

Designing a Disaster Resilient Community in Flood-prone Zones of Srinagar, Uttarakhand

Kartikay Puri^{1*}, Ayush Aryan²

Abstract

Uttarakhand, a state that scuffles with the dual challenges of climate change and rapid development, is particularly vulnerable to devastating floods. This research delves into the critical issue of strengthening community resilience against such disasters. By examining the interconnected factors of preparedness, mitigation, and response, the study aims to develop a robust framework for safeguarding lives and livelihoods in flood-prone regions. A cornerstone of this research is the exploration of traditional knowledge systems, which have proven invaluable in predicting and responding to natural hazards. Coupled with modern early warning systems and meticulously planned evacuation procedures, these insights can significantly enhance a community's ability to anticipate and prepare for floods. Moreover, the study underscores the importance of mitigation strategies, such as constructing flood-resistant infrastructure and implementing sustainable land management practices. These measures can effectively reduce the impact of floods and build long-term community resilience. The research also emphasizes the role of community-driven initiatives in ecosystem restoration. By revitalizing natural habitats, communities can enhance their environment's capacity to absorb excess water, thereby mitigating flood risks. This approach not only protects against disasters but also contributes to overall ecological health. By comprehensively analyzing these facets of flood resilience, the study offers a blueprint for creating safer and more sustainable communities in Uttarakhand. The findings are particularly relevant to Srinagar, a region identified as highly vulnerable to flooding. Ultimately, this research provides invaluable guidance for policymakers, community leaders, and disaster management agencies in their efforts to build resilient communities capable of weathering the challenges posed by climate change and extreme weather events. The research seeks to empower communities to take ownership of their safety and well-being, fostering a proactive approach to disaster management. By integrating traditional wisdom with modern scientific knowledge, this study offers a promising path toward a more resilient future for Uttarakhand and other flood-prone regions.

Keywords: Vulnerable, preparedness, mitigation, disaster management, flood mitigation

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INTRODUCTION

The influence of natural disasters has increased rapidly across the globe, making the risk of disasters a global concern. Previous studies and sources suggest that over 390,054 Asians were killed over the time phase of 2006 to 2015.

Srinagar, residing in the Garhwal Himalayas region of Uttarakhand, is renowned for its revered pilgrimage sites, and the beauty of this town is eye-lifting. However, this prestigious landscape is no stranger to nature's wrath; Landslides, Cloud Bursts, and Flash Floods are regular and wreak havoc on livestock, infrastructure, and the local people of the

region. The erratic weather patterns of the region can aggravate the frequency and intensity of such disasters. Flash floods and landslides in mountainous regions are the most catastrophic natural disasters that cause loss of life and damage to infrastructure and other economic activities [1]. In the last 30 years, floods have contributed to approximately 50% of the 80 million people affected by natural disasters. On an economic front, flood damage is worth more than USD 11 million worldwide [2].

This research dives into the concept of forming a disaster resilient community that is prepared, responsive, and favorable to recovering from the harm caused by the disaster. This study aims to examine the strategies and initiatives that could be put in action to favor Srinagar's community to become more resilient towards disasters. The results, if and when applied, will support the community to become safer for the people and the infrastructure, establishing itself as an elite example of resilience and preparing for disasters. Anthropogenic activities such as the construction of dams, roads, and deforestation have further aggravated disasters that have disrupted the Himalayan ecosystem in various states such as Uttarakhand [3].

This study was conducted to understand the frequency and response of the community towards disasters, and what steps should be followed to make the community thrive more and stronger toward disasters. This study focused on the following four aspects:

- *Vulnerability to disasters*: How do major factors, such as geographic locations and climate change, make the region more prone to such disasters?
- *Understanding resilience strategies*: By understanding community adaptation and preparedness towards disasters, we can learn and develop methods of responding to disasters.
- *Learning from local knowledge*: Disaster Management policies can be improved by involving local people in learning about the self, and the government can implement strategies in constructing a disaster-prepared society. The traditional knowledge and practices of local people can be effective in reducing disasters not only in designated areas but also in similar places facing similar problems.
- *Informing policy and planning*: Learning policies and strategies from resilient communities can inform policies for Uttarakhand and other disaster-prone regions.

