual environments (Behravan et al., 2024). While AI models, particularly in natural language processing (NLP), have made strides in multilingual understanding, significant gaps remain. Many AI systems are primarily trained on high-resource languages, leaving minority languages and dialects underrepresented, which can result in delayed or distorted emergency communications (Jiao, Lewis, Xu, Sussman, & Atkinson, 2024). Cultural differences also influence risk perception, communication styles, and trust in automated systems, which AI models often overlook—failure to incorporate cultural and linguistic diversity risks excluding vulnerable groups from critical response efforts. Inclusive AI design must prioritise diverse language datasets, dialect-specific fine-tuning, culturally sensitive user interfaces, and community engagement throughout model development and deployment. Future disaster AI systems should integrate continuous learning from localised data and support multilingual, culturally adaptive communication strategies to ensure equitable access to life-saving information.

Governance gaps further exacerbate these issues, including the lack of international standards for AI deployment in disaster contexts, unclear liability when automated decisions lead to harm, and fragmented data-sharing protocols across jurisdictions. Several studies stress the importance of participatory governance and human-in-the-loop approaches to ensure inclusivity and accountability (Dean & Payne, 2013; Andrae, 2025). Integrating AI into disaster policy and field operations requires not only ethical foresight but also technical adaptability. Systems must be interoperable with legacy infrastructure while maintaining real-time capabilities. Building ethical AI ecosystems for disaster management also involves educating stakeholders, continuous monitoring, and establishing adaptable standards that reflect diverse cultural and regional needs.

The convergence of these technical, ethical, and policy challenges underscores that effective disaster AI is as much a social endeavour as it is a technological one.

4.2. Policy Integration & Stakeholder Collaboration

A crucial yet often underrepresented dimension of AI in disaster management is the role of policy integration and stakeholder collaboration. Effective AI deployment depends not only on technological robustness but also on institutional readiness and community acceptance. Many AI systems struggle to gain traction due to misalignment with local disaster protocols or a lack of awareness among responders. Policies must be adapted to accommodate AI's rapid evolution while ensuring interoperability, accountability, and inclusivity. For instance, local governments need guidance on procurement, training, and oversight of AI tools. Meanwhile, cross-sector partnerships—with academia, tech firms, NGOs, and emergency services—can co-develop tailored solutions and support knowledge exchange.

One compelling example is the Rescue Me system, which relies on real-time data integration from sensors, calls, and social media to coordinate emergency services more efficiently (Sreeketh et al., 2024). Another example is the implementation of AI analytics in regional flood forecasting by the IBM PAIRS system, which supports proactive decision-making at the municipal level (Sharma et al., 2025). These platforms highlight the need for regulatory frameworks that strike a balance between innovation, data privacy, and operational resilience.

Embedding AI into national disaster strategies and harmonising standards at the international level is crucial for maximising AI's global impact. Beeravelly (2024) highlights the benefits of cloud-based platforms in enhancing scalability and facilitating data sharing among agencies, while Gevaert et al. (2021) advocate for the implementation of AI accountability mechanisms to ensure equitable representation. Only through multi-level collaboration and aligned incentives can AI systems move from pilots to scalable solutions that truly enhance disaster resilience.

5. Conclusion and Future Work

The integration of artificial intelligence into disaster management has demonstrated clear benefits, including rapid, real-time analysis of heterogeneous data streams (such as satellite imagery and sensor outputs), enhanced early warning through predictive modelling, improved situational awareness via computer vision and natural language processing (NLP), and optimised response coordination and resource allocation. Case studies such as Delft FEWS, DroneDeploy, and Rescue Me exemplify how AI-driven platforms can accelerate damage assessment and streamline multi-agency collaboration, making disaster response both more proactive and scalable.

Looking ahead, three priority areas emerge for future research and development:

• ***Multi-Modal AI–IoT Convergence: Future systems must fuse diverse data sources, such as IoT sensor networks, drone and satellite imagery, and text reports, into unified, edge-enabled*** platforms that remain operational even when central infrastructure fails. By deploying AI models at the edge (e.g., on-device ML for seismic sensors or onboard drone chips), disaster response tools can sustain low-latency hazard detection and decision support under austere conditions (Sharma et al., 2024).

Table 1. Comparison of Edge Computing and Cloud AI for Disaster Response (Moon Technolabs, 2023)

Feature	Edge Computing	Cloud AI
Latency	< 100 ms	> 500 ms
Connectivity	Works offline	Requires broadband
Compute Cost	Low per node (cheap devices)	High aggregated (expensive servers)
Data Privacy	Data stays local (so more secure)	Centralised storage (Data sent to the cloud)
Examples	Onboard drone damage detection	Centralised flood prediction

• Another emerging priority is ***human collaborative Decision Support:*** Rather than supplanting expert judgment, AI should serve as an explainable, interactive aid to human responders. Human–AI collaborative decision support systems enhance the capabilities of emergency managers by providing actionable recommendations while preserving human oversight. Advances in XAI (e.g., SHAP, LIME) will be crucial in building trust, enabling emergency managers to identify which factors drive AI recommendations, such as evacuation routing based on predicted fire spread, and to integrate those insights with local contextual knowledge (Matin & Pradhan, 2023). For example, the IBM Intelligent Operations Centre for Emergency Management integrates real-time data streams, including weather reports, emergency calls, and infrastructure status, into an interactive dashboard. This system allows human users to run scenario simulations (e.g., predicting the cascading impacts of a significant flood) and evaluate AI-recommended actions, combining automated insights with human expertise.

Similarly, the FEMA Planning Assistant for Resilient Communities (PARC) utilises AI-powered dialogue interfaces to support local governments in developing hazard mitigation plans. Rather than replacing human planners, it suggests customised strategies and explains regulatory frameworks, which users then review and modify based on local knowledge and priorities. Emerging multi-agent AI frameworks, like EvoTaskTree, are also promising. These systems autonomously develop decision trees for emergency actions yet require human supervisors to validate critical steps. This collaborative model enhances transparency and accountability, ensuring that AI acts as a partner, not a replacement, in complex disaster management decisions. Future training programs for emergency responders should integrate modules on AI interpretation, much like today's GIS or radio communication certifications. Only by fostering intuitive, explainable, and collaborative AI systems can disaster response truly leverage the combined strength of human and machine intelligence.

• ***Democratisation and Global Standards: To ensure equitable access, open-source AI toolkits and low-code platforms should be developed, allowing smaller agencies and NGOs to customise risk mapping and simulation models without specialised*** expertise. International collaboration—through shared disaster data repositories, interoperable model formats, and mutual aid agreements for AI analysis—will help lower-resource regions adopt lifesaving technologies, thereby narrowing resilience disparities worldwide (Jing et al., 2022).

AI's integration into disaster response delivers demonstrable gains in speed and accuracy, yet its full potential depends on overcoming data-sharing barriers and ensuring transparent, human-centred implementations. By advancing multi-modal edge computing, fostering transparent human-–AI partnerships, and establishing global cooperative frameworks, the field can transition from isolated pilots toward scalable, resilient solutions that protect vulnerable communities in the face of escalating climate and industrial hazards.

To translate these insights into actionable strategies, we offer the following recommendations for local authorities, humanitarian organisations, and emergency services:

- **Invest in Multilingual AI Tools:** Deploy NLP models trained in local languages and dialects to ensure inclusive communication during emergencies.
- **Prioritise Explainable AI Systems: Select decision-support tools that provide transparent reasoning, allowing** responders to understand and adapt AI recommendations.
- **Develop Offline-Capable Solutions:** Utilise edge computing technologies that operate independently of continuous internet access to ensure operational resilience.
- **Foster Cross-Sector Collaboration:** Partner with academic institutions, tech companies, and community organisations to co-develop and adapt AI tools for local contexts.
- **Incorporate Cultural Sensitivity:** Integrate cultural knowledge into AI training and decision processes to enhance trust and effectiveness in diverse communities.

Implementing these strategies can enhance the inclusivity, trustworthiness, and operational effectiveness of AI systems in disaster response.

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Article

Understanding Ransomware Through the Lens of Disaster Risk: Implications for Cybersecurity and Economic Stability

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ABSTRACT

Ransomware has emerged as a modern digital crisis, mirroring the widespread disruptions typically associated with natural or artificial disasters. As global economies grow increasingly interconnected through digital systems, the fallout from ransomware attacks stretches far beyond mere technical breaches. These incidents result in severe financial damage, disrupt operations, erode reputations, and contribute to broader socioeconomic instability. This study adopts a disaster risk perspective to examine the broader economic and social impact of ransomware, particularly its effects on critical infrastructure and public trust in institutions. Through a multi-case analysis of sixteen significant ransomware attacks between 2015 and 2025, the research highlights a recurring pattern: direct and indirect costs often compound, with impacts varying from ransom demands and halted services to reputational loss and sector-wide vulnerabilities. The rise of Ransomware-as-a-Service (RaaS) has also made these attacks more accessible and complex, deepening the threat landscape. The findings underscore the need to integrate cybersecurity into comprehensive disaster risk management strategies. Policymakers, institutions, and businesses must adopt a forward-looking approach—emphasising continuous risk evaluation, resilient digital infrastructure, and collaboration across sectors. To protect economies from escalating cyber threats, adaptive regulations and anticipatory defences are no longer optional—they're essential.

KEYWORDS

Ransomware; cybersecurity; disaster risk; digital economy; financial impact; critical infrastructure; cyber resilience; socio-economic consequences; risk governance; ransomware-as-a-service (RaaS).

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1. Introduction

In the current digital economy, over 60 per cent of commercial transactions occur online, exposing cyberspace to vulnerabilities and necessitating high-quality security for optimal and transparent transactions (Valackienė & Odejayi, 2024). Insights from last year's World Economic Forum (2024) underscore that global financial stability faces threats from the rising frequency and sophistication of cyberattacks. Tactics have evolved through the use of artificial intelligence, ransomware-as-a-service, and advanced social engineering techniques, enabling attackers to bypass traditional cyber defences. This notion is further supported by various insurance companies assessing cybersecurity risks in businesses (Hiscox Group, 2024), which highlights the crucial role of cybersecurity in the global economy (Kala, 2023). More than 5. 4 billion people and countless groups and organisations actively use the internet. According to estimations and remarks from Kuzior et al. (2022, 2024), the digital transformation market is projected to grow from $ 469.8 billion in 2020 to $ 1.01 trillion in the 2025 business year. It may reach up to $ 3.9 trillion by 2027, with a compound annual growth rate of 16%. 1%.

Despite the increasing literature on ransomware's technical elements, there remains a shortfall in integrated analysis connecting financial impacts to broader disaster risk perspectives (Cvetković, Renner, & Jakovljević, 2024; Jurišić & Marceta, 2024; Mokhele, 2024; Molnár, 2024; Rebouh, Tout, Dinar, Benzid, & Zouak, 2024; Umer, 2024; Vidović, Cvetković, & Beriša, 2024). Understanding the economic stability implications of ransomware and its effects on critical infrastructure and public trust is a significant research gap in the realms of cybersecurity and risk governance. While numerous studies have delved into the technical dissection of ransomware attacks, few have investigated their broader consequences on financial stability, sectoral resilience, and public trust through a holistic, disaster- centric analytical framework (Axon, Erola, Agrafiotis, Uuganbayar, Goldsmith, & Creese, 2023; Benmalek, 2024; Connolly, Wall, Lang, & Oddson, 2020; Goodell & Corbet, 2022; Molina, Torabi, Sarieddine, Bou- Harb, Bouguila, & Assi, 2022; Mott et al., 2024; Pattnaik et al., 2023; Reshmi, 2021; Wollerton, 2023; Zimba & Chishimba, 2019). This research seeks to address this gap. Given the increasing intensity, frequency, and extensive impact of ransomware attacks, these incidents lend themselves to interpretation within a disaster risk framework.

According to the United Nations Office for Disaster Risk Reduction (UNDRR), disaster risk is defined as the potential loss of life, injury, or destroyed or damaged assets that could occur to a system, society, or a community in a specific period, determined probabilistically as a function of hazard, exposure, vulnerability, and capacity (Cvetković, 2023; Cvetković, 2024a, 2024b; Cvetković & Grbić, 2021; Cvetković, Nikolić, & Ivanov, 2023; Cvetković & Renner, 2024; Cvetković & Šišović, 2024; Cvetković, Tanasić, Renner, Roković, & Beriša, 2024; Cvetković, 2024a; Cvetković, Dragašević, Protić, Janković, Nikolić, & Milošević, 2022). When viewed through this lens, ransomware can be seen as a digital hazard that disrupts systems at scale, amplifies vulnerabilities, and tests institutional readiness to absorb and recover from shocks. Like natural or technological disasters, ransomware strikes often occur abruptly, cause widespread disruption, and require coordinated responses across multiple sectors (Al-ramlawi, El-Mougher, & Al-Agha, 2020; Aleksandrina, Budiarti, Yu, Pasha, & Shaw, 2019; Carla, 2019; Cvetković, 2019; Cvetković & Janković, 2020; Cvetković & Martinović, 2020; Cvetković Šišović, 2024; Cvetković, Tanasić, Ocal, Kešetović, Nikolić, & Dragašević, 2021; Kumiko & Shaw, 2019; Perić & Cvetković, 2019; Vibhas, Bismark, Ruiyi, Anwaar, & Rajib, 2019; Wedawatta, 2012). This perspective broadens the understanding of ransomware—framing it not solely as a cybersecurity issue, but as a form of digital disaster with profound economic, societal, and institutional implications.

Scalability and anonymity uniquely characterise cyberattacks (Tarter, 2017). As digital transformation accelerates, vulnerabilities proliferate across customer channels (Farahbod et al., 2020), affecting business operations, supply chains, and human capital. This occurs unless security is integrated into the initial designs (George et al., 2024). The increasing complexity of cyberspace exacerbates cyber inequalities, widening the gap between large and small businesses and deepening the divide between developed and emerging economies, creating sectoral disparities (World Economic Forum, 2025). Securing a digital future is crucial in this age of technological advancement and interconnect-

edness. This commitment to effective cybersecurity is essential for individuals, organisations, and societies (Cobos, 2024; Thakur, 2024).

The central aim of this paper is to examine ransomware as a complex, multidimensional threat that extends beyond traditional cybersecurity narratives. These narratives often focus narrowly on technical vulnerabilities, breach response, and system recovery, without addressing the broader systemic, financial, and social ramifications of large-scale cyber incidents. By situating ransomware within the broader framework of disaster risk, the study evaluates its immediate financial impacts—such as ransom payments, recovery expenditures, and operational disruption—and its longer-term effects, including reputational harm, institutional instability, and socio-economic disparities. This perspective offers a more comprehensive understanding of ransomware as a digital hazard with systemic implications, capable of eroding economic resilience, compromising critical infrastructure, and eroding public confidence in both governmental and private institutions. Ultimately, the paper seeks to inform the development of integrated risk governance strategies that reflect the dynamic and interconnected nature of today's cyber threat landscape. Methodologically, the study draws upon a structured qualitative framework rooted in multiple case studies. The selected cases span diverse geographical and sectoral contexts and are analysed using thematic coding to identify patterns of financial loss, institutional disruption, and socio-economic consequences.

Additionally, this study employs a multiple case study framework, examining sixteen globally significant ransomware incidents that occurred between 2015 and 2025. The analysis draws on various sources, including institutional documents, academic publications, and financial reports. The paper is organised as follows: Section 2 reviews the theoretical underpinnings and economic dimensions of cyberattacks; Section 3 introduces a classification of ransomware threats; Section 4 details the research methodology; Sections 5 and 6 analyse the financial, economic, and social impacts; and Section 7 concludes with key takeaways for policy and practical applications.

Metods

This research employs a qualitative-descriptive approach, utilising multiple case studies to examine the financial, operational, and societal impacts of ransomware, with a focus on its disaster-like effects and sector-wide ripple effects. A purposive sampling method was used to select sixteen significant ransomware cases from 2015 to 2025. These incidents involved private companies, public entities, critical infrastructure, and even national governments. Selection criteria included data availability, the scale of financial impact, and variation in attack methods and targeted sectors. Data were sourced from various sources, including peer-reviewed studies, institutional reports, cybersecurity datasets, published financial records, and media coverage.

A structured thematic analysis was employed to explore the complex impacts of ransomware attacks. The findings were organised into four main categories: (1) direct financial losses, including ransom payments, data recovery costs, and downtime-related expenses; (2) indirect financial losses, such as rising insurance premiums, legal and compliance costs, and revenue decline from lost customers or contracts; (3) broader economic disruptions, encompassing supply chain breakdowns, service delays, productivity losses, and liquidity challenges; and (4) reputational and societal effects, including diminished public trust, psychological strain on employees and citizens, breaches of data privacy, and weakened institutional credibility. This framework provides a comprehensive view of ransomware—not just as a cybercrime, but as a disruptive phenomenon with devastating consequences across economic and social domains. To frame these findings, the study adopts a disaster risk perspective, treating ransomware as a complex socio-technical threat that can destabilise economies and weaken infrastructure resilience. Cross-case comparisons revealed recurring patterns and vulnerabilities, providing the basis for informed policy discussions and governance recommendations in cyber risk management.

2. Impact of cyber attacks on digital society and economy

The COVID-19 pandemic has prompted many business entities, primarily from the public and private sectors, to adopt a hybrid business environment that incorporates remote work. Initially, it had a positive impact on both the human capital of companies and their economic and financial results. However, it has also caused an exponential increase in risks due to the use of unsecured devices and applications based on Cloud directories for data transfer (Rahman & Islam, 2022), thereby expanding the exposure of companies to potential attacks, while at the same time, cybercriminal actors are taking advantage of this established dependence of individuals and legal entities on digital technologies (Cook et al., 2023).

Table 1. Regional distribution of the cost impact of cyberattacks.
Source: Authors calculation based on data (Sviatun, et al., 2021).

Area / Region	Regional GDP (in trill. $)	Costs of cyberattacks (in bill. $)	Losses caused by cyber attacks (in % of GDP)
North America	20.2	140-175	0.69-0.87
Europe & Central Asia	20.3	160-180	0.79-0.89
East Asia and the Pacific	22.5	120-200	0.53-0.89
South Asia	2.9	7-15	0.24-0.52
Latin America and the Caribbean	5.3	15-30	0.28-0.57
Sub-Saharan Africa	1.5	1-3	0.07-0.20
Middle East and North Africa	3.1	2-5	0.06-0.16
Global	75.8	445-608	0.59-0.80

A territorial diversification of the impact of costs and losses from cyber incidents and attacks has been identified, which we see in the results of the authors' empirical research (Sviatun et al., 2021) that the highest loss rate as a percentage of GDP is determined in Europe and Central Asia, North America and East Asia and the Pacific, and countries from these regions are characterised by high income and income rates, more advanced technological infrastructure, a high degree of urbanisation, education, and business digitalisation (Tariq, 2018).

Globally, the impact of cyberattacks on the world economy is significant (Schwarz et al., 2021), as this sophisticated social phenomenon is rooted in deep and comprehensive geographical and socioeconomic causes (Chen et al., 2023). Cyber threats also impact an organisation's revenue, reducing it through lost sales, contracts, market share, additional funding, or licenses. In a business context, these typically include marketing and commercial aspects related to sales. However, we also consider that some revenue may not necessarily have such an origin, for example, in public and non-profit organisations (Couce-Vieira et al., 2020).

A cyber incident that disrupts the functioning of vital service segments of critical infrastructure can cause widespread chaos, endanger lives, and cause long-term socioeconomic damage to the economy. While the security of digital components in critical infrastructure serving essential services is crucial to maintaining resilience, the combination of digital capabilities and physical components introduces new potential risks arising from the combined effect of digital vulnerabilities and the complexity of the physical world (International Chamber of Commerce, 2024).

3. Vector modalities and attack classification

The digital age has given rise to a wide range of cybersecurity threats that exploit vulnerabilities in technology, processes, and human behaviour (Thakur, 2024). Ransomware, malware, and distributed denial-of-service (DDoS) attacks are examples of evolving cyberattack methods (Cremer et al., 2022).

Of the above vector modalities, ransomware attacks are classified as a distinct form of high-tech crime experiencing the highest growth rate for years. According to research by Putnik et al. (2022), estimates indicate that every 11 seconds, one legal entity becomes a victim of a ransomware attack. Unlike viruses that attach to trusted files or applications and damage or destroy them when launched, worms are a type of malicious software that spreads without user interaction, causing network congestion, computer system slowdowns, or disruptions in basic operating processes (Thakur, 2024), the evolution of ransomware through improvements in the use of encryption and attack vectors, developed attack monetisation modalities, and financial flows through digital payment currencies, which provide discretion of the identity of the contracting party in repayments, defines it as the prevailing malware today (August, et al., 2019). Since this attack modality is based on extortion, it infects a computer system. Furthermore, it prevents access to files, data, and other confidential information, as well as access to the entire system.

Initially, they implied human interaction, however, looking at the genesis of development, today it is not necessary for the initial infection and its spread through a computer system, where it is characterised by the characteristics of a worm malware, which moves from the infected to unprotected systems in the same computer network without interaction and additional participation of the attacker (August, et al., 2022). Today, ransomware, the fastest-growing and most complex type of cyberattack, does not require technical knowledge and has a broad scope of action, providing anonymity to the attacker. As a result, it poses a serious risk to global economic flows (Chin, 2024).

The relentless evolution of malicious software poses a significant challenge to cybersecurity, with ransomware emerging as a ubiquitous and destructive threat (Krivokapić et al., 2023). Malware, designed to disrupt electronic devices, constantly evolves, hampering efforts to mitigate its impact. The lack of public disclosure regarding malware attacks, driven by concerns about sensitive information and potential reputational damage, hinders collaborative prevention efforts and makes comprehensive research difficult (Muniandy et al., 2024).

Its attack cycle includes exploitation, infection, delivery, execution, backup manipulation, file encryption, user notification, and cleanup (Muniandy et al., 2024). New techniques have increased the profitability of attacks and the likelihood of success. This includes targeting high-value business entities and ransomware as a service (Gulyas & Kiss, 2023), where ransomware criminals sell customised software packages to the user (The Financial Action Task Force, 2023).

Ransomware as a Service (RaaS) refers to a criminal business model in which ransomware criminals provide ransomware software kits on the Dark Web or engage in elements of a ransomware attack, including malware distribution, initial compromise of the victim's network, data exfiltration, or ransom negotiations for affiliates in exchange for a fee and/or a percentage. Criminals may also purchase stolen credentials to access and exploit victim systems, enabling ransomware distribution, and may obtain intelligence on specific industries in specific jurisdictions to inform their targeting and maximise the effectiveness of their attack (The Financial Action Task Force, 2023). The RaaS model has reduced the cost and technical expertise required to conduct ransomware attacks, thereby lowering the barriers to entry and enabling less sophisticated criminals to engage in such activities.

As one case study in this research, ransomware is an economically destructive phenomenon that leads to real-world security consequences that often exceed the costs of paying the ransom. In addition to the loss of revenue that an organisation may suffer, other costs may be obvious, some may not. The more obvious costs include paying the ransom (if paid), remediation of the incident, new hardware, software, and incident response services, insurance deductibles, legal fees and litigation, and public relations (Seng et al., 2024).

Financially motivated ransomware attacks utilise vectors such as email, spam, and phishing, making tracking difficult due to the use of virtual currencies like Bitcoin to pay ransoms. Several notable ransomware variants, including: BadRabbit, BitPaymer, Cerber, Cryptolocker, Dharma, DoppelPaymer, GandCrab, Locky, Maze, MeduzaLocker, NetWalker, NotPetya, Petya, REvil, Ryuk, SamSam, and WannaCry, have contributed to this evolving threat landscape (Muniandy et al., 2024), some of which are sampled for analysis in this study.

4. Classification of ransomware costs and expenses

A comprehensive approach to the economic aspects of cybersecurity must include a thorough consideration of the direct and indirect costs of cybersecurity measures, as pointed out by researchers (Lis & Mendel, 2019), and the expected damage caused by cyberattacks, especially the type of ransomware attacks studied in the cyberspace of the digital economy. Financial motives for cyber incidents and attacks are the dominant motive in their analysis, accounting for 74% of detected cyber incidents globally and 80% in high-income countries, according to Cobos (2024). In contrast, only 41% of detected incidents in developing countries were primarily financially driven.

By differentiating costs in accounting, a clear division has been formed into direct and indirect costs arising from a cyber attack (Cashell et al., 2004). In this case, direct costs include returning the entire computer system to its original state before the cyber incident, which include additional expenditures on labor and materials but also depend on increased resource expenditures on cybersecurity (software or hardware upgrades).

Direct cost is the monetary equivalent of losses, damage, or other suffering experienced by an individual victim as a result of a cyberattack, which includes the loss of monetary value and related inconvenience (Wang et al., 2019). When accounting for and treating investment costs in cybersecurity, it is necessary to consider, according to Kunzler (2023), the investment matrix that balances the potential costs of a cyber attack, its associated risks, and the costs of security measures. Then there are the costs arising from the interruption of the entity's operational business, which include lost revenue from the sale of goods, works and services, as well as the loss of productivity, which, under the influence of the domino factor, spreads to customers (Fotis, 2024) but also suppliers (Jimmy, 2024), as well as to the entire organisation (Onuka et al., 2023).

Indirect costs include the type of costs that tend to increase after a cyberattack and immediately after the initial damage to the business entity is repaired, and arise from loss of reputation, damage to the brand, loss of customers, insurance costs and premiums (ThankGod, 2024), litigation and tax costs, economic damage to the parent entity's subsidiaries, higher investments in cybersecurity for preventive response and opportunity costs of budget resource allocation. They are mainly associated with the economic concept of negative externalities on third parties (Lis & Mendel, 2019). Therefore, indirect costs are characterised by a predominantly intangible nature (Wang et al., 2019), and their consequences are multiple because they affect different aspects of the business, consumers and the broader economy (Cobos et al., 2024).

Table 2. Typology of the most significant direct and indirect losses and costs caused by ransomware attacks.

Direct losses	Indirect losses
Payment of the ransom	Recovery process which includes investigation costs, verification costs for checking the system (diagnostics and remediation) and restoration costs to restory the system to the network (testing)
Data breach	Loss of data as an operating loss caused by business interruption
Other claims for liability for losses suffered by third parties	Loss of customers and business clients
The market value or replacement value of the property or servicies destroyed	Loss of reputation

The critical distinction between the direct and indirect costs of ransomware attacks lies in the exponential growth potential of indirect losses arising from them, compared to the finite limit of direct losses. This dynamic represents a disproportionate burden on society (Cobos, 2024) and has far-reaching consequences for the digital economy, which spills over into the real physical economic sector and business.

5. Analysis and financial assessment of the consequences

The analysis reveals that cybersecurity is a multidimensional, heterogeneous, and dynamic challenge among countries, which may face different optimisation problems depending on their threat environment (Cobos, 2024). It encompasses economic, political, social, digital, and technical-technological aspects. The distribution and proliferation of detected cyber incidents by income and geographical regions are complex and influenced by several interrelated factors, such as economic prosperity, political stability, cybersecurity capacity, and geopolitical tensions (Cobos et al., 2024).

Investing in security technologies represents a capital expenditure. However, as Lee (2021) states, the optimal investment comes at the point where the marginal increase in the price of a cyber investment is equal to the marginal reduction in the financial loss from a cyber attack. Analysing the subject sample through case studies, it was found that the implementation of robust cybersecurity measures effectively reduced the occurrence of financial data breaches. Through comprehensive encryption protocols and multi-factor authentication, organisations were able to improve the security of sensitive financial information (Grace, 2023).

Based on available data, the median reported direct loss and damage to a company from all cyber incidents was around $0.4 million, with three-quarters of reported losses below $2.8 million (International Monetary Fund, 2024). However, the distribution is highly skewed, with some incidents incurring losses of hundreds of millions of US dollars and accumulating financial damage of several billion dollars. Such extreme losses can lead to liquidity problems for business entities and even threaten their solvency.

Ransomware can cause significant negative consequences for the victim, including non-recovery and recoverable costs. The various types of damages that can occur include financial losses, such as ransom payments and the recovery process, operational losses caused by business interruption, and data loss resulting from data breaches, which will be discussed in detail below. However, ransomware can also affect third parties, giving rise to liability claims for losses suffered by these parties, including loss of customers and reputational damage (Krivokapić et al., 2023).

Econometric analysis suggests that digitalization and geopolitical tensions significantly increase the risk of cyber incidents (International Monetary Fund, 2024). Based on an extensive survey of available data from previous empirical research, literature, news articles, and official databases of international institutions reporting on cyber attacks, the analysis identified the factors of financial damage, expenditures, and costs caused by ransomware attacks in a sample of 16 case studies over the period 2015 to 2025.

Table 3 outlines the direct and indirect financial damages linked to sixteen major ransomware incidents reported between 2015 and 2025. Direct losses range from moderate figures—such as $1.87 million in the Technion University case—to extreme levels, including the $10 billion damages reported in the MOVEit and NotPetya attacks. While direct costs are often substantial, indirect losses carry even more profound implications. These include legal fees, regulatory fines, system recovery expenses, and long-term disruptions to business continuity. Particularly severe financial impacts were observed in cases involving critical infrastructure and healthcare systems. Overall, the findings underscore the disproportionate growth of indirect costs relative to direct ones, highlighting the potential of ransomware to trigger systemic economic instability.

Table 3. Analysis of financial damage, expences and costs of ransomware attacks in period 2015-2025 business year. Source: authors calculation and research.

No.		1	2	3	4	5	6	7	8
Case study		Cryptolocker (2015)	SamSam Ransomware (2016-2018)	Locky Ransomware (2016-2018)	Malicious program code "NotPetya" (2017)	Ransomware attack „WannaCry" (2017)	Ryuk Ransomware (2018–present)	DoppelPaymer Ransomware (2019-present)	Company "Enel Group" (2020)
Financial damage, expences and costs	**Direct**	$18 million	$6 million	$1 billion	$10 billion	$4 billion	$150 million	$43,27 million	$14 million
	Indirect	Costs for remediation of damage to computer systems and restoration of operational processes, loss of production, loss of reputation	$30 million	Costs caused by the loss of important data can result in significant disruptions to the functioning of organisations. Loss of productivity where business entities were forced to invest large amounts in the recovery of the system, which led to exponential growth in operating expenses	Losses due to production disruptions, delivery delays, and additional costs for recovery and investments in cybersecurity	Millions of dollars in losses due to impact on key services and organisations	Loss of data, downtime, loss of reputation	Loss of data, reputational damage, disrupted operation of organisations	$84.02 million (data recovery expenses, legal fees, and disclosure fees - company GDPR compliance penalties)
No.		9	10	11	12	13	14	15	16
Case study		Company "Garmin" (2020)	Company „Kaseya Inc." (2021)	Company „Colonial Pipeline" (2021)	Republic of Costa Rica (2022)	Data Transfer Software "MOVEit" (2023)	University and Research Institute "Technion" (2023)	Company „Change Healthcare Inc." (2024)	Company "Southern Water" (2025)
Financial damage, expences and costs	**Direct**	$10 million	$70 million	$4,4 million	$1.66 billion (2.4% of the country's GDP)	$10 billion	$1.87 million (80 bitcoin - BTC)	$22 million	$5,7 million
	Indirect	$15.2 million in damages and further costs of service interruptions, loss of revenue from disabled apps and services, legal costs, class action lawsuit	Loss of revenue due to service interruptions, legal costs and capital expenditures for system restoration	Estimated losses of over $420 million per day. Costs due to downtime in operations include loss of revenue, breach of contractual obligations, and increased operating costs resulting from system restoration and crisis management.	Increased costs for repairs and restoration of the system. Negative impact on import/export logistics.	Multiplier factor of ongoing costs (operating costs due to business downtime, legal costs and damages to affected users)	Postponement of exams, blocking networks, temporary loss of access to data, blocking of the website. Loss of reputation and trust in academic institutions.	$8.87 billion ($2.87 billion - response costs and $6 billion - assistance to health care providers, as well as litigation costs)	Costs for system recovery, loss of confidence in security, increased costs on technological improvements

Table 4 broadens the focus by categorising each incident's economic and social outcomes. A consistent pattern emerges: essential services—such as healthcare, transportation, education, and public administration—are frequently disrupted. These service interruptions are often accompanied by public distrust, reputational setbacks, and heightened psychological stress. In critical cases, such as

WannaCry and the Colonial Pipeline incident, the consequences escalated into public safety concerns, prompting governmental intervention and emergency actions. This division between economic and social impacts further highlights the multifaceted nature of ransomware, which resembles disaster events in its capacity to disrupt digital infrastructures and societal stability.

Table 4. Analysis of economic and social consequences of ransomware attacks in period 2015-2025 business year. Source: Authors calculation and research.

No.		1	2	3	4	5	6	7	8
Case study		Cryptolocker (2015)	SamSam Ransomware (2016-2018)	Locky Ransomware (2016-2018)	Malicious program code "NotPetya" (2017)	Ransomware attack „WannaCry" (2017)	Ryuk Ransomware (2018–present)	DoppelPaymer Ransomware (2019-present)	Company "Enel Group" (2020)
Consequences	Economic	Huge drop in production, interruption in operations, long-term consequences on business productivity	Significant disruptions in work processes, increased recovery costs, loss of efficiency	Increased recovery costs, loss of trust in IT security, large technological investments for recovery	Significant losses have been reported in global companies such as Maersk, FedEx, and Merck, among others. Disruption in the transport and logistics sector. Increase in the price of goods that did not arrive on time.	The enormous damage to large corporations, particularly in industries such as healthcare and logistics, has a significant economic impact on a global scale.	Major business interruptions, disruption of public services (especially in health care and municipalities)	Significant recovery costs, loss of trust in IT security, high costs of legal and security services	Huge financial costs on restoring the system and recovering from attacks
	Social	Loss of personal data, stress for individuals, erosion of trust in data security	Deterioration of public confidence in the safety of infrastructure, stress for citizens	Erosion of user and patient trust, stress for employees, data privacy risks	Increased distrust in public and private financial institutions, a decrease in spending, and a negative impact on confidence in the health sector, as vaccine production was interrupted.	Disruptions to public services, especially in health care facilities, cancellations of 19,000 medical appointments, loss of life in some cases, negative impact on the business of NHS, FedEx, Telefónica, and others	Deterioration of public trust in data and infrastructure security, stress for workers and citizens	Potential loss of life (in the case of the Düsseldorf hospital), violation of public trust, stress for employees	Potential loss of customer trust, impact on reputation and data security

No.		**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Case study		**Company "Garmin" (2020)**	**Company „Kaseya Inc." (2021)**	**Company „Colonial Pipeline" (2021)**	**Republic of Costa Rica (2022)**	**Data Transfer Software "MOVEit" (2023)**	University and Research Institute "Technion" (2023)	Company „Change Healthcare Inc." (2024)	Company "Southern Water" (2025)
Consequences	Economic	Increased risk of future attacks, reputational damage, system restoration costs, and legal costs	Disruption of many companies, increased renewal costs, legal processes, decline in trust in the IT sector	Fuel outages were reported across the U.S. Southeast, especially in states such as Georgia, North Carolina, and Virginia. People panicked and rushed to buy fuel, which led to shortages at the supply stations.	Disruptions in fiscal and tax systems, non-payment of salaries to employees, paralysis of public services.	Global revenue losses for affected firms and organisations, loss of competition in specific sectors	Disruptions to the university's work, including the postponement of important academic activities such as exams, affect students and the academic calendar. Potential risk to research and sensitive data in the field of cybersecurity.	Severe disruptions in the processing of medical claims and payments, significant disruptions in the healthcare industry	Loss of data, interruption in water supply, damage to reputation

Consequences	Social	Loss of customer trust, possible negative impact on corporate reputation and future sales
		Difficulties for small and large companies, reducing trust in the security of digital platforms
		Gas stations have been closed, fuel prices have risen, and transportation, including air travel, has been disrupted. Citizens and public services have been affected by fuel shortages. Social tensions due to shortages.
		There is a growing concern among citizens about disrupted government services and an increased fear of compromised sensitive data. The impact on the public sector and the living standards of citizens who depend on state services, as well as the increased burden on public services.
		65 million users harmed, privacy violations, personal and corporate data compromised
		Loss of confidence in the security of academic institutions, disruptions in student activities. Public pressure on the university and the government to respond to the attacks.
		Data exposure of 190 million people, massive legal proceedings, patient trust significantly damaged
		Potential disruption of services for citizens, increased stress for employees

Table 5 details the attack vectors and techniques used across the analyzed cases, revealing a clear progression in complexity. Early methods, such as phishing emails and malware attachments (e.g., CryptoLocker, Locky), have evolved into advanced, multi-vector attacks employing zero-day exploits, supply chain breaches, and ransomware-as-a-service models. Tactics now often include automation, stolen credentials, and lateral movement within networks, reflecting a trend toward more scalable and professionalised cybercrime. Encrypted communications and anonymous payment systems—most notably cryptocurrency wallets—continue to hinder attribution and response. This evolution supports the interpretation of ransomware as more than just a criminal act, positioning it as a form of digital disaster within contemporary risk governance frameworks.

Table 5. Analysis of vector metodology of ransomware attacks in period 2015-2025 business year. Source: Authors calculation and research.

No.	1	2	3	4	5	6	7	8
Case study	Cryptolocker (2015)	SamSam Ransomware (2016-2018)	Locky Ransomware (2016-2018)	Malicious program code "NotPetya" (2017)	Ransomware attack „WannaCry" (2017)	Ryuk Ransomware (2018–present)	DoppelPaymer Ransomware (2019-present)	Company "Enel Group" (2020)
Vector methodology of cyber attack and incident	Phishing emails, malicious attachments, data encryption, and ransom demand	Manual delivery, attacks on JBoss servers, abuse of RDP and VPN vulnerabilities, privilege escalation, subsequent data encryption	Phishing attacks utilise malicious Word documents to trigger macros, resulting in ransomware downloads. Once activated, Locky encrypts a wide range of data types, including data on network components. It used a combination of RSA and AES encryption, making the data inaccessible without a decryption key that could only be obtained by paying the ransom.	An attack through compromised Legitimate Software Updates (M.E.Doc). The malware spread like a worm, disguised as ransomware, but the goal was to cause destruction, not extort money.	The attack exploited a security vulnerability in Microsoft Windows operating systems (EternalBlue exploit)	An attack that begins with a compromise of a network (usually via TrickBot), delivered manually, involving network mapping and data exfiltration before launching the attack.	Sfir -phishing attacks, exploitation of out-of-date vulnerabilities, network mapping, privilege escalation, fast encryption of offline data	Attack via Netwalker and Snake ransomware, encrypting data within the company

No.	9	10	11	12	13	14	15	16
Case study	**Company "Garmin" (2020)**	**Company „Kaseya Inc." (2021)**	**Company „Colonial Pipeline" (2021)**	**Republic of Costa Rica (2022)**	**Data Transfer Software "MOVEit" (2023)**	**University and Research Institute "Technion" (2023)**	**Company „Change Healthcare Inc." (2024)**	**Company "Southern Water" (2025)**
Vector methodology of cyber attack and incident	The attack utilised WastedLocker, which was developed by the notorious group Evil Corp. Systems were encrypted, and services such as Garmin Connect, flyGarmin, Strava, and inReach were rendered inaccessible. The attackers demanded $10 million to decrypt the data.	The attack was carried out through Kaseya V.S.A. software, which allowed malware to be inserted, encrypting data on more than 1,000 systems. The attackers demanded a ransom of $70 million in Bitcoin.	The attackers, who were members of the hacker group Darkside, gained access through an employee's VPN account and applied data encryption software.	The attackers used ransomware to coordinate attacks on multiple government agencies (Ministry of Finance, Ministry of Education, Social Security Fund).	Ransomware group "Clop" exploited a zero vulnerability in "MOVEit" software	The attackers used the software DarkBit, which targets Windows operating systems. They added the "Darkbit" to the "AES-256" encryption to encrypt data.	Citrix portal without multi-factor authentication, data exfiltration, file encryption	Attack through Black Basta ransomware, use of phishing attacks or vulnerabilities in the network

6. Discussion

The evidence presented in this paper reinforces the classification of ransomware as a high-impact, cross-border threat that mirrors large-scale disruptive events typically categorized as disasters. Its spread through digital infrastructure, exploitation of systemic weaknesses, and far-reaching secondary effects—particularly on public trust, service continuity, and social stability—position ransomware within the broader category of complex socio-technical risks requiring coordinated, multisectoral responses (Andersen, 2025; Axon et al., 2023; Connolly & Wall, 2019; Moussaileb, Cuppens-Boulahia, Lanet, & Bouder, 2021; Nagar, 2024; Robles-Carrillo & García-Teodoro, 2022; Singh & Sittig, 2016; Sudheer, 2024; Wilner et al., 2019; Yuste & Pastrana, 2021).

Notably, the concentration of indirect and intangible costs in essential sectors like healthcare, utilities, and government services reveals a significant policy gap: the absence of adaptive cyber resilience frameworks tailored to critical infrastructure (Cvetković, 2013; Cvetković & Kezunović, 2021; Cvetković, 2024b; Hromada & Lukas, 2012; Koliou, van de Lindt, Ellingwood, Dillard, Cutler, & McAllister, 2018; Mijalković & Cvetković, 2013; Vidović, Cvetković, & Beriša, 2024). This issue is especially pressing in transition and lower-capacity economies, where digital advancement often outpaces the development of effective risk management systems. The proliferation of ransomware-as-a-service (RaaS) further enlarges the threat landscape, increasing the volume of attacks and diversifying their targets—strengthening the case for framing ransomware as an evolving disaster phenomenon.

Over the last decade, an exponential growth in ransomware strains and changes in the malware market have been identified, which implicitly affect the challenges, risks, and threats to the barriers that prevent large-scale cyber attacks (August et al., 2019). A comprehensive analysis of empirical evidence and data has produced a systematic overview in Tables 3, 4 and 5 of this paper. The period from 2015 to 2019 was identified in the analysis as an early stage of gradual but exponential growth in cybercrime, including ransomware attacks, which resulted in significant losses and financial damage, primarily comprising direct and indirect costs that were unpredictable per attack. The most significant case studies were found to be the "Locky", "NotPetya" malware and "WannaCry" ransomware attacks. Then, from the end of 2019, the crisis caused by the coronavirus pandemic occurred, which in 2020 was a catalyst for the development and vector distribution of ransomware attacks through a rapid degree of digitalisation and the establishment of a hybrid business model, primarily on critical infrastructure as a vital interest of every state, through the health sector, the financial sector and the energy sector.

Collectively, the findings from Tables 3, 4, and 5 strengthen the framing of ransomware as a form of digital disaster. These incidents share key characteristics with traditional disasters—unpredictability, large-scale disruption, cascading impacts, and significant financial and human costs. The comparative analysis highlights that attacks targeting healthcare and government sectors often result in the highest indirect losses and the most profound societal consequences. This underscores the need for cyber resilience efforts to prioritize sectors that are both highly dependent upon and vulnerable to digital infrastructure. Additionally, the evolution of attack methods underscores the need for ongoing adaptation in technical defences and organisational risk management strategies.

By establishing continuous monitoring of threats arising from ransomware attacks, it was found that in 2021, there were record ransom payments for ransomware attacks ($1.1 billion), indicating the growth of cybercrime and the characteristic of greater profitability of cyberattacks on the digital economy. In 2022, the number of reported cyberattacks continued to grow, and the financial damages were significant - indicating increased incidents and a growing, primarily negative impact on the economy. Total global losses from cyberattacks in 2023 exceeded $12.5 billion, representing a 22% increase from the previous year. Ransomware attacks were among the most significant. In the first half of 2024, payments to victims of ransomware attacks totalled $460 million, representing a 2% increase compared to the same period in 2023. Projections indicate a continued growth trend in cyberattacks, of which ransomware attacks are the type with the most significant impact on the digital economy, resulting in devastating socio-economic consequences for the economy and population, and above all, for critical infrastructure.

From a governance standpoint, these findings underscore the urgent need for integrated risk management strategies that extend beyond technical enhancements. Governments should incorporate cyber-disaster scenarios into national emergency planning, mandate cyber incident reporting, and incentivize investments in cyber hygiene—particularly within the public sector. The response must extend beyond infrastructure security for private-sector organisations, particularly in finance, healthcare, and energy. It should also enhance organisational resilience through staff training, redundancy protocols, robust data recovery plans, and insurance coverage that reflects contemporary digital risks. Public-private partnerships and shared platforms for threat intelligence are key to managing sectoral interdependencies.

At the international level, the extraterritorial nature of ransomware necessitates deeper collaboration on attribution, enforcement, cryptocurrency oversight, and intelligence sharing. Ultimately, future research should prioritise the development of quantitative models that capture both direct and indirect costs, as well as scenario-based simulations to assess sector-specific preparedness. Longitudinal studies tracking recovery trajectories post-attack could further enrich the understanding of institutional resilience, complementing the cross-sectional insights provided in this study.

7. Conclusion

This paper has shown that ransomware should no longer be viewed solely as a cybersecurity challenge, but as a complex and evolving disaster risk with far-reaching consequences for economic stability, institutional resilience, and public trust. Drawing on sixteen high-impact case studies, the research presents a typology of financial losses and systemic disruptions, highlighting the disproportionate impact on critical infrastructure and the compounding nature of indirect costs. By framing ransomware as a form of digital disaster, the study contributes to a more integrated approach to cyber risk within the broader context of disaster risk governance and resilience planning.

The findings point to several practical implications, calling for coordinated but context-specific action from key stakeholders: a) governments should incorporate ransomware preparedness into national risk strategies, encourage transparent incident reporting, and provide fiscal incentives for cybersecurity investments; b) private-sector entities need to implement zero-trust architectures, develop insurance solutions tailored to cyber threats, and enhance organisational resilience that extends beyond technical safeguards; c) at the international level, institutions must advance cross-bor-

der collaboration—particularly in regulating virtual assets, supporting joint law enforcement efforts, and setting global standards for cyber disaster response.

The financial impact of cybercrime has reached staggering proportions, with projections indicating an alarming upward trend. An unfortunate aspect of today's online society affects businesses of all sizes. The global scale of financial flows associated with ransomware attacks has grown dramatically in recent years. New techniques have increased the profitability of attacks and the likelihood of success. These include targeting large, high-value entities and ransomware-as-a-service (RaaS), where ransomware criminals sell customised software kits to affiliates. The consequences of a ransomware attack can be dire, posing significant national security threats that include damage and disruption to critical infrastructure and services. A ransomware attack is a form of extortion, and FATF standards require it to be criminalised as a predicate offence for money laundering (The Financial Action Task Force, 2023). Ransomware criminals exploit the international nature of virtual assets to facilitate large, near-instantaneous cross-border transactions, sometimes without the involvement of traditional financial institutions that have programs in place to prevent money laundering and terrorist financing.

Ransomware attacks are on the rise globally, and any business or organisation can be a target of these attacks, which require additional attention and preparation in terms of business cybersecurity and the complete protection of the digital economy. As Krivokapić et al. (2023) point out, it is crucial that all relevant institutions, including financial institutions, are informed about the ransomware attack and the ransom payment. This is important because it provides sufficient evidence for possible legal proceedings or cancellation of ransom payments. Additionally, business entities should invest in insurance policies that include cybersecurity coverage, as standard commercial policies often do not provide sufficient protection against cyberattacks. These insurance policies help cover the costs arising from attacks, such as ransomware (Cobos et al., 2024). Since states cannot always effectively protect themselves from cyber attacks, it is recommended that they encourage investment in cybersecurity. This can be supported by introducing tax breaks and double deductions for costs related to cybersecurity.

The first recommendation is to continue investing in workforce education and training, enabling individuals to identify threats and respond effectively (World Economic Forum, 2025). Then, it is necessary to adopt a zero-trust approach, which minimizes the risk of attacks by treating all requests as potentially malicious. It is also crucial to enhance incident response plans to respond promptly to cyberattacks and mitigate their impact. Advanced technologies, such as artificial intelligence and automation, should be used to improve threat detection and predictive analytics, but with caution against attacks launched by artificial intelligence (Thakur, 2024). Collaboration and information sharing among members of the cybersecurity community are also key to strengthening defences. Data protection and privacy should be a top priority, alongside regulatory compliance and transparent communication. Finally, it is essential to regularly assess and update security to identify new vulnerabilities and adapt defences to emerging threats, as cybersecurity is an ongoing process that requires a proactive approach, collaboration, and the integration of modern technologies to successfully confront evolving threats.

This study has limitations. The analysis relies on publicly available data, which may exclude undisclosed or underreported incidents. Future research should focus on analysing longitudinal data, identifying sector-specific vulnerabilities, and modelling recovery trajectories following major ransomware events. In closing, confronting the ransomware threat demands more than just technological fixes. It requires a fundamental shift in how digital risk is conceptualised, governed, and financed. Without integrated, adaptive, and inclusive strategies, ransomware may become one of this century's defining disaster threats.

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Article

Assessing Agricultural Vulnerability to Climate Change: A Study on Flood-Induced Loss and Damage in Rajapur, Bardiya, Nepal

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ABSTRACT

More frequent and severe extreme climate events have caused both economic and non-economic losses to local communities in disaster-prone areas due to climate change. This study examines the economic loss and damage to agriculture caused by an unseasonal flood in October 2021 in Rajapur Municipality, located along the Karnali River. The lower Karnali basin is highly prone to flooding, and Rajapur, situated between two arms of the river, has a long history of such events. Using household surveys, focus group discussions (FGDs), key informant interviews (KIIs), and secondary literature, the study assessed flood-related losses among small, medium, and large farmers based on key indicators from the Building Information Platform Against Disaster (BIPAD), including agricultural land, paddy production, stored grains, livestock, and farm machinery. The October 2021 flood, which occurred just before harvest, caused significant economic losses. Small farmers incurred a loss of $21,709.77, medium farmers faced a loss of $50,225.24, and large farmers experienced a loss of $32,393.49, resulting in a total production loss of $104,328.10. Small and medium farmers suffered greater impacts on their livelihoods, income, and food security than large farmers. Coping mechanisms included purchasing rice, consuming wheat instead of rice, taking loans, working as labourers, abandoning education, and cultivating spring-season rice. While adaptation measures, such as early warning systems and embankments, have helped prevent human casualties, mitigating agricultural losses remains a challenge as floodwaters continue to devastate farmlands, underscoring the need for improved flood management strategies to safeguard agricultural productivity and rural livelihoods.

KEYWORDS

Climate change; flood damage; agricultural loss; economic loss; coping mechanisms; adaptation strategies.

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1. Introduction

The sixth assessment report by the Intergovernmental Panel on Climate Change (IPCC) concludes that humans have altered the climate system, and its impact on ecosystems, lives, and livelihoods is inevitable (IPCC, 2021). The climate-induced loss (irreversible change) and damage (repairable, recoverable impact), both economic and non-economic (such as loss of culture, identity, ecosystem services, and biodiversity), will continue to rise (Oxfam, 2022). Floods are one of the most prevalent disasters, posing a significant threat to millions of people worldwide. They are defined as the overflow of a stream or other body of water beyond its usual boundaries or the buildup of water in areas that are typically dry (Oates, 2007). The frequency of floods is increasing, resulting in massive losses of lives, livelihoods, agriculture, infrastructure, public services, and property, with the scale of damage also growing each year (Tripathi, 2015).

The Loss and Damage (L&D) discourse began in 1991 within the global climate change negotiations, when the Alliance of Small Island States (AOSIS) proposed an international insurance pool to compensate for irrecoverable losses resulting from sea level rise that exceeded physical and social adaptation limits (INC, 1991). Loss and damage cover both sudden catastrophes, such as floods and cyclones, and gradual phenomena, like sea-level rise and glacial retreats (UNFCCC, 2013). Flood is the second most impactful disaster in terms of their impact on agriculture after drought. It has resulted in a loss of USD 21 billion in Least Developed Countries (LDCs) and Low-Middle-Income countries (LMICs) from 2008 to 2018. Climate factors, such as temperature rise, glacier melting, extreme precipitation, and sea level rise, as well as anthropogenic factors like development projects, land-use and land-cover changes, and river encroachment, have also contributed to flooding events (Huggel, 2020; Bronstert, 2003; UNEP, 2020).

According to the World Bank's Climate Change Group, flooding is not only the most common disaster but also the one with the most significant financial and humanitarian impact in terms of the number of people affected and financial asset exposure. Approximately 1.46 billion people worldwide are directly exposed to flood hazards, with about 1.37 billion residing in South and East Asia (Rentschler & Salhab, 2020). Extreme climate events have threatened the global food security. Worldwide extreme events, such as the flooding in the U.S. in 2019, the 2010 Pakistan floods, and the 2017 South Asian floods, have had negative impacts on crop production (Shirzaei et al., 2021). South Asia is home to major rivers, including the Brahmaputra and Ganges, which are located in the Hindu Kush Himalayan region. In the rainfed lowlands of South and Southeast Asia, flash floods completely submerge plants for 10–15 days, which reduces rice production (Septiningsih et al., 2009).

Nepal is considered one of the global hot spots for climatic disasters. In the top twenty poorest countries, Nepal ranks fourth and thirteenth in terms of climate change impacts and flood risk, respectively (Oxfam, 2023). Floods are one of the most devastating events in Nepal, accounting for 7,599 deaths and costing billions of dollars between 1954 and 2018. (EMDAT 2019). Climate change significantly impacts rain-fed agriculture and the livelihoods of subsistence farmers, directly affecting food production. The Terai region is severely affected by climate change, including droughts, floods, and landslides (Huggel, 2020). In Nepal, the concept of loss and damage is relatively new in the context of climate change policy. Only a few references have been made in legal and policy documents, where more emphasis is given to research and studies to enhance knowledge of climate-induced loss and damage. However, this has failed to provide a clear understanding of adaptation and loss and damage (Practical Action, 2021). A report published by the Ministry of Forest and Environment in 2018 describes Nepal's vulnerability to climate change and disasters (MoFE, 2021).

Nepal ranks 10th in the Long-Term Climate Risk Index (CRI), which identifies the 10 countries most affected from 2000 to 2019 (Eckstein & Kreft, 2021). Furthermore, 50 out of 77 districts are vulnerable to the effects of climate change (Ministry of Finance and Economics, 2021). The research domain by Aryal and his colleagues in 2019 mapped hazard and assessed risk areas on both the east and west banks of the Karnali River that are vulnerable to flooding for different returns year

periods. They found that flood erosion of agricultural land poses a threat to food security and has a direct impact on the livelihoods of people (Aryal et al., 2020). In 2017, flood losses in the agricultural sector were valued at around USD 69.5 million, whereas recovery needs were estimated at USD 61.6 million (NPC, 2017). Rajapur municipality and Geruwa rural municipality in the Bardiya district have been designated as rice super zones by the Prime Minister's Agriculture Modernisation Project (PMAMP) (PMAMP, 2022) due to their high agricultural productivity. The people of this area are heavily reliant on agriculture, which is the primary source of their livelihood. Frequent flooding can have a profoundly detrimental impact on agricultural production, compromising food security. Rajapur Municipality, situated in the Bardiya district of Lumbini Province, is located in a low-lying region of Karnali and has a long history of flooding (DWIDP, 2014). Karnali River's annual overflow has had both economic and non-economic impacts on the livelihood of people in the Karnali basin. The unprecedented rainfall in October 2021 affected thousands of farmers, resulting in loss and damage to agricultural production, as well as to their lives and livelihoods.

This study was conducted to assess the loss and damage to crops caused by the 2021 flood, which resulted from unprecedented rainfall, and to explore the coping mechanisms employed by farmers in dealing with agricultural loss and damage. For the study, wards 1, 3, 4, and 7, located alongside the Karnali River branch, were selected based on their exposure to and severity of flood impacts in previous years (Rajapur Municipality, 2021; Practical Action, 2021). This study aims to estimate the loss and damage incurred by three different types of farmers in the Rajapur area, namely small, medium, and large holders, with landholdings of 0.038 ha, 2.28 ha, and above 2.28 ha, respectively. This study aims to fill the gap in assessing the loss and damage to crops caused by unseasonal flooding events.

2. Materials and methods

2.1. Study site

The research was conducted in Rajapur Municipality, situated in Bardiya District, Lumbini Province, Nepal. The Municipality is located between two flood-prone branches of the Karnali River, which originates on the Tibetan Plateau, traverses through Nepal, and ultimately merges with the Ganges in India. Rajapur shares its eastern boundary with Geruwa Rural Municipality, its western boundary with both Kailali District and Geruwa Rural Municipality, and borders the Indian State of Uttar Pradesh to the south. The Municipality spans a latitude of 28°21'25.16" N to 28°29'43" N and a longitude of 81°03'25.63" E to 81°12'52" E (Source: LDCRP, 2021) and is located between 142 and 154 meters above sea level covering an area of 127.08 km2.

Bardiya, situated in the flood-prone lower Karnali region, was selected due to its history of experiencing devastating floods in 1983, 2009, 2013, 2014, 2017, and 2021. Indigenous and vulnerable communities in this region, with limited adaptive capacity, are disproportionately affected, deepening the socio-economic inequality. While numerous flood-related studies have been conducted in Rajapur municipality, research on agricultural loss and damage remains underexplored. This gap underscores the importance of the present study, which focuses on four wards - 1, 3, 4 and 7 of Rajapur Municipality were selected due to their proximity to the right branch of the Karnali River and their historical exposure to frequent flooding events. These wards contain villages that are vulnerable to seasonal riverine floods, which have caused repeated damage to agricultural livelihoods and infrastructure (DEOC, 2021) (Rajapur Municipality, 2021).

Agriculture dominates land use in Rajapur Municipality, accounting for approximately 57.89% of the total land area. Most of the population practices subsistence farming, with key crops including rice, wheat, maise, mustard, and pulses. Given its geographic exposure and dependence on climate-sensitive agriculture, the area represents a critical site for examining the impacts of flood-related hazards on rural livelihoods (Fig. 1).

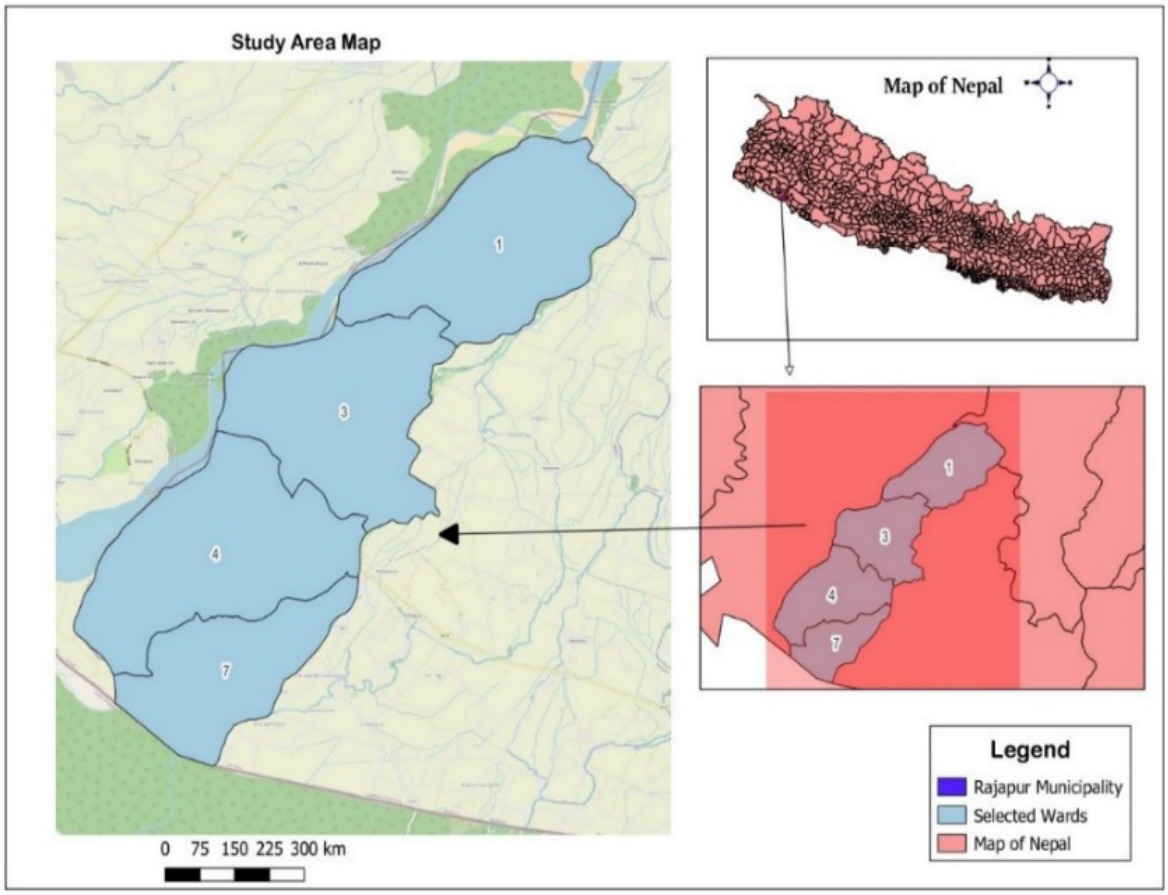

Figure 1. The study area comprises wards 1, 3, 4, and 7 of Rajapur Municipality.

2.1. Data collection

Primary data were collected through a multistage sampling approach. In the first stage, a total of 160 households were selected from four wards of Rajapur Municipality, with 40 households sampled from each ward using Cochran's formula to determine an appropriate sample size (see Table 1). In the second stage, the sampled households were categorised into three types of farmers: large (n = 20), medium (n = 54), and small (n = 86), based on landholding size and local classifications. To ensure comparability across categories, losses and damages (L&D) were calculated on a per-household basis.

Table 1: Data collection using different formulas.

Data collection	Formulae
Sample size	*Cochran's formula* $n_o = Z^2pq/e^2$ Where, Z = statistical value corresponding to the level of confidence required (1.96) P = the (estimated) proportion of the population which has the attribute in question (0.95) q = 1 – p (0.05) e = the margin of error (5%)
Sample Size Calculation in Smaller Populations	Modification for the Cochran Formula for Sample Size Calculation in Smaller Populations $N = (n_0/(1+((n_0-1)/N))$. Where, $n_{0=}$ Cochran sample size N = household number N = sample size

Primary data were obtained through a structured, questionnaire-based household survey and direct personal observations using a simple random sampling technique. To enrich the quantitative data and validate findings, qualitative methods were also employed. These included focus group discussions (FGDs) and key informant interviews (KIIs) conducted with local farmers, community leaders, ward representatives, government officials, members of the Karnali River Management Committee, and representatives from national and international governmental and non-governmental organisations (I/NGOs).

Secondary information was obtained from a range of published and unpublished sources, including academic articles, research theses, official reports, policy documents, journals, and relevant websites. Hydrological and meteorological data were sourced from the Department of Hydrology and Meteorology (DHM), Nepal. Additional supporting data were collected from various institutional sources, including Rajapur Municipality, the local office of the Department of Agriculture, the District Emergency Operation Centre (DEOC), and reports produced by national and international governmental and non-governmental organisations (NGOs).

Table 3. Hydrological and Meteorological Stations were used in this study.

S.N.	Station Name	Latitude	Longitude	Elevation (m)	Parameters
1	Tikapur	28°32′ N	81°6′ E	149	Temperature
2	Rajapur	28°26′ N	81°5′ E	133	Precipitation
3	Chisapani	28°38′ N	81°17′ E	201	Discharge

2.2. Data analysis

The study conducted a comprehensive quantitative and statistical analysis of climatological time-series data (1992–2021) and field survey data, focusing on Nepal's four seasons: Winter, Pre-monsoon, Monsoon, and Post-monsoon (DHM, 2017). Hydrological and meteorological data, including temperature, precipitation, and discharge, were analysed using MS Excel and SPSS. Temperature trends were evaluated by examining the minimum and maximum seasonal trends, with linear trendlines applied to days with temperatures below or above average. Precipitation data were categorised using indices from the Expert Team on Climate Change Detection and Indices (ETCCDI) (Yu et al., 2013). Seasonal discharge trends were also analysed, and flood event trends were derived from rainfall, discharge data, field surveys, and secondary information sources.

The analysis of loss and damage focused on household data, organised under themes such as agricultural land, production, stored grains, livestock, and farm machinery. Losses were estimated using indicators from the Building Information Platform against Disaster (BIPAD) (Tamrakar & Bajracharya, 2020; FAO, 2020) (Table 2), with local units (kattha and NPR) converted to hectares and USD (1 NPR = 0.0082 USD as of March 25, 2022). Descriptive statistics, including mean, standard error, and standard deviation, were calculated. A framework for assessing unavoidable climate change impacts (Fig. 2) was developed to evaluate the impacts on agricultural land, production, stored grains, livestock, machinery, and income (Table 3). Coping mechanisms were analysed, and their percentages were presented in a bar graph, providing insights into adaptation measures and their effectiveness.

3. Results

3.1. Variation in Temperature, Rainfall, and Discharge

The study reveals significant temporal variations in temperature, precipitation, and river discharge patterns across the selected meteorological and hydrological stations.

At the Tikapur meteorological station, analysis of data from 1992 to 2021 revealed a declining trend in minimum temperatures during the winter, monsoon, and post-monsoon seasons. In con-

trast, maximum temperatures have shown an increasing trend in all seasons except the post-monsoon season. Notably, extreme temperature events were recorded, with the highest temperature reaching 45 °C in 2012 and the lowest dropping to 0 °C in both 2013 and 2021. The frequency of days exceeding 40 °C has shown a marginal decrease, declining at a rate of –0.004 days per year (Fig. 2).

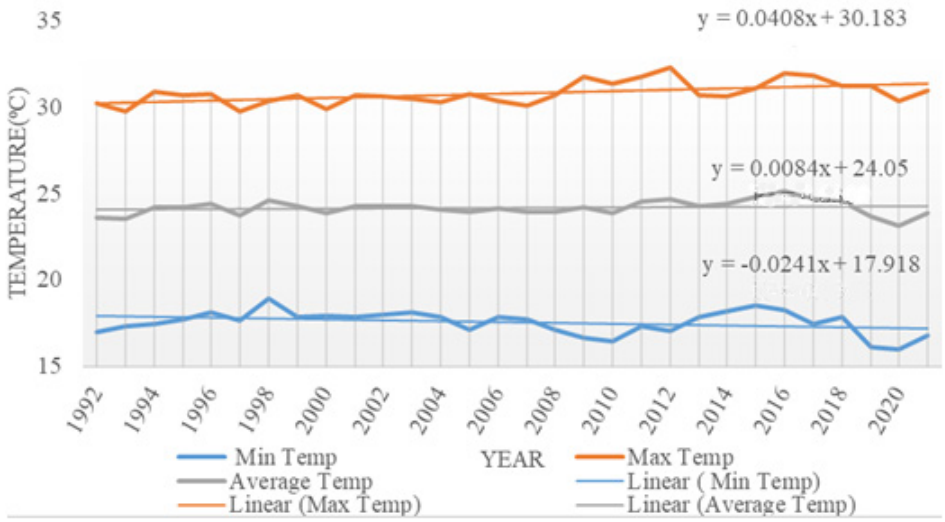

Figure 2: Annual trends in minimum, maximum, and average temperature (1992-2021), Tikapur Station.

In the Rajapur area, seasonal temperature trends demonstrate that maximum, minimum, and average temperatures are generally increasing at a rate of 0.30°C per year. However, minimum temperatures are decreasing at a rate of 0.09 °C per year across all seasons except for the pre-monsoon season. These patterns suggest an increasing prevalence of extreme temperature conditions, thereby increasing the risk of prolonged droughts and heat waves in the region.

Rainfall trends also show a notable shift. The Rajapur region is experiencing an overall increase in annual rainfall, with a higher frequency of intense downpours replacing historically consistent rainfall patterns. Concurrently, periods of extended drought have become more common, a trend likely to be exacerbated by ongoing climate change. Quantitative analysis indicates an upward trend in total annual rainfall, increasing at a rate of 8.806 mm per year. The highest recorded annual precipitation occurred in 2007, while the lowest was observed in 2019 (Figure 4 and Table 5). As global temperatures rise, the hydrological cycle intensifies, resulting in more extreme precipitation events and an increased risk of flooding.

The overall trend in discharge over the past thirty years indicates a decline in the annual discharge of the Karnali River, with a decrease of -2.665 m^3/s per year. While discharge decreased during the winter, pre-monsoon, and monsoon seasons, it showed an increasing trend in the post-monsoon season at 1.370 m^3/s per year. This rise in post-monsoon discharge heightens the risk of unseasonal floods. Record highs were observed in 1998, while the lowest discharges were recorded between 2011 and 2016 (Fig. 5 and Table 6).

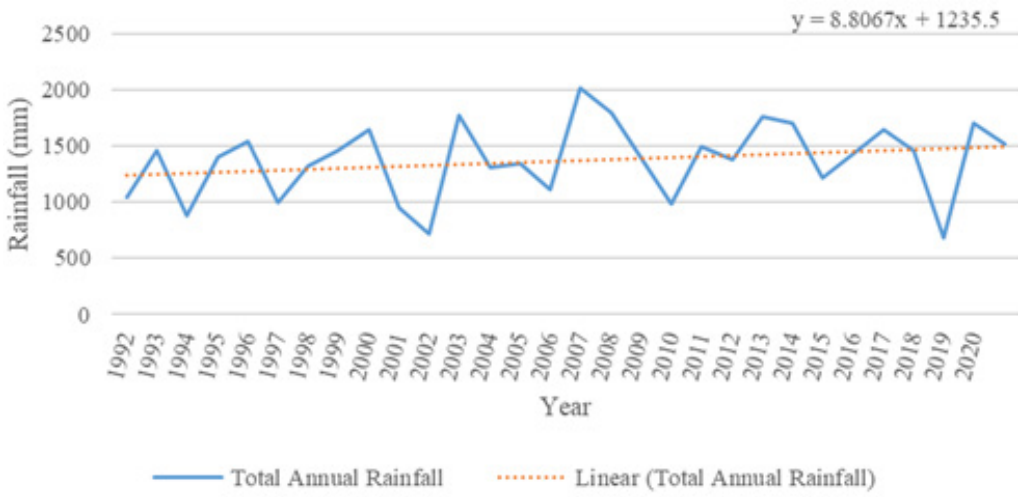

Figure 3: Annual Rainfall Trend in Rajapur Area (1992 - 2021)

3.2. Flood Event Trend

The analysis of flood events in Rajapur, Bardiya, from 1992 to 2021 revealed an increasing trend in the frequency of major floods (Figure 4). Over the past 30 years, 16 significant flood events have been recorded, with minor flooding and seasonal inundation reported almost annually. The most catastrophic flood occurred in 2014, reaching a peak discharge of 17,900 cubic meters per second, resulting in extensive socio-economic and environmental damage. Notably, post-monsoon flooding events in 2009 and 2021 resulted in substantial losses, particularly in the agricultural sector, with paddy fields being severely impacted. The increasing trend in both frequency and intensity of flood events underscores the growing vulnerability of the region to climate-induced hydrological extremes.

3.3. Analysis of Loss and Damage in Agriculture

The unseasonal flood event that occurred between October 17 and 21, 2021, had severe socio-economic impacts on agriculture in Rajapur, Bardiya. A total of 144.81 ha of land was inundated, affecting farmers across all scales of production. Large-scale farmers incurred losses of 17.79% (11.523 ha), medium-scale of 7.13% (7.131 ha), and small scale of 16.98% (3.240 ha). The estimated paddy production losses were 86 metric tons for large-scale farmers, 79.2 metric tons for medium-scale farmers, and 31.7 metric tons for small-scale farmers, corresponding to yield reductions of 34.67%, 41.27%, and 53.39%, respectively.

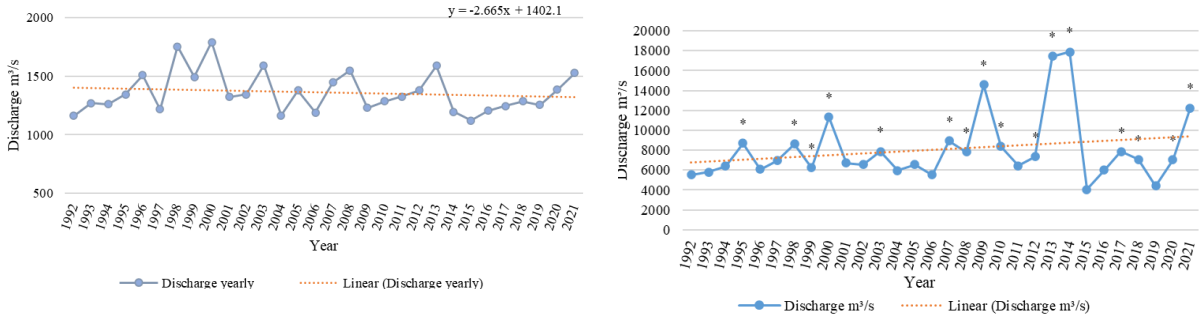

Figure 4: Annual seasonal discharge of the Karnali River and Flood Events for the duration of 1992 - 2021

The economic valuation of these losses was substantial, with large farmers losing an estimated USD 19,407.10, medium farmers USD 17,872.59, and small farmers USD 7,153.55. In addition to paddy yield losses, large farmers suffered disproportionately high losses in livestock, farm equip-

ment, and food grain storage, with 32.57 metric tons of stored grain destroyed, resulting in storage losses of USD 9,924.93 and livestock losses of USD 9,569. These damages had profound implications for food security: large farmers reported a food deficit lasting 3.8 months, medium farmers for 4.93 months, and small farmers for 3.11 months.

Losses in farming inputs were also critical. A total of 9.04 metric tons of paddy seeds, valued at USD 4,841.69, and 18.67 metric tons of fertilisers, valued at USD 6,591.46, were destroyed. Moreover, labour disruptions translated to wage losses of USD 19,204.40. Income losses across farmer categories were deeply skewed, with large farmers experiencing a 40.22% drop, while medium and small farmers suffered significantly higher proportional losses—88.74% and 91.75%, respectively. On a per-farmer basis, income losses amounted to USD 809.76 for large farmers, USD 217.32 for medium farmers, and USD 19.62 for small farmers. Restoration costs for affected farm machinery totalled USD 483.80, with large farmers incurring USD 270.60, medium farmers incurring USD 131.20, and small farmers incurring USD 82.00.

Despite these impacts, the delay in disbursing compensation significantly hindered recovery efforts. Accelerated and targeted compensation mechanisms would have provided vital support for the early restoration of livelihoods, particularly for small and medium-scale farmers who were disproportionately affected (see the table below). These findings underscore the need for adaptive disaster risk reduction strategies and the timely mobilisation of post-disaster recovery support to safeguard rural livelihoods in flood-prone areas.

Table 3: Analysis of loss and damages to the agriculture of the study area.

Loss and damage on agricultural land					**Input to paddy production (mt)**				
Farmer's Type	Large	Medium	Small	Total	Farmer's Type	Large	Medium	Small	Total
Total land (ha)	64.763	60.9717	19.0714	144.806	Sowed seed (mt)	3.87	3.413	1.753	9.036
L&D (ha)	11.523	7.131	3.24	17.452	Fertilisers (mt)	8.4	6.84	3.429	18.669
L&D (%)	17.793	11.695	16.988	12.052	Total Input (mt)	12.27	10.253	5.182	27.705
No. of farmers	20	54	86	160	No. of farmers	20	54	86	160
Damage per farmers (ha)	0.576	0.132	0.038	0.746	L&D per farmers (mt)	0.614	0.19	0.06	
Total Loss and Damage ($)	1726	26875.5	9860.5	38462	***Input to paddy production (in USD)***				
L&D per farmer ($)	86.3	497.694	114.657		Farmer's Type	Large	Medium	Small	Total
Loss and damage in paddy production					sowed seed	2062.71	1819.129	959.851	4841.69
Farmer's Type	Large	Medium	Small	Total	Fertilisers (mt)	2886.4	2467.872	1237.183	6591.455
Previous Year (mt)	248	191.9	71.45	511.35	Wages	10332	5428.4	3444	19204.4
This Year (mt)	162	112.7	33.3	308	Total Input cost	15281.11	9715.401	5641.034	30637.55
Loss and Damage (mt)	86	79.2	38.15	203.35	No. of farmers	20	54	86	160
L&D %	34.677	41.271	53.394	39.767	L&D per farmers	764.056	179.915	65.593	
No. of farmers	20	54	86	160	***Sell details***				
Production damage per farmer (mt)	4.3	1.467	0.444	6.21	Farmer's Type	Large	Medium	Small	Total
L&D ($)	19407.1	17872.59	8609.082	45888.77	PY sell (mt)	133	58.6	8.15	199.75
L&D per farmer ($)	970.355	330.973	100.105	286.804	TY expected to sell (mt)	133	58.6	8.15	199.75
Loss and damage of stored grains					TY total sell (mt)	79.5	10.7	0.8	91
Farmer's Type	Large	Medium	Small	Total	Loss and Damage (mt)	53.5	47.9	7.35	108.75
No. of farmers	20	54	86	160	No. of farmers	20	54	86	160
L&D (mt)	10.13	14.065	8.37	32.565	L&D per farmers (mt)	2.675	0.887	0.085	
L&D per farmers (mt)	0.507	0.26	0.097		L&D (mt) %	40.226	81.741	90.184	
L&D ($)	3437.588	3738.751	2748.588	9924.926	***Income details***				
L&D per farmer $	171.879	69.236	31.96		Farmer's Type	Large	Medium	Small	Total
Loss of livestock					PY income $	29823.92	13140.46	1827.556	44791.94
Farmer's Type	Large	Medium	Small	Total	TY's expected income of $	30013.31	13223.91	1839.162	45076.38
L&D ($)	7552.2	1607.2	409.6	9569	TY's total income is $	13818.15	1488.398	151.7	15458.25

Loss and damage on agricultural land					**Input to paddy production (mt)**				
No. of farmers	20	54	86	160	Loss and Damage ($)	16195.16	11735.51	1687.462	29618.14
L&D per farmer ($)	377.61	29.763	4.763		No. of farmers	20	54	86	160
Farm machinery damage					L&D per farmer	809.758	217.324	19.622	
Farmer's Type	Large	Medium	Small	Total	L&D ($) %	53.96	88.745	91.752	
Farm machinery damage	270.6	131.2	82	483.8	***Support Received***				
L&D per farmers	13.53	2.43	0.953	16.913	Farmer's Type	Large	Medium	Small	Total
Loss of Food Sufficiency					USD ($)	832.79	3209.73	5167.16	9209.68
Farmer's Type	Large	Medium	Small		Note: $ - US dollar mt – metric tons ha - Hectare		PY – Previous year TY – This year		
PY average (Month)	12	11.444	6.721						
TY average (Month)	8.2	6.556	3.279						
Loss (Month)	3.8	4.849	3.442						

Table 4: Descriptive statistics.

Indicators	Large				Medium				Small			
	Mean± SE	**SD**	**Min**	**Max**	**Mean± SE**	**SD**	**Min**	**Max**	**Mean± SE**	**SD**	**Min**	**Max**
land (ha)	0.576 ± 0.147	0.658	0	2.004	0.132± 0.029	0.215	0	1.002	0.037±0.009	0.086	0	3.239
USD	86.31± 22.48	100.53	0	328	497.69± 170.042	1249.551	0	5781	114.66± 76.89	713.09	0	5756.4
Production (mt)	4.3 ± 0.658	2.94	1.5	12	1.466± 0.147	1.085	0	5	0.443± 0.041	0.385	0	1.5
USD	970.35± 148.56	664.40	338.50	2707.968	330.974± 33.321	244.859	0	1128.32	100.106± 9.370	86.897	0	338.496
Food (month)	3.8± 1.047	4.686	0	12	4.849± 0.539	3.929	0	12	3.686± 0.261	2.422	0	10
Stored (mt)	0.506± 89.191	1.102	0	4.3	0.260± 0.077	0.57	0	3.2	0.097± 0.024	0.227	0	1
USD	171.88± 89.19	398.88	0	1637.13	69.236± 21.194	155.749	0	810.439	31.960± 7.453	69.12	0	331.116
Machinery (USD)	8.2± 6.379	28.53	0	123	2.429± 1.307	9.608	0	49.2	0.953± 0.582	5.398	0	41
Livestock (USD)	377.61± 289.14	1293.053	0	5740	29.762± 17.626	129.529	0	820	4.762± 2.270	21.058	0	160

3.4. Coping Strategies and Socioeconomic Consequences among Farming Households

The farming community in Rajapur has adopted a range of short-term coping strategies to address the recurrent loss and damage caused by unseasonal flooding. As a direct response to the disruption in paddy production, many farmers have opted to purchase rice from the market to ensure household food security. Additionally, there has been a noticeable shift toward cultivating alternative crops, such as wheat, and an increased emphasis on spring-season rice production, an initiative promoted by the Prime Minister's Agricultural Modernisation Project (PMAMP). Farmers have also reduced the sale of their paddy harvests instead of conserving it for subsistence, reflecting heightened vulnerability and concerns about food security.

Despite these adaptive responses, the broader socioeconomic impacts remain severe, particularly among smallholder farmers. The study found that approximately 70% of small farmers resorted to taking loans from local cooperatives and women's groups (mother groups). In comparison, 10% reported withdrawing their children from school due to financial constraints. Labour migration has become a dominant survival strategy, with nearly 90% of smallholder families reporting that at least one family member had migrated for work, primarily to urban centres in Nepal and India. This pattern highlights the growing economic precarity driven by climate-related disruptions to agriculture.

Furthermore, rather than selling wheat to generate income, smallholders are now retaining it for household consumption—an indication of both declining income streams and eroding food self-sufficiency. These farmers are also disproportionately reliant on humanitarian assistance, receiving essential supplies such as food, water, shelter materials, and hygiene kits. In contrast, medium and

large-scale farmers received less aid, likely due to their relatively higher asset base and coping capacity.

A significant point of concern is the delay in government compensation for flood-related losses. As of August 2022, no compensation had been disbursed, and available schemes appear skewed in favour of landowners, primarily large farmers, excluding vulnerable groups such as landless sharecroppers and small tenant farmers. This systemic exclusion exacerbates existing inequalities and undermines the resilience of the most affected populations.

4. Discussion

4.1. Temperature, Rainfall and Discharge Analysis

The analysis of climatic variables and hydrological trends in Rajapur highlights a significant shift in seasonal weather patterns over the past two decades. The observed variation in temperature, rainfall, and river discharge aligns with broader regional and global climate change projections (IPCC, 2020). Notably, the minimum temperature in the winter and post-monsoon seasons has reached 0°C in recent years, a phenomenon that has not been previously recorded. This emerging pattern of colder winters and post-monsoons may signal greater climatic variability and an increased risk of frost damage to winter crops. Conversely, the increasing trend in minimum temperature during the pre-monsoon and monsoon seasons, along with a persistent rise in maximum temperature across all seasons, underscores a shift toward overall warming, supporting the findings of Gyawali (2019) and Khatiwada et al. (2015) in other regions of Nepal.

Such thermal variations have direct implications for agroecosystems and crop calendars, particularly affecting the germination, flowering, and harvesting phases of staple crops such as paddy and wheat. Elevated temperatures during the monsoon and pre-monsoon periods can also intensify evapotranspiration and soil moisture loss, thereby compounding the vulnerability of rain-fed agricultural systems, which are predominant in regions like Rajapur.

Precipitation analysis reveals increasing trends in total annual rainfall and wet-day precipitation during all seasons except the pre-monsoon season. These shifts in rainfall dynamics suggest a heightened risk of extreme weather events and associated hydrological hazards. The increasing precipitation, however, does not uniformly translate to increased water availability, as evidenced by declining annual discharge trends in the Karnali River at Chisapani station, corroborating the findings of Khatiwada et al. (2016).

This decoupling between rainfall and discharge may be attributable to several factors, including changes in land use and land cover, increased surface runoff due to reduced infiltration, and disruptions in natural water retention capacity. Moreover, the study indicates that the discharge trend decreases during the winter, pre-monsoon, and monsoon seasons, while an anomalous increase is observed during the post-monsoon period. This pattern strongly suggests the growing influence of glacial meltwater in sustaining river flow during the late monsoon and post-monsoon periods—an assertion supported by higher discharge levels in Chisapani station after August, even when rainfall subsides.

The linkage between increased post-monsoon discharge and unseasonal flooding events is particularly concerning. The 2021 flood events in multiple districts, including Melamchi (Sindhupalchowk), Manang, Mustang, and Gorkha, were triggered by extended monsoon activity that arrived two weeks earlier than usual and lingered beyond its typical duration (World Bank, 2022). These unseasonal and compound climate events caused catastrophic impacts, including the loss of lives, damage to critical infrastructure, agricultural destruction, and disruption of livelihoods. The recurrence of such events highlights the need for enhanced early warning systems, improved glacial monitoring, and the integration of seasonal forecasts into planning and agricultural decision-making.

Overall, the climatic and hydrological patterns observed in Rajapur reflect a broader climatic disequilibrium, underscoring the need for adaptive and resilient management of water and agricultural

resources. Without robust intervention, continued shifts in precipitation and discharge regimes will exacerbate flood risks and water insecurity, posing long-term challenges to food security and rural livelihoods in the Karnali Basin and beyond.

4.2. Flood Dynamics and Impacts

The analysis of flood events in Rajapur Municipality over the past three decades reveals an alarming trend of increasing frequency and severity, with profound implications for both human well-being and agricultural productivity. While floods have long been a recurring hazard during the monsoon season, recent years have seen an intensification in their magnitude and impacts, consistent with broader hydrometeorological changes attributed to climate change. The most catastrophic event in recent memory occurred in 2014, when a peak discharge of 17,900 m^3/s resulted in 12 fatalities and an estimated USD 24.6 million in physical damages (Practical Action, 2021). While monsoon rainfall remains the dominant driver of these flood events, post-monsoon floods are also becoming increasingly common. They are often exacerbated by accelerated glacial melt due to rising temperatures in the upstream catchments (Khatiwada et al., 2016).

A particularly illustrative example occurred in October 2021, when an unseasonal post-monsoon flood caused significant damage to the agricultural sector. Over 20 hectares of farmland were eroded or buried, leading to direct losses estimated at over USD 38,000. Cumulatively, more than 460 hectares of productive agricultural land have been lost to riverbank erosion and flood damage, with wards 1, 3, 4, and 7 of Rajapur Municipality identified as the most severely affected areas (Rajapur Municipality, 2021). These localised findings support broader regional studies that document the intensification of flood hazards across the Karnali Basin (Bhawani et al., 2023; Dugar, 2016).

The increasing recurrence and destructiveness of flood events in Rajapur present a serious threat to food security, land tenure, and rural livelihoods. This is particularly concerning in a socio-economic context where a large proportion of households rely on subsistence agriculture and lack the financial capacity to recover from repeated shocks. This situation calls for urgent intervention through the development and implementation of integrated flood risk management strategies. This includes investment in upstream watershed conservation, community-based early warning systems, climate-resilient crop diversification, and the enforcement of land-use zoning to reduce exposure. Without such measures, the vulnerability of Rajanpur's agrarian communities will continue to grow in parallel with climate-induced hydrological extremes.

4.3. Loss and damage

This study highlights the disproportionate financial and livelihood impacts of flooding across different farmer categories in Rajapur Municipality. In this rice-growing region, agriculture, particularly paddy cultivation, forms the backbone of the local economy. While all farmer groups were affected, small and medium-scale farmers suffered the most severe livelihood losses relative to their capacity to absorb shocks. Although large farmers experienced the highest proportion of land damage (17.93%), the per capita L&D value was significantly higher among medium and small farmers, at USD 497.69 and USD 114.66 per farmer, respectively, compared to USD 86.30 among large farmers. This discrepancy is attributed to the greater vulnerability of smallholders residing in high-risk floodplains adjacent to the Karnali River, where exposure is highest (Newar, 2014).

