Publisher: Scientific-Professional Society for Disaster Risk Management

International Journal of Disaster Risk Management

Journal homepage: https://internationaljournalofdisasterriskmanagement.com

Review Article

Understanding Crowd Dynamics and Disaster Risks in Kerala Temple Festivals: Strategies for Effective Management

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Received: 5 September 2024; Revised: 25 November 2024; Accepted 3 December 2024; Published: 25 December 2024.

Abstract

Temple festivals in Kerala are vibrant cultural events that draw massive crowds, creating a complex environment where crowd dynamics can pose significant disaster risks. The large number of attendees, combined with limited space and inadequate safety measures, makes these festivals vulnerable to incidents such as stampedes, fires, and structural collapses. Despite the recurrence of crowd-induced disasters, there remains a gap in comprehensive disaster management strategies tailored to these unique events. This paper examines the critical aspects of crowd behaviour during Kerala's temple festivals and the associated disaster risks. It explores past incidents to identify key risk factors and assesses current preparedness and response mechanisms. This study explored a mixed-methods approach to examine crowd dynamics and disaster risks in Kerala temple festivals. Primary data were collected through field observations and semi-structured interviews with festival organizers, local authorities, and participants. Secondary data included incident reports and archival records of past festivals. The findings were synthesized to propose evidence-based management strategies. The analysis revealed critical risk factors associated with crowd dynamics during Kerala temple festivals, including overcrowding in confined spaces, inadequate evacuation routes, and lack of real-time communication systems. GIS-based spatial mapping highlighted congestion hotspots and high-risk zones. Interviews with stakeholders identified gaps in preparedness and coordination among organizers and emergency services. The proposed management strategies demonstrated the potential to mitigate risks, enhance crowd safety, and ensure efficient emergency response. Effective crowd management at temple festivals requires a multidisciplinary approach that involves spatial analysis, stakeholder collaboration, and robust catastrophe preparedness. The study highlights the significance of conducting preventive risk assessments and dynamic crowd monitoring techniques to avoid disasters. Implementing the proposed measures can considerably improve public safety, serve as a model for comparable cultural events, and help to shape legislation for disaster risk reduction in large crowds.

Keywords

Crowd Dynamics, Crowd-Induced Disasters, Temple Festivals, Stampedes, Public Safety.

1. Introduction

Kerala is a land of magnificent centres of holy pilgrimages. Temples of Kerala attract many people due to their architectural style, rituals, colourful festivals, and so on. Temple festivals attract not only people from surrounding places but also from neighbouring states. Temple festivals promote the true spirit of communal harmony and mass gathering as they attract people from inter-districts or even from inter-state. Temple festivals in Kerala are an integral part of the state's cultural and religious landscape, attracting large crowds of devotees and tourists alike. These events, renowned for their grandeur and elaborate rituals, often bring together tens of thousands of people in confined spaces, resulting in complex crowd dynamics. While these festivals serve as significant socio-religious gatherings, they also present considerable challenges to public safety, particularly in terms of disaster management.

Some of Kerala's temples draw large crowds because of their rich cultural heritage and historical significance. Sabarimala hill shrine pilgrimage, Attukal Devi temple, Thrissur Pooram, Nemmara temple festival, and so on are well-known. Many temple festivals include free food distribution, entertainment, pyrotechnics, and religious rituals. Therefore, religious festival sites attract people from a wide range of religious backgrounds by acting as venues for worship, entertainment, and business. Religious gatherings attract large groups with various physical and behavioural characteristics (Illiyas et al., 2013). Venues for large gatherings are vulnerable to crowd dangers, and implementing an efficient crowd control system presents several difficulties. According to studies, 67% of human stampedes in India occur at religious mass gatherings (Illiyas et al., 2020). The study focuses on major disasters in Kerala that coincide with temple festivals.

Temple festivals are strictly secular. However, the festivals of state-run big temples are entirely dedicated to temple arts and forms. Pooram-style displays combine activities such as drumming, elephant procession, and fireworks. In the past, Hindu reformers condemned the usage of fireworks during temple festivities. Mannathu Padmanabhan, a social reformer and the founder of the Nair Service Society has identified four harmful behaviours ("Nalukettu" means four knots). They are "Case Kettu"—bundles of litigation; "ThaliKettu"—child marriage; "KuthiraKettu"—processions with adorned idols of horses or temple cars; and "Vedi kettu"—fireworks. He had consistently pushed society to stop such practices. (Satisan, 2016). Around a century ago, Sree Narayana Guru, a saint, social reformer, and the founder president of SNDP Yogam, warned Hindu society about the excesses of fireworks displays. Guru emphasised that society should use its money for public good rather than waste it on pyrotechnics. He declared, "We don't need Kari. (Elephants) and Karimarunnu (gunpowder) anymore." (Satisan, 2016)

Crowd-induced disasters, including stampedes, fires, and structural collapses, have repeatedly occurred during temple festivals in Kerala, highlighting an urgent need for effective disaster risk management. The high density of participants, limited exit routes, minimal crowd control measures, and inadequate emergency response facilities can quickly escalate minor incidents into large-scale tragedies. Moreover, the presence of pyrotechnics, animals, and temporary structures during these festivals adds to the risk, complicating emergency management. Understanding crowd dynamics, particularly in situations where cultural and religious sentiments influence behaviour, is critical for identifying potential disaster risks and developing targeted strategies that ensure participant safety, minimise response times, and prevent catastrophic outcomes.

