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Article

Exploring Non-Structural Flood Risk Management Measures in Haor Areas of Sunamganj, Bangladesh

Hajera Aktar[1], Syeda Ismat Ara Jahan[2], Md Rakib Mia[3], Habibur Rahman Masrur[4]

[1] Department of Political Studies, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh; hajera-pss@sust.edu (H.A.); siajsust@gmail.com (S.I.A.J.); rakibpss017sust@gmail.com (M.R.M.); habiburrahmanmasrur40@gmail.com (H.R.M.)

* Correspondence: rakibpss017sust@gmail.com

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ABSTRACT

This is a qualitative study focusing on non-structural flood management measures to support Boro rice farmers in Tahirpur Upazila in Sunamganj District, a highly flood-prone area. The objective of the study is to analyze existing non-structural flood management practices, including flood forecasting and dissemination processes, as well as farmer education and training. This study found that floods, especially flash floods, are devastating and sorrowful for the farmers in the area, destroying their crops, hard work, and livelihood. They remain far from modern technology-based agricultural and information systems. According to experienced respondents, one of the major problems of non-structured flood risk management is the unavailability of timely upstream information, particularly for adjacent flood-prone areas in India, including Meghalaya, which leads to unexpected flash floods in the study area. Due to insufficient data or information, residents in the study area still rely on perception and indigenous knowledge regarding flood-related issues. This study gathers extensive data through in-depth interviews and Key Informant Interviews (KII). Additionally, other convenient techniques have also been used to collect relevant information.

KEYWORDS

Non-structural, flood risk management, boro farmers, haor areas, Bangladesh.

1. Introduction

Floods are among the most devastating and recurrent disasters worldwide (World Health Organization, 2024). The whole world is suffering from various natural disasters, such as floods, and Bangladesh ranks among the top nations (Alam, 2025). The northern side of Bangladesh is surrounded by haor wetlands, particularly in the Sunamganj district, which is at high risk of natural disasters, including flash floods that recurrently affect agriculture, homesteads, and infrastructure (Mondal et al., 2021). The Haor area of Sunamganj District in Bangladesh is known for its distinctive bowl-shaped depressions, which are crucial to the Bangladesh economy and ecology. It covers most of 3,669.58 square kilometers (Kazi Rokonuzzaman et al., 2023). This area has around 373 haor land and covers 859,000 hectares, accounting for 43% of the total area of the haor district in Bangladesh (Md Al-Fahad, 2025). Every year, the Sunamganj region is affected by

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flash floods in pre-monsoon, particularly in March-April, causing overnight damage to homesteads, crops, and local infrastructure such as embankments and roads (Haque et al., 2022). Geographically, the Sylhet division, particularly the Sunamganj district, is vulnerable to flooding, river erosion, and other natural disasters that are related to agricultural activities (Islam et al., 2022).

Historically, the focus has been on structural interventions, such as dam construction and embankment construction, to control floods. However, the suffering caused by damage to household tools and crop loss often results in high costs and creates a multi-sectoral problem that persists throughout the year. So, the Haor region is poorly maintained in terms of the infrastructure that once protected against floods (Ahmed, 2023). So, the structural measures may not be sufficient to address the multifaceted nature of flood risk in the Haor region. As such, exploring non-structured flood measurement has gained significant attention in flood risk management strategies and adaptation in the Sunamganj haor region.

Non-structural flood management measures are strategies that aim to reduce the loss of life and property without relying on physical infrastructure. These measures include flood forecasting and early warning systems, flood hazard mapping, public awareness and education, community participation, capacity building, and institutional arrangements (Narmilan, 2018). Such measures are particularly important in Bangladesh, where low-lying geography and dependence on agriculture make communities highly vulnerable to floods.