The impact on paddy production further underscores the asymmetric burden borne by smaller farmers. Losses in paddy yield were estimated at 34.67% for large farmers, 41.27% for medium farmers, and 59.39% for small farmers, significantly undermining food security and income generation. Compounding this, the quality of harvested grains deteriorated due to waterlogging and sediment deposition, forcing farmers to sell at reduced market prices. While large farmers also suffered notable losses of livestock and machinery, their greater access to capital and diversified income sources enabled a more rapid recovery. In contrast, small and medium farmers, often reliant on single-sea-

son harvests and lacking formal safety nets, faced prolonged hardship, including the loss of up to five months' worth of staple food supply.

Significantly, the vulnerability of smallholder farmers is exacerbated by prevailing land tenure arrangements. Many operate under shared cropping systems such as *Adhiya* and *Bataiya*, wherein landless or resource-poor households cultivate land owned by larger landholders, absorbing a disproportionate share of agricultural risks (Kocanda & Puhakka, 2012). As a result, small farmers lost over 88% of their annual agricultural income in the aftermath of the flood due to both yield reduction and damage to stored grain reserves. These findings are consistent with broader patterns observed in South Asia, where marginalised groups often reside in flood-prone zones with limited adaptive capacity.

Given these dynamics, the study emphasises the importance of targeted post-disaster support mechanisms, including direct financial aid, land rehabilitation, access to improved seed varieties, and the promotion of flood-resilient agricultural practices to enhance the resilience of small and medium-scale farmers. Addressing these inequities is essential not only for food security but also for long-term sustainable development in climate-sensitive agrarian regions like Rajapur.

4.4. Adaptation Measures and Strategies

Floods significantly disrupt agricultural livelihoods in Rajapur Municipality, compelling farmers, particularly those with limited landholdings, to adopt various coping and adaptation strategies in the aftermath of disasters. As highlighted by Jha (2017), such events degrade land quality and reduce agricultural productivity, forcing smallholder farmers to adjust employment and livelihood strategies to ensure survival. Common adaptive responses include purchasing rice for household food security, shifting to wheat as a dietary substitute, cultivating spring-season rice, storing paddy instead of marketing it, taking out informal loans, and engaging in short-term labour migration. Small farmers, in particular, emerge as the most vulnerable group, often demonstrating limited adaptive capacity even during non-flood years due to their marginal economic status and dependency on subsistence farming (Amarnath & Saikia, 2017).

The financial insecurity of smallholders often results in school dropouts, loan dependence, and manual wage labour. Male members of affected households frequently migrate to urban areas for seasonal work. These households also lack access to mechanised equipment, resulting in dependency on sharecropping agreements, often with relatively resource-rich Tharu landowners (Kocanda & Puhakka, 2012). While the Nepal Red Cross Society, in collaboration with several I/NGOs, provided immediate relief worth approximately USD 9,210, this fell short of compensating for the extensive damages to agricultural assets and livelihoods. Moreover, government compensation schemes suffered from bureaucratic delays, which prevented timely access to essential agricultural inputs, such as seeds and fertilisers, thereby constraining farmers' ability to recover in subsequent planting seasons.

Despite these challenges, several community-level and institutional adaptation measures have been implemented. The Karnali River Management Project has constructed a 17-kilometer-long embankment along the Karnali and Geruwa Rivers, providing partial protection to flood-prone areas. However, these structures remain insufficient against high-magnitude events, as evidenced by the 2020 breach of a 500-meter section in Tihuni village and the 2021 overflow incident, which caused widespread agricultural damage (Boyd et al., 2017). The Early Warning System (EWS) linked to the Chisapani gauge station, triggering alerts when water levels exceed 9 meters, has proven effective in reducing human casualties, complemented by sirens and mobile alerts. Over time, societies have employed various methods to mitigate the impact of natural disasters. Early Warning Systems (EWSs) are widely valued as a key non-structural tool for enhancing preparedness and reducing risks (Sukhwani et al., 2019). However, the design and effectiveness of these systems can vary significantly depending on a country's level of scientific, technological, and economic development, impacting their performance in different scenarios (Cvetković et al., 2021).

Traditional flood mitigation strategies, such as machan (elevated dwellings), raised wells, and thatis (double-story homes for storing essentials), remain in use. Community-based mechanisms,

including Community Disaster Management Committees (CDMCs), local search and rescue teams, youth groups, and trained volunteers, are actively mobilised during emergencies (Practical Action, 2021). Adaptive agricultural practices are also evolving. Farmers are increasingly shifting to less flood-sensitive crops, such as vegetables and sugarcane, and using hybrid seed varieties (albeit at the cost of local genetic diversity), while also experimenting with spring paddy cultivation. Though rare, some have initiated tree plantations along field boundaries for erosion control. Other structural and agronomic adaptations include the installation of improved drainage systems and the expansion of sharecropping arrangements to manage labour and land use during recovery periods.

Collectively, these strategies reflect both reactive coping and proactive adaptation in response to escalating climate risks. However, gaps in institutional support, inadequate infrastructure, and social inequities continue to hinder long-term resilience, particularly among the most vulnerable farmer groups.

The study faced several limitations. Climatological and hydrological data were sourced from a single station due to time and financial constraints, and the analysis focused on a single year's flood event, limiting a broader temporal perspective. Additionally, the study concentrated on economic loss, overlooking the non-economic impacts that are crucial to understanding livelihoods. The flood's occurrence during the paddy harvesting season resulted in a primary focus on paddy, with limited attention to other crops.

5. Conclusion

The Rajapur area is experiencing an increasing frequency and severity of extreme weather events, particularly flooding and inundation, driven by observable trends in rising temperatures and erratic precipitation. These climatic shifts have caused extensive economic loss and damage (L&D) in agriculture, affecting lives, livelihoods, property, and critical infrastructure. This study estimates economic losses due to land degradation (L&D) by calculating the market value of losses related to land, paddy production, stored grains, livestock, and agricultural machinery while deliberately excluding non-economic losses. Although adaptation mechanisms, such as Early Warning Systems (EWS), have reduced human casualties, agriculture-dependent communities continue to face heightened risks, particularly due to the erosion of arable land, sediment deposition, and declining yields linked to unsustainable practices, including the overuse of chemical fertilisers.

Embankments, although providing limited protection, have failed to withstand large-scale floods, with dam failures resulting in catastrophic losses. Smallholder farmers remain the most vulnerable group, enduring profound impacts on landholding, production, and income. Medium-scale farmers also report losses in food security and stored grain stocks. In contrast, large-scale farmers, despite comparatively less direct crop damage, have incurred notable losses to farm machinery and livestock. These stratified impacts underscore the urgent need for differentiated policy responses.

Despite the growing relevance of climate-induced labour and development (L&D), it remains a nascent concept in Nepal's policy landscape. Incorporating this framework into national and local strategies is crucial, particularly in addressing the vulnerabilities of marginalised, agriculture-reliant communities. Sharecroppers, often overlooked in compensation schemes, invest heavily in cultivation but suffer disproportionately during floods. Current compensation mechanisms primarily benefit large landowners, exacerbating inequalities and leaving small farmers more susceptible to chronic poverty. Equitable compensation systems must be revised to reflect the actual burden borne by those most affected.

Importantly, non-economic L&D, though harder to quantify, often results in deeper, long-term consequences. These include the loss of education (due to school dropouts), increased indebtedness from emergency loans, psychological distress, and weakened social cohesion. Broadening the scope of L&D assessments to include these dimensions will lead to more accurate and just adaptation policies. Future research should also explore underexamined sectors such as forestry, rural infrastructure, and transportation networks, which are integral to agricultural resilience.

Adaptation strategies must be strengthened through targeted awareness programs and farmer training focused on climate-resilient practices, including the use of flood-tolerant and short-duration crops, spring-season paddy cultivation, and efficient irrigation techniques. Promoting nature-based solutions, such as bio-engineering interventions and riparian afforestation, offers sustainable avenues for managing flood risk. Furthermore, building institutional capacity to provide incentive grants, technical support, and localised research in L&D can empower communities to adapt proactively.

Lastly, government programs like the Prime Minister's Agriculture Modernisation Project should undergo a critical reassessment to ensure equitable access and responsiveness to the specific needs of smallholder and sharecropping farmers. By prioritising investments in disaster risk reduction, livelihood resilience, and inclusive adaptation planning, Nepal can better safeguard its vulnerable farming communities from the escalating threats posed by climate change.

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Annexes

Proposed Indicators in BIPAD

Sector	Subgroup	Indicators	Description
Productive	Agriculture	Land	Area of crop field destroyed and damaged
			Economic loss
		Productivity	Amount of production lost
			Economic value of production loss
		Stored Grains	Amount of stored grains lost
			Economic value of stored grains
		Livestock	Number of livestock dead
			Economic value of dead livestock
		Farm machinery	Economic loss due to damaged/destroyed productive assets in the agricultural sector

Assessment of Loss and Damage of agricultural land

Sectors	Assessment
Land Area	Loss and Damage (ha) = Total Land-(Land loss+ Land Damage) Loss and Damage ($) = Lost land value + restoration cost
Production	Loss and Damage (mt) = Previous year yield- This year's net yield Loss and Damage ($) = Economic value of expected yield – economic value of this year's yield.
Stored Grains	Loss and Damage (*mt*) = Quantity of stored grains* pre-disaster value of destroyed stored grains
Livestock	Loss ($): Pre-disaster value of dead animals
Farm Machinery Damage/ Asset damage:	Repair cost of partially or fully destroyed assets
Food sufficiency	Loss (Month): Average sufficiency month pre-disaster – average sufficiency month post-disaster
Income	Loss and Damage: Previous year's total sell – This year's total sell Loss and Damage ($) = Previous year income – (This year's selling price* total sell)
Input	Loss and Damage: Input used*Input prices
(Inputs are considered as seeds that are used for sowing, fertilizers used, and labor wages)	

Total wet day precipitation, Days with heavy precipitation and Days with very heavy precipitation.

Details	Winter	Year	Pre-Monsoon	Year	Monsoon	Year	Post-monsoon	Year
Total Rainfall (mm)	1943.55		2811.9		34903.05		823.8	
Total wet day Precipitation (PCP ≥ 1 mm)	228	1997	215.5	2011	1839.1	2007	220.1	1998
Days with heavy Precipitation (PRCP ≥ 10 mm)	52.5	1996	104.2	2011	228.8	2008	39.4	1997
Days with very heavy precipitation (PRCP ≥ 20 mm)	198.3	1997	143	2021	1688.8	2007	214.5	1998

Seasonal Discharge (High, low, and average)

Details	Winter	Year	Pre-Monsoon	Year	Monsoon	Year	Post-Monsoon	Year
High Discharge (m^3/s)	438	2020	750	1998	4085	2000	2008	2021
Low Discharge (m^3/s)	285	2012	337	2016	2203	2015	679	2015
Average Discharge (m^3/s)	372		487		2931		997	

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Article

Domestic Hiking Tourism for Post-COVID Recovery and Transformation

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ABSTRACT

The COVID-19 pandemic has profoundly disrupted global tourism, necessitating adaptive recovery strategies. This study explores the role of domestic hiking tourism in Ethiopia as a resilience mechanism for post-pandemic recovery and transformation. Using a qualitative case study approach, interviews were conducted with 16 hiking organisers in Addis Ababa to assess the factors contributing to the growth of hiking tourism, the challenges faced during the pandemic, and its potential as a catalyst for tourism recovery. Findings indicate that shifting travel preferences, increased health awareness, the influence of digital media, and emerging government initiatives have fueled the rise of hiking tourism. However, regulatory gaps, enforcement of health protocols, and political instability remain key challenges. Despite these obstacles, domestic hiking tourism has played a crucial role in revitalising the tourism industry, fostering community engagement, and promoting local economic development. This study highlights the importance of policy support, infrastructure investment, and regulatory frameworks in sustaining Ethiopia's growing hiking tourism sector as a long-term recovery strategy.

KEYWORDS

COVID-19; domestic hiking tourism; post-COVID recovery; tourism resilience.

1. Introduction

The outbreak of the lethal COVID-19 pandemic had a profound impact on the global health sector, leading to widespread socio-economic crises (Arbulú, Razumova, Rey-Maquieira, & Sastre, 2021). Among the hardest-hit sectors, tourism suffered severely due to travel bans, curfews, a sharp decline in demand, and restrictions on people's movement (Sharma, Thomas, & Paul, 2021; Pasquinelli & Trunfio, 2021). Despite ongoing challenges, various measures were implemented to address the crisis and facilitate recovery. However, the pandemic significantly altered people's perceptions of lifestyles, underscoring the need for resilience and transformative efforts to ensure sustainability and operational continuity across multiple sectors, including tourism (Noorashid & Chin, 2022).

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Prior research has highlighted that crises and disasters can create opportunities to reshape the tourism industry by promoting resilience and sustainable recovery strategies (Faulkner, 2001; Faulkner & Vikulov, 2001; Scott, Laws, & Prideaux, 2008; Manojlovic et al., 2025; Cvetkovic et al., 2022; Port & Jawahar, 2024; Sheikh, 2024). More recently, studies have extensively examined the effects of the pandemic and the opportunities it presents for the tourism sector. However, it is essential to note that much of this research is grounded in Western perspectives (Arbulú et al., 2021). To date, few studies have attempted to conduct research in developing countries, notably in an African context, on the pandemic's impact and implications for building a resilient tourism industry (Soliku, Kyiire, Mahama, & Kubio, 2021; Salem, Elbaz, Elkhwesky, & Ghazi, 2021). For instance, Soliku et al. (2021) analysed the pandemic's effects on resilience in Ghana's eco-tourism sector, while Salem et al. (2021) examined government initiatives to mitigate the pandemic's impact on Egypt's hotel industry.

Despite the rapid growth of hiking tourism, no research has specifically explored its role in Ethiopia's tourism recovery during and after the pandemic. Consequently, this study aims to bridge that gap by employing a case study approach that focuses on multiple travel clubs and hiking organisers in Addis Ababa. It examines how the pandemic influenced the rise and expansion of hiking tourism. Based on this understanding, the study addresses three main research questions: (1) What factors contributed to the development of hiking tourism in Ethiopia? (2) What challenges did hiking organisers face during the pandemic, and how were they overcome? (3) How can hiking tourism serve as a catalyst for tourism recovery and transformation in the post-pandemic era? The study thus develops a conceptual framework of crisis as an opportunity to rethink, reset, and redefine tourism in the post-COVID-19 pandemic era. The study, therefore, adds new knowledge and insights into the use of crisis and disaster as opportunities for the recovery and transformation of the tourism industry.

2. Literature Review

2.1 Definition of Hiking

Hiking, recognised globally by various terms such as bushwalking, trekking, tramping, or simply walking, involves travelling on foot through natural landscapes, often with supplies and equipment and can range from a few hours to days or even weeks, on or off-trail (Buckley, 2006). Recently, hiking has gained recognition as a cost-effective travel option and a tool for enhancing both physical and mental well-being. The benefits of hiking are evident in the positive emotional responses of participants, including feelings of joy, happiness, and psychological improvement after the hike. These mental and physical enhancements align with the wellness benefits that hiking tourism provides, making it increasingly popular worldwide (Bichler & Peters, 2020).

While hiking is a popular leisure activity in many Western countries, its definition can vary according to regional and cultural perspectives. For example, in Spain, Gomez-Martin (2019) defines hiking as "an activity that involves following paths, which may or may not be signposted, on foot, for sporting and cultural purposes" (p.1). In Norway, hiking is often associated with leisurely trips on foot during the summer and cross-country skiing in winter (Svarstad, 2010). In New Zealand, it is described as a long, vigorous walk (Nordbo & Prebensen, 2015). Similarly, in Malaysia, hiking is a form of outdoor recreation that emphasises both physical and mental fitness (Nordin & Jamal, 2021).

Several studies have highlighted the various benefits of hiking, particularly its connection to wellness tourism and health improvement (Lee, Manthiou, Chiang, & Tang, 2017). For instance, Nordbo and Prebensen (2015) emphasise how hiking enhances physical and mental fitness. In Israel, hiking plays a crucial role in promoting emotional attachment to the country, as well as fostering national and political revival (Collins-Kreiner & Kliot, 2016).

2.2. Hiking Tourism in Ethiopia

In Ethiopia, the tourism industry has been severely affected by the pandemic. Main tourism entities, including tour operators, travel agents, car hire companies, accommodations, and attraction providers, were among the most impacted (UN, 2020). Following the first reported case of COVID-19 on March 13, 2020, Ethiopia enforced travel restrictions, social distancing measures, and isolation protocols (Harris et al., 2021). Although the country did not close its airports, tourist destination sites were shut down to curb the spread of the virus (Abegaz, Beyene, & Emiru, 2020). These measures resulted in a 69% decline in international tourism (MoT, 2020). However, on September 23, 2020, Ethiopia reopened its tourism industry, allowing fully vaccinated tourists to return after a six-month closure (Kucheran, 2020).

As public health concerns limited international travel, Ethiopian domestic tourism, specifically nature-based tourism such as hiking, gained renewed interest. This shift in demand and a change in tourist behaviour presents a valuable opportunity to examine how hiking tourism can contribute to post-pandemic recovery and long-term transformation in Ethiopia's tourism landscape. This aligns with Faulkner's (2001) assertion that crises and disasters can serve as catalysts for positive change, stimulating innovation, market recognition, product repositioning, and the emergence of new business opportunities.

Domestic hiking tourism in Ethiopia is a relatively new development in the country's tourism industry. In the inbound tourism market, hiking is often regarded as trekking or walking to renowned destinations such as the Simien, Bale, and Abune Yoseph mountains, typically organised as multi-day excursions by inbound tour operators. In the domestic travel market, however, hiking is primarily a recreational outdoor activity arranged by travel clubs and independent organisers, providing an escape from the hustle and bustle of city life.

Before the COVID-19 pandemic, the Addis Hiking Group was founded by gym trainer Biniam Shirfo and his companions. They began organising hikes from Addis Ababa to the Sululta Highlands and the Gullele Botanical Garden Mountains, which surround the capital city (Tigabu, 2016). This group was likely among the first to promote hiking as a tourism-related business activity to the general public. Their trips aimed to visit the scenic landscapes surrounding Addis Ababa while encouraging connections among adventure enthusiasts.

Today, numerous hiking groups and individuals organise public hiking tours with scheduled departure dates, primarily on weekends, including Saturdays and Sundays. These tours vary from single-day hikes to short excursions. Popular domestic hiking destinations include Wonchi, Debre Libanos, Yerer Mountains, Gemesa Gedel, Menagesha Suba Forest, Ensaro, Chebera Churchura, and Bale Mountains National Park, among other natural attractions. These destinations provide diverse landscapes, rich biodiversity, and cultural heritage, making hiking a growing segment in Ethiopia's tourism sector.

2.3. Hiking Tourism amid COVID-19

Since the outbreak of the COVID-19 pandemic, governments worldwide have implemented travel bans, curfews, and movement restrictions (Ioannides & Gyimóthy, 2020). Most countries closed their borders to foreign tourists to curb the spread of the virus, resulting in significant disruptions to global travel and tourism. This, in turn, created socio-economic challenges and negatively impacted both health and mental well-being (Abbas, Mubeen, Iorember, Raza, & Mamirkulova, 2021; Ugur & Akbıyık, 2020).

Undoubtedly, the pandemic has had a significant impact on reshaping customer behaviour and travel intentions. For instance, it has altered consumer behaviours, attitudes, and decision-making processes, forcing tourism stakeholders to adapt to the new normal. As Pasquinelli and Trunfio (2021) have expressed, COVID-19 has had a profound impact on post-pandemic travel behaviour and attitudes. Similarly, Toubes, Araújo Vila, and Fraiz Brea (2021) observed shifts in tourist consumption behaviour in Spain as travellers adjusted to the new normal. In the same context, Luo and

Lam (2020) also identified changes in mobility intentions and psychological attitudes among Hong Kong travellers. Likewise, Im, Kim, and Choeh (2021) documented a swift shift in Korean behaviours, leading to increased risk aversion.

Likewise, recent studies (Rogerson & Rogerson, 2021; Chan, 2021) have demonstrated that COVID-19 has significantly altered the patterns of tourism demand and supply. As a result, understanding tourist behaviour during and after crises such as COVID-19 is crucial for effective destination recovery planning (Golets, Farias, Pilati, & Costa, 2021). This necessitates research into changes in tourist behaviour and preferences to develop effective strategies for the sector's survival. Furthermore, during these crisis times, it is essential to formulate recovery and resilience strategies for post-pandemic tourism development while also strengthening socio-economic linkages with other sectors (Kampel, 2020).

Parallel to these findings, the literature suggests that considerable efforts have been made to mitigate the pandemic's impacts by fostering an adaptive and resilient tourism industry. For example, Abbas et al. (2021) highlighted the renovation of tourism infrastructure, improving staff quality, and embracing digital technology as crucial strategies for recovery. Similarly, Assaf and Scuderi (2020) emphasised several recommended actions for both the tourism industry and governments to mitigate economic losses during the pandemic. Their joint analysis suggested strategies such as market diversification, technological innovation, funding for tourism promotion, and the easing of visa regulations.

In the same vein, many scholars and organisations have highlighted domestic tourism as a potential beacon of hope and a catalyst for the recovery of the tourism sector (Rogerson & Rogerson, 2021; Abbas et al., 2021; Persson-Fischer & Liu). Emerging studies also indicate that policies are increasingly focused on promoting domestic tourism, with expectations that domestic and regional tourism will recover before international tourism (WTO, 2020; Arbulú et al., 2021; Noorashid & Chin, 2022). Therefore, understanding domestic travel is crucial for the sector's recovery. In times of crisis and disaster, such as the COVID-19 pandemic, domestic tourism plays a crucial role in the recovery of the tourism sector (World Tourism Organisation, 2020). Unlike other forms of tourism, domestic tourism contributes to regional economic development, preserves jobs, sustains livelihoods, and offsets the decline in international tourist arrivals caused by crises and disasters.

Although domestic tourism in Ethiopia has traditionally been centred around religious pilgrimages, its growth in the leisure and adventure tourism sectors has been limited. This can be attributed to a general lack of enthusiasm for travel and exploration (Bayih & Singh, 2020). The pandemic, however, has shifted people's perspectives on tourism, prompting them to reassess their attitudes towards travel. The crisis has presented an opportunity to transform travellers' behaviour and intentions towards adventure tourism. As Burnett (1998) noted, crises and disasters can lead to positive change and have a transformational effect. In this context, the rise of hiking tourism, driven by COVID-19 restrictions, is a promising example of post-pandemic tourism recovery in Ethiopia.

As suggested by Kash and Darling (1998) and Scott et al. (2008), tourism crisis recovery may require a fundamental shift in operations, the creation of new networks, adaptation to more sustainable practices, emergency preparedness, product repositioning, and the stimulation of new business opportunities. During the pandemic, tourism stakeholders in Ethiopia have faced challenges from the uncertainty associated with COVID-19. Therefore, greater resilience and transformation are necessary to revive the industry and prepare for post-pandemic development.

Consequently, this paper aims to explore how domestic hiking tourism has contributed to building resilience, transforming Ethiopia's tourism sector, and supporting recovery from the COVID-19 crisis's impacts.

2.4 Domestic Hiking Tourism for Resilience and Transformation Amid COVID-19

The COVID-19 pandemic has shed new light on the role of tourism and its potential for redefining industry practices. This crisis presents an opportunity to adopt sustainability as a central focus

for the future of tourism development (Pasquinelli & Trunfio, 2021). In this context, tourism necessitates a resilient strategy to adapt to new global conditions, meet emerging demands, and transform the industry for sustainable growth.

Although COVID-19 has significantly impacted the tourism sector, it has also led to the promotion of outdoor activities such as hiking, trekking, and walking as a means to sustain local economies, support tourism businesses, and encourage tourism recovery (Sharm et al., 2021). The surge in outdoor leisure activities has been especially notable in developing countries, where hiking and trekking have gained popularity as safe, low-risk alternatives during the pandemic (Nordin & Jamal, 2022; Hettiarachchi & Lakmal, 2018; Narvekar & Dayanand, 2020).

In this new climate, outdoor adventure tourism has emerged as a viable option for post-pandemic recovery. It is increasingly recognised for promoting health, fitness, and well-being in natural, rural, and mountainous environments. During the pandemic, many people turned to national parks, nature reserves, and other natural destinations to escape the constraints of urban life, which further accelerated interest in nature-based tourism (CBI, 2021). Moreover, adventure tourism activities, such as hiking, are considered low-risk in terms of COVID-19 transmission and are becoming increasingly common (Wengel, 2020).

Amid these changing circumstances, domestic tourism—particularly through outdoor adventure activities—plays a significant role in addressing the decline of mass international tourism, which was heavily impacted by the pandemic. Recent research suggests that domestic and regional tourism may recover faster than international tourism (WTO, 2020; Arbulú et al., 2021). Therefore, understanding and promoting domestic hiking tourism is vital to the sector's recovery.

However, while outdoor adventure tourism has grown in popularity, challenges such as over-tourism are beginning to emerge. As restrictions ease, some hiking destinations are experiencing increased visitation, leading to overcrowding and potential environmental degradation. For instance, Mackenzie and Goodnow (2020) observed an increase in overtourism at popular hiking destinations due to pandemic-driven demand. Similarly, Nordin and Jamal (2022) identified over-tourism in Community-Based Tourism in Brunei during the pandemic. Despite these challenges, domestic hiking tourism holds strong potential to become a key driver in the recovery and transformation of the tourism industry in the post-pandemic era.

In light of these emerging trends, this paper aims to investigate how domestic hiking tourism has contributed to the recovery and transformation of Ethiopia's tourism industry, with a focus on the ways it mitigated the impacts of the COVID-19 crisis.

2.5. Theoretical framework of the study

The theoretical framework for this study is based on the Resilience Theory, which offers valuable insights into crises and the responsive mechanisms necessary to address the effects of the COVID-19 pandemic in the tourism sector. Resilience Theory was first developed by Holling (1973) and has since been adapted and expanded by scholars across various disciplines, including ecology, psychology, and socio-economics. According to Pisano (2012), resilience refers to a system's capacity to absorb disturbances, adapt to change, and reorganise while maintaining its core functions. In the context of tourism, resilience involves the strategic management of crises to ensure business continuity, adaptability to diverse risks, and responsiveness to new emergencies and environmental challenges through effective mitigation strategies that engage stakeholders (Noorashid & Chin, 2021). This theoretical framework is particularly relevant to tourism, as it conceptualises recovery not merely as a return to pre-crisis conditions but as an opportunity for growth and transformation. In this study, Resilience Theory provides a foundation for analysing how Ethiopia's tourism sector has leveraged the COVID-19 pandemic as an opportunity for recovery and sustainable tourism development. Specifically, this study examines the promotion of domestic hiking tourism in Ethiopia through this lens, highlighting its role in fostering resilience and long-term sectoral transformation.

3. Methods

This study employed a qualitative case study approach, utilising purposive sampling to select participants. A case study is a qualitative research design that focuses on the in-depth exploration of complex phenomena within their real-life contexts. It is beneficial for understanding intricate social processes and individual experiences, allowing researchers to collect detailed data through methods such as interviews and observations (Baxter & Jack, 2008). Twenty owner-managers of hiking organisations in Addis Ababa, Ethiopia, were identified and interviewed due to their active roles in organising hiking tours and sustaining operations during the COVID-19 pandemic. The interviews were conducted between May and June 2022.

To gain an in-depth understanding of the factors that contributed to the rise of hiking tourism in Ethiopia during the pandemic, the study employed semi-structured interviews. These interviews focused on key themes, including the challenges faced by hiking organisers, their perceptions and experiences in mitigating the effects of COVID-19, and their strategies for adapting to the evolving tourism landscape. Given the lack of pre-existing research on hiking tourism in Ethiopia, the combination of semi-structured interviews and purposive sampling allowed for a comprehensive exploration of participants' knowledge and experiences in managing hiking tours during the crisis.

While 20 professional hiking organisers were initially recruited for the study, the final sample size was determined by the principle of data saturation—the point at which no new insights emerged (Mohajan, 2018). In this study, saturation was achieved after 16 interviews, confirming the sufficiency of the data collected. All interviews were conducted with the participants' informed consent, ensuring ethical compliance.

The transcribed interviews were analysed using inductive qualitative content analysis to identify key themes related to the role of hiking tourism in Ethiopia's post-pandemic recovery. The data were reviewed multiple times to develop initial codes, which were then organised into broader thematic categories (Mohajan, 2018). To enhance reliability, the coding framework was refined through iterative analysis and critical self-reflection. Validity was strengthened through member checking, in which selected participants were asked to confirm the accuracy of interpretations, and peer debriefing, which provided external perspectives on emerging themes. Ethical standards were rigorously upheld by assigning pseudonyms and ensuring participant confidentiality throughout the research process. Maintaining participant anonymity during data collection, analysis, and reporting is a fundamental principle in qualitative research (Creswell, 2014).

4. Results

4.1. Factors Contributing to the Growth of Hiking Tourism in Ethiopia

Hiking tourism in Ethiopia has experienced significant growth in recent years, driven by a combination of socio-economic and technological factors. Although hiking has traditionally been included in Ethiopia's adventure tourism packages for international visitors, its popularity within the domestic travel market has notably increased, especially in the post-pandemic era. This rising trend can be attributed to shifting travel preferences, growing interest in domestic tourism, heightened awareness of health and wellness, the influence of social media, and emerging government initiatives aimed at promoting tourism.

4.1.1 Changing Travel Preferences and Domestic Tourism Growth

One of the primary drivers behind the rise of hiking tourism in Ethiopia is the shift in travel preferences among both domestic and international tourists. As the global tourism industry increasingly shifts toward more sustainable and experience-based travel, activities such as hiking have gained considerable traction (CBI, 2021). Interviews with hiking organisers revealed that many travellers are now seeking nature-based experiences, adventure, and opportunities for cultural exchange, which Ethiopia's diverse tourism offerings fulfil in abundance.

The COVID-19 pandemic further accelerated this shift, prompting a surge in domestic tourism. With international travel restrictions in place, many Ethiopians turned to exploring their own country, uncovering scenic trails in destinations like Wonchi-Dendi Ecotourism, Menagesha Suba Forest, and Yerer Mountain. The affordability and accessibility of hiking, compared to international travel, made it an appealing alternative. As interviewee R03 noted:

> *"Unlike international travel, hiking is an affordable and accessible adventure. You do not have to worry about the cost of visas, long-haul flights, or expensive hotel stays. Instead, all you need is a good pair of comfortable hiking shoes, a few essentials like water and snacks, and a sense of adventure".*

4.1.2 Health and Wellness Awareness

Another significant factor contributing to the growth of hiking tourism in Ethiopia is the rising awareness of health and wellness, especially in the aftermath of the COVID-19 pandemic. The crisis underscored the importance of physical fitness and mental well-being, prompting more individuals to seek outdoor activities as a form of recreation and self-care. As an eco-friendly and physically engaging activity, hiking gained popularity as a therapeutic way to reconnect with nature, manage stress, and maintain a healthy lifestyle. In this context, an increasing number of residents in Addis Ababa have turned to hiking as a means of escaping the city's hustle and bustle. For many, it offers a refreshing break from daily routines while contributing positively to both mental and physical well-being.

4.1.3 The Role of Social Media and Digital Platforms

Social media has significantly contributed to the rise of hiking tourism. Platforms such as Instagram, Facebook, and TikTok have emerged as powerful tools for promoting hiking activities, primarily through visually appealing content. Respondent R07 shared a compelling perspective, stating:

> *"We regularly share our hiking adventure experiences on Telegram, Instagram and Facebook, and the response has been impressive! The moment we post breathtaking photos of scenic trails in the Menagesha-Suba forest, the view of Wonchi Lake and mountains, and serene forests, people get inspired and immediately want to join. The stunning landscapes, combined with the joy of outdoor exploration, spark curiosity and excitement, making our hiking trips more popular than ever."*

The viral nature of social media has contributed to cultivating a strong hiking culture in Ethiopia by raising awareness of the country's rich natural heritage and inspiring a broader audience to participate in outdoor excursions. This digital exposure has helped expand a growing community of hikers who value adventure, wellness, and social interaction, thereby reinforcing the role of hiking tourism in the post-pandemic recovery of the tourism sector.

4.1.4 Emerging Infrastructure Development

Despite historically limited government policies and infrastructure support, recent efforts indicate a growing recognition of tourism's importance in Ethiopia. Under the Ten-Year Homegrown Economic Reform Agenda (Planning and Development Commission, 2020), tourism has been prioritised as a key sector, prompting the launch of various destination development programs. Notably, government-led initiatives such as Dine for Sheger and Dine for Ethiopia have attracted significant investment and successfully promoted domestic travel, thereby stimulating interest in both rural and urban tourism. These shifts have contributed to the growing popularity of outdoor activities, particularly hiking, which has become a favoured weekend recreational option.

Recognising this emerging trend, the government has begun to extend more support to the tourism sector. As one interviewee (R02) remarked, the Ministry of Tourism is increasingly identifying hiking tourism as a promising niche, particularly in the context of post-pandemic recovery. This marks a notable shift in policy direction, where hiking is viewed not merely as a leisure pursuit but also as a strategic component of national tourism development and economic revitalisation.

4.2. Challenges Faced by Hiking Organizers Amid the Pandemic

The COVID-19 pandemic severely disrupted the global travel and tourism industry, including Ethiopia's hiking tourism sector. Government-imposed travel restrictions halted international travel, necessitating significant adaptations within the industry (Arbulú et al., 2021; Vouloutidou et al., 2021). Even after the lifting of these restrictions at the end of September 2020, hiking organisers continued to face substantial challenges. These included enforcing health protocols, navigating an unregulated market, and dealing with the impact of political unrest, all of which hindered the sector's recovery.

4.2.1 Challenges in Enforcing Health Regulations

As domestic hiking tourism surged after pandemic-related restrictions were lifted, organisers struggled to enforce COVID-19 health and safety measures. When asked about the health regulations, the respondent indicated that ensuring compliance with mask mandates, sanitisation protocols, and social distancing proved difficult. As highlighted by Participant P09, this challenge requires immediate attention:

> *"We used to remind hikers to bring their face masks, carry hand sanitisers, and follow COVID-19 safety protocols. However, enforcing these measures on the trails proved to be quite challenging. With the open-air environment and the physical exertion involved, many found it difficult to keep their masks on at all times. While we did our best to promote safety and responsibility, ensuring full compliance among all participants was not always easy".*

4.2.2 Unregulated Market

Prior to the COVID-19 pandemic, tour operators and guides were required to have licenses, but hiking tourism remained an unregulated sector. The lack of proper control and oversight exacerbated the issue, as anyone could organise hikes without obtaining the necessary legal registration or licensing. This led to inconsistencies in service quality, pricing disparities, and an overall unstable market. The absence of a licensing system to uphold professionalism and service quality has allowed unqualified tourist guides and operators to enter the sector, leading to inconsistent service standards and market instability. Inadequate training among some guides led to issues related to safety, navigation, and customer service, ultimately undermining the quality of the hiking experience. Additionally, the lack of oversight made it difficult for credible operators to compete with unlicensed providers, who often offered lower-priced, subpar services. The absence of regulation thus created an uneven playing field, complicating efforts to improve the overall quality of hiking tourism

4.2.3 Impact of Political Instability

Ethiopia has experienced political instability, with the government issuing State of Emergency decrees in various parts of the country since November 2015 (Kebede, 2018). A dispute between the Federal and Tigray Regional governments escalated into a conflict on November 4, 2020. It escalated into a full-scale war, having a profound impact on the recovery of both domestic and international tourism. In response to the widespread security concerns, the government declared a six-month State of Emergency on November 2, 2021. As a result, hiking tourism was severely disrupted and brought to a halt. Although the war was primarily confined to the northern part of the country, the overall security situation discouraged travel throughout the country. As a result, some organisers postponed planned hikes to conflict-affected areas, such as Simien and Abune Yoseph Mountain, until stability was restored. Even after the state of emergency was lifted, travel demand did not immediately return to pre-war levels and took time to recover. This indicates that political crises tend to have long-lasting adverse effects, often requiring extended periods for recovery compared to other types of crises.

In response to the challenges posed by the pandemic, hiking organisers adopted various strategies to sustain their businesses. To comply with health regulations and rebuild traveller confidence, many offered smaller, private hiking tours, ensuring safer group experiences. Digital marketing

played a crucial role, with organisers leveraging social media platforms to promote hiking opportunities and reassure potential tourists about safety measures. As stated by interviewee P16, how they tackle the challenges:

> *"We increased our online presence by focusing on showcasing the beauty and uniqueness of local hiking spots. Through captivating photos, engaging stories, and informative posts, we showed the diverse landscapes, wildlife, and unique attractions that make these trails worth exploring. By emphasising the natural wonders right at our doorstep, we sparked curiosity and encouraged locals to explore destinations they may not have previously considered. This strategy helped us to regain the trust of local tourists gradually and encouraged more people to explore the outdoors once again."*

To further adapt, many organisers diversified their services by incorporating eco-tourism and wellness-focused hikes and broadening their appeal to cater to shifting consumer preferences.

4.3. Hiking Tourism as an Opportunity for Tourism Recovery and Transformation

Crises and disasters often stimulate new demand, drive technological shifts, and challenge businesses to transform and adapt to changing conditions (Abbas et al., 2021). In this context, COVID-19 catalysed change, influencing consumer behaviour and driving up demand for outdoor adventure tourism. At the same time, it helped tourism operators recognise and respond to these evolving consumer preferences (Noorashid & Chin, 2021). In Ethiopia, this crisis has catalysed a transformation of the tourism sector, particularly by underscoring the potential of domestic hiking tourism. Based on the findings, four main recovery and transformational factors contribute to the resilience and growth of hiking tourism in Ethiopia. These factors include:

4.3.1 Hiking Tourism as a Catalyst for Recovery

Historically, crises have prompted destinations to adapt and innovate. For example, following the Asian Economic Crisis of 1997–1998, Australian tourism redirected its marketing efforts and developed new products and policies (Ritchie, 2004). Similarly, the COVID-19 pandemic has prompted a shift in Ethiopia from an emphasis on international tourism to a focus on domestic markets. As the pandemic restrictions eased, residents sought outdoor activities, leading to a surge in interest in local hiking opportunities. This shift is evident in the words of respondent R12, who thoughtfully reflected on this issue and explained:

> *"After months of isolation and partial lockdowns, locals began to take a renewed interest in hiking and other outdoor activities as a way to unwind and reconnect with nature. Many people who desired fresh air and physical activity turned to the outdoors as a safe and therapeutic escape from stress. Hiking offered them a much-needed break from the confines of home and work, allowing them to explore their surroundings, rejuvenate their mental and physical health, and rediscover the joy of nature. This shift in interest not only helped boost local tourism but also fostered a stronger sense of community, as more people embraced outdoor adventures together".*

This trend aligns with findings by Haywood (2020), who noted that the pandemic significantly altered the attitudes of local populations towards domestic tourism. As international travel became more uncertain and restrictive, people shifted their focus to exploring nearby destinations, seeking the comfort and safety of familiar environments. Haywood also emphasised how the pandemic fostered a deeper connection to local landscapes and led to a surge in domestic travel as people sought relaxation and new experiences closer to home.

4.3.2 Diversifying Hiking Destination and Activities

The hiking organiser demonstrated that offering diverse destinations and incorporating cultural activities played a crucial role in sustaining hiking tourism in Ethiopia during the pandemic. A study by Sharm et al. (2021) also confirmed that diversifying tourism products and services while utilising natural environments is a crucial strategy for enhancing resilience and sustainability in

post-COVID-19 tourism. The success of this approach was evident, as hiking organisers achieved significant milestones from their strategic efforts to diversify offerings for the domestic market. This aligns with findings from other studies (Noorashid & Chin, 2021; Kristiana, Pramono, & Brian, 2021; Giampiccoli & Mtapuri, 2021), which emphasised that expanding niche tourism products and leveraging natural resources are effective ways to revitalise the industry.

In the case of hiking tourism in Ethiopia, trips initially focused on specific destinations such as Wenchi (Wonchi) Crater Lake, Debre Libanos Monastery, Lake Ziway (Dambal), and nearby areas. However, as hiking tourism grew, organisers began to diversify and expand their operations to new destinations, including Yerer Mountains, Ensaro, Menelik-Meskot, Ankober, and Kormasho. These destinations offer unique experiences and provide personalised services to their customers. Moreover, to make hiking tours more distinctive and engaging, various activities were incorporated, including tree planting, cultural exchange programs, local language learning, and traditional music and dance performances. Beyond adventure, hikers also participated in charity work by providing school supplies such as exercise books, pens, and pencils to students in need.

Consequently, the pandemic enhanced hiking organisers' expertise in selecting destinations, designing packages, and arranging hiking tours to meet the interests of residents. Additionally, it fueled greater interest among residents in outdoor activities, leading to more extended stays, overnight hiking programs, and an increasing number of departures to various hiking destinations.

4.3.3 Fostering Local Engagement and Sense of Local Belongingness

The pandemic encouraged the focus on domestic tourism and strengthened Ethiopians' connection to their natural and cultural heritage. As Sharma et al. (2021) stated, travelling to nearby destinations has fostered a sense of place attachment and community pride. Similarly, the expansion and diversification of hiking activities have also contributed to building a sense of local belongingness and pride among Ethiopians. Travelling to a close-to-home destination boosts cultural exchange and community connection with local places and the natural environment. This has been validated by scholars in tourism research, both during and post-pandemic times. For instance, Mackenzie and Goodnow (2020) emphasised that post-pandemic adventure travel is confined to local and micro-adventures. Likewise, Haywood (2020) indicated that the pandemic changed tourist travel patterns to more domestic, short-day, and outdoor activities. Based on the study findings, hiking allowed most residents of Addis Ababa to develop a sense of place attachment and gain a deeper understanding of their country. This result reconfirmed the previous study by Collins-Kreiner and Kliot (2016), which found that hiking helps create a strong feeling and sense of identity among Israelis.

Furthermore, Sharma et al. (2021) stress that the feeling of belongingness motivates and drives for quick revival and recovery of the tourism industry. This context may apply to the current domestic hiking tourism in Ethiopia. As the hiking organisers claimed, the pandemic has made locals appreciate what nature has gifted to the country while also contributing to the development of domestic tourism. Boosting domestic tourism is also a national Sustainable Development Goal of the country, to be achieved by 2030 (MOCT, 2020). The pandemic has allowed us to recognise the capacity of domestic hiking tourism and served as an intervention for the sector's development. This is also evident in Community-Based Tourism (Noorashid & Chin, 2022) in Brunei and other Southeast Asian countries (Adams, Choe, Mostafanezhad, and Phi, 2021).

While the pandemic has driven the transformation of tourism from its traditional way of operating to a new, demand-oriented, outdoor adventurous model. As a result, hiking has emerged as a new concept for the domestic market amid the pandemic. Currently, domestic hiking tourism is being utilised as a resilience measure for the country's tourism industry.

4.3.4 Leveraging Crisis for Tourism Transformation

The challenges posed by COVID-19 have also presented opportunities to rethink and reshape Ethiopia's tourism sector. This transformation can be framed through three critical actions: First, rethinking tourism operations by recognising the risks of depending solely on international markets, which has led to a strategic shift toward domestic tourism. This includes creating customised

and diversified tour packages for local communities. Second, we will reset the sector with a strong emphasis on environmental sustainability and community involvement. By adopting eco-tourism principles, operators are adding value for both tourists and host communities and, third, redefining the tourism sector by focusing not just on increasing visitor numbers but on improving the quality of experiences and their positive impact on local communities. Hiking tourism now serves as a conduit for cultural exchange, community empowerment, and environmental stewardship.

This strategic realignment positions Ethiopia's tourism industry to emerge more resilient and sustainable in the post-pandemic era. While the COVID-19 pandemic has posed significant challenges to Ethiopia's tourism sector, it has also unveiled opportunities for growth and transformation. The rise in domestic hiking tourism, driven by shifts in consumer behaviour and a growing appreciation for local natural resources, has transformed the industry's landscape.

4.4 Conceptual Framework of COVID-19 Crisis, Tourism Recovery and Transformation

During the COVID-19 pandemic, various scholars proposed frameworks for post-pandemic tourism recovery. Sharma et al. (2021) emphasised resilience, while Bai and Ran (2022) focused on stakeholder collaboration in China's tourism supply chain. Tiwari and Chowdhary (2021) highlighted the role of sustainable energy in recovery. This study presents the COVID-19 crisis as a transformative opportunity, particularly for the emergence of hiking tourism in Ethiopia. The proposed conceptual framework, as shown in Figure 1, is structured into three phases: pre-pandemic, during the pandemic, and post-pandemic.

Prior to the pandemic, Ethiopia's tourism sector relied heavily on international visitors, with minimal or no domestic hiking tourism. During the COVID-19 pandemic, the international tourism industry was halted by measures taken to control the spread of the virus. During the COVID-19 crisis, people developed a behavioural shift towards outdoor relaxation, seeking health and wellness, where government support for outdoor activities was revealed. As restrictions eased, domestic hiking emerged as a popular alternative, reshaping travel preferences and giving rise to new tourism patterns. At this phase, the transformative power and positive effect of the pandemic changed customer behaviour and resulted in the origin and rise of hiking tourism in Ethiopia. Consequently, it is essential to strike a balance between the positive and negative effects of the pandemic. Thus, alongside the use of technology to mitigate the negative impact of the pandemic, it is essential to accelerate tourism operations for post-pandemic development. Considering the transformative power and positive effects of the pandemic, it is crucial to ensure tourism recovery and transformation. The post-pandemic phase is characterised, first, by building resilience, including diversifying hiking destinations, offering wellness and eco-tourism activities, and promoting community involvement. Second, tourism recovery is expected to bring benefits such as increased local travel demand, job creation, and income generation. Third, tourism transformation is evident in new travel norms, a demand for soft outdoor activities, digital promotion of tourism, and a growing sense of local belonging.

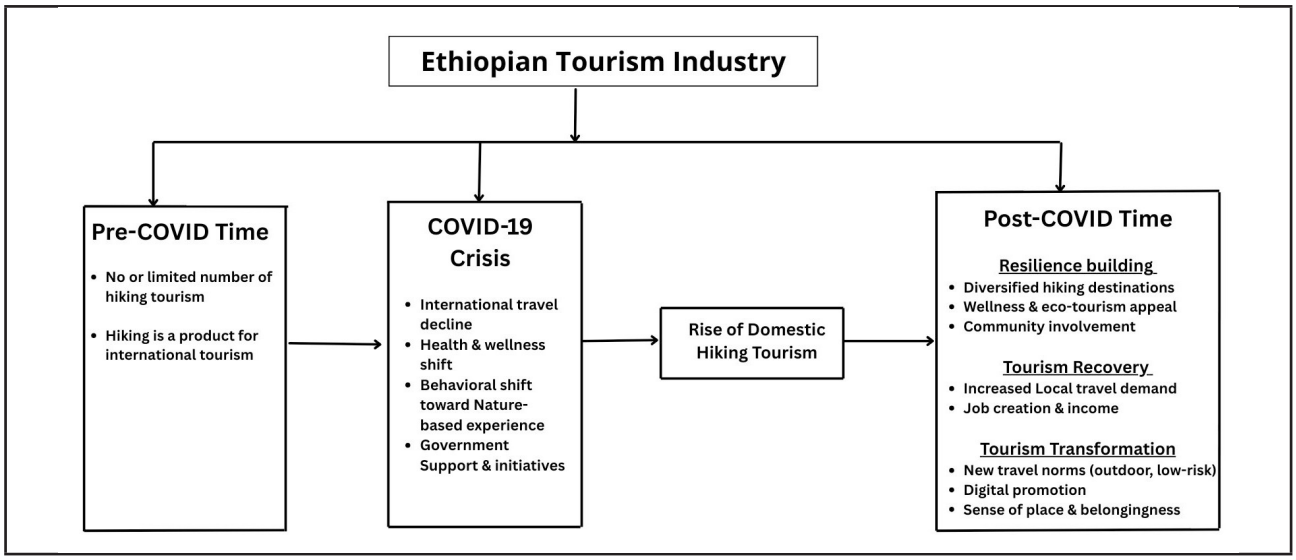

Figure 1. COVID-19 and Tourism: Recovery & Transformation Framework. Source: Author's elaboration.

5. Discussion

This study has examined the rise of domestic hiking tourism and detailed the impacts of COVID-19 on hiking tourism from the perspective of organisers during the pandemic. In this context, the study found that hiking tourism in Ethiopia has emerged as a significant segment within the domestic tourism market, driven by evolving travel preferences, increased health awareness, and the power of digital media. The growth of hiking tourism has been further reinforced by government initiatives aimed at promoting domestic travel, especially in the post-pandemic era. This is a widely recognised finding in recent research on tourism recovery from the COVID-19 crisis (Noorashid & Chin, 2021). However, challenges such as a lack of regulatory oversight, health and safety compliance issues, and political instability have hindered its full potential. Despite these obstacles, the sector has demonstrated resilience through innovative marketing strategies, flexible tour offerings, and the growing enthusiasm for outdoor recreational activities. The COVID-19 pandemic has also reshaped Ethiopia's tourism sector, accelerating the growth of domestic hiking tourism as a resilient and adaptive response to the pandemic.

Additionally, many countries have turned to domestic tourism to mitigate the losses resulting from international travel restrictions. For instance, Vietnam's domestic tourism market made a significant contribution to its recovery in 2022, highlighting the potential of local travel to revitalise the economy (Tung & Duc, 2023). Sub-Saharan Africa faces unique challenges in harnessing domestic tourism, yet it remains a critical strategy for recovery, emphasising the need for tailored approaches to overcome inherent constraints (Matiza, 2022).

In brief, the study's findings provided evidence of the potential for crises and disasters to drive positive change through product repositioning, adjustments to existing operational practices, and the recognition of new markets. Hence, it can be concluded that Ethiopia's domestic hiking tourism has emerged as a key driver for recovery and future growth. Therefore, it is highly recommended that sustainable hiking tourism development be ensured through policy support, infrastructure investment, and adherence to quality standards, as these will be crucial for the long-term success of Ethiopia's hiking tourism.

6. Conclusions

The study presents three main academic implications. First, the study reveals a shift toward nature-based and experience-driven tourism, aligning with global trends that emphasise sustainability, wellness, and cultural exchange. Hence, the study offers new insights and knowledge to

help understand post-pandemic travel behaviour, revealing an increasing preference for local and cost-effective outdoor experiences.

Second, while research on the COVID-19 crisis has increased, much of the literature has focused on its adverse impacts on health, society, and the economy. However, only a few studies have indicated the pandemic's positive, opportunistic, and transformative potential (Seabra & Bhatt, 2022; Abbas et al., 2021). The pandemic prompts a reevaluation of pre-COVID tourism operations and the development of new strategies for tourism recovery and sustainability. The adaptability of hiking tourism businesses in Ethiopia demonstrates how crisis response mechanisms, such as digital marketing and product diversification, can help mitigate external shocks. Third, it also underscores the growing role of social media. Social media is playing an increasingly vital role in shaping travel decisions and promoting niche tourism by influencing consumer behaviour, enhancing destination visibility, and fostering engagement. This study contributes to the enrichment of the literature on how social media enhances tourism recovery and transformation following crisis and disaster.

The study has several practical implications for tourism entrepreneurs and policymakers in the Ethiopian context. First, the study has practical implications for governments to develop tourism sector-wide contingency plans and risk management strategies to ensure resilience against political instability and public health crises. The study's findings indicate that the government can recognise how the COVID-19 pandemic has changed consumer behaviour, which helps in developing better tourism recovery strategies. By adapting policies and actions to fit the new normal, where travellers prefer safer outdoor and domestic experiences, authorities can create a more resilient and sustainable tourism sector. Second, the study suggests that the government should take a leading role in regulating and licensing hiking organisers to ensure consumer rights and promote recovery and crisis management. It urges the government to establish a clear regulatory framework, including licensing, safety standards, and compliance monitoring for hiking operators. Finally, this study emphasises the significance of domestic hiking tourism, which played a crucial role in revitalising the tourism industry, particularly during times of crisis such as the COVID-19 pandemic. Consequently, to support domestic adventure tourism, targeted institutional support is essential. This can involve financial incentives, such as micro-grants and tax relief, for local tourism businesses. Additionally, capacity-building programs focused on marketing, environmental management, and digital promotion, as well as basic infrastructure development, including marked trails, rest areas, and sanitation facilities. Additionally, domestic tourism should be integrated into national strategies for resilience and recovery. These actions will help ensure a safer, more sustainable, and resilient tourism sector.

Despite its contributions, the study has several limitations. Its focus on popular hiking destinations near Addis Ababa restricts the generalizability of findings to other regions of Ethiopia. Furthermore, the study primarily examines organised urban hiking groups, which may introduce bias by excluding informal or rural hiking practices that could present alternative perspectives. The informal nature of many hiking groups presents challenges in obtaining comprehensive data on participation rates and economic impact. Additionally, the study primarily captures insights from hiking organisers while lacking extensive government perspectives on policy and regulation. Given its short-term focus, future research should adopt a longitudinal approach to assess long-term sustainability trends in Ethiopia's hiking tourism sector. Addressing these limitations will provide a more holistic understanding of the industry and guide future policy and strategic decisions for sustainable development.

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Article

Predictors of Disaster Response Self-Efficacy Among Adult Residents in Selected Highly-Dense Barangays in Tondo, Manila

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ABSTRACT

The Philippines' geographical location and high population density, along with the effects of climate change, make the country vulnerable to disasters like typhoons, fires, earthquakes, and volcanic eruptions. Densely populated areas, such as Tondo, Manila, are especially at risk, necessitating stronger community disaster preparedness and response efforts. Thus, this study examined the predictors and level of disaster response self-efficacy (DRSE) among adult residents of highly dense barangays in Tondo, Manila. The study utilised a descriptive correlational research design. A total of 281 participants from three selected, highly dense barangays in Tondo, Manila, were recruited through convenience sampling. Data were collected using an adapted and validated instrument that assessed disaster response self-efficacy and its associated predictors. The reliability of the instrument was confirmed using Cronbach's alpha, and the data were analysed using multiple linear regression in IBM SPSS Version 25. Significant predictors of disaster response self-efficacy included community support ($B = 0.382$, $p < 0.000$), past disaster experience ($B = 0.196$, $p < 0.000$), perceived susceptibility ($B = 0.169$, $p = 0.006$), and monthly income ($B = -0.00000685$, $p = 0.005$). No significant associations were observed for gender, education level, duration of residence, geographical perspective, or perceived severity of the condition. Overall, participants exhibited high disaster response self-efficacy. Community support, past disaster experiences, and perceived susceptibility all enhance disaster response self-efficacy in highly dense urban populations, while income constraints appear to be a limiting factor. These findings underscore the need for targeted public health strategies to strengthen community resilience and preparedness in vulnerable areas.

KEYWORDS

Predictors; disaster response; self-efficacy; highly-dense barangays; Tondo; Manila.

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1. Introduction

Disasters, as defined by the Disaster Risk Reduction Resource Manual (2008) and the UNDRR (2024), are emergencies caused by natural or human-induced hazards that disrupt communities, particularly in high-risk areas. These disasters are often unpredictable and can strike anywhere, exposing individuals to significant harm and exacerbating vulnerabilities in areas that lack resources for timely intervention, particularly those with poor maintenance (Uhm et al., 2019).

The Philippines ranks among the most disaster-prone countries globally due to its location in the Pacific Ring of Fire (Holden et al., 2017). Frequent occurrences of typhoons, earthquakes, and volcanic eruptions put it at high risk for severe natural disasters, which are compounded by the effects of climate change (Ridulme & Garcia, 2017). Additionally, low public preparedness and insufficient knowledge of climate-related risks intensify the impact of these disasters (Bollettino, 2020).

The rapid and unregulated pace of urbanisation is a significant factor contributing to disaster risk, as cities, with their dense populations, are particularly vulnerable to both natural and artificial hazards (Parvin et al., 2015). This is especially evident in urban areas, where the risk of earthquakes is increasing due to the high concentration of housing and people. Similar trends have been observed in several Asian developing countries, including India, Indonesia, Nepal, and Pakistan, where field surveys have highlighted heightened vulnerability to such disasters (Okazaki & Pribadi, 2015).

In urban areas, such as the National Capital Region (NCR), high population density further amplifies vulnerability. With over 21,765 people per square kilometre, the NCR exceeds national urbanisation rates, driven by rural-to-urban migration and the pursuit of better opportunities (Philippine Statistics Authority, 2021a; Choi, 2021). Tondo, a district within the NCR, exemplifies this urban density, with approximately 631,000 residents as of 2024, making it one of the most densely populated places in the world (Lena, 2022). Such high-density environments pose increased risks for disasters due to congestion and limited access to resources (Donner & Rodriguez, 2011).

Recent data highlights the magnitude of Tondo's vulnerability. In 2023, more than 13.7 million Filipinos were affected by natural hazards, coinciding with the onset of a severe El Niño phenomenon expected to persist until mid-2024 (OCHA, 2024). Fire incidents are alarmingly frequent, with approximately 12,000 cases reported annually in Tondo alone, necessitating the implementation of enhanced fire prevention and management strategies (Kurata et al., 2023). Furthermore, Tondo's low-lying geography makes it susceptible to flooding, which is exacerbated by inadequate flood control measures, climate change, and the annual occurrence of 20 typhoons (Gilbuena, 2013; UNDER, 2023).

Although physical hazards pose significant threats, especially in densely populated areas like Tondo, Manila, disaster vulnerability is also shaped by underlying social conditions. Social factors, including socioeconomic status, minority background, and household composition, have been linked to lower levels of disaster preparedness (Rao et al., 2022). These social vulnerabilities, which also include limited access to education and weak community support systems, can substantially hinder individuals' ability to prepare for, respond to, and recover from disasters.

Disaster response self-efficacy—the belief in one's ability to plan and execute effective disaster response measures—plays a crucial role in reducing risks and improving disaster outcomes (Labrague et al., 2021). Factors such as community support, past disaster experiences, and social and cognitive dimensions have been identified as significant contributors to disaster preparedness (Drabek, 2005; Legesse, 2016). Similarly, risk perception has been found to shape fire preparedness in urban areas (Cvetković, 2019; Cvetković, 2024). Professional training and experience also contribute to increasing one's disaster preparedness (Cvetković & Janković, 2020). Furthermore, coordination and collaboration between organisations enhance the community's disaster response (El-Mougher, 2022).

However, existing literature on disaster response self-efficacy has primarily focused on broader populations, neglecting the unique challenges of densely populated urban areas, such as Tondo (Gumasing et al., 2022; Gumasing & Sobrevilla, 2023). Moreover, the studies often exclude artificial disasters, further limiting the understanding of disaster response self-efficacy in such contexts (Tan et al., 2024). This study seeks to address these gaps by identifying predictors of disaster response

self-efficacy among adult residents in Tondo. Specifically, it aims to assess the level of disaster response self-efficacy among residents in selected barangays. It explores the impact of sociodemographic factors, geographical perspectives, past disaster experiences, community support, and disaster attitudes on residents' ability to respond effectively during disasters.

By doing so, it provides critical insights for public health and nursing professionals to develop tailored disaster response plans and strategies. The findings of this research aim to support local government units in enhancing disaster preparedness programs while also informing disaster nursing curricula. Ultimately, this study contributes to strengthening community resilience in one of the country's most vulnerable urban areas.

2. Objectives

This study aimed to determine the level of disaster response self-efficacy among adult residents in selected highly dense barangays in Tondo, Manila. It also sought to examine whether there was a significant relationship between disaster response self-efficacy and sociodemographic factors (gender, age, educational attainment, monthly income, and duration of residence), geographical perspective, disaster attitude, perceived susceptibility, perceived severity, past disaster experience, and community support.

3. Methods

The study utilised a descriptive correlational research design. This design seeks to determine the relationship between the variables without the researchers manipulating any of these variables (Bhandari, 2021).

3.1. Sampling and Participants

This study surveyed 281 adult residents from three highly dense barangays in Tondo, Manila, focusing on those aged 18–59 who had lived in these areas for at least six months. Participants with debilitating conditions (e.g., physical disabilities, speech and language impairments, hearing or vision issues) or psychological/emotional distress (e.g., PTSD, depression, anxiety) were excluded to ensure reliable responses. A sample size calculation using the Raosoft sample size calculator was based on a population of 654,220 residents (Philippine Statistics Authority, 2021), with a 90% confidence interval and a 5% margin of error. A minimum sample size of 271 was determined, aligning with Cohen's (1988) guidelines for multiple linear regression at an effect size of 0.02, which ensures sufficient power for detecting minor effects (Selya et al., 2012). The three barangays were selected based on population density and research objectives, with 91 participants recruited per barangay through convenience sampling. This non-probability method, commonly used in disaster and prehospital research (Stratton, 2021), involved selecting participants who were available during data collection. In households with multiple eligible adults, all were invited to participate, ensuring comprehensive data from the target population.

3.2. Measures

The study adapted an instrument from Gumasing et al. (2022) on Filipinos' response efficacy during Typhoon Conson (Jolina) 2021, focusing on disaster response self-efficacy. The original tool included eight sections, but for this study, six were used: (1) Sociodemographic Data, (2) Geographical Perspective, (3) Past Disaster Experience, (4) Disaster Response Self-Efficacy, (5) Community Support, and (6) Disaster Attitude, with the latter divided into Perceived Susceptibility and Perceived Severity.

The survey included 45 questions. Sociodemographic Data consisted of 5 items (gender, age, education, income, and duration of residence), while Geographical Perspective had six yes/no questions. The remaining sections used a 5-point Likert scale to measure agreement, ranging from 1 (strongly disagree) to 5 (strongly agree). Likert scales were applied to Past Disaster Experience (6 items), Disaster Response Self-Efficacy (12 items), Community Support (5 items), and Disaster Attitude (11 items across Perceived Susceptibility and Severity). Geographical Perspective scores were binary (Yes = 1, No = 0), yielding a total range of 0–6. Past Disaster Experience, Community Support, and Disaster Response Self-Efficacy were scored on a scale of 6 to 30, 6 to 30, and 12 to 60, respectively. The mean of responses in each category was used to classify disaster response self-efficacy into high, moderate, or low scores, as described by Li et al. (2017). Disaster Attitude had a range of 11–55 points, with the mean score providing a classification of high, moderate, or low attitudes.

Participants were oriented about the study and given 30 minutes to complete the questionnaire, with additional time allowed if necessary. This ensured accurate, thoughtful responses. The reliability of the tool was confirmed through a pilot test with 17 participants in Barangay 34 of Tondo, yielding a Cronbach's alpha of 0.913. The instrument's sections had the following reliability scores: Geographical Perspective (α = 0.723), Past Disaster Experience (α = 0.823), Community Support (α = 0.797), Perceived Susceptibility (α = 0.752), Perceived Severity (α = 0.785), and Disaster Response Self-Efficacy (α = 0.793).

Before field deployment, the questionnaire was translated into Filipino to ensure clarity, with validation conducted by a panel of disaster experts. Harman's Single Factor Test showed no standard method bias (CMB), confirming the tool's validity for this study.

3.3. Data collection

The study commenced following approval from the UST College of Nursing Ethics Review Committee and Research Board. After obtaining permissions from barangay chairpersons and conducting briefings in three highly dense barangays in Tondo, Manila, 281 participants were selected through convenience sampling, focusing on those aged 18–59 who had lived in Tondo for at least six months and were able to participate voluntarily. The survey was conducted in these three barangays, with a minimum of 91 participants from each. The research team was divided into two groups to distribute the Likert-scale questionnaires efficiently, and participants were given 30 minutes, with additional time allowed if necessary. If multiple participants were in the same household, they answered separately to prevent bias.

Participants were informed about the study's purpose, protocols, and the safeguards in place for their privacy. They provided informed consent, understanding their voluntary participation and the option to withdraw at any time without consequence. Data privacy was strictly ensured. Once collected, the data were analysed using multiple linear regression analysis, examining how sociodemographic factors, geographical perspective, past disaster experience, community support, and disaster attitude predicted Disaster Response Self-Efficacy.

4. Results and Discussion

Table 1 reveals the level of disaster response self-efficacy among residents in a highly dense barangay in Tondo, Manila, highlighting their confidence in handling disasters. The study found that residents of highly dense barangays in Tondo, Manila, demonstrated strong disaster response self-efficacy, reflecting high confidence in individual preparedness and self-protection.

Table 1. Level of Disaster Response Self-Efficacy of Adult Residents in a Selected Highly-Dense Barangays in Tondo, Manila

Indicators	Mean	SD	Interpretation
1. I can prepare and secure my property in the event of a disaster.	4.04	1.031	High DRSEa
2. I have a safety plan for dealing with a disaster.	4.15	0.904	High DRSEa
3. I can prepare an emergency kit ahead of a disaster.	4.22	0.974	High DRSEa
4. I can secure food and water ahead of a disaster.	4.24	0.966	High DRSEa
5. I can protect myself against a disaster.	4.23	0.894	High DRSEa
6. I can evacuate ahead of a disaster when necessary.	4.31	0.842	High DRSEa
7. Evacuating ahead of time will protect me from a disaster.	4.40	0.852	High DRSEa
8. Securing our property ahead of time will protect our assets from damage caused by disasters.	4.22	0.983	High DRSEa
9. Distribution of relief goods and rescue supplies will help me during a disaster.	4.36	0.884	High DRSEa
10. Deploying emergency teams and emergency responders will help me during the disaster.	4.40	0.897	High DRSEa
11. Broadcasting information and emergency information will help me during a disaster.	4.39	0.900	High DRSEa
12. The suspension of work and classes during a disaster will protect people from the disaster.	4.38	0.968	High DRSEa
Overall Disaster Response Self-Efficacy	4.28	0.651	High DRSEa

Legend: 3.68–5.00 (High), 2.34–3.67 (Moderate), 1.00–2.33 (Low)

a

Disaster Response Self-Efficacy

Residents reported feeling capable of securing their property (M = 4.04), having safety plans (M = 4.15), preparing emergency resources (M = 4.22), and protecting themselves during disasters (M = 4.23). These results align with prior studies showing that higher perceived self-efficacy leads to greater preparedness (Mideksa, 2021; Ung et al., 2015), which involves a person thinking and organising activities to achieve a desired goal in preparation for a disaster.

Regarding evacuation preparedness, residents showed confidence in evacuating promptly (M = 4.31) and the protective benefits of timely evacuation (M = 4.40). This aligns with research indicating that high self-efficacy strengthens evacuation plans and responses (Lindell & Perry, 2011; Newnham et al., 2017), suggesting that people with higher self-efficacy may be more likely to recognise the complex barriers to evacuation and develop a plan to overcome them. In terms of asset protection, respondents displayed strong awareness of the importance of safeguarding physical assets (M = 4.22), such as homes and belongings, to mitigate disaster-related losses (Islam & Walkerden, 2022; Motsholapheko et al., 2010).

External support measures also received strong support, with participants agreeing on the value of relief distribution (M = 4.36), emergency teams (M = 4.40), and reliable communication systems (M = 4.39). This highlights the crucial role of government and community resources in disaster response (Xu et al., 2020; Houston et al., 2019), reflecting the importance of collaborative efforts in disaster management.

Overall, with a mean score of 4.28, the results indicate a high level of disaster response self-efficacy among Tondo residents, highlighting their preparedness, awareness of timely evacuation, and reliance on external support systems.

Table 2 presents the relationships between the predictors and the residents' disaster response self-efficacy among adult residents in selected highly dense barangays in Tondo, Manila. Results show that monthly income, perceived susceptibility, past disaster experience, and community support significantly influenced self-efficacy, with community support being the strongest predictor. Other variables, including gender, age, education level, duration of residence, geographical perspective, and perceived severity, did now show significance.

Table 2. Relationship of Factors to the Disaster Response Self-Efficacy of the Adult Residents in Selected Highly-Dense Barangays in Tondo, Manila

Predictor Variable	B	SE B	β	t	p	Conclusion
Gender	0.017	0.052	0.015	0.327	0.744	Not Significant
Age	-0.001	0.003	-0.030	-0.401	0.689	Not Significant
Education level	-0.009	0.011	-0.042	-0.837	0.403	Not Significant
Monthly income	-.00000685	0.000	-0.139	-2.821	0.005	Significant
Duration of residence	-0.002	0.003	-0.050	-0.667	0.505	Not Significant
Geographical perspective	-0.030	0.020	-0.073	-1.457	0.146	Not Significant
Disaster attitude: Perceived Susceptibility	0.169	0.061	0.177	2.784	0.006	Significant
Perceived severity	0.068	0.051	0.077	1.351	0.178	Not Significant
Past Disaster Experience	0.196	0.045	0.229	4.364	0.000	Significant
Community Support	0.382	0.051	0.396	7.423	0.000	Significant

Significant p-value: p <0.05

4.1. *Sociodemographic Predictors*

4.1.1. Gender

Gender (B = 0.017, p = 0.744) showed a positive but statistically insignificant relationship with disaster response self-efficacy, rejecting the hypothesis that gender significantly impacts self-efficacy. Although gender is a dichotomous variable, the results do not support the idea that adult males exhibit higher self-efficacy than females. This contradicts Bronfman et al. (2019) and Qiu et al. (2023), who suggest men are more disaster-prepared. However, the study aligns with Cuesta et al. (2022), noting that women tend to have higher risk perceptions, which could contribute to greater preparedness and self-efficacy. The findings suggest that varying perceptions, awareness, and involvement in disaster preparedness contribute to gender differences in self-efficacy.

4.1.2. Age

Age (B = -0.001, p = 0.689) displayed a negative, statistically insignificant relationship with disaster response self-efficacy, rejecting the hypothesis of a positive link between age and self-efficacy. Although older adults typically exhibit lower preparedness due to health and vulnerability (Olawuni et al., 2020; Bronfman et al., 2019), the current study found no significant age-based differences. This contrasts with findings from Hua Yao (2019), who also reported no significant association between age and disaster preparedness confidence.

4.1.3. Educational Level

Educational level (B = -0.009, p = 0.403) did not significantly influence disaster response self-efficacy. This finding aligns with Peng et al. (2020), who highlighted that disaster-specific knowledge, rather than formal education, is crucial for enhancing self-efficacy in disaster response. While higher education may contribute to disaster readiness (Çiriş Yildiz & Yildirim, 2022), the current study

suggests that exposure to targeted disaster education programs or practical experience may be more influential in building self-efficacy. Accordingly, disaster preparedness may depend on specialised knowledge and community support rather than general education alone.

4.1.4. Monthly Income

Monthly income showed a significant negative relationship with disaster response self-efficacy (B = −0.139, p = 0.005), indicating that higher income is associated with lower self-efficacy. This counterintuitive result may stem from wealthier individuals relying on private protection systems and external resources, such as insurance or professional rescuers, which reduces the need to develop personal disaster response skills. Yu et al. (2022) highlighted that socioeconomic status, including income, influences preparedness and self-efficacy. Lower-income groups, often with limited external support, tend to be more resourceful, increasing their disaster response self-efficacy. Rivera (2022) also found higher self-efficacy among economically disadvantaged populations, attributing this to their reliance on personal coping strategies. These results suggest that higher-income groups may feel less inclined to engage in community-level preparedness due to their financial resources, underscoring the relationship between income, readiness, and self-confidence.

4.1.5. Duration of Residence

Duration of residence (B = −0.002, p = 0.505) revealed a negative but statistically insignificant relationship with disaster response self-efficacy, rejecting the hypothesis that longer residence predicts higher self-efficacy. This finding contrasts with Adeola's (2009) study, which found that the duration of residence was significant in predicting evacuation outcomes during Hurricane Katrina. However, the results align with Bollettino et al. (2020), who noted that long-term residents in the Philippines often exhibit complacency and lower disaster preparedness. Participants in this study reported that their barangays are rarely affected by severe disasters, leading to a reduced sense of urgency for preparedness. Prolonged exposure to disasters may diminish perceived risks, as noted by Mirzan and Turan (2022), with long-term residents displaying less inclination to prepare due to increased attachment to their community and environment.

4.1.6. Geographical Perspective

The geographical perspective (p = 0.146) was not significantly related to disaster response self-efficacy (DRSE), suggesting that geographical awareness alone does not enhance disaster preparedness. This aligns with Qiu et al. (2023), who noted that while geographic knowledge can inform risk understanding, it must be coupled with proper disaster preparedness and training to address disaster risk and emergency response (DRSE) effectively. Gammon et al. (2023) further emphasised the importance of community engagement and trust in disaster response systems. The negative regression coefficient (B = −0.030) indicates that respondents in perceived low-risk areas may underestimate potential threats, leading to complacency and reduced preparedness. A majority of respondents did not perceive their area as vulnerable to certain disasters, such as typhoons (59.07%) or flooding (76.16%), which may reduce their sense of urgency in responding to disasters. This highlights the need to integrate geographic education with practical disaster training to enhance preparedness.

4.1.7. Disaster Attitude

4.1.7.1. Perceived Susceptibility

Perceived susceptibility was positively related to DRSE (B = 0.177, p = 0.006), indicating that higher vulnerability perceptions were associated with increased disaster preparedness. This is consistent with Kurata et al. (2022) and Bempah & Øyhus (2017), who found that recognising vulnerability drives proactive measures. The positive regression coefficient (0.69) suggests that as residents' perceived susceptibility increases, their confidence in disaster response also grows. This supports the findings by Hudson et al. (2020), who linked risk perceptions to higher self-efficacy. However, Qiu et al. (2023) argued that the relationship can vary depending on household circumstances. In this

study, over half of the respondents (56.94%) lived in homes that might heighten their vulnerability to damage during disasters, which likely influenced their perception and preparedness.

4.1.7.2. Perceived Severity

Perceived severity was not significantly associated with DRSE (B = 0.068, p = 0.178). This aligns with Jackson (1981) and Rüstemli & Karanci (1999), who found no correlation between perceived disaster severity and preparedness. While some studies, such as those by Ong et al. (2022) and Gumasing et al. (2023), have reported that higher perceived severity leads to greater preparedness, the current findings suggest that long-term residency may reduce perceptions of disaster severity. Respondents who have lived in their areas for many years (mean = 29.85 years) may perceive minimal future risks, especially if prior disasters caused little harm, which can lead to complacency.

4.1.8. Past Disaster Experience

Past disaster experience (B = 0.196, p < 0.000) was a significant positive predictor of disaster response self-efficacy (DRSE). Previous exposure to disasters enhances preparedness, knowledge, and confidence, fostering resilience for future challenges. Kato (2021) and Bollettino et al. (2020) emphasised that firsthand experience not only improves readiness but also equips individuals with essential skills to manage future disasters effectively. However, Demuth et al. (2016) found that traumatic experiences in hurricane-prone areas could lower self-efficacy.

The present findings support the idea that past disaster experiences positively influence DRSE, even if they involve trauma, as these events build competence and practical skills. Repeated exposures help residents develop effective strategies to handle future disasters. Despite the potential negative impacts of trauma, as noted by Panighari and Suar (2021), such experiences encourage knowledge sharing within communities, further improving disaster preparedness. Given the vulnerability of Tondo's densely populated areas to frequent disasters, respondents have developed coping strategies and heightened disaster risk reduction and emergency response (DRSE) capabilities, often due to repeated exposure and desensitisation. These experiences contribute to increased resilience and improved disaster readiness.

4.1.9. Community Support

Community support (B = 0.382, p < 0.000) showed a significant positive relationship with DRSE, underscoring the importance of local resources in disaster preparedness. Access to training programs, resource distribution, and disaster response systems greatly enhances residents' confidence and readiness. This finding aligns with those of Gundran et al. (2022) and Sofyana et al. (2024), which highlight the effectiveness of community-based disaster programs.

Research indicates that such programs lead to significant improvements in knowledge, skills, and engagement in disaster response activities, directly boosting DRSE. In Tondo, where resources are limited and the population is highly vulnerable, community-based approaches, such as disaster training and the distribution of first aid kits, can enhance both individual and collective preparedness. The study suggests that strengthening community support can significantly improve disaster response efforts, particularly in communities with established disaster management committees.

Table 3 presents the summary of the multiple linear regression model. The results show a strong positive relationship (R = 0.671) between disaster response self-efficacy and its predictors, including community support, duration of residence, gender, education level, monthly income, geographical perspective, past disaster experience, perceived severity, perceived susceptibility, and age.

Table 3. Multiple Linear Regression R Model Summary

Model Summary					
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0.671[a]	0.450	0.429	0.41166	1.949

[a] Predictors: (Constant), Community Support, Duration of residence, Gender, Education level, Monthly income, Geographical Perspective, Past Disaster Experience, Perceived Severity, Perceived Susceptibility, Age

[b] Dependent Variable: Disaster Response Self-Efficacy

The R Square value of 0.450 indicates that these predictors explain 45% of the variability in DRSE. The adjusted R-squared value of 0.429 accounts for the number of predictors and sample size, providing a more accurate estimate of the model's goodness of fit. The standard error of the estimate (0.41166) suggests the model's predictions are reasonably close to the observed data, further validating its accuracy. The Durbin-Watson statistic (1.949) indicates no significant autocorrelation in the residuals, confirming the independence of residuals and reinforcing the model's reliability.

5. Conclusions

In conclusion, adult residents of the selected highly dense barangays in Tondo, Manila, demonstrate a high level of disaster response self-efficacy, reflecting strong confidence in their ability to respond to disasters. The study identified key predictors of disaster response self-efficacy, including monthly income, perceived susceptibility, past disaster experience, and community support. These factors highlight the importance of financial resources and community engagement in enhancing individuals' confidence in disaster response. Additionally, perceived susceptibility and past disaster experience can be leveraged to strengthen disaster response self-efficacy further.

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Female Gender Empowerment, Individualism, Collectivism, and Resilience: A Comparative Study in the Context of Disaster Risk Management

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ABSTRACT

The paper examines the relationship between female gender empowerment, societal ideologies (individualism and collectivism), and disaster resilience. It examines whether higher female empowerment is correlated with greater individualism and whether male empowerment aligns with collectivist values. Additionally, it evaluates how these ideological orientations influence societal resilience in disaster contexts. Utilising data from the Global Gender Gap Report, Hofstede's Cultural Dimensions, and the UNDRR Resilience Index, this study employs Pearson's correlation analysis to determine relationships between gender empowerment and ideology. At the same time, multiple regression modelling assesses their impact on disaster resilience. Findings reveal a strong correlation between female empowerment and individualism, as well as between male empowerment and collectivism. Regression results indicate that individualism has a negative influence on resilience, while collectivism enhances resilience. These results suggest that collectivist societies, often characterised as male-dominated, may provide stronger structural support for disaster risk management, whereas individualistic societies linked to female empowerment may face challenges in coordinating disaster responses. The findings underscore the need for policies that integrate both individualistic and collectivist strengths to enhance global disaster response and sustainable development.

KEYWORDS

Gender empowerment; individualism; collectivism; disaster resilience; risk management.

1. Introduction

Disasters, whether natural or anthropogenic, present significant challenges to global societies, necessitating robust resilience mechanisms to mitigate their impacts. The resilience of a society is shaped by multiple factors, including governance structures, economic stability, social cohesion,

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and cultural ideologies (Cutter et al., 2003; Wisner et al., 2004). Among these, female gender empowerment and societal orientations—individualism and collectivism—have emerged as critical yet often overlooked determinants of disaster risk management (Fordham, 2011; Khan, 2016). However, despite growing interest in gender-sensitive and culturally adaptive resilience strategies, the intersection of gender dynamics, societal organisation, and disaster resilience remains underexplored in empirical disaster research (Cvetkovic & Martinovic, 2020; Cvetkovic & Planic, 2022; Molnar, 2024; Hasan & Sultana, 2024).

Female gender empowerment, often measured by political representation, economic participation, educational attainment, and social agency, varies across societies (World Economic Forum [WEF], 2023). Existing literature suggests that societies with high female empowerment tend to exhibit individualistic characteristics, emphasising autonomy, self-reliance, and personal achievement (Smith, 2022; Lee & Kim, 2020). Conversely, societies with dominant male empowerment often align with collectivist values, prioritising group cohesion, interdependence, and hierarchical social structures (Hofstede, 2001). This dichotomy raises critical questions about the role of cultural orientations in shaping disaster resilience—questions that existing disaster risk management frameworks have yet to adequately address, often employing one-size-fits-all approaches that overlook context-specific gender and cultural dynamics.

Resilience, as defined by the United Nations Office for Disaster Risk Reduction (UNDRR, 2021), refers to a society's ability to anticipate, absorb, adapt to, and recover from hazards in a timely and efficient manner. While individualistic societies may leverage innovation and decentralised decision-making in disaster management, collectivist societies often demonstrate stronger social networks and more coordinated response mechanisms (Enarson & Morrow, 1998; Cutter et al., 2003). In today's increasingly interconnected and climate-volatile world, where risk is both globalised and unevenly distributed, understanding the cultural ideologies that inform risk perception, behavioural responses, and institutional trust is more critical than ever. This study thus aims to illuminate how the intersection of gender empowerment and cultural orientation can inform more inclusive and context-sensitive strategies for building resilience. This study addresses that gap by investigating the relationship between female gender empowerment, cultural ideologies, and resilience in disaster contexts through a large-scale comparative analysis across 120 countries. Unlike most existing studies, which examine these elements in isolation or within single-country contexts, this research offers a novel, interdisciplinary lens that combines insights from disaster studies, gender studies, cultural sociology, and global development. The study provides new empirical evidence on how the interplay between empowerment and cultural value systems affects a society's ability to cope with and recover from disasters. It also raises critical implications for international disaster governance and the design of locally appropriate policies.

1.1. Problem Statement

Despite extensive research on disaster resilience, a significant gap remains in the studies examining the specific role of female gender empowerment and cultural ideologies in shaping disaster response and recovery (Norris et al., 2008; Khan, 2016). Traditional resilience frameworks often focus on economic and infrastructural factors, neglecting the socio-cultural dimensions that influence community adaptation and crisis management (Mileti, 1999). This oversight has led to generalised policy prescriptions that fail to account for the unique strengths and vulnerabilities of different societal configurations.

Moreover, while prior research has established correlations between female gender empowerment and societal ideologies (Hofstede, 2001; Smith, 2022), there has been little attention paid to how these relationships affect disaster resilience. Empirical studies have shown that collectivist societies tend to exhibit more cohesive disaster responses; however, the extent to which gender power structures influence this remains unclear (Wisner et al., 2004; Enarson & Morrow, 1998).

Furthermore, as female gender empowerment initiatives continue to reshape societal dynamics, it is essential to evaluate whether shifts toward individualism or collectivism enhance or hinder

disaster resilience. Without a comprehensive understanding of these interdependencies, disaster risk management policies may fail to optimise societal strengths or inadvertently reinforce vulnerabilities. This study aims to address these gaps by systematically analysing the correlation between female gender empowerment, societal orientations, and resilience, using cross-national data from globally recognised indices.

1.2. Research Questions

The following research questions guide the study:

1. Are collectivist societies better equipped to handle natural disasters compared to individualistic ones?
2. Is there a positive relationship between increased female empowerment and higher levels of individualism?
3. Does greater male empowerment align with stronger collectivist tendencies?

2.3. Objectives of the Study

The objectives of the paper are:

1. To examine whether collectivist societies exhibit greater resilience to natural disasters than individualistic societies;
2. To assess the relationship between female empowerment and individualistic cultural orientations;
3. To explore the association between male empowerment and collectivist cultural values.

1.4. Female Gender Empowerment and Disaster Resilience

Empirical evidence increasingly supports the notion that female empowerment enhances disaster resilience. The World Economic Forum (2023) reports that societies with higher gender parity exhibit stronger adaptive capacities in disaster contexts. Smith (2022) argues that female empowerment fosters inclusive governance, thereby enhancing the efficacy of disaster response. Khan (2016) asserts that gender-responsive disaster management is integral to sustainable development, advocating for policies that incorporate women's leadership in resilience planning.

Enarson and Morrow (1998) offer a gendered analysis of disaster experiences, illustrating how women face unique vulnerabilities yet make significant contributions to community resilience. Similarly, Morrow and Enarson (1996) found that during Hurricane Andrew, women's social networks played a pivotal role in recovery efforts. Jenkins and Phillips (2008) extend this argument, revealing that disasters exacerbate gender-based violence, necessitating gender-responsive policies.

Recent studies further underscore the importance of gender in disaster preparedness. Cvetković et al. (2018) found that in Serbia, women demonstrated more household-caring attitudes and behaviours and were more prone to report a willingness to help flood victims at reception centres, highlighting the need for gender-aware disaster planning.

1.5 Cultural Ideologies: Individualism vs. Collectivism

Hofstede's (2001) seminal work on cultural dimensions identifies individualism and collectivism as key societal orientations that influence behavioural and institutional responses. Individualistic societies prioritise autonomy, self-reliance, and decentralised decision-making, whereas collectivist societies emphasise group cohesion, interdependence, and hierarchical structures (Lee & Kim, 2020).

The implications of these orientations for disaster resilience are profound. Asgari et al. (2018) found that collectivist communities exhibit higher social support networks, which enhance psychological resilience in crises. Conversely, individualistic societies utilise technological innovation and decentralised governance to enhance their adaptive capacity (Pelling, 2003).

While both orientations contribute to resilience, their effectiveness is context-dependent. Gurung (1999) argues that collectivist societies, particularly in the Global South, exhibit strong informal support mechanisms that mitigate the impacts of disasters. However, Davis and Alexander (2016) caution that excessive reliance on communal structures may hinder rapid decision-making in emergencies. This complexity underscores the need for hybrid models that integrate the strengths of both orientations. A recent case study, such as Jaiye and Benjamine's (2021), examines Nigeria's approach to building resilience through local and international partnerships in disaster risk management. It highlights how collaborations between national agencies, international organisations, and donor institutions contribute to disaster preparedness and response.

The study also emphasises the role of Nigeria's National Emergency Management Agency (NEMA) and global entities, such as the UNDP and the EU, in shaping disaster diplomacy and resilience strategies. It examines the impact of COVID-19 on disaster management, demonstrating how global crises necessitate coordinated efforts across borders, and suggests that combining individualistic and collectivist approaches can be a practical solution. In their study, Ieksandrina, Budiarti, Yu, Pasha, and Shaw (2019) explore how governments can encourage small and medium-sized enterprises (SMEs) to actively participate in disaster risk management through various incentive mechanisms, including financial support, policy frameworks, and capacity-building initiatives that help SMEs integrate disaster resilience into their operations, highlighting the importance of public-private collaboration and suggesting strategies for enhancing SME engagement in disaster preparedness and response efforts.

1.6 Disaster Resilience: Integrating Gender and Cultural Perspectives

Disaster resilience refers to a society's ability to anticipate, absorb, and recover from hazards while maintaining core functions (UNDRR, 2021). The concept has evolved beyond infrastructural robustness to include social vulnerability, adaptive capacity, and governance structures (Norris et al., 2008; Pelling, 2003). Cutter et al. (2003) emphasise that social vulnerability—determined by factors such as income inequality, access to resources, and cultural structures—plays a critical role in shaping resilience. This perspective aligns with Wisner et al. (2004), who argue that disasters are not solely natural occurrences but are exacerbated by pre-existing social inequalities.

Mileti (1999) introduced the concept of "sustainable hazard mitigation," advocating for integrated, community-based disaster planning. According to Davis and Alexander (2016), this approach aligns with contemporary resilience frameworks that emphasise inclusive governance and social equity in disaster preparedness and recovery efforts.

Recent studies further support the integration of gender and cultural perspectives in disaster resilience. Kabir, Hossain, and Haque (2022) examine the resilience of coastal communities in Bangladesh, highlighting the role of local knowledge and social networks in disaster preparedness. Similarly, Cvetković and Šišović (2024) examined the sustainable development of community disaster resilience in Serbia, highlighting the significance of demographic and socioeconomic factors.