Kerala's temple festivals, renowned for their cultural and spiritual vibrancy, often attract massive crowds, creating potential disaster scenarios due to crowd mismanagement. These festivals, drawing millions of devotees, reflect the state's cultural richness and expose the vulnerabilities in managing large-scale gatherings. Historical instances highlight the dire need for effective crowd management strategies. Despite advancements in disaster management frameworks, there remains a critical gap in integrating localised strategies that address the unique dynamics of Kerala's temple festivals. This study seeks to analyse the crowd dynamics during Kerala temple festivals, identify disaster risks, and propose a framework for effective management strategies tailored to these culturally significant events. By addressing these gaps, the study aims to contribute to the development

of sustainable and culturally sensitive approaches to crowd management, ensuring the safety and sanctity of these festivals.

This paper aims to explore the dynamics of crowds during temple festivals in Kerala and assess the associated risks while proposing strategic interventions to enhance disaster preparedness and management. By examining past incidents and current disaster management practices, the study will highlight the need for a more systematic approach to prevent crowd-induced disasters and safeguard the lives of festival-goers

1.1. Objective

The primary objective of this paper is to analyze the crowd dynamics and disaster risks associated with temple festivals in Kerala, to propose effective strategies for disaster management. Specifically, the paper seeks to:

- Analyze the crowd dynamics and disaster risks associated with temple festivals in Kerala and propose effective strategies for disaster management.
- Examine the behavioural patterns and movement of large crowds during temple festivals, identifying the factors that contribute to crowd-induced disasters.
- Assess the current disaster management practices and response mechanisms employed during such events, highlighting gaps and areas of improvement.
- Analyze past incidents of crowd-induced disasters at temple festivals in Kerala to uncover recurring risk factors and the effectiveness of mitigation measures.
- Propose strategic interventions for improving disaster preparedness, including better crowd control, infrastructure enhancements, and emergency response coordination.
- Develop a framework for proactive disaster management at large cultural and religious gatherings, aimed at reducing the likelihood of tragedies and ensuring public safety.

The goals of this research are to contribute to the development of more effective disaster management strategies that can protect participants at temple festivals while retaining both their safety and the cultural importance of these events.

1.2. Review of Literature

The study of crowd dynamics and disaster risks has been a significant area of research in disaster management, particularly in the context of mass gatherings. Temple festivals in Kerala, known for their religious and cultural significance, also present a unique set of challenges due to the congregation of large crowds in often restricted spaces. This section reviews key studies and literature related to crowd behaviour, disaster management, and festival safety, focusing on both global and local perspectives.

Disaster Management: A Disaster Manager's Handbook by Carter W. Nick (2008), published by the Asian Development Bank, serves as a comprehensive guide for disaster management professionals, offering a practical framework for mitigating, preparing for, responding to, and recovering from disasters. The handbook emphasizes a systematic approach to disaster management, combining theory, case studies, and actionable strategies for practitioners. ADB's focus is on enabling countries to strengthen their disaster management capacities, particularly in developing regions where vulnerabilities to disasters are heightened due to socioeconomic factors. The book guides both natural and man-made disasters, offering insights into the critical elements required for building resilient communities. For Kerala's temple festivals, where large-scale events take place in potentially hazardous environments, preparedness and mitigation are vital. The handbook's guidance on structural planning and public awareness campaigns can help authorities develop strategies to ensure safer festival environments. For instance, crowd control barriers, designated exit routes, and clear signage can reduce risks during these events.

WHO's "Public Health for Mass Gatherings: Key Considerations" is one of the most thorough texts outlining basic public health concepts for mass gatherings. It offers a framework for evaluating health risks, as well as surveillance systems and response tactics designed for huge crowds. Effective disaster management in large crowds necessitates a multifaceted approach that includes planning, real-time monitoring, and prompt response. The United Nations International Strategy for Disaster Reduction (UNISDR, 2015) emphasises the need for preparedness, early warning systems, and risk assessment in managing major occurrences.

In Kerala, disaster management authorities have been increasingly focusing on festival safety. The Kerala State Disaster Management Authority (KSDMA, 2020) has laid out guidelines for large religious gatherings, though challenges remain in their implementation. Studies by Narayanan and Menon (2020) suggest that while safety measures are in place, coordination between various stakeholders—temple authorities, local government, and disaster management teams—remains fragmented, reducing the effectiveness of these measures.

The literature suggests that crowd-induced disasters at temple festivals in Kerala stem from a complex interplay of crowd behaviour, inadequate infrastructure, and fragmented disaster management efforts. While significant research has been done on crowd dynamics and mass gathering safety, there is a notable gap in studies focused specifically on the religious and cultural context of Kerala's festivals. Addressing these challenges requires a holistic approach that integrates traditional practices with modern disaster management strategies, including better planning, stakeholder coordination, and technological advancements.