In general, flood risk management measures combine structural and non-structural measures in an integrated approach (Lagat, 2023). Structural measures include those that protect vulnerable areas, which engineers and local inhabitants, such as dams and river embankments, prefer. Besides this, nonstructural measures comprise flood forecasting and warning, flood hazard and risk management, public participation, and institutional arrangement (Tingsanchali, 2011). The prerequisite for non-structural measures is knowledge of the danger, including key parameters such as probability, type, and extent of impact. Point out areas at risk; flood hazard maps, information, and education must keep flood awareness alive, maintain a high-quality forecasting system, and protect persons (Egli, Gallen, 2002). As geographically, Bangladesh is a low land as well as flood is a common natural disaster here, in addition, agricultural is the central based of economy, nonetheless flood safety cannot be reached in most vulnerable areas with the help of structural means only, further flood risk reduction via non-structural measures is usually indispensable, and a site-specific mix of structural and non-structural measures seems to be a proper solution. Since sustainability requires thinking about future generations, the climate change issue becomes important.

In addition, indigenous knowledge and local institutional roles are critical in designing context-specific flood adaptation strategies (Alam, 2025). Non-structural measures lend themselves well to application in climate change adaptation strategies. Given the high uncertainty in assessing climate change impacts, the flexibility of adaptation strategies is particularly advantageous. The findings of the study will provide practical insights for local government, policymakers, and NGOs (Non-Governmental Organizations) to reduce flood risk and promote sustainable strategies.

The specific objectives of the study are: to explore existing flood forecasting and dissemination processes to inform farmers about floods; to analyze existing flood risk management-related education and training facilities to support farmers; to understand farmers' perceptions and participation in these activities to ensure sustainability.

2. Methodology

This study adopted a qualitative approach to explore the availability, perceptions, experiences, and views of individual farmers, government officials, and NGO workers regarding existing non-structural flood risk management measures in the Haor area of Bangladesh, especially in Tahirpur Upazila of Sunamgonj district.

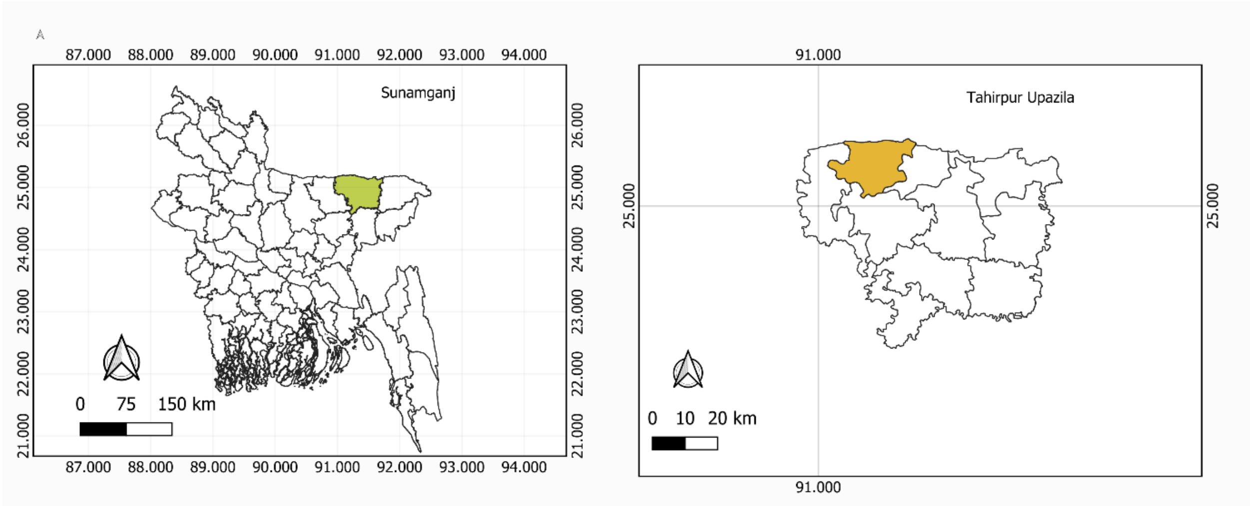

Figure 1. Map of the Study area (Sunamganj and Tahirpur Upazila).