The survey goes beyond the community's current state and explores what could make the community more reliable and resilient, asking about the flood mitigation measures in place and their comfort level, and discussing the improvement or implementation of disaster preparedness in the community. Finally, they learned what kind of information and programs would be most beneficial in preparing for the future. By taking part in the survey, people play a vital role in shaping the future of Srinagar and Garhwal. The information provided is key to developing effective strategies to keep the community safe from floods.

We aimed to improve the ability of the region to withstand floods, mainly focusing on how the community copes and how well the current preparedness system is. The strength of the community was also examined. This includes how residents use their social networks, traditional knowledge, and resources to manage floods, and the current preparedness methods involving studies on early warning systems. Evacuation plans and their effectiveness in reducing flood risk. The state is divided into two regions, Garhwal (western region) and Kumaon (eastern region), as shown in Figure 1, with 95 development blocks in 13 districts.

This study takes into account an 11 km stretch of the Alaknanda River, which falls within the Srinagar valley; however, the focus of the study remains on the meandering reaches.

LITERATURE REVIEW

Cities are becoming more vulnerable to flooding because of development and climate change. Despite this risk, traditional floodplains are appealing owing to their amenities.

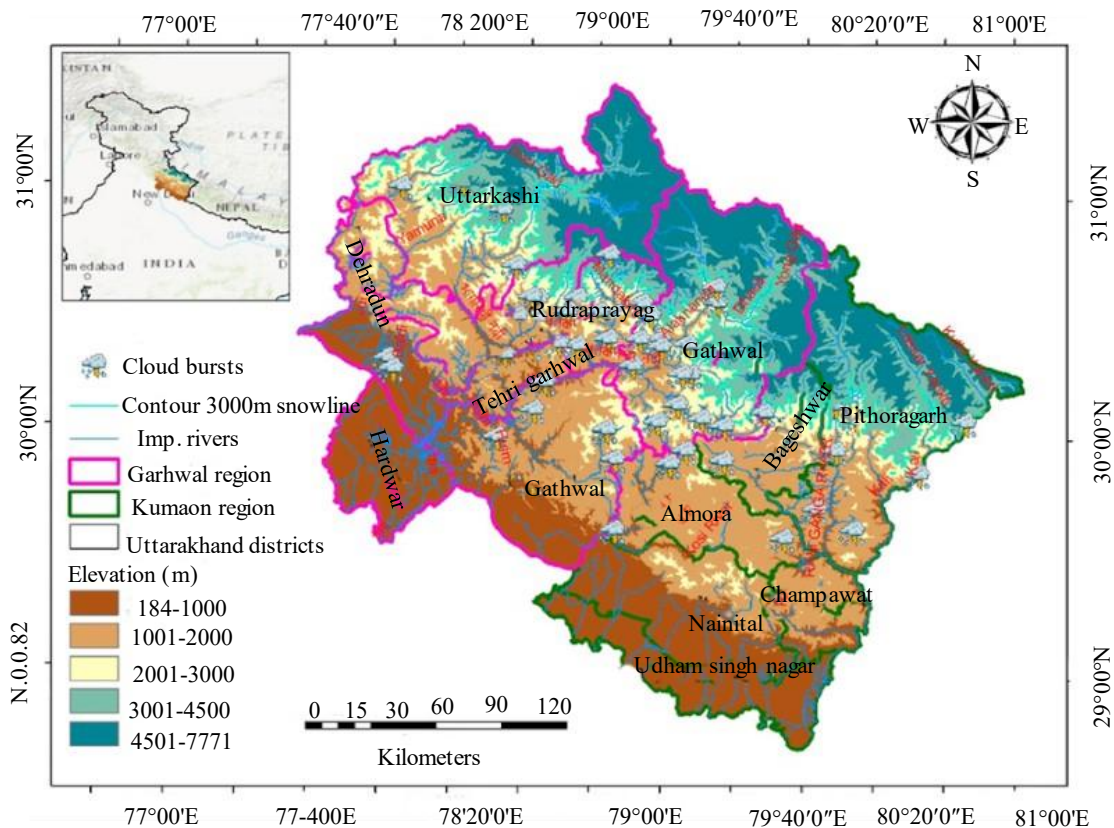


Figure 1. Map of Uttarakhand showing district, regions, and locations of cloudbursts [4].