2. Methodology

This study adopted a mixed-methods approach to investigate crowd dynamics and disaster risks associated with Kerala temple festivals. A descriptive and analytical methodology was employed to identify significant risk factors and evaluate the effectiveness of current management practices. Primary data were collected through field observations conducted during major temple festivals, focusing on crowd movement patterns, spatial layouts, and emergency response procedures.

To gain qualitative insights, semi-structured interviews were conducted with festival organizers, local authorities, and emergency responders. Secondary data, including incident reports, archival records, and documented case studies from previous festivals, were analyzed to understand historical trends and recurring issues.This study explored a mixed-methods approach to examine crowd dynamics and disaster risks in Kerala temple festivals. Primary data were collected through field observations and semi-structured interviews with festival organizers, local authorities, and participants. Secondary data included incident reports and archival records of past festivals. The findings were synthesized to propose evidence-based management strategies.

3. Issues of Crowd Management

The crowd management system includes the operational planning and procedures used to manage the process and facilitate mobility concerning crowd-related functions. Crowd management and crowd control are not interchangeable terms. Crowd control refers to the tactics used to respond when a crowd's behaviour begins to breach accepted crowd management expectations. (Soo & Avery, 2003). In Kerala, crowd control measures were implemented in all of the major pilgrimage sites. Massive crowds at religious sites during the pilgrimage or festival season cause tremendous worry among officials.

Disaster management is focused on disaster prevention and risk mitigation. "Organised or unplanned event if the number of people attending is sufficient to strain the planning and response resources of the community, state, or nation hosting the event" is the standard definition of a mass gathering (WHO, 2008). Mass gatherings present significant issues in terms of infectious and

non-communicable disease surveillance, emergency planning, environmental health, vaccination, crowd management, and so on (Lancet Infectious Diseases, 2010). A crowd refers to a large number of people group, with or without an organised structure. When big groups of people gather, crowd management becomes challenging. Crowd management is the ability and implementation of plans to organise or regulate a big group of people in an orderly manner (Deshpande & Gupta). Crowd disasters aren't a new phenomenon. However, the ever-increasing mass gatherings at religious sites raise worries.

Crowd disasters are a recurring problem in India. These instances underscore the importance of good crowd management in the country (Bala, 2018). It is vital to develop a systematic approach to identify gaps and increase crowd management capacity. The majority of crowd disasters are man-made and may be avoided or managed with proper planning and preparation. The biggest cause of crowd tragedies during mass gathering events in India has been recognised as "lack of planning and preparedness." Understanding visitors and stakeholders, risk assessments, safety and security measures, facility and emergency planning, and transportation and traffic management should all be part of the planning process (Bala 2018).

Table 1. Major events of disasters in temple festivals in Kerala.

Sl. No	Disaster	Date/ year	Enquiry commission	Nature of causalities
1	Sabarimala fire	1950	K.Kesava Menon	Temple fire
2	Guruvayur temple fire	1970	Gangadharan Thampy Commission	Temple fire
3	Malanada Temple Fire Cracker Accident	1990		25 people had been killed
4	Sabarimala stampede	1999	Justice Chandrasekhara-Menon Committee	52 killed
5	Sabarimala stampede pulled tragedy	2011	Justice M.R. Hariharan Nair	102 killed
6	Firecracker Accident at Puttingal Temple, Kollam District	2016	Justice N Krishnan Nair, Justice S Gopinath	109 were killed more than 400 injured
7	Firecracker accident Veerarkavu Temple near Kasaragod's Nileshwar.	2024	Special Investigation Team (SIT) appointed by the state government	150 people were injured four killed.

Source: Data collected from various sources.

In 1950, 1999, and 2011, the Sabarimala hill shrine witnessed three major unfortunate incidents, highlighting the risks associated with large-scale gatherings during temple festivals. The temple is governed by the state-sponsored Travancore Devaswom Board (TDB), an autonomous body responsible for temple management in Kerala. In 1999, approximately 52 pilgrims lost their lives in a tragic stampede. A similar but more catastrophic incident occurred in 2011 at the Pampa hilltop during the Makarajyothi festival, when a stampede caused by overcrowding claimed the lives of 102 pilgrims. These events underscore the persistent challenges in managing the influx of devotees during peak pilgrimage seasons.

In addition to stampedes, Kerala has witnessed several firecracker tragedies in connection with temple festivals, particularly in the Travancore and Malabar regions. Notable incidents include 1990: A firecracker mishap that caused significant casualties and property damage.2016: The Kollam Puttingal Temple tragedy, where an explosion during an unauthorised firework display resulted in over 100 deaths and hundreds of injuries. 2024: A recent firecracker incident in the Travancore region, again highlighted gaps in safety protocols during festivals. These tragedies point to the pressing

need for a comprehensive framework to ensure the safety and well-being of devotees while preserving the cultural essence of temple festivals. For detailed information, refer to Table 1, which provides a timeline and impact assessment of these incidents.

Temple festivals have become hotspots for all kinds of risks, and a few of them have turned into disasters. Casualties in religious incidents have resulted from elephants' violent behaviour, firework accidents, human stampedes, and other causes. The concentration of a huge population in a small geographical region for a short time, as well as the diversity of the audience, always provides a challenge to safety measures unless they are meticulously planned, executed, and monitored (Illiyas et al., 2015). In Kerala, disaster management authorities have been increasingly focusing on festival safety. The Kerala State Disaster Management Authority (KSDMA, 2020) has laid out guidelines for large religious gatherings, though challenges remain in their implementation. Studies by Narayanan and Menon (2020) suggest that while safety measures are in place, coordination between various stakeholders—temple authorities, local government, and disaster management teams—remains fragmented, reducing the effectiveness of these measures.