Therefore, this study collected qualitative data using a case study method, which enables a researcher to examine data within a specific context closely. In most cases, a case study method selects a small geographical area or a very limited number of individuals as the subjects of study (Kusunoki, 2020; Zainal, 2007). Tahirpur upazila was selected purposively, considering the availability of government and non-government non-structural flood management measures to support boro rice farmers.

To acquire in-depth qualitative data, the study has involved several categories of research participants, including farmers (both male and female), the Upazila Agricultural Officer, NGO workers, and the Local Government Rural Engineering Department (LGRD/LGED) officer. A total of 10 in-depth interviews, 4 Key Informant Interviews (KII), and 2 Focus Group Discussions (FDGs) were conducted. Each FDG consisted of 6-10 participants.

The study mainly uses a convenience sampling technique to select the sample, as convenience is a type of non-probability or nonrandom sampling where members of the target population that meet certain practical criteria, such as easy accessibility, geographical proximity, availability at a given time, or the willingness to participate, are included in the study (Dörnyei, 2007). Data collection continued until sufficient depth of information was achieved and recurring patterns were observed across interviews and discussions.

In-depth interview techniques and checklists are used to collect relevant information. Each interview lasted approximately 45-60 minutes. FGDs were conducted to gather farmers' perspectives on flood forecasting, early warning dissemination, and preparedness practices. Data were also collected through Key Informant Interviews (KIIs) with relevant officials to understand institutional perspectives. Observation techniques were used to assess the current state of flood management activities in the study area. In addition, some secondary sources of data, particularly document review, were used to support the primary data.

The collected data were analyzed with thematic analysis. Thematic Analysis is a method used for 'identifying, analyzing, and reporting patterns (themes) within the data' (Braun & Clarke, 2006). The analysis followed an inductive approach, in which themes emerged from recurring patterns in participants' responses. After data collection, interview notes, and careful review several times. Meaningful segments of text were identified and grouped into related categories based on similarities in response. These categories were then organized into border themes reflecting major issues related to non-structural flood risk management. Representative statements from participants were used to illustrate each theme.

Ethical considerations were maintained throughout the research process. Participants were informed of the purpose of the study, and their voluntary participation was ensured. Confidentiality and anonymity were preserved during data analysis and reporting.

3. Results

3.1. Flood forecasting, dissemination, and warning system

Flood Forecasting and Warning Centre (FFWC) under the Bangladesh Water Development Board (BWDB) issues flood warnings in the haor region. In addition, 'Climate Adaptation and Livelihood Protection (CALIP)', a supplementary project supported by the International Fund for Agricultural Development (IFAD), has been developing a community-based early flash flood warning system (FFEWS) in the Sylhet Basin. However, it is still in the experimental stage. The Flood Forecasting and Warning Centre (FFWC) issues a deterministic warning just three days before the flood and an extended warning seven days before the flood. However, the FFWC flood warning system is reported to be insufficiently capable of issuing a strong, dedicated early warning system for flash floods with a considerable lead time in the Haor region.

Key informant interviews revealed several challenges to developing an early flash flood warning system in haor areas. The most commonly cited challenge is insufficient data. The existing system relies heavily on floodwater information from upstream countries. The larger catchment areas of the major rivers like the Ganges, the Brahmaputra, and the Meghna lie outside the country, for which sufficient data are not available. In the words of an interviewee-

We do not have sufficient data, specifically for the rivers located in other countries. FFWC needs a larger-scale operation in the haor areas to produce a strong flash-flood warning.

Furthermore, the Bangladesh Meteorology Department (MBD), responsible for collecting weather data, is also unable to generate sufficient pre-monsoon weather data. Pre-monsoon weather data is very important for detecting flash flood events. Lack of sufficient manpower, frequent load shading, and inadequate RADAR stations largely hinder MBD's capacity to gather sufficient pre-monsoon weather data.