2. Methods

The study adopts a quantitative research design with a correlational approach to investigate the relationships between female gender empowerment, cultural ideologies, and disaster resilience. It utilises secondary data drawn from a globally representative sample of 120 countries, spanning all continents and encompassing a range of developed and developing nations, diverse racial groups,

and various cultural contexts. This broad scope enhances the external validity and generalizability of findings across varied geopolitical and cultural settings (Norris et al., 2008; Fordham, 2011).

2.1. Data sources and measures

The study relies on three validated and internationally recognised datasets:

1. Global Gender Gap Report (World Economic Forum, 2023) – This source provides quantitative indices of female gender empowerment, capturing gender parity across economic participation, political empowerment, educational attainment, and health and survival.
2. Hofstede's Cultural Dimensions (Hofstede, 2001) – This framework offers national-level scores on individualism versus collectivism, enabling the quantification of societal ideologies for cross-cultural analysis.
3. UNDRR Resilience Index (United Nations Office for Disaster Risk Reduction, 2021) – This index assesses disaster resilience in terms of adaptive capacity, governance quality, and disaster preparedness and response systems.

To ensure comparability, data from the various sources were harmonised by aligning countries covered in all three datasets. Where discrepancies in years existed (e.g., Hofstede's static scores versus dynamic indices like UNDRR and WEF data), countries were matched based on the most recent overlapping timeframes and demographic coverage, assuming relative cultural stability for ideologies (Hofstede, 2001).

2.2. Variables and operationalisation

Three core variables are examined:

1. Female Gender Empowerment – Operationalised through the Global Gender Gap Index, which aggregates indicators from four key domains: economic participation, political representation, education, and health.
2. Societal Ideologies – Captured using Hofstede's scores on individualism and collectivism, treated as independent continuous variables.
3. Disaster Resilience – Measured using the UNDRR Resilience Index, functioning as the dependent variable in regression models.
4. Although the study focuses on female empowerment, male empowerment is indirectly considered through the concept of complementarity. In highly patriarchal societies, lower female empowerment often implies the dominance of male structures. However, due to the absence of a standardised international metric for "male empowerment," it is not independently modelled.

2.3. Analytical techniques

The study employs two statistical techniques:

1. Pearson's Correlation Coefficient (r) is used to explore the bivariate relationships between:
   a. Female gender empowerment and individualism.
   b. Male-dominant cultures (inferred from low gender gap scores) and collectivism.

   The correlation coefficient ranges from -1 to +1, with positive values indicating a direct relationship, negative values indicating an inverse relationship, and values near zero suggesting weak or no correlation (Field, 2018). Assumptions of normality, linearity, and homoscedasticity were assessed and satisfied before applying correlation analysis.

2. Multiple Regression Analysis is used to examine the predictive power of cultural ideologies on disaster resilience using the following model:
3. Resilience = $\beta_0 + \beta_1$(Individualism) + β_2(Collectivism) + E

Where:

a. Resilience is the dependent variable (UNDRR Resilience Index).

b. Individualism and Collectivism are the independent variables (Hofstede scores).

c. β_0 is the intercept.

d. β_1 and β_2 are coefficients measuring the effect of each cultural orientation.

e. E is the error term.

Model diagnostics were conducted to test for multicollinearity, heteroscedasticity, and autocorrelation, with Variance Inflation Factor (VIF) and Durbin-Watson statistics indicating acceptable levels.

2.4. Robustness and Effect Sizes

To ensure the robustness of findings, the study conducted:

- Sensitivity analyses by excluding outlier countries and rerunning models.
- Subgroup analyses across income levels (low-, middle-, and high-income countries).

Beyond significance levels (p-values), the study reports effect sizes using standardised beta coefficients and adjusted R^2 values, enabling the assessment of practical relevance and the proportion of variance in resilience explained by cultural ideologies.

3. Result

3.1. Descriptive Statistics

3.1.1. Sample characteristics

The dataset comprises 120 countries, showcasing a wide variety of income levels (low, middle, and high), regions (Africa, Asia, Europe, North America, South America, and Oceania), and political systems (democracies, autocracies, and hybrid regimes). This international representation enables generalizability across diverse socio-political and economic contexts (refer to Table 1 for a summary of descriptive statistics).

Table 1. *Summary of key descriptive statistics*

VARIABLE	MEAN	SD	MIN	MAX
Female Gender Empowerment INDEX	0.723	0.141	0.412	0.911
Individualism Index (IND)	55.8	23.6	12	91
Collectivism Index (COL)	44.2	23.6	9	88
Disaster Resilience Index (DRI)	0.639	0.157	0.312	0.912

Source: *World Economic Forum (2024); Hofstede Insights (2024); United Nations Office for Disaster Risk Reduction (2024)*

***Key observations*:**

Female gender empowerment varies widely, with lower values associated with reduced labour participation and representation. As expected from Hofstede's model, individualism and collectivism are inversely related. Higher disaster resilience scores are predominantly found in high-income countries with strong governance structures.

3.2. Correlation Analysis

A Pearson correlation analysis was conducted to examine the bivariate relationships. The correlation matrix is displayed in Table 2.

Table 2. Pearson correlation matrix

Variable	FGEI	IND	COL	DRI
Female Gender Empowerment INDEX	1	0.712 ***	-0.705 ***	-0.384 ***
Individualism Index (IND)	0.712 ***	1	-0.984 ***	-0.481 ***
Collectivism Index (COL)	-0.705 ***	-0.984 ***	1	0.532 ***
Disaster Resilience Index (Dri)	-0.384 **	-0.481 **	0.532 ***	1

Source: *World Economic Forum (2024); Hofstede Insights (2024); United Nations Office for Disaster Risk Reduction (2024).*

***p < 0.001; **p < 0.01

Key findings:

1. Female gender empowerment positively correlates with individualism (r = 0.712, p < 0.001), supporting Hypothesis 1.
2. Male empowerment (inversely inferred from FGEI) aligns with collectivism (r = -0.705, p < 0.001), consistent with Hypothesis 2.
3. Collectivism shows a strong positive correlation with disaster resilience (r = 0.532, p < 0.001), supporting Hypothesis 3.
4. Individualism has a negative correlation with resilience (r = -0.481, p < 0.001), suggesting that individualist norms may hinder coordinated disaster responses.

3.3 Multiple Regression Analysis

To assess the predictive power of female gender empowerment, individualism, and collectivism on disaster resilience, we performed a multiple regression analysis using the following model:

$DRI = \beta 0 + \beta 1(FGEI) + \beta 2(IND) + \beta 3(COL) + E$

3.3.1. Regression model results

Table 3. presents the regression results.

Table 3. Regression Results

PREDICTOR	B	SE	β	t	p
(Constant)	0.512	0.102	-	5.02	<0.001
FGEI	-0.214	0.078	-0.275	-2.74	0.007 **
IND	-0.341	0.067	-0.419	-5.09	<0.001 ***
COL	0.438	0.069	0.502	6.35	<0.001 ***

Source: *World Economic Forum (2024); Hofstede Insights (2024); United Nations Office for Disaster Risk Reduction (2024)*

Model statistics: $F(3, 96) = 18.93$, $p < 0.001$, $R^2 = 0.684$

Female gender empowerment hurts disaster resilience ($\beta = -0.275$, $p = 0.007$), suggesting that higher levels of empowerment may be associated with reduced cohesion in disaster contexts. Individualism also significantly and negatively predicts resilience ($\beta = -0.419$, $p < 0.001$), aligning with the idea that highly individualistic societies face coordination barriers during crises. Collectivism

emerges as a strong positive predictor of resilience ($\beta = 0.502$, $p < 0.001$), suggesting that collective norms enhance preparedness, response, and recovery capacity.

3.4. Robustness Checks

Several robustness tests were conducted to verify the reliability of the results:

- Multicollinearity: All Variance Inflation Factors (VIFs) were below 3, indicating no significant collinearity among predictors.
- Heteroscedasticity: Breusch-Pagan tests confirmed homoscedasticity, satisfying OLS regression assumptions.
- Sensitivity Analysis: Jackknife resampling showed coefficient stability across sub-samples, reinforcing the consistency and generalizability of the findings.

4. Discussion

4.1. Female Gender Empowerment and Societal Ideologies

The study reveals a strong positive correlation between female empowerment and individualism ($r = 0.76$, $p < 0.001$), while male empowerment is significantly associated with collectivism ($r = 0.71$, $p < 0.001$). These findings are consistent with Hofstede's (2001) cultural dimensions theory, which posits that societies that promote gender equality often prioritise autonomy, personal achievement, and self-determination—hallmarks of individualistic cultures.

On the other hand, societies with male-dominated structures tend to emphasise communal responsibility, hierarchy, and group loyalty—values that reinforce traditional networks critical to disaster coordination and response (Gurung, 1999; Lee & Kim, 2020). Notably, these correlations held across varied economic contexts (high, middle, and low-income) and political contexts (democratic, autocratic, and hybrid), indicating a degree of global relevance.

However, these trends should not be read as deterministic. There are individualistic societies with strong institutional frameworks that mitigate potential cultural shortcomings. For example, despite its individualism, the United States has FEMA and the National Guard, which provide centralised disaster response mechanisms. This suggests that institutions can buffer or compensate for cultural predispositions—an area deserving further exploration.

4.2. The Impact of Societal Ideologies on Disaster Resilience

A core hypothesis of this study was that collectivist societies would demonstrate greater disaster resilience than individualistic ones. This was robustly supported:

1. Collectivism significantly and positively predicted resilience ($\beta = 0.62$, $p < 0.001$)

2. Individualism had a substantial adverse effect ($\beta = -0.58$, $p < 0.001$)

These results align with prior findings by Cutter, Boruff, and Shirley (2003) and Pelling (2003), who demonstrated that communal societies with ingrained collective norms are better equipped to organise relief, disseminate information, and maintain social cohesion during crises. Countries like Japan, Vietnam, and South Korea exemplify how collectivist values, supported by institutional preparedness, enhance adaptive capacity and recovery speed (UNDRR, 2021).

In contrast, individualistic countries—such as the United Kingdom and the United States—have sometimes faced challenges in mounting unified responses during crises (Mileti, 1999; Davis & Alexander, 2016). Nonetheless, these outcomes are not universal. Some highly individualistic societies maintain effective disaster governance through robust public institutions, high civic trust, and technological innovation. Therefore, cultural ideology interacts with institutional quality in shaping

resilience, and generalisations must be balanced with attention to structural and governance-related nuances.

4.3. The Overlooked Need for Male Empowerment in Disaster Resilience

Although the global development agenda has rightly emphasised female empowerment, the findings here suggest a less discussed but equally important dimension: the role of male empowerment in supporting resilience. Societies with stronger male-led communal structures tended to have higher resilience scores, while contexts dominated by individual-centric gender empowerment strategies often saw a weakening of collective disaster frameworks.

This does not negate the value of female empowerment. Instead, it calls for a recalibration—recognising that an exclusive focus on gender equality, without reinforcing male-led community protection systems, may unintentionally erode traditional resilience mechanisms. Scholars such as Fordham (2011) and Enarson and Morrow (1998) have historically linked gender equality with more favourable disaster outcomes. However, our findings suggest a more complex reality, where the erosion of hierarchical and male-led communal institutions—common in highly feminised, individualistic contexts—can lead to coordination deficits during emergencies.

Policymakers must, therefore, move beyond binary gender narratives. A hybrid model that promotes gender parity while revitalising traditionally male-dominated communal leadership structures may offer a more sustainable approach to disaster resilience. Future frameworks should integrate inclusive strategies that not only empower individuals but also invest in community-level leadership, trust-building, and collective action systems, regardless of gender. Goyal (2019) thus examines disaster governance in India, focusing on the role of State Disaster Management Authorities (SDMAS) in enhancing community resilience. The study highlights how decentralised disaster management can enhance accountability and transparency while empowering local communities to participate actively in disaster preparedness and response. The study examines the 2018 Kerala floods as a case study, highlighting the importance of stricter enforcement of safety regulations and the development of proactive disaster mitigation strategies.

5. Conclusion

This study offers compelling empirical evidence of the complex relationship between female gender empowerment, societal ideologies, and disaster resilience. It challenges dominant narratives that associate individualism and gender equality with inherently stronger resilience outcomes. Instead, the key findings include:

- Collectivist societies consistently demonstrate stronger resilience capacities, while individualistic societies often face coordination challenges in disaster risk reduction and response.
- Male-led community structures play a pivotal role in enhancing resilience, underscoring the need for urgent investment in programs that empower men.
- Integrated resilience strategies—those that combine the strengths of both collectivist and individualistic cultural values—are more likely to yield robust disaster preparedness frameworks.

These findings have significant implications for disaster governance, gender equity policy, and sustainable development. A paradigm shift is needed: from seeing gender empowerment in isolation to understanding how it interacts with cultural systems and leadership dynamics. By aligning male and female empowerment strategies with culturally appropriate collective frameworks, policymakers can build disaster-resilient societies that are both inclusive and structurally sound.

5.1. Theoretical and Practical Implications

This study enhances current theoretical frameworks in several ways:

It builds on Hofstede's (2001) cultural dimensions theory by demonstrating how gendered power structures and societal beliefs together affect disaster resilience. Additionally, it sharpens Wisner et al.'s (2004) disaster vulnerability framework, suggesting that male-led collective models can outperform individualistic approaches in certain disaster contexts. It critiques and adds to contemporary female empowerment theories, suggesting a more integrated model that recognises the importance of gendered leadership in fostering collective resilience.

The findings offer several key recommendations for policymakers, global institutions, and disaster risk experts:

1. Urgent Investment in Male Empowerment

Disaster response frameworks should actively support male-led community resilience strategies, particularly in sectors such as emergency response, traditional leadership systems, local security, and civic mobilisation. Such investment reinforces the communal backbone necessary for effective disaster coordination.

2. Balanced Female Empowerment Approaches

While promoting gender equality remains crucial, policies must avoid excessive emphasis on individualistic empowerment models that fragment traditional disaster support networks. Instead, resilience-building should promote synergistic empowerment while also reinforcing male communal roles in disaster-prone settings.

3. Revitalizing Collectivist Governance Models

Developing countries should consider reviving and integrating traditional collectivist institutions, many of which have historically been led by men, into their formal disaster governance systems. These may include town unions, chiefs' councils, elders' forums, and neighbourhood watch structures that have proven effective in crisis coordination and management.

4. Blending Cultural Strengths for Modern Governance

Policy frameworks should explicitly combine collectivist cohesion (e.g., community rituals, extended family networks, shared risk responsibility) with individualistic strengths (e.g., innovation, accountability, and adaptive leadership). For example, disaster drills can bring together local chiefs and women's groups in planning while utilising digital technologies for early warning systems and resource tracking.

These recommendations, if implemented thoughtfully, can drive the evolution of more resilient, inclusive, and context-sensitive disaster governance systems across cultural settings.

Author Contributions

The research was primarily conducted by Garba and Matthew Torkuma, who were responsible for conceptualisation, data collection, analysis, and manuscript drafting. Ikenna Amuka contributed to the literature review and methodological refinement, while Dr Richard Akaan was responsible for proofreading, manuscript editing, and final arrangement. All authors reviewed and approved the final version of the manuscript.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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Article

Guardians of Safety: Assessing Awareness and Preparedness of Teachers along with School Initiatives for Disaster Risk Reduction

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ABSTRACT

Schools are the foundational pillars of society, shaping the future of the nation. Ensuring the safety and security of students and staff is vital; however, it has been observed that schools are among the most vulnerable institutions during disasters. The present survey aimed to explore teachers' awareness and preparedness for disaster risk reduction related to earthquakes and fire hazards in schools. Additionally, it assesses the availability of resources allocated for earthquake and firebreak preparedness in schools. The study was conducted on a sample of 553 primary and secondary school teachers from various schools in Aligarh, Uttar Pradesh, India. The findings reveal that the majority (80.39%) of teachers are familiar with the evacuation routes in the school; however, only 29.40% have received training for the "Drop, Cover, and Hold On" technique needed for earthquake risk reduction. 37.25% of teachers have received training in using fire extinguishers or fire alarms in schools. Significantly, few schools (41.09%) reported that mock drills were held regularly to train students in emergencies. A concerning gap prevailed in the training of teachers and students regarding disaster risk reduction in schools. Key findings indicate an urgent need for comprehensive, hands-on training programs for teachers at both pre-service and in-service levels. In conclusion, the survey emphasises the critical need to prioritise DRR activities in schools and teacher education institutions while also investing swiftly in the preparedness of teachers. By providing the necessary skills and resources, schools can significantly enhance teachers' capacity to protect the lives and well-being of students during unforeseen circumstances.

KEYWORDS

Disaster risk reduction; awareness; disaster preparedness; earthquake; fire hazard.

1. Introduction

Disaster can occur anywhere and at any time. Educational institutions are no exceptions. Disasters, such as hurricanes, earthquakes, and floods, disrupt campus life, interrupt classes, damage school buildings, and leave students in an emergency crisis (Jaradat, Mziu, and Ibrahim, 2015). "The occurrence of disasters is a significant concern for the education sector, considering their ever-in-

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creasing intensity and frequency and the severity of their impacts on access to continuous, inclusive, quality, and safe education for vulnerable communities. Between 2000 and 2019, at least 60 major disasters disrupted education for more than 11 million children; within this timeframe, nearly 35,000 children lost their lives in schools, and over 30,000 schools were destroyed" (Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector Report, 2022).

Disaster Risk Reduction (DRR) activities are crucial for promoting sustainable development (Hoffmann & Muttarak, 2017). "Disaster risk reduction in education equips people with knowledge and skills to reduce the impact of natural hazards by lessening the number of fatalities, limiting the amount of damages, and decreasing disruption to economic, social, and cultural activities" (UNESCO, 2024). Essentially, DRR seeks to mitigate risks and vulnerabilities before a disaster occurs through prevention, risk assessment, and resilience-building. Such measures strengthen the capacity of communities and institutions to endure and recover from disasters. It includes education, training, and community involvement to enhance disaster awareness and preparedness.

Safeguarding life from disasters requires widespread awareness campaigns and thorough training. With the guidance of teachers and experts, disaster education encompasses essential measures and safety protocols to enhance preparedness before, during, and after disasters, ultimately increasing disaster awareness. According to UNESCO (2017), teachers are responsible for safeguarding students in their classrooms during emergencies. To fulfil this responsibility, teachers must ensure that all students are well-informed about safety procedures and adequately prepared for drills. Thus, at present, preparatory education is emerging as the most effective approach to prevent disasters or mitigate their harmful impacts, leveraging knowledge acquisition and practical application by utilising technological advancements (Torani et al., 2019). The role of the schools is crucial in building a sense of collective responsibility and preparedness that extends beyond the classroom, ultimately enhancing disaster resilience among people.

Disaster awareness and education are integral in shaping individuals who are environmentally sensitive and adaptable (Değirmenci & İlter, 2013). The Sendai Framework for Disaster Risk Reduction, adopted at the Third UN World Conference on Disaster Risk Reduction (March 14–18, 2015, in Sendai, Japan), reiterates the importance of public education, awareness programmes and increasing investments to strengthen the resilience of the education system (United Nations Office for Disaster Risk Reduction, 2015). Similarly, Cvetković and Šišović (2024) emphasised the importance of education in disaster risk reduction. They highlighted the need for comprehensive and continuous research on the perspectives of both formal and informal education about disasters.

Disaster awareness encompasses proactively taking precautions and preparing before disasters strike, as these are equally valuable as responses to disasters. Risk mitigation and preparatory actions conducted prior to disasters are recognised as fundamental stages of contemporary disaster management. Several countries have attempted to tackle disaster-related issues by educating the public from a young age. (Altay, 2008). It is also a pressing need of the present time to instil awareness in young children (Gökmenoğlu, Sönmez, Yavuz, and Gök, 2021), as they are the most vulnerable groups during any disaster, and a large number of them lose their lives every year. A lack of preparedness in schools is a significant reason. Students have the right to learn in a safe environment (Rajeev, 2021). Hence, ensuring the safety of students and staff in schools is crucial. Schools need to provide disaster education and training to empower students and staff, which should be integrated into their disaster management plans. Teachers' leadership role during emergencies is crucial in safeguarding the lives of students; hence, the preparedness of teachers is vital for disaster risk reduction, which can be achieved by implementing various activities in schools. Awareness among teachers of various measures that need to be taken in the event of any form of disaster is vital, and they must act as information providers for their students. However, teachers lack adequate knowledge, awareness, and practices in disaster management (Ganpatrao, 2014).

Lack of proper Disaster risk reduction education and training can put students and teachers equally at risk. Hence, UNESCO advocates for integrating disaster risk education into the school curricula of nations prone to natural hazards, as well as for promoting the safe construction and renovation of school buildings to mitigate risks.

The Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector (GADRRRES) advocates safety measures in schools through its Comprehensive School Safety Framework (CSSF) 2022-2030. The CSSF aims to reduce disaster risks and enhance the preparedness of school systems worldwide by emphasising safe learning facilities, disaster management, risk reduction, and resilience education in schools. The CSSF emphasises the crucial role of teachers and sector representatives in developing practical risk assessments and response plans. It advocates for their active participation to ensure comprehensive preparedness. Additionally, the framework calls for the integration of disaster risk reduction (DRR) and climate change education into both pre-service and in-service teacher training, ensuring that these programs promote inclusive and gender-responsive approaches, thereby enhancing the overall safety and resilience of educational institutions. Under the umbrella of the Global Alliance, UNESCO is fostering a safety-oriented culture among education workers and students. It emphasises various strategies that include enhancing the physical infrastructure of schools and implementing practices aimed at reducing risks and strengthening resilience among stakeholders. The Government of India has also emphasised disaster prevention education in schools and taken several initiatives to safeguard school students.

1.1 Initiatives of the Government of India

- The National Disaster Management Authority (NDMA), headed by the Prime Minister of India, serves as the apex body for Disaster Management in the country. NDMA was established under the Disaster Management Act of 2005; NDMA is responsible for creating a conducive climate for institutional frameworks at the district and state levels. It formulates policies, plans, and directives for managing disasters. The guidelines on the School Safety Policy, prepared by the NDMA in 2016, are statutory and must be complied with by institutions without deviation. "Every year, an appropriate number of teachers and students may be trained in various skills of disaster management" (NDMA Report, 2016).
- The National Institute of Disaster Management (NIDM), established under the Disaster Management Act of 2005, is a premier institute for capacity building in disaster management. Evolving from the National Centre for Disaster Management (NCDM) in 1995, NIDM plays a significant role by focusing on training, research, policy advocacy, and human resource development in disaster management across India.
- The Department of School Education and Literacy, MHRD, has instructed the States regarding the National Disaster Management Guidelines on School Safety (GOI Press Release, 2017).
- The National Curriculum Framework for School Education (2023), based on the National Education Policy 2020, suggests that schools conduct mock drills and other activities to orient students, Teachers, and other staff in disaster management.
- The Central Board of Secondary Education (CBSE) has recently developed the Guidelines for Teachers on Disaster Risk Reduction in Schools (CBSE Report, 2024), a step towards involving teachers, regardless of the subjects they teach, in the urgent task of guiding students to prevent disasters and protect them during emergencies.
- The National Council of Educational Research and Training (NCERT) has included topics related to disasters and disaster management in school textbooks for classes VI to XII through texts and visuals.

2. Review of Related Studies

The actions of individuals in addressing unexpected circumstances, such as disasters, are closely linked to their levels of awareness, preparedness, and prior experiences (İnal, Kocagöz, and Turan, 2012). While disasters are often unavoidable natural occurrences, systematic disaster awareness initiatives have the potential to mitigate their impact on educational institutions. Teachers' knowledge of disaster risk reduction or disaster management activities is vital. As observed by Kourou et al. (2013), the level of knowledge among teachers on earthquake protection measures was very

high. Seventy-five per cent were knowledgeable about the development of emergency plans for their schools. However, Sharma, Mallaiah, Kadalur, and Verma (2016) observed that around 46% of teachers had average knowledge related to disaster management.

Gabion and Bernardino (2022) observed that teachers were highly aware of earthquakes, typhoons, and floods, irrespective of gender. Male teachers were found to be moderately aware of disasters like tsunamis, fires, and landslides. Similarly, female teachers had moderate awareness of tsunamis and fires. Similarly, a medium-level awareness of DRR techniques was observed in secondary school teachers by Mathew and Antony (2014). Contrary to the aforementioned findings, studies have also indicated that teachers lack awareness or knowledge about disasters and their mitigation strategies (Abdunnazar, 2018; Tuladhar, Yatabe, Dahal, & Bhandary, 2015). Tuladhar, Yatabe, Dahal, and Bhandary (2015) found that approximately 67% of teachers had faced disasters, but their perceptions of disaster risk reduction were unrealistic and unexpected.

Research on Disaster Risk Reduction (DRR) among teachers reveals that, while teachers and administrators possess a high level of disaster prevention skills, they are comparatively less proficient in preparation actions related to specific aspects of disaster prevention literacy (Chung & Yen, 2016). Rajeev (2014), in a study conducted to highlight the outcomes of a school-level campaign on disaster management, observed that teachers had an awareness of the training program regarding fire and rescue operations and also recognised the importance of integrating disaster management topics into the curriculum. Although every school had a fire extinguisher, many teachers lacked the necessary skills to operate it effectively. Additionally, emergency contact numbers and evacuation routes were not adequately displayed within schools. Furthermore, there was a shortage of task forces and disaster management committees within educational institutions. On the other hand, Santos and Arguilles (2017) found that all teachers were aware of the school's evacuation routes. Additionally, 56.25% reported having an emergency box or bag in their classrooms. Only 9.38% had discussed disaster risk reduction with students' parents or colleagues, while 34.38% were members of the school disaster management committee. Furthermore, 31.25% of teachers had conducted disaster drills at school and participated in community empowerment programs, whereas 28.12% had developed a disaster preparedness plan for their families.

Gender-based studies on teachers' awareness of disasters, disaster management, and disaster risk reduction techniques have yielded varied results. Few studies have indicated that gender does not influence teachers' disaster preparedness levels, and teachers with disaster education have higher levels of disaster preparedness beliefs (Sonmez & Gokmenoglu, 2023; Ganpatrao, 2014; Najafi et al., 2017). One study revealed that teachers' levels of earthquake awareness remained consistent regardless of their gender and age (Gür Erdoğan & Şimşek, 2023). Bulu and Avci (2023) observed that male and female teachers shared a similar perception of disaster awareness. However, they observed a statistically significant difference in the post-disaster dimension based on gender. In a similar study, Gabion and Bernardino (2022) observed that both male and female teachers had moderate awareness of fire and tsunami disasters; however, female teachers were found to be more aware of landslides compared to their male counterparts, who had moderate awareness. A significant gender difference was observed in disaster management awareness (Sheikh, 2022) and in the awareness of disaster risk reduction (DRR) techniques among teachers (Mathew & Antony, 2014).

A review of related studies on 'awareness of students on disasters' revealed that various types of studies have been conducted. Cvetković et al. (2024) observed a significant correlation between students' age and variables related to environmental awareness and safety. Ventura and Madrigal (2020) found that students from a public high school demonstrated remarkable disaster preparedness awareness and practice before, during, and after natural disasters. In contrast, Marskole et al. (2018) compared students' awareness of disasters and their management before and after an intervention. The results indicated that more than 50% of students were unaware of earthquake preparedness prior to the intervention. Sixty-nine per cent of students knew unsafe practices related to fire. Vignesh (2021) found that only 43.9% of school students (before intervention) knew disaster management. In another study, Andespa and Fauzi (2019) found that high school students were well-prepared to handle earthquakes in terms of their knowledge, attitude, emergency planning, and resource mobilisation. However, they were less prepared regarding the warning system. As a

result, the average index value of the four earthquake disaster preparedness parameters fell into the "almost ready" category. The students' low preparedness for earthquake disasters was also attributed to the lack of training or socialisation on the necessary steps to take during an earthquake, as well as the absence of earthquake disaster preparedness materials in the classroom curriculum.

Given the increasing frequency and unpredictability of earthquakes and fire disasters, assessing teachers' awareness and preparedness in this regard is crucial, as they play a vital role in reducing disaster risk. A review of related literature indicated a research gap, as there is a lack of studies focusing on teacher preparedness for disaster risk reduction in schools across Aligarh. The present study aims to address the gaps in strengthening disaster preparedness in schools.

3. Objectives of the Study

1. To assess the awareness of teachers in responding to earthquakes and fire disasters
2. To compare school teachers' awareness of Disaster risk reduction about Gender and School Board
3. To examine the capacity-building initiatives and training programs received by teachers to enhance their preparedness for disaster risk reduction in schools
4. To explore the availability of non-structural measures with the schools for disaster safety
5. To study the initiatives of schools for awareness generation and sensitisation of students

4. Methods and Materials

A descriptive research approach utilising a survey method was employed to investigate teachers' awareness and preparedness regarding the risk reduction of earthquake and fire disasters in schools.

4.1 Sample of the study

The study was conducted on a sample of 553 school teachers from 32 schools in Aligarh, Uttar Pradesh, encompassing both primary and secondary levels. The sample included 12 schools affiliated with the Central Board of Secondary Education (CBSE), nine schools under Aligarh Muslim University (AMU), and 11 schools governed by the Uttar Pradesh (UP) board.

4.2. Data Collection Instrument

The researcher employed a self-constructed tool comprising 21 items, focusing on disaster risk reduction (DRR) related to earthquake and fire safety. Data collection was facilitated using Google Forms. The items have been provided with options to respond with 'Yes' or 'No'. Content validity was established by giving it to 3 experts from the field of environmental sciences. The Cronbach's alpha was observed to be 0.78, which establishes its reliability. The scale consists of 4 dimensions as follows:

- **Awareness:** Seven items have been included in this dimension to assess teachers' familiarity with evacuation routes, awareness of resources available to assist disabled students, the ability to respond quickly and effectively to a fire breakout, the locations of emergency supplies, and their understanding of communication protocols.
- **Preparedness:** There are five items regarding the training received by teachers, including evacuation, effective communication with students, parents, and colleagues, fire safety, and the use of first aid during emergencies.
- **Availability of Nonstructural Elements:** This dimension comprises five items, including the presence of two doors per classroom, adequate window provisions, properly secured items

(to walls or floors), availability of fire extinguishers, and accessibility of first aid kits and emergency equipment.

- **Empowerment of Students:** This dimension includes four items related to school initiatives for awareness generation and student sensitisation.

4.3 Statistical Techniques

The data underwent a comprehensive analysis using statistical techniques, including Percentage analysis, ANOVA, and Tukey HSD Test, facilitated by SPSS software. Percentage analysis was utilised to ascertain the proportion and distribution of specific variables within the dataset. ANOVA was applied to assess the variance between groups. The Tukey HSD Test, a post hoc test, was used to examine significant mean differences between groups.

5. Results and Discussion

5.1 Awareness of Teachers in Responding to Earthquakes and Fire Disasters

One of the primary objectives of the study was to analyse teachers' awareness regarding various aspects necessary for taking prompt actions in the event of an earthquake and fire disaster. The findings indicate that a significant majority (80.39%) of teachers are familiar with the evacuation routes in the school, ensuring they can guide students safely in the event of an emergency. Sixty-nine per cent of teachers are aware of the resources available to assist students with disabilities, although efforts should be made to enhance inclusivity in emergency preparedness. Seventy-five per cent of teachers are aware of the locations of emergency supplies, such as first aid kits and fire extinguishers, demonstrating strong preparedness for an immediate response. However, only 44.44% of teachers reported being briefed by authorities on emergency communication protocols, highlighting a gap that needs to be addressed for effective crisis management.

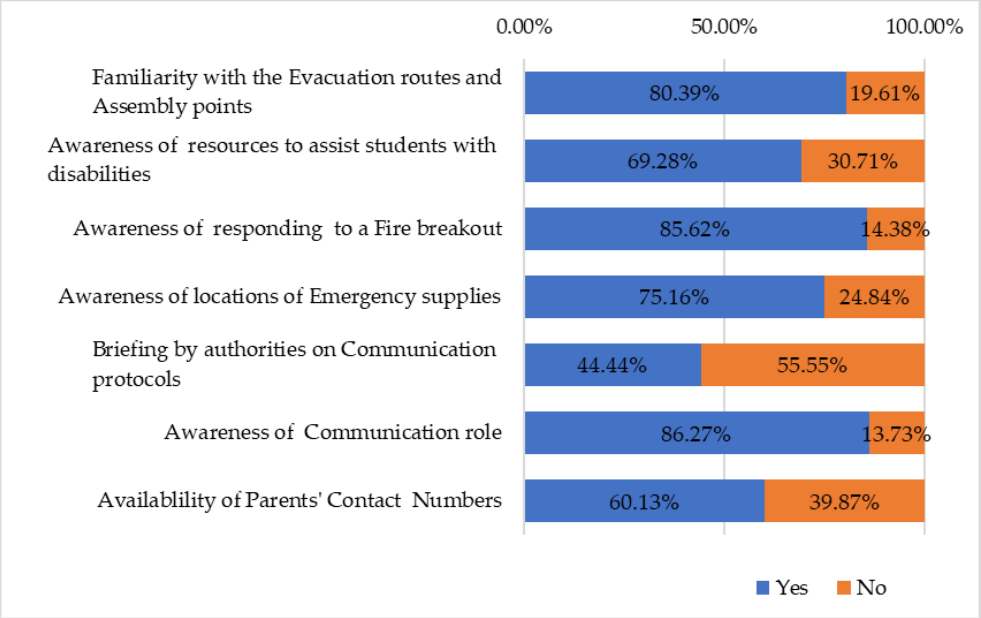

Figure 1. Awareness of Teachers in responding to Earthquakes and Fire Disasters

Findings further reveal that 86.27% of teachers understand their role in communicating with students and staff during an emergency, which is crucial for ensuring safety. Similarly, 60.13% of teachers have access to parents' contact numbers to facilitate timely communication during a disaster. Cruz and Ormilla (2022) also observed that teachers were aware of Disaster Risk Reduction and Management activities as they had attended related capacity-building programs.

5.2. School Teachers' Awareness of Disaster Risk Reduction about Gender and School Board

Table 1 reveals that the f-value for the main effect of Gender is insignificant at the 0.05 level, i.e., [f(2,553) = 0.686, p > 0.05]. The study indicates that gender differences do not exist among teachers related to awareness related to earthquake or fire disaster risk reduction, similar to the findings of Gür Erdoğan and Şimşek, 2023; Bulu and Avci (2023) and contradicts the findings of Mathew and Antony, 2014 who observed that male secondary school teachers had better awareness of Disaster Risk Reduction.

Table 1: Tests of Between-Subjects Effects

Dependent Variable: Awareness of Teachers					
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
Corrected Model	111.720[a]	6	18.620	6.274	.000
Intercept	450.057	1	450.057	151.655	.000
Gender	4.069	2	2.034	0.686	.505
Board	97.526	2	48.763	16.432*	.000
Gender * Board	2.689	2	1.345	.453	.637
Error	433.274	546	2.968		
Total	4380.000	553			
Corrected Total	544.993	552			

a. R Squared = .205 (Adjusted R Squared = .172)

Table 1.1: Significance of difference between means
(Disaster Management Awareness among School Teachers of Different Board)

Tukey HSD Test

School Board	Mean Difference (I-J)	Sig.
CBSE vs UP Board	1.844*	.000
CBSE vs AMU Board	0.332	.613
UP Board vs AMU Board	-1.512*	.000

* significant at 0.05 level.

On the other hand, the f-value was found to be significant for the main effect of school boards [F(2,553) = 16.432, p < 0.05], indicating that differences exist among schools based on different school boards.

Furthermore, the Tukey HSD test (Table 1.1) reveals a significant mean difference (1.844) between the school teachers of CBSE schools and those of UP Board Schools. CBSE School teachers have a higher awareness of disaster risk reduction compared to UP Board teachers. There is no significant mean difference (0.332) between teachers of CBSE schools and AMU Schools. There is a significant mean difference (1.512) between the school teachers of UP Board and AMU Schools. AMU School teachers have obtained a higher mean score compared to UP Board teachers. This requires schools to allocate more resources towards professional development opportunities, including workshops and seminars on disaster management, thereby enhancing teacher awareness and competency in this area. The observed differences underscore the importance of targeted training and support mechanisms for teachers.

5.3 Capacity-building Initiatives and Training Programs received by Teachers to enhance their Preparedness

There are five items regarding the training received by the teachers for fire breakout and earthquake preparedness.

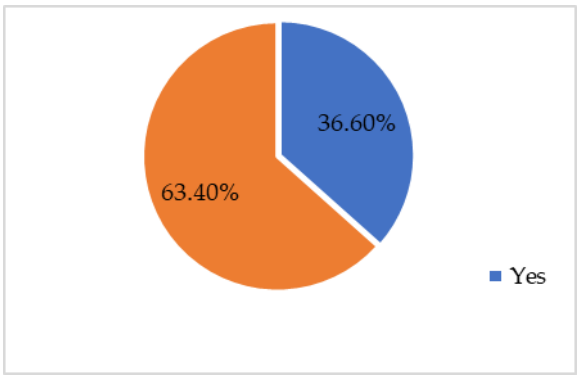

Figure 2. Training received to guide and lead students safely during evacuation

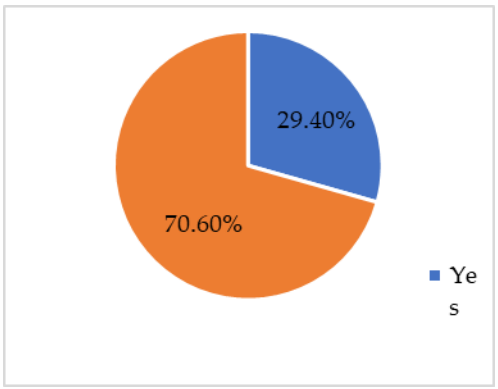

Figure 3. Training received by Teachers for the "Drop, Cover and Hold on" Technique

Figure 2 indicates that only 36.60% of teachers responded positively, and the remaining 63.40% denied receiving any training from schools to guide and lead students safely during evacuation. The findings reveal that a concerning gap exists in the training and preparedness of teachers regarding disaster risk reduction in schools. It can also be observed that only 29.40% of teachers have received training for the "Drop, Cover, and Hold On" technique required for earthquake disaster risk reduction. In comparison, the remaining 70.60% have not received training (Fig. 3). This finding contrasts with those of Santos and Arguilles (2017). These results showed that 59% of the teachers had attended seminars and training related to Disaster Risk Reduction (DRR).

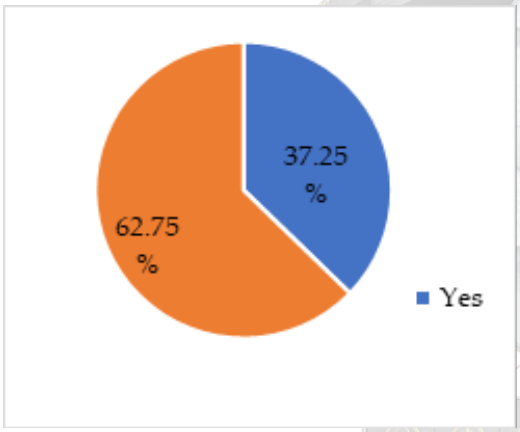

Figure 4. Training received by Teachers for using Fire Extinguishers or Fire Alarms

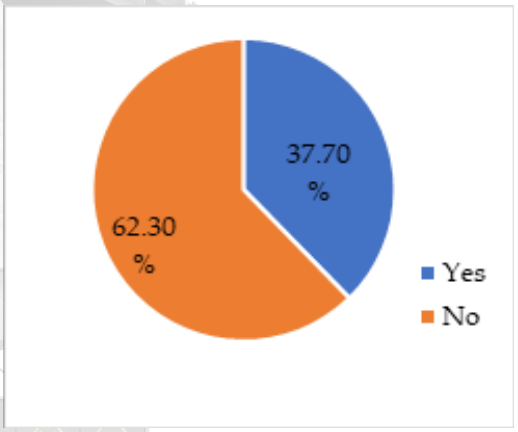

Figure 5. Preservice Training Received

Figure 4 indicates that 37.25% of teachers have received training on using fire extinguishers or fire alarms in schools, while 62.75% have not. Similarly, 62.30% of teachers have not received any preservice training on disaster management during their B.Ed or M.Ed course. It is also evident from Figure 5 that only 37.70% of teachers have received training on Disaster management activities during their Teacher education program.

Figure 6 indicates that only a few teachers (37.7%) have received guidance on addressing students' potential anxiety or fear related to earthquakes or other emergencies in a calm and reassuring manner. In contrast, 62.3% of teachers have not received any guidance from school authorities, which is a matter of grave concern. Chung and Yen (2016) had a similar observation that teachers were comparatively less proficient in preparation actions related to specific aspects of disaster prevention literacy.

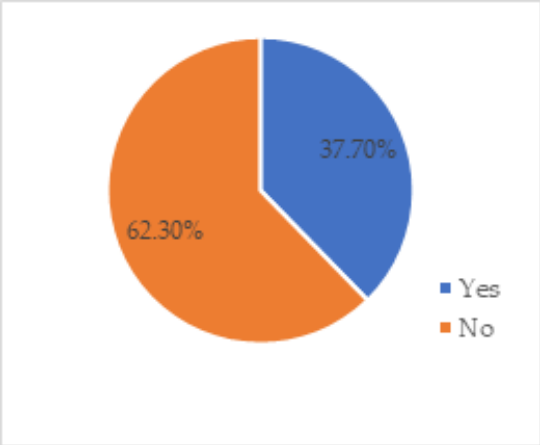

Figure 6. Guidance received by Teachers to address Students' potential Anxiety or Fear

With the unpredictability of natural disasters and emergencies, it becomes imperative for schools to prioritise comprehensive training for teachers, ensuring they possess the necessary skills and knowledge to provide comfort, reassurance, and guidance to students when faced with such challenges. By addressing this gap, schools can foster a safer and more supportive learning environment, promoting resilience and well-being among students in times of crisis. As viewed in prior studies, "the conduct of different trainings regarding DRR, drills, first aid, fire safety, search and rescue, swimming, and evacuation and emergency shelter is necessary" (Ahmedabad Action Agenda for School Safety, 2007 as cited in Mamogale, 2011). This will deepen teachers' understanding of different hazards and risks, empowering them to respond in establishing a disaster-resilient and safe school community.

5.4 Availability of Non-Structural Measures with the Schools for Disaster Risk Reduction

The study aimed to explore the availability of non-structural measures in schools for disaster safety. The easy evacuation of students from classrooms during emergencies is vital. It is evident from Fig. 7 that only 44.4% of schools have implemented the provision of two doors for easy evacuation during earthquakes or any such emergencies, indicating a proactive approach to safety measures. In contrast, 55.6% of schools lack this facility, indicating a need for improvement.

All the schools (100%) have adequate openings in their classrooms for ventilation and lighting, ensuring a conducive learning environment. However, while 84.31% of schools have secured fixtures, such as almirahs, shelves, and ceiling fans, properly to the walls or floor, 15.69% lack this crucial safety measure, potentially posing hazards during emergencies. Furthermore, the majority of schools (91.5%) have properly positioned pots or planters in corridors or playgrounds to facilitate smooth evacuation during disasters, highlighting a positive safety initiative.

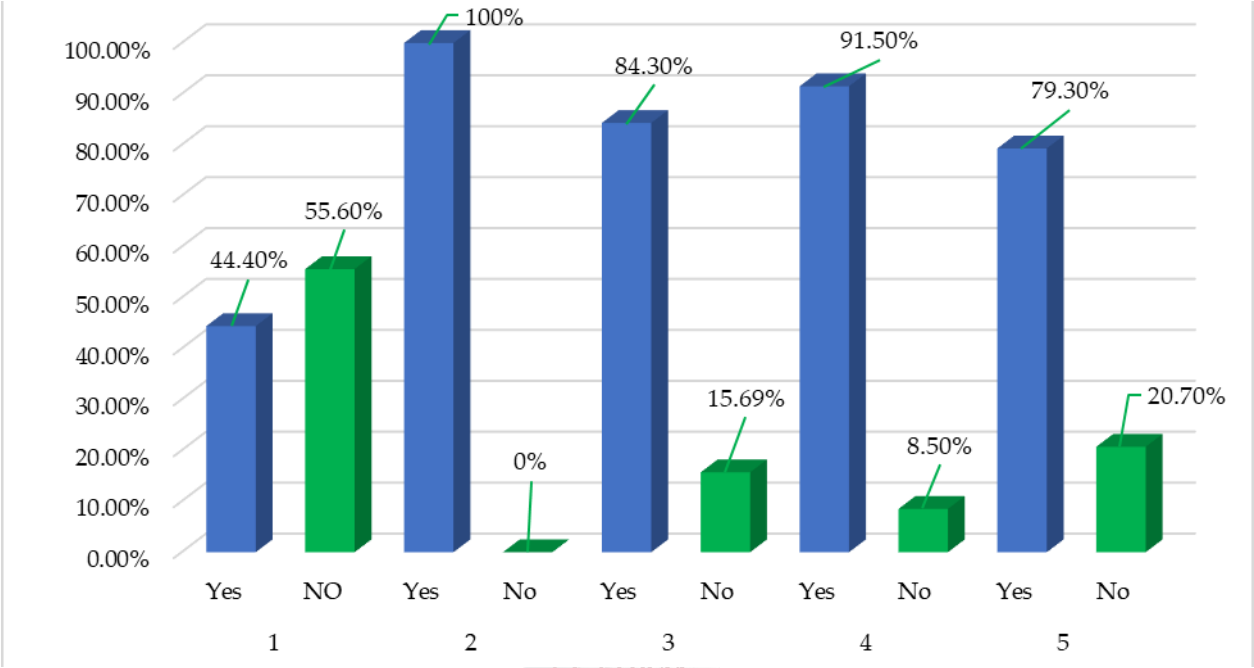

Figure 7. Availability of Non-Structural Measures with the Schools for DRR. Notes: 1) Availability of two doors in the classroom for easy evacuation; 2) Availability of adequate openings in the classroom for ventilation and lighting; 3) School fixtures properly secured; 4) Safe placement of pots for easy evacuation; 5) Regular maintenance of emergency equipment.

However, it is a matter of concern that 8.5% of schools still have not prioritised this aspect of safety. Moreover, while 79.43% of schools have procured and maintained emergency equipment, such as fire extinguishers and first aid kits, 20.70% have not, indicating a significant gap in emergency preparedness. Schools need to recognise the importance of comprehensive safety protocols to ensure the well-being of students and staff during emergencies and continue to address existing gaps in safety measures. Similar to the present finding, Gajbhiye (2014) also observed that safety norms were not given priority in most schools and were often violated due to ignorance and a lack of knowledge. The researcher also observed that exit routes were blocked in most schools by placing all the extra storage and broken furniture. Fire extinguishers were outdated, and schools were unaware of this fact. Contrary to the above findings, Acierto, Robas, and Monte (2023) observed that elementary schools in the Philippines have fully implemented safe learning facilities and partially implemented enabling environment and school disaster risk reduction management criteria.

5.5 Initiatives of Schools for Awareness Generation and Sensitization of Students

It is also vital for the school to take initiatives regularly to generate awareness and sensitise students. The findings indicated a mixed picture regarding the implementation of disaster preparedness activities in schools. It is clear from Figure 8 that very few schools (41.09%) reported holding mock drills regularly to train students for emergencies, indicating a lack of a proactive approach to safety. A notable portion of schools (58.91%) still lack this essential practice. Similar results were obtained by Balu (2020), who observed that 43% of schools had conducted safety drills at least once a year.

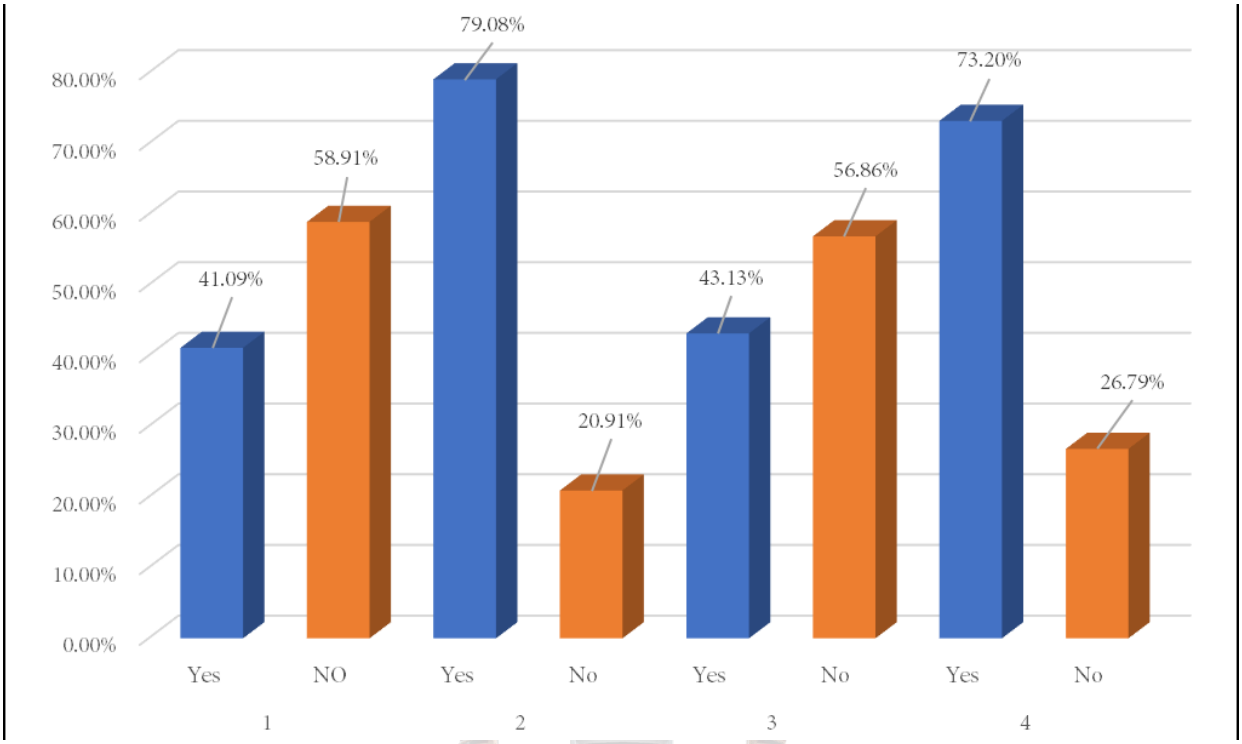

Figure 8. School Initiatives for Awareness Generation and Student Sensitisation. Note: 1 Mock drill was conducted; 2 Students trained for Fire Safety Protocols; 3 Experts were invited to empower students and teachers; 4 Extracurricular activities

The fact that 79.08% of schools have taught students about fire safety protocols demonstrates a positive step towards raising awareness among students. However, a significant portion of schools have not yet implemented such training, highlighting potential gaps in safety education. 43.13% of schools regularly invite experts to empower students and teachers regarding disaster management activities, while a considerable number of schools have not utilised external resources to enhance disaster preparedness. It is also evident from Fig 8 that 73.20% of schools have conducted extracurricular activities to educate students about disasters and their commendable management, indicating a holistic approach to disaster preparedness education. In a similar study, Cvetković, V. (2016) concluded that it is vital to encourage individuals to take preventive measures and familiarise themselves with safety procedures. The researcher emphasised that a vital step in enhancing preparedness is the careful design and implementation of specific disaster-related topics, along with imparting practical skills at both the primary and secondary stages of education to empower students.

6. Conclusion and Recommendations

Schools and teachers play a crucial role in disaster risk reduction by adopting effective mitigation strategies and preparing for emergencies. Often, a lack of awareness exacerbates the impact of disasters, complicating emergency management efforts for authorities. Disaster education is fundamental to transforming the concept of disaster management in the country. The Ministry of Human Resource Development, in collaboration with the National Disaster Management Authority (NDMA), should undertake significant nationwide initiatives periodically, as well as establish effective monitoring mechanisms to empower all stakeholders, ensuring they are equipped to manage disasters effectively.

Teachers play a crucial role in disaster preparedness, serving as the first line of defence in schools during emergencies. Therefore, regular training is necessary to equip them with the knowledge and skills required to protect students effectively. Enhanced awareness programs and comprehensive preparedness plans should be implemented to foster a culture of safety within the school community.

Schools, as vital platforms for imparting knowledge, skills, and attitudes necessary for disaster preparedness, have a critical role in raising disaster awareness among students. Similarly, training students in disaster preparedness is crucial to ensure they can respond effectively in the event of an emergency. Hence, integrating Disaster Risk Reduction (DRR) into the educational framework, along with an experience-based curriculum, is not just an option but a necessity. It should be incorporated not only in schools but also in teacher education programs to equip prospective teachers.

The National Council for Teacher Education (NCTE), as a regulatory body, should take a proactive role in promoting disaster preparedness by mandating Disaster Risk Reduction (DRR) training as an essential component of teacher education programs in India. This directive can ensure that prospective teachers are equipped not only with pedagogical skills but also with the practical abilities needed to respond effectively during emergencies. Additionally, certification programs that assess and validate teachers' disaster readiness can be introduced. Ultimately, prioritising and investing in robust safety measures in educational institutions is crucial for mitigating the impact of potential disasters. By doing so, we can create safer and more resilient learning environments for teachers and students.

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Conflicts of Interest: The author declares no conflict of interest.

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Article

Project DINGGIN: Empowering Communities through Risk-Based and Inclusive Cash Transfer in Disaster-Prone Areas in Bangladesh and Philippines

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ABSTRACT

Disaster-prone communities in Albay, Philippines and Bhola, Bangladesh, face recurring typhoons, cyclones, and floods that simultaneously destroy homes, disrupt livelihoods, and threaten food security. Traditional cash transfer programs (CTPs) for disaster relief often lack inclusive, risk-informed design and fail to account for the intersectional vulnerabilities of at-risk groups. Project DINGGIN (Dynamic Inclusive Network for Governance, Guidance, Intersectionality, and Nexus) addresses this gap by developing a risk-based, community-informed cash transfer framework. The approach bridges bottom-up risk data gathered through household surveys, participatory risk mapping, focus groups, and interviews with top-down policy frameworks within a humanitarian-development-peace nexus approach. Data from Albay and Bhola revealed that affected households prioritise simultaneous home rebuilding and income recovery; however, existing cash assistance is fragmented and not well-coordinated. Using a decision-support dashboard, local governments and communities co-developed tailored Cash Transfer Values (CTVs) reflecting each community's specific disaster risks and socioeconomic needs. The results demonstrate that an integrated cash transfer strategy—addressing shelter, food, and livelihoods together—can provide immediate relief while strengthening long-term resilience. For example, households in high-risk zones received larger grants for shelter reinforcement and livelihood restoration, aligning assistance with locally identified needs. This risk-informed, inclusive CTP model improved community ownership and met humanitarian Sphere standards for equity and adequacy. The discussion of Project DINGGIN's pilot indicates strengthened multi-sectoral coordination and highlights areas for improvement, such as providing multi-phase support beyond the emergency phase, offering financial literacy training to beneficiaries, and implementing adaptive disbursement schedules. The study concludes that empowering communities to co-design cash interventions not only ensures a more effective disaster response but also institutionalises resilience-building for future crises, aligning with national disaster management plans and international frameworks.

KEYWORDS

Community-managed disaster risk reduction (CMDRR); risk-based cash transfer; hybrid governance; participatory risk mapping; disaster preparedness; humanitarian nexus; community resilience.

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1. Introduction

Communities living in high-disaster-risk areas, such as Albay in the Philippines and Bhola in Bangladesh, face the constant threat of natural hazards that disrupt lives, devastate livelihoods, and erode long-term resilience. Albay, located in the Bicol region, is one of the most disaster-prone areas in the Philippines. It is frequently impacted by typhoons and monsoon-induced floods, exacerbated by volcanic eruptions from Mount Mayon. This recurring exposure to natural hazards leads to the destruction of homes, critical infrastructure, and agricultural assets, pushing vulnerable populations deeper into poverty and food insecurity. Bhola, a coastal island in Bangladesh, similarly faces annual cyclones, storm surges, and river erosion that decimate fishing communities, displace families, and strip away access to essential services. The repetitive cycle of recovery and loss in both Albay and Bhola underscores a critical challenge in humanitarian response: building long-term resilience while addressing immediate needs.

In response to these cyclical disasters, Cash Transfer Programs (CTPs) have become a widely adopted intervention among governments and humanitarian actors. The appeal of CTPs lies in their flexibility, enabling affected families to prioritise their own needs, whether for shelter, food, or livelihood recovery. Despite their proven efficiency, traditional CTPs often apply a one-size-fits-all approach that overlooks the granular differences in risk exposure and vulnerability within communities. For instance, households in low-lying, flood-prone areas may require different forms of support compared to those in landslide-prone uplands. However, standardised cash transfers frequently fail to reflect these disparities. More critically, vulnerable subgroups—such as women-headed households, persons with disabilities (PWDs), elderly populations, and Indigenous communities—face barriers to accessing these financial lifelines due to structural inequalities and insufficient targeting mechanisms.

This highlights a pressing gap in the design of cash-based interventions: the need for risk-informed, community-centred cash transfer models that are inclusive and adaptive to local vulnerabilities. Traditional approaches to CTPs often fragment assistance into sectoral silos, separating cash for food, shelter, or livelihood without a cohesive strategy that links these components to community resilience. Furthermore, many interventions remain top-down, sidelining local voices in decision-making processes. The result is a cycle of dependency rather than empowerment, where cash transfers meet short-term needs but fail to foster sustainable recovery and resilience.

To address these shortcomings, Project DINGGIN (Dynamic Inclusive Network for Governance, Guidance, Intersectionality, and Nexus) was conceptualised. Grounded in the principles of inclusive governance and nexus-based approaches, DINGGIN advances the concept of cash assistance by bridging humanitarian relief, development, and peace-building efforts. Unlike conventional models, Project DINGGIN introduces a risk-based, community-driven framework that integrates local knowledge and real-time risk assessments into cash programming. The initiative places community members—not external actors—at the centre of decision-making, ensuring that cash allocations reflect the specific risks and recovery needs of marginalised groups. This model is built on four foundational pillars:

1. *Community Resilience Theory.* Emphasising local capacity to adapt, self-organize, and recover from shocks (Carla, 2019; Kabir et al., 2022). This theory underlines the importance of community agency in disaster response and long-term recovery.
2. *Participatory Development Approaches.* Asserting that development interventions are more sustainable and impactful when communities actively participate in decision-making, planning, and implementation. Project DINGGIN operationalises this through community-led assessments and participatory planning processes.
3. *Intersectionality Framework.* Recognising that overlapping social factors (gender, disability, income status, and geography) create differential vulnerabilities in disasters. Cash transfers under DINGGIN are calibrated to account for these intersecting inequalities, enhancing inclusivity.

4. *Bridging Leadership and Hybrid Governance Models and emphasising* multi-stakeholder collaboration that links local governments, civil society, humanitarian actors, and community organisations to co-create solutions. This governance structure ensures that cash assistance is not just disbursed but managed in a way that strengthens local capacity for risk management.

Central to DINGGIN's innovation is its community-derived risk assessment model, where local stakeholders map hazards, vulnerabilities, and coping mechanisms. This data is integrated into a government-hosted decision-support system that informs cash transfer allocations based on real-time needs and predicted risks.

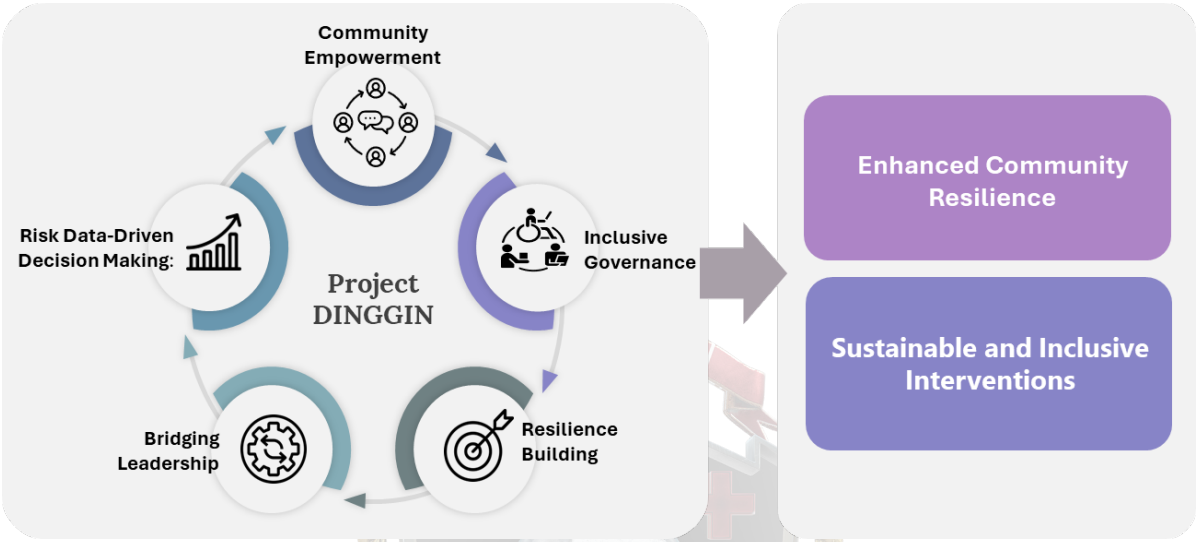

Figure 1. Project DINGGIN's conceptual framework

As illustrated in *Figure 1*, Community-derived data on risks and vulnerabilities inform a government-hosted decision-support system, which then guides a tailored cash transfer program, ultimately aiming to enhance community resilience. This approach builds on several bodies of theory and practice. Community resilience theory emphasises the capacity of communities to adapt, self-organise, and recover from shocks (Norris et al., 2008). Participatory development approaches argue that interventions are more effective and sustainable when local stakeholders are actively involved in planning and decision-making (Chambers, 1997). Intersectionality highlights that overlapping social factors (gender, disability, poverty, etc.) create differential vulnerabilities in disasters (Crenshaw, 1989), implying that relief must be sensitive to these differences. Bridging leadership and hybrid governance frameworks stress the importance of multi-stakeholder collaboration—linking government, civil society, and communities—to solve complex problems (Institute of Medicine, 2015; Ostrom, 1990). Project DINGGIN integrates these concepts, positing that a risk-based, inclusive Community-Based Disaster Risk Reduction (CBDRR) can simultaneously achieve immediate humanitarian goals and long-term risk reduction by empowering communities and linking their insights with institutional support.

1.1. Research Objectives

This study seeks to develop, implement, and evaluate Project DINGGIN's community-centred cash transfer framework in two high-risk settings: Albay, Philippines, and Bhola, Bangladesh. Specifically, the research objectives are as follows:

- To assess local risk profiles, capacities, and needs in Albay and Bhola, identifying key vulnerabilities and community-driven priorities for cash-based interventions.

- To design a Cash Transfer Value calculation model that incorporates localised risk data, exposure levels, and intersectional vulnerabilities, including gender, disability, and socio-economic status.
- To evaluate the framework's effectiveness in addressing multi-sectoral needs—specifically in shelter, food security, and livelihoods—while enhancing community resilience and disaster preparedness.

1.2. Significance of the Study

The significance of this research extends beyond short-term relief. By grounding cash assistance in localised risk assessments and community decision-making, Project DINGGIN introduces a paradigm shift in Cash Transfer Programming. It demonstrates how inclusive, risk-based cash interventions can simultaneously address humanitarian needs and foster long-term community resilience. This model also presents a replicable blueprint for local governments and humanitarian agencies in other disaster-prone regions, offering a pathway toward adaptive, inclusive, and sustainable disaster risk reduction.

The following sections will explore the literature and policy landscape guiding inclusive disaster cash transfers, outline the study's methodology, and present findings from Albay and Bhola. Discussions will reflect on the implications of Project DINGGIN, including its potential to influence policy and practice in disaster risk reduction and anticipatory action globally.

Figure 2. Project DINGGIN Theoretical Framework

1.3. Literature Review

1.3.1. Resilience and Disaster Risk Reduction (DRR)

Academic discourse on disasters increasingly frames community resilience as a key outcome for interventions. Norris et al. (2008) describe community resilience as a set of adaptive capacities that enable a community to withstand and recover from shocks and stresses. These capacities—such as social capital, information and communication, and economic resources—are vital for disaster-prone communities. Cash transfer interventions, if designed with resilience in mind, can enhance these capacities by providing resources that households use to prepare, respond to, and adapt to shocks. However, a critique in the literature is that many cash programs focus predominantly on short-term relief rather than resilience building.

The research underscores a critical gap in conventional CTPs where risk reduction objectives are not fully integrated. Traditional cash transfers often meet immediate needs but fail to facilitate in-

vestments in safer housing or livelihood diversification, which are crucial for mitigating future risk. For example, in high-risk areas such as Albay (Philippines) and Bhola (Bangladesh), hazard-specific vulnerabilities, such as typhoon-induced flooding or river erosion, remain unaddressed when cash disbursements are uniform and not risk-calibrated. Project DINGGIN addresses this by integrating community-driven risk assessments into cash transfer design, enabling the customisation of aid based on localised risk data. This enables not only immediate recovery but also sustainable adaptation.

DINGGIN's model aligns with global resilience frameworks, such as the Sendai Framework for Disaster Risk Reduction (2015–2030), which promotes anticipatory action and local capacity building. Its risk-informed design sets it apart from conventional models by emphasising community-based risk profiling that informs not only the amount of cash but also its purpose—whether for reinforcing homes, protecting livelihoods, or accessing food supplies ahead of disaster shocks.

1.1.4. Participatory and Inclusive Approaches

Development scholars such as Chambers (1997) argue that interventions are more effective and sustainable when local stakeholders are actively involved in planning and decision-making. In disaster management, Community-Based Disaster Risk Reduction (CBDRR) has emerged as a key framework that leverages local knowledge for hazard assessment and preparedness planning. Van Aalst, Cannon, and Burton (2008) emphasise that participatory methods, such as risk mapping, allow communities to better understand their vulnerabilities and craft locally relevant action plans.

Both the Philippines and Bangladesh have adopted CBDRR as part of their national disaster management strategies. This participatory model fosters local ownership and ensures that community voices inform and shape preparedness and recovery plans. An evolution of this model is evident in the Community Managed Disaster Risk Reduction (CMDRR) framework, which emphasises local leadership throughout the entire disaster management cycle—from risk assessment to recovery. According to Binas (2009), CMDRR empowers local groups to develop risk reduction strategies and present them to local authorities, ensuring that plans are community-driven and contextually relevant.

Project DINGGIN builds on these principles by establishing community-driven cash transfer mechanisms. Risk assessments are led by community members, whose insights determine how much cash is allocated and for what purposes. This model not only amplifies local agency but also aligns with the Sendai Framework's call for All-of-Society Engagement and local capacity-building.

1.3.2. Intersectionality and Vulnerability

The concept of intersectionality, introduced by Crenshaw (1989), provides a framework for understanding how overlapping social categorisations—such as gender, age, disability, and economic status—compound individuals' disaster vulnerability. For example, women-headed households often experience greater challenges in accessing aid and recovering from disasters due to socio-economic barriers. Similarly, persons with disabilities (PWDs) face distinct obstacles during evacuations or in accessing shelters. Both Bangladesh and the Philippines have legal mandates in place to protect these vulnerable groups during disaster response. Bangladesh's Disability Rights and Protection Act (2013) and the Philippines' Magna Carta for Persons with Disabilities (1992) provide legal frameworks for inclusive disaster response. However, traditional aid programs rarely calibrate cash assistance to reflect these varying vulnerabilities. Cvetković *et al.* (2021) suggest that local authorities and communities should be at the centre of disaster management. They stress that capacity-building in DRM means "developing skills to reduce and cope with disasters and disaster risks in communities at the local levels" However, the study also highlights critical gaps: many local disaster teams lack proper training or qualifications, legal responsibilities for DRM are poorly enforced, and necessary planning (hazard assessments, rescue schemes) is often incomplete. In short, the system remains only "partially established at the local level", with formal DRM obligations unevenly fulfilled. The authors emphasise that community empowerment is key. They note that "the highest effectiveness is at the community level, where specific needs are met". In other words, disaster plans are most ef-

fective when local people are involved in their design and implementation. Indeed, *Sphere* standards similarly state that affected people have the right to "fully participate in decisions related to their recovery", and the 2018 *Sphere Handbook* highlights a "stronger focus on the role of local authorities and communities as actors of their recovery". Cvetković *et al.*'s findings echo these principles: They observe widespread community involvement in prevention (e.g. local drills and school programs) and recommend formalising this participation. The study concludes that strengthening local DRM capacity requires continuous reform and local ownership. In particular: "Local self-governments allocate funds for DRM and civil protection supplies," but "coordination is still seen as weak," and voluntary citizen engagement is not yet standardised. The authors warn that without proper support, local governments risk becoming "bureau-politically incompetent" placeholders. They highlight one stark insight: *"Members of disaster management teams within local self-government units have neither the necessary qualifications nor proper education and training for DRM"* At the same time, Cvetković *et al.* note the potential for community-driven resilience: capacity-building at the local level can "substantially reduce global disaster losses" by ensuring that "members of the community carry out all activities". Overall, their empirical evidence strongly supports a localised, participatory approach, aligning with the Grand Bargain's localisation agenda and Sphere's focus on community agency.

In contrast to institutional capacity, the second study examines the disaster perceptions of young adults. Across 537 university students in Turkey, Serbia and N. Macedonia, Cvetković *et al.* (2019) find high levels of fear, especially of natural hazards. Key results: *"An excessive level of fear [was reported] of both earthquakes and epidemics"*. Students were most concerned about their safety and, to an even greater extent, the health of their parents. Personal or familial vulnerability thus outranked concern over material losses. The sources of this fear were largely experiential: "Bad weather conditions, pictures of the consequences of disasters, and past disaster experience were found to exacerbate fear". This insight suggests that inclusive approaches must specifically address the perspectives of females (and youth): Cvetković *et al.* Importantly, they advocate community-involved education. In practice, this means moving beyond classroom lessons to include family and community forums. For example, they note that discussing disaster threats in family settings and reframing them as collective "challenges" can improve coping: turning *"'threat' talk into 'challenge' talk"* leads to better performance and lower fear. Basic needs (e.g. being without food) indicate that social safety nets matter. The data imply that preparedness programs should address these concerns, not just infrastructure. Moreover, the authors note that involving young people in disaster planning can break down the "protection vs participation" barrier. By empowering youth to participate (e.g., in school safety committees, student-led drills, and community hazard mapping), we both reduce paralysing fear and build local resilience. These recommendations align with Sphere's participatory ethos – the Handbook reaffirms that people have the right to "fully participate" in their protection and recovery.

Project DINGGIN addresses this gap by customising cash transfer amounts based on household characteristics, ensuring that aid is responsive to the intersectional vulnerabilities of its recipients. For instance, additional funds are allocated for women-led households, families with members who require assistive devices, and elderly populations. This targeted approach advances equity and inclusivity in disaster response.

1.3.3. Bridging Leadership and Hybrid Governance

Disaster resilience often requires collaborative governance models that bridge local knowledge and institutional support. The bridging leadership paradigm describes a multi-stakeholder approach where government agencies, NGOs, the private sector, and community groups co-create solutions. Ostrom (1990) argues that effective governance involves polycentric arrangements that allow communities to manage shared risks in a coordinated manner.

Both the Philippines and Bangladesh have institutional mechanisms for multi-level coordination. The Philippines utilises Local Disaster Risk Reduction and Management Councils (LDRRMCs), while Bangladesh operates Union Disaster Management Committees (UDMCs). These structures are designed to integrate local inputs into broader disaster planning and response.

Project DINGGIN capitalises on these structures by employing a hybrid governance model—a government-hosted yet community-populated risk database that guides cash allocation. This system strengthens vertical and horizontal integration, ensuring that local needs are directly linked to policy decisions.

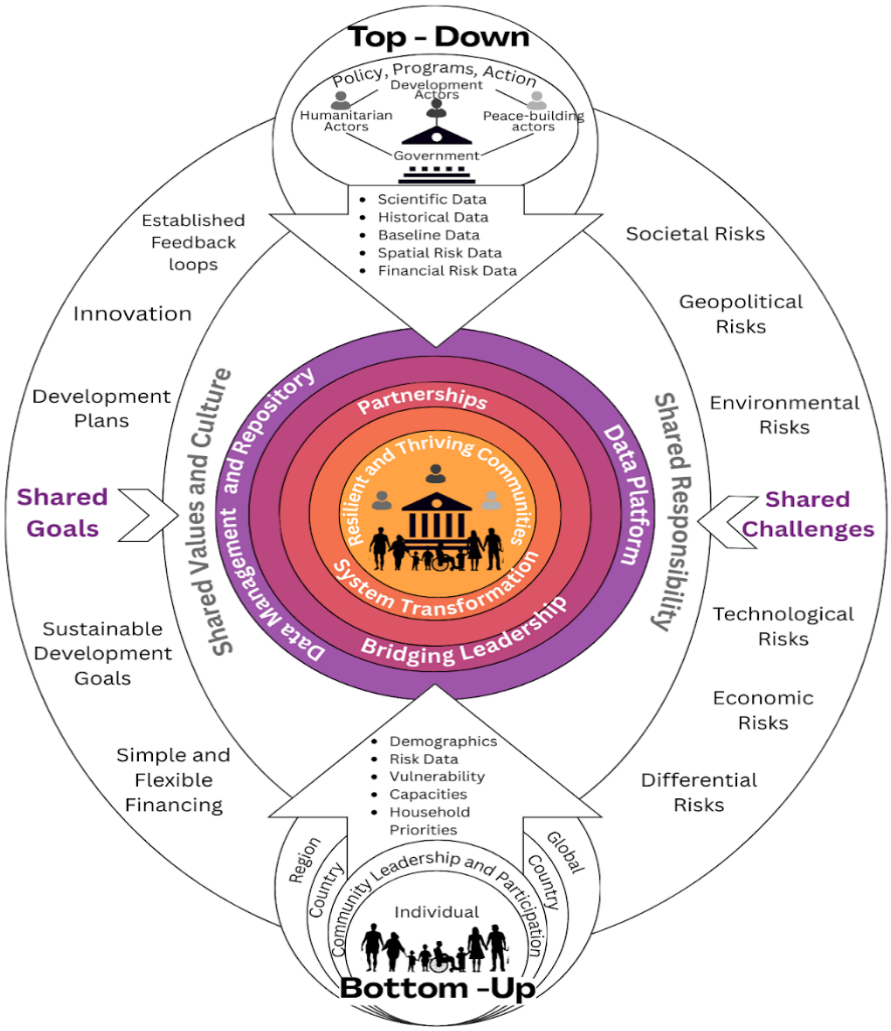

Figure 3. Project DINGGIN's Hybrid Governance Model

These structures are meant to ensure that disaster planning and response are inclusive and coordinated. However, bridging the gap between high-level policy and local action remains a significant challenge. Project DINGGIN's strategy of a government-hosted but community-populated risk database exemplifies hybrid governance, as it requires political will and policy support from authorities while being driven by community data and participation. This not only enhances vertical integration (where local needs inform national programs and vice versa) but also encourages horizontal collaboration among agencies (e.g., social welfare, agriculture, housing) to deliver a unified cash assistance program. Such an approach aligns with global initiatives, including the 2016 Grand Bargain commitments, which advocate for increased local ownership and coordination in humanitarian responses.

1.3.4. Humanitarian–Development–Peace Nexus

The Humanitarian–Development–Peace Nexus highlights the importance of integrating short-term relief with long-term recovery and peacebuilding efforts, where humanitarian aid, development, and peacebuilding efforts should not occur in silos in protracted crises or recurrent disaster contexts. In practice, cash transfers are viewed as a tool that can bridge this nexus: emergency cash can meet immediate needs, while, if sustained or linked to social protection systems, it can sup-

port recovery and build resilience. Both Bangladesh and the Philippines have been piloting forecast-based financing and anticipatory action mechanisms, where cash or other aid is delivered when a hazard warning triggers before the disaster fully strikes, to reduce its impact. Case studies by the Red Cross in Bangladesh (flood preparedness cash distributions) and in the Philippines (pre-typhoon cash support to secure livelihoods) demonstrate the potential of such proactive approaches. However, implementing risk-triggered or seasonal cash transfers at scale presents several challenges, including determining appropriate triggers and transfer values, as well as avoiding duplication with post-disaster aid. The literature suggests more evidence is needed on effective models for predictive, risk-triggered cash assistance. Project DINGGIN contributes to this area by designing cash transfers that factor in *seasonal calendars* of hazards and by recommending adaptive disbursement schedules (e.g., providing funds ahead of the peak typhoon or flood season in each locale).

1.3.5. Policies and Standards

Both case study countries have robust disaster management policies that inform this research. In Bangladesh, the *Standing Orders on Disaster* (SOD, revised 2019) is a comprehensive guideline that assigns specific roles to all ministries and local bodies in disaster preparedness and response (Government of Bangladesh, 2019). The SOD emphasises risk assessments and addresses shelter, food, and livelihoods in recovery planning, aligning with the concept of multi-sectoral cash support. Bangladesh's *Disaster Management Act* (2012) provides the legal foundation, prioritising the protection of vulnerable communities and emphasising the integration of risk reduction into emergency response. In the Philippines, the *National Disaster Risk Reduction and Management Act* of 2010 (Republic of the Philippines, 2010) and its implementing plans (NDRRMP 2020–2030) likewise promote comprehensive recovery measures, including the use of cash-for-work and emergency cash assistance as key strategies. A notable feature of the Philippine system is decentralisation: Local government units (LGUs) are expected to tailor national guidelines to their specific contexts, which supports the idea of locally calibrated cash interventions. Both countries are also signatories to international humanitarian standards. The Sphere Standards (Sphere Association, 2018) establish minimum benchmarks for areas such as shelter, food security, and livelihoods in humanitarian responses. Sphere guidance on cash assistance highlights that *the amount of cash must be sufficient to meet basic needs with dignity*, and programs should be accessible to all segments of the population. By incorporating Sphere considerations and national policy criteria into its design, Project DINGGIN's framework strives to be policy-compliant and rights-based. For example, ensuring that the computed cash grants in Albay and Bhola at least cover the cost of a basic food basket and essential shelter materials for an average household (to meet minimum needs) reflects adherence to these standards.

In summary, the literature and policy review underlines several critical points: (1) Cash transfer programs in disasters can be more powerful if they are risk-informed and oriented toward resilience rather than relief alone; (2) Community engagement and local data are key to designing relevant and inclusive aid interventions; (3) Social differences must be recognised – *one-size-fits-all aid can perpetuate inequality*, whereas inclusive design can advance equity; (4) Effective solutions require bridging actors and knowledge across different levels, embodying a hybrid governance model; and (5) There is alignment and opportunity to embed such approaches within existing national and international frameworks. Project DINGGIN's approach is built upon these insights, seeking to contribute a practical example of how they can be operationalised. By combining participatory methods with data analysis and aligning with existing policies, the project aims to demonstrate a novel model for disaster cash transfers that addresses known gaps in current practice. The next section outlines the research conducted in the two communities to implement this model.

2. Methods

2.1. Study Sites and Participants

We conducted the study in two hazard-prone communities: one in Albay province, Philippines, and one in Bhola district, Bangladesh. In Albay, the focus was on several barangays (villages) in a

coastal municipality highly exposed to typhoons and flooding. In Bhola, we focused on a union (a cluster of villages) along the Meghna River, which is regularly affected by riverbank erosion and cyclonic storms. We used a mixed-methods case study design to capture both quantitative and qualitative dimensions of community risk and the impact of cash transfers.

2.2. Sampling and Generalizability

In Albay, we collaborated with local officials to engage five barangays that had recently experienced disasters. Community assemblies were held to invite participation. A total of *89 community members* took part in Participatory Risk Mapping (PRiMa) exercises across the barangays, and *60 households* were surveyed via a structured questionnaire (one respondent per household). The survey respondents were 78% female (largely reflecting that women were available and willing to respond during daytime visits), with a median age of 46 years. Household income levels were generally low, with 97% of surveyed families reporting monthly incomes below PHP 10,000 (approximately USD 200), indicating a high incidence of poverty.

In Bhola, due to logistical and accessibility constraints (the study coincided with ongoing flood recovery in remote chars), a smaller group of participants was reached. We conducted focus group discussions and key informant interviews with seven community members (including local elders and a women's group leader) to gather data on risk perception and livelihood challenges. While the sample size in Bhola is limited, its inclusion is justified as it provides in-depth qualitative insights critical for understanding local-specific risks and vulnerabilities. Recognising its limitations in statistical generalizability, we applied methodological triangulation, integrating qualitative insights with secondary data on demographics, hazard history, and existing response mechanisms to enhance reliability. Future scaling of the study would benefit from expanded sampling to strengthen generalizability.

2.3. Data Collection Methods

We employed multiple data-gathering methods to ensure a comprehensive understanding of community needs and the effectiveness of cash transfers:

2.3.1. Household Survey

In Albay, the survey collected quantitative data on socio-economic status (household size, income sources, land/home ownership, etc.), disaster experiences (frequency of evacuations, damage to house in last 5 years), risk perceptions (e.g. "How likely do you feel a severe storm will impact you in the next year?" on a Likert scale), and prior use or access to cash assistance. It also inquired about how households would prioritise spending a hypothetical cash grant for disaster preparedness or recovery. The survey results provided baseline metrics – for instance, the percentage of houses damaged by recent typhoons (87% reported some damage in the past five years) and the distribution of primary livelihoods (farming 40%, small trading 30%, fishing 20%, others 10% in our Albay sample). In Bhola, given the very small survey count, quantitative data was not statistically significant; however, we noted that all participating households in Bhola were landless labourers or smallholder farmers/fishers, confirming the community's high dependence on climate-sensitive livelihoods.

2.3.2. Participatory Risk Mapping (PRiMa)

We facilitated mapping sessions where community members identified hazard-exposed zones, important resources, and vulnerable households on local maps. In Albay, participants worked in small groups to draw their barangay map, marking houses, farms, evacuation centres, etc., and then overlaying the map with symbols for hazard impacts (flood-prone areas, houses damaged in the last typhoon, etc.). This exercise revealed granular details—for example, one barangay's map highlighted a low-lying sitio (hamlet) where nearly all homes (approximately 50) are inundated with

knee-deep water during heavy rain due to poor drainage. Participants also mapped the locations of particularly vulnerable households (like an elderly person living alone or a family with a disabled child). In Bhola, the few participants collectively sketched their village and recounted how a 2020 cyclone caused the river to engulf several homesteads; they pinpointed eroding riverbanks and where people relocate seasonally. The PRiMa results directly informed the identification of who should receive higher cash transfers and for what purpose (e.g., households near the riverbank in Bhola might need funds for temporary relocation or house elevation, as identified in the map discussion).

2.3.3. Focus Group Discussions (FGDs)

We conducted separate focus group discussions (FGDs) at each site to explore the qualitative aspects. In Albay, a mixed-gender FGD (12 participants) discussed community coping strategies and gaps in aid. Participants noted that while they receive early warnings and occasionally relief goods after disasters, *"money to rebuild livelihoods comes very late or not at all,"* underscoring a delay in support for income recovery. Another FGD with women (8 participants, including several sari-sari store owners and farmers' wives) shed light on how women manage household finances post-disaster; they emphasised the importance of cash for purchasing food and school materials so that family life can return to normal quickly. In Bhola, an FGD of 5 men (farmers and fishermen) described how they often take loans from local moneylenders at high interest rates after disasters to repair nets or buy seeds, as external assistance is minimal beyond some rice distribution. These discussions underscored community priorities and informed what the cash transfers should cover.

2.3.4. Key Informant Interviews (KIIs)

Interviews with local officials and aid workers provided valuable context on existing programs and the challenges they face. For example, Albay's municipal officer explained that they have an emergency fund. However, it is limited and primarily used for relief goods and emergency shelter rather than direct cash distribution – except for a small cash-for-work program that employed residents for cleanup after a typhoon. An NGO worker in Bhola explained how a lack of banking infrastructure on the chars (river islands) makes cash delivery difficult, often requiring physical transport of cash, which poses security issues. These insights were important for designing the delivery mechanism of our proposed cash program (e.g., whether mobile cash transfers, over-the-counter payments, or in-person disbursements would be feasible in each site).

2.3.5. Risk-Based, Intersectional Cash Transfer Value (CTV) Formula

The formula for calculating the Cash Transfer Value (CTV) considers several factors that reflect the household's basic needs, vulnerabilities, risks, and specific circumstances. The formula is designed to ensure that cash transfers are proportionate to the risks and needs of each household. Project DINGGIN's approach to cash transfers is deeply informed by the CMDRR principle of community ownership over disaster planning and recovery (Binas, 2009). The computation of the Risk-Based, Intersectional Cash Transfer Value (CTV) is detailed in the published white paper titled *A Risk-Informed, Inclusive Approach to Cash Transfers: Hybrid Governance for Resilience Building*. The white paper outlines the formula that determines differentiated cash assistance amounts based on:

- Basic Needs Multiplier (BNM)
- Household Impact Factor (HIF)
- Risk Impact Factor (RIF)
- Shelter Vulnerability Factor (SVF)
- Purpose Multiplier (PM)
- Top-ups for specific vulnerabilities

Interpretation and Application:

1. The formula ensures that households facing multiple disadvantages receive more assistance.
2. The modular nature allows for context-specific adjustments.

3. CTVs are calculated based on updated data inputs from community assessments, ensuring relevance and fairness.
4. This method ensures that the calculated cash transfer value is risk-informed, intersectional, and contextually adaptive, upholding the principles of equity and resilience as emphasised in Project DINGGIN

This structured formula ensures that cash transfer values are not arbitrary but reflect the unique risk exposure and socio-economic conditions of each household. For detailed computation steps and formula derivation, please refer to the white paper (*A Risk-Informed, Inclusive Approach to Cash Transfers: Hybrid Governance for Resilience Building*, 2024)

2.4. Analysis and Framework Development

Our analysis proceeded in two stages: an assessment of community needs and capacities, and the formulation of a risk-based cash transfer scheme. We created an analysis framework combining quantitative thresholds with qualitative criteria, aligned to policy standards:

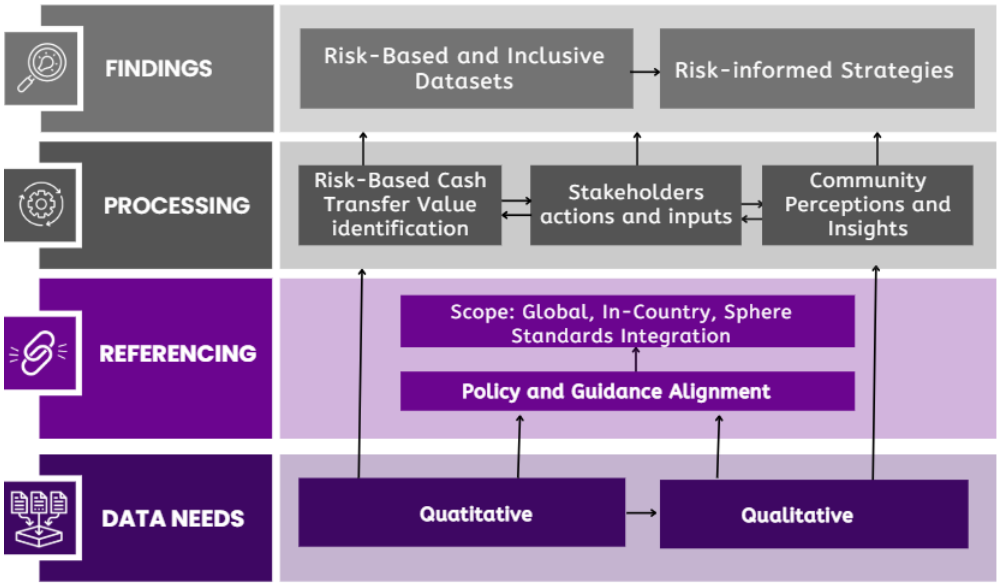

Figure 4. Project DINGGIN Analysis Framework

2.4.1. Quantitative Analysis

Survey data in Albay were analysed to determine the median costs of critical needs. For instance, we calculated the average cost to repair a typical damaged house roof (from respondents' estimates) and the average monthly expenditure on food. These figures helped establish a baseline "transfer value" needed per household to address each sector (shelter, food, livelihood) at a basic level. We also computed risk metrics. Using the damage reports and risk perception, we assigned each surveyed household a composite risk score, incorporating factors such as high-risk area (+1), very low income (+1), and having a vulnerable member (+1), among others. Although Bhola's sample was too small for statistical analysis, we used available data (e.g., local crop loss statistics and typical income levels) to inform assumptions for Bhola's needs.