Table 2. Firecracker Incidents in Kerala(religious centre-based disasters)

Sl.No.	Year	Place	Impacts
1	1952	Sabarimala Temple	68 killed in fire cracker tragedy
2	1978	Thrissur Pooram	20 person lost life
3	1984	Kandashamkadavu Catholic Church Thrissur	20 dead
4	1987	Velur Kuttamooli temple	20 dead
5	1989	Kandashamkadavu Catholic Church	12 dead
6	1990	Malanada Peruviruthi Temple	33 dead
7	1999	Aloor Chamundikavu Temple, Palakad	8 dead
8	2006	Thrissur Pooram	7 dead
9	2006	Paramekkavu Temple	4 killed at a unit producing crackers
10	2008	Maradu Kottaram Temple festival	3 dead
11	2016	Kottaram Bahagvathy Temple	1 killed in a fire at a craker unit near temple
12	2016	Puttingal Temple	Fire and Explosion 107 dead several buildings damaged

Source Parkash, Surya. (2016). Brief Report on Reconnaissance Study of Puttingal Temple Fire Incident (Sunday, 10 April 2016), Paravur, Kollam District, Kerala State.

In 1952, at least 68 people were killed in a cracker bomb at the Sabarimala Lord Ayyappa temple. Another tragedy occurred in 1987 when 27 spectators sitting on a railway track and watching the fireworks at the Sri Jagannatha Temple in Thalassery were run over by a train. The deafening noise created by the display had drowned out the sound of the approaching train. In 1990, a blast at a cracker storeroom at a shrine in Malanada, Kollam, killed 26 people. In 2006, another explosion occurred in the storeroom where firecrackers were stored for the famous Thrissur Pooram celebration, killing seven people. An accident occurred on Saturday, April 13, 2013, during the Nenmara-Vallangi Vela event. Aside from one person who died in the subsequent uproar, more than 25 others were injured, including two female civil police officers. As the size of pyrotechnic displays has grown, so has the number of fireworks-related accidents. People have perished in explosions caused by the fabrication or bursting of firecrackers.

The Poruvazhy Malanada Temple is situated in the Kollam district of Kerala and is unique in India as the only temple dedicated to Duryodhana, the antagonist of the Mahabharata. The temple's festivals, including its annual Kettukazhcha festival held in March, draw large crowds of devotees.

The temple is known for its vibrant processions and elaborate fireworks displays that are an integral part of the celebrations. The Malanada Temple fireworks tragedy refers to a devastating incident that occurred at the Poruvazhy Malanada Temple in Kerala, known for its unique worship of Duryodhana, a character from the Mahabharata. Fireworks are a significant part of temple festivals in Kerala, but they also pose significant risks when safety measures are not adequately followed.

4. Disasters in the Sabarimala pilgrimage

Deadly stampedes are relatively common in temples in India, where large crowds - sometimes millions - gather in small areas without security measures or crowd control. Sabarimala is a well-known Hindu shrine situated on a hilltop in the Pathanamthitta district of Kerala. The pilgrimage, which honours Lord Ayyappa, requires a strenuous trek through the Western Ghats forests to reach the Sabarimala temple. During the pilgrimage, the Sabarimala temple received an unprecedented rush. Pilgrims had to wait for hours in long barricades to perform the holy vision. Pilgrims who complete the vision and continue for one or two days are suffering from a severe shortage of space because most nerves are used. This creates difficulties for the devotees who arrive later. During heavy days, pilgrims are forced to stand in queues for up to ten hours, as there is no place to be.

However, the pilgrimage has faced several disasters over the years due to various factors like overcrowding, inadequate infrastructure, and natural calamities. The following are some of the most notable disasters: the temple is surrounded by 18 hills in the Periyar Tiger Reserve forest area. The temple is open for worship for a limited amount of time—a total of 1,431 hours are available for darshan at the temple. The temple is also accessible for darshan on the first five days of each month. If 10 devotees received darshan per second—it is difficult to allow pilgrims to loiter before the sanctuary for too long—the pilgrims would only number 51,516. (Gurukkal 2018).

During the pilgrimage season, thousands of devotees visit Sabarimala every day. Due to the large influx of pilgrims during festival season, disaster management is a significant concern for the state administration. The pilgrims have to reach the temple through difficult treks in the forest as the vehicles cannot reach there. An inflow of more than two crore people during the pilgrimage season (November to January) results in significant environmental damage and considerable biotic pressure. Under the guise of wanting to satisfy the urgent requirements of pilgrims, the TDB has been enforcing urban development directly in the heart of the tiger reserve, completely disregarding the natural environment and its rules. Deforestation, the repurposing of forest land, and flagrant violations of the Kerala Forest Act of 1961, the Wildlife Protection Act of 1972, and the Forest Conservation Act of 1980 have all been implicated. (Gurukkal, 2018).