Another issue is the reliance on the traditionally set-up danger level of the rivers. Geographically, the Haor region is different from other parts of the country. There are several submergible dams here. This requires that the danger level of the rivers in the haor areas should be set differently. Key informant recommended an additional danger level for pre-monsoon flash-flood forecasting in the Haor. The respondent commented-

We have a common flood danger level for different rivers across the country. The geography of the haor areas differs; it should be considered when setting the danger level. A more dedicated effort is required to collect data regarding the dams and low-lying areas of haors and set up danger levels accordingly.

However, several participants questioned the effectiveness of a flash-flood warning system that would alert farmers to flood events several days in advance. The two- or three-day warning could not help them much with harvesting the paddy. This is because farmers in the Haor areas are largely dependent on a labor-intensive system to harvest the crop. The supply of labor is often inadequate and costly, especially during floods. They emphasized developing a flood warning system that would alert them about the occurrence of a flood well in advance. As one participant says—

The warning could not help us; we had already invested our money and labor. Now, if they say the flood is coming one or two days later, what do we have to do? Nothing. I think they issue the warning a considerable period in advance; otherwise, a one- or two-day earlier warning would not help us at all.

From the above, it has been found that the present flash flood warning system in the haor areas is not capable of producing a strong flash flood warning. They lack sufficient data, manpower, and technological infrastructure. In addition, the danger level for different rivers should be updated to account for the geography of haors.

3.2. Nature of Flood in the Haor Region

The nature of floods generally affects the Sunamganj district from March to April (Table 1). Besides, floods inundated the crops, which is a huge economic issue for those people. In here, a table shows the flood water entered date and the damage to crops in hectares, and calculates with BDT Taka:

Table 1. Historical Flash Flood of Sunamganj. Source: Bangladesh Bureau of Statistics Report 2011.

Year	Flood water entered the Haor	Inundated the Boro crops	Extent of damage	Damaged Boro crops in hectares	Cost of damage (in billion BDT)
1996	16-Mar	18-May	75%	29,822	41
1998	23-May	23-May	40%	11,579	23
1999	8-Apr	6-May	70%	10,950	9.7
2000	30-Apr	30-Apr	70%	1,355	4.3
2001	27-Apr	30-Apr	70%	4,963	19
2002	14-Apr	18-Apr	70%	21,677	70
2004	13-Apr	15-Apr	90%	95,402	348

Participants have been found to have a deep understanding of the history and nature of floods in their own locality. The knowledge developed through their daily observations of their surroundings, close ties to their environment, and an accumulated understanding over generations. People can describe and explain how the nature of floods and their vulnerability have changed over time. The following are participants' experiences of the 2022 flood, which washed away their crops. A respondent said

In 2022, a devastating flood occurred in our locality within a very short period, lasting several days. Paddy was damaged and ultimately washed away. We were not even able to harvest a single paddy grain. We were ready to harvest the paddy. Suddenly, I felt we needed to do it in a hurry. Eventually, I found that it would not be possible to harvest the crop at all. The flood just destroyed my money and labor in just one or two days. When the flood started, the paddy field became a large lake, destroying our crops. The embankment fell in a single night. In the morning, we had completely lost hope of harvesting any crops.

When the respondents described the history of the flood, they could even recall the specific period when it began. Such stories about the history and nature of past floods represent the devastating nature of floods in haor areas. They recalled the 2022 flood and the consequent loss of large crops.

3.3. Indigenous ways to anticipate flood

Accurate flood warnings and their dissemination are important preparatory measures to reduce paddy losses during floods. It has been found that villagers practice early warning or traditional forecasting. However, the most effective system cannot be determined without perceiving the systems more seriously. According to the participants, they receive early flood warnings in several ways. One way was observing weather behavior, such as a black cloud in the northern sky, a gloomy sky, and continuous rainfall. Another way is to observe animal behavior, such as cockroaches flying at night, insects flying in the sky or in crop fields, birds flying in the sky, grasshoppers flying in the sky, etc. However, the most commonly cited and more accepted way is the behavior of the water in the river and canal. Several participants reported that they could understand the nature of the flood from observing the current's increasing speed and the height of the river's waves. As participants were sharing their experiences

The flight of cockroaches at night has been regarded as a warning of continuous rain in the days that follow. Moreover, it happens so in many cases. The behavior of water in the river and canal is important. The speed of water flow in rivers and canals increases during flood events. During the time, specifically one or two days later, the sky started to turn cloudy. The eastern sky becomes very cloudy; this is the ultimate sign that rain is approaching. We then need to be ready to get our crops home immediately.