2.4.2. Qualitative Analysis

We reviewed FGD transcripts and PRiMa outputs to contextualise the numbers. Qualitative insights helped, for example, to prioritise which needs should be met first and identify potential challenges that might arise when using the cash. In Albay, community members strongly voiced the need for materials to strengthen houses *before* the next typhoon season, emphasising that the timing

is crucial. In Bhola, people highlighted the need for resources to protect livelihoods (such as boats, nets, and livestock) that are often overlooked in aid, which usually focuses on immediate relief. We also noted culturally specific factors: in Albay, mutual aid systems ("Bayanihan") exist, so a strategy that encourages community groups to pool part of their cash for communal goods (like repairing a shared evacuation shelter) was considered; in Bhola's conservative rural society, ensuring that women can safely access cash was considered (e.g., having distribution points in safe locations).

2.4.3. Policy Alignment

We cross-checked our emerging recommendations with national policy provisions and Sphere standards. For example, Sphere sets a minimum standard for food security, stating that households should have access to 2,100 kilocalories per person per day. Using local prices, we estimated the cost of a food basket to meet this calorie need. We ensured that our cash transfer for food in each context would be sufficient for an average household to meet that standard for at least one month after the disaster. We also considered government aid norms: in the Philippines, there is a national guideline (as of 2021) that each affected family receive PHP 5,000 in financial assistance after a major disaster. If our community data suggested a higher amount was needed for truly adequate support, we noted the discrepancy and framed recommendations to advocate for higher support or top-ups for specific groups.

Using these analyses, we designed the Project DINGGIN cash transfer framework. The framework determines cash grants based on three primary components: (a) Household risk category, (b) Intersectional vulnerability factors, and (c) Sector-specific needs. Each household is categorised (e.g., high risk–high vulnerability, high risk–low vulnerability, low risk–high vulnerability, low risk–low *vulnerability*) and assigned a cash package accordingly. High risk was defined by location/exposure and past disaster impact, while high vulnerability was defined by the presence of compounding factors (poverty level, vulnerable dependents). For instance, a *high-risk–vulnerable* household (say, an impoverished family in a flood zone with a disabled member) would qualify for the maximum transfer values across all sectors: funds to rebuild or reinforce housing, plus funds for food and livelihood recovery, calculated at above the baseline level to account for their added needs. Meanwhile, a *lower–risk, lower–vulnerability household might receive a smaller cash amount,* mainly for basic needs, on the premise that their capacity to cope is higher.

We also incorporated a seasonal/disaster-triggered element: the framework proposes that in Bhola, cash disbursements be split into multiple tranches timed before and after the monsoon/cyclone season, whereas in Albay, a single larger disbursement at the onset of typhoon season might be sufficient (with the option to activate an additional tranche if an actual typhoon hits). This was based on observed seasonal patterns and was informed by anticipatory action models.

To facilitate implementation, the project developed a digital decision-support tool (conceptual prototype). This *"risk-informed data platform"* compiles all the community data (survey results, map outputs, etc.) in a dashboard that local authorities can use.

Key features include a database of all households with their corresponding vulnerability profiles, a map view that highlights risk hotspots, and an automated calculator that suggests cash transfer amounts for each household or cluster of households. The platform is intended to be maintained by local government units (e.g., the Provincial DRR Office in Albay and the District Commissioner's Office in Bhola) to ensure sustainability and integration with official systems. Real-time disaster alerts (from meteorological agencies) could be linked to the platform so that when, for example, a cyclone warning is issued for Bhola, the system can flag the beneficiaries and recommend payout amounts for cash transfers.

Finally, we evaluated the framework by simulating its application using historical disaster scenarios. For Albay, we retrospectively applied the model to data from the 2020 Super Typhoon Rolly (Goni) impact in the area, examining how our proposed targeting and transfer values compared to the actual values provided and identifying any remaining gaps. For Bhola, we used a severe flood event scenario. We also gathered feedback from community representatives and local officials on the draft framework (through a validation workshop in Albay and follow-up phone calls with contacts in Bhola due to COVID-19 travel restrictions at the time). Their feedback (e.g., concerns about

dependency and suggestions for in-kind aid pairing) was taken into account in refining the recommendations.

Overall, the methodology is participatory and data-driven, combining community engagement tools with analysis techniques. Ethical approval was obtained through local governance structures. Informed consent was provided by all respondents and participants, with assurances that the data would be used to advocate for better support for their communities. The limitations of the data—particularly the smaller sample in Bhola—are acknowledged, and the analysis was cautious in drawing quantitative conclusions for that site. Nevertheless, the rich qualitative information and the comparative nature of the study offer valuable insights. In the next section, we present the key results, highlighting both communities' situations and the outcomes of applying the risk-based inclusive framework.

3. Results

3.1. Community Risk Profile and Needs Assessment

3.1.1. Albay, Philippines – Multi-Hazard Vulnerability

The surveyed barangays in Albay paint a picture of a community under chronic stress from natural hazards. About 87% of households reported sustaining house damage from typhoons or floods in the past five years, with common issues being torn roofs, collapsed walls (often made of light materials), and water damage to floors and belongings. Many homes are makeshift or semi-permanent, and recurring storms erode their structural integrity over time. Land ownership is another concern: only 40% of surveyed families own the land their house sits on; others occupy land informally (e.g., along riverbanks or coastal easements). This uncertainty can deter them from investing in sturdier homes and also makes them ineligible for some government housing assistance programs. Livelihood-wise, households rely on farming (rice, coconut, vegetables) and small trade (sari-sari convenience stores, handicrafts). Nearly all these income sources are seasonal and climate-sensitive. For example, farmers reported losing an entire planting season's harvest to flooding, and small store owners noted that their inventory spoils or is depleted when supply chains are cut after disasters. As a result, food insecurity looms in the post-disaster period. While Albay has a rich agricultural base, families often lack storage facilities or savings; many respondents reported having less than one week's worth of food at home in the event of a disaster. This is compounded by the fact that infrastructure damage often isolates communities (impassable roads), making market access difficult.

Community perceptions reflect a high degree of anxiety about disasters. In risk ranking exercises, residents identified shelter damage and income loss as their top concerns, even above the immediate risk of injury or loss of life. This indicates an understanding that while they have adapted to survival during storms (early evacuations are common and have saved lives), the long-term recovery – rebuilding homes and livelihoods – is where they feel most vulnerable. They also expressed a strong desire for self-reliance: rather than only receiving tarps or food packs, many would prefer resources that allow them to "get back on their feet" quickly, such as cash or tools.

3.1.2. Bhola, Bangladesh – Erosion and Isolation

The community in Bhola is smaller and more geographically isolated. Riverine erosion has, over the years, reduced the available habitable land, forcing families to relocate inland or to other chars frequently. Houses are typically made of corrugated iron sheets or thatch, raised on plinths (earth mounds) to guard against flooding. However, major cyclones with storm surges can wash away even these elevated homes. All participants from Bhola recounted experiences of displacement – moving to embankments or cyclone shelters for days to weeks after an event. Livelihood disruption in Bhola is severe because the local economy is narrow, primarily relying on subsistence farming and fishing. A cyclone can ruin crops in the field and kill livestock; floods can prevent sowing for the next season or make fishing impossible due to debris and equipment loss. A few small businesses (like tea stalls) also suffer from prolonged customer absence and supply issues. Unlike Albay, where

some outside assistance does reach (owing to better connectivity), Bhola residents often receive minimal aid. Government relief in past floods was described as "a few kilos of rice and some lentils per family" – helpful for immediate food needs but insufficient to recover livelihoods or homes.

The risk perception in Bhola is fatalistic yet pragmatic: people recognise that they cannot prevent floods or cyclones, so they emphasise the importance of adaptation. For example, some families have started building temporary platforms to move animals during floods, and there is interest in training for alternative livelihoods (such as sewing or small-scale trades) that are less climate-dependent. Critically, the lack of formal financial services in the charred area means families have virtually no savings accounts or insurance. Any shock thus plunges them deeper into debt or poverty. Food security in Bhola quickly deteriorates post-disaster, with local markets destroyed or inaccessible and no buffer stocks, leaving many to depend on relief or loans to eat. Malnutrition is a concern raised by local health workers, especially for children in the months following a significant flood.

In both sites, vulnerable groups face extra challenges. In Albay, about 15% of surveyed households are women-headed (widows or wives of migrant workers); these households had lower incomes on average and reported difficulty rebuilding homes due to a lack of labour or resources. Persons with disabilities were present in around 8% of Albay households and 10% of the small Bhola sample; their families often incurred additional costs (medicines, mobility aids) and needed help to reach aid distribution points or evacuation centres. These findings underscored the need for targeted support within the cash program for such groups.

3.2. Existing Cash Assistance Landscape

Before implementing the Project DINGGIN framework, we documented what forms of cash or assistance these communities have been receiving to establish a baseline. In Albay, formal cash assistance has been limited. The national government's conditional cash transfer program for poverty, the Pantawid Pamilyang Pilipino Program (4Ps), is operational, and approximately 50% of surveyed families were 4Ps beneficiaries, receiving modest monthly stipends to cover education and health expenses. However, the 4Ps are not designed for disaster response, and their payout amounts (roughly PHP 1500 or USD 30 per month per family) are not calibrated to disaster losses. After disasters, Albay communities mostly rely on in-kind aid, including food packs, used clothing, and some shelter repair kits (such as corrugated sheets, nails, and tarps), typically provided by the Department of Social Welfare and Development (DSWD) and NGOs like the Red Cross. We found only one instance of a cash-for-work program post-typhoon (after Typhoon Tisoy in 2019, a local NGO paid a few dozen community members PHP 300 per day for 10 days to help clear debris). There have been no systematic risk-based cash programs previously. Local officials acknowledged that while they recognise the value of cash (cash is faster and provides people with choice), they lack guidelines and resources to implement it at scale. This lack of coordinated cash initiatives often left needs unmet in Albay: for example, some families could not afford to repair their roofs fully and lived under leaking roofs long after the typhoon, which affected their health and livelihoods (as goods and grains kept getting wet).

In Bhola, direct government cash aid is virtually non-existent in the char areas. The primary government support for affected families is relief goods. Occasionally, NGOs or the local district administration have provided a one-time cash grant to a small number of families after a significant cyclone. One respondent recalled an NGO giving BDT 5,000 (approximately USD 60) to 20 families after Cyclone Amphan, specifically those whose homes had been destroyed. However, these efforts were sporadic and lacked comprehensive coverage. There is also a practice in Bangladesh of providing GR (Gratuitous Relief) cash to disaster victims; however, in practice, remote char communities tend to be last in line due to access issues. Thus, Bhola's community largely did not expect formal cash aid; instead, they often resorted to informal community help or migration (e.g., a non-disabled family member going to town to find labour work to earn money for rebuilding). The lack of coordination is evident – multiple actors (government, NGOs, charities) might come with small projects, but no unified program addresses all needs. This has resulted in *uneven assistance*: one village might receive a new tubewell for safe water from a charity, while a neighbouring village gets nothing;

some households are selected by an NGO for livelihood grants, while others are left out despite similar conditions, leading to perceptions of unfairness.

3.3. Design of Risk-Based Cash Transfer Values

Applying the Project DINGGIN calculation formula in these communities led to a set of tailored Cash Transfer Values (CTVs) and support packages. A core outcome of the analysis was a matrix of multipliers that varies by household profile:

3.3.1. Shelter Support

Given the extent of housing damage in Albay, we proposed a *tiered shelter grant*. Households in high-risk zones (e.g., within an identified floodplain or coastal strip) would receive a higher amount specifically earmarked for shelter strengthening (e.g., to purchase roofing materials, wooden beams, or hire carpenters). In Albay, this amounted to an estimated PHP 10,000 (approximately USD 200) for high-risk households and PHP 5,000 (approximately USD 100) for others, on average. The higher tier was roughly the cost of rebuilding a 20 m^2 nipa hut roof with improved materials. In Bhola, where homes are highly vulnerable, we set a single shelter grant level. However, we recommended that material support (such as tarpaulins and toolkits) accompany the cash, as markets on the char are limited. The proposed Bhola shelter cash was BDT 8,000 (approximately USD 95) per household, intended for purchasing materials such as bamboo and reeds to reconstruct houses or reinforce embankments around homesteads. Notably, *renters and landless families were included (whereas in some government programs, only landowners receive* housing assistance). This was crucial in Bhola, as many who lose their homes are on government land; our model treats them equally for shelter cash because their need is the same.

3.3.2. Food Security Grant

To cover immediate food needs and prevent hunger, we allocated a portion of the transfer specifically for food. In both communities, we calculated roughly a one-month food supply cost. In Albay, about PHP 3,000 (USD 60) would allow an average family (5 members) to meet basic food requirements for 4 weeks (assuming supplementation with any salvaged crops or relief goods). In Bhola, staple prices are lower; about BDT 2,500 (USD 30) could suffice for a month's basic staples (rice, lentils, oil). These food grants also indirectly protect livelihoods – if families are not forced to spend limited savings or sell assets to eat, they can use resources to restore their income activities. The program design thus integrated food support into the cash transfer rather than providing separate food aid, aligning with the idea that cash enables choice. Community feedback supported this: many participants stated that their first use of cash would indeed be to purchase food and cooking fuel, highlighting that it is a priority.

3.3.3. Livelihood Restoration

Recognising that getting families back to earning a living is key to resilience, a portion of the CTV was allocated for livelihood inputs. In Albay, we tailored this by occupation:

- Farmers would receive vouchers or cash (~PHP 2,000, or USD 40) for seeds, fertiliser, or small tools to replant lost crops.
- Fisherfolk (a minority in our Albay sample) would get support to repair nets or boat engines.
- Small business owners could use their grants to restock inventories. The project team even considered distributing this livelihood portion in the form of specific grants (such as a farming kit or a micro-enterprise grant) to ensure it was used for productive purposes, but ultimately kept it as cash with guidance, as needs differ by household.

In Bhola, the main livelihood support was aimed at fishers and farmers, with a value of around BDT 3,000 (USD 35), which could help replace a fishing net or purchase seeds and tools. For day labourers, this amount could serve as a small cash-for-work payment if community rebuilding pro-

jects are organised (effectively paying them while they repair local infrastructure). A crucial aspect is timing – for farmers, getting this cash before the planting season is essential. Therefore, the plan stipulated that livelihood grants be disbursed as soon as conditions allowed (soil was ready for planting or waters were safe for fishing), independent of other aid if needed.

3.3.4. Intersectional Top-Ups

To operationalise inclusivity, specific households receive additional cash top-ups on top of the base amounts above:

- Women-Headed Households: In both locales, these households were to get ~10% extra cash. The rationale is that they often have fewer income sources and higher care burdens. Hence, the extra funds provide a buffer (for example, to hire labour for repairs that a male family member might otherwise do or to purchase prepared foods if they are occupied caring for children). We saw that without such consideration, these families risk falling further behind.
- Households with persons with disabilities (PWDs) or chronically ill members: Another ~10% top-up was designated. This was to cover any special needs (medicines, assistive devices, or simply the higher cost of living with disability, such as transportation needs).
- Extreme Poor Households: Those identified as having *very low income and assets (e.g., no stable income, landless labourers*, no livestock) were also given an extra allowance. This recognises that they have the least capacity to recover; even a small cash infusion can yield a high marginal benefit for them. In our Albay survey, families earning below PHP 5,000 per month were categorised in this group; in Bhola, those with essentially no monetary income (living solely on subsistence farming or fishing). These criteria often overlapped – for instance, a widowed older woman with no income would qualify for multiple top-ups. Rather than arbitrarily stacking bonuses, the framework capped the total bonus to prevent it from being too high relative to others while ensuring that such a person would receive the maximum on the spectrum.

3.3.5. Community/Collective Grants

An innovative element tested in Albay was a small community grant (pooled fund) given to the barangay committee to manage, intended for communal resilience projects (like clearing drainage canals or reinforcing a flood wall). Each barangay was offered PHP 20,000 (USD 400) for a project of their choice related to disaster preparedness or recovery. This incentivised collective action and bridged leadership – and indeed, one barangay decided to use it to purchase materials for repairing their evacuation centre's roof, an outcome benefiting all. At the same time, although not a household cash transfer per se, the community-directed fund acknowledged that some resilience-building measures are best tackled at the community level rather than the household level.

Table 1: Calculated Cash Transfer Values for Project DINGGIN by Household Profile and Context.

Household Profile	Base Support Package	Top-Up Criteria	Total Proposed Value (Illustrative)
General Household (Base Support)	Shelter, Food, Livelihood = $200 (PHP 10,000 / BDT 16,000)	N/A	$200
High-Risk Location *(e.g., floodplain, coastal strip)*	Base + 20% for Shelter Reinforcement	+ $40 (PHP 2,000 / BDT 3,200)	$240
Female-Headed Household	Base + 10% for Economic Stability	+ $20 (PHP 1,000 / BDT 1,600)	$220
Households with Persons with Disabilities (PWDs)	Base + 15% for Accessibility and Health Needs	+ $30 (PHP 1,500 / BDT 2,400)	$230
Extremely Low-Income Household	Base + 10% for Basic Needs Augmentation	+ $20 (PHP 1,000 / BDT 1,600)	$220
Maximum Cumulative Top-Up	Base + High-Risk + Female-Headed + PWD + Low Income	Maximum allowable top-ups aggregated by vulnerability	$310

Note: *The final transfer values are subject to adjustment based on* Community Risk Assessments: Data collected through Participatory Risk Mapping (PRiMa); Government Proxy Data: Validation with local government disaster risk data to reflect market conditions and community needs; Monitoring and Adaptive Learning: Continuous review and adjustment based on post-distribution monitoring and community feedback mechanisms.

This adaptive structure reflects the differential vulnerability and intersectionality central to Project DINGGIN's inclusive governance approach, ensuring that cash transfers are equitable, sufficient, and reflective of real-world risks and household capacities. These figures were tailored to local price levels and needs at the time of study (late 2024) and would be adjusted for inflation or changing conditions. It is essential to note that these packages are planned amounts; the actual distributed amounts may differ based on final funding availability and verification of household conditions. However, the proportional differences (e.g., that a high-risk, highly vulnerable household receives roughly 60-70% more than a lower-risk, lower-vulnerability household) illustrate the principle of *risk-based, needs-based allocation*. This represents a departure from typical flat-rate assistance and was a key outcome of the project.

3.3. Implementation and Community Uptake

During the pilot implementation planning in Albay (which was done as a controlled exercise in one barangay), community reception was very positive. When the framework was explained in community meetings, residents expressed that this was the first time they had seen a systematic method that listened to their inputs (through surveys and mapping) and then translated that into clear, tangible assistance differentiated by need. There was a sense of transparency and fairness because the criteria were openly discussed; everyone understood why specific households might receive more than others – not due to favouritism, but because of risk and vulnerability factors. This **transparency is crucial for community trust** in any cash program. The barangay leaders were involved in validating the list of recipients and their categories (cross-checking, for example, that the list of women-headed households was complete, etc.). This participatory targeting helped reduce potential conflicts or jealousy, a common issue in aid distribution.

In Bhola, although we did not fully implement a cash distribution (only designed it), we discussed the model with the Union Council. They were intrigued by the idea of *anticipatory cash transfers* before the flood season and mentioned that it aligns with the national move towards forecast-based financing. However, they pointed out logistical constraints: distributing cash on a char would require either a boat trip by officials or using a mobile money agent, both of which need planning. The community members consulted were naturally eager about the prospect of receiving assistance tailored to their needs. One fisherman noted that if he had received, say, BDT 5,000 immediately after the last cyclone, he could have repaired his boat in time for the fishing season rather than waiting months for NGO assistance and losing income in the interim.

The project also evaluated efficiency considerations: a single consolidated cash program is likely more cost-effective than multiple separate interventions. By combining shelter, food, and livelihood into one program, administrative and delivery costs can be shared. In Albay, we simulated that using a digital cash transfer (through a payment provider or bank mobile app) would reduce overhead and also promote financial inclusion (many 4Ps beneficiaries already have cash cards or bank accounts that could be leveraged).

3.4. Outcomes and Benefits Observed

While a full rollout was beyond the capstone project's scope, we projected outcomes based on our data and small pilot exercises:

3.4.1. Faster Recovery

Households that would receive the integrated cash could begin repairs and replanting **weeks** earlier than they usually might. For example, in our Albay pilot barangay, after a moderate flood, those who received a modest cash grant (we tested PHP 3,000 per household for immediate needs in that event) rebuilt their damaged walls or bought food *without* taking loans and reported being back to regular economic activity sooner. This suggests that risk-based cash can shorten the recovery period and reduce harmful coping mechanisms (like debt and selling assets). The holistic nature of the support (covering multiple needs) meant families did not have to make the painful choice of "repair the house or buy food" – they could do both. This prevents development backslides; instead of disasters pushing them deeper into poverty, appropriate aid helps them rebound closer to their pre-disaster state or better.

3.4.2. Equity and Inclusion

By providing additional resources to the most vulnerable, the program strengthens social protection for those who often fall through the cracks. Women-headed families in our Albay case were able to hire labour to repair their roofs, something they could not do on their own. In Bhola, a disabled man's family (hypothetical scenario from our design) would get enough to secure their hut and also not worry about skipping meals – a significant improvement from typical aid where such households often suffer quietly. This approach upholds the dignity of at-risk groups, aligning with the principles of humanity. It was also noted that community members felt seen and heard; as one participant said, *"Alam nilang mas mahirap ang sitwasyon namin, kaya mas tutulungan kami"* (They know our situation is more complex so that they will help us more) – indicating an improved perception of fairness.

3.4.3. Multi-sector Resilience Building

The combined impact of addressing shelter, food, and livelihood concurrently is an overall strengthening of community resilience. Families with safer housing will suffer less damage in the next storm. Those who can maintain food security and income are less likely to migrate or disintegrate (which can erode community cohesion and the local economy). We can foresee metrics such as a reduction in assistance dependency over time: if each shock's impact is mitigated, communities may need less external aid in subsequent events. The inclusion of a community project grant (in Albay) also left a physical legacy – the repaired evacuation centre roof means that in the next typhoon, evacuees will have a secure place, which is a community-level resilience gain.

3.4.4. Coordination and Governance

The process of implementing Project DINGGIN's framework necessitated coordination between community committees and local government. In Albay, barangay leaders worked with the Municipal DRRM Office to manage the pilot – a relationship that was strengthened as they jointly made decisions on targeting and logistics. This bridging of bottom-up and top-down efforts demonstrates improved governance. The local government, having access to community data, could allocate resources more rationally, and community members, seeing support from authorities that matched their needs, likely increased their trust in institutions. In Bangladesh, although at an earlier stage, engaging the Union Council with the data platform concept started a conversation on how local and national systems (like early warning) could integrate with community-level response.

3.5. Challenges and Areas for Improvement

Not everything was perfectly smooth. Some challenges observed or anticipated include:

- *Delivery Mechanisms:* In Albay, several beneficiaries did not have bank accounts or mobile wallets, so distributing physical cash at a central point had to be done (with safety measures). This carries some risk and overhead. We identified the need for financial inclusion initiatives

(e.g., helping people set up accounts or e-money apps during non-disaster times) to facilitate future cash aid.

- *Risk of Misuse:* A common question with cash aid is whether money will be spent as intended. Our follow-ups in the pilot indicated that most participants prioritised essentials, but there were a few cases of spending on non-essentials. To mitigate this, the program included community orientation on recommended usage and one-on-one counselling for the most vulnerable families. Additionally, linking some funds to vendors (such as issuing vouchers for hardware stores) can ensure that shelter funds are directed to the shelter. Finding the right balance between flexibility and guidance is an area that needs refinement.
- *Scaling and Sustainability:* The pilot was small. Scaling up to the entire municipality or district would require significant funding and management capacity. Integration with larger social protection systems (like expanding government cash programs to include a disaster-triggered top-up) could be a solution. We also note that continuous data updating is necessary – the risk data we collect will become outdated as situations change (e.g., new families, changes in vulnerabilities). Thus, we recommended establishing a local team or committee responsible for updating the dashboard annually and after each event.
- *External Factors:* Cash alone does not solve everything. For instance, in Bhola, even with cash, if a cyclone breaches the embankment, the community still faces displacement. Infrastructure investments (like more substantial embankments and better shelters) are needed in parallel. Our model does not directly address those larger structural issues, but by documenting needs, it can influence authorities to invest in them. Additionally, issues such as market availability: after a disaster, local markets may not have sufficient goods (especially in Bhola). In such cases, cash recipients might have to travel or wait for markets to stabilise. Coordination with market-restoring efforts and possibly staging the cash release when supplies are in place were recommendations we put forth.

In summary, the results from Project DINGGIN's application indicate that a risk-based, inclusive cash transfer program is not only feasible but highly beneficial at the community level. It provides a more nuanced and compelling form of assistance than blanket distributions, empowering those who are most in need. Communities responded positively, underscoring the importance of trust and participation in the delivery of aid. Both case studies demonstrated that, although the specifics differ (typhoon vs. cyclone contexts, archipelagic vs. riverine geography), the underlying principle remains the same: incorporating local risk knowledge and vulnerability data results in more effective *and impactful cash aid*. The following discussion section will interpret these findings within the broader context of disaster risk management, compare them with other studies, and outline the implications for future policy and programming.

4. Discussion

The implementation of Project DINGGIN's framework in Albay and Bhola demonstrates a shift towards evidence-based, people-centred disaster assistance. The discussion of results yields several key insights and broader implications for disaster risk management policy and practice.

4.1. Integrated Multi-Sectoral Support Improves Outcomes

A primary takeaway is that addressing shelter, food security, and livelihoods simultaneously through cash transfers significantly enhances the quality of recovery. Traditionally, post-disaster aid has been delivered in siloed components. For example, families might receive a shelter repair kit from one agency and separate food aid from another, often with a time gap in between. Our results suggest that when these needs are met concurrently, families can allocate resources more efficiently and utilise the assistance in a complementary manner. In Albay, recipients of the integrated cash were able to purchase construction materials, hire labour to repair their homes, and buy groceries,

all within the first critical weeks after the disaster. This simultaneity meant that, for instance, a farmer could focus on planting a new crop (with provided seeds and tools) without worrying that his family would go hungry or that their shelter would be unsafe. By preventing trade-offs between basic needs, the integrated approach accelerates a holistic recovery. This finding aligns with the concept of holistic recovery emphasised in resilience literature, whereby meeting interrelated needs produces synergistic effects. Households were not forced to prioritise one necessity over another, which often happens when aid is fragmented.

Furthermore, this multi-sectoral strategy contributes to sustainable risk reduction. Families that rebuild stronger houses and restore their livelihoods are inherently more resilient to the next hazard. In Bhola, although the data was qualitative, it is evident that a family that can reinforce its shelter and resume earning quickly will be better prepared for the next flood season. Over time, if such support is consistently provided, communities can break the cycle of destruction and slow the recovery process. These findings reinforce arguments by practitioners that *cash transfers, when sufficiently valuable and comprehensive, can serve as a bridge between relief and development*. By injecting capital for recovery promptly, they lay the groundwork for longer-term improvements (e.g., home upgrades or livelihood diversification) rather than just short-term survival.

4.2. Inclusivity and Equity in Aid Distribution

Project DINGGIN's framework operationalised inclusive governance principles by actively identifying and prioritising the most vulnerable segments for additional support. The positive community reception to this targeting suggests that, contrary to some concerns that differentiated aid might cause jealousy, there was a broad understanding and acceptance of the rationale when it was communicated transparently. This suggests that communities acknowledge internal inequities and appreciate when aid programs take them into account. It also speaks to the importance of participatory targeting: involving community leaders in validating beneficiary lists built trust in the process.

The special provisions (for women-headed households, people with disabilities, etc.) ensured that those often marginalised were not left behind. These groups can be seen as multipliers of impact. For instance, supporting a women-headed household has community-level benefits, as women often invest in their children's well-being and participate in communal activities. Similarly, assisting a person with disability adequately can enable that household to contribute productively to the community (rather than being stuck in dependency). Thus, inclusive cash transfers not only uphold humanitarian principles of impartiality and dignity but also strengthen community functioning. This resonates with global humanitarian commitments to "Leave No One Behind" and recent case studies of disability-inclusive cash assistance (CBM Global, 2020), which show that tailoring aid to vulnerable groups improves overall program effectiveness.

However, achieving accurate equity requires robust data and outreach. In our project, the identification of vulnerable households was greatly aided by the baseline survey and community mapping. In many disaster responses, such detailed profiling is not done due to time constraints. This raises a point for replication: investing in preparedness-phase data collection (as part of disaster preparedness plans) can pay off in the response phase by enabling targeted aid. Governments and NGOs could incorporate vulnerability assessments into regular social surveys or disaster drills, thereby having lists ready when an event occurs. Project DINGGIN's decision-support dashboard is an example of how data could be stored and quickly used to inform distribution. This approach requires careful data protection and regular updates, as sensitive information about household vulnerabilities must be kept secure and up-to-date.

This approach is strongly aligned with global commitments, such as the Grand Bargain's localisation agenda, which prioritises local leadership and contextualised solutions for disaster recovery. The Grand Bargain, launched during the World Humanitarian Summit in 2016, emphasises the shift of power to local actors by channelling at least 25% of global humanitarian funding directly to local and national responders. Furthermore, Project DINGGIN's integrated, localised response mechanisms align with the Sphere Handbook's latest updates, which emphasise community-centred plan-

ning and gender-responsive approaches in disaster recovery. Sphere standards advocate for local actors to be at the forefront of humanitarian action, emphasising the critical role of communities in building resilience and responding effectively to crises. Studies by Cvetković et al. (2021) emphasise the importance of capacity development for local self-governments in effective disaster management, while Cvetković, Öcal, and Ivanov (2019) demonstrate that empowered local communities are more effective in responding to disasters. These works emphasise the need for localised Disaster Risk Reduction (DRR) models that are participatory, inclusive, and community-driven—principles that Project DINGGIN operationalises on the ground in Albay and Bhola.

These findings underscore the importance of building local capacities not just for immediate recovery but for long-term resilience. When local governments and community groups are adequately trained, resourced, and empowered, they can drive disaster preparedness and recovery initiatives independently. Project DINGGIN serves as a practical model for how global commitments, such as the Grand Bargain and Sphere standards, can be implemented at the community level, with clear pathways for sustainable and inclusive recovery.

4.3. Bridging Leadership and Local Empowerment

The process and outcomes of Project DINGGIN exemplify a successful instance of bridging leadership, where local community members, local officials, and external experts collaborated to co-create a solution. Instead of a top-down imposition or a purely grassroots initiative, the project fostered a middle ground: community voices shaped the program design, and local authorities provided the enabling environment (approvals, alignment with policies, and, in the future, potential resources). This collaborative model is particularly relevant for disaster risk reduction, which inherently spans multiple sectors and stakeholders. By engaging community leaders in Albay's barangays and Bhola's union council, the project enhanced local capacity to manage and implement assistance. These local actors effectively became partners in humanitarian response, not just beneficiaries or observers. For example, barangay officials in Albay learned how to use risk data to prioritise aid—a skill that can improve all kinds of local planning beyond this project.

From the governance perspective, such an approach strengthens the social contract between citizens and government. When people see the government delivering aid that genuinely matches their needs and does so in a fair, transparent manner, their trust in institutions can improve. In the Philippines, where local governments are at the forefront of disasters, successes in community-driven programs like this can reinforce the importance of devolved disaster risk reduction (DRR) governance as envisioned by RA 10121. In Bangladesh, this can contribute to the push for localisation of aid under the global Grand Bargain, demonstrating that empowering local committees with the right tools yields effective outcomes. Notably, our project's alignment with national frameworks (NDRRMP, SOD, etc.) means it did not create a parallel system but worked within existing structures – this is crucial for scalability.

One challenge for leadership arises in coordinating across sectors: the cash program had to involve agencies responsible for social welfare (for beneficiary welfare), agriculture (for livelihood inputs), and disaster management (for hazard info and overall coordination). Bridging these institutional silos can be difficult. In Albay, initial coordination meetings were held to clarify roles (e.g., the agriculture officer provided input on seed packages, the social welfare office assisted in identifying PWD households, etc.). Such inter-agency collaboration is often weak in bureaucratic settings. Our project acted as a catalyst for these departments to communicate because it presented a clear, common goal (a successful community recovery). This underscores that *innovative pilot projects can serve as a platform to break bureaucratic silos*. For sustained impact, however, formal mechanisms (such as a Memorandum of Understanding between departments or a joint task force for disaster cash response) may be necessary.

4.4. Comparison with Traditional Approaches and Literature

Comparing Project DINGGIN's approach to traditional disaster aid approaches yields important contrasts.

4.4.1. Speed vs. Precision

Traditional approaches often prioritise speed (blanket distribution of standard relief) at the cost of precision (targeting and tailoring). Our approach sacrifices some speed upfront (due to the need to collect and analyse data) to achieve precision. The question is whether this is acceptable in fast-onset disasters. One solution is to conduct data collection during the *preparedness phase*, as noted so that when a disaster strikes, the framework can be quickly activated. In our pilot, having baseline data allowed us to simulate a response plan within 48 hours of a disaster using the dashboard. This is comparable to or faster than the timeline of many government relief efforts, which sometimes take a week to roll out assistance fully. Thus, having pre-crisis information is key – a finding in line with the concept of **anticipatory action** and forecast-based financing literature, which emphasises early investment in data and planning.

4.4.2. Effectiveness

The integrated cash approach appears to achieve more with the same or slightly more resources. While it might seem costlier because vulnerable households receive more, consider that in a traditional scenario, the same household might receive multiple rounds of different aid (food packs, then shelter materials, then a livelihood program), often delivered by different agencies with their overheads. By consolidating aid, Project DINGGIN can reduce duplication and overhead. A rough cost-benefit analysis in Albay indicated that for every PHP 1 spent on the program, the "value" of outcomes (in terms of house repairs achieved, income restored, etc.) was higher than the value achieved per PHP 1 spent in a prior disaster where aid was provided in kind. This aligns with global research showing cash transfers can be more cost-efficient than in-kind aid (because they cut logistical costs and allow beneficiaries to bargain hunt). Moreover, by preventing losses (such as avoiding asset sales and malnutrition), cash aid has secondary benefits that are not captured in immediate output metrics.

In the literature, some studies have criticised cash programs for not always considering social dynamics – for example; they may exclude women's control or overlook community power imbalances. Our approach aimed to mitigate this by involving women in planning and ensuring they could access and control their aid (e.g., by paying them directly). This aligns with recommendations from gender analyses of cash programs, which advocate for women's empowerment in aid delivery. Early indications in our pilot showed women did indeed often become the decision-makers on spending the cash (which tends to lead to better household welfare outcomes, as studies in development economics suggest).

We also compare our findings with research that focuses on intersectionality. A gap highlighted by researchers is that humanitarian programs rarely disaggregate assistance sufficiently to meet the needs of marginalised groups. Our project provides a working example of how to operationalise that disaggregation. If anything, a further step could be to *tailor communication and training*, along with cash; for example, ensuring that disabled persons receive messaging in accessible formats or that women are informed of services like childcare during livelihood activities. We touched on training (financial literacy) in recommendations, which leads to the next point.

4.5. Recommendations for Improvement and Scaling

While the results are promising, we identified several areas for improvement to enhance the framework's long-term impact:

4.5.1. Linking Relief to Resilience (Multi-phase support)

As noted, one-off cash grants address immediate recovery, but long-term resilience building requires sustained engagement. We recommend a multi-phase cash transfer scheme: an emergency tranche (as we implemented), followed by a second tranche several months later aimed at resilience investments. This second tranche could be conditional or designated for specific uses, such as retrofitting homes or investing in climate-resilient livelihood equipment. For example, after families have stabilised, providing another grant for, say, purchasing flood-resistant rice varieties or constructing household rainwater tanks could help them move beyond recovery into development gains. This idea aligns with the "build back better" principle in Disaster Risk Reduction (DRR). It ensures that the momentum gained in recovery is not lost, allowing households to make improvements that reduce future risk. Donors and governments would need to plan budgets not only for immediate relief but also for subsequent support. Over time, as communities become more resilient, the need for considerable relief might diminish, justifying the investment.

4.5.2. Integrating Capacity Building

Money alone can be insufficient if people lack knowledge on how to utilise it to reduce future risk. Cash transfers should be accompanied by financial literacy and livelihood training. In Albay, we conducted a seminar on budgeting post-disaster income and prioritisation, which participants found helpful. We propose institutionalising such training (even integrating it into regular community meetings or 4Ps family development sessions for the Philippines). Additionally, sharing best practices – for example, demonstrating how to rebuild a house more safely (such as tie-down techniques for roofing and elevating storage for food) – can help beneficiaries use cash effectively for mitigation. In both countries, existing extension services (such as agricultural extensions) could be mobilised to provide advice coinciding with cash disbursement. For livelihoods, training on alternative income streams (such as backyard poultry, craft-making in Albay, or drought-resistant farming in Bhola) could help utilise the cash more sustainably by diversifying how it is invested.

4.5.3. Seasonal and Hazard-Specific Adjustments

Our framework included the concept of timing cash before known seasonal peaks. Formalising seasonal cash transfer schemes could greatly benefit places with predictable lean or hazard seasons. In Bangladesh, the concept of monsoon response cash can be linked to forecast models. If river levels reach a critical threshold, the system automatically triggers cash transfers to registered households, helping them evacuate or protect their assets. This is akin to forecast-based action pilots by the Red Cross, which have shown success in early distribution. Similarly, in typhoon-prone areas, having pre-disaster cash for preparedness (e.g., to buy plywood to board up windows or stockpile food) can reduce damage and losses. Project DINGGIN's data-driven approach can inform what those amounts should be and for whom (not everyone might need it; focus on high-risk groups). For scaling, working with meteorological agencies and integrating triggers into the dashboard would automate this process. It moves humanitarian response into the realm of disaster risk financing, where funds are released based on risk indicators before a disaster entirely unfolds—a cutting-edge practice.

4.5.4. Data Management and Information Systems

The creation of the risk-informed data platform is a valuable output, but its maintenance is critical. We recommend that local governments institutionalise this dashboard as part of their disaster risk reduction (DRR) information systems. This means allocating personnel (e.g., a GIS officer or DRR analyst) to update data regularly and utilising the platform not only for cash programs but also for general planning (it could map all hazard risks in the area, not just for cash). Interoperability with national databases (like the Disaster Management Information Systems in each country) will ensure longevity beyond the project. Additionally, data from each disaster event should be fed back into the system to improve it (learning which households remained at risk, etc.). Protecting privacy is also essential – guidelines on data protection (perhaps following principles similar to those out-

lined in the GDPR, adapted to the humanitarian context) should be followed when sensitive information is collected.

4.5.5. Policy Integration and Advocacy

To sustain and replicate such frameworks, it is important to embed them in official policy or contingency plans. For instance, the provincial government in Albay could adopt a resolution that in the event of disasters, they will implement an inclusive cash transfer program guided by the data collected, effectively making Project DINGGIN's approach the standard operating procedure. In Bangladesh, advocacy to include char communities in social safety nets (perhaps using our data as evidence) could yield funding for our proposed interventions. Also, sharing the success story with national authorities can influence resource allocation; if central governments allocate special funds for anticipatory cash or adaptive social protection, local units like Bhola's could tap into them to execute this approach.

It is also worth linking with global initiatives, such as the Anticipatory Action program and the World Bank's adaptive social protection programs, which are actively seeking models to connect relief with development. Our findings support their case with micro-level evidence. International NGOs and donors might also be interested in funding scale-ups, given that the approach aligns with the modernisation of aid (localisation, cash, data-driven).

5. Conclusions

This study, through Project DINGGIN, has demonstrated that risk-based and inclusive cash transfer programming is not only possible in disaster-prone areas but also highly effective in addressing the complex needs of affected communities. By actively involving communities in assessing their risks and needs and by using that information to tailor cash assistance, we effectively bridged the gap between what people require and what aid delivers. In both Albay, Philippines, and Bhola, Bangladesh, the approach empowered local stakeholders. It provided timely, adequate support that helped families rebuild their homes, secure food, and revive their livelihoods in the wake of disasters.

Crucially, the Project DINGGIN framework contributes to a shift in disaster management paradigms – from a one-size-fits-all relief model to a data-driven, people-centric model. It aligns with and reinforces national disaster management policies (such as the Philippines' NDRRMP and Bangladesh's SOD) by operationalising their calls for risk-informed and inclusive practices. It also advances global humanitarian commitments to enhance the effectiveness of aid (as outlined in the Grand Bargain) and to ensure that no vulnerable group is left behind. Households that historically might have been overlooked or under-served (like those of women, people with disabilities, and the ultra-poor) received enhanced support, embodying principles of social justice and humanitarian equity.

The success of these case studies provides a compelling case for scaling up and replicating similar models elsewhere. The ingredients that made it work – strong community engagement, pre-disaster data collection, flexible cash instruments, and coordination across governance levels – can be introduced in other disaster-prone regions. Each context will have its nuances, but the core lesson stands: when aid is informed by granular risk and social data, it becomes more impactful. Communities are not monolithic, and treating them as such in aid programs can lead to inefficiencies and injustices. Instead, embracing community heterogeneity and complexity leads to more efficient allocation of resources and better outcomes.

From a policy perspective, integrating this approach into standard disaster response protocols could significantly improve national resilience. For instance, governments could establish *"cash preparedness"* systems, where vulnerable households are identified and even pre-registered for emergency cash transfers, much like early warning systems exist for hazards. Doing so would institutionalise the gains of Project DINGGIN. It would also exemplify the humanitarian-development nexus in action: using what is essentially a relief mechanism (cash aid) in a way that supports development goals (poverty reduction, empowerment, capacity building).

5.1. Limitations and Future Research

While discussing the positive outcomes, we must acknowledge limitations. The Bhola case's small sample means our results there are more tentative and qualitative; a larger pilot in Bangladesh would strengthen the evidence. Future research should test the framework in various contexts (e.g., urban disasters and drought scenarios) to assess its adaptability. There is also a need to track *long-term impacts*, as our study primarily captured immediate to short-term results. A longitudinal study following families for a year or two could reveal if the cash assistance had lasting effects on income, asset building, or reduced disaster losses in subsequent events. Measuring community-level outcomes (like overall poverty rate changes or infrastructure improvements) would also tell us if scaling up yields developmental benefits.

Additionally, *a cost-effectiveness analysis at scale would be valuable. While we have qualitatively argued for efficiency, a* rigorous analysis could quantify the return on investment of risk-based inclusive cash versus traditional aid. This would be persuasive for policymakers and donors if it shows significant savings or benefits. Another interesting angle is the social dynamics: Does receiving differential aid have any adverse social consequences (envy, dependency, changes in community cohesion)? Our initial observation was that good communication mitigated envy; however, this should be closely monitored in larger implementations. Some cultural contexts might respond differently.

Finally, the role of technology (mobile money, digital IDs, etc.) in enhancing such programs is a frontier to explore. In Bangladesh, mobile financial services are widely available on the mainland; extending them to chars might revolutionise aid delivery there. In the Philippines, digital disbursements are increasingly used; linking our dashboard with an e-payment system could expedite cash transfers once triggers are hit. Research on the most user-friendly yet secure tech solutions for last-mile delivery will complement the framework.

In conclusion, Project DINGGIN demonstrates a transformative approach to supporting communities affected by disasters. By listening to communities and responding with flexible yet structured support, we not only help them recover but also equip them to face future adversities better. The empowerment felt by the participants – knowing they had a say in their recovery and receiving the means to drive it themselves – is perhaps one of the most valuable outcomes, as it fosters self-reliance and hope. As climate change and other factors intensify disaster risks globally, adopting risk-based, inclusive approaches to cash transfer programs will be essential in enhancing the resilience of the most vulnerable populations. This research contributes a practical model for doing so, and it calls on practitioners and policymakers alike to build on and expand these findings, ultimately striving for a humanitarian system that truly "hears" the voices of communities and acts on them for a more resilient future.

Author Contributions: The statement below outlines the individual contributions of each author to the completion of this research article, titled "Project DINGGIN (Dynamic Inclusive Network for Governance, Guidance, Intersectionality, and Nexus): Empowering Communities through Risk-Based and Inclusive Cash Transfer."

Rhinadel M. Cañete:

As the technical expert for Cash Transfer Programming in Project DINGGIN, I contributed to the design of a research framework that integrates community priorities with co-owned solutions. I facilitated community consultations to ensure that cash transfer values accurately reflect the diverse needs of marginalised groups, including single-headed households and individuals with disabilities. My role involved analysing differential risks, emphasising that vulnerability is not about incapacity but rather the proximity to hazards and the specific elements at risk, such as children, homes, or livelihood assets, that may be exposed and impacted. I also supported the development of a data-sharing platform designed as a decision-making tool, bridging top-down and bottom-up systems while enabling communities to co-own data with government, humanitarian, development, and peace actors. This approach ensures that cash assistance is context-specific, inclusive, and empowering, amplifying local agency and decision-making. Ultimately, the research highlights the importance of collaborative, evidence-based solutions in fostering resilience and promoting sustainable recovery.

Samantha Kay L. Lisay:

As the shelter and design expert for Project DINGGIN, my role was to provide a shelter lens to the project. I contributed to gathering literature on the perspectives of the shelter sector regarding the use of Cash Transfer Programs, as well as collected data from key informants at shelter agencies. I also played a crucial role in developing and implementing the methodologies in the Philippines and helped interpret the data gathered from both Albay and Bhola. My goal was to support the research framework by collecting and interpreting information from various sources, including the literature, household and practitioner surveys, key informant interviews, and community consultations. Based on the research findings, I led the initial concept design process for a data-sharing platform that will serve as a decision-making tool for the government and humanitarian actors, as well as an opportunity for communities to share information on their risks. My role also involved creating presentation visuals with the team, ensuring that Project DINGGIN would be presented well and could obtain buy-in from stakeholders. Ultimately, I complemented the team's expertise with my own technical and design background to produce a research and capstone project that will empower communities and support decision-makers in building resilience for Albay and Bhola.

Md. Nazmus Sayadat:

As a professional banker, I contributed to examining Project DINGGIN from a financial perspective, including private sector engagement in the banking industry. My focus was on Shelter, Livelihood, and Food Security and how cash transfers or equivalent mediums contributed to disaster situations. In my primary focus area, **Bhola, Bangladesh**, particularly in Char Fasson and Monpura, I analysed how disasters impacted these locations, the frequency of such events, and local coping mechanisms. Through site visits to housing projects, vulnerable areas, and local government offices, I gained insights into the compatibility of government measures, the interventions of NGOs, and local perspectives on coping strategies. My research highlighted that many residents living below the poverty line face challenges accessing digital financing, as they rely heavily on government grants and NGO support. I contributed to identifying alternative sources of stable earnings, as suggested by community consultations, and integrated these recommendations into the study to support the continuity of Project DINGGIN in Bangladesh. These findings provide a deeper understanding of vulnerabilities in Bhola, offering guidance for future resilience-building initiatives and external actor engagement.

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Article

Smart Life Safety Jacket for Rescuers

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ABSTRACT

Smart Life safety jackets have been widely used in flood rescue operations for many years. However, most of these jackets are outdated and lack integration with modern technology. Due to this, rescuers often encounter several operational challenges. Therefore, the implementation of advanced technology in the design of life safety jackets has been considered necessary for improving disaster response efficiency. The primary objective of this study is to develop a bright life safety jacket that incorporates modern technologies, including the Internet of Things (IoT), wireless sensor networks, GPS, and oxygen level monitoring. Real-time condition tracking, including rescue time, has also been set as a significant focus of this research. A design-based methodology has been adopted to integrate multiple advanced technologies into the bright jacket. Key components include IoT modules, sensors, GPS, wireless communication networks, and user interaction systems. Various technical and usability aspects have been explored through literature reviews and feasibility studies conducted during different stages of the research. Through this study, a bright life safety jacket has been proposed that is equipped with modern features intended to enhance rescue operations. Key functionalities, including GPS tracking, oxygen level detection, wireless sensor networks, and real-time communication through IoT platforms, have been incorporated to enhance coordination between rescuers and control rooms.

The proposed clever life safety jacket design offers several advantages, including enhanced situational awareness and reduced risk of injury. By using modern sensor and cloud technologies, the safety and efficiency of both rescuers and victims during flood emergencies are expected to be significantly enhanced.

KEYWORDS

Smart Life Safety Jacket; Internet of Things; GPS; sensors; ESP-32 microcontroller; results.

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1. Introduction

The primary purpose of a life safety jacket is to act as an advanced warning system before an accident, ultimately ensuring the saving of lives. The jackets are designed for various purposes, including protection from electrical accidents, aquatic catastrophes, or industrial risks faced by workers in the building industry. Despite their extensive usage, traditional life safety jackets do not integrate contemporary innovations and technologies, thereby providing areas for improvement.

Studies have shown that incorporating Internet of Things (IoT) technology into life safety jackets has the potential to enhance their capabilities. Through IoT, it is possible to create a bright life safety jacket that monitors the wearer's physical condition and relays real-time information to control centres. This new method enables rescue teams to respond swiftly to emergencies, resulting in improved safety outcomes (Cvetković & Miljković, 2024; Molnar, 2024; Marceta & Jurišić, 2024; Sudar et al., 2024).

The application of GPS technology for determining the location of tracking devices using satellite signals plays a significant role in enhancing the safety capabilities of life safety jackets. Integrating GPS into the life safety jacket provides geo-location monitoring with high accuracy, ensuring a rapid response time during an emergency.

An intelligent life buoyancy jacket may be equipped with various sensors and technologies that can track lifesaving parameters, including heart rate, blood pressure, and body temperature. Microcontroller devices built into it can process sensor data, which is then sent to the cloud server for real-time monitoring in the control room.

Cloud technology provides a centralised location for storing and analysing sensor data, enabling instantaneous communication between rescue teams and control rooms.

The suggested jacket has incorporated sophisticated cooling technologies, such as gel cooling pads and DC fans, to ensure a pleasant body temperature in hot weather. These technologies are designed to promote the wearer's comfort while minimising the risk of heat-related disorders. By combining all these technologies, a bright life safety jacket can offer various advantages, including enhanced safety, increased comfort, and improved effectiveness during emergency response processes. The combined use of IoT sensors, microcontroller devices, cloud technology, and advanced cooling systems enables the creation of an innovative life safety jacket, a vital asset in preventing accidents and saving human lives.

The goal of this research paper is to design a bright life safety jacket that utilises the latest technologies to enhance features and provide safety in various environments. The solution presented here has the potential to improve safety outcomes and save lives; therefore, it is a valuable contribution to the domain of life safety jackets.

Figure 1 (I & II). Life Safety Jacket for Rescuers.

Life jackets are used for rescue workers (Figure 1) in flood-related situations where modern sensor technology or IoT is not utilised.

2. Literacy Review

In the realm of performance apparel, Lim et al. (2015) analysed ventilation patterns and temperature distribution in running wear jackets using computational fluid dynamics (CFD) simulations. Their study revealed that slits positioned at the lower back significantly improved air exchange due to natural upward airflow generated by body heat. This insight supports design strategies that promote efficient ventilation and thermal comfort in non-permeable garments.

The integration of innovative technology into wearable safety equipment has seen notable developments in recent years. Akhil Xavier et al. (2018) introduced a safety jacket designed for water accidents, which activates an automatic inflation mechanism upon contact with water. It is equipped with GPS and GSM modules to transmit the user's location to emergency services, addressing the limitations of conventional life jackets, which are often bulky and lack real-time communication capabilities.

Shingade et al. (2018) thus designed an IoT-based women's safety jacket, acknowledging the increasing concerns about physical and sexual assaults on women, especially in India. This paper presents a wearable safety system comprising a microcontroller, GSM and GPS modules, a zapper circuit, and pressure sensors, enabling real-time tracking and emergency communication. The author has designed this device in such a way that when the user is in a distress situation and needs help, she activates it, which sends an alert SMS containing her location to all pre-registered contacts, triggers a loud alarm sound, and also activates the self-defence Zapper. This project was inspired by the unfortunate incident of the Delhi Nirbhaya case in 2012, which underlined the pressing need for technological intervention in matters related to gender-based violence. Women's public safety demands responsive, proactive safety measures at its core—embedded systems and IoT.

In a parallel domain, Randhawa et al. (2018) focused on activity and posture classification using fabric-integrated sensors. Their approach utilised stretch sensors, pressure sensors, and accelerometers embedded into a bright jacket to gather physical response data. The study emphasised the importance of sensor linearity and repeatability for reliable data acquisition. Subsequently, machine learning algorithms were employed to classify human physical activities based on sensor readings. This work demonstrates the potential of wearable systems in posture monitoring and activity recognition applications, particularly in areas that require biomechanical tracking or rehabilitation assistance

In the defence sector, Rakshitha M. et al. (2019) Proposed a bright jacket for soldiers that monitors vital health parameters such as heartbeat, pulse rate, and body temperature. This information is transmitted to the base station using GSM or Wi-Fi modules, enabling timely medical intervention and enhanced situational awareness during missions.

Abro et al. (2019) proposed a bright jacket designed explicitly for coal miners, whose working conditions often lead to fatal incidents. Their work focused on integrating various sensors, including hazardous gas detectors, pulse rate monitors, GPS, and temperature and humidity sensors, into a wearable prototype. The system continuously transmits critical health and environmental parameters via a Wi-Fi shield to a dynamic IP address, enabling real-time monitoring from a remote base camp. In emergencies, the last known GPS location and continuous pulse data of miners enable prioritised rescue operations, potentially saving lives in disaster scenarios.

A multi-functional life-saving jacket was developed by Vasanthakumar M. et al. (2020), Targeting applications in aviation and marine environments. This bright jacket features advanced technologies, including GPS tracking, health monitoring sensors, a water temperature sensor, and an electric shock mechanism designed to deter marine predators, thereby significantly enhancing survivability in hostile conditions.

Further exploring the potential of wearable technology, Swati A. Sakhare et al. (2020) Reviewed the development of IoT-enabled bright clothing. They emphasised how embedded sensors in textiles can track biometric data, interact with mobile devices, and offer applications across health, fashion, and safety domains. The research depicts furthermore the future of bright garments within the global IoT framework. With increasing concern about environmental extremities and the protec-

tion of personnel enduring such conditions, especially in some military and athletic settings, recent research has focused on integrating smart textiles and wearable technologies to enhance thermal comfort, health monitoring, and environmental adaptation.

Similarly, Hashimoto et al. (2021) investigated the impact of an active cooling system in a high-heat environment during various physical exercises, including the use of a cooling vest and a fan-attached jacket. Both systems could decrease core temperature, heart rate, and sweat rate, with the fan-attached jacket indicating better performance, even at an ambient temperature of 40°C and 50% relative humidity (RH). The study's results demonstrated that evaporative cooling by forced air can be highly efficient, indicating that fan-based systems are effective in mitigating heat stress.

To address the rapidly shifting climatic challenges in India, Gaikwad et al. (2022) have designed a bright safety jacket specifically for army personnel. The jacket enhances field safety and awareness by integrating GPS, IoT modules, and other sensors, enabling the monitoring of health and geolocation tracking.

Srievatsan and Jindal (2022) developed a new method to improve water safety by creating a smart lifejacket that utilises GPS and GSM technologies. Their work contributes to an important topic, the location of victims of drowning, which is rarely covered in current life-saving methods. The system they described works on a push-pull switch principle wired between the lifejacket and the vessel. This activates a Raspberry Pi system when disconnection occurs. The device then uses GPS to track its location while sending its coordinates via GSM. This is a significant improvement to the potential for immediate rescue by contacting a responder with the victims' local before the presumed victim's drowning, which answers one critical challenge associated with drowning incidents. Their prototype demonstrates how embedded systems can address practical problems in real-time during an emergency.

Expanding the application of wearable systems to defence, Suman and Jyothi (2023) developed an innovative system for Indian Army soldiers aimed at enhancing situational awareness and improving medical emergency response. Their system integrates GPS tracking, real-time health monitoring (including pulse and body temperature), and RF-based communication. What's intriguing about the design is that they have added emergency push-buttons, which, once pressed, send a health status and the soldier's GPS location to the base via SMS. The technology allows for soldier-to-base and soldier-to-soldier communication in tactical scenarios that require rapid response.

Balaji et al. (2023) introduced a bright IoT-enabled safety jacket explicitly designed to enhance the safety of workers in mining and construction environments. It discusses significant occupational hazards, including exposure to toxic gases (CO, CO_2, CH_4), fire, temperature extremes, and seismic activity associated with mining operations. This system combines various types of sensors—gas, fire, temperature, humidity, and ultrasonic sensors—on a body-worn platform that sends up-to-date environmental information via Wi-Fi. This information is processed through microcontrollers and monitored remotely through the Blynk app and a centralised control room, enabling prompt alerts and interventions. Their research underscores the importance of real-time environmental monitoring and automated hazard detection in reducing fatalities and enhancing response times in high-risk industrial operations.

Renusha et al. (2024) proposed an innovative, intelligent life jacket that incorporates Long Range (LoRa) communication technology to enhance water safety for both recreational and professional users. Their system integrates automatic inflation, GPS-based location tracking, and real-time biometric monitoring to ensure comprehensive protection in aquatic environments. A notable feature is the use of machine learning algorithms to detect emergencies such as sudden immersion or irregular vital signs, enabling timely intervention. The use of LoRa enables long-range signal transmission, which is particularly beneficial in remote or maritime locations. This study demonstrates how integrating IoT and AI technology can significantly enhance water safety outcomes, particularly in situations where there is a high risk, such as when cold water enters and becomes extremely cold itself.

The Smart Saviour life jacket introduces a new dimension to aquatic safety, as reported by Jakarta et al. (2025). The system utilises IoT technology for efficient detection and monitoring of survivors during emergencies on water. Environmental and physiological sensors (GPS: NEO-6M; heart rate

and body temperature sensors) were attached using the ESP32 microcontroller and the real-time ESP-NOW data transmission protocol. Rescue teams can dynamically prioritise their responses using live geolocation and health indicators displayed on a dynamic dashboard. System evaluations demonstrated connectivity close to perfection, synchronisation speed that outstrips many competitors, and sensor accuracy (98% for heart rate measurement and ±0.5°C for water temperature variance); all of these factors point to its use in life-saving operations during aquatic disasters.

3. Problem Statements

After reviewing several research papers related to life safety jackets, it has been observed that all such jackets are primarily designed for protection during water-related incidents or flooding. Some papers focus on jacket health monitoring, while others concentrate on jacket location and tracking. The outer surface of the jackets is typically made of polyester or a similar plastic-type fabric, while the interior is composed of a sponge-like plastic material. Some jackets are capable of floating in water for up to seventy-two hours, while others function for a shorter duration. Most jackets are manufactured in red or saffron colours and are not equipped with any electronic devices or technological gadgets. Due to this limitation, the exact location of individuals wearing these jackets during rescue operations remains unknown. The physical condition of the wearer is also not separately detectable.

In addition, after examining multiple research papers on bright life jackets, it has been observed that GPS has been utilised in some cases. Still, the primary focus has remained on location tracking. Several studies have demonstrated the use of wireless sensor networks to monitor both location and physical health parameters. In some designs, jackets have been developed for medical monitoring, and technologies such as sensor systems and cloud storage have been applied in similar ways. Other research papers have only focused on the body's cooling function. While some life jackets have been designed to display information such as body oxygen levels and heart rate on an LCD, no research paper has been found that displays all parameters—health condition, location, Toxic gas detection, and cooling system—together in one system. Furthermore, while lithium batteries have been used to power innovative features in various designs, details regarding the charging process of these batteries have not been included. Although multiple outputs have been presented in some studies, proper functional steps and modern design features for the bright jacket have not been explained.

Therefore, in the present study, an attempt has been made to design a life jacket suitable for the weather conditions of the Indian subcontinent, which will include a proper communication system from the control room with the necessary instructions. It is considered essential to monitor the wearer's health condition and provide an integrated cooling system. The jacket is intended to be user-friendly for the person wearing it. Additionally, complete data will be sent to the control room through a cloud server using IoT technology. Unlike previous studies, warning sound systems and Gas sensors will also be included in the present work. As a result, significant benefits are expected to be provided to the rescue team.

4. System Requirements

The hardware and software requirements for creating an improved design of the Smart Life Safety Jacket are shortly described below:

4.2. Hardware Components-

In this research paper, the hardware used to create and develop the proposed model is described below:

- **ESP32 Microcontroller: The ESP32 is a microcontroller device that features Wi-Fi and Bluetooth capabilities**. Due to its low cost and various Internet of Things applications, this device is useful. It is also used to make a wearable bright Jacket.

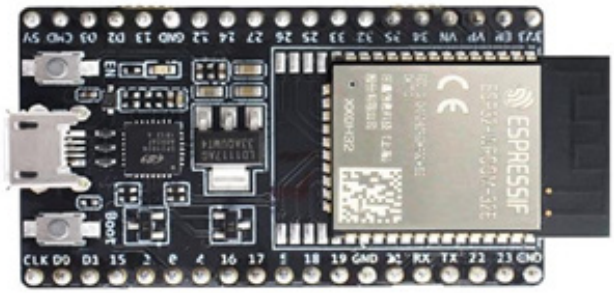

Figure 2. ESP 32 Microcontroller Board.

- **Moisture sensor:** Moisture moisture is a sensor device that usually determines the amount of water in some parts. This device is known in response to sudden increases or acceptance of water levels.
- **Body Temperature Sensor**: A body temperature sensor is a specialised electronic device created to measure body temperature accurately. This device can monitor the exact temperature of the body.
- **Heart Pulse Sensor:** A pulse sensor is a device that measures an individual's heart rate. Typically, the heart rate in adult people is 70-100 beats per minute.
- **Gas Sensor:** Gas sensing is primarily used to detect various types of natural, unnatural, or harmful gases. Gas sensors can convert gas concentrations into electrical signals, which are then considered as an output value. These sensors are primarily used to detect the presence of odourless gases in the environment that pose a threat to human health. Depending on the type of gas, these gas sensors can be of different types. In this Proposed model, a simple gas sensor is used, which will indicate in a hostile environment when the oxygen content is low or a flammable gas is present.
- **SPO2 Sensor:** The SpO2 sensor measures blood oxygen saturation by detecting the percentage of haemoglobin that is bound to oxygen. This is typically used in a medical environment, particularly in cases involving patients with dementia, and provides essential health information. As integrated into wearable devices like life jackets, it can continuously monitor the user and check whether they have proper oxygen levels of 96%-100%.

Figure 3. SPO2 Sensor.

- DC Fan: A fan that operates on DC (Direct Current) or at a constant current, such as a battery voltage, is referred to as a DC fan. Typically, DC fans use 5 volts, 12 volts, 24 volts, and 48 volts. Usually, we see DC fans used for cooling in various computer devices. However, I have shown the use of two DC fans here. The whole-life safety jacket, which I aim to demonstrate in my research paper, incorporates health monitoring capabilities within the coat, enabling the person wearing it to maintain a cool body temperature throughout their life.
- **GPS Sensor:** It stands for Global Positioning System. GPS is a modern technology that knows the exact location of a place or user through satellites. In the GPS sensor system, a satellite tracking system is installed, allowing the precise location of the person with the GPS device to be determined through the antenna.

Figure 4. GPS Sensor Device.

- **Buzzer:** A buzzer is a mechanical audio device that transforms any electrical signal into sound. The primary purpose of a buzzer is to act as a signal, alerting individuals to potential danger or an alarm. DC voltage and current are usually used to run this device.
- **Lithium Ion Battery:** In this research paper, the use of lithium-ion batteries as a part of a power supply. This battery is composed of lithium-ion cells and is rechargeable. It is used in devices like smartphones, Smart Watch, and laptops. It is increasing due to its lightweight design, fast charging capabilities, and long service life.
- **Connecting Wires:** Connecting wires is necessary to create various types of experimental circuits or to connect microcontroller devices to different sensor devices. Additionally, a connecting wire is required to complete a circuit on the breadboard or to supply power to other devices. For ease of understanding, different colours of connecting wires are used.
- **LED Indicator:** These LED lights are used to indicate a signal. Different colours indicate the direction of the signal. Here, we mainly tried to highlight the aspects of night rescue and life-jacket operations associated with these lights.
- **LCD Screen:** On the LCD screen, we see the output, which is displayed in abbreviated form. So that some information is available to the beneficiaries and they can observe it directly.
- **Cooling gel Pad:** A gel cooling pad is a type of device that helps regulate body temperature. These pads contain a specially formulated gel. Those that absorb body heat and lower the melting temperature to feel cool. As it requires no external power, its use is increasing in jackets and medical applications. Control can be managed as needed with the help of innovative applications. Rescuers use this device to keep the body cool. Using this device in a bright life safety jacket will provide the rescuer with a comfortable experience.

Figure 5. Cooling Gel Pad.

4.3. Software Descriptions-

In this research paper, the software used to create and develop the proposed model is as follows:

- **Arduino:** Arduino programming language. Here, after sketching a plan, the program required for execution is uploaded to the Arduino microcontroller board or ESP32 Microcontroller Board.
- **Cloud Server:** A Cloud server is an internet technology that allows users to store and access data from anywhere at any time, provided an Internet Connection and a Computer Device are available. Here, users can Store and manage data. A Cloud Server is a virtual infrastructure that performs application data processing and storage.

5. Proposed System

The earlier sections of this research article identified several issues with bright life safety jackets. To address these issues, sensor devices such as SPO2 sensors, water moisture sensors, gas sensors, and heart pulse sensors are integrated into the life safety jacket. These sensors collect various essential data, including information on the body, location, and other real-time conditions, which are then transmitted to the cloud server via an ESP-32 microcontroller. The collected data is communicated to the user or control room at specified time intervals through a wireless sensor network. A lithium-ion battery powers the entire system, offering advantages such as quick recharging times and portability due to its lightweight nature. Additionally, two DC fans are incorporated into the life safety jacket to maintain a cool body temperature. The article also explores potential improvements and upgrades to enhance the technological capabilities of the bright life safety jacket. As a result, rescuers wearing this jacket can benefit from advanced features when participating in emergency rescue operations.

Figure 6. Proposed Model Front Side.

Figure 7. Proposed Model with Cooling Pad Back Side.

The design shown in the proposed model *(Figure 6 and Figure 7)* includes the entire circuit device installed on the life safety jacket in a waterproof manner. Two LED indicators and two DC fans are installed at the front (*Figure 6*). The back of the coat *(Figure 7)* features a cooling gel pad for added comfort.

After designing the proposed model, the necessary devices were connected and placed in a waterproof box on the right side of the bright life safety jacket. A rechargeable Lithium-Ion Battery powered it. Additionally, after installing the circuit in the life safety jacket, a Wi-Fi network connection was used for communication. After a test run, the circuit worked properly and was monitored through a report. The range of Wi-fi is 100 meters (approximately). If it is necessary to extend the range beyond this, the GSM 4G/5G data connection method can be used. And its range will be as far as the sim's tower location.

6. System flowchart diagram for Smart Life Safety Jacket

Flow-chart diagrams illustrate the process flow of how the proposed model works. In this research paper, a system flowchart diagram for a bright life safety jacket is presented. This diagram illustrates how the proposed Smart Life Safety Jacket enhances user safety. This diagram illustrates that the sensor devices are first activated and begin working. The real-time data is collected and processed by the microcontroller device and subsequently converted into various signals. If an ab-

normal reading is detected, the meter sends a buzzer sound or a message to the control room via a cloud server. This flowchart diagram was created for continuous monitoring to protect the wearer of the Smart Life safety jacket. Additionally, this research paper includes a flowchart diagram and a working algorithm to facilitate technical understanding.

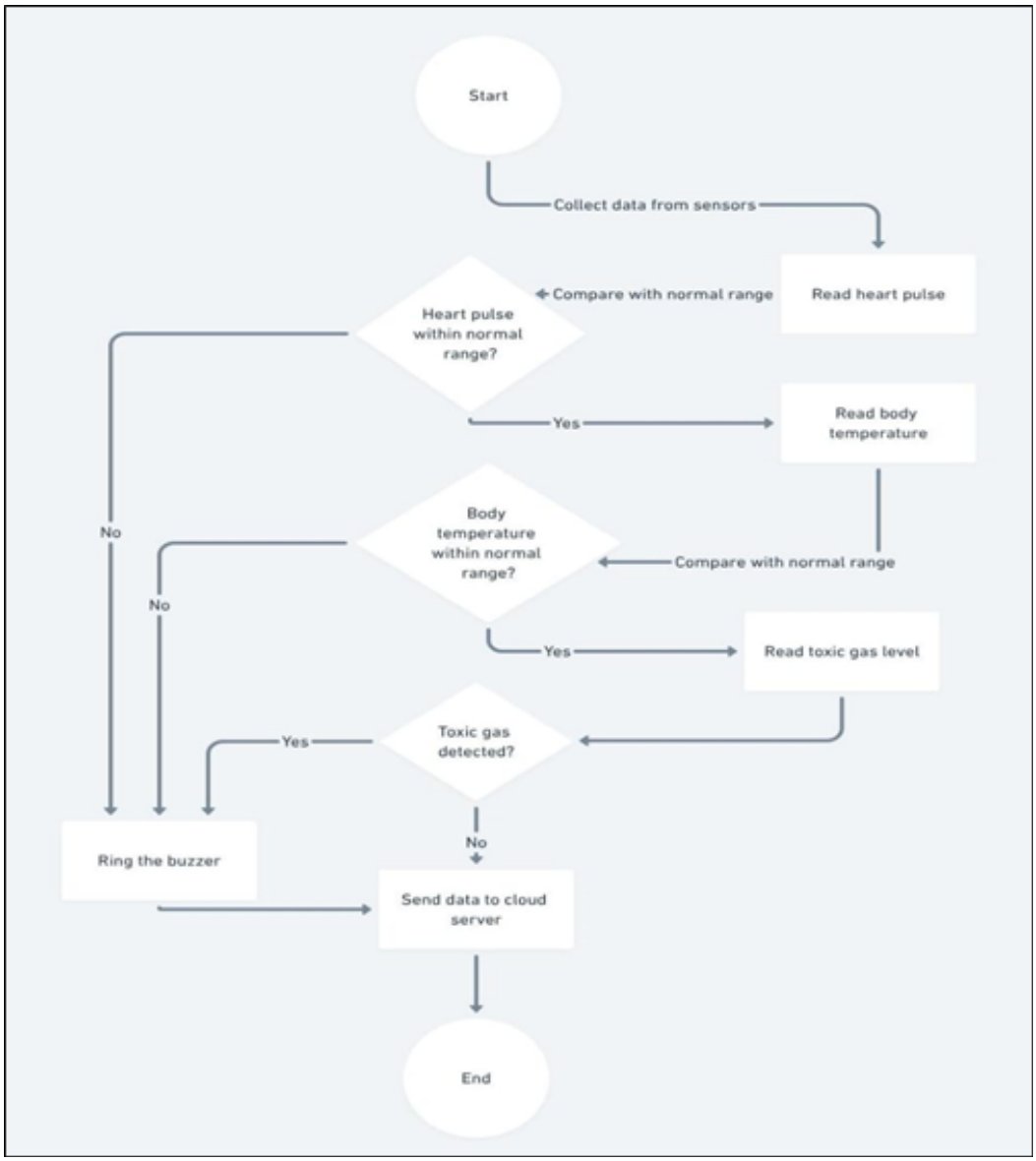

Figure 8. System Flowchart Diagram for Smart Life Safety Jacket.

7. Working Algorithm

The ESP32 and sensors are set up by integrating temperature sensors (LM35), gas sensors (MQ2), output censorship, and GPS sensors._Wi-Fi is connected through the ESP32. Rules for detecting problems are defined, which include excessive body temperature (above 38°C or 100.4°F), high concentrations of gas that pose a threat, abnormal heart rate (less than 50 or greater than 120 beats per minute), and hypoxemia (SpO2 lower than 90%).

Sensor data is read every second, with the temperature values being captured from the LM35 sensor, gas concentration from the MQ2 sensor, heart rate from the pulse sensor, and location data from the GPS sensor. These readings are then compared to the predefined threshold values to identify any abnormalities.

If any issue is identified, an alert is sent immediately. If no problems are found, a message containing the sensor readings, recorded location, and timestamp is compiled and transmitted to the cloud server. The process is repeated every second, ensuring that the limit settings and parameters are considered as needed.

8. Circuit Diagram

The schematic for a bright life safety jacket, designed primarily for rescuers, shows the integration of both health and environmental monitoring sensors and components. The central element is an ESP-32 microcontroller, which performs all connections through wires on a breadboard. These include a heart pulse sensor and LM35 temperature sensor for vital sign measurements, along with a gas sensor for detecting hazardous gases. The GPS module will provide the user's real-time location. All data from these sensors will be processed and displayed on an LCD screen by the ESP-32. In the event of high temperatures or other hazardous conditions related to toxic gas detection or irregular heartbeat, an alert can be triggered using a buzzer with an LED indication to notify either the user or the rescue team. This compact system has been adequately powered and interlinked using a breadboard, allowing for seamless integration within the jacket. This bright jacket is, therefore, much safer for rescue personnel, as it continuously monitors their health and surroundings during critical missions, alerting them remotely and tracking their location in real time.

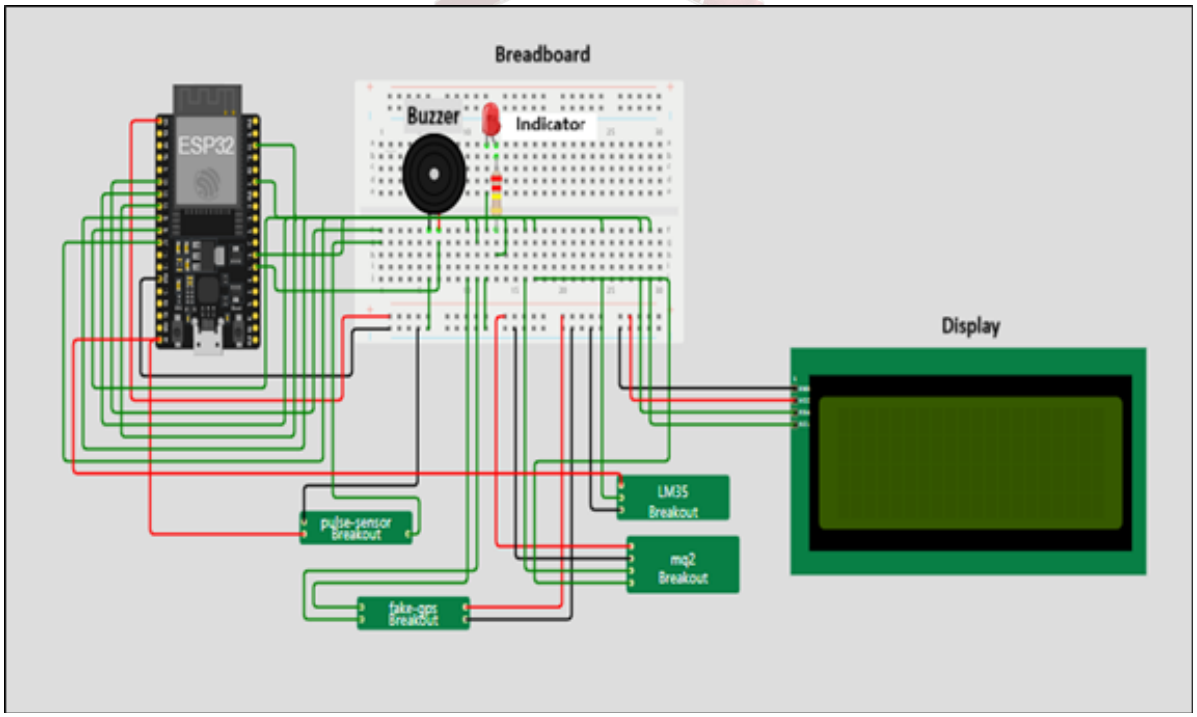

Figure 9. Circuit Diagram.

9. Hardware Specifications and Estimated Cost for Smart Life Safety Jacket

The hardware specifications, limitations, and possible estimated costs to build the circuit design of the Bright Life safety jacket are described below

9.1. Hardware Specifications and Limitations-

The specifications and limitations of the sensor technologies and hardware devices used in this research paper are as follows –

- **LM35 Temperature Sensor**

  Accuracy: ±0.5°C at 25°C;

  Output: Analog voltage, 10mV/°C

  Current Consumption: ~60µA

- **MQ Series Gas Sensor**

  Preheat Time: approximately 24 hours for optimal accuracy.

  Current Consumption: 150mA approximately (due to heating element)

  Limitations: High power consumption; sensitive to humidity and temperature variations.

- **Heart Rate Sensor**

  Current Consumption: 0.6mA during active measurement.

  Limitations: Sensitive to motion artefacts; requires proper placement.

- **16x2 LCD Display**

  Display Type: Alphanumeric.

  16 Character 2 no of Line

  Current Consumption:

  Without Backlight: <1mA

  With Backlight: Approximately 20mA

  Limitations: Backlight brightness may vary between units; current draw depends on the backlight resistor value.

- Power Consumption Analysis

  ESP32 Microcontroller: 160–260mA approximately during Wi-Fi operations.

  MQ Gas Sensor: approximately 150mA.

  Heart Rate Sensor: approximately 0.6mA.

  LM35 Temperature Sensor: approximately 0.06mA.

  Buzzer: 30mA approximately (active state)

  LCD Display: 20mA approximately.

- **Total Estimated Current Draw**: Approximately 360–460mA

- **Battery Life Estimation**

  Using a 3.7V, 2000mAh LiPo battery with a DC-DC boost converter (assumed efficiency of 90%) to supply 5V:

Adequate Capacity at 5V:

$$Effective\ Capacity = 2000mAh \times \frac{3.7v}{5v} \times 0.9 \approx 1332mAh$$

Total Calculated Battery Life:

$$Battery\ Life = \frac{1332\ mAh}{460\ mA} \approx 2.9h$$

The runtime battery life is approximately 2.9^{h}, which corresponds to about 2 hours and 54 minutes.

9. The device performance and estimated cost of various devices used in the Smart Life Safety Jacket are presented in the form of two tables below:

9.1. Table 1. Device Performance (Heart Rate and SpO_2) -

Parameter	Measured Value	Standard Deviation
Heart Rate Accuracy	96 bpm	0.6 bpm
SpO_2 Accuracy	1.9%	0.5%

Heart Rate and SpO_2 Accuracy Level.

Here, with an average heart rate of 96 bpm and a standard deviation (SD) of 0.6 bpm, the graphic shows us that we have a consistent and balanced heart rate. With a standard deviation of 0.6 bpm, the heart rate measurements are very close to the mean value and hence show a stable Rhythm.

The given SpO_2 accuracy values, ±1.9% and 0.5%, likely refer to the accuracy of the SpO_2 Sensor and how it compares to actual blood oxygen saturation values.

9.2. Total estimated Cost for Smart Life Safety Jacket circuit-

The cost estimate is calculated below:

Table 2. Total estimated Cost to make Smart Life Safety Jacket internal circuit.

Component	**Estimated Price (USD)**
ESP32 Development Board	$9.95
Active Buzzer Module	$5.99
LED Module	$0.52
Breadboard	$4.95
SpO_2 Sensor (MAX30102 Module)	$5.61
MQ-2 Gas Sensor Module	$5.50
Body Temperature Sensor (MAX30205)	$7.82
Total	**$40.34**

Total estimated Cost *(in USD $)* to create the primary circuit.

Therefore, the circuit design of the bright life safety jacket proposed in this research paper will cost about **$40.34** to build.

10. Results:

Here are the results obtained from the cloud after successfully running the complete Smart Life Safety Jacket circuit-

Heart Rate: 96 BPM || GAS: Non Detected || Temperature: 96.05 F || LAT: 24.123793 LON: 88.695635
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Heart Rate: 96 BPM || GAS: Non Detected || Temperature: 96.05 F || LAT: 24.123793 LON: 88.695635
Heart Rate: 96 BPM || GAS: Non Detected || Temperature: 95.05 F || LAT: 24.123793 LON: 88.695635
Heart Rate: 96 BPM || GAS: Non Detected || Temperature: 96.05 F || LAT: 24.123793 LON: 88.695635

In this Results section, the output of the experimentally run entire circuit design is reported. The heart rate is 96, 97, **or 98 BPM** ***(Heart Rate: 96 BPM)***. The gas being detected is either toxic or non-toxic. However, no poisonous gas was detected in this case *(GAS: Non-Detected). The body temperature reads 96°F (Temperature: 96.05°F),* which is considered normal. The output here displays the latitude and longitude geo-location (LAT/LON: 24.123793, 88.695635), which is detected via the GPS sensor. The geo-location is also being recorded on the server for emergencies and future analysis. Whenever a rescuer goes to a remote location to rescue, this record may help the monitoring team identify some crucial moments.

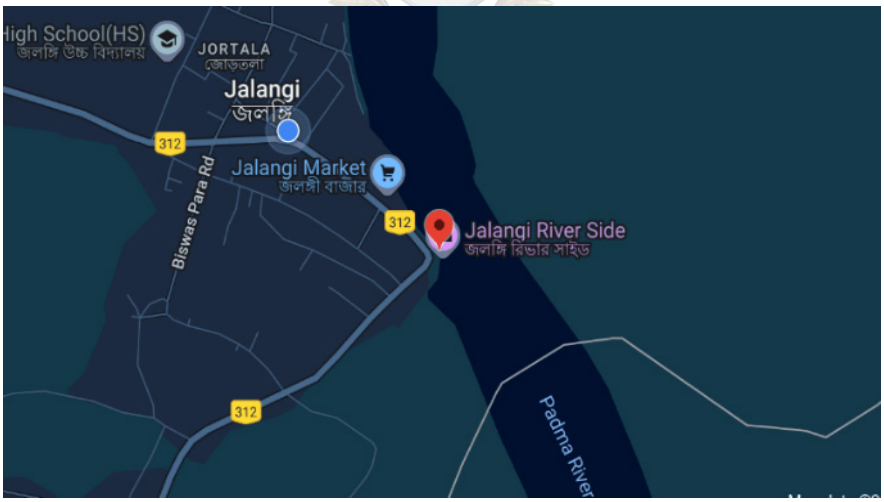

Figure 10. Position the jacket according to the current location using the GPS sensor.

Other devices, such as the buzzer, LED indicator light, and DC fan, were not included in the report but functioned as expected, directly connected to the power source. Life safety jackets, which are utilised in rescue missions conducted under direct sunlight, are made of heavily heat-trapping and low-breathability polyester materials. Their extended use can lead to thermal discomfort and even heat stress. To mitigate this issue, the integration of active cooling technologies, such as DC-powered fans and cooling pads, has been implemented into the jacket design. *(Figure 6)* The

cooling pads enhance heat dissipation, while the DC fans augment airflow and provide relief. These modifications aim to improve comfort and operational performance while maintaining safety and enabling the extended use of life jackets in high environments.

In this research paper, the proposed design incorporates all sensor technology and other electronic devices used in the basic circuit design (Figure 9) by connecting them with wires. The main sensors used in the Bright Life safety jacket, as described in this research paper, functioned correctly.

11. Future Work

This research article demonstrates the functionality of various sensors with a modern design in the Smart Life safety jacket. This time, we will discuss several points on how these life safety jackets can be modernised and improved using computer science.

- **Uses Of Integrated AI and Machine Learning:** Environmental data can be processed pattern-wise by artificial intelligence. As a result, the person wearing the bright jacket will have the ability to predict environmental risk factors. In turn, this might enable the jacket to adjust to the user's bodily state and consequently offer a range of safety measures.
- **Data Analytics:** The data obtained through all the sensors used in the Bright Life safety jacket must be collected. All that collected data can help improve the user's security using mathematical models or through data analysis. To achieve this, various methods of data analysis can be applied, such as big data analysis, clustering, and regression, among others. This makes the data analysis method more accurate in terms of security.
- **Intelligent Safety System:** Buoyancy aids or firmings that save vital areas upon an impact by self-inflating can be built into the jacket. The jacket might trigger an automatic safety system after a serious crash, such as activating a rescue drone or warning a team of nearby helpers.
- **Environmental sensors and other detection techniques are used. Various types of sensors are used for environmental monitoring, and the use of these bright jackets is expected to** increase. Such as sensors used to detect temperature, toxic gases, accelerometers, etc., to alert in case of an emergency automatically. A variety of toxic gas detection systems can also be installed.
- **Energy independence and using a charging System:** A power supply is typically used to run bright jackets, which in turn draws power from a lithium battery. These batteries require regular charging. However, if this part also installs a solar charging system, then the need to charge the jackets during the rescue operation will be significantly reduced. Thus, it will be possible to design an environmentally friendly intelligent life safety jacket by incorporating these innovative technologies.
- **Improved Communication Systems:** The first thing needed is effective communication between the rescuer and the control room conducting the rescue. In the event of a minor emergency, a microphone or public announcement system may be used. However, in cases of long-distance communication, a two-way communication system or a satellite-based wireless system can be used. In some cases, hum radio communication systems can also be used, where typical cell service may not be available. Various modern drones, radios, or mobile applications can also be used.
- **Advanced Materials and Design:** To expedite rescue operations, life safety jackets must be designed and developed to be lightweight, comfortable, and constructed from strong, durable materials. It is long-lasting and improved with modern technology, which also has an indigenous touch. Additionally, jackets should be made of fabrics that are both comfortable and functional, even with minor damage.
- **Waterproof and Ruggedness:** As noted at the beginning of this research paper, these life safety jackets are designed to stay afloat for a specified period. Additionally, a special plastic sponge-type material is used in these jackets. If we can install this sponge-type material in the jackets by laminating it with a

plastic cover, the time it stays afloat in water will increase. Additionally, the durability of the coat will also be enhanced.

12. Conclusions

The Smart Life Safety Jacket is a revolutionary innovation developed using the Internet of Things (IoT) and other modern sensor technologies, along with a modern communication system. This bright life safety jacket provides physical safety for rescuers, tracking their activity and current location. This research paper presents the advanced design of a Smart life safety jacket, which includes the detection of body temperature, oxygen level, and heart condition, as well as an advanced GPS location sensor and a Gas sensor to detect toxic gases. The DC Fan and Gel cooling pad have been used to keep the body cool in the climate of the Indian subcontinent, and the physical condition of the person wearing this bright jacket can also be monitored using a cloud server. As a result, it will be possible to assess the physical condition of rescuers and provide additional security in very high-risk rescue operations. The always-on LED indicator is also attached to the shoulder of this jacket to illuminate during active rescue operations. Finally, suppose the design of this Smart life jacket is implemented. In that case, rescue work will speed up and, utilising modern computer technology (IoT), will move ahead with the modernisation of life safety jackets in an indigenous way. The modernly designed jacket has worked properly, and the work duration and estimated cost are also tabulated in this research paper. Ultimately, this research paper will play a significant role in the future, advancing or making progress in flood rescue operations. Finally, to reiterate, the safety jacket commonly used in outdoor Rescue Works activities will remain the same, with other components, such as radium, and utilise the latest technology. A Smart Life Safety Jacket for Rescuers is designed in this research paper. If this proposed model is implemented, the Smart Life Safety Jacket will play a crucial role in taking advanced measures during disaster development.