This means that creating towns that are flood-resistant requires a multifaceted strategy. Using nonstructural methods, such as land-use regulations and financial incentives, is a strategy. Flood damage can be considerably decreased with risk-informed planning according to the Boulder Colorado framework test [5]. For Pakistani and Indian flood zones, an alternative strategy emphasizes the use of inexpensive, environmentally friendly building materials such as mud and bamboo. This promotes independence and gives communities more authority. Resilience is also influenced by social variables. According to a Taiwanese study, strong communal bonds improve a community's ability to recover from calamities. It is important to see disasters as social concerns that call for cooperation among people, governments, and scholars [6].

Although flood protection systems can be evaluated using decision-making techniques such as Cost-Benefit Analysis (CBA), these tools are not fully capable of accounting for the value of human life. Artificial intelligence (AI)-driven platforms are being developed to enhance cooperation, knowledge exchange, and decision-making for flood-resilient design and planning, artificial intelligence (AI)-driven platforms are being developed [7]. Being aware of the community is essential for their readiness. Research conducted in Jakarta, Indonesia, revealed that flood risk awareness, reaction capability, and recovery ability are desirable traits of communities that are flood-resilient.

A European study found that effective risk management required public participation. Resilience measurements are crucial. An Indonesian study proposed a framework with an emphasis on community-based programming that uses metrics to evaluate a community's overall resilience [8]. A disaster resilience model that incorporates technological innovation, spatial planning, mitigation, and adaptation is necessary. Additionally, urban planning should be given more consideration, with an emphasis on mitigating and responding to floods. Cities can become more flood-resilient by combining nonstructural measures, social awareness, community participation, and creative design [9].