In a nutshell, the study finds that the Haor people rely on indigenous knowledge to get early warning regarding disasters. Hardy people need to protect their mono-crops from floodwater. To do so, they rely on observation to varying degrees. To get early warning, river behavior, along with a gloomy sky and a southward wind, are highly effective symptoms, as most respondents mentioned them.

3.4. Farmer's training to adapt to climate-adaptive rice farming

Usually, floods occur in the haor regions during May-June. Under these usual conditions, boro rice has enough time to mature by mid-April. The exception occurs when an early flood takes place and washes away the crops. In recent years, the frequency of early flash floods has increased. Moreover, timely prediction and warning of early flash floods are not always possible. Given the situation, farmers must adopt flood-adaptive rice farming. This would help them reduce the risk of crop loss and harvest the crop before an early flash flood occurs.

Most boro rice farmers in the Haor areas depend on conventional rice farming. They usually cultivate traditional rice varieties and follow the traditional seeding and transplanting calendar. These traditional farming practices need to be replaced with flood-adaptive rice farming, which includes changes in the traditional rice varieties and agricultural methods. Farmers should be made aware of the drawbacks of traditional farming and trained in various aspects of flood-adaptive rice farming. Key-informant interviews revealed several issues that farmers should be made aware of to help them save the paddy.

Firstly, the cultivation of appropriate rice varieties in the Haor regions is necessary to escape flash floods. At present, two high-yielding varieties (HYVs), namely, BRRI Dhan 28 and BRRI Dhan 29, are cultivated in around 90% arable lands of the haor in Sunamganj. The maturation times of BRRI Dhan 28 and BRRI Dhan 29 are 120 days and almost 160 days, respectively. Due to its long lifespan and the possibility of flood occurrence, BRRI Dhan 29 is highly vulnerable to being washed away by an early flash flood. This variety is not ideal for the Haor areas due to its high risk of flash-flood damage.

The farmers should therefore adopt the rice variant, which has a considerably shorter life span. However, among all participants, only two farmers knew the life spans of the two commonly cultivated rice varieties, BRRI 28 and BRRI 29. They reported learning about the life span from a short training session on rice farming that they received at the Upazila level. From then on, they do not cultivate BRRI 29. Moreover, they also disseminated it to other farmers in their locality. A farmer says-

We knew it from the Upazila training. Since then, we stopped cultivating 29 rice. Earlier, we had no such information. Now, in our village, no one cultivate 29 rice. We are aware of it, now.

However, the situation is different in other study areas. The participants do not know anything about the life span of different rice variants. They did not happen to receive any training from government or non-government organizations. However, one key informant reported that the government has stopped supplying BRRI 29 seed. He complained that, despite the ban, the farmers illegally collected BRRI 29 seed and cultivated it. The respondent commented-

The farmers cultivate BRRI 29, even though they have been told not to. This year, the supply of BRRI 29 was banned, yet they collected the seed illegally. They cultivated BRRI in all the haors.

In addition, early seeding and early transplanting are very important to secure the mature rice crop from early flash floods. This is because early flash floods occur at the end of March, as in 2017. If there is a possibility of a very early flash flood at the end of March, the rice crop must be harvested by then. In such a situation, early seeding and early transplanting are essential to protect the rice crop from early flash floods. However, not all participants were convinced of the benefits of early seeding and early transplanting. They argued that early seeding and early transplanting would always be possible, as their arable land often remains underwater for long periods. They need to wait until the water gets out and the land is ready for seeding. As one participant says

We cannot just do seeding when we want. We had to wait until the water was gone. We also cannot transplant the seed as long as the land stays underwater. We had to wait. Many farmers seed lately, even more lately, because of the water.