The temple witnessed two big crowd disaster occurrences. The first occurred in 1999, when a people stampede erupted on a mountaintop near Pamba in Sabarimala, killing 52 pilgrims. The second incident occurred in 2011 on Makarajyothi day in Pullumedu, killing 102 pilgrims. The rush at the Makara Jyothi viewpoint claimed the lives of 102 pilgrims from Tamil Nadu, Karnataka, and Andhra Pradesh. On Makaravilakku day, both occurrences occurred distant from the shrine, Sannidanam. Huge audiences watch Makaravilakku and Makara Jyothi from various perspectives scattered across two districts in remote locations, making catastrophe preparedness more complicated. Approximately 22 government ministries and central forces assist at Sabarimala to ensure the safe conduct of the pilgrimage season. Rumours, small accidents during the waiting period, bad crowd control, ineffective law enforcement, indiscipline, a lack of hygiene, and inadequate sanitary facilities are frequently cited as causes of such disasters.

Pullumedu is situated in the major section of the Periyar Tiger Reserve. The Sabarimala temple saw an unprecedented influx of devotees, who had to wait in lengthy, winding lines for hours to receive the hallowed darshan. The Sannidhanam is experiencing a severe lack of space because the majority of the nada pandal is being used by pilgrims who stay for a day or two after completing darshan. This generates challenges for devotees who arrive later. Because of the Sannidhanam's limited space, pilgrims are compelled to wait in lines for up to ten hours on busy days.

5. Preventive Measures and Current Situation

After the major stampedes in 1999 and 2011, authorities have taken several measures to improve safety. This includes improving road infrastructure, enhancing medical facilities, deploying additional security personnel, and implementing crowd management systems like virtual queue systems. The Kerala government has also focused on environmental conservation, as the influx of pilgrims has led to significant pollution in the ecologically sensitive Western Ghats region. Despite these efforts, challenges persist due to the sheer volume of devotees and the difficult terrain. The Sabarimala pilgrimage continues to be a test of physical endurance and spiritual devotion, but it is also a reminder of the need for better safety and crowd management practices. The investigation into the deaths found that the state government was negligent in ensuring public safety.

6. Firework Disasters in temple festivals

The severity of a disaster determines how fire threats affect medical care. Emergencies frequently challenge the healthcare system due to a lack of human preparedness, skills, knowledge, equipment, resources, and money. Fireworks displays are a traditional practice in southern India, particularly at temples. Numerous accidents have been documented as a result of earlier explosions. According to one estimate, similar rivalries in various places of worship have claimed the lives of over 700 people in the last two decades since independence. In 1978, six people were killed when a cracker accidentally fell on spectators in Thrissur. In 2006, another explosion occurred at the storage where firecrackers were stored for the famous ThrissurPooram festival, killing seven people. One of the primary reasons for such catastrophes is the lack of strict legislation governing the manufacture and exhibition of fireworks.

The fireworks industry is dangerous, and transportation and storage pose threats to life and property. Bursting fireworks on celebratory occasions is not unusual in any state of the country; nevertheless, public displays of fireworks are more common in Kerala. Many festivities in the state are celebrated along these lines. Thrissur pooram, Nenmara Vallangi Vela, Arattupuzha pooram, Chinakathur pooram, and others are among them. The most remarkable spectacle of the 'Pooram' festival is the majestic and thunderous display of fireworks, which begins late at night and ends just before daybreak (usually before 4:00 a.m.). Thousands of people from all over the state attend the fireworks show, which is a unique experience in Kerala.

Due to the rapidly growing number of temples and the size of festivals, fireworks are a common feature of Keralan temple celebrations and are only expected to grow in number. Fireworks displays are an important component of Kerala temple festivals, attracting a big crowd and potentially resulting in fatal accidents if proper security precautions are not taken. The organisers bear responsibility for the festival's safe conduct, and government ministries or agencies are not liable for the overall safety of religious audiences. For some high-priority events, state agencies would provide their assistance.Disasters, whether natural or man-made, can strike at any time and from anywhere in the country. These calamities are largely unforeseen, making them even more destructive because public government has a lower level of disaster preparedness. Fireworks displays are a traditional practice in southern India, particularly at temples. As a result, many explosion-related accidents have been reported. According to one estimate, approximately 700 people have died as a result of religious disputes in the last 20 years since independence.

The Kerala government has introduced stricter criteria for temple celebrations, including fireworks, which include obtaining district administration authorisation, guaranteeing appropriate explosive storage, and stationing safety officials at the event venues. There have been initiatives to promote awareness among devotees and temple committees about the dangers of fireworks and the need to follow safe practices. The emphasis has turned to supporting more regulated and controlled fireworks displays. Despite the regulations, fireworks remain an important element of Kerala's temple culture, and instances like the one in Malanada highlight the persistent contradiction between cultural tradition and public safety.

A fire accident during a Theyyam performance at a temple near Neeleswaram in 2024 October 29 left 154 people injured, eight of them seriously, when firecrackers stored in the vicinity exploded The incident happened at Anjoottanbalam Veererkavu Temple near Neeleswaram in this northernmost district of Kerala The safety precautions were not taken. The incident reportedly occurred due to inadequate safety precautions and improper storage of fireworks, emphasizing the need for more stringent regulations and compliance with safety protocols during such events.