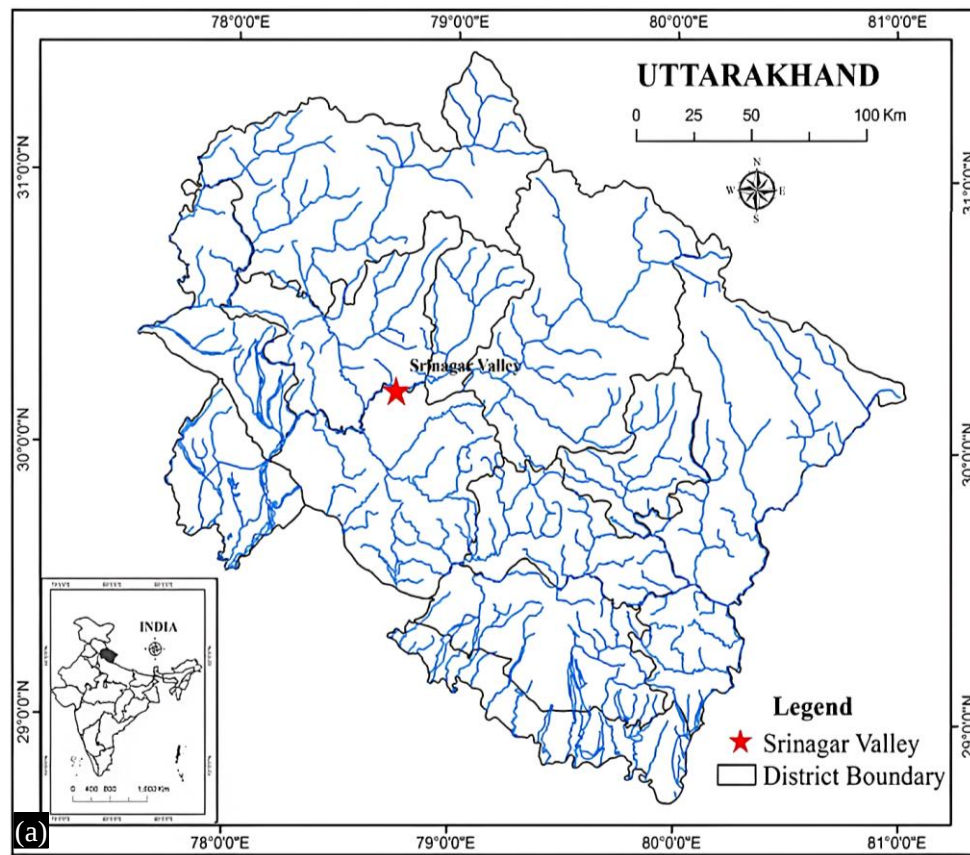




Figure 2. (a) Location of the study area in Uttarakhand, (b) The standard FCC of Srinagar Valley showing the Alaknanda River (LANDSAT ETM+, 2000), and (c) Location of studied sites along the surveyed stretch of the river [10].

The studies explored various aspects of building flood-resilient communities:

- *Planning and policy:* Effective flood risk management requires informed planning (e.g., Boulder, Colorado) and consideration of social factors, such as community spirit (Taiwan). Economic incentives and regulations can guide development away from the floodplains (Figure 2).
- *Building materials:* Affordable and locally available materials such as bamboo and mud can be effective in rebuilding flood-prone areas in developing countries.
- *Community engagement:* Public participation is crucial for effective risk management (Europe), and community awareness is the foundation of preparedness (Jakarta, Indonesia). Studies have emphasized collaboration between researchers, policymakers, and residents.
- *Decision-making tools:* CBA is a common tool for assessing flood protection measures, but it has limitations. AI-driven platforms are being developed to improve flood-resilient design and planning.
- *Measuring resilience:* A framework that uses indicators to assess a community's overall resilience, including preparedness, response capacity, and recovery ability.

Overall, there is no single solution. Building flood resilience requires a multifaceted approach that considers the social aspects, planning, design, and community engagement.

RESEARCH METHODOLOGY

Garhwal and Uttarakhand drastically improved flood preparedness. To understand the arsenal of the locality and how well equipped the community is and to identify the area of improvement, and keeping in mind the importance of community collaboration, a survey was conducted delving into the personal experience of people with floods. Ask localities about their property types and whether they have been affected by past flooding. They were asked to share their level of awareness about the risks and typical warning systems. The survey also studied the community's preparedness, exploring designated evacuation routes, and opportunities to participate in flood drills.

The particular interest behind the survey was to learn the community's perspective on the biggest challenges that the community faces during floods. Is there a lack of an evacuation plan? Difficulties in obtaining higher ground due to limited transportation. Perhaps, there is a need for improvement in flood warning systems.

To learn about the community perspective on the biggest challenges Srinagar's community faces during floods, we utilized a quantitative approach to gather data from the residents of Srinagar, Garhwal. The survey employed a mix of closed-ended and open-ended questions to capture specific details and subjective experiences. A series of demographic questions were put forward about their residency and property type; then, we delved into the personal experiences of people with floods, including their frequency and water depth.

To evaluate the current level of awareness and preparedness of the community, a survey probe on flood risk knowledge, flood warning systems, and community participation in preparedness drills was conducted. Beyond the personal experiences of individuals, the survey explored the community's overall preparedness. Residents will weigh in on the adequacy of evacuation plans, access to transportation during floods, and effectiveness of communication during floods [11].

The final part of the survey investigated the individual and community mitigation strategies. The floodproofing measures implemented by residents at home and their comfort discussing preparedness with neighbors. The survey was conducted by inviting suggestions for additional community flood mitigation projects and pleading with what information would be most helpful to residents in preparing for future floods.

The collection of data can identify and pinpoint areas where Srinagar thrives and falls short of flood resilience and preparedness efforts. These data are instrumental in informing future policies and programs designed to build more resilient Srinagar Garhwal.

RESULTS

The survey that was carried out in Srinagar, Garhwal, provided insightful information about the advantages and disadvantages of the community's present flood preparedness strategy. In the total filled form, we collected data on participation, which may create a plan for constructing a more disaster resilient Srinagar by finding survey results.

Flood Awareness and Community Engagement

While a moderate level of flood awareness exists (30%), there is a clear need to bridge this knowledge gap (Figure 3). Residents with firsthand experience (28%) can be invaluable assets. Engaging them in community outreach programs leverages their experiences to educate others effectively.