The key informant also stressed the need for mechanization in rice farming so that farmers can harvest their crops quickly, soon after they are mature, using technologies and machinery. This would also help them save the crop.

3.5. The role of public education in flood preparedness and flood management

Haor Development Board is firmly responsible for the overall development of Haor, especially the agricultural economy. However, it is a matter of great concern that they are not strongly concerned about it. One Key Informant (Researcher and agricultural economist) interviewed as:

The Water Development Board and the respected Engineer of this department are responsible for protecting the crops of the Haor area from flash floods. However, the flood that occurred last year, in April and March, is due to the fault and corruption in the dam's construction, and civil society, social workers, the masses of people, as well as other concerned people, are responsible for it. He also says that the strong and sustainable construction of dams, flood control, and sustainable development are the primary demands of people in the Haor areas. He also argues that the government should engage the beneficiary to maintain damp.

3.6. Agricultural land planning and protection of the Khal (lake) to reserve flood water

The flooding of the haor is inevitable as it is situated in a geographically low-lying area. The rainwater would naturally drain into the haor areas, damaging the crops. However, appropriate land planning and protection of natural water reservoirs (i.e., khal) would help reduce the crop loss. The land planning here demonstrates that farming in the low-lying areas should be based on the fact that they should not be cultivated, but rather used as a water reservoir. This would save the crop cultivated in relatively elevated areas, provided that the rainwater is supplied to the low-lying area.

Key informants reported that appropriate land planning would effectively help reduce the risk. They emphasized that there should be sufficient reservoirs to store floodwater. They recommended that some low-lying haors should remain uncultivated, serving as reservoirs for floodwater. This would guarantee the saving of crops cultivated in upper areas. In his words

The 37 haors do not need to be cultivated; if it happens, we would transfer floodwater to the non-cultivated haor areas. This is possible, and it would largely help save the crop.

However, while discussing the possibility of such land planning, the farmers rejected the idea. This would be tough largely because most people are highly dependent on the monocrop. Such planning would therefore require alternative income-generating opportunities for the people who would need to leave their place to reserve floodwater.

The protection of natural reservoirs such as khals, beels, and canals would largely help preserve the floodwater. Due to the rich diversity of fish and the opportunities in the fishing business, most khals, beels, and canals are being encroached upon. The encroachers have been exploiting the resources to maximize profits. The natural process of poly development, soil erosion from hills, and the dumping of garbage are also reducing the water-retention capacity of the khals, beels, and canals. Furthermore, the farmers were found to lack a general awareness of the importance of these water bodies in retaining floodwater. Key informant recommended increasing awareness of the importance of protecting natural water bodies and their appropriate use at the local level.

In summary, given the geographical characteristics of haor areas, increased reservation capacity would effectively help protect the crop from floods. Agricultural land planning that focuses on avoiding the cultivation of low-lying areas would largely retain floodwater. The natural reservoir would also serve as a water source. However, they are to be protected and utilized efficiently.

4. Conclusion

Haor is the worst flood-affected part in Bangladesh, covering about 1.99 million hectares (19,998 sq km) of land (Master Plan of Haor Area, 2012). The area remains underwater for almost six months, either in stagnant or flash-flooding conditions, which makes the inhabitants' crop production and livelihood practices distinct from those of other parts of the country. Agriculture is the primary occupation of the Haor districts, with Boro rice (80%) covering 80% of the area (Huda, 2004). Aman and hybrid rice are also produced in a limited area (Huda, 2004; Das, 2004). Rice production is of great significance to the district's agricultural production. The productivity of this land contributes to food surplus in this region as well as the total country, and it may be believed that there is a potential for further increases in land for agricultural purposes. Flood is an indispensable part of the haor life, so non-structural support before and after the flood is very urgent to reduce loss of life and property. The government should maintain a strong policy, especially by deploying police to develop hard areas. To resolve the manpower crisis and develop infrastructure, different initiatives should be introduced to reduce losses. A warning system is important and should be developed so that, in place of perception, farmers can rely on modern technology to protect their crops and themselves.

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