7. Fire Cracker Accident at Puttingal Temple

None of the previous tragedies, however, matched the devastation at Paravur Puttingal Temple at the Kollam district of southern Kerala**.** (Devasia,2016) A major tragedy occurred in Paravur, Kollam district, due to a fireworks accident during a large religious gathering. The annual festival at the Puttingal Devi Temple near Kollam features a fireworks display, and the temple is located about 70 kilometres from the state capital, Thiruvananthapuram. The disaster unfolded when sparks from the fireworks ignited a storage area known as the 'Kambapura', where firecrackers were kept. This triggered a massive explosion, and the flames spread rapidly, trapping devotees within the temple grounds. After the incident, charred bodies and human remains were scattered throughout the temple compound (PTI, 2016). The explosions also caused chunks of concrete and plaster to fall from the temple and nearby structures, killing and injuring many. Numerous fatalities have occurred in fireworks-related accidents, often due to illegal storage, unauthorised manufacturing and display, and a lack of safety awareness. The Explosive Rules of 2008 regulate safety measures for fireworks displays at festivals, but the Paravur fireworks disaster remains Kerala's worst tragedy of the 21st century in terms of the number of deaths in a single incident and one of the most devastating in modern history. Fireworks accidents, though unintended, often result in some of the most horrifying injuries and fatalities (Thummarukudy, 2016).

Temple authorities should take lessons from the Kollam tragedy by prioritizing the safety of festival spaces before accommodating large crowds. Despite growing concerns over health and safety, the increasing number of pilgrims attending temple festivals continues. Authorities must develop strategies to manage these crowds, especially in high-risk areas. The government should implement stricter disaster management measures to ensure public safety. While safety guidelines for the use and storage of fireworks are in place, enforcement remains weak. Powerful supporters of religious centres, often shielded by political influence, must be held accountable for ignoring local governance and due process. Ignorance and negligence in the safe handling of fireworks chemicals have often led to fireside tragedies in Kerala, from 1952 until the newest incident at Puttingal Temple. Neither the temple nor its surroundings were impervious to disasters. Many people perished as a result of falling concrete debris caused by fireworks that burnt an explosives warehouse. If devotees and people are to be safeguarded from such disasters, temples and their surrounds must be disaster-proofed, which entails rationalising their scale and intensity. The usage of fireworks must be either prohibited or managed with the utmost caution.

There was no clearance for fireworks at the Kollam temple. The incident could have been avoided if the local authorities had followed the law. The organisers must have obtained the necessary authorisation by the rules established by the central government's Petroleum and Explosives Safety Organisation. There are additional guidelines for where fireworks can be held, how people should be evacuated from such locations, and the safe distances must be maintained. Certain chemicals and combinations (e.g., sulphur and potassium chlorates) are prohibited throughout the country, and the Kerala High Court has prohibited the manufacture of certain types of indigenous explosives due to their hazard. These issues were not resolved.

The fireworks contractors did not create an adequate buffer zone between the ignited explosives area and the assembled crowd. The fireworks were let up in a small location, and people gathered as close as they could. The most dangerous aspect was that many factions were competing against each other, making the event a test of their financial muscle and weaponry. Banned substances were freely utilised, and rules were broken with impunity. The district administration can also be

blamed. The district government, with the assistance of the local police, could have intervened, but they either ignored the risks or were overpowered by public opinion The loss of lives and property may have been avoided if they had investigated the sites, read the instructions to the organisers, and prevented the illegal fabrication of explosives (Kumar 2016).

The decision to ban fireworks is contentious and possibly impractical. The Kollam tragedy should serve as a warning to all temple administrators that the space available for staging festivities should be the major consideration for inviting crowds into festival grounds. True, safety and health concerns are not keeping many individuals from joining the growing number of pilgrims to temple towns and festivals. Good logic would suggest that authorities devise strategies to guarantee that huge groups do not congregate in high-risk regions. The government should also develop new and more robust disaster management plans that map out major public locations where huge crowds congregate and identify all hazards to them. The Kollam fire catastrophe serves as a message to leaders and citizens alike that public safety must take precedence over all other considerations.

Public safety is critical, but it requires the active participation of local governments, which have increasingly been marginalised. Disaster managers must be aware of potential dangers and develop comprehensive disaster prevention, readiness, and response strategies. Although fireworks displays are customary at temples, studies suggest that events at specific locations result in significantly greater mortality tolls. What made this calamity even more tragic was that the district government had instructed the temple authorities to cancel the fireworks display in response to objections from surrounding residents. Despite the District Magistrate's orders, the temple management, with the support of lower-level officials and security agencies, went ahead with the event. The explosion killed over 109 people and injured almost 400. A nearby three-story concrete building was extensively damaged, and debris from the bomb caused serious casualties within a 500-meter radius. Approximately 150 kg of pyrotechnics were lit during the event. The rescue attempts were led by a high-level team that included the Prime Minister.