Enhancing Flood Warning Systems

Local media remain the primary source of flood warnings (56%), underlining the importance of collaboration between disaster management authorities and media outlets. Expanding outreach through government websites and social media platforms (18% utilization) and strengthening neighborhood networks (20%) can significantly improve the reach and effectiveness of flood warnings. This multi-channel approach ensures that timely warnings reach all residents regardless of their access to technology.

Evacuation Planning and Drills

A significant knowledge gap exists regarding designated evacuation routes (39% were unsure). Developing clear and accessible evacuation plans with well-marked routes, evacuation drills, and communicated assembly points is crucial.

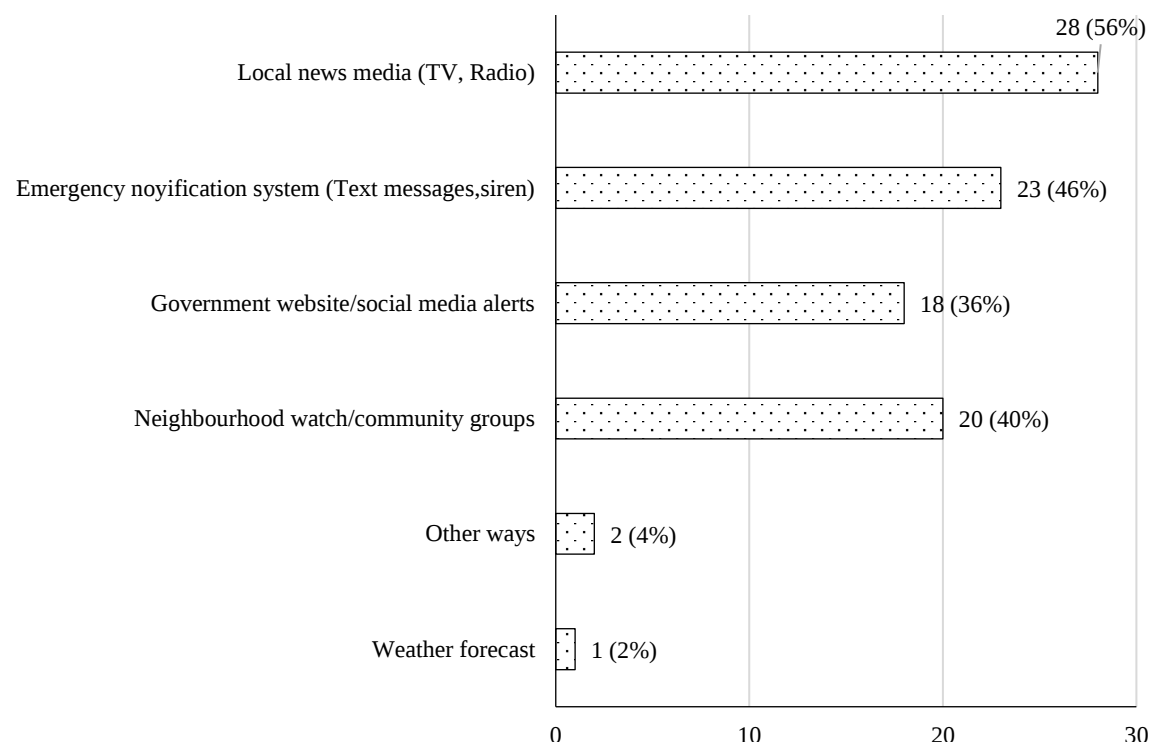


Figure 3. Flood warnings received by the community.

Currently, limited participation in flood preparedness workshops (29%) necessitates organizing regular sessions to equip residents with practical skills. These workshops should cover topics such as safe evacuation procedures, first aid, flood safety measures at home, and mental health preparedness to address the stress of a flood event. Additionally, incorporating training in basic flood mitigation techniques that residents can implement to protect their homes, such as using sandbags or sealing crawl spaces, would further empower the community.