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Review

Large-Area Emergency Lockdowns with Automated Driving Systems

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ABSTRACT

Region-wide restrictions on personal vehicle travel have a long history in the United States, from riot curfews in the late 1960s to travel bans during snow events to the 2013 shelter-in-place "lockdown" during the search for the perpetrator of the Boston Marathon bombing. Because lockdowns require a tremendous amount of resources to enforce, they are often limited in duration or scope. The introduction of automated driving systems may enable governments to quickly and cost-effectively implement large-scale lockdowns by disrupting wireless communications, inserting road closures into digital maps, exploiting a vehicle's programming to obey all traffic control devices, or coordinating with vehicle manufacturers. Future vehicles may lack conventional controls, rendering them undrivable by the public. As travel restrictions become easier to implement, governments may enforce them more frequently, over longer durations and wider areas. This article examines the practical, legal, and ethical implications of lockdowns in scenarios where most driving is highly automated and offers guidance on the development of lockdown policies.

KEYWORDS

Travel restriction; automated vehicle; autonomous vehicle; self-driving; robotaxi.

1. Introduction

Governments have long used travel restrictions to control population movement during emergencies. These restrictions can take various forms. Individual roads, bridges, and tunnels may be closed to private vehicle traffic, as was done for all routes into Manhattan following the terrorist attacks of September 11, 2001 (DeBlasio et al., 2002, pp. 22–30). Curfews may also be enforced, where pedestrian and vehicle traffic are prohibited during certain hours. Several jurisdictions have curfew laws for minors, and curfews in the United States have been enforced for all adults during emergencies, such as the 1965 Watts riots in Los Angeles, California (McCone et al., 1965). Authorities may order citizens to "shelter-in-place" and remain in their homes or business during an emergency, although several states do not have specific statutes that allow mandatory shelter-in-place orders (McGinty, 2015).

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In recent years, the terms "shelter-in-place" and "lockdown" have gained prominence in emergency management. While often used interchangeably, these terms have distinct meanings in the United States. A lockdown typically refers to situations involving an active shooter (Merriam-Webster, n.d.), while shelter-in-place orders are generally issued for extreme weather events or potential chemical/radiation exposure (American Red Cross, 2003).

Governments rarely enforce large-scale lockdowns due to their unpopularity, high costs, and enforcement challenges. Transportation agencies may need to deploy barriers, while police or military personnel must enforce closures. The cost of this additional personnel is in addition to the lost tax revenue resulting from the closure of businesses. In the United States, lockdowns have generally required public support or a large police or National Guard presence, and often both.

These challenges are mitigated with the introduction of automated driving systems (ADS). SAE International defines an ADS as "the hardware and software that are collectively capable of performing the entire DDT [dynamic driving task] on a sustained basis" (SAE International, 2021). More advanced ADS can perform the entire driving task without any input from a passenger and may thus operate without a human driver or passenger. These ADS, referred to as Levels 4 and 5, may or may not be equipped with conventional controls (SAE International, 2021). Because these ADS would be completely reliant on their software and wireless communication systems to operate, governments could potentially restrict their movements simply by coordinating with a few ADS developers, fleet owners, or mapping service providers. Alternatively, authorities might be able to place low-cost barriers, such as traffic cones, at key locations and leverage the software's adherence to traffic laws. Enacting and enforcing lockdowns could become far more cost-effective, leading to potential abuse by governments without a firm legal framework for their permissible use.

While these approaches would only restrict the movement of personal and commercial vehicles, this is still a significant impact. In the United States, 87% of trips are conducted by personal vehicle (Bricka et al., 2024).

This article examines the potential risks of mandatory shelter-in-place orders, also known as "lockdowns," during emergencies in a future where automated driving systems, lacking controls that a human passenger can operate, are in widespread use.

The primary objective of this research is to examine the practical, legal, and ethical implications of large-area lockdowns in a future where automated driving systems are prevalent. Specifically, this paper aims to:

1. Analyze the characteristics and legality of historical lockdowns using the 2013 Boston Marathon bombing response as a case study.
2. Explore the potential methods by which governments could restrict ADS movements during emergencies.
3. Propose guidelines for the ethical initiation and enforcement of lockdowns in the era of ubiquitous automated driving.

As automated driving systems become more sophisticated and widespread, the ease with which governments can implement travel restrictions may lead to their more frequent use, potentially over longer durations and wider areas. This raises important questions about the balance between public safety and individual liberty, the role of private technology companies in emergency management, and the potential for abuse of these capabilities.

The remainder of this article is organized as follows. First, the characteristics of lockdowns are described, with the 2013 voluntary lockdown in Boston, Massachusetts, following a terrorist attack serving as a case study. Then, how automated driving systems enable inexpensive and rapid enforcement of lockdowns is explored. Finally, guidelines for ethical initiation and enforcement of lockdowns are presented for policymakers, ADS developers, and emergency management professionals.

By addressing these issues, this paper contributes to the growing body of literature on the societal impacts of automated driving systems. It provides valuable insights for transportation planners,

emergency management officials, and policymakers as they prepare for a future where ADS play a central role in personal mobility.

2. Lockdown characteristics

2.1. Boston case study

On April 15, 2013, at 2:49 p.m., two bombs detonated 12 seconds apart near the finish line of the still underway Boston Marathon, killing three spectators and injuring hundreds more. Two suspects were later identified from video surveillance. Before they could be apprehended, the suspects killed a police officer in nearby Cambridge and exchanged fire with police in Watertown, seven kilometres from the initial bombing. One suspect escaped from the shootout. By 2 a.m. the following morning, Boston-area residents began receiving automated phone calls and notices on their doors advising them to shelter in place (United States. Cong. House. Committee on Homeland Security, 2014, p. 31). Shortly after 8 a.m. on April 19, Massachusetts Governor Deval Patrick requested that Boston-area residents stay indoors, not answer the door unless it was a police officer, stay away from windows, and refrain from congregating outside (Struck & Sullivan, 2013). Police cordoned off a 20-block area in Watertown and conducted building-by-building searches for the remaining suspect. The shelter-in-place request was lifted shortly after 6 p.m. that day (Struck & Sullivan, 2013). Sometime later, a Watertown resident living outside the cordoned area found the injured suspect lying in a boat parked in his backyard. By 9 p.m., police had the suspect in custody (Feldman, 2013).

During the 16-hour lockdown, public transit was shutdown, Amtrak passenger trains to and from New York were stopped and searched (New Canaan Advertiser, 2023), taxis were ordered off the street for part of the day, professional baseball and hockey games were cancelled, and nearly all businesses, offices, and universities were closed (Struck & Sullivan, 2013). Reporters observed nearly empty streets throughout the day, a stark contrast to the usual Friday pedestrian and vehicle traffic (Struck & Sullivan, 2013).

The lockdown received widespread support in the Boston area. A survey of 500 Massachusetts residents conducted after the lockdown by the independent group MassINC showed 91% of respondents approved of actions taken by the government, with 48% fearing the response would not go far enough to end terrorism (Scholtes & Margetta, 2013). Media interviews of Boston residents also demonstrated nearly universal support for police actions (Quinn, 2013). The elected representative of Massachusetts's 8th congressional district, whose constituents include Bostonians, reported receiving no complaints about the shelter-in-place request (Sylvester, 2014).

Outside of Boston, reactions were mixed. In a national survey conducted by *The Washington Post* (2013) During the lockdown, 48% of respondents worried that the government would go too far in its investigation, due to concerns about constitutional rights, versus 41% who thought it wouldn't go far enough. Images of police in combat uniforms and body armor traveling on suburban streets in armored personnel carriers drew comparisons to a military occupation (Sylvester, 2014). Although the shelter-in-place request was voluntary, some commentators interpreted it as "strongly" suggested (Bray, 2013), with the governor's statement advising that residents "should not" answer their doors and noting that private businesses "will remain closed until further notice" (Struck & Sullivan, 2013). Others objected to the cost of the lockdown, estimated at between $250 to $330 million (Green & Winter, 2013).

A lockdown of Boston's scale was unprecedented in the U.S. at the time (Struck & Sullivan, 2013). Major fugitive hunts in the aftermath of the Oklahoma City bombing in 1995, the 2002 mid-Atlantic sniper attacks, and the 1996 Atlanta Olympic bombing all avoided lockdowns. The only comparable terrorism-related lockdowns in recent history followed the attacks of September 11, 2001 where five percent of Manhattan closed to vehicle traffic for 30 days (DeBlasio et al., 2002, p. 24), and the 2015 Paris attacks when Brussels was locked down for five days while authorities searched for suspects (Escritt & Macdonald, 2015).

2.2. Legal aspects

In the United States, the rights of citizens to travel between individual states is generally protected by the Constitution (American Jurisprudence 2d, 2006a, sec. 659). In an emergency, however, fundamental rights such as travel may be temporarily limited or suspended (American Jurisprudence 2d, 2006a, sec. 664).

While travel between states is a protected right, many state and federal courts have reached differing conclusions regarding whether travel within a state is constitutionally protected (American Jurisprudence 2d, 2006a, sec. 662). Although the Supreme Court has declined to decide the issue, several states' constitutions establish a state constitutional right to travel within the state (American Jurisprudence 2d, 2006a, sec. 662). Curfew laws at the city or county level have been held as valid against constitutional objections, so long as they are enacted or promulgated during civil disorder or riots, and if reasonable notice is given (American Jurisprudence 2d, 2006b, sec. 2). In Massachusetts, mayors and city managers are permitted to enact curfews in response to civil disorder or other dangers, provided two hours' notice is given (Mass. Gen. Laws Chap. 40 § 37A). For an extensive analysis of intrastate travel rights, see Wilhelm (2010).

Internationally, freedom of movement is generally protected under Article 13 of the Universal Declaration of Human Rights (United Nations, 1948), a document developed by the United Nations in 1948 with 48 countries voting for its adoption by the UN General Assembly.

2.2. Costs

Officials may be reluctant to lock down a city during an emergency due to the societal costs. The Boston region has a gross domestic product of almost USD 1 billion per day, but the lockdown affected only a portion of the region and much of the lost revenue was simply delayed; experts estimated the economic losses at between $240 to $333 million per day for Boston (Green & Winter, 2013).

Cities may need additional police to enforce a lockdown, such as the 19,000 National Guard troops deployed to Boston during the lockdown (Friedersdorf, 2015). Boston has one sworn officer for every 317 residents (Federal Bureau of Investigation, 2016). If working alternating 12-hour shifts, one officer would be on duty for every 634 residents. In contrast, the standard ratio of police officers to attendees for effective crowd control is 1:100 (Harris, Edwards, Homel, & Fuller, 2015). As one-fifth of Boston's payroll is devoted to police (ACLU of Massachusetts, 2023), a six-fold increase in police presence for any significant length of time would be unsustainable.

3. Lockdowns and automated driving systems

The Boston lockdown was voluntary and occurred in 2013 when humans manually drove all vehicles. The act of driving has become increasingly computerised over the years. Anti-lock brakes, stability control, and cruise control have advanced into adaptive cruise control and lane-keeping functions on production vehicles, automating the gas, brake, and steering functions in certain conditions. These features rely on advanced cameras, laser and radar sensors, and computerised control of steering and braking systems. While today's production vehicles can drive themselves in limited scenarios, e.g., self-parking (Tenhundfeld, de Visser, Ries, Finomore, & Tossell, 2020) and well-marked freeways (Mueller, Cicchino, & Calvanelli, 2024) automakers and technology firms have deployed vehicles capable of handling complex urban traffic in a range of weather and lighting conditions. At least one system is currently operating as a driverless taxi service in multiple U.S. cities with over 90 million kilometers traveled (Kusano et al., 2025).

The increasing automation of the driving process may simplify the enforcement of a mandatory lockdown. There are several ways that a government can quickly and cheaply restrict the movements of vehicles with ADS. Three examples are discussed in this section: jamming wireless communications, altering digital maps, and exploiting vehicles' strict adherence to traffic laws.

Each of these methods can be overcome by the human driver taking manual control of the vehicle. Future vehicles, however, may lack conventional controls, or controls may be restricted in some way to prevent operation by unlicensed or impaired drivers. Even when controls are available, passengers who may have never driven before may find themselves unable to operate the vehicle. In these situations, passengers may request a human driver in an off-site operations centre to control the vehicle via wireless communications. This process is referred to as teleoperation (Neumeier, Gay, Dannheim, & Facchi, 2018), and has been demonstrated several times using existing cellular networks (Davies, 2019). Remote operators could potentially control the vehicles and ignore the restrictions, but they may be unwilling to assist; their employers may be unwilling; governments may block the necessary wireless communication; and there may not be an adequate number of remote operators to service all vehicles in a lockdown at once.

This section explores the various methods governments can use to restrict the movement of vehicles equipped with ADS.

3.1. Jamming wireless communication

Most automated driving systems use occasional wireless communication via cellular networks, either to communicate with remote operators (Dano, 2023), receive data on road conditions (Dano, 2023), or updating the high-definition (HD) maps required for automated driving (Liu, Wang, & Zhang, 2020). To restrict automated driving, officials may attempt to disrupt wireless communications between vehicles and the infrastructure. This could be accomplished through deploying devices that deliberately interfere with radio or GPS signals, referred to as signal jammers (Arjoune & Faruque, 2020; Grover, Lim, & Yang, 2014). In the United States, the use of these technologies by state and local authorities are prohibited under the Communications Act of 1934. Federal agencies may jam signals after seeking a waiver, and sources have acknowledged using these devices during the 2009 presidential inauguration ceremony in Washington, DC to prevent remote controlled bomb attacks (Hsu, 2009). Although state governments are currently prohibited from jamming signals, they have repeatedly requested exemptions (Kinnard, 2019).

3.2. Altering digital maps

If automated vehicles cannot be driven manually by their passengers, then governments wishing to restrict the movement of automated vehicles have several available strategies. Road closures could be entered into navigation map services such as Google Maps, Apple Maps, Waze, or other proprietary navigation maps used by ADS developers. This would prevent a vehicle's navigation system from using roads into and within a lockdown area.

Governments may only need to partner with a handful of companies to effect a lockdown using these methods. As of 2020, two companies, Alphabet (parent company of Google Maps and Waze) and Apple have near-complete control of the navigation software market (Riley, 2020). Similarly, two companies—Waymo and Zoox—constitute 99.9% of all driverless travel in California (California Department of Motor Vehicles, 2025). This may not require explicit cooperation from mapping companies, as transportation agencies routinely send road closure information to mapping services automatically (Goodall & Lee, 2019).

Most ADS also rely on high-definition (HD) maps of most roads, comparing the locations of various objects from a vehicle's lidar sensors with map data to distinguish between static and moving objects, and to geolocate a vehicle's position by triangulating the distance to buildings and signs (Liu et al., 2020; Waymo, 2020). These HD maps are routinely updated using lidar data collected by probe vehicles, and new map details, such as the locations of construction barriers, may be shared among AVs in near real-time. These maps are considered so critical to automated driving that the Chinese Internet search company Baidu at one point considered shifting its focus to primarily making and distributing HD maps as a service for automated driving systems (Metz, 2018).

Governments could request that HD map providers "close" roads or digitally insert representations of physical barriers in the map in such a way that ADS programming will not permit them to drive onto these roads. A map provider, for example, could insert a "digital fence" that an ADS will not drive into, regardless of its sensor readings. Governments could also leverage existing relationships with navigation providers (Waze, 2022) to insert digital closures in the same way that they provide alerts on weather and special events.

Although these strategies may require cooperation from ADS developers or mapping software companies, such cooperation from private industry is not unprecedented, especially in a crisis. As one example, YouTube, Facebook, Twitter, and Reddit cooperated with police to remove a video of a mosque shooting in Christchurch, New Zealand within minutes of its posting (Chan, 2019).

3.3. Explositing ADS adherance to traffic laws

Authorities might also deploy low-cost physical barriers that ADS have been programmed to respect as road closure warnings. A single traffic cone or police tape, even without an officer present, might be sufficient to close a road to driverless traffic. Automated driving systems have been vulnerable to these strategies in real-world deployments, in one instance being immobilized by a traffic cone placed on a vehicle's hood (Kerr, 2023). Although a passenger could easily exit the vehicle and remove the obstruction, these could still impede vehicles without passengers, and could slow others to walking speed if a passenger is required to remove multiple obstructions per kilometer.

Much of the cost of enforcing a vehicle travel ban can be minimized by using automated enforcement tools. Police can track a vehicle's location, time of movement, movement over time *i.e.* tracking, speed, and unique identification using GPS, toll tag sensors, license plate readers, Wi-Fi/Bluetooth sensors, or some other type of vehicle-to-infrastructure communication such as cellular V2X (Papathanassiou & Khoryaev, 2017).

3.4. Human driving difficult or impossible

Vehicles equipped with ADS may not have conventional controls, making them undrivable for their human passengers. Some examples today are low-speed shuttles in operation in several cities (Dennis & Brugeman, 2019, pp. 63–93), and certain robotaxi designs (Duncan & Thadani, 2025). Some low-speed shuttles with ADS do not have conventional controls such as a steering wheel or pedals, but rather handheld devices similar to a video game controller to allow the backup driver, or "conductor," to control the vehicle when the automated driving system cannot (National Transportation Safety Board, 2019).

In the United States, the National Highway Traffic Safety Administration (2018, 2022) has begun the process of adapting its safety standards to permit vehicles with non-conventional controls. If future vehicles can drive consistently without passenger intervention, then the described low-cost efforts to enact lockdowns (signal jamming and altering maps) may become even more effective, as passengers will have no way to override the ADS and operate the vehicle.

3.5. Staff cannot support remote operation

Suppose the passengers are unable to drive the vehicle and the automated driving system is affected by lockdown measures. In that case, a driver employed by a third party may remotely control the vehicle using wireless communications. This is generally referred to as "remote operation" where an operator may observe the vehicle's environment and select a path for the ADS to follow, or "teleoperation" where a remote operator takes full control of the vehicle and can perform the driving task. At least six ADS developers can operate vehicles remotely in some capacity (Amador,

Aramrattana, & Vinel, 2022, p. 130140), while five other companies specialized in remote operation technologies for automated vehicles (Davies, 2019).

Several states, including Texas, Florida, and California, explicitly permitted remote operation of vehicles (California Department of Motor Vehicles, 2018; National Conference of State Legislatures, 2020; Stoeltje, Antonio, & Goodin, 2017). Among these, some states require that remote operators be available during testing of automated vehicles without an on-board human driver (Amador et al., 2022, p. 130151; California Department of Motor Vehicles, 2018; Ducey, 2015). However, no jurisdiction mandates a one-to-one ratio of remote operators to automated vehicles.

ADS developers may never employ a one-to-one operator-to-vehicle ratio, as the only cost advantages it offers over a human driver in the vehicle are lower wages due to outsourcing (Goodall, 2020). Instead, remote operators may work in teams, responsible for monitoring several vehicles and taking control as requested either by the passengers or the automated driving system. Using this approach, a few remote drivers could be responsible for a large fleet of vehicles, resulting in substantial cost savings.

It is unlikely that the supply of available remote drivers at any given time will be able to handle the demand should an entire city suddenly require them for all driving. The number of remote operators needed to manage a fleet can be estimated using queueing theory. Call centers with known call durations and volumes use the Erlang C formula to estimate staffing needs (Klungle, 1997). The Erlang C formula estimates the probability P_c that an incoming call cannot be immediately answered given the total staffing N and call demand A using the equation:

$$P_c(N,A) = \frac{\frac{A^N N}{N!(N-A)}}{\sum_{i=0}^{N-1}\frac{A^i}{i!}+\frac{A^N N}{N!(N-A)}},$$

where A is the average number of calls λ divided by average number of calls that can be answered by a single operator in the same amount of time μ given in the equation $A = \lambda/\mu$.

Using this approach and assuming 100% of current vehicle travel using ADS, Goodall (2020) estimated the number of remote operators needed to support all United States driving. Assuming that an ADS requires assistance once per 397 hours of operation—the rate at which Waymo ADS disengaged in 2018 in California—and if each assistance requires an average of five minutes, then 19,072 remote operators working shifts could support all United States driving. According to the United States National Household Travel Survey, vehicles in the United States are in operation 101 billion hours per year (Federal Highway Administration, 2017). When divided by 8,760 hours in a year, this suggests that 12 million vehicles are on the road at any given moment, and 147,000 in Boston. If remote drivers were needed for all these vehicles simultaneously, there would not be an adequate number of remote drivers (19,072) in the United States to handle the assistance requests (147,000).

4. Guidance criteria

As automated driving systems (ADS) become more prevalent, the potential for governments to implement large-area lockdowns more easily and frequently raises significant ethical and practical concerns. This section proposes a framework for developing guidance criteria to ensure that such lockdowns are implemented justly, effectively, and with due consideration for individual rights and societal needs.

In emergencies with incomplete information, authorities may be tempted to make tactical decisions that restrict liberty. While such restrictions are often unavoidable in limited contexts, such as traffic stops, decisions affecting an entire city should be made using political reasoning and with careful consideration of their broader implications. As Harvard professor Herman "Dutch" B. Leonard noted in his testimony before Congress regarding the Boston lockdown:

"For example, the decision to issue a shelter-in-place request was appropriately framed as a policy issue by operational commanders and was put to political leaders for resolution, and this may provide a good illustration of the kind of process of issue identification and resolution that needs to

be addressed in the [National Incident Management System (NIMS)]. It is imperative for NIMS to provide more guidance on the process by which tactical commanders should work in conjunction with an appropriate decision-making process for elected leaders. Both have important but different roles to play, and NIMS currently lacks systematic ways to help these two groups each to stay within their own designated 'lane.'" (U.S. House of Representatives Committee on Homeland Security, 2014, p. 23)

This observation highlights the importance of a clear decision-making framework that involves both operational and political leadership when considering large-scale lockdowns.

When rights must be restricted during an emergency, authorities should adhere to the "least restrictive alternative" principle to maintain safety and security while minimizing infringement on individual liberties (Jennings & Arras, 2008). In the context of ADS-enabled lockdowns, this means limiting the scope of travel restrictions to the smallest necessary geographic area, minimizing the duration of the lockdown, restricting the fewest possible modes of travel, and allowing for essential movement within the restricted area. By adhering to these principles, authorities can strike a balance between public safety needs and respect for individual freedom, thereby minimising potential economic and social disruption.

Jennings and Arras (2008) recommend that authorities pursue voluntary compliance rather than mandatory enforcement whenever possible. This approach is ethically superior and often more effective, assuming that the necessary behaviors can be achieved. To encourage voluntary compliance, authorities should provide clear, transparent communication about the reasons for the lockdown, offer rational persuasion, correct misinformation promptly, and consider public opinion while addressing concerns proactively. However, when individuals pose a serious threat to others by their unwillingness to comply with restrictions, there may be ethical justification for compelling compliance.

The unique capabilities of ADS present both opportunities and challenges for implementing lockdowns. Guidance criteria should address the use of digital map alterations and geofencing to restrict ADS movement, protocols for emergency override of ADS controls by authorized personnel, safeguards against potential abuse or hacking of ADS lockdown mechanisms, and provisions for essential services and emergency vehicle operations.

To ensure that ADS-enabled lockdowns are implemented ethically, authorities should respect the privacy and confidentiality of individuals affected by the restrictions, protect restricted individuals from undue social stigma and humiliation, ensure that adequate resources are available to enforce requirements fairly and humanely, provide clear criteria for initiating, maintaining, and lifting lockdowns, and establish oversight mechanisms to prevent abuse of emergency powers.

Guidance criteria should also address exceptions to lockdown orders, such as medical emergencies, access to healthcare, essential workers, critical infrastructure maintenance, caregiving responsibilities, family reunification, and individuals with special needs or vulnerabilities. To prevent the unnecessary prolongation of emergency measures, guidance should include regular review of the continued necessity of lockdown measures, clear criteria for lifting or modifying restrictions, and sunset provisions that automatically terminate emergency powers after a specified period unless explicitly renewed.

Given the potential for cross-border implications of ADS-enabled lockdowns, guidance criteria should address coordination with neighbouring jurisdictions and countries, compliance with international human rights standards and freedom of movement agreements, as well as protocols for managing international travel and border crossings during lockdowns.

By developing comprehensive guidance criteria that address these various aspects of ADS-enabled lockdowns, authorities can ensure that emergency measures are implemented effectively, ethically, and with due respect for individual rights and societal needs. As ADS technology continues to evolve, these criteria should be regularly reviewed and updated to reflect new capabilities, challenges, and ethical considerations.

5. Conclusions

This paper has examined the potential implications of automated driving systems (ADS) on the implementation of large-area emergency lockdowns. Three key points were explored: the historical context and characteristics of lockdowns, how ADS could facilitate more efficient lockdown enforcement, and the ethical and legal challenges this capability presents.

The analysis suggests that ADS-enabled lockdowns could be implemented more quickly and cost-effectively than traditional methods, potentially leading to their more frequent use. This capability raises important questions about the balance between public safety and individual liberties, as well as the role of private technology companies in emergency management and response.

A framework for developing guidance criteria for ADS-enabled lockdowns was proposed, emphasizing the importance of using the least restrictive measures necessary, promoting voluntary compliance, ensuring transparency, and establishing clear oversight mechanisms. This framework is intended as a starting point for further discussion and refinement by legal scholars, ethicists, and policymakers.

The goal of this paper was not to definitively solve these complex issues, but to outline the challenges and potential consequences of ADS-enabled lockdowns. Future research should focus on developing more detailed protocols for ADS-enabled lockdowns, exploring the technical feasibilities and limitations of proposed restriction methods, and conducting analyses of potential societal impacts.

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Article

Ensuring Disaster Management Practices in Academic Libraries of Ghana: The Issues at Hand

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ABSTRACT

The study focused on ensuring disaster management practices in academic libraries of Ghana, with a specific emphasis on a technical university library in Ghana. The convenience sampling method was used to select the study participants. The participants consisted of 455 respondents drawn from the university community. The study adopted a descriptive survey. The researchers used a Five-point Likert scale questionnaire to measure the various constructs. The researchers on the campus of a technical university in Ghana administered this. Out of 455 questionnaires distributed, 443 were valid for analysis. This represented 97.4% of the sample size and was valid for analysis. Using the Statistical Package for the Social Sciences (SPSS) version 25.0 computer software, the data obtained were analysed. The results showed that all the hypotheses tested indicated a positive relationship between the independent variables (Causes of Disaster, Technological Approaches, Challenges of Disaster Management, and Disaster Management Policy) and the dependent variable (Disaster Management Practices), except for the relationship between Challenges of Effective Management and the dependent variable. This suggests that the management of academic libraries in ensuring practical disaster management issues of the causes of disasters such as flooding, power fluctuations, power surges, fire outbreaks, roof leakages, earthquakes, mutilation, hacking of the library computers, plumbing defects as well as activities of pests (termites, cockroaches, rodents) among others should be given attention. The study recommends implementing technological approaches, such as fire detectors, fire extinguishers, smoke detectors, fire alarms, and CCT cameras, among others, to mitigate the occurrence of natural disasters. The study further recommends that academic libraries, in their pursuit of achieving effective disaster management, should develop a disaster recovery plan and policy to guide implementation. The policy should outline timelines for staff training, periodic inspections, security upgrades, repair of leakages and assembly points, and creation of awareness about disasters and emergency response lines, among others, as they form the core elements of ensuring disaster management practices in an emergency.

KEYWORDS

Causes of disaster; technological approaches; challenges of disaster management; disaster management policy; disaster management practices; disaster recovery plan.

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1. Introduction

Disaster is an occurrence that causes damage and disruption to everyday activities. Libraries and Information Centres are vulnerable to a wide range of disasters, including natural events such as floods, earthquakes, and storms, as well as human-made threats like theft, criminal damage, fire, war, conflict, terrorism, inadequate security, and poorly maintained buildings, among others. There are also technical disasters, which include power outages, computer network breakdowns, gas leaks, communication failures, and issues with cooling, heating, and ventilation systems (Ottong & Ottong, 2013; Abdulsalami et al., 2022).

Disaster management encompasses all management issues necessary to deal with incidents that threaten library buildings, collections, services and human lives (Cvetkovic & Martinovic, 2020; Goyal, 2019; Mano & Rapaport, 2019). Since some public libraries of today are technology-driven, many nascent disasters are evolving. For example, changes in energy systems and lack of electricity supply endanger traditional library materials, just as digital materials are useless without energy supply. However, the unpredictability of their occurrences, including how they occur and which one occurs first, has been a great concern to individuals and organisations worldwide, including academic libraries in Ghana. The endemic damage caused by disasters in libraries, whenever one strikes, leaves the affected library in a deplorable condition (Abonyo, 2016; Ayoung et al., 2015).

Regardless of how the threats manifest or how they impact academic libraries, safeguarding and preserving their collections should be a top priority in their policies. It is very significant to note that the key to achieving this goal lies in effective preservation management, which enables long-term planning and informed decision-making. It will, therefore, be fair to assert that no public library is immune to these disasters, depicting that any of them could befall any academic library at any moment, as it is inescapable without appropriate control measures. The current study aims to advance disaster management practices in academic libraries of Ghana, using the Koforidua Technical University Library (KTUL) as the focal point of discussion. There have been recorded instances of disasters affecting libraries worldwide, including those in Africa and Ghana. These disasters have led to the elimination of entire collections of libraries.

The observation that disaster preparedness is not a significant concern in academic libraries is compounded by the fact that most disasters that occur in academic libraries are not adequately documented, and a significant number of cases go unreported (Abonyo, 2016; Ayoung et al., 2015). The effects of disasters range from financial implications to disruption of services, damage to library buildings, stacks, machines, staff, and physical communication channels such as roads, rails, and virtual channels like LAN, WAN, and the internet, among others. A visibility study conducted on the state of ensuring disaster management in KTUL reveals that there are no strategies in place to protect their holdings against disasters (Abonyo, 2016; Ayoung et al., 2015).

The preliminary investigations and observations indicate a state of disrepair, with leaking roofs, broken louvres, dead bulbs, dirty curtains, theft, mutilation, and exposed electrical wires, among others, in the library. Given the assertion above, this study aims to examine the process of ensuring disaster management practices at KTUL to protect their holdings against disasters through the phases of disaster management and planning, including prevention, preparedness, response, and recovery, if applicable. Though there have been some studies on disaster preparedness and management practices across the globe, for example, Abonyo (2016), IIo et al. (2020; 2018), Ismail et al. (2023), Ishola (2017), Taukur (2021), Rasaki (2021), Oyeniran (2023) Adeola et al., (2023) Simone and Carroll (2022) among others are some of the studies to mention. These studies typically concentrated on academic libraries in liberal universities without any connection to the technical university libraries in Ghana. The interesting scenario is that in Ghana, the researchers came across only a few studies, for example, Ayoung et al. (2015) and Frempong-Kore et al. (2022); this confirms that the issue of disaster preparedness and management is still not widely known and also a concern hence there is a gap that current study is to fill. The study aims to advance disaster management practices in academic libraries of Ghana, utilising the Koforidua Technical University Library (KTUL) as a case study.

1.1. Purpose and objectives

The purpose of this study was to examine the process of ensuring disaster management practices in academic libraries in Ghana, addressing the existing issues. The study seeks to address the specific objectives:

- To find out the causes of disaster in academic libraries in Ghana
- To find out the technological approaches to disaster management in academic libraries in Ghana
- To examine the challenges to effective management of disasters in academic libraries in Ghana
- To assess the emergency response plans of academic libraries in Ghana

1.2. Research questions

The study seeks to find answers to the following research questions: These are:

- ***RQ1*** – What are the causes of disaster in academic libraries in Ghana?
- ***RQ2*** – What are the technological approaches to disaster management in academic libraries in Ghana?
- ***RQ3*** – What are the challenges to effective management of disasters in academic libraries in Ghana?
- ***RQ4*** – Are there any emergency response plans for academic libraries in Ghana

1.3. Conceptual framework

In this study, the researchers incorporated aspects and concepts from theory, literature, contextual knowledge, and modelling to formulate a conceptual framework that guides the objectives and a literature review (see Figure 1). Ngulube (2020) contends that a conceptual framework can be formulated by incorporating aspects of theories, concepts from literature, or models. The construct causes of disasters, technological approaches to disaster management, challenges of effective disaster management, disaster management policies, and disaster management practices (Frempong-Kore et al., 2022; Abareh, 2014; Ayoung et al., 2015). As a result, the conceptual framework depicted in Figure 1 serves as the foundation for this study, informed by the literature and the identified models. Furthermore, these constructs influenced the study's objectives and literature review.

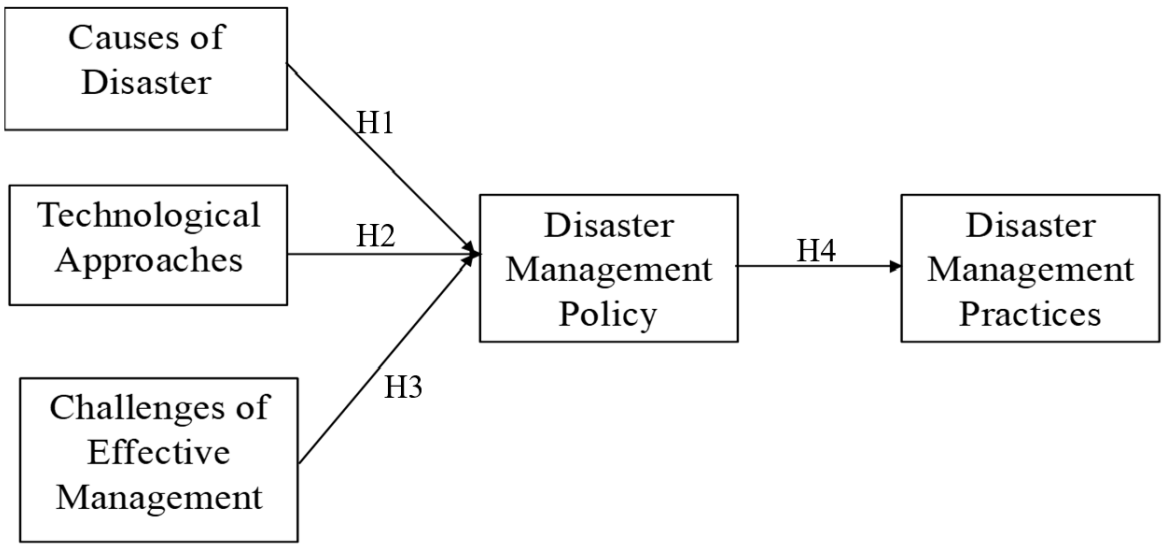

Figure 1: Research model.Source: Authors' Construct, 2024.

1.4. Literature review

Disaster perspective and causes in academic libraries

In the context of academic libraries, floods and fires are the most common disasters that destroy collections. According to Corrall and Brewerton (1999), the term encompasses both natural and man-made phenomena, such as storms, earthquakes, pests, blasts, asbestos, bombs, robberies, and civil disorder. Records show that Ghana has experienced a variety of disasters, including fires, earthquakes, floods, and arson cases (Adinku, 2005). The Aglonby Library in Accra, Ghana, was destroyed in the 1939 earthquake. The Agricultural Development Bank's headquarters caught fire in 1984, resulting in the destruction of valuable records. Akussah (1991) asserted that there were many attacks on Ghana's traditional libraries and archival materials; however, terrorist attacks were minimal. Any disaster is hazardous to humanity and properties, irrespective of the type and where it may occur. The devastating consequences of disasters are so severe that institutions like libraries need to prioritise disaster prevention measures over recovery measures (Frempong-Kore et al., 2022).

Another critical element that every library needs is the ability to formulate measures to recover quickly after a disaster; this will help the library achieve its institution's core objectives. In 1966, the Arno River in Florence "burst its banks and caused catastrophic flooding of the Bibliotheca Nazionale Centrale''. The flood destroyed one million volumes of documents (Fortson, 1992). In 1986, the Los Angeles Central Public Library's collections were also destroyed by arsonists. In 1988, a fire consumed 400,000 materials, including one-quarter of the newspapers at the USSR Academy of Sciences Library, due to defective wiring (Harvey, 1993). In 1997, the Morgan Library at Colorado State University was similarly damaged by a flood, which destroyed half of its collections (Alire, 2008).

According to Hlabaangani and Mnjama (2008), the old Immigration Department building in Gaborone, Botswana, caught fire in the 1990s, resulting in the destruction of a significant number of records. Numerous resources, including library materials, were destroyed in the attack on U.S. government offices in Kenya and Tanzania (McMichael, 2007). Oluwatola et al. (2015) posited that fire attacked the President Kennedy Library of Ahmadu Bello College, Zaria, where some library materials were consumed. In Ida, North Central Nigeria, students' protectors set fire to the Federal Polytechnic. Disasters can be caused by nature. These include floods, earthquakes, and tornadoes. Man can cause disasters. These include civil unrest, arson, and vandalism. Generally, the assumption is that disasters are large-scale events; however, most disasters are more minor in scope and less newsworthy, such as roof leakages and termite activities, yet just as destructive (Abareh, 2014).

Diamond (2006) further highlighted that natural disasters are those that occur as the result of any natural occurrence that causes significant damage and loss of life or the emergency that is the consequence of such an event or forces occurring in nature. He further added that artificial disasters are caused by human action, negligence, error, or the failure of a system. Man-made disasters are, in turn, categorised as either technological or sociological. In terms of technological disasters, failures can occur due to engineering failures, transportation accidents, or environmental disasters. On the other hand, sociological disasters often have a strong human motive, such as criminal acts, stampedes, riots, and war, among others (Abareh, 2014; Ayoung et al., 2015; Frempong-Kore et al., 2022).

Technological approaches to disaster management in academic libraries

The existing literature (Superio et al., 2024; Fatade et al., 2023; Frempong-Kore et al., 2022; Iroeze, 2021) on disaster management in academic libraries in Ghana and the wider West African region highlights several key concerns. Frempong-Kore et al. (2022) examine the state of disaster preparedness in selected university libraries in Ghana, revealing a concerning lack of preparedness. The study found that while all the surveyed library staff were aware of the potential for disasters, there was a significant shortage of disaster-resistant equipment, such as smoke detectors and fire extinguishers, beyond basic fire extinguishers. Additionally, the study highlighted the absence of disaster management committees and inadequate staff training in disaster preparedness. Building on these findings, the study further underscored the critical need for Ghanaian academic libraries to develop comprehensive disaster management policies and plans. The finding also emphasises the importance of disaster preparedness in academic libraries, as they are particularly vulnerable to a range

of natural and human-induced disasters, including fire, floods, theft, and vandalism. The literature also sheds light on the challenges associated with disaster management in digital libraries, which are becoming increasingly prevalent in academic institutions (Frempong-Kore et al., 2022). In their work, Cvetković and Šišović (2024) noted that education is one of the most important measures for reducing non-structural risk from the increasingly severe and frequent consequences of disasters.

Kehnemuyi (2021) and Ghorbanzadeh et al. (2020), for example, outline the potential threats to digital libraries, such as hardware failures, software malfunctions, and cyber-attacks, and the need for robust disaster management strategies to ensure the preservation of valuable digital collections. A study by Anyaoku et al. (2019) highlights the significance of digital information resources in disaster management. It emphasises the crucial role of information and communication technologies in developing effective disaster management plans for libraries and information centres.

Technological factors encompass aspects related to or involving the application of scientific advances, including any tool, technique, product, process, or method that benefits disaster management. Shuvasish and Sibsankar (2015) stated that technological advancements, especially in the information and communication sector, have provided a real yardstick for warning, preparing, sharing, and responding quickly to disasters, thereby minimising their impact. In some cases, it is even possible to avoid the damage caused by a natural disaster. Shuvasish and Sibsankar (2015) further listed technologies which can be helpful in the reduction of damage by a disaster:

Challenges to effective management of disasters in academic libraries

With the increasing shift towards digital collections, Biswas and Chaudhuri (2012) outline the potential threats to digital libraries, including hardware failures, software malfunctions, and cyberattacks, and emphasise the need for robust disaster management strategies to ensure the preservation of valuable digital collections. Brown (2021) highlights the evolving challenges in disaster management for libraries in the digital age. Additionally, the study by Kaur and Mahajan (2021) emphasised the significance of digital information resources in disaster management. It highlighted the critical role of information and communication technologies in developing effective disaster management plans for libraries and information centres. Disaster management in digital libraries presents unique challenges, as digital resources are more vulnerable to a distinct set of threats compared to physical collections. Hardware failures, software malfunctions, and cyber-attacks can lead to the loss of irreplaceable digital materials (Orenia & Cabonero, 2023). Furthermore, the reliance on complex information and communication technologies in digital libraries requires specialised expertise and robust backup and recovery procedures (Kaur & Mahajan, 2021).

Yamson and Cobblah (2016) recommended the use of Closed-Circuit Television (CCTV), electronic sensors, and electronic surveillance systems, as well as the need to employ well-trained security personnel in the library. Ilo, Ngwuchukwu, Michael-Onuoha, and Segun-Adeniran (2019) found that inadequate disaster facilities and equipment, as well as poor funding, were the most significant challenges confronting disaster mitigation in federal and state universities in Nigeria. Robert (2018) listed weak organisational policies regarding disaster management, a weak emergency plan, a poor attitude toward disaster management among staff members, general poverty within the institutions, and overpopulation as some of the factors that limit organisations from effectively managing disasters and security. Iroeze and Iroeze (2021) investigated the current status of preparedness in disaster management among academic libraries in the Southeast geopolitical zone of Nigeria. A base level of knowledge on disaster preparedness and current practices was assessed through a questionnaire distributed to 380 librarians at five academic libraries. Three hundred fifty-six responses were received, and after sorting, 337 were analysed. Frequency and percentage tables were used to analyse the collected data. Flood and fire were identified as significant threats to disaster in most academic libraries in the Southeast. Most of the academic libraries do not have a written disaster preparedness plan. Disaster preparedness measures and staff involvement in disaster preparedness by these libraries were found to be generally inadequate.

Sustainable disaster emergency response plans in academic libraries

Numerous studies (Frempong-Kore et al., 2022; Abdullahi et al., 2022; Ilo et al., 2018; Asamoah et al., 2018) on disaster management in academic libraries in Ghana and the wider West African region highlight several key concerns. These studies examine the state of disaster preparedness in selected university libraries in Ghana, revealing a concerning lack of preparedness. The study further underscored the critical need for Ghanaian academic libraries to develop comprehensive disaster management policies and plans. The literature also sheds light on the challenges associated with disasters in complex information and communication technologies in digital libraries. Libraries, as repositories of knowledge and cultural heritage, face a constant threat from various disasters, both natural and human-made (Abdulsalami et al., 2022). These disasters can cause significant damage to collections, infrastructure, and equipment, disrupting services and leading to the potential loss of invaluable resources. The importance of disaster preparedness and management in libraries is well-documented in the literature (Ismail et al., 2023; Orenia & Cabonero, 2023; Iroeze, 2021; Aburuki, 2016; Velasquez et al., 2016). There is no one-size-fits-all model for developing emergency response plans (ERPs) for all libraries. Factors such as the funding authority's financial strength for emergency preparedness undertakings, staff strength of the organisations out of which members are drawn and designated as an emergency response team, availability of emergency equipment for prevention, preparedness and response drills, leadership philosophy of the emergency response team leader and others are essential determinants (IIo et al., 2020; 2018),

In addition, each library should examine its unique characteristics in terms of emergency antecedents, vulnerabilities, facilities, structure, resources, and user community, among others, to develop an ERP that is responsive to identified hazards. Furthermore, the integration of relevant stakeholders' insights, especially in the case of an academic library, is essential for the formulation process of the plan (Miles et al., 2018). To this end, numerous emergency management frameworks have been proposed to guide libraries in developing institution-specific ERPs (IIo et al., 2020; 2018). Kostagiolas et al. (2011), about the disaster management plan of the National Library of Australia, mentioned the need for libraries to accommodate two broad phases of the emergency management cycle – pre-disaster activities (emergency preparedness plans, mitigation, and prevention) and post-disaster activities (giving detailed analyses of response and recovery processes). According to the "Anatomy of a Disaster Plan" by the American Alliance of Museums (2012), the following are vital areas for consideration in the preparation of an emergency preparedness and control plan: introduction, emergency preparedness and prevention, response procedures, emergency clean-up and salvage procedures, and institution-specific information. Cvetković et al. (2021) found that the most important predictor of local self-government preparedness for disasters is the assessment of the relevant legislation.

The proposal by Halsted et al. (2005) appears more comprehensive, outlining 11 steps for developing a meaningful emergency management framework for libraries.

Having identified the peculiar items necessary for formulating an institution-specific plan, the decision becomes necessary as to whether the guidelines (the plan's contents) should be documented (written down) for everyone to follow in the event of an emergency. Some of the libraries that have ERPs have them in two formats – written and unwritten. The WERP does not eliminate hazards/emergencies or ensure everything is salvaged during and after an emergency response. However, suppose the guidelines are consciously written and religiously followed during an emergency response. In that case, they have the potential to help minimise the extent of damage and the cost of recovery (Hamilton, 2016), as response efforts will be well coordinated through the plan. The UERP, on the other hand, only exists in the minds of stakeholders. In the event of an emergency, response efforts will be discretionary, and as a result, the process will lack proper coordination. As noted earlier, whether written or unwritten, if relevant items are not captured in the plan, it may still not serve its purpose. However, it may still not be responsive if it is not regularly being evaluated and updated to accommodate emerging threats. It had earlier been reported that some librarians believe that disasters rarely occur in libraries (Zaveri, 2015; Abareh, 2014). Additionally, it was found that librarians do not differ in their views on the role of emergency preparedness, preservation, and conservation as safety measures for information resources in federal and state university libraries (Ilo et

al., 2020). Whether or not this perception applies to ERPs concerning emergency preparedness and control in university libraries is uncertain.

2. Methods

An explanatory research approach was employed to identify and establish the fundamental relationships and linkages between various constructs, providing further insight and a broader perspective on the determinants of disaster management practices in the academic library environment, with KTUL in focus.

Population

All permanent staff and registered students at the Koforidua Technical University (KTU) were considered as the target population for this study. The rationale was to ensure that each participant had an equal opportunity to contribute to the subject, thereby gathering a substantial number of responses for the study. The participants were selected from five faculties: the Faculty of Applied Science and Technology, the Faculty of Engineering, the Faculty of Built and Natural Environment, the Faculty of Business and Management Studies, and the Faculty of Health and Allied Sciences. The total population for the study was 8040 (in Table 1). The researchers obtained the information from the Registrar's office.

Sampling Technique

Convenience sampling was adopted for the study. The rationale for using this technique was its practical approach to gathering data quickly and efficiently. Again, the entire target population was difficult to reach. However, this cannot justify the absence of limitations in terms of generalisation and potential bias. The inherent limitation was that the data collected could not be generalised to other universities in Ghana.

Population sample

According to Cooper and Schindler (2014), a smaller set of the larger population is referred to as a sample size. The study employed Yamane's (1973) statistical formula to determine an appropriate sample size from a finite population. This formula was used to determine the representative sample size from each of the faculties as follows:

$$n = N / (1 + Ne^2)$$

Where n = required sample size

N = size of the population

e = alpha level, that is, allowable error e = 0.1 at 95% confidence interval

Equation 1:

$n = N / (1 + Ne^2)$

2766/ (1+2766(0.1)2 =99

Equation 2:

1398/ (1+1398(0.1)2 =93

Equation 3:

587/ (1+587(0.1)2= 84

Equation 4:

2755/1+2755(0.1)2=95

Equation 5:

534/ (1+534(0.1)2=84

Hence, the sample size for the study consisted of 455 participants.

Table 1: Population and Sampling.

Faculty	Population	The sample size for each faculty
Faculty of Applied Science and Technology	2766	99
Faculty of Engineering	1398	93
Faculty of Built and Natural Environment	587	84
Faculty of Business and Management Studies	2755	95
Faculty of Health and Allied Sciences	534	84
Total	**8,040**	**455**

Source: Registry of Koforidua Technical University, 2024.

Operational Definitions

Operational Definitions (OP) describe the procedures, methods, and instruments used to quantify or qualify a particular phenomenon, making it possible to observe, record, and analyse data. OP ensure that abstract concepts are clearly understood and consistently applied. By standardising measurement procedures, operational definitions promote reliability and reproducibility. Table 2 illustrates the OP adopted for the study. The various constructs that inform the study include causes of disasters, technological approaches, challenges to effective management, disaster management policy frameworks, and disaster management practices, along with their respective sources, which indicate the hypothesised relationship.

Table 2: Operational definitions of constructs.

Constructs	Operational definitions	Sources	hypothesised relationship
Causes of disasters	Natural or artificial factors leading to a danger	Abonyo (2016), IIo et al. (2020; 2018), Ismail et al. (2023), Ishola (2017)	CD- TA
Technological approaches	The specific scientific measure of mitigating dangers	Rasaki (2021), Oyeniran (2023)	TA- CEM
Challenges of effective management	Systematic control of a dangerous situation	Simone and Carroll (2022)	CEM- DMPc
Disaster Management Policy Framework	Guidelines for managing disasters	Rasaki (2021), Oyeniran (2023)	DMPc- DMP
Disaster management practices	Benchmarking or standard practices in terms of dangers	IIo et al. (2020; 2018), Ismail et al. (2023), Ishola (2017)	DMPc- CD

Source: Adopted from existing Literature, 2024

Measurement development

In this study, the development of the survey instruments was guided by Churchill's 1979 proposal for designing a survey instrument (Bhattacharjee, 2012). The questionnaire was developed based on a literature review and the adaptation of previous items that have demonstrated rigorous and significant validity in the field of library and information science, particularly in the context of waste management practices in academic libraries (Tijani et al., 2022). The variables measured included the causes of disasters, technological approaches to disaster management, challenges to effective disaster management, and sustainable disaster management policies. The questionnaire consists of two parts. Section A of the questionnaire pertains to the demographic characteristics of the respondents, including their gender, age, educational qualifications, and academic level. Section B relates to the research model's endogenous and exogenous variables questions, which were powered on a five-point Likert Scale ranging from 1= 'strongly disagree' to 5= 'strongly agree'

Data collection

The questionnaire was hand-delivered to a sample of 455 participants. The participants included users from various categories, such as library staff, faculty staff, administrative staff, and students. The participants were given the questionnaire as and when they visited the library. This procedure was chosen because it allows for a better response rate, especially in situations where participants do not complete questionnaires appropriately unless the researcher is present. However, bearing in mind that minimum contact was made during the questionnaire-filling process to reduce researcher bias. After one month of administering the questionnaire, a total of 453 questionnaires were retrieved, out of which 10 were identified as unfit for further analysis because they were incomplete. Hence, 443 questionnaires were correctly filled, representing a highly acceptable response rate of 97.4%.

Data analysis

In testing the research model, the partial least squares structural equation modelling (PLS-SEM) technique, a second-generation multivariate analytic technique capable of processing latent constructs and simultaneously assessing the measurement and structural models, was used. In other words, PLS-SEM simultaneously models structural paths, that is the theoretical relationships between latent constructs and measurement paths between latent constructs and their indicators. PLS-SEM software, SmartPLS3, was used to analyse the data.

The reasoning behind the use of PLS-SEM is that it enables researchers to simultaneously examine a series of interrelated dependent relationships between a set of constructs, represented by several variables or constructs while accounting for measurement error.

Thus, Structural Equation Modelling's (SEM) ability to simultaneously test relationships incorporated into an integrated model has contributed to its widespread application. Presently, there are two conventional approaches for SEM; the Covariance-Based (CB-SEM) approach used in LISREL (Linear Structural Relations), AMOS (Analysis of Moment Structures), and EQS (Anderson & Gerbing, 1988; Bentler, 1995; Bollen, 1989), and the Variance-Based (PLS-SEM) approach used in PLS-PC, PLS-Graph, Smart-PLS and XLSTATPLS (Chin, 1995 1998; Esposito et al.,, 2010; Fornell & Cha, 1994; Hansmann & Ringle, 2004; Wold, 1985). These two approaches belong to the family of techniques that Fornell (1987) and Lohmoller (1989) referred to as the second generation of multivariate data analysis techniques.

Partial Least Squares (PLS-SEM), a relatively new, powerful multivariate analysis technique with roots in path analysis (Wold, 1985), is ideal for testing structural models involving multiple constructs with multiple latent variables (Fornell, 1987; Lohmoller, 1989; Wold, 1989). According to Tenenhaus et al. (2005), unlike CB-SEM, a PLS-SEM analysis does not require any distributional assumptions to be fulfilled (Wold, 1975). It can provide robust and accurate fits for relatively small sample sizes (Tenenhaus et al., 2005).

Additionally, the PLS-SEM method has been designed as a prediction-oriented approach to SEM that relaxes the demands on data and the specification of relationships set by CB-SEM (Jöreskog & Wold, 1982). For example, PLS-SEM can reliably estimate very complex models using only a few observations without imposing distributional assumptions on the data. Consequently, the two-step approach analytical procedures proposed were applied to the measurement and structural models. Besides, the bootstrapping method (5,000 resamples) was employed to test the significance level of path coefficients and loadings (Anderson & Gerbing, 1988; Ashill, 2011).

In a nutshell, the statistical properties of PLS-SEM particularly make it worthwhile for exploratory research settings that are ''simultaneously data-rich and theory-primitive'' (Wold, 1985, p. 589). Besides, its capabilities also support its use for theory testing; hence, it qualifies as a suitable approach to meeting the challenges faced by disaster management researchers, including the authors of this study, who are confronted with the increasing complexity of theories and cause-effect models (Hair, Ringle, & Sarstedt, 2011).

The use of PLS-SEM is gaining momentum and interest in various disciplines, including information systems (Chin & Gopal, 1995; Compeau & Higgins, 1995), marketing (Ashill & Jobber, 2009; Hulland, 1995), and organisational behaviour (Howell & Higgins, 1990).

3. Results and discussion

Evaluation of the measurement model

To achieve valid results, reliability, convergent, and discriminant validity, as well as the hypothesis of the measurement model were assessed. Convergent validity is the degree to which indicators of a latent construct converge or share high proportions of variance in common. Convergent validity is established when all indicators (observed) load highly on their assigned factors, for instance, with a loading of 0.5 or higher. Thus, it measures the extent to which items are free from random error and, as such, is capable of providing consistent results (Hair et al., 2010). As demonstrated in Table 4, all factor loadings are higher than the value of 0.6. Alternatively, Average Variance Extracted (AVE), which measures the variation explained by the latent variable about the random measurement error, is a commonly used criterion for assessing convergent validity. Fornell and Larcker (1981), as shown in Table 4, recommend that an AVE value of at least 0.5 indicates that the latent construct is able to explain, on average, 50 per cent of the variance of its indicators, thereby demonstrating adequate convergent validity. This requirement is fulfilled in this research, as it is demonstrated that AVE values for all the constructs shown in Table 4 are above the recommended threshold of 0.5. Finally, about composite reliability, all the scores are well above the cutoff value of 0.7 (Hair et al. (2010). Discriminant validity assesses the degree to which the measures of different constructs differ from one another.

The establishment of discriminant validity can be done in two ways, as indicated in Tables 4 and 5. The first method involves examining cross-loadings, which are obtained by correlating the values of each latent variable component with those of all other items. The second method involves comparing the square root of the average variance extracted (AVE) for each construct with the correlations among constructs. Suppose the square root of each AVE is much larger than any correlation among any pair of latent variables, and it should be higher than .50. In that case, the validity of the measurement model is established. In this study, as shown in Table 3, the correlation values are less than the square root of the AVE values, indicating acceptable discriminant validity (Chin, 1998; Fornell & Larcker, 1981).

Table 3: Demographic information of respondents.

Gender	Frequency	Percentage (%)
Male	243	54.8
Female	200	45.2
Total	443	100
Age groups	Frequency	Percentage
20-25	187	42.2
26-30	108	24.4
31-35	109	24.6
36-40 & above	39	8.8
Total	443	100
Faculty	Frequency	Percentage
Faculty of Applied Science and Technology	102	23.0
Faculty of Engineering	85	19.0
Faculty of Built and Natural Environment	63	14.2
Faculty of Business and Management Studies	115	26.8
Faculty of Health and Allied Science	78	17.0
Total	443	100

Source: field data, 2024

Table 3 shows that the majority, 243 (58.8%) of the respondents, were male, while females constituted 200 (45.2%) of the respondents. This indicates that more males answered the questionnaire compared to their female counterparts. Additionally, the results in Table 3 show that most of the

respondents were between the ages of 20-25 (42.2%), while 108 fell between the ages of 26-30 (24.4%), followed by 31- 35 (24.6%), and 39 (8.8%) of the respondents were in the age bracket 36-40 and above. Table 2 confirms that the majority, 115 (26.8%), of respondents who completed the questionnaire were students from the Faculty of Business and Management Studies. This was followed by students from the Faculty of Applied Science and Technology (109, 23.0%), students from the Faculty of Engineering (85, 19.0%), and so on.

Table 4. Structural model results of Loadings – Cross loadings and reliability statistics.

Items	CD	DMPc	CEM	TA	DMP	CA	CR	AVE
CD 1	0.865	0.326	0.316	0.395	0.423	0.867	0.911	0.785
CD 2	0.853	0.320	0.311	0.338	0.384			
CD 3	0.875	0.270	0.301	0.311	0.269			
CD 4	0.859	0.242	0.286	0.180	0.211			
DMPc 1	0.898	0.371	0.242	0.242	0.242	0.886	0.985	0.858
DMPc 2	0.917	0.372	0.370	0.270	0.270			
DMPc 3	0.915	0.356	0.326	0.326	0.326			
DMPc 1	0.769	0.301	0.320	0.320	0.320	0.871	0.864	0.649
CEM 2	0.860	0.316	0.371	0.371	0.371			
CEM 3	0.865	0.311	0.371	0.372	0.372			
CEM 4	0.797	0.286	0.372	0.356	0.356			
TA 1	0.854	0.395	0.356	0.301	0.301	0.829	0.863	0.677
TA 2	0.849	0.338	0.395	0.316	0.316			
TA 3	0.867	0.311	0.338	0.311	0.311			
TA 4	0.589	0.180	0.311	0.286	0.286			
DMP1	0.889	0.423	0.423	0.423	0.395	0.746	0.852	0.585
DMP 2	0.627	0.211	0.211	0.211	0.338			
DMP 3	0.784	0.384	0.384	0.384	0.311			
DMP 4	0.709	0.269	0.269	0.269	0.180			

Source: Field Data, 2024

Notes: Causes of Disaster (CD), Disaster Management Practice (DMPc), Disaster Management Policy (DMP), Technological Approaches (TA), Challenges of Effective Management (CEM), Cronbach's alpha (CA), Composite reliability (CR), Average variance extracted (AVE).

Table 5: Test of Discriminant Validity (Fornell–Larcker criterion)

	Causes of Disaster	Disaster Management Practices	Disaster Management Practice	Technological Approaches	Challenges of Effective Management
Causes of Disaster	0.863				
Disaster Management Practices	0.683	*0.810*			
Disaster Management Practice	0.670	0.697	*0.814*		
Technological Approaches	0.812	0.635	0.624	0.889	
Challenges of Effective Management	0.656	0.695	0.611	0.662	*0.758*

Source: Field Data, 2024

Structural model and hypothesis testing

After the construct measures had been proven to be reliable and valid, the next stage was to assess the structural model results, displayed in Table 6. Before assessing the structural model, the researchers conducted a test for multicollinearity on all variables. The assessment of the variance inflation factor (VIF) demonstrated the non-existence of multicollinearity, and all variance inflation factors obtained were lower than 1.234, which is far less than the conservative threshold of 5.0, as recommended by Rogerson (2001).

Table 6: Hypothesis testing of paths

Hypothesis	Path		Path Coefficient	T-Statistics	P-Values	Result
H1	CD	DMPc	0.428	4.258	0.024	Supported
H2	TA	DMPc	0.697	23.559	0.000	Supported
H3	CEM	DMPc	0.111	0.075	0.941	Not Supported
H4	DMPc	DMP	0.555	6.711	0.000	Supported
Total Indirect Effect						
	CD	DMP	0.361	4.260	0.024	Supported
	TA	DMP	0.109	0.064	0.941	Not Supported
	CEM	DMP	0.462	4.718	0.000	Supported

Source: Field Data, 2024

The model explained 0.687% of the variation in Disaster Management Policy and 0.768 % variance in Disaster Management Practices. Out of the four hypothesised relationships stated in this study, three are supported. As assumed in H_1, Causes of Disaster have an association with Disaster Management Practices with a path coefficient of ($\beta = 0.428^{***}$). This implies it supports H_1. This revelation confirms the previous research outcomes of authors such as Tijani et al. (2022) and Frempong-Kore et al. (2022), as well as IIO et al. (2018), who share a common idea that disaster management practices are associated with the causes of disasters. Also, H_2 states that Technological Approaches influence Disaster Management Practices. This is confirmed by the path coefficient ($\beta = 0.697^{***}$). The outcome corroborates the conclusions of authors such as Ismail et al. (2023), Frempong-Kore et al. (2022), and Oyeniran (2023) that the adoption of technological approaches in mitigating disasters affects the disaster management practices in place.

Similarly, the Challenges of Effective Management influence Disaster Management Practices, with a path coefficient ($\beta = 0.111$ ***); although positive, this does not support H_3. This finding is not significantly different from that of Oluwole (2019) and Kolawole et al. (2015), as well as Adeola et al. (2023), who claimed that disaster management practices adopted cannot be without challenges in ensuring a disaster-free environment.

Similarly, H_4 demonstrated a positive effect of Disaster Management Practices on Disaster Management Policy. This was significant, with a path coefficient ($\beta = 0.797^{***}$). This result is not far from the position of authors such as Abonyo (2016), Tijani et al. (2022), and Kalawole et al. (2015), who argue that disaster management practices should be aligned with a suitable disaster management policy. Overall, the implication is that in the process of ensuring disaster management practices in academic libraries, critical success factors such as the causes of disasters and effective disaster management practices are key. Technological approaches, as well as disaster management policies, should be taken into consideration.

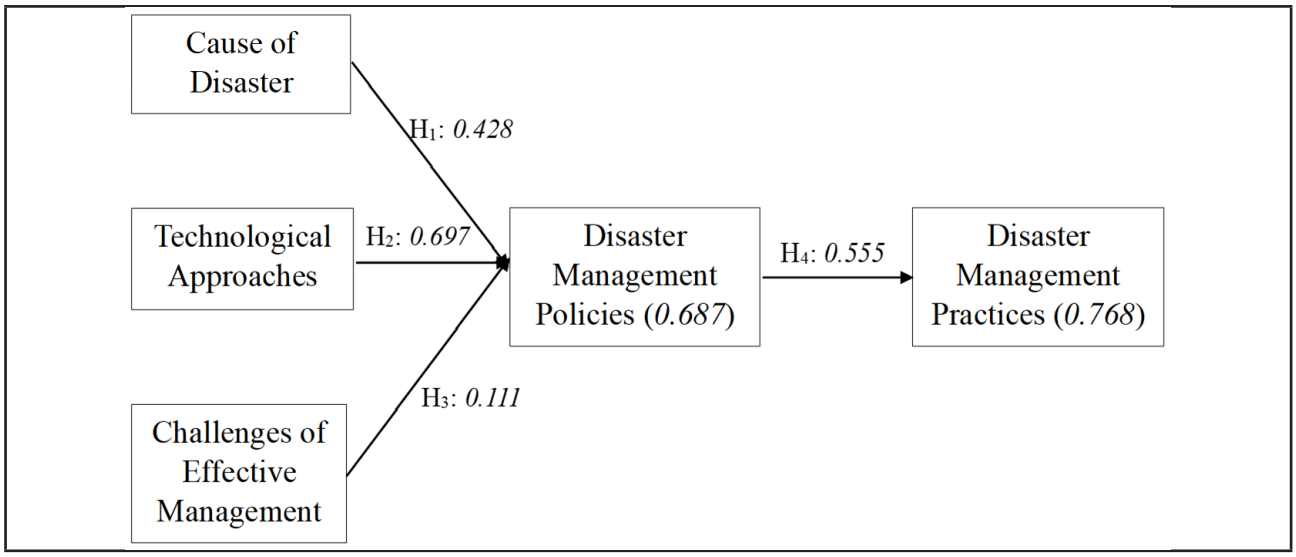

Figure 2: Structural model and path coefficient, 2024.
Source: Field data, 2024.

4. Recommendations

Based on the findings of this study, the researchers recommend possible solutions to ensure long-term measures for effective disaster management practices in academic libraries, especially those of technical universities. Therefore, the following measures were recommended:

The management of academic libraries should develop a comprehensive disaster management policy, as it forms the core of ensuring effective disaster management practices in an emergency.

The management of the academic libraries should organise regular training and drills on disaster management for all library staff.

The management of the academic libraries should install necessary disaster management systems such as fire detectors, fire extinguishers, smoke detectors, and fire alarms for earlier detection of a flood, power fluctuations, power surges, fire outbreaks, roof leakages, earthquakes, mutilation, hacking of the library computers, plumbing defects as well as activities of pests (termites, cockroaches, rodents) among others.

5. Conclusion

Based on the methods and results, the study concludes that the causes of disasters, technological advancements, and the presence of disaster management policies all have a substantial impact on disaster management practices at Ghana's Technical University Libraries (TULs). The linkages between these constructs and their effects on disaster readiness and response in the academic library setting were successfully identified through the explanatory research approach, which was combined with a descriptive survey design. Although the results may not apply to Traditional Universities, the researchers were able to obtain valuable insights from the university community by using convenience sampling with a sizable sample of 455 individuals, of which 443 responses were considered legitimate.

The findings highlight the importance of prioritising technical interventions and preventive measures, such as installing fire alarms, extinguishers, and surveillance systems, to mitigate the effects of disasters. The lack of a substantial correlation between the difficulties of effective management and catastrophe management procedures also highlights a potential area for further research and development. Notably, the report promotes the adoption of thorough catastrophe recovery procedures that involve public awareness campaigns, regular inspections, and employee training. Other TULs

seeking to enhance resilience and ensure continuity in academic library services during emergencies can utilise these findings as a starting point.

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APPENDIX 1

Questionnaire for Participants

Dear Respondents,

We kindly request that you spare us a few minutes of your time to answer this questionnaire. The purpose of this study is on the title **" Ensuring Disaster Management Practices in Academic Libraries of Ghana: The Issues at Hand."**

Please be assured that your responses to the questions will be kept confidential and used solely for this research. You have the option to discontinue your participation at any time you deem necessary.

Thank you. Yours sincerely,

Section A: Demographic information of respondents

Gender: i. Male [ ]; ii. Female [ ]

Age: i. 20-25 [ ]; ii. 26-30 [ ]; 31-35 [ ]; 36-40 [ ] 41-45 [ ]

Level: i. 100 [ ]; 200 [ ]; 300 [ ]; 400 [ ]

Department, faculty of respondents

i. Faculty of Applied Science and Technology [ ]

ii. Faculty of Engineering [ ]

iii. Faculty of Built and Natural Environment [ ]

iv. Faculty of Business and Management Studies [ ]

v. Faculty of Health and Allied Science [ ]

Kindly tick (⚜) on a scale of 1- 5, where 1= Very often; 2= Often; 3 = Sometimes; 4 = Rarely; 5= Never)

Section B: Causes of disaster in academic libraries

Causes	Very Often	**Often**	**Sometimes**	**Rarely**	**Never**
Flood					
Draught					
Earthquakes					
Neglect/inadequate maintenance					
Fire					
Theft					
Riots					
Roof leakage					
Plumbing defect					
Mutilation					
Insects					
Fungi					
Rodents					
Cockroaches					
Termites					

Kindly tick (✓) on a scale of 1- 5, where 1= Very common; 2= Common; 3 = Occasionally; 4 = Rare; 5= Never)

Section C: Technological approaches to disaster management in academic libraries

Causes	Very Common	Common	Occasionally	Rare	Never
Metal detectors					
Smoke detectors					
Fire alarms					
Fire extinguisher					
CCTV/surveillance cameras					

Kindly tick (✓) on a scale of 1- 5, where 1= Strongly agree; 2= Agree; 3 = Neutral; 4 = Disagree 5= Strongly disagree)

Section D: Challenges to effective management of disasters in academic libraries

Causes	**Strongly agree**	**Agree**	**Neutral**	**Disagree**	**Strongly disagree**
Inadequate/poor funding					
Lack of disaster control plan					
Improper use of technological equipment					
Inadequate training					
Inadequate staff					
Lack of awareness of what to do when disaster strikes					

Kindly tick (✓) on a scale of 1- 5, where 1= Very often; 2= Often; 3 = Sometimes; 4 = Rarely; 5= Never)

Section E: Emergency response plans of academic libraries

Causes	Very Often	Often	Sometimes	Rarely	Never
Flood Response Plan					
Drought Response Plan					
Earthquake Response Plan					
Maintenance and Repair Response Plan					
Fire Safety Response Plan					
Theft Prevention and Response Plan					
Emergency Evacuation Plan					
Pest Control and Management Plan					

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Article

University Students' Perception, Knowledge, and Preparedness of Flood Disaster Risk Management in Assam (India)

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ABSTRACT

Assam is a state in India that is highly vulnerable to floods. This study aims to evaluate flood disaster risk perception, knowledge, and preparedness among university students in Assam. A quantitative survey was conducted through an online questionnaire. A total of 50 samples (25 PhD, 25 postgraduate) were collected. Participants were asked about their perceptions of flood risk, knowledge, and preparedness regarding flood disaster risk management. By using the structured questionnaire and Pearson's Chi-Square test to determine the statistical significance of differences between the university students. The finding shows that 96% admit that riverine communities are vulnerable to floods. Although 78% of households need emergency plans, only 4% practice evacuation drills. Eighty-four per cent of PhD students exhibit a higher risk perception of interruption in essential services during a flood. Overall, 62% were aware of the Assam State Disaster Management Authority (ASDMA). At most, 28% understood district-level flood management systems. Awareness of ASDMA notably correlated with trust in timely warnings (52% aware and 48% unaware). Despite 86% of respondents monitoring weather alerts, 82% were unaware of community warning signals, and 56% had an unavailability of emergency contacts. The study highlights an analytical gap between theoretical awareness and practical preparedness among university students in Assam. The findings emphasise the need to integrate disaster drills into academic curricula, strengthen community-institutional partnerships, and develop localised educational tools to bridge this gap. These strategies are necessary for enhancing resilience in flood-prone regions of Assam, establishing knowledge, and promoting actionable preparedness.

KEYWORDS

Disaster; risk management; university students; perception; knowledge; preparedness; flood management; Assam.

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1. Introduction

Floods are among the most devastating natural disasters in the world, often bringing suffering and loss of life. India is ranked high amongst the most flood-prone countries in Asia. The country accounts for approximately one-fifth of global flood-related deaths, nearly 12% of its total land area, and around 40 million hectares are vulnerable to various types of flooding (Mohanty et al., 2020). In India, floods typically occur due to heavy and prolonged monsoon rains. These rains frequently cause rivers and drainage systems to overflow. Other reasons include the narrowing of river channels, erosion of riverbanks, and the accumulation of silt in riverbeds. Poor drainage systems, sudden cloudbursts, and other weather events exacerbate the situation (Bhattacharyya & Bora, 1997; Dhar & Nandargi, 2003). The country has experienced numerous severe floods over the years. One of the worst was the 2012 Assam flood. During the 2014 floods in Assam, 1,846 villages were affected, and approximately 1.6 million people were forced to evacuate their homes. In 2016, the damage increased, affecting 2,893 villages and displacing 1.7 million people (Mohanty et al., 2020). Floods in Assam occur almost every year. About 31,500 square kilometres (12162.33 square miles), or nearly 39.58% of the total land of Assam, is prone to flooding (National Remote Sensing Centre, 2016).

National guidelines recommend that state governments enhance flood management education by incorporating both technical and non-technical knowledge about floods into school and college curricula. At the national level, this includes teaching people what to do before, during, and after a flood to ensure their safety. It also focuses on training key groups, such as elected leaders and government staff, through activities like mock drills. There is also a push for research in flood prediction using tools like scenario analysis and computer models, along with collecting detailed data on rainfall, river flow, and land features. In Assam, the focus is on raising public awareness, sharing flood hazard zone maps with local communities, and establishing monsoon forums at both the state and district levels. Assam also highlights the importance of educating the public about flood risks. (Bezboruah et al., 2021).

National guidelines recommend that state governments can enhance flood management by incorporating both technical and practical knowledge into education. This includes teaching people what to do before, during, and after floods. This also includes training officials through mock drills, conducting research using computer models to predict flood situations, and collecting detailed information about rainfall, rivers, and land (Bezboruah et al., 2021).

According to the Ministry of Education, India (2024), it is estimated that there are 4,33,00000 students enrolled in India during the academic year 2021-2022. In Assam, approximately 40,215 students are studying in all colleges and universities (Directorate of Higher Education, Assam, 2016). Although there are many students in Assam, there remains a lack of research on how they perceive flood risks, their knowledge of floods, their preparedness, and their understanding of commonly used flood-related terms.

This research aims to understand how university students in Assam perceive and comprehend the risk of flooding. The findings can serve as a valuable suggestion to government authorities, institutions, and organisations to incorporate this knowledge into their education and awareness programs. This can be helpful to people and students in better understanding flood risks, making it easier to implement preventive actions that can reduce the damage caused by natural disasters, such as floods (Perić & Cvetković, 2019).

1.1. Theoretical and conceptual understanding

1.1.1. Risk Perception

Risk perception refers to how individuals or communities recognise and assess the likelihood of a disaster occurring, as well as the potential negative consequences associated with it. It is a psychological phenomenon influenced by various factors such as past experiences, personal motivations, emotions like fear and worry, comprehension of the hazard, and social context (Lechowska, 2018).

Within the framework of the psychometric paradigm, individuals make subjective judgments about the severity and acceptability of different risks, as well as the extent to which those risks should be regulated. This approach aims to identify the underlying factors that influence how people perceive various types of risks (Cvetkovic, 2016).

A significant contribution to the development of risk perception theory comes from Paul Slovic and his colleagues (Slovic et al., 1991), who initially explored these perceptions through personality theory and later expanded their work using the psychometric model. Their research emphasised that individuals form perceptions based on personal beliefs and characteristics they associate with specific disasters.

Slovic also proposed two key dimensions of risk perception in the modern world:

- "Risk as feeling" – an intuitive and emotional response to danger.
- "Risk as analysis" – a rational, calculated assessment based on logic and available information.

In one of his well-known studies, Slovic and Weber (Slovic & Weber, 2002) investigated the role of trust in shaping public responses to risk. His findings revealed that trust is fragile, can be easily damaged by a single adverse event, and is difficult to rebuild once lost. This insight is crucial in disaster management, where trust in authorities and communication sources directly affects how people perceive and respond to warnings and preparedness efforts.

1.1.2 Preparedness

Preparedness encompasses both physical actions and psychosocial readiness, enabling individuals and communities to respond effectively to disasters. Social-cognitive biases can influence these actions, highlighting the importance of providing people with accurate risk information and practical preparedness measures to ensure safe and informed responses (Cvetković et al., 2018).

This study also considers how individuals might behave in future disaster scenarios. The Transtheoretical Model of Change views preparedness as a process that evolves through five stages: pre-contemplation, contemplation, preparation, action, and maintenance. Similarly, the Theory of Planned Behavior explains that an individual's intention to act is shaped by subjective norms, attitudes, and perceived behavioural control, all of which vary across individuals and demographic groups (Cvetković et al., 2018; Citizen Corps National Survey, 2006; Ajzen, 1991).

Understanding these variations is important for tailoring education and community-based initiatives that strengthen flood preparedness. Existing research also demonstrates a strong link between disaster-related knowledge and preparedness, highlighting that both proactive (before a disaster) and reactive (during or after a disaster) activities are crucial for mitigating the negative impacts of natural hazards (Cvetković et al., 2015; Cvetković & Janković, 2020).

1.2 Flood Perception

A large body of literature on flood risk perception has constructed a strong understanding of how personal factors such as age, education, and experience are connected to how people understand flood risk (Botzen et al., 2009; Lechowska, 2018; Shah et al., 2020; Lechowska, 2021; Lin & Opdyke, 2024). Even though it is well established that personal factors shape individuals' understanding and response to flood risk (Wachinger et al., 2012; Morris, 2003; Wang et al., 2018), it is important to perceive how young people view flood risks because they can gain the most from efforts to reduce the impact of such disasters.

In Assam, research on students' perception of flood risk is also minimal. In this study, we use the age group defined by the United Nations Office for Disaster Risk Reduction (UNDRR, 2020), which categorises youth as those between 15 and 30 years old, including young adults. This is a broader age range than the one usually used by the United Nations, which defines youth as those aged 15 to 24 (United Nations, 1981). Helping young people better understand flood risks can increase their

awareness of vulnerabilities and encourage them to take action to stay safe (Rufat et al., 2015; Zhong et al., 2021).

1.3 Flood Knowledge

Knowledge is an important part of understanding how people perceive risks(Johnson, 1990). It can improve disaster preparation both directly by encouraging action and indirectly by increasing awareness. Risk education also helps communities to prepare for floods by building their ability to cope with disasters (Dufty & Webber, 2008). These researchers also emphasise that education is crucial for mitigating disaster risks and enhancing community resilience. A study conducted over four years in the United States found that university students generally had a limited awareness of flood risk. Still, their understanding improved as they aged, based on a four-year study in the United States (Ponstingel et al., 2019). Similarly, an evaluation by the New South Wales State Emergency Service (SES) found that communities exposed to flood education programs for over a year were better prepared and more likely to evacuate when needed (Dufty & Webber, 2008). However, even with educational efforts that focus on improving people's understanding of flood warnings and information, many still struggle to comprehend the messages (Árvai, 2014) fully.

1.4 Flood Preparedness

Being prepared for disasters means understanding how people perceive the risks associated with them. Better preparation enhances the ability to reduce the adverse consequences, considering their frequency, nature, and intensity, as well as their cumulative impact on personal safety, which can be achieved through appropriate training (Marčeta & Jurisic, 2024). There is no single standardised approach to disaster management. However, with the common goal of reducing the impact of disasters and promoting a culture of preparedness, the integration of disaster risk reduction practices across various sectors has been considered and implemented. Collaboration between schools and communities in disaster preparedness involves several important and complex factors that contribute to building resilience. The constantly changing environment, shaped by various interconnected elements, extends beyond the existing system and supports cooperation during disasters or in preparation for them. This collaboration creates opportunities to respond more effectively, encourages changes in behaviour, raises stakeholder awareness, and promotes adaptive actions (Rico, 2019).

2. Methods

2.1 Study Design

This study uses a quantitative descriptive survey to evaluate flood disaster risk perception, risk-related knowledge, and preparedness among university students in the state of Assam(India). The primary aim is also to analyse and understand awareness levels and knowledge among two academic groups: PhD students and postgraduate (master's) students. These groups are selected due to their presumed exposure to environmental and disaster-related topics during their academic training.

2.2 Study Population and Sampling Procedure

The target population consisted of a pilot survey of randomly selected PhD and postgraduate students from various universities in Assam, with the inclusion criteria being current enrollment in full-time academic programs at these universities across the state of Assam.

A multistage sampling method was used to choose the study design and participants in Fig.1:

- Stage 1: Assam, as a region, was selected because it is highly affected by floods each year. Flood-prone areas of Assam account for 39.58% of the state's total area. This indicates that the flood-prone area of Assam is four times the national average for flood-prone areas in the country (Government of Assam, India, 2022).
- Stage 2: A purposive sampling method was used to target master's and PhD students, who are more likely to engage with topics related to disaster risk at the university level.
- Stage 3: Participants were randomly selected from groups of master's and PhD students.
- Stage 4: The questionnaire was sent to groups of master's and PhD students. A total of 100 invitations were sent to students studying at universities in Assam to maintain the diversity of our sample. We omitted 10 incomplete responses from the analysis, resulting in 50 (50%) valid surveys.

The survey link was shared with 100 students from multiple universities in Assam through student groups and personal contacts. Survey responses were anonymous to the research team, with participants informed of this before commencing the survey. A total of 50 students participated: 25 PhD students and 25 postgraduate students. Respondents submitted the questionnaire from April 1, 2025, to April 22, 2025.

The sampled students were briefed on research principles and ethics before starting the study, as stated in the heading of the questionnaire. Students were asked about three important aspects and dimensions of disaster risk: perception, knowledge, and preparedness. These included flood disaster risk perception (comprising five indicators), flood disaster risk-related knowledge (comprising four indicators), and preparedness (comprising five indicators).

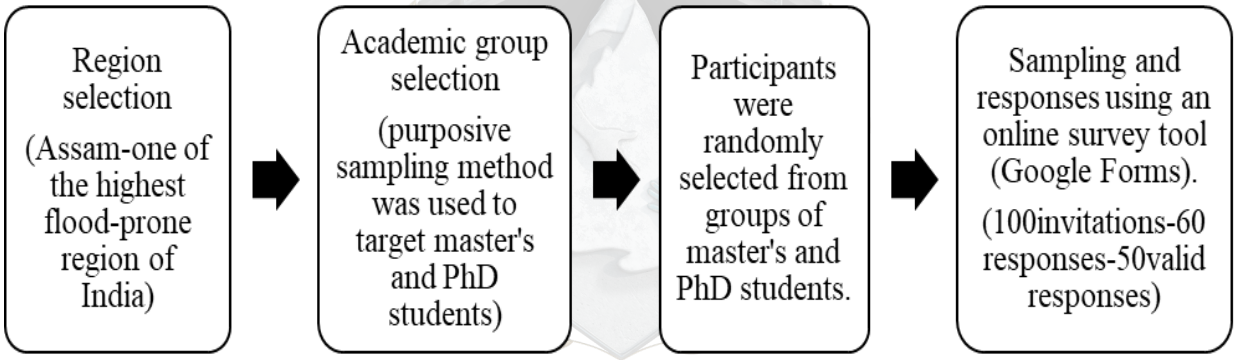

Figure 1. Stepwise sampling strategy of the research.

2.3 Data collection, methodology, and validation

An online survey questionnaire was designed and structured in three main dimensions. In this survey, our focus was on riverine flooding. The data was collected using a structured online questionnaire consisting of three parts:

- Demographic details: (e.g., gender, age, district, residence type, place of permanent residence(urban or rural), district of permanent residence, degree level, educational institution, and the degree they were pursuing.
- Students were asked about their perception of flood disaster risk, knowledge related to flood disasters, and preparedness for flood disasters in Assam.
- Yes/No format questions based on three core themes:

  Perception (5 indicators),
  Knowledge (4 indicators),
  Preparedness (5 indicators).

Before distribution, the questionnaire was reviewed by two subject experts in disaster management to ensure content validity. A pilot test was also conducted with 10 students to assess clarity and

reliability. Minor revisions were made based on feedback, including simplifying technical terms and enhancing the question flow in the questionnaire.

Participants were informed of the voluntary and anonymous nature of the survey, and their consent was obtained before participation. Ethical research practices, including confidentiality and informed consent, were strictly adhered to throughout.

The collected data were systematically entered into spreadsheets and analysed using descriptive statistical methods. This analysis aimed to explore the relationship between students' perception, knowledge, and preparedness concerning flood disaster risks. Special emphasis was placed on understanding how students articulate their awareness of existing disaster management systems. To gain insights into both local and broader awareness levels, several questions were formulated to assess knowledge at the district and state levels. We, therefore, anticipate variations in perception, knowledge, and preparedness at both the master's and PhD levels. This study employs the Pearson Chi-Square test to determine if there is a statistically significant difference in responses between the two educational levels. Pearson's Chi-square test compares the proportion of responses among these two categories with the overall sample proportion. To compute the test statistics for the Pearson test, the following formula is used:

$$X^2 = \sum \frac{(O_i - E)^2}{E}$$

Where is the observed proportion for student i, and E is the expected (overall) proportion. The null hypothesis of Pearson's Chi-Square test of independence is "there is no difference in proportion among groups". If the p-value of the test is less than 5% but greater than 1%, then the null hypothesis is rejected at the 5% significance level. If the p-value is less than 1%, then the null hypothesis is rejected at a 1% level of significance.

3. Results

3.1. Students' Flood Disaster Risk Perception

The survey results in Figure 2 show that 30% of the total sample of student respondents believe that their "home is situated in a flood-prone area of Assam." However, the differences in responses among regions were not statistically significant (P-value = 0.122). When asked about the fatalities, 56% of the total sample respondents think that people will lose their lives in a major flood in their area; this perception was slightly higher among PhD students (60%) compared to master's students (52%). However, no statistically significant difference was found (P-value 0.568).

On average, 80% of the issue of infrastructure and services of the total sampled respondents believed that essential services (e.g. water, electricity, health care, transportation) could be interrupted during a major flood in their area(that belief is more common in PhD(84%) and masters(76%) student. The difference is statistically significant (P-value 0.022). To understand the views of students concerning early warning systems, 62% of the total sampled students felt that flood warnings do not reach students and communities in time to allow them to take safety measures. The difference is found to be statistically insignificant (P-value = 0.145). As shown in Fig. 2, 96% of the total students agreed that "communities living in river basins of Assam are at risk of flood-related disasters" (P-value 1).

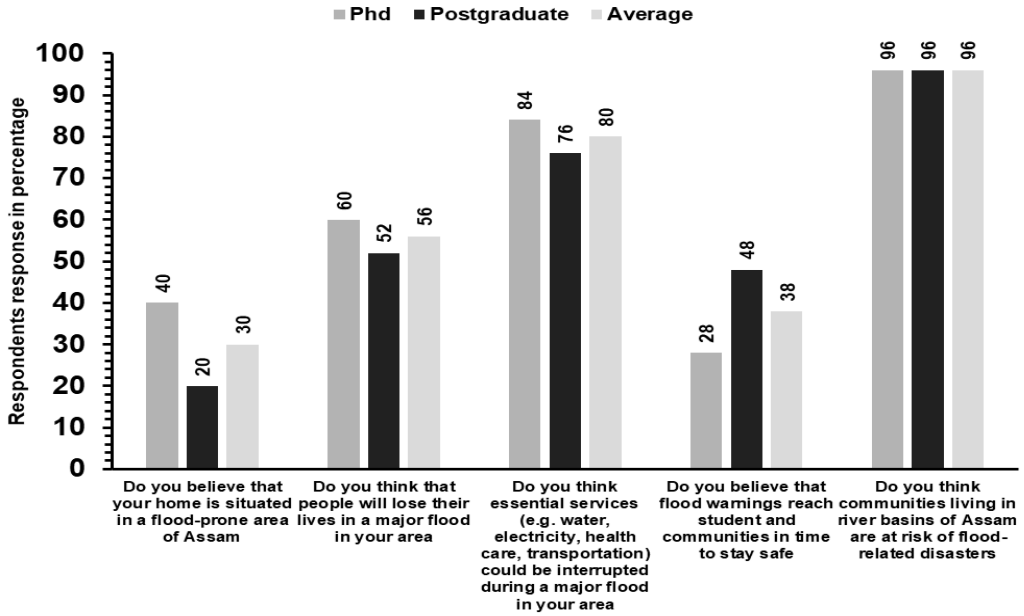

Figure 2. Question on: Students' flood disaster risk perception

3.2 Student flood disaster risk-related knowledge

When students were asked about flood disaster risk-related knowledge, the findings show that, on average, 28% of respondents from PhD programs had experienced flood disasters between 2010 and 2024, with higher rates among PhD students (36%) compared to master's students (20%). However, the differences in flood experience between the two academic groups were not statistically significant (P-value 0.207). 72% of the total respondents students are unaware of the "flood management system of their district," and on average, 28% only know about the system in their district. However, this difference was also not statistically significant (P-value 0.207).