In 2023, the Kerala High Court partially overturned a single-bench ruling directing raids on religious sites to seize illegally stored firecrackers. The division bench, led by Chief Justice AJ Desai and Justice VG Arun, ruled that no fireworks should be used between 10 p.m. and 6 a.m. However, it gave district administrations the authority to decide whether firecrackers might be used during limited hours if necessary. The judge further stated that bursting firecrackers is not a religious need and warned that infractions would result in contempt of court proceedings. The administration also claimed that the court had not considered whether fireworks were part of the necessary religious rites in Kerala's temples. It emphasised that fireworks have traditionally been an important feature of temple festivals, bringing people together and supporting the state's secular and cosmopolitan character.

In 2024, the Kerala High Court compelled the District Collector to issue fireworks rules, which permitted fireworks displays under tight restrictions. The court ruled that only certain fireworks items allowed by the court might be used and that qualified specialists must supervise the display. Fireworks storage areas were to be at least 200 meters from the show site. The Union government has recently implemented new limits for fireworks displays, sparking concerns about their influence on Kerala's historic festivals such as Thrissur Pooram. The requirements demand strict safety precautions, such as a minimum distance of 200 meters between fireworks storage and display areas and at least 100 meters between spectators and the display site. Additionally, fireworks must be kept at least 250 meters from hospitals and schools. The regulations require that fireworks be handled only by individuals who have been certified by the Petroleum and Explosives Safety Organisation (PESO).

These changes were introduced in response to the 2016 Puttingal Temple disaster, which heightened public concern about fireworks safety. Event organisers must submit applications 15 days in advance, explaining the types of fireworks used and potential risk zones in case of an accident. They must also secure public liability insurance and carry out a simulated safety exercise two days before the event. Potassium chlorate is prohibited, and organisers must follow fire safety requirements established by local fire departments. The fatal tragedy at the Veerarkavu Temple emphasises the critical need for more stringent enforcement of fireworks rules at religious celebrations. While the

Kerala High Court has decided on the conditions for allowing fireworks, and the state administration has advocated for tradition preservation, occurrences like this highlight the need to put public safety first. With the Union administration strengthening rules, the task will be to strike a balance between cultural traditions and the necessity to avert such catastrophes.

The comprehensive examination of crowd dynamics and disaster risks in Kerala's temple festivals underscores the critical need for integrating soft power and institutional skills to enhance disaster management frameworks, as highlighted in studies addressing Montenegro's EU accession strategies (Sudar, Cvetković, & Ivanov, 2024), COVID-19 management challenges in India (Port & Jawahar, 2024), flood vulnerability assessments (Aktar, Shohani, Hasan, & Hasan, 2021), school-community disaster preparedness (Carla, 2019), and community disaster resilience in Serbia (Cvetković & Šišović, 2024).

Effective crowd management planning should include a thorough carrying capacity assessment, which allows administrators to engage in risk-informed planning. Without this, it is difficult to accurately gauge the threshold of safe crowd sizes, heightening the risk of preventable disasters. Additionally, proactive disaster preparedness, coupled with strict monitoring and accountability measures, is essential to ensure that the use of fireworks remains within legal and safety guidelines. Effective crowd management at temple festivals requires a multidisciplinary approach that involves spatial analysis, stakeholder collaboration, and robust catastrophe preparedness. The study highlights the significance of conducting preventive risk assessments and dynamic crowd monitoring techniques to avoid disasters. Implementing the proposed measures can considerably improve public safety, serve as a model for comparable cultural events, and help to shape legislation for disaster risk reduction in large crowds.

Preventive Measures

- Better Crowd Control Mechanisms: Deploying trained personnel, using technology like RFID tracking for crowd movement, and creating more entry/exit points can help manage large crowds effectively.
- Infrastructure Improvements: Upgrading temple infrastructure, including expanding pathways and building additional exits, can mitigate risks.
- Real-time Monitoring: The use of surveillance systems and real-time monitoring of crowd density can help authorities act quickly during dangerous situations.
- Limiting Attendees: Imposing restrictions on the number of people allowed in the temple premises at any given time, especially during festivals, could reduce overcrowding.
- Public Awareness Campaigns: Educating devotees on safety measures, crowd behaviour and emergency protocols can play a vital role in preventing disasters.

Kerala's temples, with their deep spiritual and cultural importance, continue to draw vast crowds. Proactive measures, along with lessons learned from past tragedies, can significantly reduce the occurrence of crowd-induced disasters.

8. Conclusion

Clear and well-defined guidelines exist in the state for the use of fireworks and explosives, yet enforcement remains weak due to administrative limitations. Powerful religious custodians often supported by a political class that bypasses local authorities and due processes, significantly contribute to these enforcement challenges. Public safety must be a non-negotiable priority, but achieving this requires strengthening local administrative powers, which have been progressively eroded over time. Effective crowd management planning should include a thorough carrying capacity assessment, which allows administrators to engage in risk-informed planning. Without this, it is difficult to accurately gauge the threshold of safe crowd sizes, heightening the risk of preventable disasters. Additionally, proactive disaster preparedness, coupled with strict monitoring and accountability measures, is essential to ensure that the use of fireworks remains within legal and safety guidelines. Through the lens of crowd dynamics, this study highlights the challenges that disaster management

authorities face and offers strategic recommendations for improving crowd control, infrastructure planning, and emergency response. By proposing a framework for proactive disaster management, the paper seeks to enhance safety measures at temple festivals and minimize the potential for future tragedies. These recommendations include improving crowd control systems, enhancing stakeholder coordination, and utilizing technology to monitor and manage large gatherings. Kerala's temples, with their deep spiritual and cultural importance, continue to draw vast crowds. Proactive measures, along with lessons learned from past tragedies, can significantly reduce the occurrence of crowd-induced disasters.