Addressing Transportation and Supply Challenges

Difficulty in accessing transportation during floods has emerged as a major concern (69%). This necessitates a robust flood response plan with designated high-water vehicles and strategically located evacuation shelters on higher grounds with accessible routes. Limited access to emergency supplies (57%) required a multi-pronged approach. Stockpiling essential supplies (food, water, and medication) in accessible locations throughout the city and establishing partnerships with local NGOs for pre-disaster resource allocation can ensure that residents have the supplies they need to weather the storm (Figure 4).

Prioritizing Infrastructure Investment

The survey results highlight the need for investment in flood-resistant infrastructure projects such as raised roads, reinforced embankments, and improved drainage systems (infrastructure damage, 54%). These measures can significantly reduce the impacts of future floods.

Promoting Home Mitigation Measures and Financial Assistance

A significant proportion of the residents (58%) lacked home mitigation measures. Educational programs that promote the benefits and proper use of sandbags, flood barriers, and basement/foundation waterproofing are crucial. Exploring financial assistance programs or low-interest loan options can incentivize the wider adoption of these measures, making homes more resilient to floodwater (Figure 5).

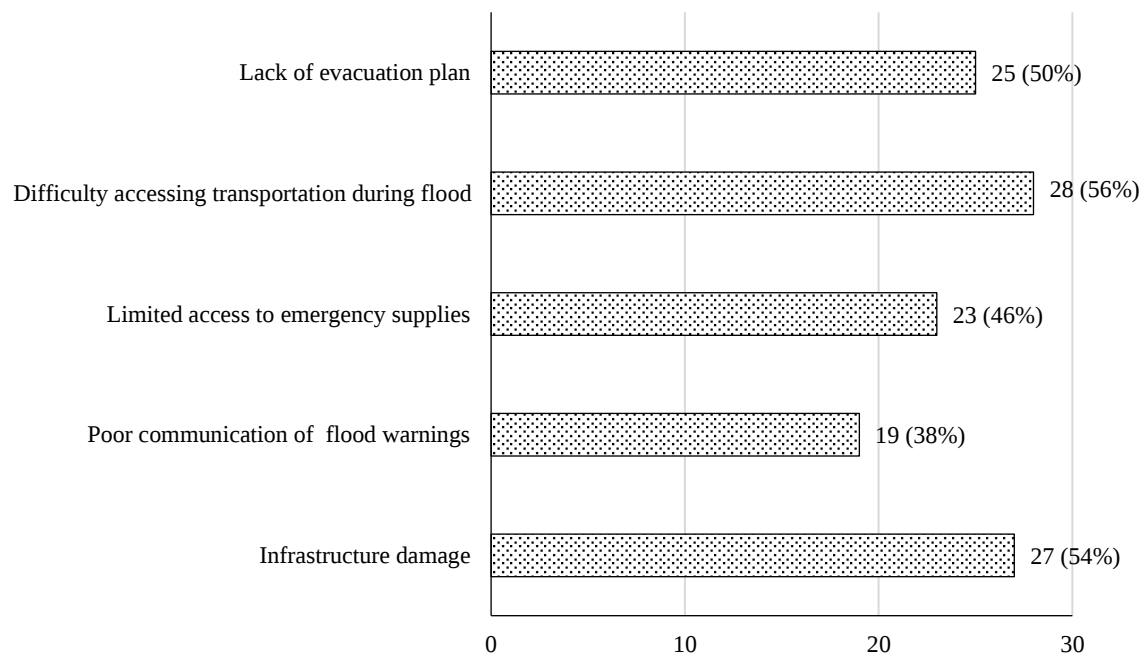


Figure 4. The biggest challenges your community faces during floods.