Additionally, 56% of the sampled students were unaware of Assam's flood management policies. This difference was statistically insignificant (P-value 0.568). Nevertheless, 62% of the respondents are aware of the ASDMA (Assam State Disaster Management Authority) and its role in flood response, although the difference is statistically significant (P-value = 0.008). However, compared to this, fewer students are aware of the disaster management system and policies of their district and the state of Assam, respectively.

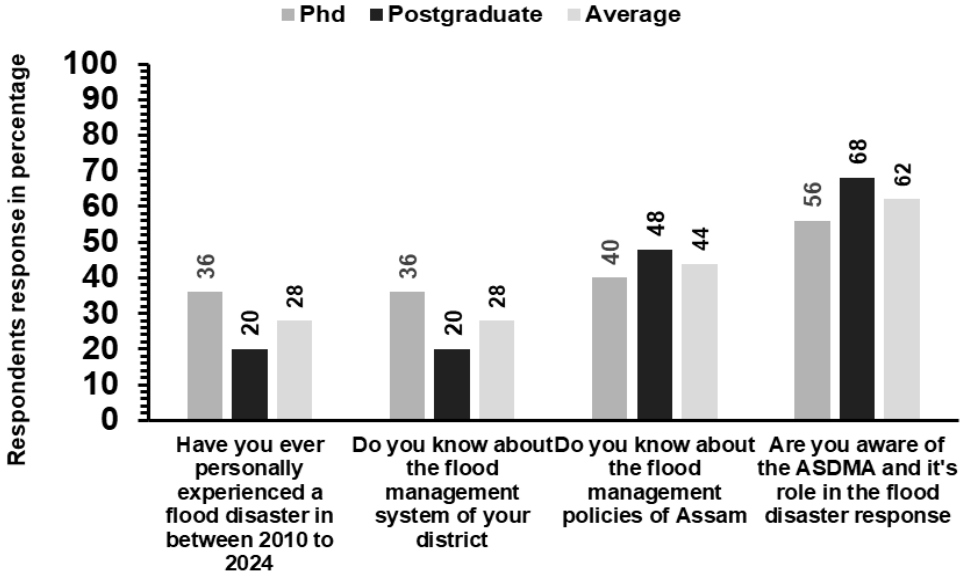

Figure 3. Questions on: Student flood disaster risk-related knowledge

3.3 Student Flood Disaster Risk Preparedness

The results of the current study, as illustrated in Fig.4, reveal a critical gap in flood disaster preparedness among students. A majority of 78% of respondents reported that their families did not have emergency plans within their household. At the same time, only 22% of respondents, on average, confirmed having an emergency family plan at home. Notably, of those emergency plans, only 4% had practised such an evacuation drill with their families. Despite 86% of respondents indicating that they usually monitor weather alerts during the rainy season, a significant gap in community awareness is evident. 82% are not familiar with their community flood warning signals compared to only 18% who are. However, while 42% of respondents know how to contact local emergency services during floods, a larger proportion, 56%, remained unaware of these protocols.

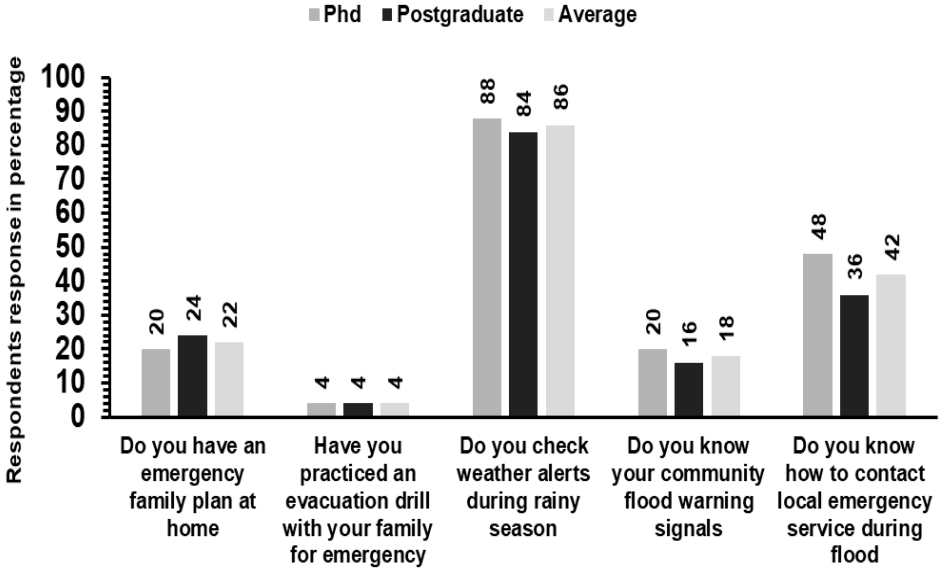

Figure 4. Questions on: Student flood disaster risk preparedness

3.4 Relationship between knowledge and perception

Our analysis revealed a statistically significant association between knowledge and perception among students regarding flood warning systems. Specifically, students who demonstrated awareness of the Assam State Disaster Management Authority (ASDMA) and its role in disaster response exhibited stronger perceptions of the efficacy and timeliness of flood warnings for safeguarding students and communities.

Table 1. Showing the relationship between knowledge and perception

Aware of the ASDMA and its role in the flood disaster response	Believed that flood warnings reach students and communities in time to stay safe
Yes	52%
No	48%
Pearson Chi-Square	6.41
P-value	0.0113

According to the Pearson chi-square test of independence, respondents aware of the Assam State Disaster Management Authority (ASDMA) were four percentage points more likely to perceive flood warnings as reaching them promptly compared to their unaware counterparts. This finding emphasises the critical role of institutional knowledge in shaping community confidence in disaster preparedness systems.

4. Discussion

The findings of this study reveal a noticeable gap between awareness of flood risks and actual preparedness actions among university students in Assam. While a vast majority of respondents acknowledged the flood vulnerability of riverine communities, only a small portion reported taking practical steps such as having emergency plans or participating in evacuation drills. This mismatch echoes earlier findings that theoretical knowledge does not necessarily lead to active preparedness unless supported by practical tools and participatory experiences (Rico, 2019). In the context of disaster risk reduction (DRR), this signals the need to move beyond information-sharing to hands-on, real-world engagement.

One key insight is the role of education in shaping preparedness. Students pursuing PhDs showed a marginally higher risk awareness and trust in institutions like ASDMA, suggesting that higher education may foster greater trust in formal systems. However, this did not significantly increase practical readiness. This aligns with prior research indicating that although formal education improves understanding of disasters, it may also reduce perceived personal risk, as individuals feel more in control due to their knowledge (Perić & Cvetković, 2019). This may help explain why students, despite being aware of the risks, often remain underprepared.

Education also plays a crucial role in how disaster risk is perceived and addressed. Studies have shown that individuals with higher education tend to believe they can manage risk better and, therefore, perceive it as less threatening (Perić & Cvetković, 2019). In our findings, although most students agreed on the importance of preventive measures, relatively few had concrete household plans or engaged in community-level preparedness. This suggests that while education enhances knowledge, it does not always inspire proactive behaviour unless it includes experiential learning or direct involvement in disaster-related activities (Cvetković et al., 2015; Rico, 2019).

Another important issue highlighted in the literature is the influence of early education and family environment. As Cvetković et al. (2015) noted, children and youth often first learn about disaster risks from their families and schools; however, non-formal education also plays a significant role. This indicates that universities should collaborate more closely with local communities to promote disaster awareness beyond the classroom. Preparedness efforts should extend beyond individual settings and into the wider public, fostering a culture of resilience.

Gender, income, and institutional trust were also influential. Similar to other studies, we found that although many students depend on institutional support, few take personal initiative (Cvetković & Janković, 2020). This is especially concerning given that institutional readiness alone cannot ensure community resilience. The safety of students should not rest solely on the assumption that institutions will respond in time. Instead, there is a need to cultivate individual responsibility and community-based action (Dela Cruz & Galanto Ormilla, 2022).

Furthermore, global frameworks, such as the Hyogo Framework for Action, emphasise the importance of education in building a "culture of prevention" (Oktari et al., 2015; Rico, 2019). Universities can be powerful platforms for building such a culture by integrating disaster education into their curricula and offering regular drills, simulations, and student-led preparedness initiatives. These initiatives should also address the needs of diverse student groups based on their backgrounds, income levels, and levels of engagement with formal education systems.

Lastly, the study highlights the limited engagement of students in actual disaster risk reduction (DRR) activities. This highlights a broader challenge in institutional disaster preparedness, where the focus remains on planning rather than on activating and empowering young people. As Cvetković et al. (2018) emphasised, differences in preparedness across groups reflect how social and demographic factors shape disaster risk reduction (DRR) outcomes. For students to become active participants rather than passive observers, universities and institutions like ASDMA must involve them in participatory training and real-world preparedness activities.

These findings underline the need to bridge the gap between awareness and action. Education must be more than just theoretical; it must also be practical, inclusive, and community-oriented. Future efforts should focus on strengthening this link through university-community partnerships,

tailored educational tools, and accessible training programs that prepare young people not only to understand flood risks but also to take action on them.

5. Conclusions

Recognising that various factors influence flood preparedness among university students, it is essential to take targeted actions to bridge the gap between awareness and action. Based on the findings of this study, it is evident that while most students acknowledge the risks of floods in Assam, very few take proactive steps to prepare for them. This disconnect should guide future interventions.

The results suggest that disaster education must move beyond textbooks and awareness posters. Students need regular practice through drills, real-life scenarios, and interactive learning tools. Mock drills, the use of flood safety comics in local languages, and simple games about preparedness can also be helpful. These tools should not only remain in schools or colleges but also reach families and local communities.

Education about disaster risks should be supported with training for teachers and ASDMA staff. When students learn from people who know how floods are managed and how warnings work, they are more likely to trust and follow instructions. More collaboration is needed among institutions such as ASDMA, universities, and village-level organisations. Local flood safety workshops, simple mobile alerts, and community drills can make a big difference in how people act during actual floods.

The results also show that knowledge of institutions like ASDMA increases trust in warnings. Therefore, disaster risk education should include clear information about how disaster management works in Assam. Universities and schools can help bridge this gap by inviting officials to speak or demonstrate safety actions.

Ultimately, further research is necessary to investigate the long-term impact of these efforts on students. It is also necessary to include students from non-academic backgrounds in future studies. As society changes and climate risks intensify, disaster education programs must also evolve to remain practical and relevant.

Author Contributions: Questionnaire, Data, and equation, and their analysis were performed, and Pritisha Barik wrote the manuscript. Pritisha Barik also conducts the survey. The study was guided and reviewed, and Anjan Bhuyan and Sanayanbi Hodam approved the manuscript. Both authors approved the final version of the manuscript**.**

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Conflicts of Interest: The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Appendix A

Table 2. Respondents' details

S.No	Degree level	Total sample
1	Postgraduate	25
2	PhD	25
3	Total	50

Table 3. University students' perception, knowledge, and preparedness-related questions integrated into a single survey

Main components	Sub indicators
Perception	Do you believe that your home is situated in a flood-prone area of Assam?
	Do you think that people will lose their lives in a major flood in your area?
	Do you think essential services (e.g., water, electricity, health care, transportation) could be interrupted during a major flood in your area?
	Do you believe that flood warnings reach students and communities in time to stay safe?
	Do you think communities living in the river basins of Assam are at risk of flood-related disasters?
Knowledge	Have you ever personally experienced a flood disaster between 2010 to 2024?
	Do you know about the flood management system of your district?
	Do you know about the flood management policies of Assam?
	Are you aware of the ASDMA and its role in responding to flood disasters?
Preparedness	Do you have an emergency family plan at home?
	Have you practised an evacuation drill with your family in case of an emergency?
	Do you check weather alerts during the rainy season?
	Do you know your community's flood warning signals?
	Do you know how to contact the local emergency services during a flood?

Source: Questionnaire

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Review Article

A Cross-National Study of Disaster Risk Management: Strengths and Weaknesses in Bulgaria, Romania, and Albania with Reflections on Serbia

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ABSTRACT

This study examines disaster risk management systems in Bulgaria, Romania, and Albania, highlighting their distinct strengths and weaknesses while drawing comparisons to Serbia's framework. The research underscores the growing urgency of disaster risk management in addressing challenges posed by natural and man-made (technological) hazards, which are further aggravated by climate change, globalisation, and socio-economic shifts. The study identifies best practices alongside systemic weaknesses by assessing the normative, institutional, and strategic frameworks of these countries. Key strengths include comprehensive legal systems, robust international partnerships, and sophisticated early warning mechanisms. However, these strengths are counterbalanced by limited local capacity, fragmented institutional coordination, and inadequate public awareness. The analysis highlights the potential for regional cooperation through a comparative lens, emphasising the importance of engaging local communities, enhancing early warning technologies, and aligning with global disaster management standards. The findings offer valuable insights into ongoing discussions about constructing resilient societies, providing practical recommendations to enhance disaster risk management systems across Southeastern Europe.

KEYWORDS

Disaster risk management, strengths, weaknesses, resilience, regional collaboration, institutional capacities, Bulgaria, Romania, Albania, Serbia.

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Beli, A., Renner, R., Cvetković, V. M., Ivanov, A., & Gačić, J. (2025). A Cross-National Study of Disaster Risk Management: Strengths and Weaknesses in Bulgaria, Romania, and Albania with Reflections on Serbia. *International Journal of Disaster Risk Management*, *7*(1), 431–460.

1. Introduction

Modern society is exposed to a vast number of different hazards. In addition to traditional natural and technical-technological hazards, new types of threats are emerging. Traditional hazards are becoming more frequent and intense (Cvetković, Renner, Lukić, & Aleksova, 2024). These changes, resulting from the development of modern society, are driven by climate change, globalisation, and technological advancement (Todić, 2013). Throughout history, people have perceived and responded to disasters in various ways, gradually developing different strategies for disaster response (Cvetković & Milašinović, 2017). With the advancement of modern society, technology, and science, there is an improvement in scientific knowledge related to disaster risk management systems (Cvetković, 2024b). Special attention is given to disaster risk management due to increasingly frequent disasters, which consistently hinder the functioning of the social system.

Disaster risk management has become a key area of interest for the scientific community, political leaders, and practitioners worldwide (Cvetković, 2024a). Today, significant scientific findings enable the management and mitigation of disaster risks (Albris, Lauta, & Raju, 2020; Twigg, 2004). With societal development and the support of a multidisciplinary approach, this field will continue to advance and broaden its knowledge. Disaster risk management today is unimaginable without the use of online services. These services enable decision-makers to quickly consider all options to make the best decision (Cvetković, 2018). The facts underscore the importance and necessity of a disaster risk management system, as well as its ongoing improvement and development. The significance of the disaster risk management system in every country is primarily reflected in disaster prevention and the reduction of potential losses and consequences. Furthermore, it is also significant in response, rescue, recovery, community rehabilitation, and mitigating the consequences of disasters.

This paper aims to examine and compare the disaster risk management systems of Bulgaria, Romania, and Albania, highlighting their strengths, shortcomings, and opportunities for development. By analysing the normative, institutional, and strategic frameworks in these countries, the study identifies best practices and proposes practical recommendations to enhance disaster resilience. Additionally, it incorporates insights into Serbia's disaster management approach, providing a more comprehensive regional perspective. This research contributes to a deeper understanding of how diverse strategies in disaster management can strengthen resilience, reduce vulnerabilities, and improve national and regional coordination.

2. Defining Disaster Risk Management Systems

The disaster risk management system is defined as a process aimed at minimising losses caused by natural and technological disasters through risk assessment, risk reduction, preparedness, response, and recovery (Cvetković & Andrić, 2023; Cvetković & Ivković, 2022; Cvetković, 2023; Cvetković, Radovanović, & Milašinović, 2021; Cvetković et al., 2021; Lavell & Maskrey, 2014). The UN Office for Disaster Risk Reduction (UNDRR) provides one commonly cited definition: disaster risk management is "the application of disaster risk reduction policies and strategies to prevent new disaster risks, reduce existing disaster risks, and manage residual risks, thereby strengthening resilience and reducing disaster losses" (UNDRR, 2020).

Disaster management includes interventions, restoration, reconstruction, damage reduction, and preparedness. This process responds to disasters and contributes to sustainable societal development. Effective management is crucial for mitigating and minimising the adverse effects of disasters. Disaster management must be integrated into all phases of development, including preparedness and reconstruction, and it requires the involvement of all societal segments (Cvetković et al., 2022).

The concept of risk is crucial for understanding disasters. It arises from three factors: hazard, exposure, and vulnerability. When a hazard, such as a cyclone, becomes a real threat, the risk transforms into a disaster that endangers lives and property. For risk to exist, all three elements—hazard, exposure, and vulnerability—must be present (Cvetković, 2017). This concept facilitates a deeper

understanding and analysis of risk, enabling us to prepare more effectively and respond to potential hazards and disasters.

Disaster risk awareness involves understanding the risks within a population, the causes of disasters, and strategies for reducing vulnerability. This includes disseminating knowledge about risk reduction and enhancing the ability to convey this information effectively. Changes in behaviour and decision-making can significantly reduce disaster risk. Studies on risk perception highlight how mental and emotional mechanisms influence how individuals or groups experience and react to risks. The actions people take before, during, and after a disaster are crucial for effective crisis management and can help reduce negative consequences (Cvetković et al., 2018).

In recent years, disaster risk management has shifted from conventional engineering approaches to more comprehensive risk mitigation strategies. This shift reflects an understanding of the complexity of risk management and the potential benefits of a holistic framework. The new approach considers compromises among various factors, such as risk reduction, capacity building, and resource allocation. Unlike traditional, single-dimensional decision-making, it encompasses both structural and non-structural measures, as well as political instruments, to enhance efficiency and resilience. The new approach also emphasises the importance of interdisciplinary cooperation and interconnections among different sectors in addressing disaster challenges (Sayers et al., 2013).

Reducing disaster risk depends on effective risk management, which includes preparedness, response, and societal recovery after a disaster. This process depends on how risk is perceived in urban settings. Risk is assessed based on the probability, frequency, and intensity of the hazard. Risk assessment is crucial for informed decision-making and planning measures to reduce risk, as well as for identifying priority areas with varying levels of risk within the framework of risk management (Izumi et al., 2019).

2. Key Elements of Disaster Risk Management Systems

Disaster risk management is a comprehensive process involving decision-making, organisation, and the application of strategies to reduce the impact of disasters (Cvetković, 2024). This systematic approach entails using all available resources and capacities of society to confront disasters. It includes structural and non-structural measures to prevent, mitigate impacts, and prepare for hazards. The key elements of disaster risk management systems include the development of political, legal, and institutional frameworks, an integrated approach that encompasses various sectors such as the economy, education, and healthcare, and the promotion of human and institutional capacity-building (Cvetković & Todorović, 2021).

Additionally, insurance programs aligned with risk mitigation strategies, support for building resilient communities, dynamic risk assessment, and self-reliance and responsibility of local communities in disaster response are important. Ultimately, international cooperation and knowledge exchange play a crucial role in effective risk management. Various actors, including individuals, social groups, and communities, play a key role in utilising available resources both individually and collectively. These actors manage to confront long-term or sudden challenges that threaten their lives, turning these situations into opportunities for improvement and development (Pavićević, Bulatović, and Ilijić, 2019).

Work on establishing a political, legal, and institutional system for disaster risk reduction contributes to a greater capacity of states to confront various risks (Cvetkovic & Martinović, 2020; Cvetković & Janković, 2020; Cvetković & Milašinović, 2017). In this regard, adopting the Yokohama Strategy emphasises the obligation of states to protect their citizens from natural disasters, focusing on strengthening state capacities and improving legislation to combat the harmful effects of natural and other hazards effectively. Furthermore, this strategy encourages regional and international cooperation to prevent, reduce, and mitigate disasters, emphasising the enhancement of human and institutional capacities, technology exchange, information gathering and distribution, as well as resource mobilisation (Cvetković, Filipović and Gačić, 2019).

Risk management involves a series of activities to implement disaster risk reduction policies using administrative, operational, and organisational skills and capacities. This approach is designed to prevent the emergence of new and reduce existing risks through integrated and inclusive activities across economic, social, educational, regulatory, health, cultural, technological, and political domains. In recent decades, a paradigm shift has occurred, shifting the focus from hazards as the primary cause to the vulnerability of communities, with a special emphasis on applying early warnings and increasing preparedness to reduce this vulnerability (Cvetković, 2020).

Cvetković (2020) emphasises that effective risk management is fundamental for successfully implementing disaster risk mitigation strategies. Within the framework of global efforts to reduce disaster risks, management is defined as a process that encourages interaction between the scientific community and practitioners, with a special focus on creating partnerships among various stakeholders, including those addressing the socio-economic aspects of this issue. This approach facilitates the exchange of expertise, experience, and resources, which contributes to a more effective response to challenges related to disaster risk management, thereby improving overall understanding and approach to this complex topic (Cvetković, 2020).

Safety in using available resources requires careful testing and evaluation to accurately assess risks. Risk management is an ongoing process that involves analysing various types of risks (Đinović, 2011, p. 117). This monograph presents a comprehensive model for risk management that encompasses the steps of identification, analysis, and risk evaluation, supplemented by empirical research. A methodology for quantitative risk classification has been developed, allowing clear differentiation between low risks, which do not require detailed assessment, and high risks, which are challenging to reduce. The proposed model was tested in a case study at the Correctional Facility, where risks were identified and analysed based on data such as job difficulty, emotional and mental stress, microclimatic conditions, and lighting levels. Additionally, risk levels for potential adverse events were assessed, and a detailed analysis was performed in the dissertation. The essential elements of vulnerability assessment and the starting basis for development include a comprehensive analysis (Keković, 2006, p. 207).

The development and application of dynamic tools for risk assessment represent a complex task requiring a comprehensive view of various factors of current vulnerability, as well as the prediction of future risks and potential losses (Adedigba, Khan, & Yang, 2018; Gerds, Cai, & Schumacher, 2008; Jamshidi, Ait-Kadi, Ruiz, & Rebaiaia, 2018; Paltrinieri, Khan, & Cozzani, 2015; Thornton, 2002; Yu, 2017). In this context, using all available data is key in creating plans, programs, and policies, especially regarding land use and human behaviour in different settlements. Additionally, community autonomy is crucial but also requires continuous capacity building. Changing policies that support the unsustainable development of local communities before and after a disaster is one of the critical steps in this process (French & Kousky, 2023; Imperiale & Vanclay, 2016; Kapucu & Sadiq, 2016). Furthermore, local communities are responsible for adopting and implementing policies to enhance their capacity to respond effectively to disasters (Cvetković, 2020).

3. The Importance of Disaster Risk Management System Analysis

The analysis of disaster risk management systems is essential for identifying and improving existing capacities and weaknesses in disaster response (Cvetković, 2024; Cvetković & Šišović, 2024a, 2024b; Grozdanić & Cvetković, 2024). The increased risk of disasters and the growing vulnerability of people and property highlight the need to enhance societal resilience. Critical examination and improvement of the existing risk management system are crucial. This involves a detailed analysis of current capacities and exploring possibilities for system improvement to ensure more effective disaster prevention and management. Focusing on a proactive approach, emphasising preventive measures and actions before disasters occur, represents an important step in improving the disaster risk management system. Transitioning from a reactive to a proactive model requires developing and applying measures to reduce risks before they arise. Additionally, analyses reveal significant

shortcomings in the existing legislative and regulatory framework, necessitating the implementation of substantial reform measures (Cvetković, 2021).

Some of the main obstacles include the inefficiency and inadequacy of current laws and regulations, indicating the need for scientific research that will generate concrete proposals for improvement. Moreover, the lack of preventive measures and low public awareness of their importance further contribute to problems in risk management. Strengthening preventive activities and educational programs, as well as addressing organisational and systemic issues, are key to improving disaster risk management systems (Cvetković, Öcal & Ivanov, 2019).

The analysis of disaster risk management systems is gaining significance due to the increasing interest in this field within social sciences, which has only recently begun to develop. In the context of the importance of disaster risk management system analysis, Alexander's (1993) analysis reveals important aspects that contribute to understanding this complex area. Alexander identified six main approaches in disaster research: geographical, anthropological, sociological, developmental, medical, and technical. These approaches represent different perspectives through which disasters can be studied and managed. The geographical approach focuses on the interactions between people and their environment, including analysing how physical aspects of the environment, such as flood- or earthquake-prone areas, affect the risks people face (Alexander, 1993). This approach helps understand spatial factors contributing to disasters and assess risks based on geographic conditions. On the other hand, the sociological approach views disasters as social events that reflect ways of life and the structures of social communities. This perspective emphasises how social structures and lifestyle patterns can influence vulnerability and the ability to recover from disasters. For example, if people inhabit coastal areas prone to flooding, their vulnerability to disasters may be greater due to the high risk of adverse effects on life, health, and property (Cvetković, 2017).

These approaches demonstrate how different perspectives can contribute to a comprehensive understanding and analysis of disaster risk management systems, enabling an integrated approach in developing strategies and policies for prevention, mitigation, and risk management.

The analysis of disaster management systems is vital for several reasons related to comprehensively understanding and enhancing capacities for disaster response. First, analysing the system can identify how different segments of the disaster management system coordinate and function together. This includes assessing the effectiveness of prevention, preparedness, response, and recovery mechanisms. Alongside this, the analysis enables the identification of shortcomings in the existing system, such as communication problems between various agencies, lack of resources, or issues in policy implementation. Second, in-depth analysis helps identify areas where the management system can be improved. For example, suppose analysis reveals that certain parts of the system are not functioning as planned or that there are significant gaps in preparedness and response. In that case, a concrete plan can be developed to improve these aspects. This is important to ensure that resources and efforts are directed toward the highest-priority areas. Third, analysis aids in developing better risk-reduction strategies. Understanding how disasters impact different aspects of society and analysing their economic, social, and environmental consequences enables the creation of tailored and practical measures for risk reduction and mitigation. This includes developing and implementing preventive measures to reduce community vulnerability to disasters. Fourth, practical analysis of disaster management systems enables better planning and improvement of response and recovery strategies. Based on analyses of past disasters and assessments of the system, robust plans for quick and coordinated responses in future situations can be built, as well as effective recovery strategies after a disaster (Cvetković, 2021).

Thus, analysing this system enables learning from past experiences and applying best practices in future disaster management. This enhances society's preparedness and resilience, which are crucial for a successful response and recovery in the event of a disaster.

4. The Disaster Risk Management System in Bulgaria

4.1. Basic Characteristics (Geographical, Climatic, Hydrometeorological) of the Bulgarian Region

Bulgaria is located in Southeastern Europe, on the Balkan Peninsula. It encompasses diverse geographical and climatic characteristics, which impact its economy, natural resources, and living conditions for its population. Its geographical position, with a total area of approximately 110,993 km², makes it a country with highly variable terrain dominated by mountain ranges and plains. To the north, it borders Romania, with the Danube River forming a natural boundary, while it borders Serbia to the west. Greece and Turkey are its southern neighbours, and to the east, it is bordered by the Black Sea, which plays a key role in maritime transport and tourism. This geographical position makes Bulgaria a crucial transit point for goods and energy transport in the region (Apostolov & Krastev, 2011).

The terrain of Bulgaria is diverse, with several main mountain ranges and plains defining its landscape. The most important mountain ranges include the Balkan Mountains, also known as Stara Planina, which stretch from west to east and divide the country into northern and southern parts. The country's southwestern part is characterised by the high Rila and Pirin mountains, with Mount Musala (2,925 meters) being the highest peak in Bulgaria and the Balkan Peninsula. These mountains are a vital water source and dominate the region's mountainous climate. The Rhodope Mountains in the south play a key role in shaping the terrain along the Bulgarian-Greek border. On the other hand, lowland regions such as the Danubian Plain in the north and the Thracian Plain in the south are essential agricultural areas of the country (Apostolov, 2013).

The climate in Bulgaria is temperate-continental. The northern and central parts of the country have a typical temperate continental climate, with cold winters and warm summers. Average winter temperatures in these areas range between -2°C and 2°C, while summer temperatures can reach between 25°C and 30°C. In the south, the climate has a continental character with Mediterranean influences, resulting in milder winters and warmer summers. The most extraordinary climate conditions are found in the mountainous areas of Rila, Pirin, and the Balkan Mountains, where winters are long and snowy, and temperatures can drop as low as -5°C. Summer temperatures in the mountains are significantly lower than in the plains, often ranging between 10°C and 15°C, making these regions suitable for developing mountain tourism and winter sports (Apostolov & Krastev, 2011).

Hydrometeorological characteristics in Bulgaria also play an important role in shaping its natural environment. The most significant river is the Danube, which forms the natural boundary with Romania and is one of the largest rivers in Europe. The Danube holds substantial economic importance as it enables navigation and influences the development of agriculture in fertile plains along its banks. Other significant rivers in the country include the Iskar, which flows through the capital city, Sofia, and the Struma and Maritsa rivers, which flow into the Aegean Sea. The Maritsa River is crucial in supplying water to agricultural regions in the southern part of the country (Radeva & Nikolova, 2020).

The Black Sea region on Bulgaria's east coast has specific hydrometeorological characteristics. The Black Sea has a significant influence on the climate of coastal regions, where winters are milder and summers are more humid compared to inland areas. This region is renowned for its well-developed tourism, thanks to its long sandy beaches and mild climate, particularly during the summer months. Humidity in coastal areas is generally higher, which affects vegetation and agriculture (Marinova et al., 2017).

Bulgaria has highly diverse geographical and climatic conditions, which affect its natural resources, economic development, and the standard of living for its population. Its combination of plains, mountains, rivers, and the Black Sea coastline creates a unique natural environment that is conducive to the development of various industries, including agriculture, tourism, and energy. However, this also means the region is highly susceptible to various disasters.

4.2. Normative and Institutional Framework for Disaster Risk Management

The normative and institutional framework for disaster risk management in Bulgaria is based on a series of legal and strategic documents that regulate the prevention, assessment, and management of natural and technological risks. This framework encompasses several key laws and national and regional strategies that integrate preventive measures and activities aimed at mitigating the consequences of disasters.

Disaster risk management in Bulgaria is regulated by the Disaster Protection Act, which is the key normative act defining the responsibilities of various institutions and government bodies. This law governs the planning and implementation of national, regional, and local activities, including the development of strategies and programs for disaster risk reduction. It emphasises the importance of preventive activities, such as risk assessment and mapping of vulnerable areas, with the application of protective measures integrated into spatial plans and infrastructure projects (See more: https://lex.bg/laws/ldoc/2135540282 - accessed 01.09.2024).

In addition to this law, the Spatial Development Act plays a key role in preventing natural disasters. Spatial planning must consider risks from floods, earthquakes, landslides, and other natural phenomena to ensure the safety of construction and infrastructure facilities. This law obligates local governments to integrate protective measures into their development plans (See more: https://lex.bg/laws/ldoc/2135163904 - accessed 01.09.2024).

The Water Act is particularly significant in the context of flood risk management, which represents one of the most considerable natural risks in Bulgaria. This law defines measures for flood protection, including the construction and maintenance of embankments, water resource management, and the application of early warning systems. Additionally, the law regulates cooperation between various ministries and agencies to ensure the coordination of activities at all levels of government (See more: https://lex.bg/laws/ldoc/2134673412 - accessed 01.09.2024).

The Environmental Protection Act regulates measures for protecting natural resources vital for reducing disaster risks, such as soil erosion and forest degradation. The protection of forests, watercourses, and other environmental elements contributes to natural resilience against disasters and reduces their impact on human activities (See more: https://www.moew.government.bg/bg/zakon-za-opazvane-na-okolnata-sreda-6671/ - accessed 01.09.2024).

The Safe Use of Nuclear Energy Act addresses technological risks and mandates strict protection and safety measures for managing nuclear and radioactive materials. Bulgaria, as a country with active nuclear capacities, pays special attention to the prevention and mitigation of nuclear accidents, establishing an institutional framework for oversight and control (See more: https://lex.bg/laws/ldoc/2135455545—accessed 03.09.2024).

Disaster risk assessment is one of the key elements of risk management in Bulgaria (Petrov, 2017; Trifonova, Metodiev, Solakov, & Simeonova, 2023). Based on the Disaster Protection Act, risk assessments include analysing and mapping risk areas for different types of disasters, such as earthquakes, floods, landslides, forest fires, and nuclear accidents. These assessments are mandatory parts of national, regional, and municipal disaster protection plans (See more: https://lex.bg/laws/ldoc/2135540282—accessed 03.09.2024).

The responsible institutions for risk assessments include the Ministry of Regional Development and Public Works for seismic and geological risk, the Nuclear Regulatory Agency for nuclear accident risks, the Ministry of Environment and Water for flood risk, and the Ministry of Agriculture, Food, and Forestry for forest fires. These institutions coordinate their activities in cooperation with local authorities to ensure comprehensive assessment and effective risk management. Disaster risk management in Bulgaria requires the continuous improvement of the institutional and normative framework, as well as the application of modern methods for risk assessment and reduction at all levels of government.

4.3. Strategic and Planning Framework for Disaster Risk Management

The National Strategy for Disaster Risk Reduction for 2018-2030 is a key strategic document that defines long-term goals in managing risks from natural and technological disasters. This strategy incorporates preventive measures, including reducing the vulnerability of critical sectors of society and the economy, such as infrastructure, construction, and spatial development. The strategy aims to establish an integrated risk management system at the national, regional, and local levels, with a particular focus on strengthening the capacities of institutions and local communities to act effectively before, during, and after disasters (See more: https://mvr.bg/docs/librariesprovider43/документи-от-дирекцията/нормативна-уредба/стратегически-документи/rms-strategijanrb.pdf?sfvrsn=119f000b_2 - accessed 04.09.2024).

One of the main strategic objectives is to strengthen institutional capacities, which involves modernising technical systems for early warning and monitoring of natural and technological disasters, as well as training personnel within relevant authorities. This goal involves enhancing the capabilities of local governments and regional institutions for risk management, ensuring that these structures can respond effectively to disasters, and implementing risk reduction measures. A key component of the strategy is raising public awareness of risks and improving the population's knowledge of self-protection measures (See more: https://mvr.bg/docs/librariesprovider43/документи-от-дирекцията/нормативна-уредба/стратегически-документи/rms-strategijanrb.pdf?sfvrsn=119f000b_2 - accessed 04.09.2024).

Another important aspect of the strategy is integrating disaster protection measures into other sectors, such as construction and spatial development. Within this approach, all infrastructure and construction projects must be designed to consider potential risks from natural disasters, such as earthquakes, floods, and landslides. The goal is to ensure that new construction projects, as well as existing structures, are built and maintained to be resilient to possible disasters, thereby reducing the risk of loss of life and material damage (See more: https://mvr.bg/docs/librariesprovider43/документи-от-дирекцията/нормативна-уредба/стратегически-документи/rms-strategijanrb.pdf?sfvrsn=119f000b_2 - accessed 04.09.2024).

The National Disaster Risk Reduction Program, developed over five years, is an operational plan for implementing the strategy. The program includes specific activities and measures applied at the national and regional levels, with a special emphasis on reducing risks from significant natural phenomena, such as floods, earthquakes, and forest fires. The program also includes activities in the field of technological disasters, such as nuclear and radiological incidents, aiming to mitigate possible risks and reduce the consequences of these events (Ministry of Interior, 2021).

At the local level, municipal and regional disaster risk reduction programs are key tools for implementing national guidelines and adapting measures to local conditions and specificities. Local governments are responsible for assessing community risks and developing and implementing measures specific to local needs. Accordingly, these programs include building protective embankments, stabilising landslides, improving water supply infrastructure, and taking forest fire prevention measures (Ministry of Interior, 2021).

Risk assessment is a fundamental element of disaster management. This process involves a detailed analysis of potential risks, mapping vulnerable areas, and assessing the impact of potential disasters on the population and infrastructure. Risk assessment must be based on scientific methods and current data and should be regularly updated to adapt to new circumstances and challenges, such as climate change. Assessment is crucial for planning and implementing preventive measures, as well as developing appropriate response and recovery plans.

The National Strategy for Disaster Risk Reduction and the programs derived from it contribute to reducing Bulgaria's overall vulnerability to disasters. It provides a comprehensive framework for the action of all actors in the disaster management system, from national institutions to local governments, thus enhancing society's resilience to disasters and reducing potential losses.

4.4. International Cooperation and Implementation of Disaster Risk Management Exercises

Regarding disaster management, Bulgaria aims to transition from a reactive system to a comprehensive system that integrates all other phases of disaster management. Expert assessment indicates that Bulgaria has the potential to develop a system that equally emphasises prevention, preparedness, and recovery activities, leveraging its existing resources for emergency response while complementing the already developed Disaster Risk Reduction Strategy (Cvetković & Todorović, 2020).

International cooperation in disaster risk management represents a crucial aspect of global and regional efforts to enhance nations' safety and resilience to natural and technological disasters. Bulgaria plays an active role in this field by participating in various bilateral, multilateral, and regional initiatives. Its collaboration with the European Union, neighbouring countries, and international organisations aims to strengthen disaster prevention, preparedness, and response capacities, as well as develop coordination mechanisms for international assistance.

Bulgaria is a significant member of the European Union Civil Protection Mechanism, which allows member states to collectively address disaster challenges through coordinated responses, resource sharing, and participation in joint exercises and training. This mechanism is crucial for large-scale disasters that exceed national capacities, providing a framework for mobilising assistance from other member states. Bulgaria regularly participates in EU-organized exercises to enhance its disaster response capabilities, including those for floods, earthquakes, and wildfires (Ministry of Interior, 2021).

In addition to EU cooperation, Bulgaria is also engaged in bilateral agreements with neighbouring countries, including Serbia, Turkey, and North Macedonia. These agreements cover mutual assistance in disasters, information exchange on potential risks, and joint prevention activities. For example, within the Disaster Preparedness and Prevention Initiative framework for Southeast Europe (DPPI SEE), Bulgaria actively collaborates with other countries in the region to develop disaster risk reduction capacities through training, seminars, and joint exercises (EU, 2022).

One notable example of bilateral cooperation is the EMERSIS I and EMERSIS II projects, which aim to enhance international coordination in disaster risk management and build response capacities in cross-border situations. These projects are implemented in partnership with neighbouring countries, including Serbia and Romania, and include joint exercises, improving communication systems, and developing joint response plans (EU, 2022).

Bulgaria has also participated in several concrete international missions in response to disasters in neighbouring countries. One example is the involvement of the Bulgarian civil protection team during the floods in the Republic of Serbia in 2014, where teams deployed high-capacity pumping modules in two shifts, with 28 and 22 crew members, respectively. This mission helped remove significant amounts of water from flooded areas, reducing damage and health risks for the population (EC, 2014). Similar missions were conducted in the Republic of North Macedonia during the 2016 floods and in combating wildfires in 2021, where Bulgarian teams sent firefighting modules and vehicles (EU, 2020).

Furthermore, Bulgaria actively participates in INTERREG-IPA CBC programs funded by the European Union to enhance cross-border cooperation and disaster response readiness. Programs like INTERREG-IPA CBC Bulgaria-Serbia and Bulgaria-Turkey include activities such as building flood prevention infrastructure, improving communication systems for early warning, and organising joint disaster training and simulations (See more at Bulgarian-Serbian Strategy Analysis and Activity Book - accessed 15.09.2024).

Bulgaria enhances its disaster prevention and response capabilities through these activities, while contributing to regional and global security. International cooperation facilitates the exchange of experiences, joint training, and coordination in crises, significantly enhancing nations' ability to address the challenges of natural and technological disasters.

4.5. Analysis of the Disaster Risk Management System in Bulgaria

The territory of the Republic of Bulgaria is exposed to numerous disasters (Nikolova, 2023; Simova et al., 2018; Trifonova et al., 2023; Velichkova, Simova, Angelova, & Uzunova, 2021; Василева et al., 2019). Bulgaria faces risks from river floods, urban flooding, and wildfires. There is a moderate risk of earthquakes, water shortages, and extreme heat, as well as a low risk of landslides, coastal floods, and storms. Floods are the natural hazards with the highest frequency. Flood risks are more significant near river systems, while the risk of drought and wildfires is higher in inland areas. High levels of inequality and access issues to healthcare systems, cooling systems, and other essential services can affect people's ability to withstand hazards. Although recent years have seen progress in international cooperation with organisations like the European Union and NATO, several key strengths and weaknesses can be identified within Bulgaria's disaster risk management system (Cvetković & Todorović, 2020).

4.5.1. Analysis of the Strengths of the Disaster Risk Management System in Bulgaria

One of Bulgaria's strengths in disaster management is its established system that encompasses all key phases: preparation, response, and post-disaster recovery. This comprehensive approach enables effective risk reduction from disaster impacts and ensures quick and coordinated responses during emergencies. Additionally, active government collaboration with the scientific community in earthquake risk assessment is beneficial, as it enables the precise identification of potential hazard zones and the timely implementation of protective measures. This approach helps Bulgaria mitigate risks to people and infrastructure, strengthening its resilience to natural disasters.

Successful international cooperation, primarily through participation in the European Union Civil Protection Mechanism and projects such as SHARE, DACEA, and ESNET, enables Bulgaria to access cutting-edge technologies and practices in earthquake risk management, thereby improving public awareness and response capacity during disasters. These projects contribute to enhanced protection and development of early warning systems, making Bulgaria a notable example in the region (Trifonova et al., 2023).

The National Platform for Disaster Risk Reduction (DRR) in Bulgaria provides a robust institutional framework for integrating disaster risk reduction (DRR) into national and local policies. In the Bulgarian context, the DRR Council under the Council of Ministers serves as the national platform, led by the Minister of Internal Affairs. According to available information, Bulgaria's national platform operates at a high level, incorporating civil society and the academic community, and supports a multisectoral approach to disaster risk management. This model facilitates active collaboration between state institutions and other societal actors, ensuring that DRR strategies are successfully implemented across all societal levels. Including the academic community also allows access to the latest research and knowledge in this field, further strengthening capacities for risk assessment and management of natural and technological disasters (See more: https://iacp-sofia.mvr.bg/docs/librariesprovider43/намаляване-на-риска-от-бедствия/ocenka_nac-strategia_nrb-06042022.pdf?sfvrsn=e6345d6d_4 - accessed 17.09.2024).

Another important strength of Bulgaria's disaster management system is the development and operational capacity of the emergency response system for nuclear incidents, which was developed by the National Institute of Meteorology and Hydrology under the Bulgarian Academy of Sciences. This system allows quick and effective responses to potential nuclear threats, which are crucial for protecting public health and safety. This approach ensures the possibility of timely interventions and minimising harmful effects on the population and environment in the event of nuclear incidents (Syrakov, Prodanova & Slavov, 2004).

Large-scale floods in Bulgaria, primarily of the rain-river type, occur due to favourable conditions for accumulating large water masses in river valleys. The organisation and conduct of rescue actions include providing first aid to all affected people in flooded areas, evacuating survivors to other settlements, and implementing hygienic-epidemiological measures. The coordination of medical assistance actions, as well as the management and logistics of healthcare institutions, is the responsibility of the director of the Regional Health Inspectorate (RZI) of the respective area. Knowledge, regular

updates, and the development of modern approaches to flood prevention and protection are of utmost importance in flood conditions.

4.5.2. Analysis of the Weaknesses of the Disaster Risk Management System in Bulgaria

Despite its strengths, Bulgaria's disaster risk management system has several significant weaknesses. One of the main drawbacks is the lack of coordination among the various institutions involved in disaster protection. Local authorities often lack sufficient resources and capacities to adequately implement risk reduction measures, leading to ineffective responses to emergencies at the local level (See more: https://mvr.bg/docs/librariesprovider43/документи-от-дирекцията/нормативна-уредба/стратегически-документи/rms-strategijanrb.pdf?sfvrsn=119f000b_2 - accessed 18.09.2024).

Although Bulgaria has access to European funds, there are challenges in effectively absorbing these funds. Weak administrative capacity at both national and local levels hinders the use of available resources for disaster prevention and recovery. This issue is further complicated by the lack of a comprehensive spatial risk database, which impedes the planning of preventive measures and identification of the most vulnerable areas (See more: https://mvr.bg/docs/librariesprovider43/документи-от-дирекцията/нормативна-уредба/стратегически-документи/rms-strategijanrb.pdf?sfvrsn=119f000b_2 - accessed 18.09.2024).

A significant problem is the lack of public awareness regarding natural disaster risks. Many citizens are not adequately informed on how to respond to emergencies, which reduces the effectiveness of early warning systems and risk awareness efforts.

The disaster risk management system in Bulgaria's rural areas faces numerous challenges that threaten these regions' socio-economic and demographic development. One key aspect is the negative impact of natural disasters, such as floods, fires, and earthquakes, which disrupt the population's basic living and working conditions. These events not only cause material damage but also impact the demographic structure of rural areas, where there is a continuous decline in population due to high mortality and low birth rates, further contributing to an ageing population process (Tsonkov et al., 2023).

As of 2024, demographic trends in Bulgaria indicate an increase in the mortality rate to 14.9‰ and a decrease in the birth rate to 8.6%, creating additional challenges for the sustainability of rural communities. The ageing population, predominant in these areas, requires special attention regarding healthcare and risk management, as their need for medical services is higher due to the prevalence of chronic diseases (Kapucu, Hawkins & Rivera, 2013).

Forest fires, whose frequency and intensity have increased significantly, pose a particular problem. In recent decades, the number of fires has increased sixfold, while the burned area has expanded by thirty-five times compared to previous decades. This trend indicates a serious ecological crisis that worsens the economic and social conditions in rural areas of Bulgaria (Tsonkov et al., 2023).

Managing these risks requires an integrated approach, including monitoring and taking preventive measures such as cleaning riverbeds and maintaining forests in sparsely populated areas. Additionally, strengthening infrastructure in rural communities is crucial for improving living conditions and mitigating the effects of natural and ecological risks (Tsonkov et al., 2023). However, the current disaster risk management system reveals weaknesses in terms of coordination and implementation of these measures, underscoring the need for stronger institutional mechanisms and better integration into the development planning process for rural areas.

In summary, for Bulgaria to overcome the weaknesses in its disaster risk management system and provide an adequate response, it is necessary to improve coordination among relevant institutions to ensure more effective cooperation in emergency management. Secondly, it is essential to increase resources and provide training for local authorities, enabling adequate implementation of protective measures. Thirdly, strengthening administrative capacities is crucial for effectively absorbing funds from European sources.

Additionally, establishing a comprehensive spatial risk database is a crucial step toward more effective planning of preventive measures. Ultimately, it is crucial to enhance public awareness of

natural disaster risks through educational campaigns, thereby contributing to the effectiveness of early warning systems and informed citizen responses in crises.

5. The Disaster Risk Management System in Romania

5.1. Basic Characteristics (Geographical, Climatic, Hydrometeorological) of the Bulgarian Region

Romania is a country with diverse geographical, climatic, and hydrometeorological characteristics that play a key role in shaping its natural and economic landscape (Morar et al., 2021; Posea & Bucharest, 1975; Zoran, Zoran, Dida, & Dida, 2012). Geographically, Romania is located in Southeastern Europe, occupying the central part of the Balkan Peninsula. It covers an area of approximately 238,397 square kilometres and has varied topography. The central part of the country is dominated by the Carpathian Mountains, which span two-thirds of its territory. Mountainous areas are surrounded by plains and hills, with the largest plain being the Wallachian Plain, located in the southern and eastern parts of Romania. To the east lies the Danube River, which serves as a significant natural border and a vital source of life support before flowing into the Black Sea (Sandu, Mateescu, & Vătămanu, 2010, p. 406).

Romania's climatic characteristics are of a continental type, with significant influences from the Carpathians, the Danube Plain, and the Black Sea. During winter, temperatures can be extremely low, especially in mountainous areas, while summers are warm and relatively dry, particularly in lowland and coastal regions. Average annual temperatures vary depending on the region – in the plains, they are around 10-11°C, while in the mountainous areas, they drop to around 2-6°C. Romania also experiences significant temperature fluctuations between summer and winter (Cheval et al., 2022).

Hydrometeorological conditions in Romania are characterised by unevenly distributed annual precipitation across the country. The average annual precipitation is approximately 600-700 mm, but in mountainous areas, it can reach up to 1,400 mm. The Danube River plays a central role in the country's hydrographic system, forming a significant part of the river network. Romania is frequently affected by flooding, particularly in areas surrounding the Danube and in the plains (Cheval et al., 2022). Additionally, snowfall in the Carpathians is important for water accumulation and impacts the country's hydrology (SFÎCĂ, 2013).

5.2. Normative and Institutional Framework for Disaster Risk Management

The normative and institutional framework for disaster risk management in Romania is defined by the Civil Protection Law. Civil protection is a component of the national security system, encompassing a series of activities, measures, and organisational tasks aimed at preventing and mitigating disaster risks, and protecting the population, material goods, and the environment from the negative effects of emergencies and armed conflicts. This system involves planning, organising, and implementing measures by the law to preserve lives and assets, and to ensure the necessary conditions for the survival of the affected population (See more: https://legislatie.just.ro/Public/DetaliiDocument/56923 - accessed 15.10.2024).

Civil protection in Romania is considered a matter of national interest, has a permanent character, and is based on the obligations of central and local public authorities, as well as other legal entities and citizens. The management of civil protection activities is organised at both local and national levels, with key tasks including risk identification in various areas, informing the population about hazards, organising interventions in emergencies, and mitigating the negative effects of disasters and explosive remnants of armed conflicts (See more: https://legislatie.just.ro/Public/DetaliiDocument/56923 - accessed 15.10.2024).

The Emergency Situations Ordinance regulates the establishment of structures for emergency management at both central and territorial levels. These structures are responsible for coordination,

planning, and supporting the decision-making process, and are organised hierarchically according to administrative-territorial divisions and areas of responsibility. Under the leadership of the Prime Minister, the National Committee for Emergency Situations functions, while the General Inspectorate for Emergency Situations, under the Ministry of Internal Affairs, serves as the technical body responsible for planning, monitoring, and managing interventions (See more: https://legislatie.just.ro/Public/DetaliiDocument/178900 - accessed 15.10.2024).

At the territorial level, county and local emergency committees serve as support bodies for decision-making, holding temporary or permanent roles. These committees oversee public emergency services, while central and local authorities play a crucial role in crisis management, encompassing measures for prevention, preparedness, response, and damage restoration.

In Romania, the risk management system encompasses various institutions at central, county, and local levels of public administration, grouped under the collective term National System for Emergency Situations Management (SNMSU). The response capability of all SNMSU components is equally important, given the different types of risks and their impact on life, the environment, and sustainable development (Comitetul Național pentru Situații de Urgență, 2020).

The system is established to ensure effective management of current emergencies that threaten or affect life, as well as in the case of disasters. Distributed responsibility among agencies, a established command and control system, an integrated decision-making process, and unified coordination of response actions characterize the SNMSU. Activation of various levels of authority (national/county/local) is determined based on the severity of the emergency, following the principle of gradual action ("think globally/act locally") and requesting support "from the bottom up," from the level whose response capacity is exceeded to higher levels. In many situations, direct activation and action at the national level are possible to ensure adequate engagement of resources for intervention, including regional or national resources or their deployment in or near the affected area (Comitetul Național pentru Situații de Urgență, 2020).

The components of the National System for Emergency Situations Management are: The committees for Emergency Situations; the Department for Emergency Situations, the General Inspectorate for Emergency Situations, Professional and Volunteer Emergency Services; Operational Centers and Coordination and Management Centers for Interventions; Operational Centers for Emergency Situations; and the Incident Commander (Comitetul Național pentru Situații de Urgență, 2020).

The National Committee for Emergency Situations is an interdepartmental body within the national emergency management system. It is chaired by the Minister of Internal Affairs, with members being ministers and heads of central public institutions.

The organisation of the system aligns with Romania's obligations as a signatory to international treaties and agreements, particularly as a member state of the European Union, given the cross-border nature of modern risks.

5.3. Strategic and Planning Framework for Disaster Risk Management

The National Emergency Prevention Strategy assesses the current state of risk factors in Romania's territory, formulates principles and priority action directions, and outlines the resources necessary for managing emergencies. The primary goal of the strategy is to strengthen the capacities of specialized institutions and local and national public administration bodies to prevent emergencies, manage them, and achieve general objectives focused on saving lives, creating an integrated emergency response system, enhancing the role of local public administration, and ensuring the proper functioning of critical infrastructure (See more: https://legislatie.just.ro/Public/DetaliiDocument/285383 - accessed 16.10.2024).

Alongside general goals, several specific objectives are set, depending on the risks generating emergencies, such as natural, technological, or fire risks. The strategy calls for reinforced measures to enhance the safety of people, communities, and assets by identifying, registering, and assessing

types of risks; informing interested parties; warning the population; limiting, removing, and suppressing risk factors; and mitigating the adverse effects and impacts of exceptional events.

Due to the frequency of floods and their increasing impact on the population, coupled with the adoption of Directive 2007/60/EC on the assessment and management of flood risks, Romania developed the National Flood Risk Management Strategy. This strategy has an implementation period from 2010 to 2035, with a budget of approximately € 17 million. It aims at integrated water management, spatial planning, urban development, biodiversity protection, agricultural and forestry development, protection of transport infrastructure, and safeguarding construction and tourist areas. This strategy outlines the necessary measures to reduce risks associated with hazardous hydrometeorological events, including the development of flood hazard and risk maps, the preparation of basin management plans for flood risk, and the updating of local and county flood defence plans. Flood hazard and risk maps were completed in 2014, and risk management plans were developed for the period 2016-2021 (See more: https://sgg.gov.ro/1/wp-content/uploads/2024/07/ANEXA-17.pdf - accessed 16.10.2024).

The primary objective of flood risk management plans is to mitigate the adverse impacts of floods on citizens' safety, public health, economic activities, the environment, and cultural heritage. These plans encompass structural and non-structural measures across five key areas of action: prevention, protection, preparedness, public awareness, and restoration and reconstruction. Measures are divided into three categories based on their level of application: national, basin level, and areas with potential risk of significant flooding (Comitetul Național pentru Situații de Urgență, 2020).

Structural measures aim to protect, prevent, and mitigate the effects of floods. Their goal is to reduce peak water levels and flood duration, thereby safeguarding material assets and the population from major floods. Implementing these measures requires a considerable amount of time and involves extensive analysis from technical, economic, environmental, and social perspectives.

The importance of non-structural measures and green infrastructure is increasingly emphasized at the European level due to its benefits. Natural flood management measures, such as increasing storage capacity for floodwater, provide ecological services simultaneously. These measures, known as natural water retention measures, support green infrastructure.

According to professional literature, non-structural measures are categorised into two types: measures to reduce flood probability (reducing hazard) and measures to enhance flood resilience. Hazard reduction measures include afforestation, slope terraces with orchards or vineyards, perpendicular agricultural work on slopes, anti-torrent and erosion work, and preventing new buildings in flood-prone areas. Resilience-enhancing measures include raising community awareness, flood forecasting, emergency management, and regulatory measures for buildings in flood zones, such as consolidating or elevating houses and waterproofing structures (Comitetul Național pentru Situații de Urgență, 2020).

The National Strategy to Combat Drought was created in response to vulnerabilities revealed by the severe drought in Romania in 2007, which particularly highlighted communities' inability to absorb and recover from its effects. To shift from passive to active risk management, Romania adopted specific measures to mitigate the impact of drought and reduce the vulnerability of affected areas (See more: https://legislatie.just.ro/Public/DetaliiDocument/84536 - accessed 17.10.2024).

To this end, the National Committee for Combating Drought, Land Degradation, and Desertification was established in 2008 and, in 2010, laid the foundation of the National Strategy aimed at preventing and combating drought effects in the short, medium, and long term (See more: https://legislatie.just.ro/Public/DetaliiDocument/84536 - accessed 17.10.2024).

The main objectives of the strategy include: Collecting necessary resources to prevent and mitigate the effects of drought (ensuring continuity of economic and social activities); Improving access to drinking water; Creating a systemic framework for effective drought management in the short and medium term (See more: https://legislatie.just.ro/Public/DetaliiDocument/84536 - accessed 17.10.2024).

In 2020, to enhance drought-related emergency management, a regulation governing the management of emergencies caused by hazardous meteorological phenomena was enacted. This regulation governs the process of identifying, assessing, and managing the risk of soil drought, and establishes procedures for alerting and rapidly intervening in the event of such an occurrence (Comitetul Național pentru Situații de Urgență, 2020).

The National Climate Change Strategy - Climate change has become an actual component of life on our planet, with its negative effects being felt both economically and socially. According to the latest special report by the Intergovernmental Panel on Climate Change (IPCC), published on October 8, 2018, limiting global warming to 1.5°C requires specific actions and measures to prevent and mitigate impacts across all socio-economic sectors. Reducing global warming to 1.5°C compared to 2.0°C would bring significant benefits to people and natural ecosystems, ensuring sustainable and equitable societal development. Anthropogenic CO2 emissions would need to decrease by about 45% by 2030 compared to 2010 levels, aiming to reach net zero around 2050 (See more: https://www.mmediu.ro/categorie/strategia-nationala-privind-adaptarea-la-schimbarile-climatice-pentru-perioada-2022-2030/419 - accessed 17.10.2024).

Faced with the scale of these phenomena and the associated dangers, countries worldwide are engaging in activities and programs aimed at mitigating the global impact of climate change. EU member states undertake climate-related projects and actions in various sectors, including industrial, agricultural, urban, forestry, and transport sectors.

As a member of the European Union, Romania is reasonably involved in this international effort. The Ministry of Environment, Water, and Forests plays an important role in fulfilling these commitments. The National Climate Change Strategy, along with economic growth based on reducing carbon emissions, represents the starting point in this mission, offering Romanian authorities support, vision, and guidelines for future concrete actions (See more: https://www.mmediu.ro/categorie/strategia-nationala-privind-adaptarea-la-schimbarile-climatice-pentru-perioada-2022-2030/419 - accessed 17.10.2024).

This strategy addresses two key aspects of the climate effort: prevention and combating the effects of climate change (through actions aimed at reducing greenhouse gas emissions), as well as adequate adaptation with minimal damage in the context of existing climate changes. The adaptation component includes Romania's efforts to mitigate the risks of forest fires, drought, hail, and floods, as well as activities in disaster risk assessment at the national level and the creation of risk maps. These issues are also addressed in other official documents and regulations.

5.4. International Cooperation and Implementation of Disaster Risk Management Exercises

International cooperation and disaster risk management exercises in Romania are part of broader European and global initiatives aimed at enhancing resilience and reducing disaster risk. Romania is actively involved in various programs through collaboration with the European Commission, particularly within the European Union Civil Protection Mechanism (UCPM). This mechanism allows member states to collaborate on strategy development and share best practices in disaster risk management (Comitetul Național pentru Situații de Urgență, 2020).

Specifically, thematic assessments have been conducted in Romania, involving independent experts who review disaster risk reduction strategies and systems, and provide recommendations for further improvements. The main focus is on risk management and prevention measures, which include engaging civil society and developing community resilience capacities at the local level.

This type of cooperation is significant as it enables countries like Romania to improve their systems and be better prepared for natural and technological disasters, such as earthquakes and floods, which frequently impact the region.

Within NATO, Romania participates in initiatives such as the Euro-Atlantic Disaster Response Coordination Centre (EADRCC), which coordinates international disaster assistance among member countries (See more: https://www.atlanticcouncil.org/blogs/new-atlanticist/six-reasons-natos-eu-

ro-atlantic-disaster-response-coordination-centre-is-important-for-our-future-security/ - accessed 19 October 2024). This engagement enhances Romania's ability to cooperate during crises, including natural disasters such as earthquakes and floods.

At the EU level, Romania participates in various civil protection exercises, including those coordinated under the EU Civil Protection Mechanism, such as the "Modex" exercises (See more: https://agenceurope.eu/en/bulletin/article/12117/12 - accessed 19.10.2024). These simulations improve Romania's readiness and coordination in cross-border emergency responses.

Romania also integrates its national strategies, led by the Department for Emergency Situations (DSU), into global frameworks, collaborating with international bodies such as the United Nations Office for Disaster Risk Reduction (UNISDR) to mitigate and manage risks such as earthquakes, forest fires, and chemical incidents (Comitetul Național pentru Situații de Urgență, 2020).

5.5. Analysis of the Disaster Risk Management System in Bulgaria

The analysis of Romania's disaster risk management system reveals significant strengths within its institutional structures and national-level cooperation but also highlights certain deficiencies that require improvement.

5.5.1. Analysis of the Strengths of the Disaster Risk Management System in Bulgaria

According to available sources, one of the main strengths of Romania's disaster risk management system is its integrated approach, which encompasses cooperation among various institutions at national, regional, and local levels, as well as international collaboration with the European Union and other organisations. Over the past few decades, Romania has developed a robust risk management system, particularly in response to natural disasters, including earthquakes and floods. Additionally, Romania has a solid legal foundation that enables the implementation of various measures for disaster risk reduction, including evacuation plans and rapid response mechanisms. One important aspect of the system is the involvement of the public and local communities in the risk management process, which contributes to the quicker and more effective implementation of preventive measures.

The World Bank and the European Union have repeatedly supported Romania's efforts to improve its disaster risk management system through funding various programs and projects (See more https://www.worldbank.org/en/news/loans-credits/2018/06/26/romania-disaster, accessed October 20, 2024). These projects include emergency response training for personnel, as well as technical assistance in planning and coordinating risk reduction measures.

A key aspect of the system is effective coordination between different levels of government (local, regional, and national) and the integration of early warning and planning systems. Romania has also demonstrated a strong capacity to respond to floods and earthquakes, although there remains a need for greater investment in prevention and the local implementation of risk management strategies. Research indicates that Romania has significantly improved its disaster risk management system in the last decade, partly thanks to international support and cooperation (Diaconu, 2022).

5.5.2. Analysis of the Weaknesses of the Disaster Risk Management System in Bulgaria

Romania's disaster risk management system faces significant weaknesses that impact the effectiveness of prevention, response, and recovery in cases of natural and technological disasters. The strategies and mechanisms established in this field are often insufficiently integrated, which reduces the system's capacity to respond adequately to crises.

Researchers highlight several challenges in implementing risk reduction measures, including a lack of resources at the local level and limited opportunities to educate the population about risks. Additionally, infrastructure improvements and the application of modern technologies in early warning and prevention systems are necessary (Oniga et al., 2020).

According to a World Bank report, there are several key areas where Romania needs to improve its disaster risk management approaches. The first significant weakness is a lack of adequate funding for preventive measures, resulting in insufficient infrastructure and resources necessary for an effective disaster response. Even when certain measures are taken, a lack of coordination often exists between different institutions, which complicates the implementation of programs at the local level (World Bank, 2021).

Second, analyses have shown that awareness and community involvement in the disaster risk management process are limited. The lack of local population engagement in planning and implementing strategies affects the effectiveness of these strategies. Studies indicate that communities actively involved in decision-making related to risks are more likely to respond appropriately in crises (Norris et al., 2008). There are also technical weaknesses within the system, including inadequate training for personnel managing crises and insufficient testing of disaster response plans. These weaknesses can lead to inappropriate or delayed responses to disasters, increasing the risk of loss of life and property (Zulean & Prelipcean, 2013).

Romania must also reconsider its international partnerships to strengthen its disaster risk management capacities. Exchanging best practices and experiences with other countries can significantly contribute to improving the existing system and reducing the weaknesses currently present.

6. The Disaster Risk Management System in Albania

6.1. Basic Characteristics (Geographical, Climatic, Hydrometeorological) of the Bulgarian Region

Albania is situated in the western Balkans, bordering the Adriatic and Ionian Seas, which confer upon it specific geographical and climatic characteristics. Much of the territory is covered by mountains and hills, while the coastal belt is relatively narrow and flat. Albania is known for its diverse terrain, which includes mountains such as the Prokletije in the north and the Pindus in the southern regions (Federal Research Division, Library of Congress, 1994).

Albania's climate varies depending on terrain and proximity to the sea. Along the coast, a Mediterranean climate prevails, characterised by mild winters and warm summers, while inland, particularly in mountainous areas, a continental climate prevails, with cold winters and cool summers. Due to this climate diversity, Albania is exposed to various natural disasters, such as summer droughts and winter floods, particularly in river valleys like those of the Drin and Vjosa rivers (Mankolli et al., 2008).

Hydrometeorological characteristics are significant for Albania due to frequent floods and seasonal droughts. High levels of rainfall in mountainous areas often result in rapid and substantial water inflows into rivers, leading to flooding in lower regions (Cekrezi, 2024). Climate change further exacerbates these phenomena, making hydrometeorological hazards increasingly frequent and severe. Albania is also susceptible to earthquakes due to its location in active seismic zones, making natural disasters a notable risk for the country.

6.2. Normative and Institutional Framework for Disaster Risk Management

The disaster risk management system in Albania is a key component of the national security policy, aimed at mitigating the impact of natural and technological disasters. It is based on a robust regulatory framework and institutional structure that aligns with international standards and European regulations.

The normative, or legal, framework for disaster risk management in Albania is defined by a series of laws, regulations, and decisions that provide the basis for action in this field. Law No. 45/2019 on Civil Protection (Government of the Republic of Albania, 2019) is the primary document regulating all aspects of disaster risk management, from prevention to response and recovery. This law replaces previous regulations and is harmonized with international documents such as the Sendai

Framework for Disaster Risk Reduction 2015-2030 (United Nations Office for Disaster Risk Reduction, 2015), adopted globally under the auspices of the United Nations.

Law 45/2019 establishes mechanisms for enhancing disaster response capacity and strengthening international cooperation. This law provides clear procedures for activating international assistance mechanisms, such as the European Union Civil Protection Mechanism, in line with Council Decision No. 1313/2013/EU (Council of the European Union, 2013), which regulates civil protection within the EU.

The institutional framework for disaster risk management in Albania is based on coordination among multiple national and local institutions. The National Agency for Civil Protection (AKMC), operating under the Ministry of Interior, plays a central role in this system. The AKMC coordinates all disaster risk reduction activities, planning, organizing exercises, and educating the public. AKMC has a central role in implementing national and international standards in this field, as well as in collaborating with international organizations (See more: https://akmc.gov.al/rreth-akmc/ - accessed 23.10.2024).

In addition to AKMC, the disaster management system includes local municipalities that are responsible for implementing preventive and response measures at the local level. They work in close collaboration with state institutions, civil society, and non-governmental organizations that support education and empower communities for disaster response.

6.3. Strategic and Planning Framework for Disaster Risk Management

Albania is vulnerable to various natural disasters, including earthquakes, floods, wildfires, landslides, snowstorms, droughts, extreme temperatures, epidemics, avalanches, technological hazards, and storms. Recent data indicate that Albania's vulnerability to disasters has increased exponentially, with many of these hazards turning into significant emergencies or disasters over the past decade.

Numerous reports and documents highlight the high levels of risk, exposure, and vulnerability Albania faces, alongside a limited capacity for coping and adaptation. In this regard, the lack of a strategic approach to Disaster Risk Reduction (DRR) is evident, with the absence of a National Disaster Risk Reduction Strategy (NDRRS) noted in successive European Commission Progress Reports for Albania, including the latest Progress Report 2021. These reports stress the need for a strategic preparedness document, which is also outlined in the National Strategy for Development and Integration (NSDI) for the 2015-2020 period (See more: https://www.undp.org/sites/g/files/zskgke326/files/202401/permbledhje_en_clear_8.6.2023.pdf - accessed 23.10.2024).

Albania's national disaster risk management framework includes developing and implementing the National Disaster Risk Reduction Strategy, spanning 2023 to 2030. This strategy lays the foundation for a comprehensive approach to risk reduction, covering legal, institutional, and operational aspects. Key institutions, such as the National Civil Protection Agency (NCPA), play a vital role in coordinating efforts among various ministries and local authorities (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 23 October 2024).

As part of the DRR Strategy, an Action Plan for Disaster Risk Reduction for 2023-2027 has been developed, operationalising the strategy's implementation. The Action Plan outlines an indicative financial framework for each activity or project cost, based on market research and proponents' experiences. It addresses six identified risks under the strategy's scope until 2030, with priority actions for each risk to be completed by 2027. In addition to individual risk management activities, the Action Plan includes groups of activities that impact multiple risks simultaneously, such as enhancing disaster risk management governance (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 23 October 2024).

Recently, Albania has focused on developing strategic projects related to disaster risk management to fulfil its obligations as a member of the European Union Civil Protection Mechanism (EU

CPM). This mechanism promotes cooperation and support among member states in responding to disasters, and Albania aims to enhance its capabilities, particularly through the establishment of new response modules, such as a "Drone Response Team."

Additionally, Albania has taken steps to introduce a unified emergency number, 112, nationwide, representing a significant advancement in synchronising emergency responses. This initiative aims to improve the accessibility and efficiency of services in emergencies, which is crucial given the frequent natural disasters in the region (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 23 October 2024).

The development of Albania's civil protection system also includes adopting policies and legislation that support effective risk management. Defining priority standard operating procedures for the civil protection system is crucial for enhancing coordination and the effective implementation of measures during emergencies.

Despite these efforts, a need remains to strengthen data collection and exchange on disaster losses. Through the DesInventar system, Albania can enhance its capacity for risk analysis and develop effective prevention strategies. Furthermore, raising public awareness and education on disaster preparedness must be a priority, thus reinforcing the capacity to respond to critical situations (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 24.10.2024).

Strategic projects also include initiatives like Alb-Adapt, which focuses on climate services and adaptation. This project is crucial for enhancing Albania's resilience to natural disasters and mitigating future risks. Overall, the Albanian disaster risk management system is undergoing significant reforms and improvements aimed at making it more efficient and resilient to the challenges posed by natural disasters (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 24 October 2024).

Preparing risk assessment documents at the district (qark) level is essential in developing Albania's disaster risk management system. These documents serve as a basis for identifying, analysing, and managing disaster-related risks, and include legal aspects of critical infrastructure. Additionally, strengthening readiness and response in emergencies involves training and equipping operational forces (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 24.10.2024).

Reinforcing the resilience of critical infrastructure and public buildings is crucial for mitigating the impacts of disasters. This involves improving data on disaster losses and managing risk information, thus creating a stronger foundation for future planning and interventions.

The rehabilitation of the hydrometeorological network, including 16 stations within the World Bank's "Disaster Risk Mitigation and Adaptation Project," represents a critical step in enhancing forecasting and disaster response capabilities. This effort is further supported by strengthening rescue and protection services and promoting volunteerism (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 24.10.2024).

Organising training and exercises is crucial to enhancing the preparedness capabilities of operational forces. Additionally, technical support for the Ministry of Trade and Economy (MTE) in negotiations related to Chapter 27 is vital for implementing strategic plans (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf—accessed 24.10.2024).

Research, development, and implementation of a National Incident Management System (NIMS) will be crucial in strengthening Albania's disaster and emergency management capacity, contributing to a comprehensive system for protecting against natural and technological risks.

Albania has laid a solid foundation for disaster risk management, yet further research and practice are needed to ensure resilience and the safety of its citizens. This strategy necessitates continuous adaptation and evolution to keep pace with changes in both natural and societal conditions.

6.4. International Cooperation and Implementation of Disaster Risk Management Exercises

International cooperation is a key component of Albania's disaster risk management system. Albania is a signatory to numerous multilateral and bilateral agreements on disaster risk reduction (DRR) and civil protection, strengthening collaboration with neighbouring countries and international organisations.

Albania has made significant progress in international cooperation within the context of Disaster Risk Reduction (DRR), particularly after opening negotiations for European Union membership in 2022. In recent years, international cooperation has gained importance, as demonstrated by the intensification of activities in this area and alignment with global standards, such as the Sendai Framework for Disaster Risk Reduction (See more: https://ec.europa.eu/commission/presscorner/api/files/document/print/en/ip_22_6944/ip_22_6944_en.pdf - accessed 25 October 2024).

Notably, Law No. 45/2019 addresses civil protection and disaster risk reduction. This law introduced a modern approach to international cooperation, encompassing the receipt of international assistance and obligating Albania to provide assistance to other countries. The law is aligned with European regulations, specifically with Council Decision No. 1313/2013/EU, which regulates the EU Civil Protection Mechanism and includes the obligation to provide humanitarian aid and establish capacities for emergency response (See more: https://www.mod.gov.al/images/akteligjore/mbrojtja-civile/Ligji-45-2019-Per%20Mbrojtjen-Civile.pdf - accessed 25.10.2024).

Albania has actively participated in numerous international conventions, agreements, and programs related to disaster risk reduction (DRR) and civil protection. This includes substantial cooperation with the European Union through the Civil Protection Mechanism, as well as through other international initiatives, such as the Euro-Atlantic Disaster Response Coordination Centre (EADRCC) within NATO. This collaboration enables Albania to receive prompt and effective international aid during significant disasters, such as earthquakes, floods, and fires, and to assist other countries, aligning with its strategy to strengthen disaster risk reduction (DRR) capacities (See more: https://www.nato.int/cps/en/natohq/search.htm?query=ALBANIA&submitSearch - accessed 25.10.2024).

In recent years, Albania has repeatedly activated these mechanisms in response to major natural disasters, such as floods and earthquakes, underscoring the importance of international cooperation in this field.

6.5. Analysis of the Disaster Risk Management System in Albania

The analysis of Albania's disaster risk management system highlights significant strengths in implementing strategic planning and collaboration at the national level. However, it also points to certain shortcomings that require improvement. These strengths are reflected in Albania's well-developed institutional and legislative framework, which facilitates coordinated disaster response and preparedness across multiple agencies. Notably, the "Action Plan for Disaster Risk Reduction 2023–2027" exemplifies Albania's commitment to proactive risk management, covering various hazards and aiming to enhance resilience infrastructure, early warning systems, and risk monitoring.

On the other hand, challenges remain, particularly in areas such as financial resources, technical capacity, and inter-agency coordination. Addressing these weaknesses, primarily through better funding, technological upgrades, and streamlined data-sharing practices, would strengthen Albania's overall disaster resilience and response effectiveness.

6.5.1. Analysis of the Strengths of the Disaster Risk Management System in Albania

An in-depth analysis of Albania's disaster risk management system underscores significant strides in several key areas. Notably, Albania has established an institutional and legislative framework that fosters integrated risk management, involving a range of institutions, including the National Agency for Civil Protection, the Ministry of Defence, and other state structures. This frame-

work facilitates the coordination of activities and efficient management of natural and technological disasters, including earthquakes, floods, fires, and technological accidents.

One of the main strengths of the system is the implementation of strategic planning, exemplified by the "Action Plan for Disaster Risk Reduction 2023–2027," which covers various aspects of risk, including earthquake, fire, flood, landslide, and technological disaster risks. This plan enhances institutional cooperation and introduces measures to strengthen infrastructure resilience, as well as to improve early warning and risk monitoring systems (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 25.10.2024).

Albania's active participation in international cooperation, particularly through the exchange of experiences and resources within the Balkan region, underscores the value of collaboration in disaster management. This cooperation, which contributes to more effective disaster response and ensures better utilization of shared resources, is a testament to the importance of regional partnerships. For example, cooperation with neighbouring countries in forest fire protection and natural disaster response has enhanced Albania's capacity for disaster risk management.

6.5.2. Analysis of the Weaknesses of the Disaster Risk Management System in Albania

An analysis of Albania's disaster risk management system reveals several critical areas that urgently require improvement to ensure better efficiency and resilience in the face of disasters. These weaknesses, stemming from financial, infrastructural, and technological challenges, as well as organizational and administrative shortcomings, highlight the pressing need for action.

The first major weakness is the insufficient financial resources allocated to the disaster risk management sector. Although there are national plans and strategies, such as the "Action Plan for Disaster Risk Reduction 2023–2027," the lack of adequate budget allocations hampers their full implementation. This mainly affects the provision and modernization of early warning systems and the training of emergency response services (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 26.10.2024).

The second weakness relates to insufficient technical capacities for disaster risk management. Many local services are not adequately equipped with the modern technology necessary to respond rapidly to disasters, such as floods, fires, and earthquakes. In some cases, even when technology is available, issues with proper utilization arise due to a lack of training (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 26.10.2024).

A third weakness is inadequate coordination among various institutions involved in disaster risk management. Although an institutional framework has been established, coordination between central and local authorities is often ineffective, leading to delayed responses in emergency situations. This is particularly problematic in the context of managing large-scale natural disasters, where quick intervention is crucial to minimize damage and losses (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 26.10.2024).

Another significant challenge lies in data collection and sharing. The lack of up-to-date and comprehensive data on disaster risks and natural hazards hinders planning and decision-making processes. Additionally, there is a need to improve capacities for data collection and analysis, which would allow for more precise risk assessments and more effective protective measures (See more: https://www.undp.org/sites/g/files/zskgke326/files/2024-01/permbledhje_en_clear_8.6.2023.pdf - accessed 26.10.2024).

The final major weakness pertains to the culture and risk awareness within communities. Despite efforts to raise public awareness of the importance of preventive measures and disaster preparedness, many communities are still not sufficiently informed or aware of the dangers. This results in inadequate community preparedness for potential disasters, increasing the risk of losses.

7. Comparative Analysis and Recommendations for Further Improvement in Bulgaria, Romania, and Albania

The comparative analysis of disaster risk management systems in Bulgaria, Romania, and Albania is crucial in understanding the strengths and weaknesses of different national approaches to this essential area. Although all three countries belong to a region prone to similar natural hazards, such as earthquakes, floods, and wildfires, their disaster risk management approaches exhibit varying levels of development and capacity. These differences can be attributed to diverse economic and social conditions and varying levels of engagement in regional and European initiatives.

As a member of the European Union, Bulgaria has significantly modernised its disaster management system through EU funds and collaboration with neighbouring countries. Its integrated early warning and emergency coordination system is a key strength. However, challenges remain in implementing measures locally, where delays and inconsistencies often arise. Additionally, capacities in rural areas remain limited, restricting the effectiveness of disaster response in these regions.

Similarly, Romania, a country highly vulnerable to earthquakes, has invested heavily in strengthening infrastructure and early warning mechanisms. While the system is well-developed nationally with strong support from the EU, Romania faces challenges in funding and inter-agency coordination, as well as a need for deeper integration of local communities into disaster management processes. One of Romania's significant strengths lies in its technological capacity and training in earthquake risk response.

Albania, on the other hand, has recently begun to make significant investments in advancing its disaster management system, particularly under its 2023–2027 strategy. Despite facing numerous challenges, including insufficient financial support, weak infrastructure capacities, and a lack of modern early warning systems, Albania's risk management strategy places a strong emphasis on regional cooperation and strengthening local capacities. This approach, which highlights the importance of community involvement and international partnerships, represents a significant step toward improving disaster resilience.

Compared to Bulgaria, Romania, and Albania, Serbia shows promising potential in disaster risk management but grapples with challenges shaped by its unique socio-economic and institutional dynamics. Bulgaria has a strong legal framework and integrated strategies prioritising early warning systems and disaster risk reduction across sectors. Romania excels in defining institutional roles, maintaining a structured emergency management system, and effectively leveraging international resources. In contrast, Albania, despite limited institutional capacity, highlights the importance of community involvement and international partnerships to mitigate systemic weaknesses.

Serbia displays notable strengths, including highly skilled personnel, significant academic contributions, and a growing presence in regional and international cooperation efforts. However, challenges persist, such as inadequate coordination between national and local institutions, constrained financial and technical resources, and inconsistent implementation of disaster risk reduction policies. A critical gap lies in lacking comprehensive risk maps and geospatial databases, which limits effective planning and targeted interventions. Public awareness of disaster risks is also low, reducing the ability of communities to engage actively in preparedness and response efforts (Cvetković, 2024; Cvetković & Šišović, 2024a).

While Bulgaria has effectively utilized the European Union Civil Protection Mechanism to strengthen its capacities and Romania has implemented successful cross-border cooperation projects, Serbia's involvement in similar initiatives remains in development. There is significant room for Serbia to learn from these neighbouring countries, especially in creating a coordinated early warning system, optimizing resource allocation, and enhancing risk communication strategies.

Serbia and Romania share a reliance on volunteer organizations and community-based disaster responses. Both nations recognize the importance of local participation but struggle to systematically integrate these efforts into their national frameworks. On the other hand, Bulgaria offers a compelling model of institutional cohesion, with seamless coordination between national and local governments—an approach Serbia could adopt to address its own institutional fragmentation.

This comparative analysis highlights the need for Serbia to strengthen its disaster risk management system by adopting proven practices from its regional peers:

- Establishing precise geospatial risk mapping systems to improve planning and resource distribution.
- Expanding public education initiatives to promote a culture of prevention and resilience.
- Enhancing local government capacity through focused training and increased funding for disaster response.
- Developing robust inter-agency coordination mechanisms and integrating volunteer efforts into national strategies.

By aligning its disaster management practices with international standards, Serbia can foster stronger regional cooperation and build a more resilient framework. Addressing systemic weaknesses while capitalizing on existing strengths positions Serbia to create a comprehensive disaster risk management system capable of responding to the complex hazards it faces.

This analysis lays a foundation for policy reform and future research, underscoring the value of shared regional experiences in overcoming challenges and advancing disaster resilience across Southeastern Europe.

Further enhancement of disaster risk management systems in these four countries will require improved regional collaboration, increased investments in early warning technology, and greater integration of local communities into disaster planning and response processes (Table 1). Additionally, raising public awareness about the importance of preventive measures and better coordination among different institutions will strengthen regional resilience.

Table 1. Recommendations for Enhancing Disaster Risk Management Systems in Bulgaria, Romania, Albania, and Serbia

Country	Identified Problems	Recommendations for Improvement
Bulgaria	1. Insufficient coordination between institutions. 2. Underutilization of EU funds. 3. Low public awareness of disaster risks. 4. Gaps in risk communication strategies. 5. Limited integration of disaster risk reduction measures into spatial planning.	1. Strengthen inter-institutional collaboration through joint training and simulations. 2. Enhance capacities to absorb EU funds via administrative training and procedural simplification. 3. Launch public awareness campaigns to educate citizens on disaster risks and preparedness measures. 4. Develop clear, standardized communication protocols for early warnings and risk updates. 5. Integrate disaster risk reduction measures into spatial planning and urban development strategies.
Romania	1. Weak integration of local communities in disaster risk management. 2. Inadequate maintenance of critical infrastructure. 3. Limited capacity of emergency response teams in rural areas. 4. Insufficient use of technology for risk mapping and management. 5. Lack of comprehensive early warning systems for floods and earthquakes.	1. Develop programs to empower local authorities and communities in disaster preparedness and response. 2. Allocate increased budgets for the maintenance of critical infrastructure. 3. Expand training programs and resources for rural emergency response teams. 4. Invest in advanced technologies for risk mapping, such as GIS and satellite monitoring. 5. Establish robust early warning systems tailored to high-risk areas for floods and seismic activity.

Albania	1. Limited institutional capacities for disaster management. 2. Lack of advanced technologies for early warning systems. 3. Low public awareness and preparedness for disasters. 4. Insufficient coordination with neighbouring countries in cross-border disaster management. 5. Weak enforcement of building codes and regulations to withstand disasters.	1. Strengthen institutional capacities through international partnerships and technical assistance. 2. Invest in early warning systems and train personnel in their effective operation. 3. Conduct nationwide education campaigns to improve disaster preparedness among citizens. 4. Foster cross-border collaborations for joint training and emergency response exercises. 5. Enforce building codes and conduct regular inspections to ensure compliance, particularly in high-risk zones.
Serbia	1. Lack of comprehensive risk maps and geospatial databases. 2. Low public awareness about disaster risks and response measures. 3. Insufficient coordination between national and local institutions. 4. Outdated equipment and inadequate resources for emergency response teams. 5. Limited engagement of NGOs and the private sector in disaster risk reduction.	1. Implement geospatial information systems (GIS) to create detailed risk maps for better planning and resource allocation. 2. Organize national campaigns to educate citizens on disaster risks and safety measures. 3. Establish clear roles and responsibilities among national and local authorities to improve coordination. 4. Allocate funding to upgrade emergency response equipment and expand resource availability. 5. Strengthen partnerships with NGOs and the private sector to integrate innovative solutions and community-driven initiatives.

6. Conclusions

The analysis of disaster risk management systems in Bulgaria, Romania, and Albania reveals varying levels of development and effectiveness in each country. Each country faces specific challenges but also holds opportunities for improvement, taking into account their unique capacities and international commitments.

In Bulgaria, the disaster risk management system is largely integrated within national institutions, emphasizing alignment with European directives and standards. Bulgaria has successfully developed an early warning system for natural disasters such as floods, fires, and earthquakes, along with efficient emergency response mechanisms. Moreover, there are well-defined coordination mechanisms among various levels of government, with local communities actively involved in planning and preparation for emergencies. The strengths of this system include a relatively strong infrastructure, EU membership, and access to European funding for disaster prevention and capacity-building initiatives.

Romania follows a similar approach, but its disaster risk management system places a higher focus on earthquake-related risks due to the region's high seismic activity. The Romanian system also aligns with European standards and has established protocols for cross-border coordination with neighbouring countries. A significant emphasis is placed on preventive measures and public education, as well as continuous improvement of infrastructure, especially in urban areas most at risk. Like Bulgaria, Romania benefits from EU membership and participates in joint disaster mitigation projects, greatly enhancing its capacity to handle various types of disasters.

On the other hand, Albania has more limited capacities compared to Bulgaria and Romania, mainly due to lower economic development and insufficient institutional support. Although progress has been made in developing its disaster risk management system, including the formation of national plans for disaster prevention and response, Albania still faces significant challenges. Primarily, there is a need for stronger early warning infrastructure and improved coordination between national and local authorities. Additionally, Albania relies on regional cooperation and international support for disaster risk management, which is crucial for enhancing its capacities.

Overall, Bulgaria and Romania have more developed systems due to EU support and long-term capacity-building strategies. Albania, while facing greater challenges, is making efforts to strengthen its system but needs to continue investing in human resources, technological capacity, and regional collaboration. To enhance disaster risk management across all three countries, further strengthening of preventive measures, public education, and improved disaster response infrastructure is recommended. Regional collaboration, especially in the context of climate change and the increasing frequency of natural disasters, will be crucial for building resilience to these events.

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Assessment of Climate-Induced Vulnerabilities and Poverty Alleviation Potential of Dry Fish Industry: An Ecological and Socio-economic Study in Cox's Bazar District, Bangladesh

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ABSTRACT

Climate change disrupts the ecosystem and decimates nature-dependent populations. The dried fish business in Cox's Bazar relies on raw fish. The community in Cox's Bazar district largely depends on these industries, which have contributed to poverty alleviation and local economic growth. However, they also have mixed ecological impacts, including positive outcomes and challenges such as waste generation. This paper assesses livelihood vulnerability in the coastal areas of Cox's Bazar and Kutubdia through the LVI, LVI-IPCC, and various statistical tests. Data collection involved a survey of 150 households at each site, two focus group discussions (FGDs) at each site, and one key informant interview (KII) in each area. The results indicate that Kutubdia Island is more vulnerable than Cox's Bazar, with an LVI value of 0.437. Initiatives for eco-friendliness, such as the adoption of Smart Solar Sun-Dryers, are being implemented. At the same time, the waste from this industry, which constitutes 14% of the waste in Cox's Bazar, is increasingly being reused for fish feed. These findings underscore the dual impact of this industry on the environment and its crucial role in the livelihoods of local communities. This will help policymakers formulate effective strategies for resource allocation, development planning, and policy formulation.