Conflict of interest: The authors declare no conflict of interest.

Funding: This research received no specific grant from any funding agency in the public.

References

1. Aktar, M. A., Shohani, K., Hasan, M. N., & Hasan, M. K. (2021). Flood Vulnerability Assessment by Flood Vulnerability Index (FVI) Method: A Study on Sirajganj Sadar Upazila. *International Journal of Disaster Risk Management, 3*(1), 1-14.
2. Bala, K. (2018). Crowd management: Issues and challenges. *International Journal of Research and Analytical Reviews, 5*(3).
3. Carla S, R. G. (2019). School-community collaboration: disaster preparedness towards building resilient communities. *International Journal of Disaster Risk Management, 1*(2), 45-59.
4. Cvetković, V., Šišović, V. (2024). Community Disaster Resilience in Serbia. Belgrade: Scientific-Professional Society for Disaster Risk Management
5. Deshpande, N. P., & Gupta, R. (2010). Crowd management using fuzzy logic and GIS. *WIT Transactions on Information and Communication Technologies, 43*.
6. Devasia, T. K. (2016). Kerala temple fire: Will the state finally ban dangerous fireworks displays? *Scroll. in.* Retrieved from https://scroll.in/article/806455/kerala-temple-fire-will-the-state-finally-ban-dangerous-fireworks-displays
7. Gurukkal, R. (2018). Yes, Sabarimala is in peril, but not the way you think. *Outlook India.* Retrieved from https://www.outlookindia.com/magazine/story/yes-sabarimala-is-in-peril-but-not-the-way-you-think/300818
8. Illiyas, F. T., Faisel, M., & Mohan, K. (2015). Safety in religious mass gatherings: Guidelines for event organisers and stakeholder agencies. *Institute of Land and Disaster Management, Department of Revenue and Disaster Management, Government of Kerala.* Retrieved from https://sdma.kerala.gov.in/wp-content/uploads/2018/11/ILDM_2015.pdf
9. Illiyas, F. T., Mani, S. K., & Mohan, K. (2020). Carrying capacity assessment for religious crowd management: An application to Sabarimala mass gathering pilgrimage, India. *International Journal of Religious Tourism and Pilgrimage, 8*(1). Retrieved from https://www.researchgate.net/publication/348525529_Crowd_Management_-An_Application_to_Sabarimala_Mass_Gathering_Pilgrimage_India
10. Illiyas, F. T., Mani, S. K., Mohan, K., & Kumar, K. (2013). Human stampedes during religious festivals: A comparative review of mass gathering emergencies in India. *International Journal of Disaster Risk Reduction, 5*, 10–18.
11. Kumar, G. P. (2016, April 10). Kerala temple fire tragedy: Why temple sites in the state are disaster zones during festivals. *Firstpost.* Retrieved from https://www.firstpost.com/india/kerala-temple-fire-tragedy-why-temple-sites-in-the-state-are-disaster-zones-during-festivals-2721500.html
12. *Lancet Infectious Diseases*. (2010). Mass gathering medicine. *The Lancet Infectious Diseases, 10*(10), 653. Retrieved from http://www.thelancet.com/journals/laninf/article/PIIS1473-3099(10)70204-8/fulltext

13. Mohan Das, K., Nayar, R., & Shaffi, M. (2015). A perilous pilgrimage: The case of Sabarimala. *Economic and Political Weekly, 50*(25). Retrieved from https://www.epw.in/journal/2015/25/reports-states-web-exclusives/perilous-pilgrimage.html
14. Parkash, S. (2016). Brief report on reconnaissance study of Puttingal Temple fire incident (Sunday, 10 April 2016), Paravur, Kollam District, Kerala State. *ResearchGate.* https://doi.org/10.13140/RG.2.1.1782.4249
15. Port, K. J. N., & Jawahar, G. (2024). Management of COVID: The Creeping Disaster in the Indian Scenario. *International Journal of Disaster Risk Management*, *6*(1), 103–110.
16. PTI. (2016, April 10). 106 killed, 383 injured in Kerala temple fire. *Deccan Herald.* Retrieved from https://www.deccanherald.com/india/106-killed-383-injured-in-kerala-temple-fire-519724.html
17. Satisan, T. (2016). Obsession ends in tragedy. *Organiser.* Retrieved from https://organiser.org/2016/04/18/67306/general/rd563e3cc/
18. Soo, J., & Avery, J. (2003). *Emergency/disaster guidelines and procedures for employees.* CCH Canadian Limited.
19. Sudar, S., Cvetković, V. M., & Ivanov, A. (2024). Harmonization of Soft Power and Institutional Skills: Montenegro's Path to Accession to the European Union in the Environmental Sector. *International Journal of Disaster Risk Management*, *6*(1), 41–74.
20. Thummarukudy, M. (2016). Kerala temple fire: Time for better planning. Deccan Chronicle.
21. World Health Organization (WHO). (2008). Public health for mass gatherings: Key considerations. Geneva, Switzerland: WHO.