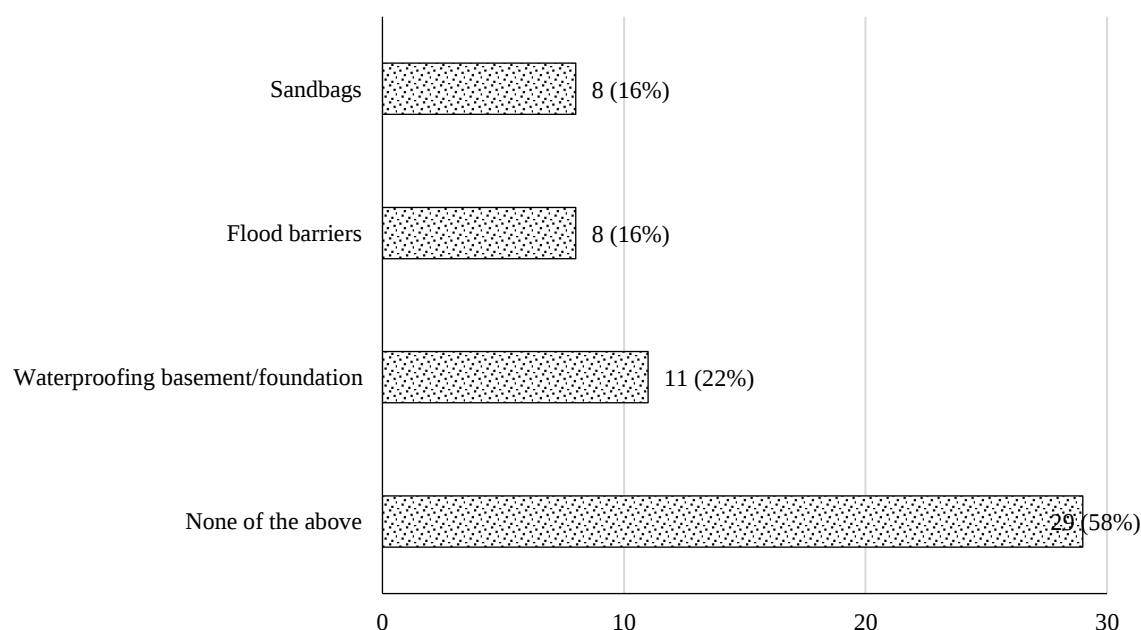


Figure 5. Flood mitigation measure.

Building a Culture of Community Preparedness

A positive sentiment exists regarding discussions with neighbors (68%). Leveraging this by organizing neighborhood meetings and workshops can foster communication and collaboration and build a network of support during floods. A strong interest in community programs (75%) presents a golden opportunity. Developing and offering a variety of programs that cater to different needs and age groups can empower residents to play an active role in preparedness. Programs can include topics such as floodproofing homes, creating emergency plans, and assembling disaster kits. Additionally, engaging local youth in community outreach programs can ensure that the knowledge and skills needed for preparedness are passed on to future generations, thus fostering a culture of long-term resilience (Figure 6).

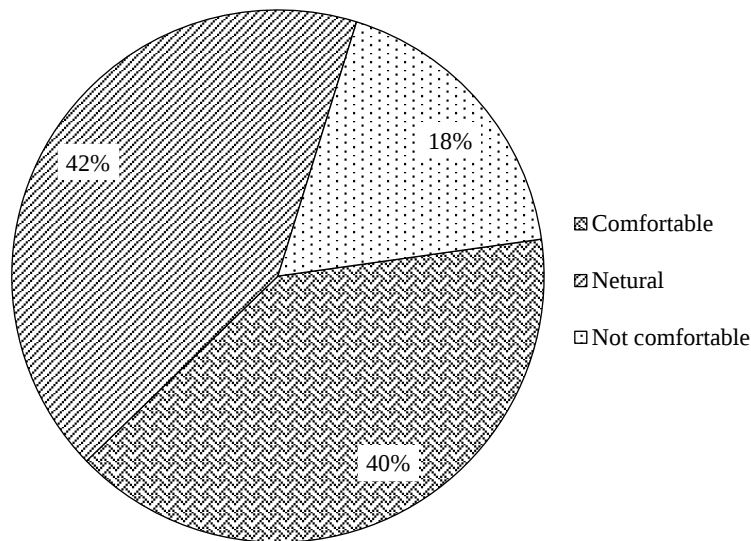


Figure 6. Discussing flood preparedness with your neighbors.

DISCUSSIONS

Advantages and Current Methods

Social Networks and Traditional Knowledge

The importance of social networks and traditional customs might be further incorporated into official disaster response strategies, and they rely on one another for support.