KEYWORDS

Vulnerability; poverty; climate change; smart solar sun dryer; dry fish industry.

1. Introduction

It has indeed contributed to global warming, with high temperature rises, growing emissions, and negative, differential impacts on the most vulnerable communities, who have contributed the least to the problem. According to the IPCC (2023), this is attributed to global climatic change resulting from the emission of greenhouse gases. According to statistics from the UN, it is estimated that approximately 40% of the world's population lives within 100 kilometres of the coastline, while

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the population of the coastlines is increasing faster than the global population. Coastal communities are facing challenges stemming from the decline of traditional industries and the impacts of climate change. Main challenges brought about by climate change, such as sea-level rise, flooding, and erosion, among others, threaten both the landscape and the livelihoods of these communities (Sørensen et al., 2018). More precisely, the increase in sea level, cyclones, and saltwater intrusions result in land degradation, which further causes negative impacts on agricultural productivity and reduces fishing opportunities (Islam et al., 2018; Magsi & Sheikh, 2017). Climate change impacts can be categorised into three orders: degradation of community capacity to reduce vulnerability, modification of agricultural landscapes and production patterns, and deterioration of livelihood assets and conditions (Huq et al., 2015).

The economic fabric of these regions is woven from diverse occupations, including fishing, farming, and tourism-related pursuits (Wahyudin, 2013; Ghosh, 2012). Also, a predominantly dry fish industry located in coastal areas of West Bengal (Payra et al., 2016) and Chittagong-Cox's Bazar region, along the Sylhet-Mymensingh – Comilla and Khulna-Barisal-Patuakhali regions (Dey et al., 2024) for the proximity of fresh supply of fish and favourable environmental conditions for sun drying (Joshua & Vasu, 2015). It is a traditional livelihood activity for low-income workers, especially in coastal communities and among fishermen, who often have limited literacy rates, as noted by Kamal et al. (2023) and Samanta et al. (2016). Due to the long shelf life and low manufacturing costs of dried fish, which facilitate long-term preservation, it is crucial for traditional livelihood activities among coastal communities, particularly among low-income individuals, as noted by Samanta et al. (2016). Women play a significant role in the drying process of fish. On the other hand, salaries and decision-making powers related to gender are subject to discrimination. The seasonality of this industry is characterised by a shift to other jobs during the off-seasons of the year. Research evidence suggests that despite these issues, the dried fish sector contributes significantly to the community's resilience through social relationships and traders' groups (Kamal et al., 2023; Mitu et al., 2021).

The dry fish industry plays a significant role in rural economies, providing employment and income for millions of poor fishermen and women through poverty alleviation and job creation (Giri & Biswas, 2018; Orewa & Iteke, 2017). This study aims to address existing research gaps in the dry fish sector by examining its role in mitigating climate change vulnerability, alleviating poverty, and balancing its ecological and climate-related impacts. It also explores how the dry fish industry has contributed to building resilience against climate vulnerabilities and identifies adaptation strategies that can strengthen these communities. To achieve these objectives, the study focuses on the following key questions: How has the industry contributed to reducing vulnerability? In what ways has it helped alleviate poverty among those involved? Moreover, what are the positive and negative impacts of the industry on the environment and climate?

1.1. Literature review

The dry fish industry, particularly in coastal and arid regions, is facing a significant threat from climate change, with profound implications for fish populations, fisheries, and the livelihoods of those dependent on this trade. Climate change-induced factors, such as increased temperatures and altered hydrologic patterns, are leading to more frequent river drying events and reduced hydrologic connectivity. These changes pose severe risks to freshwater fish species by limiting access to spawning habitats, as seen in ecosystems such as the Verde River basin (Jaeger et al., 2014). In the Arctic, the drying of tundra streams affects the genetic variations and population structure of species like the Arctic grayling, underscoring the challenges of maintaining biodiversity under climate stressors (Golden et al., 2021). Similar vulnerabilities are evident in Africa, where inland fisheries face rising temperatures and sea levels, which exacerbate the difficulties for local fishing communities (Udo & Akpan, 2021). Traditional preservation techniques, such as dry salting, may not be sufficient to address the anticipated effects of climate change on the dry fisheries sector (Khashroum, 2022).

Socioeconomic conditions, environmental factors and limited income diversification further compound the vulnerability of dry fishing communities. In Bangladesh, for example, the dry fish indus-

try struggles with low income, poor literacy rates, and inadequate compensation during off-seasons, forcing many to seek alternative livelihoods (Kamal et al., 2023). Similar challenges are observed in Madagascar (Ranaivomanana & Mahafina, 2024) and Malaysia (Islam et al., 2022), where fishing communities' reliance on natural resources and lack of diversified income sources lead to heightened vulnerability and generalised poverty. In Colombia, despite fishing households earning more than non-fishing households, significant barriers, such as restricted access to financial markets and lower education levels, exacerbate their vulnerability (Maldonado et al., 2022). These challenges highlight the need for targeted policies to enhance resilience and diversify income sources within these communities (Omitoyin et al., 2021).

Despite these challenges, the dry fish industry plays a critical role in poverty alleviation, particularly in coastal communities. It is a vital source of livelihood, especially for women and contributes significantly to food and nutrition security due to its high micronutrient content (Pradhan et al., 2023). Research indicates that fishing households generally have a lower likelihood of living below the poverty line, highlighting the sector's potential to enhance food security and reduce poverty (Martuscelli, 2022). In Bangladesh, innovative models, such as the proposed social business on Maheshkhali Island, aim to empower local dry fish processors by eliminating intermediaries, thereby increasing their income and reducing poverty (Ullah & Uddin, 2015). Similar opportunities for poverty reduction exist in Nigeria, where the dry fish trade has shown profitability despite challenges such as high lending rates and transportation issues persisting (Orewa & Iteka, 2017).

Addressing the vulnerabilities faced by dry fishing communities requires a comprehensive approach that incorporates both multifaceted and targeted adaptation and policy interventions. Research indicates that poverty among fishermen is exacerbated by low income, inadequate fishing gear and insufficient education, necessitating interventions that empower marginalised groups, particularly women (Kahar & Broto, 2023). However, effective policy implementation is often hindered by poor coordination among government units, a lack of infrastructure, and inadequate access to financial resources (Nurkaidah et al., 2016). Moreover, poverty in fisheries is intertwined with broader social issues, including gender inequality and community exclusion, which complicates alleviation efforts (Jentoft et al., 2010). Gender mainstreaming policies are essential, as current regulations often overlook the protective aspects for women in fisheries, perpetuating their poverty (Purwanti et al., 2022). Therefore, a holistic strategy involving local governments, educational institutions, and the private sector is crucial to enhance community participation, improve resource management, and ultimately foster sustainable economic development in these vulnerable communities (Jentoft et al., 2010; Purwanti et al., 2022; Nurkaidah et al., 2016).

The dry fish industries also have both positive and negative impacts on the ecology. According to Khashroum (2022), traditional practices can increase environmental pressures on fish through overfishing and habitat degradation, thereby posing a threat to the long-term sustainability of the industry (Khashroum, 2022). Together with this fact comes the socio-economic vulnerability of dry fishing communities, most of which lack the wherewithal and infrastructure to cope with such changeable conditions. In Bangladesh, for instance, dry fishers face challenges such as low income and inadequate compensation during off-seasons, which force them to exploit natural resources unsustainably (Kamal et al., 2023). Similar patterns of ecological strain and socioeconomic vulnerability are evident in Madagascar (Ranaivomanana, 2024) and Malaysia (Islam et al., 2022), where the over-reliance on natural resources heightens the environmental impact of the dry fish industry.

2. Profile of study region

Cox's Bazar is a mountainous area and home to the longest natural sea beach in the world (Wikipedia, 2024). In Bangladesh, Cox's Bazar area has some of the worst rates of hunger and poverty (Maclean, 2019). It contains three islands: Saint Martin, Kutubdia, and Moheskhali. For this study, two different locations from Cox's Bazar district are selected. The first is "Kaisarpara" village, Uttor Dhurung union, Kutubdia Upazila (sub-district). More precisely, the area is located between "21° 54' 24.3246" north latitude and 91° 51' 23.5182" east longitude," shown in Figure (1). The second one is

the "Nazirartek" village, locally known as "Chor," located in Cox's Bazar's Sadar Upazila (sub-district). More precisely, the area is located between "21° 27′ 53.2584" east latitude and 91° 57′ 1.6848" north longitude," as shown in Figure (2). The main reason behind selecting these two study areas is that they are most concentrated on dry fish industries and two well-known coastal areas of Bangladesh, which have faced several natural disasters over the decades.

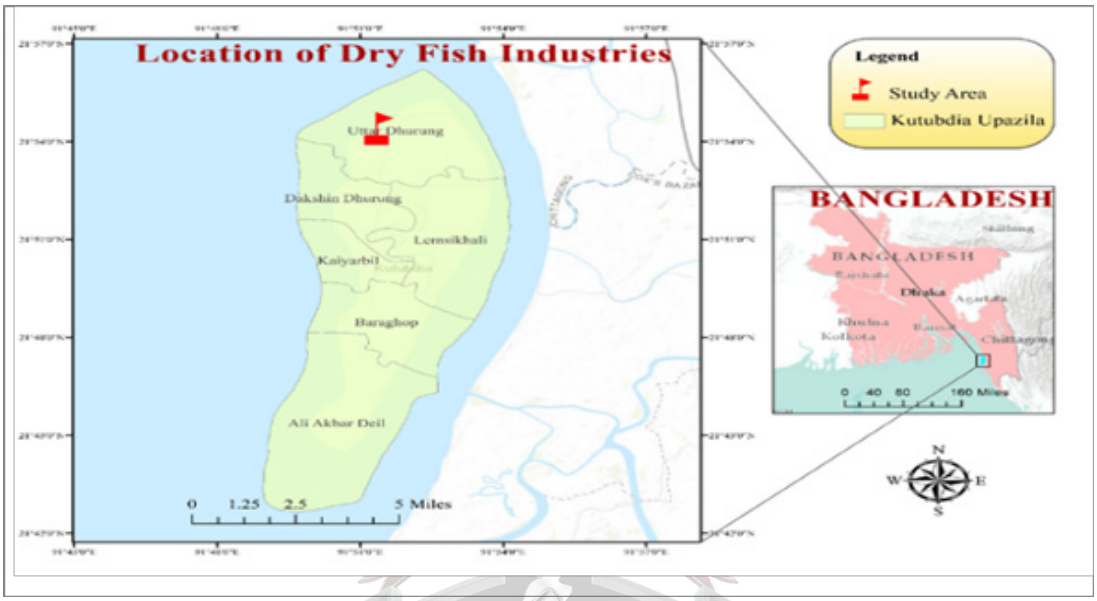

Figure 1. Survey point in Kutubdia.

3.1 Characteristics of the village, Kaisarpara, Kutubdia

With a population of just over 125,000, Kutubdia is an island and an Upazila (sub-district) with an area of 215.80 square kilometres. It is regarded as one of the most remote and vulnerable islands in the area (Alam & Alam, 2023; BFRI, 2020). It is surrounded by water; the Bay of Bengal is in the west, and the Kutubdia Channel is in the east. The primary mode of transport is boat, which helps to communicate the Island with the mainland and transport goods. Recently, it was connected to the national grid via a 33 kV line (Dhaka University, 2023).

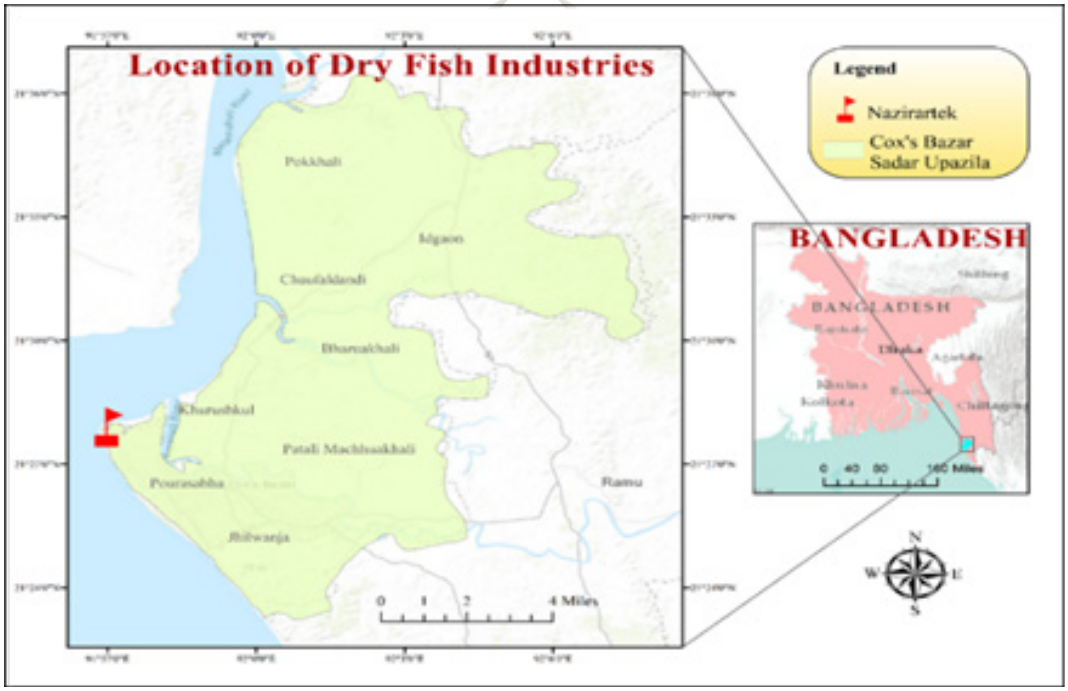

Figure 2. Survey point in Cox's Bazar's Sadar Upazila.

3.2 Characteristics of the study area, Cox's Bazar's Sadar Upazila

Cox's Bazar main subdivision is the most well-known district of Bangladesh for its natural beauty. In Cox's Bazar's Sadar Upazila, there are over 20,000 workers and 1,500 producers specialising in dried fish. The connectivity is significantly better than that of Kutubdia Upazila (sub-district) (Kamal et al., 2023). The study area is well-connected to the CBD (Central Business District) and the district town and is also a popular tourist destination. These industries are privileged to have a marketing opportunity. This district and the capital of Bangladesh are now connected by train.

4. Methods

4.1 Data sources and collection techniques

A household questionnaire survey was conducted in both study areas from May to June 2024. To delve deeper into this, focus group discussions were conducted with 8-10 fishermen and workers from dry fish industries in each study area. Besides, key informant interviews were conducted with veteran fishermen who had been in this profession for a long time. These interviews were supplemented by in-depth elaboration of the pros and cons of various adaptation strategies adopted by them. Secondary data were obtained from NASA Power, the (LGED), and the (BBS).

4.1.1 Sample size for household survey

The Yamane formula is used to determine the sample size for a household survey, which is a prevalent and widely used method. Using a 90% level of confidence, 10% precision, and 50% prevalence, the required sample size has been calculated with the Yamane formula as follows:

Here, n = sample size for household survey, N (Number of households). According to the BFRI (2020), Cox's Bazar's Sadar Upazila, 1 number. Ward has 4,532 households, and Kutubdia Upazila, Uttor Dorong Union, has 4,889. e (Margin of error) = 0.10, n = 4532/(1+4532 * (0.10)2) = 98 sample size of household for Cox's Bazar's Sadar Upazila and n = 4889/(1+4889 * (0.10)2) = 98 sample for Kutubdia Upazila. However, due to the logistical implications and the fact that it was a single research work with no external funding, a reduced sample size of approximately 75 households per area was selected. This will translate to a total of 150 samples in both areas on sunny days.

4.2 Assessing Vulnerability through Livelihood Vulnerability Index (LVI)

Researchers commonly employ two approaches to estimate LVI. A proposal by Hahn was among them to estimate vulnerability due to climate change (Hahn et al., 2009). Some researchers used the balance-weighted technique, which included calculating the LVI (Adu et al., 2018). This method employs a three-step calculation approach and has been used by several studies due to its structured framework, which addresses both the primary and secondary components of family livelihoods. This study used the IPCC concept of vulnerability to climate change in calculating the LVI for each chosen family.

In the framework by (Hahn et al., 2009), seven primary variables were used, while this study has, in addition, two major components developed to make a total of nine: Socio-demographic Profile (SDP), Social Network (SN), Health (H), Water (W), Livelihood Strategies (LS), Food (F), Resources (R), Ecosystem (E), and Natural Disasters & Climate Vulnerability (NDCV). While the conventional LVI includes some ecosystem-related variables, this study delineates Ecosystem, Natural Disasters, and Climate Variability as separate elements to more accurately represent local conditions (Basiru et al., 2022). The Ecosystem component highlights community reliance on natural resources and services, while Natural Disasters and Climate Variability underscore the escalating effects of climatic extremes (Basiru et al., 2022).

These data were collected using various qualitative and quantitative tools and then coded in SPSS. Microsoft Excel was used to standardise the data using equations (2), and the choice of equation depends on the relationship between the minor components and vulnerability.

If the variable has a positive relationship with vulnerability:

$$\text{Index } X_{iu} = \frac{X_{id} - Min\ X_i}{Max\ X_i - Min\ X_i} \quad \ldots. (2) \text{ (Hahn et al., 2009)}$$

If the variable has a negative relationship with vulnerability:

$$\text{Index } X_{iu} = \frac{Max\ X_i - X_{iu}}{Max\ X_i - Min\ X_i} \quad \ldots\ldots (3) \text{ (Adu et al., 2018)}$$

In this equation, Index Xiu denotes the standardised index value of the study area. At the same time, Xiu signifies the actual value for each sub-indicator, expressed in formats such as percentages, ratios, degrees Celsius, or counts. Max Xi represents the maximum value for the sub-component across both areas, and Min Xi indicates the minimum value for the indicators in both areas. For indicators expressed as percentages, the maximum value is 100, and the minimum value is 0. Before assigning the maximum and minimum values of MSD (mean standard deviation) of the monthly average of the maximum, minimum, and precipitation, the daily temperature standard deviation is calculated for each month using equation (4).

$$SD = \frac{\sqrt{\Sigma(X_i - \mu)^2}}{N} \quad \ldots\ldots (4) \text{ (Gupta, 2014)}$$

In equation (4), SD represents the standard deviation, Xi represents the average monthly value for maximum temperature, minimum temperature, or precipitation, μ represents the mean value of the average monthly data, and N represents the number of months. After calculating the value, the maximum and minimum values are assigned.

Then, the significant components are combined from several sub-components; therefore, using equation (5), the Index value for the primary component is calculated.

$$M_k = \frac{\sum_{i=1}^{n} Index\ Xi}{n} \quad \ldots\ldots\ldots\ldots (5) \text{ (Adu et al., 2018)}$$

In the equation (5), Mk denotes the index value for n principal components. The aggregate of indices Xi represents the summation of the standardised values of all minor components inside the "k" main components, and n denotes the total minor components. Following the computation of the index value for principal components, the LVI for each research region is determined using equation (6).

$$LVI_U = \frac{(W_{SDP}SDP_U + W_{SN}SN_U + W_H H_U + W_W W_U + W_{LS}LS_U + W_F F_U + W_R R_U + W_E E_U + W_{NDCV}NDCV_U}{W_{SDP} + W_{SN} + W_H + W_W + W_{LS} + W_F + W_R + W_E + W_{NDCV}} \quad \ldots\ldots\ldots\ldots (6)$$

(Hahn et al., 2009)

In the equation, LVIu represents the index value for each study area, Wx represents the number of minor components under each major component, and finally, SDPu, SNu, Hu, Wu, LSu, Fu, Ru, Eu, and NDCVu are the values calculated by equation (5) for the primary component. The LVI scaled from zero, meaning minimal vulnerability, to 0.6, which means high vulnerability (Adu et al., 2018).

4.3 Determining LVI–IPCC through the IPCC Framework

Another way to calculate livelihood vulnerability is LVI – IPCC. The significant difference between these two methods is that this method uses three weights instead of one to evaluate vulnerability. In this technique, the significant components are categorised into exposure, adaptive capacity and sensitivity. With this more detailed and accurate explanation, vulnerabilities are better understood.

For this three-factor contributing model, the significant component is initially identified using equation (7).

$$CF_c = \frac{\sum_{i=1}^{n} W_{li} M_{ic}}{\sum_{i=1}^{n} W_{li}} \quad \text{…….(7) (Yamane, 1967)}$$

In equation (7), CFc denotes the contributing factor value, Wli represents the number of subcomponents beneath the central component for each contributing factor, and Mic signifies the index value for the primary component, as computed using equation (5). Upon determining the contributing component value, the aggregate value (LVI-IPCC) is calculated using equation (8).

(LVI-IPCC) = (E-A) x S ……. (8) (Hahn et al., 2009)

In this equation no (8), E stands for exposure, A stands for adaptive capacity, and S stands for sensitivity. From zero (least susceptible) to one (most vulnerable), the LVI-IPCC Index is ranked (Hahn et al., 2009). The LVI was estimated using Microsoft Office Excel 2013, following the methods provided by Hahn et al. (2009).

4.3.1. Limitations of LVI and LVI-IPCC

The LVI and LVI-IPCC frameworks exhibit drawbacks, including oversimplified aggregation that may overlook intricate relationships, limited local applicability due to their generalised structure, and a static categorisation of vulnerability that does not account for evolving situations over time.

4.4 Comparison of mean value (Independent sample t-test)

This research employed an independent sample t-test to compare the differences in several minor components and validate the LVI value. The equation required for the independent sample t-test is:

$$t = \frac{X1 - X2}{\sqrt{\frac{SDp^2}{N1} - \frac{SDm^2}{N2}}} \quad \text{…….(9) (Gupta, 2014)}$$

In equation (9), t stands for the t-test value, X1 is the mean value of the first group, X2 stands for the mean value of 2nd group, SDp is the standard deviation of the first group, and SDm is the standard deviation of the 2nd group, N1 is the number of observations for the first group and finally N2 stands for several observations for 2nd group.

Ethics Statement

Ethics approval was obtained from the Chairman of the Department of Urban and Regional Planning, Pabna University of Science and Technology (Ethics Committee). Additionally, participants provided informed consent to participate in this study.

5. Results

5.1 LVI between Kutubdia Island and Cox's Bazar's Sadar Upazila

Table no (1) represents the major and minor LVI (Livelihood Vulnerability Index) values adopted for this study at various locations in Cox's Bazar District, with a particular emphasis on dry-fishing communities and industries mainly based on the exploratory analysis of the study area, some key minor-components were developed and modified, which differ from other studies.

Indicator number	Sub-component	Kutubdia	Cox's Bazar's Sadar Upazila	Major component	Kutubdia	**Cox's Bazar's Sadar Upazila**
1	Percentage of Female-headed household	0.17	0.27	Socio-demographic profile (SDP)	0.341	0.354
2	Percentage of household head schooling	0.09	0.12			
3	Percentage of disabled family members	0.07	0.07			
4	Percentage of working members under the age of 15	0.20	0.19			
5	Dependency ratio	0.70	0.65			
6	Percentage of other job opportunities	0.82	0.83			
7	Percentage of dependency on other occupation	0.25	0.28	Livelihood strategies (LS)	0.179	0.250
8	Natural resources and livestock index	0.28	0.40			
9	Percentage of shift to another job after nine-month	0.15	0.17			
10	Percentage of bad condition of business	0.04	0.15			
11	The ratio of money borrowed and land from a neighbour	0.81	0.82	Social Network (SN)	0.464	0.473
12	Percentage of assistance received from government/NGO	0.09	0.21			
13	Percentage of local residency	0.49	0.39			
14	Percentage of deficiency of food faced by the household	0.24	0.19	Food (F)	0.600	0.597
15	Percentage of having three or two times meal	0.69	0.66			
16	Percentage of better food facilities after nine-month	0.87	0.94			
17	Percentage of facing skin problems after working in the dry fish industry	0.24	0.27	Health (H)	0.405	0.367
18	Distance from home to clinic	0.80	0.52			
19	Percentage of health issues due to climate change	0.24	0.27			
20	Percentage of not taking treatment from hospital	0.34	0.41			
21	Percentage of having land	0.95	0.95	Resources (R)	0.808	0.803
22	Percentage of accommodation facilities from the industry owner	0.87	0.78			
23	Percentage of having own house	0.55	0.65			
24	Percentage of households that grow livestock	0.86	0.83			

25	Time to bring drinking water (min)	0.36	0.09	Water (W)	0.324	0.132
26	Percentage of water availability problem	0.39	0.09			
27	Percentage of difference in test of water from near area	0.22	0.21			
28	Percentage of decrease in fish quantity	0.47	0.43	Ecosystem (E)	0.453	0.450
29	Percentage of Disappeared fish species	0.40	0.47			
30	Percentage of decrease in size of the fish	0.45	0.43			
31	Percentage of caught fish with potential for growth	0.49	0.47			
32	MSD of the monthly average of the average maximum daily temperature	0.37	0.26	Natural disaster and climate variability (NDCV)	0.429	0.294
33	MSD of the monthly average of the average minimum daily temperature	0.37	0.24			
34	Number of natural disasters faced	0.68	0.44			
35	MSD of the monthly average precipitation	0.30	0.24			
Total LVI for both areas						
Kutubdia :				0.437		
Cox's Bazar's Sadar Upazila:				0.411		

Note: Indicators 6, 11, 15, 16,21, 22, and 23 have inverse relationship with the vulnerability

Household head schooling (0.12) is higher in Cox's Bazar's Sadar Upazila than in Kutubdia Island, indicating that, in this perspective, Cox's Bazar's Sadar Upazila is more vulnerable than Kutubdia Island. Conversely, the LVI values for the minor components of working members under 15 (0.20), dependency ratio (0.7), and other job opportunities in the area (0.82) indicate that Kutubdia Island is more vulnerable than Cox's Bazar's Sadar Upazila based on these components. As a tourist destination, Cox's Bazar and Sadar Upazila generate more sources of income, followed by Kutubdia. This makes it more convenient for the fraction of family members with disabilities, as the LVI is the same for both places.

The combination of all the sub-factors into one main factor, namely socio-demographic data (SDP). The overall value of LVI for socio-demographic data (SDP) is 0.341 for Kutubdia Island and 0.354 for Cox's Bazar's Sadar Upazila. This means that Cox's Bazar's Sadar Upazila is weaker than Kutubdia Island in terms of socio-demographic factors, as the LVI value is higher for Cox's Bazar Sadar Upazila.

The second major component is Livelihood Strategies (LS), which comprises four minor components. The highest LVI values for Cox's Bazar's Sadar Upazila are observed in dependency on other occupations (0.28), shift to another occupation after nine months (0.17), and poor business conditions (0.15). Therefore, all these minor components indicate greater vulnerability in this area compared to Kutubdia Island. The overall LVI score for the primary component of Livelihood Strategies is also higher for Cox's Bazar's Sadar Upazila, at 0.250, indicating greater vulnerability. This is because, for the sub-component of natural resources and livestock index, Cox's Bazar's Sadar Upazila has a score of 0.40, which is higher than that of Kutubdia Island, where people have better access to natural resources and grow livestock.

The third major component is the Social Network (SN), comprising three minor components. Although the first two minor components have a positive relationship with vulnerability, an inverse relationship is used here. Therefore, despite having lower LVI scores, the ratio of borrowing and lending money, as well as assistance from the government or NGOs, indicates greater vulnerability for Kutubdia Island compared to Cox's Bazar's Sadar Upazila. The last sub-sector, the local residential area, has a higher value for Kutubdia Island (0.49) than Cox's Bazar's Sadar Upazila, indicating a higher vulnerability. The weakness of this overall factor is evident in Cox's Bazar's Sadar Upazila, with a value of 0.473.

The fourth essential element is food (F), including three minor components. All LVI values are higher for the kutubdiya Island (0.600), indicating greater vulnerability. Approximately 34.7% of the households in these two areas are unable to afford three meals a day, and 18.7% of these households are located on Kutubdiya Island. Around 56.7% of households do not face food deficiency while working in the dry fish industry, with 30.7% of these households being from Cox's Bazar's Sadar Upazila. As a result, Cox's Bazar's Sadar Upazila is slightly less vulnerable than Kutubdia Island, with a vulnerability score of 0.597.

The fifth major component, Health (H), shows that Kutubdia Island has a higher overall vulnerability index (0.405), indicating greater vulnerability compared to Cox's Bazar's Sadar Upazila. An independent t-test (table 2) reveals a significant difference in the mean distance from home to clinic ($P=0.000 < 0.05$). The average distance from home to the clinic for households in Kutubdia is 19.75 km, whereas, in Cox's Bazar's Sadar Upazila, the average distance is 12.79 km. Due to the nature of their work, many individuals face skin problems when handling materials without proper safety measures. According to the respondents in this study, 50.7% of people experience skin issues, with 26.7% of these cases originating from Cox's Bazar's Sadar Upazila.

Table 2. Comparison of Clinic Distances Between two area.

F		Levene's Test for Equality of Variances		t-test for Equality of Means		Mean
		Sig.	t	df		
Distance of clinic from home	Equal variances assumed	31.028	0.000	9.28	148	Kutubdia 19.75km
	Equal variances are not assumed.			9.28	117.72	Cox's Bazar's Sadar Upazila 12.79km

Another important major component is Water (W), which is divided into three minor components. The vulnerability index is 0.324 for Kutubdia Island and 0.132 for Cox's Bazar's Sadar Upazila. As the index is higher for Kutubdia Island, households in this area are more vulnerable to water-related issues. Statistical evidence supporting this finding is provided by an independent sample t-test (table 3), the results of which are detailed below:

Table 3: Comparison of Water Collection Time Between two area.

F		Levene's Test for Equality of Variances		t-test for Equality of Means		Mean
		Sig.	t	df		
Time to bring drinking water	Equal variances assumed	103.21	0.000	7.909	148	Kutubdia 14.45 min
	Equal variances are not assumed.			7.909	92.550	Cox's Bazar's Sadar Upazila 3.79 min

Table 3 shows a significant difference ($p=0.000 < 0.05$) in the time taken to collect drinking water. Households in Kutubdia Island take an average of about 14.45 minutes, underlining a greater challenge compared to Cox's Bazar's Sadar Upazila, where the average time is just 3.79 minutes.

According to the survey, 82% of households use borewells, and many neighbours in Kutubdia rely on boreholes. Additionally, 8% of homes in Kutubdia and 6.7% in Cox's Bazar's Sadar Upazila utilise electric household appliances. Power tools and downhole wells are also used by 7.3% of homes; Cox's Bazar's Sadar Upazila is home to all of these. In comparison to aspects surrounding Cox's Bazaar, these data emphasise the difficult circumstances Kutubdia Island residents face while attempting to obtain drinking water, thereby intensifying their overall heightened susceptibility. The dry fish business is closely tied to environmental concerns, climate change, and ecology. Fish is a vital part of human nutrition and health, and it forms a significant building block of daily survival due to its high protein and iodine content. Given this, the present research introduces a new primary component called Ecosystem (E), comprising four minor components.

Informed sources through FGD and KII, the sources of raw fish for the Cox's Bazar dry fish sector were found to originate from many other sources, including other countries. Bay of Bengal fish, on the other hand, is the only source of income for the Kutubdia Island industry. It has created dependence, and as such, Kutubdia fishermen and business owners capture fish that might grow bigger. Nonetheless, the values of the vulnerability index for Kutubdia and Cox's Bazar are significantly close, 0.453 and 0.450, respectively, meaning Kutudia Island is somewhat at greater threat. They reported that climate change hurts the ecology of the sea. They further said that fewer and fewer fish are found nowadays compared to the past.

The ninth and final main component is Natural Disaster and Climate Vulnerability-NDCV. Being surrounded by rivers and the sea, Kutubdia experiences a higher frequency of natural disasters. The average maximum temperature per year, which was 32.762°C in Kutubdia and 31.618°C in Cox's Bazar, fluctuated significantly between the two municipal areas from 2013 to 2022. Similarly, Cox's Bazar received an average of 6,934.42 mm of rainfall per year from 2013 to 2022, while Kutudia received an average of 7,044.41 mm. This is the reason behind the increased frequency of floods in Kutubdia. The vulnerability index also establishes this, with a score of 0.429, indicating that Kutubdia Island is more vulnerable than Cox's Bazar's Sadar Upazila. The general conclusion obtained from the findings was that both areas are vulnerable to climate change; however, Kutubdia has a higher score of 0.437 compared with Cox's Bazar's Sadar Upazila at 0.411.

5.2 LVI - IPCC

The first research question regarding the LVI–IPCC is shown in the table (4). According to the IPCC, enhancing climate change adaptation reduces the vulnerability to climate change. According to Table 4, Kutubdia is more exposed to climate change and natural disasters, with a value of 0.429, compared to Cox's Bazar. In addition, Kutubdia also shows greater sensitivity towards the impacts of climate change, at 0.524, compared to Cox's Bazar, at 0.481. The focus group discussions, however, revealed that some modern strategies have been adapted to the dry fish industry in Cox's Bazar's

Sadar Upazila. It is revealed that among the 64.7 per cent of households that solely depend on the dry fish industry, 32.7 per cent come from Cox's Bazar. This has hence provided a high value of the LVI–IPCC for the contributing factor of adaptive capacity, 0.350, indicating that this industry is mitigating low community climate change vulnerability through its adaptation strategies. Overall, the values of IPCC – LVI for Cox's Bazar Sadar are –0.027, and for Kutubdia Island, they are 0.057. According to Hann, the vulnerability scale ranges from –1, indicating less vulnerability, to +1, indicating greater vulnerability (Hahn et al., 2009). Thus, Kutubdia is more vulnerable than Cox's Bazar.

Table 4. LVI-IPCC calculation for constructing factor.

IPCC contributing factors to vulnerability	Cox's Bazar's Sadar Upazila	Kutubdia
Adaptive capacity	0.350	0.319
Sensitivity	0.481	0.524
Exposure	0.294	0.429
LVI–IPCC	-0.027(less vulnerable)	0.057More vulnerable)

This analysis highlights the increased vulnerability of Kutubdia Island to climate change in comparison to Cox's Bazar's Sadar Upazila, underscoring the need for adaptation strategies to mitigate these impacts.

5.3 Role of dry fish industry in poverty alleviation

Economic growth and employment generation are primary mechanisms for poverty reduction. An industry becomes sustainable when it has a sufficiently large and skilled workforce. Table 5 indicates that 36% of respondents have not transitioned to another sector despite having alternative sources of income available to them. Additionally, approximately 51.3% of respondents reported that they do not have an alternative income source aside from the dry fish industry.

Table 5. Cross tabulation between alternative source of income and tendency to shit to another sector.

Crosstab				
Yes		Shift to another sector. No		Total
Alternative source of income	Yes	12.7%	36.0%	48.7%
	No	18.7%	32.7%	51.3%
Total		31.3%	68.7%	100.0%

Figure 3 shows that 39% of respondents are involved in the dry fish industry due to generational ties, 27% lack other skills, and 19% have not found alternative employment in the area. This data indicates that the dry fish industry is the primary sector for employment generation. The Focus Group Discussion report provides an overview of the employment structure, and these two sections highlight how the dry fish industry contributes to poverty reduction through the creation of employment opportunities.

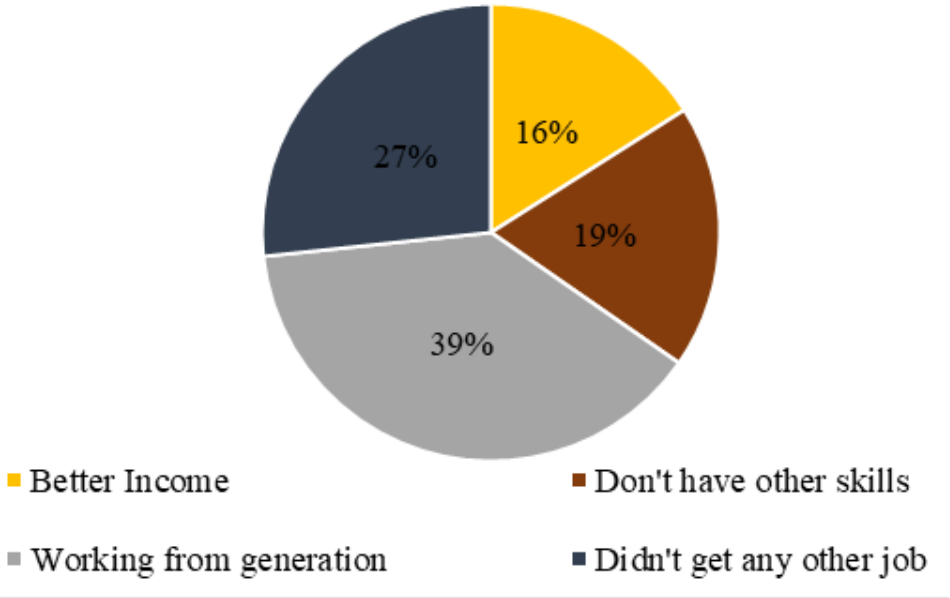

Fig 3. Reason of working in dry fish industries.

5.4 Positive and negative impact of dry fish industries on ecology

The dry fish industry has a direct impact on two grounds: air and water pollution. In Cox's Bazar's Sadar Upazila, the use of chemicals in the industry is more prevalent compared to Kutubdia, where the use is comparatively lower. Again, a considerable amount of waste is generated by this industry, and 84.7% of the waste is disposed of near water bodies (Table 6), which ultimately affects the local ecology. The positive side, however, is that 15.3% of the industries recycle their waste to produce fish food used in land-based fish farming. Another negative impact is the odour produced by the industry, which pollutes the air around it. The waste disposed into water bodies causes it to flow into other places, and the fish populations have decreased compared to their initial levels.

Table 6. Disposal Place of wastage generated from dry fish industry.

		Reuse	Waterbody
Study Area	Kutubdia	1.3%	48.7%
	Cox's Bazar	14.0%	36.0%
Total		15.3%	84.7%

Statistical evidence was also found. A chi-square test (table 7) has been conducted to see if there is any impact of this industry on ecology.

Null hypothesis: There is no effect of chemicals used and processing/catching small fish, which has the potential to grow more in the decreasing of fish size, decreasing in the quantity of fish and disappearance of fish species.

Alternative hypothesis: There is an effect of chemicals used and the processing and catching of small fish, which has the potential to lead to a decrease in fish size, a decrease in fish quantity, and the disappearance of fish species.

Table 7. Chi-square test to explore impact in ecology.

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.545[a]	1	0.001		
Continuity Correction	5.808	1	0.016		
Likelihood Ratio	5.508	1	0.019		
Fisher's Exact Test				0.026	0.026
N of Valid Cases	150				
Phi = 0.277					

The Pearson chi-square value is 0.001 < 0.05, so the null hypothesis is rejected, indicating a significant impact of chemical use on the catch of small fish, which has the potential to grow more, contributing to the decrease in fish size, quantity, and disappearance of fish species. The phi value is 0.277, indicating a moderate impact. Moreover, another impact is identified through the Focus Group Discussion (FGD) mentioned below.

5.5 Report of Focus Group Discussion

Two FGDs were conducted in different locations of the Cox's Bazar district, one in Nazirartek (Cox's Bazar's Sadar Upazila), where the largest dry fish industries are located, and another in Kutubdia Island. A group of 6 to 8 people attended the discussion. The "Ecosystem" component was included in response to persistent input from key informant interviews and focus group discussions. Participants underscored the significance of natural systems for sustenance and climate resilience. Their contributions identified a deficiency in the original framework and facilitated the delineation of pertinent indicators, ensuring the component aligned with local goals and environmental conditions. The objective of the FGD was:

- To explore the problems of the people.
- Employment scenario in every stage of the drying process.
- The impact of environmental change on the lives and ecosystems.
- To explore the adaptation strategies they adopt against climate change.

Findings on Employment: There are several differences between these two points in terms of connectivity, investment opportunities, job options, and causes of the jobs. The raw materials, that is, fish, are gathered in two ways. At the Kutubdia point, the industry owners catch fish directly from the Bay of Bengal. However, at Nazirartek Point, the industry owners purchase fish from suppliers' third-party owners located near the industry site or from Chittagong.

These collected fish are sent to the sorting area by 4-5 workers. For the sorting process, 10-15 workers are appointed daily. Again, around 9-10 workers are appointed on a nine-month contract basis, each with a fixed salary. They not only sort out the fresh fish but also spread the selected fishes on elevated platforms from the ground, locally called "Macha."

However, the wages are too low for the laborers. According to Habiba, a day labourer from Nazirartek, they earn 400 BDT per day, and the availability of work is 18-20 days per month. In contrast, female labourers from Kutubdia receive 200 BDT per day for the same work. The prepared fish are then cut or uncut and set to dry for 10 to 14 days. After this period, the workers sort the dried fish again to better quality. This industry is highly effective in creating employment, generating income for residents, increasing government revenue, and reducing poverty in this region.

Findings on the impacts of climate change on ecology: Ecology is the primary victim of climate change, and it highly affects companies whose core business depends on natural resources, such as the dried fish industry. This industry is entirely dependent on raw fish from the ocean and the

fishermen and workers who have been associated with it for generations. Their observations and experiences can be cited as important evidence about climatic changes and their effect on the ocean ecosystem. According to the household survey, approximately 38.67% of respondents have been involved in this industry for generations.

From Kutubdia, Moin Uddin, a fisherman and businessperson of the dry fish industry, said, "Earlier, we needed to run the boat for only 1.5 hours and catch a sufficient amount of fish".

"Nowadays, we have to drive 4-6 hours and still do not get as much fish as before." Likewise, another dry fish businessman, Mir Kashem, said, "Earlier, we used to dry 20 tons of fish every month. Nowadays, we hardly manage to get 10 tons of raw fish to dry." Having observed this phenomenon, a fisherman named Minhaj remarked, "One type of fish which turns colour with the water's hue, like the jellyfish, has increased immensely in recent times. Because of them, other fishes are abandoning the place, and so we catch very few." He informed that 10 species of fish, locally called Patra, Arfula, Chaindavuga, Lakka, some kinds of shrimp, and Guara, had either vanished or their number decreased over time.

Mir Kashem also mentioned that the uncertain rainfall hampered fish drying badly, causing losses. In such cases, to recover losses, they typically take out loans at a high interest rate.

Adaptation Strategies: Although people cannot control climate change, its impacts are pervasive; however, they can adopt strategies to mitigate its harmful effects. In this research, the following adaptation strategies adopted by the respondents of Nararirtek, Cox's Bazar are:

1. Adoption of Smart Solar Sun Dryers.
2. Diversification in fish drying techniques.
3. Diversification of livelihoods.
4. Adoption of storage systems for raw and dried fish (In limited industry).

In contrast, the people of Kutubdia are far behind in adopting adaptation strategies. The present strategies being adopted by them are:

1) changing fishing grounds,

2) taking loans,

3) diversifying livelihoods through the salt industry and cultivation of groundfish and

4) using nets, which is forbidden by the government.

6. Discussion

6.1 Field observations versus results

Field observations have recorded that, compared to other areas, Cox's Bazar's Sadar Upazila has better schooling facilities and a far more developed communication system. These, among other minor components of adaptive capacity, place Cox's Bazar's Sadar Upazila at a relatively high level of resilience. Many working NGOs are involved in the region, and a well-developed market with substantial investment and technological development ensures job opportunities. Being an urbanised area, Cox's Bazar's Sadar Upazila offers various alternative employment opportunities. Secondly, most of the employers in Cox's Bazar's Sadar Upazila provide accommodation facilities to their workers, which is certainly not a typical case in Kutubdia. It can be inferred from these observations that the vulnerability is lower in Cox's Bazar's Sadar Upazila due to its high adaptive capacity. In support, it can be seen from the LVI calculations represented in Figures 4 and 5 that adaptive capacity in Cox's Bazar's Sadar Upazila is higher compared to the other areas.

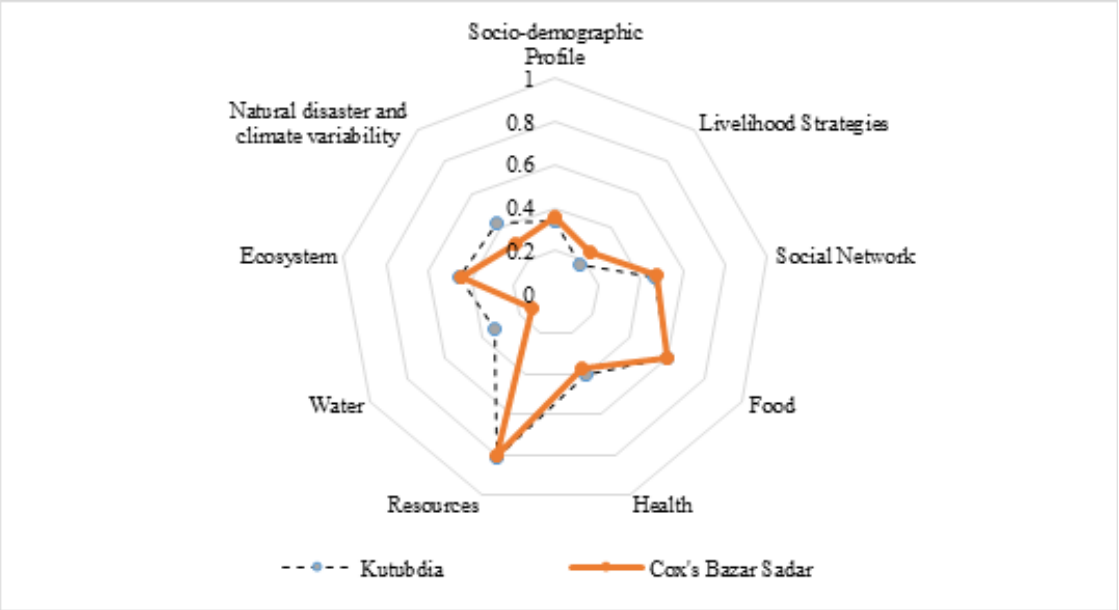

Fig 4. Spider diagram of major component.

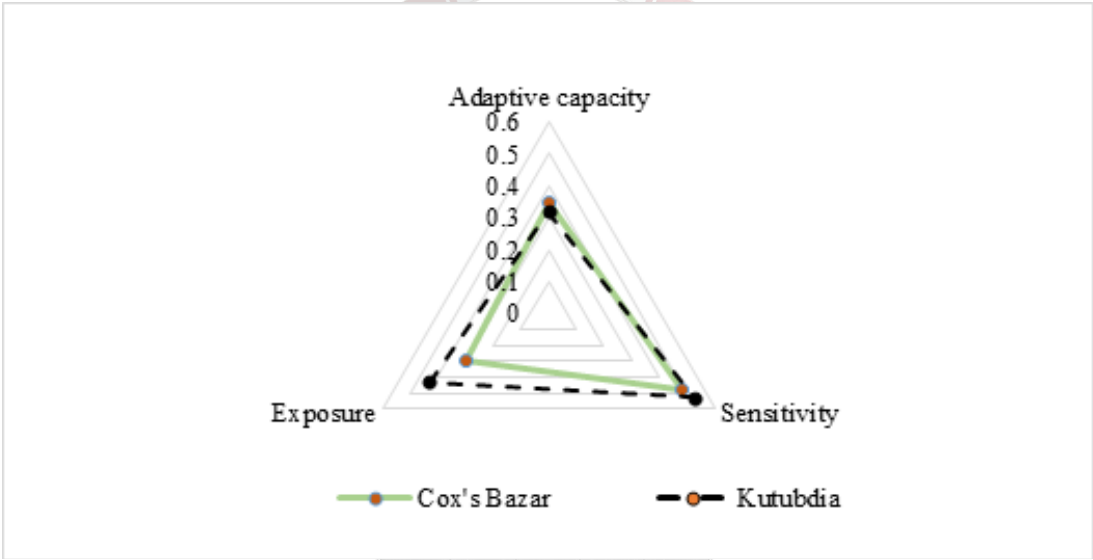

Fig 5. Triangle diagram from LVI-IPCC of study area.

Regarding exposure, critical areas have been identified through field observations in Kutubdia. The housing conditions are not good, and almost all the houses are made of bamboo and tin, making them easily destroyable. According to the survey, 100% of respondents and the community expressed an urgent need for improvement in the water supply, specifically regarding the adequate number of tube wells. The access roads also remain seriously damaged, mainly due to frequent natural disasters. People become accustomed to these disasters and do not fear them, although the proximity of homes and industries to the Bay of Bengal—less than 200 meters in many places—raises their risk factor. In contrast, the case of Cox's Bazar's Sadar Upazila is different. Houses are located 1 to 5 kilometres away from the seashore, with good road connectivity and a high percentage of brick wall houses. Cox's Bazar's Sadar Upazila is also prone to various types of natural disasters; however, the frequency and intensity are much lower than in the case of Kutubdia.

Field observations indicate that Kutubdia is more exposed to climate change impacts than Cox's Bazar's Sadar Upazila. The findings shown in Figures 4 and 5 indicate that Kutubdia has a heightened susceptibility to natural catastrophes and climatic variability, hence rendering it more sensitive to climate change.

Geographically, the two areas are separated by a very short distance; hence, their ecosystems and resources are almost identical. People from these two regions share similar practices, including rearing livestock and poultry, as well as tree plantations. However, the quality of water in Kutubdia is significantly poorer than in Cox's Bazar.

Health is yet another crucial parameter where Cox's Bazar's Sadar Upazila has clear advantages. The area has over three to four hospitals, including a government hospital with competent doctors and more than one dispensary within a half-kilometre distance. In contrast, Kutubdia has only one hospital, which is uninhabited, with most houses vacant and lacking competent medical staff and equipment. There is also the scarcity of job availability and lower wages in Kutubdia, which make it impossible for most people to afford three meals a day or even food with the right amount of nutrition.

These observations collectively suggest that Kutubdia is more vulnerable in terms of exposure, indicating that its sensitivity and overall vulnerability will be higher, as shown in Figures 4 and 5.

Table 8 presents the results of the paired two-sample t-test, evaluating the mean values of critical components in the study areas to determine if there is a significant difference between them. Table 8 indicates that the p-values for all major components are < 0.05. As a result, all null hypotheses have been rejected, indicating a statistically significant difference between the two sites for all essential components.

SPS-DRM

Table 8. Two-sample t-test results between Cox's Bazar and Kutubdia for the primary component.

Major Components	Mean	Std. Deviation(SD)	Standard Error Mean	t-value	Degree of freedom	Significance (2-tailed)
Socio-Demographic Profile	1.15	0.61	0.18	6.53	11	0.00
Livelihood Strategies	1.29	0.58	0.21	6.25	7	0.00
Social Network	1.03	0.63	0.26	4.01	5	0.01
Food	0.90	0.63	0.26	3.50	5	0.02
Health	1.11	0.55	0.19	5.75	7	0.00
Resource	0.69	0.55	0.19	3.57	7	0.01
Water	1.27	0.45	0.18	6.95	5	0.00
Ecosystem	1.05	0.53	0.19	5.55	7	0.00
Natural Disaster and Climate Variability	1.14	0.48	0.17	6.71	7	0.00

6.2 Justification of results by comparing with other research

According to a study by Toufique and Yunus, the LVI for the socio-demographic profile of coastal areas was 0.348 (Toufique & Yunus, 2013). As can be noted, our results, which range between 0.341 and 0.354, are very close to that analysis. Additionally, their study suggests that people residing near the sea are more susceptible than those residing some distance away from it. This is also consistent with our findings, where Kutubdia, being a place close to and surrounded by the sea, shows higher vulnerability, with an LVI value of 0.437. The same applies to Cox's Bazar, which is also situated in a coastal area but is significantly less vulnerable, with a slightly lower LVI value of 0.411, thereby placing it at a relatively safe distance from the ocean.

According to ACAPS 2020 (ACAPS, 2020) in a report entitled "Cox's Bazar Upazila Profiles," 70% of Cox's Bazar's Sadar Upazila's economy is driven by occupations in trade and service industries, including hospitality, labour, and trade-related to fishing, together with small and medium enterprise industries. Next in importance are occupations in manufacturing and industry, particularly in construction. On the other hand, the economy of Kutubdia is primarily based on agriculture and fishing, which suggests a lower level of employment compared to that in Cox's Bazar's Sadar Upazila. It thus somewhat closes the economic gap, as our study's findings show that the dependency level on specific jobs and the difficulty in switching to another job are higher in the case of Kutubdia.

On the aspect of natural disasters, what also emerged in the ACAPS report (ACAPS, 2020) was that while both regions are vulnerable, Cox's Bazar's Sadar Upazila is not likely to experience a direct hit of cyclones, though remaining susceptible to the effects of strong winds, storm surge, and flooding. In contrast, Kutubdia reportedly faces more climatic vulnerabilities, including climate-induced displacements resulting from various disasters, saltwater overflow, and extreme drought during summer days, which hinder agricultural practices. All these make Kutubdia more vulnerable, with an LVI score of 0.429 against 0.294 for Cox's Bazar's Sadar Upazila upazila. This further confirms the conclusion drawn from our study.

Our research also examines the skills of local people in both areas and further investigates how the dry fish industry contributes to poverty reduction. A study by Ullah and Uddin (2015) was conducted in Moheskhali, an Upazila of Cox's Bazar district, which is similar to Kutubdia. Their study further shows that almost all dry fish producers belong to the low-income group; despite several development programs, efforts to alleviate poverty have not been able to reach the poorest segments of society. The dry fish industry is very prominent, with an ever-increasing demand in both local and international markets, indicating a growing potential for income and employment.

Comparative research findings indicate that, overall, wages and employment are higher in Cox's Bazar's Sadar Upazila, as it has a high demand and a larger market for dry fish. This industry is pivotal for reducing poverty in this area, thus showing that the economy is progressing differently in Cox's Bazar's Sadar Upazila compared to Kutubdia. It calls for focused interventions to overcome the vulnerabilities identified in the latter sub-district.

Finally, this study found that the people of these coastal areas face socio-economic difficulties and lack access to alternative job opportunities. A similar study conducted in Nigeria found that natural disasters brought socioeconomic distress to the victims (Ogunleye & Arohunsoro, 2024). Another research in Hong Kong reveals that the coastal region confronts issues of elevated poverty rates and significant deterioration of coastal resources (Sekarningrum & Yunita, 2019). This aligns completely with this study.

6.3 Advantages and disadvantage of Smart Solar Sun Dryer as an Adaptation Strategy

The Smart Solar Sun Dryer is a technique that utilises solar energy to dry fish. Majorly it involves placing the solar panel on top of a greenhouse-like structure. Through solar energy, the setup could drive a heater that provides the required temperature for drying fish. During the field visit, it was found that two organisations, including the Coastal Foundation and the Ministry of Fisheries and Livestock, have experimentally provided this technology to local users. The benefits and drawbacks of this were noted after using it for months.

Advantages:

- No Electricity Needed: It does not use a single watt of electricity.
- Better Quality: It produces fish of higher quality than traditional drying methods.
- Drying in any Weather Condition: It can be used even on rainy days for drying purposes.
- Efficient: It can dry the fish in less than a week.
- Less Labour Needed: Manpower required to dry fish is reduced.
- Eco-Friendly: The mechanism is easy to handle and eco-friendly.

• Higher Market Value: Dried fish produced through this technique commands higher market prices. While traditionally dried fish is sold at 1,200 BDT per kilogram, fish dried with the solar sun dryer is sold at 2,000 BDT per kilogram.

Disadvantages:

- Insect Infestation: Treated with chemicals to prevent insect attacks after some days.
- Lower Quantity: The quantity of the output is lower compared to traditional drying techniques.
- Financial Losses: The lower quantity puts the seller in a dilemma about how to sell more fish, thereby sustaining financial losses.

Against the backdrop of changing climate conditions, sudden rainfall, and natural disasters, the Smart Solar Sun Dryer acts as an effective alternative. Whereas the traditional methods have to remain suspended during the rainy seasons and often get damaged by sudden rainfall, this solar-based strategy enables continuous processes and thus becomes resilient for fish drying in inclement weather conditions.

7. Conclusion and Recommendations

The coastal area of Bangladesh is prominent for its fisheries, salt production, and dry fish industries. Dry fish, being a preservable product, is an excellent attraction to national and international tourists. A large group of local people has been engaged in this industry for so many decades. This community and the business are greatly affected and dependent upon environmental factors, especially climate. It is among the significant sources of employment for the illiterate and other marginalised members of society.

This study will analyse the effects of climate change on the livelihoods of those engaged in this business using the IPCC-LVI methodology. It will hence attempt an in-depth analysis of all the various sectors of livelihood in the community. The research also attempts to discover how this industry works towards reducing poverty and is one important avenue that enables poverty reduction in these areas.

Specific to this research, the study identifies unique adaptation strategies developed by communities in their fight against climate change. This adds new minor and major components related to the livelihoods of this community and the dry fish industry, aspects that previous research has not addressed but are instrumental in understanding the sector. These findings can serve as a guideline to help frame the supply chain framework and are likely to attract the attention of government authorities as the industry continues to be fragmented and unorganised.

The current study recommends more vibrant NGO support in Kutubdia compared to Cox's Bazar's Sadar Upazila, as Cox's Bazar's Sadar Upazila has already received privileged support. The people of Kutubdia are the most vulnerable and suffer the most; hence, support is essential in this direction.

Project-Based Implementation of Smart Technology and Machinery: Smart technology and machinery should be introduced on a project basis, accompanied by low interest rates and flexible instalments. For example, "Aman Traders," a company in Cox's Bazar's Sadar Upazila, has achieved enormous success by adopting innovative technology and has already been endorsed and awarded by the government.

Policy and Framework Development: Policies and frameworks should be formulated to guide the timing of fish harvest and storage. Through the implementation of the time-bound fishing approach, it would be easier to enforce the storage of fish to be dried using innovative technology during off-seasons, thereby reducing the environmental and ecological impact.

Market Framework Development: Design a comprehensive framework for the market, enabling better organisation and continued investment attraction, thereby enhancing market value. This will generate new employment opportunities, higher incomes, and scaling up businesses.

Health Effects of Chemical Use in Smart Solar Sun Dryers: This study will investigate the potential health effects of chemical use in Smart Solar Sun Dryers and whether it can lead to health issues in the local population.

Controlling the Disadvantages of Smart Solar Sun Dryers: This will involve identifying ways to mitigate the current disadvantages of Smart Solar Sun Dryers, thereby enhancing their effectiveness and efficiency.

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Article

Teachers' Perception Towards Responses of COVID-19 Pandemic Management in Gandaki Province of Nepal: A Cross-Sectional Survey

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ABSTRACT

The coronavirus disease 2019 (COVID-19) pandemic has impacted numerous organisations, including those in the health, education, livelihood, and development sectors. The outbreak of COVID-19 resulted in the prolonged closure of many educational institutions. Health and education authorities made concerted efforts to maintain teaching and learning activities in schools. Teachers' perceptions are crucial for the effectiveness of future pandemic response initiatives. Therefore, this study aims to assess teachers' perceptions of the responses to the COVID-19 pandemic. An institution-based cross-sectional study was conducted among teachers in community schools from June 29 to August 28, 2023, in the Gandaki Province of Nepal. The sample size consisted of 732 individuals, selected using a multi-stage cluster sampling method. A pretested questionnaire was self-administered. Data were analysed using the chi-square test and logistic regression at a 5% significance level. This study reveals that 69.7% of teachers held inadequate perceptions regarding efforts to manage the COVID-19 pandemic and reopen schools. Teachers with more experience (B = 0.11; p = 0.57) and those from urban municipalities (B = 0.02; p = 0.26) had a more positive perception of the responses. However, gender, monthly family income, work experience, number of family members, and municipal type were insignificantly associated with teachers' perceptions of the responses to manage the COVID-19 pandemic. This study demonstrates that teachers had an inadequate level of perception regarding responses to COVID-19 pandemic management and the reopening of schools. These results suggest that policymakers and managers in the health and education sectors must develop comprehensive responses to prevent the entry and spread of COVID-19 among teachers, as well as to enhance the resilience of schools and society for future epidemics.

KEYWORDS

Disaster; COVID-19; cross-sectional; perception; responses; teachers.

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1. Introduction

Any disasters shake institutions. Institutions often temporarily adapt their strategies in the aftermath of a disaster. Disaster events, such as epidemics or pandemics, continually provide a "litmus test" for institutional effectiveness, efficiency, and accountability (Cvetković et al., 2022, 2024; Ocal et al., 2020). To foster a positive perception of responses to crises, institutions must comply with disaster management guidelines, including planning, equitable resource distribution, and making disaster management structures more transparent and equitable (Mokhele, 2024).

The outbreak of coronavirus disease 2019 (COVID-19) has affected the lives of millions of people worldwide. All types of organisations, including health and education, had to face the long-term impact of this pandemic. Primarily, these organisations in developing countries found it difficult to cope with the challenges imposed by multiple episodes of the COVID-19 pandemic. Very soon after the outbreak, educational institutions were closed to prevent the entry and spread of COVID-19 among teachers, students, and staff. As a result, millions of students were forced to stay out of their educational institutions. After a few weeks, the concerned authorities in health and education, in particular, made digital and online services to revitalise the teaching and learning process. However, the faculty of business schools were not prepared for online teaching and learning and did not receive adequate logistical support from their institutions (Shrestha & Tamrakar, 2023). However, teachers' experiences of abrupt changes in pedagogical modality and their responses are conspicuously absent in the existing literature (Shrestha et al., 2022). Despite some efforts since the first case was detected in Nepal, the government's responses were insufficient (Rayamajhee et al., 2021) to manage the COVID-19 pandemic.

Generally, communities are not immune to any disasters or disaster-related losses. Reducing loss and enhancing community resilience by shifting the concerned authority's approach from reactive to proactive is crucial. Moreover, the COVID-19 pandemic led to infodemics in the media, a decline in social interaction, isolation, and loss of income, which exacerbated psychological problems, inadequate personal protective equipment, an underprepared health system, unorganised public quarantine centres, and public violations of lockdowns (Bhatt et al., 2020). Different stakeholders made efforts to contain and mitigate the COVID-19 pandemic. The federal, provincial, and local governments coordinated their response to the COVID-19 pandemic by enhancing local public health service delivery, preventing transmission, conducting epidemiological investigations and tracking, mitigating the pandemic's impact on other services, and supporting social and economic relief activities (Mainali et al., 2021). The three-level governments of Nepal play important roles in meeting citizens' demands for basic services (Chaudhari, 2019). The COVID-19 pandemic highlighted the crucial role of sub-national governments in providing uninterrupted services to their citizens. The COVID-19 pandemic led academic institutions to prioritise covering academic courses rather than developing skills in students and preparing them for a better future (Dawadi et al., 2020). The COVID-19 pandemic not only impacted child development, education, and health but also exacerbated inequalities and inequities within the community (Marchant et al., 2021).

During the COVID-19 pandemic in Jordan, more than 80.0% of medical students adopted social isolation strategies, regular hand washing, and enhanced personal hygiene measures as their first line of defence against the virus (Khasawneh et al., 2020). Teachers adopted the online learning process without prior experience (Lie et al., 2020). Different stakeholders, including institutions, teachers, publishers, and parents, joined forces to create digital resources such as textbooks and learning materials, making virtual classrooms possible. Prevention strategies were implemented at both personal and population levels. At a personal level, the use of masks, sanitisers, hand washing, and isolation was followed. However, lack of social interaction, isolation and loss of income were raised as pertinent issues that potentially led to psychological consequences. Institutional quarantine facilities were established at schools, campuses, hostels, hotels, and other accommodation facilities, with the coordination of local governments. Isolation facilities were also organised by provincial governments and various public and private hospitals across the country (Rayamajhee et al., 2021).

The COVID-19 pandemic presented opportunities for teachers and students to learn about information and communication technology (ICT) and explore new approaches to teaching and learning

activities. Additionally, universities and professional organisations provided ICT training at university departments for online classes. During the pandemic, teachers demonstrated their ability to create online learning environments as an alternative to physical classrooms. Despite limited access to and understanding of digital technology, as well as the absence of administrative assistance, teachers and students created an online learning environment (Adhikari & Rana, 2024). However, the study shows an increasing digital gap between rural and urban areas (Gurung & Poudel, 2021). It poses a high risk of discontinuation of effective online learning techniques in post-pandemic circumstances. The COVID-19 pandemic has presented an opportunity for academic institutions, lecturers, and students to integrate contemporary technology into their teaching methods. The high level of enthusiasm among university lecturers for utilising the ICT resources available for online teaching during the pandemic increased their ICT abilities and teaching strategies. Many students were able to strengthen their self-learning skills through online learning.

COVID-19 remains a global pandemic due to its high transmissibility. Government-coordinated efforts across the globe can be containment and mitigation measures. COVID-19 is controlled by early surveillance, testing, contact tracing, and strict quarantine strategies. These strategies can be made effective by the application of digital technologies in pandemic management and response, as highlighted in pandemic planning, surveillance, testing, contact tracing, quarantine, and healthcare (Whitelaw et al., 2020). The Ministry of Health and Population and the Ministry of Education jointly developed infection prevention and control guidelines for educational institutions to build resilience in these institutions for the COVID-19 pandemic in the days to come. Therefore, teachers' perceptions of responses are crucial to adopting and sustaining infection prevention and control measures in school settings in the future. However, teachers' perceptions of responses to the COVID-19 pandemic are relatively scant in Nepal. Therefore, this study aimed to assess teachers' perceptions of responses towards the COVID-19 pandemic and their association with teachers' socio-demographic characteristics.

2. Methodology

This cross-sectional study was conducted from June 29 to August 28, 2023, in community schools of Gandaki Province, Nepal. The total number of teachers in Gandaki Province was 31,888, as reported in the Flash Report 2018/19 of Nepal. The sample size was calculated by $n= z^2 p (1-p)\div e^2$ where n-sample size, confidence interval-95%, percentage of vaccinating population (p) & percentage of not vaccinating population (q) & marginal error (e) = 0.05. For elaboration, the prevalence of full dose vaccination ≥ 18 years on October 31, 2021, dashboard record MoHP (p) = 36.1%= 0.36 & non-vaccination (q) = 1-0.36= 0.64. Therefore, (n_0) = 1.96 ×1.96× 0.36×0.64÷ (0.05)2 = 354. Finite population size of school teachers (N= 31,888) and n_o= 354 correction for proportions, effective sample size formula is n = no/(1+ (no-1)/N) = 354÷ 1.01 = 350.49= 350. The design effect was calculated as 1 + p (no-1). Where intracluster correlation (p) = 0.19 and average size of cluster (n_0) = total of number of teachers ÷ total number of schools in Gandaki province = 31888÷4594= 6.94= 7, design effect = 1+ 0.15 (7-1) = 1+.9= 1.9. The effective sample size (n) = sample size ×design effect = 350×1.9= 665. A 10% non-response rate was assumed, resulting in a sample size of 665 + 66.5 = 732. Moreover, the target populations were in Manang (P1 = 315), Kaski (P2 = 5,562), and Nawalparasi East/Nawalpur (P3 = 3,519). $p = P_1+ P_2+ P_3$, p=5562+315+3519. = 9396 (Flash report, 2018/19). The proportionate sample sizes for Manang, Kaski, and Nawalparasi East district were as follows: Manang (n1) = 732 × 315 ÷ 9396 = 24.29, Kaski (n2) = 732 × 5562 ÷ 9396 = 433.3, and Nawalparasi East district (n3) = 732 × 3519 ÷ 9396 = 274.05. Nepal has three ecological belts (Mountain, Hill, and Terai), which correspondingly represent the Manang, Kaski, and Nawalpur districts. Multi-stage cluster sampling was used. Firstly, rural and urban municipalities were randomly selected. Secondly, wards were randomly selected. Lastly, all teachers from the selected schools were requested to complete the questionnaire.

The questionnaire was prepared based on various existing literature. The questionnaire was reviewed by faculty and health experts. The tool contains background variables and core response items derived from the guidelines, policies, and practices of governments (federal, provincial, and local/municipal). Fifteen item statements on activities (risk communication and community engage-

ment guidelines) from the health and education sectors of government and other stakeholders (development partners, parents) were developed to control the spread of COVID-19. The tool was first developed in English and then translated into the Nepali language. Pilot testing was conducted among 36 teachers from a different study site. Statements were contextualised according to their suggestions. Finally, the instrument was administered in Nepalese language. Data were collected through self-administration during the teachers' leisure periods.

Data were edited, coded, and analysed using descriptive and inferential statistics in the Statistical Package for the Social Sciences (SPSS) version 27.0. The summative score of fifteen-item statements was categorised into adequate (mean and above) and inadequate (below the mean) by the mean value. Chi-square tests and logistic regression were used to identify predictors and assess the extent of their contribution to responses regarding COVID-19 pandemic management and reopening schools, with a p-value of 0.05.

Ethical approval was initially obtained from the School of Education at Kathmandu University. Furthermore, ethical clearance was obtained from the Institutional Review Committee (IRC) of Kathmandu University School of Medical Sciences (IRC-KUSMS) on August 10, 2022. The registration number was 143/ 22. The autonomy and confidentiality of participants were strictly maintained throughout the research process.

3. Results

3.1. Background Characteristics of Respondents

Table 1 shows that 53.7% of teachers were female, and 75.7% of teachers had 20 years or less of teaching experience. Almost an equal number of teachers had families with five or more members (49.1%) and those with fewer than five members (50.9%). Additionally, 83.6% of teachers had a monthly income of 20,000 Rs or above in their families, and 68.9% of teachers were from urban municipalities.

Table 1. Background Characteristics of Respondents (n=737).

Backgrounds	Attributes	Frequency	Percentage
Gender	Male	341	46.3
	Female	396	53.7
Work experience	≤ 20 years	549	75.7
	≥21 years	146	24.3
Number of family members	<5 members	375	50.9
	≥5 members	362	49.1
Monthly family income	<20,000Rs	121	16.4
	≥20,000Rs	616	83.6
Municipal type	Rural	229	31.1
	Urban	408	68.9

3.2. Responses for COVID-19 Pandemic Management

The results show that 87.3% of teachers positively reported enforcement of risk communication and community engagement guidelines to prevent COVID-19; the National Health Education Information and Communication Centre (NHEICC) disseminated information about preventive measures for COVID-19 (97.0%), and the Government of Nepal has implemented COVID-19 infection prevention and control guideline (92.2%). The government adopted a digital/remote or closed-united groups (CUG) strategy to reorganise the education system, including schools. A majority of teachers (89.3%) reported that the government of Nepal implemented the students' learning facilitation guideline-2077, and the government enforced the smart lockdown strategy for school operations through local-level governments/municipalities (83.6%). Due to the spurious distribution of COV-

ID-19 in the community, the Government directed schools to support students' learning through remote or digital media (89.3%). To address the outbreak management of COVID-19 in the future or for long-term management, the government of Nepal has adopted extensive vaccination against COVID-19 for students and teachers in schools aged 12 years and above (89.3%), as shown in Table 2.

Additionally, 87.8% of teachers agreed that municipal had coordinated schools to operate following preventive measures against the COVID-19 pandemic, collaborated with the school management committee to monitor preventive measures (74.9%), supported common goods of COVID-19 (masks, sanitiser, water, and soaps) to schools (87.0%) and community-based organisations had donated common goods of COVID-19 to schools (85.3%). A majority of teachers (80.9%) rated that parents/guardians supported alternative learning activities at school, and municipalities made COVID-19 vaccines accessible to schools (92.8%). However, teachers rated municipalities as having established quarantine centres (53.7%) and isolation centres for the COVID-19 pandemic (38.0%), as shown in Table 2.

Table 2. Statement of Responses towards COVID-19 Pandemic Management.

	Items	Yes n(%)	No n(%)
1	The GON enforced guidelines for risk communication and community engagement.	641(87.0)	96(13.0)
2	NHEICC disseminated information messages about COVID-19 preventive measures through mass media.	715(97.0)	22 (3.0)
3	The GON enforced the COVID-19 infection prevention and control guidelines.	665(90.2)	72(9.8)
4	The GON enforced the Alternative Learning System Facilitation Guideline of 2077.	658(89.3)	79(10.7)
5	The GON executed a smart lockdown strategy for school reoperation.	616 (83.6)	121(16.4)
6	The GON suggested learning through remote or digital media in schools.	658(89.3)	79(10.7)
7	The GON executed a strategy of voluntary vaccination against COVID-19 for teachers and students (12 years and above).	675 (89.3)	79 (10.7)
8	Municipals coordinated schools to re-operate following preventive measures	647(87.8)	90 (12.2)
9	Municipals and SMC jointly monitor COVID-19 preventive measures.	552 (74.9)	185(25.1)
10	Municipals supplied COVID-19 goods (masks, sanitiser, soaps) to schools.	641(87.0)	96(13.0)
11	Community-based organisations supplied COVID-19 goods to schools.	629(85.3)	108(14.7)
12	Parents supported alternative learning activities over traditional school settings.	596(80.9)	141(19.1)
13	Municipal made COVID-19 quarantine at schools.	396 (53.7	341(46.3)
14	Municipalities made COVID-19 isolation centres at schools.	280 (38.0)	457(62.0)
15	Municipalities made COVID-19 vaccines accessible to schools.	684(92.8)	53(7.2)

Note-SMC- school management committee, the government of Nepal, NHEICC- national health education information, communication and centre

3.3. Teachers' Perception of Responses to COVID-19 Pandemic Management

Table 3 depicts that 69.7% of teachers perceived an inadequate response to managing the COVID-19 pandemic and reopening schools.

Table 3. Perceived level of responses to manage the COVID-19 Pandemic.

Perceived level	Number	Per cent
Inadequate	514	69.7
adequate	228	30.3

3.4. Association of perceived responses to Pandemic management with Participants' Variables

Table 4 shows that there is an almost equal number of male (30.5%) and female (30.0%) teachers with an adequate understanding of responses regarding COVID-19 pandemic management. Gender was not significantly related to teachers' perceptions of responses to pandemic management (p = 0.89). Furthermore, perceived adequate responses to COVID-19 pandemic management were lower among those with 20 years or less of work experience (29.5%) than among those with 21 years or more (31.5%). Work experience was insignificantly related to teachers' perceptions of responses to the COVID-19 pandemic ($p = 0.56$). Furthermore, perceived adequate responses to COVID-19 pandemic management were nearly equal among teachers with a family size of five or fewer (30.4%) and those with a family size of five or more (30.1%). Family size was not significantly related to teachers' perceptions of responses to the COVID-19 pandemic ($p = 0.30$). Likewise, perceived adequate responses to COVID-19 management were almost equal among teachers from families with a monthly income below 20,000 Rs (31.4%) and those with an income of 20,000 Rs and above (30.0%). The monthly family income had no significant impact on teachers' perceptions of COVID-19 pandemic management ($p = 0.7$). Teachers' perceived adequate responses to COVID-19 pandemic management were higher among those from urban (31.5%) than rural (27.5%) municipalities. The type of municipality was insignificant ($p = 0.27$) in terms of teachers' perception of efforts in managing the COVID-19 pandemic.

Table 4. Associations of Perceived Responses to Pandemic with Participants' Characteristics.

variables		Inadequate n (%)	Adequate n (%)	X^2	p
Gender	Male	237(69.5)	104(30.5)	0.01	0.89
	Female	277(69.9)	119(30.1)		
Work experience	≤ 20 years	387(70.5)	162(29.5)	0.33	0.56
	≥21 years	120(68.2)	56(31.8)		
Number of family members	<5 number	261(69.6)	114 (30.4)	0.07	0.93
	≥5 number	253(69.9)	109 (30.1)		
Monthly family income	<20,000Rs	83(68.6)	38(31.4)	0.09	0.76
	≥20,000Rs	431(70.0)	185(30.0)		
Municipal type	Urban	348(68.5)	160(31.5)	1.18	0.27
	Rural	166(72.5)	63(27.5)		

3.5. Logistic Regression Analysis on Perceived Responses with Participants' Characteristics

The results show that experienced teachers with 21 years or more of experience were more likely to have a positive perception of responses regarding the COVID-19 pandemic (B = 0.11; odds ratio (OR) = 1.11, p = 0.57). Teachers from urban municipalities were more likely to have unfavourable perceptions (B = 0.02, OR = 1.22; p = 0.26). However, municipal type and teaching experience were insignificant in teachers' perceptions of responses to the COVID-19 pandemic. Moreover, female participants (B = -0.02, OR = 0.98; p = 0.90), monthly family income ≥ 20,000 Rs (B = -0.074, OR = 0.92; p = 0.51), and number of family members (B = -0.007, OR = 0.99; p = 0.93) had negative relation in perception to response about the COVID-19 pandemic management in school. The model of work experience, municipal type, female teachers, teachers with a monthly family income of 20,000 rupees or above, and family members of 5 or more poorly predicted teachers' perceptions of responses regarding COVID-19 pandemic management, as shown in Table 5.

Table 5. Logistic Regression Analysis on Adequate Responses with Background Characteristics

Variables	B	Ex(B)	p
Gender *(female reference male)*	-0.020	0.980	0.908
Work experience *(≥21 reference ≤ 20 years)*	0.111	1.118	0.570
Family size *(≥5referrnce <5 members)*	-0.007	0.993	0.936
Family income *(≥20,000 reference <20,000Rs)*	-0.074	0.929	0.517
Municipal type *(urban reference rural)*	0.206	1.229	0.261
Constant	-0.075	0.417	0.002

4. Discussion

This study reveals that 69.7% of teachers perceived inadequate responses to the management of the COVID-19 pandemic and the reopening of schools. Similarly, a study has shown that resource-limited countries lack testing, tracing, and isolation capacity and are unable to establish quality quarantine centres throughout the nation (Rayamajhee et al., 2021). A comprehensive health literacy campaign, along with assurance of quality care for older adults and individuals with comorbidities, supports the effective management of future pandemics.

Moreover, the present study shows inadequate perceived responses to the COVID-19 pandemic. In case of pandemic conditions of public health, different activities such as enabling parental engagement and support; improving digital competence amongst pupils, teachers and parents; considering opportunities for smaller class sizes and additional staffing; and improving mechanisms of communication between schools and families, and between government and schools (Marchant et al., 2021) support to continue education activities in schools. During the pandemic, a digital divide was observed in the teaching and learning activities of students (Gurung & Poudel, 2021) and teachers. The availability and accessibility of information and communication technologies (ICTs) for online teaching during pandemics, lockdowns, or other challenging conditions, as well as the engagement of students in collaborative learning activities (Adhikari & Rana, 2022), provide alternative ways to sustain academic activities. During the COVID-19 pandemic in Jordan, educational institutions, including medical schools, more frequently utilised social media to disseminate knowledge and conduct routine classes through online messaging plans in the early stages of medical and public health emergencies. (Khasawneh et al, 2020).

The present study shows better response efforts in urban municipalities (B = .206, odds ratio = 1.229, p = 0.261). It might be due to poor coordination between different levels of government, particularly between province and local levels (Chaudhary, 2019 & Mokhele, 2024).). Therefore, local levels are blamed for bypassing the province, as the linkage between them and the province is poor due to insufficient laws and regulations. Moreover, digital services were not effective at all local levels in Nepal.

The study has implications for municipals, families and schools. Municipalities should reform their policies and advocate for effective pandemic management within their territories.to prevent the spread of outbreaks and continue school operations during and after disasters. Furthermore, school-based disaster intervention programs help promote the perception and coping skills of teachers, students, staff, and parents. Under these conditions, school authorities and leaders can enhance disaster education among teachers, students, and parents by communicating effectively about disaster risk and management.

This study is not free from some limitations. This cross-sectional design identifies an association, but it requires precautions to understand causal relationships among variables. The tool was self-administered among teachers. It may increase recall bias or lead to socially desirable reports. Future research should employ a longitudinal design, incorporating other variables, to establish causal relationships.

5. Conclusion

The present study reveals that 69.7% of teachers had an inadequate perception of responses to COVID-19 pandemic management in schools. Interventions from concerned authorities in health, education, and social security during outbreak management help promote teachers' perceptions and inform their preparedness for future disasters, such as the COVID-19 pandemic, in schools. Furthermore, this study suggests that interventions that consider the personal and situational characteristics of schools can help make society and communities resilient to future pandemics. Moreover, this study suggests that policymakers and academicians provide disaster education to in-service and prospective teachers to promote teachers' positive perceptions and practical responses for future pandemics.

This study also suggests that the relevant authority should advocate for continuous training in disaster management, including the use of digital technology, better resource allocation, improved infrastructure, and effective coordination among government agencies and development partners at both national and international levels. Nepalese teachers should enhance their efforts, skill, willingness, and efficiency to exemplify resilience and solidarity in the face of adversity, embodying the spirit of a nation that refuses to bow to the forces of nature.

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Declination of the Strategic Compass: Transatlantic Elites, German Leadership, and the Future of European Security

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ABSTRACT

The appointment of Friedrich Merz as Germany's new Chancellor, following an unusual repeat vote, marked a significant shift in German and broader European political dynamics. This paper examines the enduring influence of transatlantic networks, notably the Atlantic Bridge (Atlantik-Brücke), on Germany's strategic orientation within the evolving European security architecture. Through comparative and analytical-deductive methods, the study explores how elite transnational structures, shaped by economic and ideological power centres, influence the implementation and limitations of the European Union's Strategic Compass for Security and Defence. The paper argues that this strategic framework, conceived as a response to contemporary crises such as the war in Ukraine, may be increasingly subject to "declinations" driven by competing geopolitical interests and internal legitimacy challenges within EU member states. By tracing the personal and institutional ties of key actors, including Chancellor Merz, the paper sheds light on the deeper geopolitical alignments that underpin NATO-EU cooperation and transatlantic risk governance. The findings highlight the urgent need for a more balanced and citizen-oriented security strategy if lasting peace and stability are to be achieved in Europe.

KEYWORDS

Security; emergency; Friedrich Merz; Atlantic Bridge; Strategic Compass; European Security; NATO; Transatlantic Elites; Risk Governance; Ukraine; Germany; EU Foreign Policy.

1. Introduction

Friedrich Merz is not a new name on the German political scene. Since his youth, he has been a dedicated member of the Youth Union, joining in 1972. It is a special and joint organisation of German youth from the ranks of the Christian Democratic Union and the Christian Social Union. It is considered the strongest youth political organisation in Germany. It was founded *before* the establishment of the new state – the Youth Union was established in 1947, and the Federal Republic of Germany (colloquially known as West Germany) was established in May 1949. This fact alone in-

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dicates the importance that the then masters of the occupied western part of the recently destroyed Third Reich, primarily representatives of the American state, attached to preparing youth for the new era. The most famous members who came from the ranks of the Youth Union were Gunther Oettinger, who was Minister-President of Baden-Württemberg; Christian Wulff, former President of Germany; Wolfgang Schäuble, former Federal Minister of the Interior; hans-gert Pottering, former President of the European Parliament and, last but not least – Helmut Kohl, Federal Chancellor from 1982 to 1998.

Even a cursory glance at these very prominent names in (West) German politics during the reconstruction of German statehood after World War II and the decades that followed shows that they were a "nursery" of future cadres and a kind of pivot of continuity. Traditional Catholic parties, such as the German Center Party, had squandered their decades-long credibility, especially on the eve of the Nazis' rise to power (during World War I and until 1932, it produced German chancellors four times). Since many Catholic priests in "Weimar Germany", such as Alois Hudal, were significantly compromised by their collaboration with the Nazis and, especially, their support for the "war channels" after World War II, a new positioning on the "centre-right" was needed. On June 26, 1945, the Christian Democratic Union of Germany (*CDU – Christlich Demokratisce Union Deutschlands*) was founded together with its "sister" Christian Social Union (*CSU-Christilich-Soziale Union*) in Bavaria, which was founded in October 1945. According to the Encyclopedia Britannica1, the two key foundations of this new alliance were a social market economy ("a mixture of a free capitalist market with strong state regulation") and the overarching principle of the "welfare state"; an anti-communist, pro-American foreign policy directed towards "European integration".

The CDU-CSU coalition won a convincing victory in the 1949 general elections. According to Britannica, this triumph was achieved primarily by two men: Konrad Adenauer (*Konrad Adenauer*) and Ludwig Erhard (https://www.britannica.com). The former became Chancellor, and the latter, as Minister of Economics and a Nazi sympathiser, was first the creator of the "German economic miracle" and then became Chancellor himself in 1963. However, some more recent sources (https://www.ineteconomics.org) claim that the real creator of this renewal was Edward Tenenbaum – an American Jew. The latest German Chancellor also comes from this and such a political "milieu", but he operates in circumstances that could be called "something old – something new". For a significant part of his political engagement in adulthood, Friedrich Merz served as an alter ego to the then-Chancellor Angela Merkel. It is believed that it was precisely because of her rise that he left politics for a while and did very lucrative work for the American law firm "Mayer (and) Brown ". The aforementioned law firm was founded in the late 19th century. The early founders were Adolf Kraus and Levy Mayer. The former, originally from the Czech Republic, was known as one of the spiritual leaders of the Jewish community in his environment, an associate of the "Sons of the Covenant" (*B'nai B'rith*). The latter was known for defending large corporations of his time from antitrust lawsuits. So, he was in the function of significant capital. Much later, Merz would also "surf" on that wave.

According to data available on the global network, Joachim-Friedrich Martin Josef Merz, as his full name is, was on the boards of directors of many powerful corporations: a) Robert Bosch" (*Robert Bosch*); b) BlackRock in *Germany*; c) Ernst and Young; d) Axa; e) German Stock Exchange" (*Deutsche Borse*) etc. This certainly contributed to significantly improving his material status and joining the ranks of millionaires and the "jet set" (owning a private plane). Now comes a much more difficult task - revitalising the German economy, the "sick man of Europe", as the British "Times" called Germany, on the 12th. January 2025 (https://www.thetimes.com), certainly alluding to the former "sick man on the Bosphorus", that is, Turkey, as it was called in the 19th century throughout Europe based on a "joke" by the Russian Tsar Nicholas I.

"He supports economically liberal policies while taking a more conservative stance on social issues. Under his leadership in the last legislative period, the CDU has more explicitly emphasised its right-wing stance. The party's new basic platform, approved in 2024, marks a clear departure from Angela Merkel's policies in many areas: it now, for example, advocates the return of compulsory military service and the retention of nuclear energy. The new program also marks the reintroduction of the concept of German culture as a Leitkultur, or core culture, in Germany. This is an issue that

Merz initiated a debate on in 2000 when he was the leader of the CDU/CSU parliamentary group in the Bundestag," claims Deutschland (https://www.deutschland.de). Apart from their disagreements on certain positions with Merkel, the central issue between Merz and "Mutti" was who would be the leader. What indeed connected them was their membership in one of the first international "clubs" established in the Federal Republic of Germany after World War II. That organisation still exists today and is called the "Atlantic Bridge " (*Atlantic Brucke*).

2. Atlantic bridge

The Atlantic Bridge organisation is a child of the Cold War. It was founded in Hamburg in 1952. As its name suggests, it is (geo)politically oriented towards expanding German-American cooperation in all fields while also supporting Atlanticist structures, the most visible part of which was – and remains – the recently founded NATO (North Atlantic Treaty Organisation), or the North Atlantic Alliance, in 1949. This support was significant in preparing German public opinion for the country's entry into the new military bloc. The Federal Republic of Germany would join this "wave" later, in 1955.

The founder of the Atlantic Bridge was Eric M. Warburg (*1900-1990*). He was a prominent member of the Jewish-German-American Warburg family. The headquarters of the family bank MM Warburg) which he managed for almost a decade in Hamburg, where the Atlantic Bridge was founded seven years after the end of World War II. Incidentally, the bank was founded by the Warburg brothers, Moses and Marcus, back in 1798. It began as a money exchange office. The most influential figure in the Warburg family was Max Moritz Warburg. His mother was from another powerful banking family, the *Oppenheims*. Brother Paul Warburg was a member of the Board of Directors of the US Federal Reserve, and Brother Felix was the son-in-law of Jacob Schiff (1847-1920), a prominent figure in the equally powerful banking firm of Kuhn, Loeb & Co. Jacob's father had worked as a broker for the rising Rothschild banking family. He went down in history not only as a great banker and railroad magnate, along with his partners, but also as the leader of a massive loan to Japan for the war against Russia (1904-1905). For his efforts, he received the Order of the Rising Sun from the Emperor of Japan.

All of the names above, in fact, constituted a kind of Western *proto-nomenclature* (Ilić, 2002, p. 20) from which, later, through generational extensions and connections with partners from Europe and the USA, the Federal Reserve Bank of the USA and the most important international monetary institutions, the Bank for International Settlements, the World Bank and the IMF, would emerge.
It is clear that the "Atlantic Bridge", as an organisation with strong foundations, had every chance of succeeding in a defeated and embittered Germany; however, it was now already overwhelmed by entrepreneurship and enrichment, marked by the so-called "economic miracle".

Friedrich Merz was at the head of the Atlantic Bridge for a full ten years. In his farewell speech, when he took over his duties in July 2019, he thanked the members and the Board of Directors for the good working cooperation: "It has been a great pleasure and an honour for me to be the President of the Atlantic Bridge for 10 years. One thing has become clear many times: the transatlantic relationship is more than trade policy or a security alliance.

"The Atlantic Bridge organisation was featured in the September 29th issue of Spiegel magazine. January 1958. described as 'The Association of Former Occupation Officials of Post-War Germany'. It is, therefore, not surprising that between 1957 and 1970, the Atlantic Bridge published an information magazine, Meet Germany, aimed at American soldiers stationed in Germany. After all, it is *a propaganda organisation of former occupying powers*. Why are people like the editor-in-chief of Bild, Kai Diekmann, its members? The *Atlantic* Bridge is just one such association out of around 600,000. That the Atlantic Bridge is an organisation that stands out among rabbit protection and breeding associations, as well as rowing and gardening associations, is clear at first glance from the list of those who are closely affiliated with the organisation or are its members. The board of directors of this prestigious association includes Walter Leisler Kiep, the former Federal Treasurer of the Christian Democratic Union (CDU). He was also a member of the Supervisory Board of Volkswagen and the

chairman of the Atlantic Bridge from 1984 to 2000. The current chairman of the Atlantic Bridge is the CDU politician Friedrich Merz, who is also a member of the Trilateral Commission, founded by David Rockefeller. The deputy president is the vice president of the Bundestag, Edelgard Bulmahn (SPD), who is also affiliated with the Rockefeller Trilateral Commission, a private interest financing community (Ulfkotte, 2014, p. 137).

Why is Kai Deckmann singled out? He is a journalist with a strange biography, who already in his younger days wrote for the Catholic school newspaper "Passepartou" and as a young man was invited to "Axel Springer", one of the largest media houses of the time. With a dizzying rise, he became a prominent journalist for "Bild", the most widely circulated tabloid in Europe at the time, and remains so to this day. He helps write and publish the biography of Helmut Kohl, the former Chancellor of Germany. Before he departs from this "valley of tears", he meets the great unifier, who, on the anniversary of the fall of the Berlin Wall, goes to the grave of Frederick II the Great (*Friedrich der Grosse*), Emperor of the Holy Roman Empire, who was also a role model for Adolf Hitler. That Kohl was no stranger to this "flirting with the Nazis " was clear early in his reign when, with Ronald Reagan, he went to the SS cemetery near Bitburg in May 1985 as a sign of "reconciliation with history".

It was not the first time that the spirit of Frederick the Great was invoked: on the famous "Day in Potsdam", on March 21, 1933, the old Marshal von Hindenburg and the new Chancellor Adolf Hitler met in front of his grave in the Garrisonkirche. It was important to present the "Führer" as the successor of the ideas of both the great Frederick and the great unifier Bismarck (*Otto von Bismarck*). At that time, a propaganda postcard was famous, showing the profiles of the king, the steel chancellor, and the Führer to emphasise the continuity and the essence of "European civilisation" (Bled, 2011, 310). The modern architecture of European security cannot be fully understood without recalling the meetings between US President Ronald Reagan, Pope John Paul II, and then-German Chancellor Helmut Kohl in June 1987. The visits were held on the occasion of Berlin's 750th anniversary, at a time when the "Berlin Wall" still existed and Germany was divided into the so-called East and West. On that occasion, Reagan solemnly declared:

"Berlin has overcome desolation and isolation time and again with will, energy, and courage. Even now, its spirit towers over the wall that presently divides the city. Today, Berlin remains close to the spiritual centre of the Western world. Americans have a special affinity for Berlin that extends beyond formal political or economic ties because we feel a kinship with its spirit of strength and creativity and because we see our hopes and ideals reflected in the deep attachment of its people to freedom and its blessings. Thousands of Americans—scholars, servicemen and women and their families, business people, diplomatic personnel, and so on—live in Berlin and make vital contributions to the life of the city. We have helped Berlin grow, and we have shared its spirit." (Reagan Library, proclamation 5665).

The most striking "triple pact" of the 20th century was neither the aggressive "Central Powers" of World War I nor the "Axis Powers" of World War II, but rather the understanding among Reagan, Wojtyla, and Kohl. Can we understand today's war in Ukraine without these facts? In an ideological sense, the "march to the East" and the expansion of NATO beyond the borders of the area for whose "preservation" it was supposedly founded, as well as the future unification of Germany, were very "compatible" with the three leaders who would go down in history as the "victors over communism", with the same ideology that Karl Marx, a descendant of a rabbi from Holland, wrote in Brussels and London.

However, even after the unification of first Germany and then (Western) Europe, it was not easy to define the term "European". It is not easy today, and Friedrich Merz, along with all other leaders of the "duplicated" EU since Maastricht, are facing this challenge. One of the authors who played a significant role in the "understanding of the Balkans" for then-US President William Clinton, Robert David Kaplan, attempted to answer this question by analysing the works of the Irish writer James Joyce. " To *be European means to be cosmopolitan, therefore free from the shackles of religion, ethnicity and other forms of group identity* "(Kaplan, 2023, p. 143).

European or not, in farewell to his long-time "comrade" in the fight for a "more liberal and European" Germany, the respected journalist Kai Deckmann published a warm column, a *de facto* obitu-

ary, on the *Kress* website on June 30, 2017, entitled "My Friend Helmut Kohl." The article states that the German Chancellor told him during their last meeting: "People are sinners, and you, my dear Kai, although you are a staunch Catholic, are no saint." https://en.ejo.ch). In any case, Helmut Kohl, while still in his prime, offered to be the best man at the wedding of Kay Deckmann and his wife. It was a kind of recognition of Deckmann for his contribution to the development of "Bild", in fact, to the Americanization and tabloidisation of the German media space. But also an example of good cooperation between the "guys from (and around) the Atlantic Bridge".

On the global business network LinkedIn, the current role of the organisation "Atlantic Bridge " is stated as follows: "Atlantic Bridge aims to deepen cooperation between Germany, Europe and America. Transatlantic cooperation remains a crucial factor in maintaining global order and stability, particularly in times of challenge. Now that *nationalist tendencies are gaining popularity worldwide*, Atlantic Bridge is more committed than ever to its mission. *It advocates for multilateralism, open societies, and free trade*. As a non-profit, non-partisan association, Atlantic Bridge strengthens the exchange between politics and business, as well as between young leaders and representatives of civil society. It provides a platform for diverse perspectives and fosters lively debate. The approximately 800 members of Atlantic Bridge are decision-makers from business, politics, science and the media on both sides of the Atlantic.

These three highlighted sentences from the above paragraph would make every devotee of the "multiculti religion" happy. Still, they would also elicit an ironic smile in at least three-quarters of the world, which comprises the vast majority of the global population. Because in these countries, "nationalist tendencies" are read as a response to threats to sovereignty; open societies are reminiscent of the role of George Soros and today's younger successors of the figure and work of Karl Popper; free trade is read as a monopoly of global world corporations; "membership by invitation" is reminiscent of – sectarianism and communist-type parties.

At that time, the entire "European " (read: pro-globalist) press and electronic media had a similar tone, and the determinants can be summarised in a few basic points discussed in the EJO (*European Journalism Observatory)* from January 20, 2017*:*

- Trump questions the post-war order
- Trump is destroying the European Union
- Frivolously dismissing the ideas of European integration and the second largest market in the world as unimportant is ignoring history and rejecting the future.
- Once destroyed, Western alliances will not be easily rebuilt.
- Trump's presidency will mark *a new beginning for US-German relations, and not in a good way.*
- There will be a growing nationalism in Europe
- Europe will be left to *make deals with Russia in a weakened position on Russian terms.*

Many of the same concerns plague European leaders today, including the newly elected, yet not a newcomer, Friedrich Merz. "European nightmare", Trump was elected for the second time, to the alleged or absolute horror of the established European and world order. During his first term, there was no war like the one that began later in Ukraine, when Joseph Biden was already at the helm of the USA, *with expressed personal interests in Ukraine*, similar to those that the late Madeleine Albright, real name Korbel, former US Secretary of State, and General Wesley Clark, real name Kane, or Goldman, had in Kosovo. "In his hawkish policy toward Russia, Biden has found a willing partner in Ukrainian President Volodymyr Zelensky. It is hardly a coincidence that Zelensky's massive turnaround in relations with Russia began just as Biden took office," Al Jazeera states, January 18, 2025).

3. Declination of the strategic compass

The "Strategic Compass for Security and Defense" document was drafted by the European External Action Service and adopted by the European Council on 25 May 2022. The document is a type of "(inter)national security strategy" similar to those used on the other side of the Atlantic, in the USA.

The Introduction already states the "main reasons" for adopting the "Strategic Compass": "Russia's war of aggression constitutes a tectonic shift in European history. The European Union is more united than ever in the face of Russia's unprovoked and unjustified military aggression against Ukraine, which grossly violates international law and the principles of the UN Charter and undermines European and global security and stability. Readers in the Balkans were certainly amused when they read the lines here, remembering the "adherence " of the EU, the USA and NATO to the UN Charter during the 1990s, when all the principles of the United Nations and the OSCE were violated. The Socialist Federal Republic of Yugoslavia was destroyed, the only state in Europe that resembled the future European Union in structure, only with far more related peoples than those who make up that union today. Not to mention the "respect" of UN Security Council Resolution 1244 of June 10, 1999.

In any case, in such a context of the "declination of the strategic compass", the revitalisation of which is expected precisely in 2025. , Friedrich Merz and all the "NATO allies" will be forced to act. 16) We have already seen that the "Atlantic Bridge" was and remains an important "reservoir of personnel" when it comes to both West Germany and today's Germany. In a similar manner to how the American Council on Foreign Relations operated for decades, this American organisation had a much broader and more autonomous space for action than the association that emerged in the middle of the Cold War in defeated Germany. In the context of achieving peace in Europe (understood more broadly than the EU), it would be undoubtedly helpful if leaders like Merz had also kept in mind what Russian leader Putin said in an interview with Oliver Stone in response to the American director's question-statement: "The US can maintain a united, pro-American Europe and NATO only with the help of an external enemy like Russia": "I can say with certainty – yes, that is true. I know it; I feel it. Without that internal discipline, the Euro-Atlantic idea is destabilising. We are not living in the Cold War era. A few years ago, certain leaders told me that our American friends asked me to intimidate them. However, they said they were not afraid. They understood that the world had undergone a significant change. Moreover, as for that external threat – it is difficult to introduce such strict discipline. It is in someone's interest, but I think such logic is wrong. Since such thinking is rooted in the past, we must also look to the future. You must understand that the world is different now, with new threats and strategic challenges. We cannot freeze and remain as if we were living in the Cold War era .", Vladimir Putin replied (Stoun, 2017, pp. 78-79).

However, one of the first joint steps taken by European leaders after the German elections was the departure of French President Emmanuel Macron, British Prime Minister Keir Starmer, and Friedrich Merz to Kyiv via train from Poland. Historical memories of when Poland was an important factor in Ukraine, as well as the severe suffering of Poles at the hands of the Nazi regime in occupied Ukraine and their satellites during World War II, were not in the foreground on this occasion. Instead of a joint celebration of Victory Day over Nazism and Fascism, the European leaders paid their "homage" to that important date. They appeared before the European and world public with a proposal for a "30-day truce".

The leading European media, and a good part of the world's media, would not be "modern" if they did not, in the foreground of the visit, especially via social networks (which are anything but social), stage a spectacle in the form of accusations that the three European leaders enjoyed using opiates on the long journey from Poland to Ukraine. This would perhaps even be comical if such an approach did not reveal something else: the complete crisis of legitimacy among (political) figures in Europe. If, in a situation where a fratricidal war is raging in one part of the Old Continent, and Putin himself said about ten years ago that "the Ukrainian and Russian peoples are not just close relatives, we are almost one people" (Stone, 2017, p. 187), and the mainstream media foreground bizarre details about the "meeting of three leaders" on a (blue) train, it is evident that kitsch civilisation and "cowboy journalism" have taken deep roots on the European continent as well.

What are some other striking features of the "Strategic Compass", an important document for understanding more the "defence climate" than the real intentions of European policymakers, as well as other steps taken so far? Let us list just a few: assessment of the strategic environment and threats facing the EU. The document is based on four pillars: action, investment, partnership, and security; rapid response capabilities in response to a crisis beyond its borders; preventing conflicts before they occur or reducing the scale or impact of violence (based on Article 21 of the Treaty on European

Union); EU-NATO cooperation is an integral pillar of work in the field of security and defence; EU-UN Strategic Partnership in (Peacekeeping Operations and Crisis Management 17).

There is no doubt that there is a danger that in the conflict in Ukraine, both sides will exploit a possible ceasefire for additional military activities and rearmament. Such experience already exists from the wars in the former Yugoslavia. The assistance to the "democratic military forces in Croatia", headed by the pro-Ustasha, therefore pro-Nazi, leader Gojko Šušak (1945-1998), who was tolerated for decades in North America, to be "used when the time comes", is well known. The funeral of this former Minister of Defense of the "new Croatia" was also "presented" by the former US Secretary of Defense – William J. Perry. By his act, he confirmed that the ties between the Nazis and their followers, which began long before the outbreak of World War II, continued with the rescue of Nazi criminals and officials immediately after its end and their incorporation into new "European communities", have survived to this day (Ilić, 2020).

Chancellor Friedrich Merz is well aware of what a "strategic compass" entails. Still, he also sees that it can have specific "declinations" and that the original text will most likely be revised, as will practice, if lasting peace in Europe is to be achieved. The main problem that EU leaders will face, especially the "chosen ones", like the trio from the "train to Kyiv", will be moral credibility. It has been damaged for a long time, and this also applies to most leaders of non-European states. *The crisis of legitimacy, as well as that of personality, which we have already discussed, has been eroding the European building since its inception*. And not only her.

"The political evolution of Europe is essentially a matter for Europeans to decide. However, the Atlantic partners have a significant stake in it. Will emerging Europe remain an active participant in the construction of a new international order, or will it be consumed by addressing its internal problems and issues? Contemporary geopolitical and strategic realities preclude the pure balance-of-power strategy employed by traditional European powers. However, the organisation of rules and norms of the emerging pan-European elite will not be able to demonstrate sufficient ability to find ways and paths for a global strategy if it does not follow the movements in geopolitical realities. The US has every reason, based on history and geopolitics, to encourage the European Union and prevent it from drifting into a geopolitical vacuum. If the US were to separate itself from Europe in politics, economics, and defence, *it would become a geopolitical island far from the shores of Eurasia. Europe itself would turn into a pendant vast areas of Asia and the Middle East .*," warned the staunch Atlanticist Henry Kissinger (*1923-2023*), born in Germany and whose real name was Heinz Kissinger, in his "Reflections on the Character of States and the Direction of History" (Kisindzer, 2015, p. 107) Kissinger had invested his entire political life in separating and hindering the cooperation of the two "communist powers", the USSR and China. Towards the end of his long life, he lived to see the establishment of the BRICS (Brazil, Russia, India, China, South Africa) group.

4. "Blackrock" as a "Stability factor"

The capitalist power elite exists throughout the world. The globalisation of trade and capital is bringing the world's elites into increasingly interconnected relationships – to the point where social scientists have begun to theorise the development of a transnational capitalist class (TCC) over the past few decades, "Peter Phillips reminds us in his excellent book "Giants – The Global Power Elite"(Filips, 2021, p. 23).

It was during the great global financial crisis of 2008, which, like the 1929 crisis, brought ruin to some and enormous profits to others, that one name began to emerge, first from the background and then more and more clearly on the world's economic and political scene – BlackRock. It originated from the slightly older company Blackstone, founded in 1985 by Peter Peterson and Stephen Schwarzman, former colleagues from the old banking house Lehman Brothers. The two incorporated their names into their firm: Schwarz (meaning "black") and Petros (meaning "stone"). That same year, Peterson became president of the American Council on (Foreign Relations), a position he held until his retirement in 2007.

Laurence Fink, co-founder, chairman and CEO of BlackRock, was "raised in a middle-class Jewish family in Van Nuys, California" (Phillips, 71). He made his name at First Boston, where he had to leave after initial success because he misjudged the market for interest rates, which caused the bank significant damage. Perhaps it was this "stubbornness" that drove Fink to create what would become the world's largest money management company. Risk management was at the forefront, and so Aladdin (Asset Liability and Debt and Derivative Investment Network) was born, an electronic system in which thousands of analysts, using thousands of computers, monitor and examine all aspects of financial markets globally. One of Aladdin's users was Deutsche Bank.

In such circumstances, it is no surprise that a politician of such reputation and "background" as Friedrich Merz would become one of the leaders of "Blackrock" in Germany.

The analysis of BlackRock's German branch operations was conducted by Werner Rigemer (Private Banker International). He published his findings at the beginning of 2025 under the title "BlackRock Germany"; in the subtitle, he calls the company "the hidden world power" (Die heimliche Weltmacht). According to Rigemer, the citizens of Germany should be aware of how the world's largest investment firm works for the benefit of the global elite and how it invests vast amounts of money in the largest corporations and banks, such as "Bayer", "Deutsche Bank", "Adidas", etc. What he particularly emphasises is that almost all public companies in Germany, as well as in many countries around the world, are heavily influenced by "BlackRock". What is even more worrying is that the organised concealment of the "mailboxes" of large clients could lead to a system of tax evasion, similar to the so-called "tax havens (ports)", which would have unforeseeable consequences for the social market economy established after World War II. Of course, there is always a fear of inflation in Germany since 1923, when a banknote with a nominal value of 100 billion marks was issued. (Rugemer, 2025). In addition to its influence in prominent private and public companies, it seems that BlackRock will pay special attention to solar energy in Germany. Decarbonisation is a priority for many governments in Europe, and there is no doubt that the new German Chancellor will give it due attention.

However, given the financial power and potential behind the American giant, it is clear that energy and security will be intertwined, as always. Dirk Schmitz has been at the helm of German BlackRock, overseeing Austria and Eastern Europe, since 2018. Before taking office, he was responsible for global markets at Deutsche Bank. 20) A greater role for BlackRock in the German, and not only German, economy should contribute to the American strategic goal – reducing dependence on Russian energy resources both in Germany and in the entire EU. "On the one hand, the EU could benefit significantly from diversifying its sources of supply and thereby increasing competitiveness in the natural gas sector. This could have a direct consequence not only of a drop in gas prices but also of stimulating producers to increase deliveries and production capacities. However, despite all the EU's efforts to implement its policy of global diversification of energy supplies, it can be safely stated that Russia will remain the most important supplier to the European continent and that such a trend will exist as a constant in the medium term, in parallel with the diversification processes that will be implemented by both the EU and Russia. On the other hand, however, in addition to the positive ones, the launch of the 'diversification at all costs' strategy could also have negative consequences for Russian-European energy relations in terms of complicating the Energy Dialogue and weakening the Russian-European energy partnership." (Milosavljević, 2014, p. 484).

Unlike the leftists from the magazine "Hintergrund ", representatives of the German Council on Foreign Relations, a sister organisation of the "club" of the same name from the USA, have a completely different "worldview" and a completely different view of the development of Europe: "It is clear that, in the current situation, Europe - especially Germany - must significantly increase its defence efforts and this must be done together with the USA, but also in cooperation with other Western countries."

Dr. Stefan Meister, discussing the consequences of the war in Ukraine for the reconfiguration of the security system in Europe, explicitly states: "Russia's large-scale attack on Ukraine has led to a profound change in German policy towards Russia. Decades of efforts towards rapprochement have given way to retreat. The polarization of political forces in Germany, particularly in terms of security strategy (Hasan & Sultana, 2024; Sudar et al., 2024; Aleksandrina et al., 2019), is becoming

increasingly pronounced despite the seemingly straightforward "EU Strategic Compass". Traditional pro-American forces, embodied mainly in the victorious SDU/CSU coalition and the aforementioned Council on Foreign Relations, have encountered serious competition in the form of the "Alternative for Germany" (Alternative für Deutschland), which is considered far-right. However, its "worldview" is far more complex. However, many left-wing circles and intellectuals across the political spectrum are also very dissatisfied that "Atlanticism" is pushing Germany too far into the "Procrustean bed of American democracy". In their "Manifesto for Germany" (2017), they call for the return of national power and advocate for a Europe of nation-states, directly opposing the globalist vision of the world and the "Eurocrats" from Brussels. They explicitly advocate protecting German borders from false asylum seekers and following the principle of protecting victims, not perpetrators. In protecting borders and victims, they also have the "understanding" of the new German Chancellor, Friedrich Merz.

Since many of the points of the "Manifesto", such as scepticism towards the euro and the EU, are very appealing to a large number of German voters, the new German government will undoubtedly have to take this into account, especially when it comes to foreign and security policy (http://www.afd.de). A fundamental sentence from the "Manifesto", when it comes to security, refers to the role of NATO: "NATO membership is in Germany's interests when it comes to foreign and security policy as long as its role, as an alliance, *is defensive.* " (https://news.err.ee). The "New World Order" (or "New World Order"), a now somewhat forgotten expression, was promoted by U.S. President George H.W. Bush in a speech to the U.S. Congress on September 11, 1990. It was the prelude to the US "intervention" in Kuwait and then in Iraq, which marked not only the military dominance of the sole superpower but also the beginning of the media dominance of CNN. By a strange coincidence, the "terrorist attack" on the US occurred *on the same date*, but in 2001. It was the prelude to the "war on terror" and the invasion of Afghanistan to overthrow the Taliban, the same Islamic fighters that the US had recruited to fight the USSR.

In a time of intoxication with the "triumph in the Cold War", the US defined the foundations of its foreign policy and future military engagement in two documents called the "Wolfowitz Report" and the "Jeremiah Report", after the Undersecretary of Defense and the Admiral who led a large group of experts. They then determined that the primary goal of US foreign policy was to maintain hegemony. To achieve this, it was necessary to maintain the status of the sole superpower through a military power sufficient to deter any nation or group of nations from threatening US supremacy. At that time, a strategy was also defined towards the European allies: " *We should act in the direction of preventing the emergence of a European security system that could destabilise NATO* " (Bodson, 1996, pp. 18-19).

These very characteristics are constant even today when it comes to the American administration, not the Americans as a people, of course. Moreover, that is why the "Alternative for Germany" has become a political problem, and not because of its alleged or real extremism towards refugees or Islam. After all, one of the party leaders does not hide in public appearances her sympathy for Margaret Thatcher, but also for homosexuals (https://www.eruactiv.com).

Most of the founders of the Alternative for Germany came from the traditional, pro-European, and pro-American CDU/CSU coalition, which was dissatisfied with the way former Chancellor Angela Merkel handled the resolution of problems in the eurozone, particularly regarding Greece and the ensuing economic crisis in 2010. Henning Conle, a German-Swiss billionaire originally from Duisburg (http://www.afd.de), also influences the financial flows in the party.

Globalisation, as a process of technical and technological connection of humanity, and globalism, as an attempt by the humiliators (Ilić, 2020, pp. 395-397) to impose their rules on the entire world, led to open protests and even conflicts in Germany, as well as in most of the world. Professor Dr Smilja Avramov predicted such a development of events a quarter of a century ago: "Today, millions of people around the world are protesting against the ideology of globalism, and not against the process of globalisation, which is normal. By protesting, they are demanding that this process be conducted through states, not by states and that democratic principles and civilisational achievements be incorporated into the process of globalisation rather than leaving the world in the hands

of barbaric, savage capitalism. This is the essence of the matter. So, it is not about the left or the right but about the answer to the essential question: whether nation-states will disappear and hand over all power to multinational companies, of which there are approximately five hundred leading ones worldwide. That is the essence of the problem and conflict" (Vukašinović, 2003, pp. 14-15)

In support of this, Christy Raik, Director of the International Centre for Defence and Security (ICDS), who previously worked at the Directorate-General for External and Political-Military Relations of the European Commission (Department for Ukraine and Moldova), points out that the future of European security now largely depends on Germany. The newly appointed Chancellor, Friedrich Merz, bears significant responsibility in this regard. Speaking about it and comparing it to the previous German government, she believes that the German position is now much more decisive and reliable and that it will increase support for Ukraine: "I believe that Germany's intention to increase its defence capabilities significantly is serious. At the same time, it is not easy to move in that direction. There are different opinions within Germany.

There is no doubt that in this turbulent sea of opposing views and policies in Germany, the greatest declination of the EU's "Strategic Compass" will occur. Chancellor Friedrich Merz, after taking a seat in the comfort of the "Blackrock" armchair, will face the greatest challenge of his career and strive to prove that the "Atlantic Bridge" remains safe and worthy of those who chose it. Last but not least, American partners can rely on him. Whether Donald Trump is also among his reliable partners remains to be seen.

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Evaluating Puntland's Disaster Risk Management Policy: Institutional Preparedness, Community Engagement and Implementation Challenges

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ABSTRACT

Disaster Risk Management (DRM) plays a pivotal role in governance, particularly in regions prone to recurrent hazards, such as Puntland and Somalia. This study critically examines the effectiveness of Puntland's 2014 Disaster Risk Management (DRM) Policy, with a focus on disaster preparedness, institutional coordination, and community engagement. Using a qualitative case study approach that includes key informant interviews, focus group discussions, and document analysis, it assesses whether the policy remains relevant in mitigating disaster risks, aligns with global frameworks, and integrates effectively into Puntland's governance system. The study applies the OECD policy evaluation framework and compares Puntland's DRM approach against global and national benchmarks, including the Sendai Framework and Somalia's 2020 National Disaster Risk Management (DRM) Policy. Findings indicate significant policy gaps, including weak institutional coordination, inadequate financial resources, and minimal public engagement in disaster response efforts, which fail to empower local governments. A case study of the Qardho district illustrates the real-world impact of these shortcomings, particularly in response delays and ineffective recovery strategies. The study emphasises the need for a comprehensive policy revision that enhances institutional capacity, defines clear stakeholder responsibilities, ensures sustainable funding, and promotes meaningful community involvement. Aligning Puntland's DRM strategy with the Sendai Framework for Disaster Risk Reduction, Sustainable Development Goals (SDGs), and Somalia's National DRM Policy (2020) can strengthen regional resilience and adaptive capacity. By addressing these deficiencies, Puntland can establish a more effective, inclusive DRM framework that safeguards vulnerable communities and mitigates disaster risks.

KEYWORDS

Disaster risk management; public policy; institutional preparedness; Puntland; community engagement.

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1. Introduction

Disasters pose a growing threat to human security, economic stability, and infrastructure development, particularly in vulnerable regions like Puntland and Somalia. The frequency and intensity of natural disasters—ranging from droughts and floods to tropical cyclones—have increased over the past three decades, exacerbating socio-economic challenges and disrupting development efforts (UNDP, 2022). The government must seek relief or reduce disaster risks through systematic efforts to analyse and manage the factors that interact with hazards to cause disasters (United Nations International Strategy for Disaster Reduction [UNISDR], 2009). Otherwise, the impacts of disaster can disrupt the progress and developmental efforts of nations, often pushing them many years back (Smith & Matthews, 2015). Puntland's 2014 Disaster Risk Management (DRM) Policy was developed to provide a structured response to disasters, yet challenges persist in its implementation. Because many policies remain theoretical frameworks rather than practical solutions, particularly in fragile states like Somalia (Ji & Lee, 2021). Policy-making is a multifaceted discipline and activity that cannot be adequately considered apart from the environment, the local community, its leadership, and even the stakeholders in which it takes place because the essence of public policy lies in society (Juma, 2015). Disaster management refers to the body of policy and administrative decisions, operational activities, actors, and technologies that pertain to the various stages of a disaster at all levels (Suriant et al., 2019; Cvetkovic et al., 2021, 2025).

This study evaluates whether the 2014 DRM policy remains relevant and responsive to current disaster management needs. This research assesses whether the policy's formulation was sufficiently inclusive and comprehensive. Are Puntland's government agencies institutionally prepared to implement it effectively? To address these questions and gather relevant insights, this paper critically reviews the 2014 DRM Policy, focusing on three key aspects: (1) Institutional Preparedness – How well are Puntland's government agencies equipped to implement DRM strategies? (2) Community Engagement – To what extent are local communities involved in disaster response and mitigation? (3) Implementation Challenges – What structural and financial barriers hinder the effective implementation of DRM policies? By evaluating the policy's effectiveness, this study aims to identify practical recommendations for strengthening disaster governance in Puntland, ensuring that DRM strategies are translated into actionable frameworks that benefit at-risk communities (UNDP, 2022).

2. DRM Policy in the State of Puntland, Somalia

The governance system of Somalia, as adopted in 2004, is characterised by a federal structure comprising three distinct layers: the federal government, state governments, and local governments. Each of these entities operates within semi-autonomous institutional frameworks and is constitutionally mandated to address the needs and demands of citizens within their respective jurisdictions, delivering services in a holistic and accountable manner. The State of Puntland, established in 1998—six years before Somalia adopted the federal system—has functioned as a semi-autonomous government within the broader federal system of the Republic of Somalia. Puntland is geographically located in the northeastern part of Somalia and occupies a total land area of 212,510 square kilometres, or roughly one-third of Somalia's geographical area. It is a semi-arid region with a warm climate, characterised by average daily temperatures ranging from 270 °C to 370 °C.

The State of Puntland shares many similarities with Somalia, and disasters can manifest in various forms, including delayed rain, floods, droughts, epidemics, and tropical cyclones, with droughts occurring more frequently. The major drought incidents remembered since 1990 include Jiqiiqan of 1990/2, Jihajihays of 1994, Naafmadoobe and Naafcadde of 1996/7, Haruure and Kartoomaley of 2001 and 2004, Ari War Maleh of 2008, Erdogan of 2011, Hawdaad of 2014, and Sima of 2016. Additionally, Puntland experienced the Tsunami disaster in 2004, which affected the coastal communities between the island of Hafun in the Bari region and the village of Garacad in Mudug, a 650-kilometre stretch of coastline, and killed at least 114 people, destroyed 100 fishing boats and the villages in the area have been either fully or partially submerged (The Office for the Coordination of Humanitarian Affairs (OCHA, 2004).

To address the hazards of Tsunamis, Puntland established the Humanitarian Affairs and Disaster Management Agency (HADMA) in 2005, operating under the leadership of Puntland's Ministry of Interior, Federal Affairs, and Democratisation. HADMA drafted a Disaster Risk Management policy in 2014, which was subsequently approved by the cabinet. This DRM Policy explicitly outlines the dos and don'ts of the Puntland government and adopts a regulatory-focused approach to disaster management and mitigation.

In 2022, HADMA was elevated into the Ministry of Humanitarian Affairs and Disaster Management (MoHADM) with presidential degree number 25 on April 18, 2022, mandating the coordination and leading distribution of humanitarian aid, developing and implementing policies, strategies and programmes related to humanitarian aid and disaster management, advocacy and Awareness activities and upholding the principles of accountability, transparency and inclusivity in all humanitarian and disaster management programmes and projects in Puntland. Due to recurrent hazards, Puntland recognised the need for the establishment of the Puntland Disaster Risk Management Policy, formulated in December 2014, which aims to provide a structured approach to disaster risk management (DRM) by addressing preparedness, mitigation, response, and recovery. The policy focuses on reducing the impact of disasters, both natural and human-induced, such as droughts, floods, and epidemics. It outlines the roles and responsibilities of various stakeholders, including the Puntland Disaster Management Council, HADMA, local governments, and international partners. According to the 2014 DRM Policy, the key aspects of the policy include (1) establishing HADMA under the Office of the President to oversee disaster management activities and ensure coordination among stakeholders, (2) Proposing financial mechanisms such as disaster management funds (3) Emphasizing the integration of disaster risk management into development planning, enhancing community resilience, and safeguarding critical infrastructure, (4) Highlighting the importance of training, public awareness, and integrating disaster risk reduction into educational curricula, and (5) Recognizing the specific needs of women and vulnerable groups in disaster preparedness and response.

3. Methods

This study employed a qualitative case design to assess Puntland's 2014 Disaster Risk Management (DRM) policy. This approach was chosen for its ability to generate in-depth insights into institutional dynamics and stakeholder perspectives within complex governance contexts (Gautam & Phaiju, 2013). Data was collected through three primary sources: document analysis, key informant interviews (KIIs), and focus group discussions (FGDs). The document review included the 2014 Puntland DRM policy, the 2020 National DRM Policy of the Federal Republic of Somalia, the DRM Strategic Plan developed by MoHADM, as well as the DRM Strategic plans of selected districts, Garowe and Qardho.

Primary data collection consisted of twelve focus group discussions (FGDs) conducted in the Garowe and Qardho districts, with each group comprising 8 to 11 participants, totalling 120 individuals. Participants were drawn from local governments' DRM units, disaster management-related ministries, Associations for Local Governments of Puntland [ALGAPL], NGOs, civil society organisations, academic institutions, and community groups, including representatives of vulnerable groups. In parallel, five Key Informant Interviews (KIIs) were conducted with senior officials from key ministries, including the Ministry of Health, Administration and Development Management (MoHADM), the Ministry of Environment, Range and Climate Change, the Ministry of Education and Higher Education, as well as the mayor of Qardho district. Qardho was selected as a focal case study due to its repeated exposure to flooding and its significance as a testing ground for the effectiveness of disaster risk management (DRM) policies in real-life emergency contexts. This helped to assess the practical aspects of institutional preparedness and community involvement during real emergencies. It also utilised secondary sources, such as academic papers, reviews, and related policy documents, specifically the DRM policy of the Federal Republic of Somalia, as the country's political system is federal with a tripartite government.

To analyse the findings, this study applied the OECD Policy Evaluation Framework, which examines six key dimensions (OECD, 2020), namely relevance – does the policy address Puntland's current disaster risks? Effectiveness – has the policy reduced disaster impacts in Puntland since 2014? Efficiency – are financial and institutional resources allocated efficiently? Coherence – how well does the policy align with Somalia's national DRM strategy and international frameworks? Impact – What measurable improvements in disaster preparedness have resulted from the policy? Moreover, sustainability – does the policy provide long-term solutions, particularly in financial and institutional capacities? The study also employed a conceptual differentiation of public policy; in the analysis of policy, the word policy is differentiated into three dimensions: 'polity', which refers to political institutions and the political system, 'politics' in the processual dimension, that is, the political process, and 'policy' which refers to public policies per se (Greece, et el., 2014). The analysis of Policy is concerned with the process of constructing public policy, focusing on the definition of the agenda and highlighting aspects such as the interests of actors participating in the political game, as well as the interaction between them (Serafim & Dias, 2012). Together, these frameworks enabled a multidimensional analysis of the DRM policy, linking theoretical constructs to empirical findings and providing a comprehensive view of its governance, implementation, and institutional effectiveness.

4. Results and Discussion

Based on the review of the 2014 Disaster Risk Management (DRM) Policy document of Puntland, the study highlighted significant gaps within the policy framework. After rigorous analysis, this section presents the study's findings:

4.1. Policy Alignment and Strategic Relevance

After rigorous analysis, the study found that Puntland's DRM policy (2014) lacks standardisation of the policy in alignment with the current international frameworks like the Sendai Framework for Disaster Risk Reduction (2015-2030), the African Union Agenda 2063, Sustainable Development Goals (SDGs 2015- 2030), Paris Agreement on Climate Change of 2020, and among others. Despite the policy states frameworks such as the Hyogo Framework for Action (2005-2015), it also outlines a broad framework for disaster management. However, it lacks detailed, hazard-specific strategies for disasters like droughts, floods, or epidemics. Likewise, the SIDRA report highlights that the 2014 policy lacks alignment with contemporary international frameworks for disaster risk management and demonstrates inadequate integration with the local ones (Somalia Institute for Development and Research Analysis [SIDRA], 2020).

The study further revealed that the 2014 Disaster Risk Management (DRM) Policy lacks alignment with other national legal frameworks related to DRM and demonstrates limited integration of disaster management across key sectoral public policies, including environmental protection, urban planning, and public health. Moreover, the policy does not acknowledge several hazards identified in the Federal Republic of Somalia's National DRM Policy (2020), such as tropical cyclones, storm surges, entomological and pest outbreaks, fire incidents, conflict and terrorism, as well as hazardous materials including marine oil spills, waste spills, and plastic pollution.

Subsequently, the 2014 Disaster Risk Management (DRM) policy does not classify conflict or terrorism as disasters, despite the war on terror and border conflicts being key strategic priorities in Puntland's government agenda. Whenever such conflicts arise, Puntland enters a state of emergency. For example, the 2011 war against Al-Shabaab in the Galgala Mountains, the 2016 Suuj-Garmaal war against Al-Shabaab, and the ongoing large-scale battle against ISIS/Da'ish in the Almaskat mountains, which involves international terrorist fighters pose a significant security threat. Additionally, Puntland has experienced multiple border disputes, which have also led to emergency declarations due to their socio-political and economic impact. Given their severe consequences, these conflicts can be considered disasters and warrant inclusion in the Disaster Risk Management (DRM)

framework. Should the government not formally recognise it as a disaster or significant threat when acts of terrorists or wars result in widespread harm and disruption?

In brief, the lack of coordination between Puntland's DRM policy and Somalia's federal disaster response mechanisms may also lead to challenges in resource sharing, policy implementation, and coordinated responses.

4.2. Institutional Coordination and Governance

In the context of DRM, the most important set of actors are government and local institutions. They play a vital role as both the primary implementers of policies and frontline responders during emergencies. "Local governments are fully responsible for the safety of their citizens and communities (Surianto et al., 2019)." Their responsibilities involve not only executing disaster management strategies but also ensuring the immediate safety and well-being of affected communities. Since they are considered the most closely connected governmental entity to local people. The local government has a direct connection with the community people to establish proactive disaster management (Kafle, 2018).

Thus, the question arises: What are the implications if such a significant institution within the government structure has its pivotal role in DRM undermined? Although the 2014 DRM policy emphasises the importance of collaboration, it appears to fail to clearly define the roles and responsibilities within the DRM governance arrangement. It does not explicitly assign roles to local governments. It does not provide precise mechanisms to prevent duplication of efforts among agencies. According to the respondents, the roles and responsibilities of local authorities are neither articulated in the policy nor were they consulted during its formulation.

Furthermore, the KIIs conducted with senior officials from local authorities revealed that they were unaware of the DRM policy's existence. This lack of awareness and practical application suggests that the policy remains largely a theoretical document with minimal on-the-ground impact. The 2014 DRM policy also failed to promote the decentralisation of essential disaster risk management tasks to local governments. These tasks include mapping and supervising high-risk areas, educating the public about potential hazards, and implementing land-use management to mitigate risks, such as construction in flood-prone or landslide-prone areas and resource mobilisation. The respondent further noted that there is no dedicated department specifically for disaster management. According to Law No. 3 of 2023 of regions and local governments, "districts are authorised to have five operational departments: finance, revenue, planning and monitoring & evaluation, social affairs, and public works." However, disaster management is addressed only as a unit within the Social Affairs Department. According to the SIDRA report, local authorities face significant challenges in managing disaster risk due to the lack of dedicated disaster management departments at the district level (SIDRA, 2020).

Based on primary data collected through interviews and field research, this highlights an apparent lack of trust by the state government in the capacity of local governments to manage disaster-related projects, thereby undermining the crucial role that local governments could play in disaster preparedness, mitigation, and recovery. Furthermore, there is a notable scarcity of professional public policy drafters, which is compounded by limited funding to hire qualified and resourceful experts (Ministry of Planning, Economic Development, and International Cooperation [MoPIC], 2020).

The second iteration of this policy should introduce new governance structures to streamline coordination among different stakeholders and build the capacity of DRM-related institutions, with clearly defined roles and responsibilities among government institutions to ensure the effective implementation of various policy actions. Otherwise, overlapping roles can lead to ineffectiveness, confusion, and resource wastage during emergencies. There must be a coordination platform under the Ministry of Humanitarian Affairs and Disaster Management in Puntland to streamline communication and clearly define roles for each stakeholder, particularly local governments. When dealing with DRM, local governments are required to serve as the implementing agent and frontline personnel. Disasters occur locally and require local-level approaches (Scot & Tarazona, 2011; Ainuddin et

al., 2013; Garschagen, 2016; Rumbach, 2015; Munene et al., 2016; Raikes et al., 2019; EDRMC, 2022). Policies and legislation related to risk management are crucial in defining the efficiency of on-the-ground implementation of the Disaster Management Plan (Surianto et al., 2019). Besides, train local government officials in disaster management through short courses and executive programmes (Ikram et al., 2020).

4.3. Financial Mechanisms and Sustainability

The 2014 Disaster Risk Management (DRM) policy proposed the establishment of a Puntland Disaster Management Fund, allocating 1% of the state-level annual budget, and a District Disaster Management Fund, derived from 2% of local taxation, to address disasters and emergencies. However, based on the key informant interviews with the MoHADM and mayoral district leadership, these initiatives have not been implemented because the proposed disaster funds rely heavily on external donations and limited government allocations, with no sustainable funding strategies in place. In this regard, the researcher posed a direct question to key policymakers at the ministerial and mayoral levels. Both parties emphasised that the proposed disaster management fund outlined in the policy document had not been established or operationalised.

Furthermore, no legislative framework had been written to administer the fund, nor had any financial resources been allocated to it. According to a SIDRA report, the policymakers clarified that no formal fund had been collected for disaster management, apart from contributions from NGOs and the community for recovery activities. Community contributions are initiated and managed by a group of trusted local sheikhs who operate independently of governmental oversight (SIDRA, 2020). The analysis highlights a significant gap between policy formulation and practical execution. The study revealed that limited financial resources remain a significant constraint, significantly undermining the government's capacity to craft attainable and actionable disaster risk management policies and strategies.

The study also proposes the establishment and operationalisation of the Puntland Disaster Management Fund (PDMF) and District Disaster Management Funds (DDMF), administered by highly prominent and trusted individuals, to ensure that sufficient financial resources are available for disaster preparedness and response. At this point, the government should formalise the role of sheikhs or other trusted community leaders by establishing a dedicated government agency responsible for managing local fund contributions and ensuring accountability and transparency. Additionally, to improve financial sustainability, Puntland should explore alternative financing models, for instance, Public-Private Partnerships (PPPs), which encourage private sector contributions in exchange for tax incentives (UNDP, 2022). Likewise, Balanggoy (2024) argues that "to explore collaborative alliances with private entities to secure financial support for training initiatives, projects, and various undertakings".

4.4. Community Engagement and Local Ownership

According to the analysis, this study observed that the 2014 DRM policy does not elaborate on mechanisms for engaging the community in planning and implementation. During the focus group discussions, most respondents identified the major factors hindering the effectiveness of DRM policy implementation at the local level as being attributed to the absence of local community participation. Limited community involvement can result in ineffective response measures and a lack of local ownership. The integrated community members share the same aim of reducing community-level hazards independently (Joerin, Shaw, Takeuchi, & Krishnamurthy, 2012). Similar results were found in the study by Balanggoy (2024), that "the ability to prevent, mitigate, and recover from disasters depends on people's and organisations' capacity, which is a part of disaster risk reduction and management (DRRM)". At the local level, there is the best knowledge about the characteristics of the local topography, available resources and living conditions. That is why local structures must be actively involved in the disaster management process in all phases, from development plans and

disaster response plans to addressing their consequences. Therefore, a bottom-up management approach is necessary in this sector to obtain a model that solves the problem at its source. (Đorđević & Gačić, 2024). Local communities play a pivotal role in strengthening the effectiveness of solidarity and cooperation within communities, facilitating individual efforts, building synergistic effects, and providing a platform for consensus-building and conflict avoidance, thereby building local social capital. Policy development and stakeholder engagement at international, regional, national, and sectoral levels determine whether awareness is raised, a common understanding emerges, norms develop, decisions are made, actions are promoted, and sustainability is ensured (Leka & Jain, 2014).

Similarly, other scholars like Milošević, Cvjetković-Ivetić, and Baturan (2024) argue that "previous studies have shown that public awareness campaigns and community-based programs play a vital role in disaster preparedness and recovery. By increasing efforts to educate citizens on their rights and responsibilities in the context of disaster recovery, the government can foster a culture of resilience and shared responsibility". Therefore, strengthening communities, making responses more efficient, and encouraging a mindset of readiness that can all be achieved through organised training programs and seminars" (Balanggoy (2024).

In line with these findings, community engagement fosters a sense of ownership among local people, and thereby, they are more likely to trust their capacities, take collective action, and support one another in responding to disaster risks.

4.5. Case Analysis: Qardho Floods and Policy Gap

Developing countries are becoming increasingly vulnerable to disasters due to the combined effects of global warming and rapid urbanisation in high-risk areas (Ricardo, Pedro, & Lucas, 2024). On 27 April, a heavy downpour in Qardho and its seasonal river catchments triggered widespread flooding in Qardho City, which has a population of 120,000 people. Since 1990, the main historical floods in Puntland, particularly in the Qardo district, have occurred in 1993, 2001, 2018, and 2020. The Qardo floods of 2020 affected 48,000 Households, killed eight people, destroyed 750 houses, damaged four boreholes, and washed away road infrastructure, farms, and other natural resources. The feeder roads connecting villages and settlements, as well as businesses, schools, markets, and offices, are affected by the floods. (International Federation of Red Cross and Red Crescent Societies [IFRC], 2020).

Although the Qardho local government made an effort to deploy various awareness-raising strategies, including posting billboards in the town centre, holding meetings with prominent individuals and the general public, and installing radios in cars, it appears that these measures were insufficient. The key informant interview highlighted that the response to the Qardho floods situation experienced delays attributed to various levels of verification regarding the number of individuals requesting assistance. A significant loss of livelihood occurred as a result of the tardiness in preparing for evacuation and responding to the situation.

The report produced by the IFRC (2020) highlights challenges such as delays in assistance due to verification processes, which result in significant livelihood losses. What if the federal government were interested in stepping in and assisting with the verification process as well? How much time did it take? Undoubtedly, empowering local governments to oversee and manage services proves to be far more effective, practical, and impactful than interventions orchestrated by a centralised authority. Consequently, it is imperative to entrust local governments with the responsibility of administering local services, ensuring administrative devolution, and granting them financial autonomy to manage their allocations and engage with donor or external funding mechanisms.

4.6. Key Challenges Identified

The findings of this study found that the 2014 DRM policy lacks a well-defined framework for community-based disaster risk reduction and management. It also does not encourage the decen-

tralisation of DRM, which is essential for enhancing mitigation and response efforts at the district level.

Furthermore, the study highlights several challenges faced by the policy, including limited financial resources, low awareness among stakeholders, and insufficient engagement from relevant actors. Equally, the Puntland Five-Year Development Plan - 4th Version (2020-2024) indicates that skilled and experienced staff is scarce in DRM at all levels of government and recognises this as a significant constraint. This limitation, coupled with inadequate infrastructure and the absence of information systems, such as early warning systems, hampers disaster preparedness and response. According to UNDRR (2019), SMS-based disaster alerts, as used in Indonesia's early warning systems, can improve local preparedness. Similarly, another best practice is to use local radios, as Ethiopia has successfully utilised radio programmes to educate rural communities about disaster preparedness (Ikram et al., 2020). Awareness is one of the first steps for actors to participate in DRM (Hermansson, 2019; Muriuki et al., 2022; Tao et al., 2023). This can be achieved through the introduction of billboards, television, radio, and leaflets, as well as the formation of environmental awareness groups that would engage residents on the need to adopt DRM (Olawuni, Olowoporoku, & Daramola, 2021).

Additionally, the lack of dedicated financial resources for disaster management further weakens Puntland's ability to address disaster risks effectively, as does the Somalia National Disaster Risk Management Policy. (2020) outlines the challenges faced in disaster risk management in Somalia, including limited workforce, technological and financial resources, and weak coordination mechanisms across various levels of government. Furthermore, the study highlights that the policy does not fully encompass all essential pillars of DRM, including effective mechanisms for monitoring and evaluation, resulting in gaps in prevention and preparedness efforts.

The aforementioned analyses support the argument presented by scholars, including Ikram et al. (2020) that developing countries need DRM to be a primary component of their governance structure.

5. Conclusions

The study concludes that Puntland's 2014 DRM policy functions merely as a document with narrowly and ill-defined provisions, due to whether at the local or national level, as in many cases, each government institution addresses disaster response separately, with limited resources while communities are not fully engaged, and policies may be influenced by the priorities of funders, such as NGOs or external sponsors, rather than reflecting the will of the government.

Ministry of Humanitarian Affairs and Disaster Management of State of Puntland to update the 2014 DRM policy to reflect global standards, i.e. Sendai Framework and Somalia's 2020 DRM Policy, in order to reflect the government's approach to DRM and remain proactive, holistic, and capable of addressing current and emerging disaster risks, with a clear roadmap for achieving the intended outcome.

The redistributive policy should ensure that institutional frameworks, roles, and responsibilities are clearly defined, streamlined, and aligned with the governance system at the state and local levels to enhance the coordination mechanism. For effective policy implementation, government officials and local communities should be capacitated through investment in short courses and training to produce trained trainers, as well as Executive Master's programs in professional studies in emergency and disaster management to handle disasters. In addition, the proposed structures, particularly the Puntland Disaster Management Council (PDMC) and all other Disaster Management structures, including the Puntland Emergency Centre and ministerial focal points, are operationalised and adequately funded. Adopting such an approach strengthens community involvement in policy implementation. It will foster grassroots engagement and localised disaster risk reduction efforts and enhance key pillars of disaster risk management, including but not limited to assessment and research undertakings, resilience building, preparedness, and community engagement.

For sustainable financing, the government is required to establish and operationalise Puntland and District DRM Funds with legal mandates, including mechanisms for community and private sector contribution. This is achieved through transparent budget allocation at the state and local government levels, as well as solicitation of funding support from development agencies and financial partners, accompanied by a detailed implementation plan annexed, including a cash project and budget breakdown. Additionally, the government of Puntland's redistributive DRM policy should explicitly adopt principles from international agreements and align its objectives with global targets, including those of the Sendai Framework and the Sustainable Development Goals (SDGs), particularly Goal 13 (Climate Action), as well as the disaster management frameworks of the Federal Republic of Somalia.

Furthermore, to enhance the effectiveness of policy formulation and decision-making, the government should establish a specialised unit for public policy review within the State House tasked with evaluating policy proposals submitted by ministries before they are presented to the Cabinet of Ministers for approval. This unit would ensure that the policy proposal aligns with established policy standards and national priorities. In cases where a proposal does not meet the required criteria, the unit would provide recommendations for improvement and return it to the respective ministry for revision, fostering a more rigorous and accountable policy development process.

As usual, the policy is often subject to continuous review and regular updates to reflect emerging challenges, particularly those related to climate change and urbanisation. Hence, the government should develop performance metrics and early warning systems tailored to Puntland's hazard profile.

Lastly, not least, the findings of this study can be generalised to other public policies of the State of Puntland, other Federal Member States, and/or the Federal Republic of Somalia, as community consultations are often undermined during policy formulation or when providing feedback about the outcome of policy implementation.

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From Vulnerability to Resilience: A Systematic Review of Odisha's Integrated Approach to Disaster Risk Reduction

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ABSTRACT

Odisha, a coastal state in India, has transformed its disaster management framework from a reactive model to a proactive, resilience-centred approach in response to frequent cyclones, floods, and climate-related hazards. This shift, necessitated by the need to protect lives, infrastructure, and livelihoods, gained momentum after the catastrophic 1999 Super Cyclone, which claimed over 10,000 lives and exposed critical gaps in preparedness. Over the past two decades, Odisha's reforms have significantly reduced fatalities through improved policies, infrastructure, and community engagement. This review examines Odisha's evolution in disaster governance from 1999 to 2024, analysing key initiatives such as the establishment of the Odisha State Disaster Management Authority (OSDMA), early warning systems, cyclone shelters, and evacuation plans. Using the PRISMA framework, the study evaluates 40 peer-reviewed articles, reports, and policy documents to assess the impact of these measures. Despite progress, challenges remain, including last-mile connectivity in disaster warnings—particularly for remote tribal communities—and the growing threats posed by rising sea levels and intensifying cyclones. Nature-based solutions, such as mangrove restoration, and community-driven programs like Odisha's Tsunami Ready initiative (involving 26 villages) offer scalable strategies for enhancing resilience. These experiences provide valuable lessons for other vulnerable regions, such as Indonesia and the Philippines. Moving forward, prioritising technological integration, decentralised governance, and sustainable recovery strategies will be crucial for strengthening Odisha's long-term climate resilience.

KEYWORDS

Disaster governance; Odisha; cyclone resilience; early warning systems; community participation; climate adaptation.

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1. Introduction

Odisha's extreme vulnerability to recurrent cyclones, floods, and droughts makes disaster governance a critical priority, as these hazards pose a significant threat to lives, livelihoods, and economic stability. The state's geographical location along the Bay of Bengal exposes it to severe cyclones. At the same time, erratic monsoons contribute to both floods and droughts, exacerbating food and water insecurity (National Institute of Disaster Management, 2020). Effective disaster governance—encompassing early warning systems, resilient infrastructure, community preparedness, and efficient response mechanisms—has significantly reduced fatalities, as demonstrated during Cyclone Phailin (2013) and Fani (2019) (Rahman et al., 2025). Odisha's proactive measures, including the establishment of the Odisha State Disaster Management Authority (OSDMA), cyclone shelters, and robust evacuation plans, have set a benchmark for disaster risk reduction (NIDM, 2020; OSDMA, 2008). Strengthening governance further is essential for achieving sustainable development, alleviating poverty, and adapting to climate change, thereby ensuring Odisha's resilience against escalating climate-related threats (Cvetkovic & Svrdlin, 2020; Cvetković & Šišović, 2024).

In India, 84 coastal districts across 13 states and union territories are affected by tropical cyclones. Among these, five states—Andhra Pradesh, Gujarat, Tamil Nadu, West Bengal, and Odisha—along with the Union Territory of Puducherry, are considered most vulnerable to wind and cyclone disasters (NIDM, 2020). The east coast of India ranks as the sixth most cyclone-prone region in the world. Although Odisha's coastline constitutes only about 17% of India's eastern coast, it has experienced around 35% of the region's cyclonic and severe cyclonic storms, with storm surges frequently inundating coastal districts (Sahoo & Bhaskaran, 2018).

The 1999 Super Cyclone, which struck Odisha on October 29 with wind speeds exceeding 250 km/h and a 6-meter storm surge, was a catastrophic turning point in the state's disaster management history, claiming over 10,000 lives and affecting 15 million people (Fanchiotti et al., 2020a). This disaster exposed critical gaps in early warning systems, preparedness, and relief coordination, prompting the state of Odisha to overhaul its disaster response framework. The state established OSDMA in 1999, pioneered community-based preparedness programs, and invested in cyclone shelters and coastal embankments (Ray-Bennett, 2018b). These measures were successfully tested during Cyclones Phailin (2013) and Fani (2019), drastically reducing casualties and positioning Odisha as a global model in cyclone resilience (Mishra & Malakar, 2020).

A systematic review of disaster governance approaches in Odisha is essential to assess policy effectiveness, identify gaps, and adapt to evolving climate risks. Given the state's frequent exposure to cyclones, floods, and droughts, a structured evaluation can determine whether current frameworks, such as early warning systems, community preparedness, and infrastructure resilience, are keeping pace with increasing disaster intensity (UNISDR, 2015). By analysing successes (e.g., reduced mortality in Cyclone Fani) and persistent challenges (e.g., post-disaster recovery, livelihood protection), such a review can inform evidence-based policy improvements. Additionally, comparing Odisha's strategies with global best practices can enhance coordination among government agencies, NGOs, and local communities, ensuring more inclusive and adaptive governance (The World Bank, 2013). Ultimately, a systematic review would strengthen Odisha's resilience, optimize resource allocation, and provide a replicable model for other disaster-prone regions.

2. Methodology

This study employs a systematic approach to examine Odisha's disaster governance framework, scrutinising its policies, government systems, and community-based programs. The methodology is designed to be transparent, accurate, and reliable in showing how Odisha changed from being vulnerable to disasters to becoming more resilient. The research follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which provides a clear, step-by-step process for reviewing studies. This helps ensure the findings are trustworthy and can be verified by others. The systematic review is particularly useful for this study, as it enables re-

searchers to gather evidence from diverse sources, compare findings, and identify gaps in disaster management strategies.

The study began by searching for relevant research papers, reports, and policy documents. Researchers first identified 250 studies from academic databases, such as Scopus, Web of Science, and Google Scholar, as well as government and international organisation reports (NIDM, 2020, 2021; OSDMA, 2008). After removing duplicate studies, 180 remained. The next step was to review the abstracts of these studies to determine if they met the inclusion criteria. This process narrowed the list down to 95 articles. Finally, the most relevant 60 studies were selected for a full review. The inclusion criteria required that studies be peer-reviewed articles, official government reports, or policy documents published between 1999 and 2024. They also had to focus on Odisha's disaster governance, including policies, institutions, and community participation. Case studies of major disasters, such as the 1999 Super Cyclone, Cyclone Phailin (2013), and Cyclone Fani (2019), were included to understand how the state of Odisha prepared for and responded to these events. Studies that were not peer-reviewed, such as opinion pieces or general reports not specific to Odisha's disaster governance, were excluded (Fanchiotti et al., 2020b; Ray-Bennett, 2018b).

The research used a combination of methods to analyze the selected studies. First, a descriptive analysis was done to trace the changes in Odisha's disaster policies over time, from before the 1999 Super Cyclone to the present day. Then, a thematic analysis was used to identify key topics in disaster governance, such as early warning systems, evacuation plans, and community training programs (Mishra & Malakar, 2020). The study also compared Odisha's disaster management strategies with those of other Indian states like Andhra Pradesh and Gujarat, as well as with global standards like the Sendai Framework (Pal et al., 2017). Finally, a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) was conducted to evaluate what Odisha is doing well in disaster management and where improvements are needed (Dash & Walia, 2020). This mixed-method approach helped provide a complete picture of Odisha's progress in disaster resilience.

While this review offers a broad assessment of Odisha's disaster governance, several limitations should be acknowledged. Methodologically, its reliance on published literature and qualitative case studies may exclude undocumented grassroots experiences and lack quantitative validation (Pal et al., 2017; Ray-Bennett, 2018b). The focus on post-1999 reforms limits historical comparisons and may miss recent policy shifts like SDG alignment (Chhotray & Few, 2012; Dash & Akhter, 2023). Geographically, a coastal focus overlooks inland hazards and urban–rural implementation gaps (Sahu, & Mishra, 2023; Shukla et al., 2025). Data-wise, few longitudinal studies track long-term recovery, while overreliance on official reports may introduce bias (Maly et al., 2022; Syal et al., 2021). Thematic gaps include limited analysis of gender and caste, and isolated treatment of technologies like AI without addressing digital divides (Gupta et al., 2022; Sharan & Gaillard, 2025). Future research should adopt mixed-methods approaches, expand the temporal lens to pre-1999, and consider cross-regional comparisons with states like Gujarat and Tamil Nadu (Kumar & Pradhan, 2022).

3. Evolution of Disaster Management Mechanism

Odisha's disaster governance has undergone significant evolution, transitioning from a relief-oriented approach to a resilience-driven framework. This transformation follows the Adaptive Governance (AG) model proposed by Djalante et al. (2011), which emphasises polycentric and multilayered institutions to enhance resilience against natural hazards. Before India's independence, disaster governance was largely reactive, focusing on post-disaster relief measures. However, in the 21st century, disaster risk reduction (DRR) has gained prominence, with Odisha emerging as a leader in disaster preparedness (Djalante et al., 2011)Following the catastrophic 1999 Super Cyclone, Odisha established the Odisha State Disaster Management Authority (OSDMA) on December 28, 1999, making it the first state-level disaster management body in India. OSDMA coordinates efforts among the State Disaster Management Authority, Revenue and Disaster Management Department, and the Office of the Special Relief Commissioner to ensure effective disaster preparedness and response. The Odisha Disaster Rapid Action Force (ODRAF) was formed in 2001, equipped with modern technology to provide immediate disaster response (Chhotray & Few, 2012; A. Mohanty et al., 2022).

3.1 Evolution of Disaster Governance in Odisha

Odisha's disaster governance can be categorized into three distinct phases:

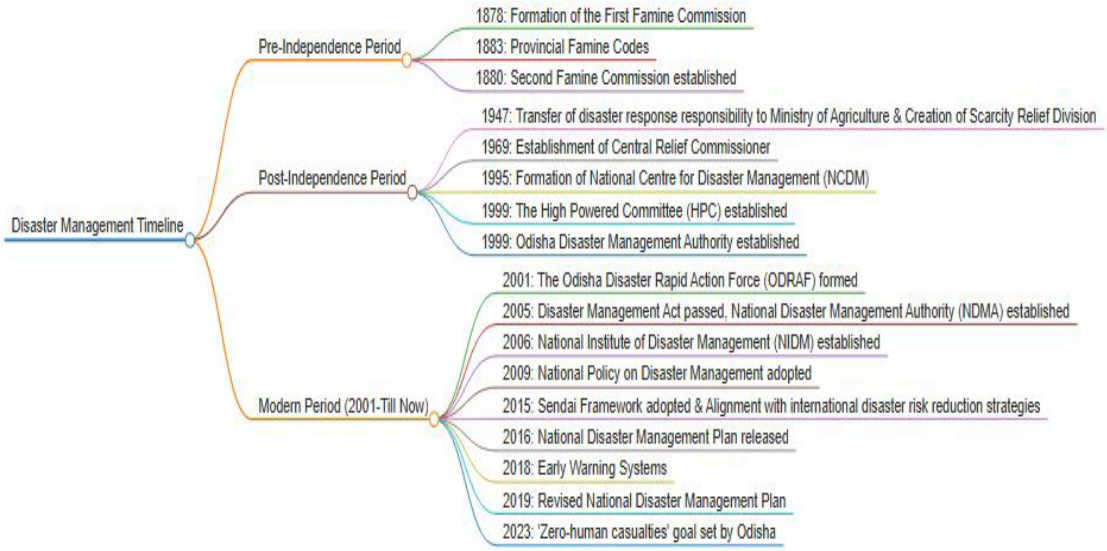

Figure 1. Institutional Response to Disaster Risk Reduction in India. Source: Government of India (GoI), 2009; NIDM. 2021; Prasad 2008; Ray-Bennett, 2011; The Asia Foundation. 2022

3.1.1 Pre-1999: Fragmented and Relief-Oriented Approaches

Prior to 1999, disaster governance in Odisha primarily focused on famine relief and post-disaster assistance. The absence of early warning systems and structured emergency response led to high casualties during major cyclones like the 1999 Super Cyclone, which claimed over 10,000 lives (Sahu, Das, & Mishra, 2023; Tomar et al., 2024).

3.1.2 1999–2010: Institutionalisation and Systemic Reforms

The 1999 disaster marked a turning point, leading to the establishment of OSDMA, which set the foundation for structured disaster governance. The Odisha Disaster Rapid Action Force (ODRAF) was launched in 2001 to conduct rapid disaster response operations(A. Mohanty et al., 2022; OSDMA, 2008). Odisha also aligned its governance framework with national policies, including the Disaster Management Act, 2005, strengthening institutional accountability (Government of Odisha, 2005), (NIDM, 2020). By the time Cyclone Phailin struck in 2013, Odisha's disaster governance had matured significantly, leading to mass evacuations and a sharp decline in fatalities (U. C. Mohanty et al., 2015).

3.1.3 2001–Present: Resilience-Building and Global Benchmarking

Since 2011, Odisha has invested in advanced early warning systems, GIS-based hazard mapping, and adopted a zero casualty policy (Chisty et al., 2022; Mohapatra et al., 2025). These initiatives align with global frameworks such as the Sendai Framework for Disaster Risk Reduction (2015) (Chisty et al., 2022). Comparative studies show Odisha's governance model shares similarities with Japan's community-led disaster drills and the Netherlands' embankment protection strategies (Nayak, 2020).

4. Key Components of Odisha's Disaster Governance

Odisha's disaster governance framework has evolved into a comprehensive system integrating institutional, legal, technological, and community-driven mechanisms. The institutional framework is led by the Odisha State Disaster Management Authority (OSDMA), which was established after the 1999 Super Cyclone. OSDMA collaborates with multiple stakeholders, including government agencies, NGOs, and international organizations, to implement disaster risk reduction (DRR) measures effectively (OSDMA, 2008). This institutional setup ensures a well-coordinated approach to preparedness, response, and recovery.

4.1. Institutional Governance and Policy Framework

Component	Key Factors	Relevance to Odisha's Disaster Governance	Authors
Institutional Framework	OSDMA, Revenue & Disaster Management Department, Odisha Disaster Rapid Action Force (ODRAF)	Established a post-1999 Super Cyclone for governance coordination and rapid response	Sahu et al. (2023), OSDMA (2021)
Legal & Policy Framework	Disaster Management Act (2005), Odisha Disaster Management Policy (2021)	Strengthens governance structure and aligns with national disaster management policies	Government of India (2005), OSDMA (2021)
Inter-Agency Coordination	Coordination between State, NGOs, Local Bodies, and Last-Mile Connectivity in Early Warnings	Ensures effective disaster response and reduces delays in relief operations	Raju & Becker (2023), OSDMA (2022)
Financial & Insurance Mechanisms	Government Disaster Funds, Micro-Insurance for Disaster-Affected Communities	Supports economic resilience and aids faster recovery for affected populations	Bhowmik & Roy (2024), Govt. of Odisha (2023)
International & National Benchmarking	Sendai Framework for DRR, Comparisons with Gujarat & Andhra Pradesh, Best Practices from Japan & Netherlands	Odisha's disaster governance model is globally recognized for cyclone management	UNISDR (2015), Nakasu et al. (2021)

The legal and policy framework provides the foundation for disaster management in Odisha. The state aligns its policies with the Disaster Management Act of 2005, which mandates proactive DRR strategies, institutional accountability, and community involvement(Government of India, 2005). Furthermore, Odisha's disaster management policy emphasizes risk mitigation through resilient infrastructure and climate adaptation strategies (NIDM, 2020, 2021).

4.2 Disaster Preparedness and Risk Mitigation

Component	Key Factors	Relevance to Odisha's Disaster Governance	Authors
Cyclone Resilience Strategies	Early Warning Systems, Evacuation Planning, Cyclone Shelters	Odisha's proactive measures significantly reduced cyclone-related casualties	Tomar et al. (2025), Mishra & Mohanty (2021)
Community-Based Disaster Management (CBDM)	VDMCs, Trained Volunteers, Public Awareness Programs	Encourages local participation in disaster preparedness and response	Nayak (2022), Das et al. (2022)
Technology & GIS Mapping	Satellite-Based Monitoring, GIS Hazard Mapping, Automated Weather Stations	Enhances disaster forecasting and improves localized risk assessments	Mall et al. (2021), IMD (2020)

Odisha has significantly enhanced its early warning systems, integrating advanced meteorological technologies to predict extreme weather events. The India Meteorological Department (IMD), in coordination with OSDMA, utilizes satellite-based monitoring and GIS mapping to provide real-time cyclone warnings. These alerts are disseminated through SMS, radio, and digital platforms, ensuring timely communication to vulnerable communities. Additionally, automated weather stations have been deployed to improve localized forecasting accuracy (Mohapatra et al., 2025).

4.3. Post-Disaster Recovery and Adaptation

Component	Key Factors	Relevance to Odisha's Disaster Governance	Authors
Post-Disaster Recovery & Rehabilitation	Build Back Better Approach, Livelihood Restoration, Infrastructure Development	Focuses on sustainable recovery and minimizing economic disruption post-disaster	UNDP (2019), World Bank (2022)
Climate Adaptation & Risk Mitigation	Coastal Zoning, Mangrove Restoration, Climate-Resilient Infrastructure	Odisha faces increasing risks due to rising sea levels and intensified cyclone patterns	Bisaria et al. (2024), Dash & Akhter (2023)

Odisha's preparedness and response mechanisms include extensive evacuation plans, mock drills, and specialized rapid response teams such as the Odisha Disaster Rapid Action Force (ODRAF). Over 800 cyclone shelters, equipped with emergency supplies, have been constructed to safeguard affected populations (Banerjee & Mohapatra, 2023). These shelters have played a critical role in reducing casualties during major cyclones like Phailin (2013) and Fani (2019) (Das et al., 2022). Odisha's coordinated evacuation strategy has been widely recognised as a global model for disaster preparedness and response.

Post-disaster, recovery and rehabilitation efforts focus on rebuilding resilient infrastructure and restoring livelihoods. Odisha follows the "build back better" principle, incorporating disaster-resistant construction techniques in housing, roadways, and coastal embankments (The World Bank, 2013). Additionally, skill development programs and financial assistance are provided to affected communities, ensuring socio-economic recovery bank (The World Bank, 2013).

4.4 Community Participation in Disaster Governance

Odisha's disaster governance framework places significant emphasis on community participation, fostering local engagement in disaster preparedness and response. Village Disaster Management Committees (VDMCs) and Panchayati Raj institutions actively contribute to capacity-building initiatives, equipping residents with emergency response skills (Nayak, 2020). The involvement of local volunteers has significantly strengthened disaster resilience, particularly in coastal regions prone to cyclonic threats (UNISDR, 2015).

Odisha's disaster governance framework exemplifies a proactive, multi-dimensional approach that integrates institutional coordination, legal frameworks, technological advancements, and community-based resilience strategies. By continuously evolving its disaster management policies and infrastructure, Odisha has emerged as a global leader in disaster preparedness and response.

4. 5. Literature Gaps Table

Category	Identified Gaps	Relevant Studies
Governance & Policy	Lack of proactive disaster prevention measures in the Disaster Management Act, 2005.	Hanspal & Behera (2024), Gupta (2018)
	Insufficient integration of local governance and community participation in policy implementation.	Syal et al. (2021), Ogra et al. (2021)
	Gaps in national-level coastal climate adaptation policies in India.	Jyotsna et al. (2024)
Data & Methodology	Limited socio-economic vulnerability data and uncertainties in datasets for flood risk assessment.	Jain et al. (2025)
	Lack of high-resolution spatial data for urban expansion modelling.	Joshi & Bhatt (2024)
	Subjectivity in Multi-Criteria Decision Making (MCDM) for landslide risk assessment.	Kadapa (2024)
Community & Social Aspects	Marginalised voices (e.g., gender-diverse groups) are excluded from disaster governance frameworks.	Sharan & Gaillard (2025)
	Barriers to meaningful community participation in post-disaster housing reconstruction.	Rahmayanti & Rukmana (2024)
	Limited focus on livelihood security in disaster recovery.	Iwasaki (2016)
Technology & Innovation	Limited empirical validation of AI and cloud-based disaster management frameworks.	Gupta et al. (2022)
	Challenges in Integrating Blockchain Technology for Disaster Response.	Poonia et al. (2021)
	GIS-enabled mobile apps lack governance and policy integration.	Sharma et al. (2020)
Economic & Infrastructure	Private sector lacks incentives for disaster risk reduction in infrastructure projects.	Jain (2015)
	High costs of private adaptation in flood-prone urban areas.	Shukla et al. (2025)
	Fiscal strain on state governments due to disaster financing.	Suresh et al. (2024)
Environmental & Ecological	Need for micro-level planning for mangrove conservation in coastal areas.	Singha et al. (2024)
	Limited focus on slow-onset disasters (e.g., droughts) in Odisha's disaster model.	Sahu et al. (2023)
	Challenges in integrating international agreements (e.g., the Sendai Framework) into domestic policies.	Raikes et al. (2022)
	Lack of longitudinal studies on post-disaster recovery outcomes.	Maly et al. (2022)

The literature reveals key gaps in disaster management, including weak policy implementation and insufficient integration of local governance. For instance, Ogra et al. (2021) underscore the persistence of top-down, response-driven frameworks with limited conceptual shift toward prevention, while Syal et al. (2021) highlight institutional resistance to frameworks like the Sendai Agreement. Additionally, community participation remains limited, as noted by Rahmayanti & Rukmana (2024), who emphasise barriers to meaningful inclusion in post-disaster housing efforts. Data limitations, such as low-resolution modelling (Joshi & Bhatt, 2024) and subjectivity in MCDM-based assessments (Kadapa, 2024), hinder accurate risk analyses. Marginalized groups, particularly gender-diverse identities like hijras and baklas, continue to be excluded from governance spaces due to binary policy frameworks (Sharan & Gaillard, 2025). Meanwhile, innovations like AI and blockchain show promise but often lack empirical validation in disaster contexts (Gupta et al., 2022; Poonia et al., 2021). On the economic front, Jain (2015) critiques the limited private-sector engagement, citing regulatory disincentives. Furthermore, environmental vulnerabilities—especially slow-onset disasters and ecosystem-based risks—receive inadequate attention (Sahu, Das, & Mishra, 2023; Singha et

al., 2024). Addressing these multifaceted gaps requires inclusive governance, high-resolution data integration, critical engagement with social identities, and robust validation of technological interventions to strengthen disaster resilience in India.

5. Effectiveness and Challenges

Odisha's disaster governance has proven effective in mitigating cyclone-related casualties through the implementation of improved early warning systems, mass evacuations, and community engagement. Notably, the Odisha State Disaster Management Authority (OSDMA) has played a central role in reducing cyclone-related fatalities. During Cyclone Phailin (2013) and Cyclone Fani (2019), Odisha successfully evacuated over a million people, drastically reducing mortality compared to the 1999 Super Cyclone, which caused over 10,000 deaths. Odisha's Zero Casualty Goal (2023) further highlights the state's commitment to protecting lives. Studies confirm that multi-organisational coordination and robust cyclone mitigation measures were instrumental in Odisha's success. The integration of structural and non-structural mitigation approaches, such as cyclone shelters, embankments, and improved forecasting technology, has strengthened Odisha's disaster resilience. Research also shows that Odisha has become a global model for disaster risk reduction (DRR) due to its proactive governance and policy reforms, which are aligned with the Sendai Framework for Disaster Risk Reduction (2015).

Beyond cyclone resilience, Odisha has made remarkable strides in coastal disaster preparedness, notably becoming India's first state to implement Tsunami Ready Villages. This initiative, driven by OSDMA and the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), has enhanced community-based preparedness against tsunamis. Under this program, coastal villages such as Venkatraipur and Noliasahi, along with 24 other villages, have received the Tsunami Ready recognition, signifying their ability to conduct timely evacuations, access early warnings, and implement local disaster response mechanisms (Kumar & Pradhan, 2022; PTI, 2024). Odisha's community-driven preparedness model, including mock drills, public awareness campaigns, and infrastructure strengthening, serves as an example for other coastal states prone to tsunami threats.

Despite Odisha's remarkable disaster governance, several persistent challenges remain, particularly in inter-agency coordination and last-mile connectivity. Research indicates that coordination gaps between state agencies and local disaster management committees occasionally hinder rapid response and resource allocation (Raju & Becker, 2013). The National Cyclone Risk Mitigation Project in Odisha has addressed these challenges, but implementation inconsistencies persist (OSDMA, 2008).Additionally, last-mile connectivity in early warning dissemination remains a critical issue, particularly for remote and tribal communities in Odisha. Studies highlight the difficulty in ensuring timely alerts to these populations due to limited mobile network coverage and inadequate infrastructure. Disaster research has underscored the need for community-driven DRR initiatives, emphasizing Panchayati Raj institutions and local governance participation (Das et al., 2022).

Odisha faces new and emerging challenges, particularly in adapting to climate change. Rising sea levels, increasing cyclone intensity, and coastal erosion pose significant threats to Odisha's long-term sustainability. Research on coastal climate risks in India points out that Odisha's adaptation measures need to integrate nature-based solutions like mangrove restoration and improved coastal zoning(Jyotsna et al., 2024).Current policies have primarily focused on disaster preparedness, but researchers argue that Odisha must transition toward a climate-resilient governance model that includes micro-level planning and synergy among sectors (Dash & Akhter, 2023). The State Disaster Management Plan (SDMP) emphasises climate adaptation strategies; however, financial constraints and administrative delays remain key barriers to effective implementation. Studies also note the need for increased investment in disaster insurance to cover infrastructure losses due to extreme weather events (Bhowmik & Roy, 2024).

6. Discussion

Odisha's disaster management framework has evolved into a globally recognised model, particularly in cyclone preparedness and response efforts. Compared to other Indian states, Odisha has demonstrated proactive governance, effective community engagement, and robust early warning systems that significantly reduce the impacts of disasters. For instance, Gujarat's earthquake resilience strategies focus on infrastructure retrofitting, while Odisha emphasizes early evacuation and shelter management (OSDMA, 2008). Globally, countries like Japan and the United States integrate technology-driven early warning systems and multi-agency coordination, similar to Odisha's OSDMA-led disaster governance (UNISDR, 2015).

Additionally, Odisha has made significant progress in tsunami preparedness, with 26 coastal villages officially recognized as "Tsunami Ready" by the Intergovernmental Oceanographic Commission (IOC) of UNESCO. This achievement places Odisha alongside Indonesia and the Philippines, two nations highly vulnerable to tsunamis. Indonesia, which experienced the devastating 2004 Indian Ocean tsunami, has implemented community-based tsunami preparedness programs, including early warning systems and evacuation drills. Similarly, the Philippines, located in the Pacific Ring of Fire, has developed multi-hazard early warning systems and coastal zoning regulations to mitigate tsunami risks. Odisha's Tsunami Ready initiative, which includes mock drills, evacuation route mapping, and stakeholder training, aligns with these global best practices, reinforcing its position as a leader in disaster resilience.

6.1 Lessons for Other Disaster-Prone Regions

Odisha's success offers valuable lessons for other vulnerable regions:

1. Community-Based Disaster Management (CBDM) – Odisha's Community-Based Disaster Management (CBDM) approach emphasises the use of trained volunteers and local shelters, which have significantly minimised casualties during disasters. By empowering communities with preparedness strategies and localized response mechanisms, CBDM enhances resilience and ensures swift action in emergencies (PTI, 2024).
2. Early Warning Systems – Odisha has effectively implemented risk-informed decision-making in its Early Warning Systems, aligning with the Sendai Framework's principles. By integrating real-time risk assessments and proactive communication strategies, the state enhances preparedness and minimizes disaster impacts(Mitra & Shaw, 2023).
3. Institutional Coordination – Odisha's disaster response framework adopts a multi-stakeholder approach, integrating government agencies, NGOs, and local communities to enhance coordination and resource allocation. This collaborative model ensures timely intervention, effective risk management, and improved resilience against disasters (Kumar & Pradhan, 2022).
4. Policy Integration – Odisha's disaster governance integrates climate adaptation strategies, creating a resilient framework for managing environmental risks. By prioritizing sustainable infrastructure, proactive risk assessments, and community engagement, Odisha sets a precedent that other coastal states can emulate to strengthen disaster preparedness (Srinivasan & Nagaraj, 2006).

7. Conclusion

Odisha's disaster governance has transformed from a response-focused model to a proactive and resilience-driven framework. The state's institutional reforms, such as the Odisha State Disaster Management Authority (OSDMA) and the Odisha Disaster Rapid Action Force (ODRAF), have significantly enhanced disaster preparedness and mitigation efforts (Sahu, Das, & Mishra Prakash Chandra, 2023). The adoption of early warning systems, GIS-based hazard mapping, and community-led initiatives has reduced cyclone-related fatalities by 99% (e.g., Cyclone Phailin in 2013 compared to

the 1999 Super Cyclone). Despite these successes, persistent challenges remain, such as coordination inefficiencies, last-mile connectivity issues, and climate adaptation gaps (Tomar et al., 2024).

7.1 Policy Recommendations

7.1.1 Strengthening Governance Mechanisms

- Decentralized DRR Frameworks: Empower Panchayati Raj institutions and urban local bodies to lead community-based disaster risk management (CBDM), as demonstrated by Odisha's successful model of cyclone preparedness (Das et al., 2022; Sahu & Mishra, 2023).
- Institutional Coordination: Address gaps in inter-agency collaboration by mandating "After Action Reviews" (AARs) post-disasters to document lessons and improve SOPs (Pal et al., 2017).
- Accountability Measures: Implement gender-sensitive and inclusive governance, as highlighted by Ray-Bennett (2018a) to ensure marginalised groups (e.g., gender-diverse communities) are included in DRR planning (Sharan & Gaillard, 2025).

7.1.2. Climate Adaptation and Nature-Based Solutions

- Ecosystem-Based DRR: Scale up mangrove conservation in Gujarat and Tamil Nadu to mitigate coastal flooding, leveraging community participation and scientific transplantation (Shah & Ramesh, 2022; Singha et al., 2024).
- Micro-Level Planning: Integrate climate adaptation into district-level policies, as seen in Srikakulam's mainstreaming of DRR and CCA (Dash & Akhter, 2023).
- Urban Resilience: Adopt Surat's "Urban Form Resilience Index" (UFRI) to balance formal/informal settlement adaptation strategies (Shukla et al., 2025).

7.1.3. Technological and Data-Driven Innovations

- AI and GIS for Early Warning: Deploy AI-driven platforms (e.g., 4-AIDE framework) for real-time hazard prediction and resource allocation (Gupta et al., 2022).
- Blockchain for Transparency: Use blockchain to track relief distribution, addressing corruption delays in post-disaster recovery (Poonia et al., 2021).
- Crowdsourcing and Mobile Apps: Expand GPS-enabled apps for community reporting, as tested in Chennai floods (Bhuvana & Arul Aram, 2019), with Odisha's early warning systems as a model (Sahu, Das, & Mishra, 2023).

7.1.4. Financial and Institutional Reforms

- Disaster Risk Financing: Establish state-level insurance pools for manufacturing units in high-risk states (Bhowmik & Roy, 2024) and incentivize CSR investments in resilience (Kanji & Agrawal, 2020).
- International Alignment: Align with Sendai Framework priorities by integrating DRR into G20 infrastructure agendas (Shaw & Kishore, 2023) and leveraging UNDP partnerships for funding.
- Livelihood Protection: Strengthen formal credit markets and livelihood diversification for farmers, as recommended by Padhan & Madheswaran (2023) in Odisha's coastal districts.

7.1.5. Community-Centric Approaches

- Participatory Reconstruction: Adopt Gujarat and Bihar's "progressive spiral" housing model, emphasizing community-led design and long-term support (Vahanvati & Mulligan, 2017).
- Social Capital Mobilization: Train local volunteers (e.g., Odisha's "Aapda Mitra") and leverage networks to reduce post-disaster conflicts (Lee & Kim, 2021).

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Editor-in-Chief
Prof. Dr. Vladimir M. Cvetković

Prof. Dr. Vladimir M. Cvetković is recognised as a leading expert in Disaster Risk Management, with a focus on Risk Reduction, Preparedness, Response, and Recovery. He is employed at the Department for Disaster Management and Environmental Security at the Faculty of Security Studies, University of Belgrade, where he teaches and conducts research in the field of disaster risk management. On June 4, 2025, Prof. Dr. Vladimir M. Cvetković was appointed to the academic title of Adjunct Professor at the Technical University of Leoben, Austria, by decision of the University Senate. This recognition reflects his long-standing scientific work and international contributions in the field of risk and safety management, encompassing teaching, mentoring, and collaborative research within the Safety and Disaster Management (SDM) master's program.

Prof. Dr. Vladimir M. Cvetković has been engaged as a lecturer at FH Campus Wien – University of Applied Sciences in Vienna, where he teaches the course "Integriertes Sicherheitsmanagement" (ILV) within the Integrated Safety and Security Management program (ISM), combining theoretical instruction with practical, workshop-based learning. Also, he is a member of the Safety and Disaster Studies (SDS) working group at the Technical University of Leoben, Austria.

In the summer semester of the 2024/2025 academic year, Prof. Dr. Vladimir M. Cvetković was appointed as a lecturer at the Faculty of Organizational Sciences, University of Belgrade, where he teaches the doctoral-level course "Risk Management in E-Business" within the Software Engineering and E-Business study program. The appointment was made upon the formal request of the Faculty of Organisational Sciences and with full lecturing and signing authority granted by the Academic Council of the Faculty of Security Studies. This role reflects his ongoing engagement in interdisciplinary academic development, integrating security and digital business domains, and strengthening collaboration across institutional and disciplinary lines.

During 2023 and 2024, he was selected as a lecturer for the prestigious Advanced Security and Defence Studies (VSBO) program, conducted within the framework of the National Defence School "Vojvoda Radomir Putnik," under the Ministry of Defence of the Republic of Serbia and the University of Defence. The program brings together senior officers of the Serbian Armed Forces, leaders of state institutions, members of the National Assembly, representatives of ministries, as well as participants from partner countries, contributing to the strengthening of international cooperation in the field of defence and security. For the 2024/2025 academic year, the program began on January 27, 2024, and runs until July 4, 2025. During the six-month intensive program, Vladimir Cvetković actively participated in delivering lectures, conducting practical analyses, and preparing participants to address contemporary security challenges. His role included not only providing education but also developing key crisis management skills, analysing current security issues, and fostering interactive learning. The program aims to enhance professional capacities and shape a new generation of experts dedicated to regional stability and security.

He is the founder and president of the Scientific-Professional Society for Disaster Risk Management and the director of the International Institute for Disaster Research. Editor-in-Chief of the International Journal of Disaster Risk Management and the International Journal of Contemporary Security Studies. He is also the Director of ProSafeNet – The Global Hub for Safety, Security, Risk & Emergency Professionals and Scientists (www.prosafenet.org), a platform dedicated to international collaboration, knowledge exchange, and the advancement of best practices in the fields of safety, security, and disaster risk management. He has authored over 300 scientific papers published in domestic and international journals and proceedings, as well as 30 books. He has participated in over 150 scientific conferences, 12 national and international projects, reviewed more than 400 scientific papers, and organised numerous training sessions in the field of disaster management. He is also the Director of ProSafeNet – The Global Hub for Safety, Security, Risk & Emergency Professionals and Scientists (www.prosafenet.org), a platform dedicated to international collaboration, knowledge exchange, and the advancement of best practices in the fields of safety, security, and disaster risk management.

He has authored over 300 scientific papers published in domestic and international journals and proceedings, as well as 30 books. He has participated in over 150 scientific conferences, 12 national and international projects, reviewed more than 400 scientific papers, and organised numerous training sessions in the field of emergency protection and rescue. He has received numerous national and international awards and recognitions, including the Danubis Young Scientist Award (2017) from the Austrian Federal Ministry of Science, Research and Economy and the Institute for the Danube Region and Central Europe for the best young scientist from Serbia; selected as the "Local Expert" for Serbia in the field of disaster risk management by the international consortium and CIMA Research Foundation; award for the best student of his generation at the Criminalistic-Police Academy (10.00 average); and one of the top cadets of the Secondary School of Internal Affairs, Pane Đukić, 35th class. He graduated in 2010 as the top student of his class (average grade: 10.00) and defended his master's thesis in 2012 at the Academy of Criminalistics and Police Studies in Belgrade.