Early Warning Systems

The existence of these systems suggests that flood preparedness is being proactively handled. However, the survey should demonstrate how well these mechanisms serve the entire community, especially residents of high-risk locations.

Areas for Improvement

Transportation and Evacuation Preparations

The survey can identify any shortcomings in evacuation preparations, such as a lack of designated routes or restricted accessibility for individuals with disabilities. To guarantee that everyone evacuates in a timely manner during floods, it is essential to evaluate the adequacy of transportation.

Awareness of Flood Risk and Drills

Programs for education can be tailored more effectively if the existing degree of local understanding of flood dangers is known. Low participation in readiness drills indicates the need for more interesting and approachable activities.

Floodproofing Techniques and Mitigation Strategies

The survey's findings can be used to determine the commonplace floodproofing techniques among households. It is also critical to ascertain how comfortable the neighborhood feels when talking to each other about preparedness measures. This may open the door to group efforts to develop mitigation techniques. Creating a more robust sprint agar is an important tactic for creating a more resilient sprint agar based on its strengths and shortcomings.

Identified: Improving Early

Warning Systems

Make an investment in easily available multilingual early warning systems that make use of community radio broadcasts, mobile notifications, and sirens. These systems are tested frequently, and educational programs are run to help people understand the meaning of warnings.

Enhancing Transportation and Evacuation Plans

Collaborate with the community to create thorough evacuation plans that include assembly locations and well-marked routes. Ensure that everyone who lives there, including people with impairments, can access it. Collaborate with regional transportation authorities to plan for flood-related transportation needs such as community shuttle services or special evacuation cars.

Awareness of Flood Risk and Drills

Conduct recurring local language initiatives to raise awareness of flood risks. Success stories from other communities and traditional knowledge should be incorporated into these efforts. Hold interactive flood drills with all residents, including the elderly and children, which mimic real-life situations.

Encouragement of Community Mitigation Strategies and Floodproofing Measures

Floodproofing measures are promoted at home by offering financial incentives and technical support. Seminars should be arranged on building methods that withstand flooding and details should be distributed on easily accessible materials for floodproofing. Collaborate with the community to determine and implement more comprehensive mitigation techniques, such as watershed protection programs, sustainable land management techniques, and ecosystem restoration projects.

Promoting Community Cooperation

Form a disaster management committee that includes representatives from the government, local businesses, and people. This group can serve as the driving force for community preparation initiatives, guarantee efficient communication in the event of flooding, and lobby the government to allocate resources.

Basic Steps in Disaster Management

To minimize the overall damage caused by disasters, one should be well prepared to face them. An efficient disaster management plan is convenient for combating disasters and preparing Srinagar to face unexpected disasters.

1. *Pre-disaster*: Prioritizing minimal damage to life, property, and environment. To reduce any potential loss, such methods involve planning and implementing various schemes, and even incorporating early warning mechanisms is crucial for preparedness before disaster strikes.
2. *Preparedness*: The response stage focuses on being ready to face a disaster that has already been visited. This involves government officials and residents working together to respond effectively. Public education and awareness programs focusing on how to react to specific disasters such as floods are crucial at this stage.
3. *Warning system*: prioritizing the importance of communication during emergencies. We have previously experienced how, due to the lack of communication, the authorities were unable to reduce the impact and failed to take weather warnings seriously. This emphasizes the need for timely warnings to reach vulnerable areas to minimize damage.
4. *Response and relief*: This stage involves various activities, such as setting up control centers, following action plans, and broadcasting warnings. After a disaster, relief projects such as rescue missions by the military, financial aid, and reconstruction projects were launched by authorities.
5. *Post-disaster stage*: emphasizing the importance of “building back better” after a disaster. This stage includes providing aid, rehabilitation, and reconstruction, as well as taking steps to minimize damage if similar disasters strike again. This may include improved tracking systems and more thorough and systematic planning.
6. *Renewal/resurgence*: The revival stage goes beyond rebuilding. The focus here is to create a sturdier and more sustainable infrastructure compared to the existing infrastructure, which includes building roads and essential facilities. However, there is an emphasis on ensuring that these developments are built responsibly and do not encroach on nature.

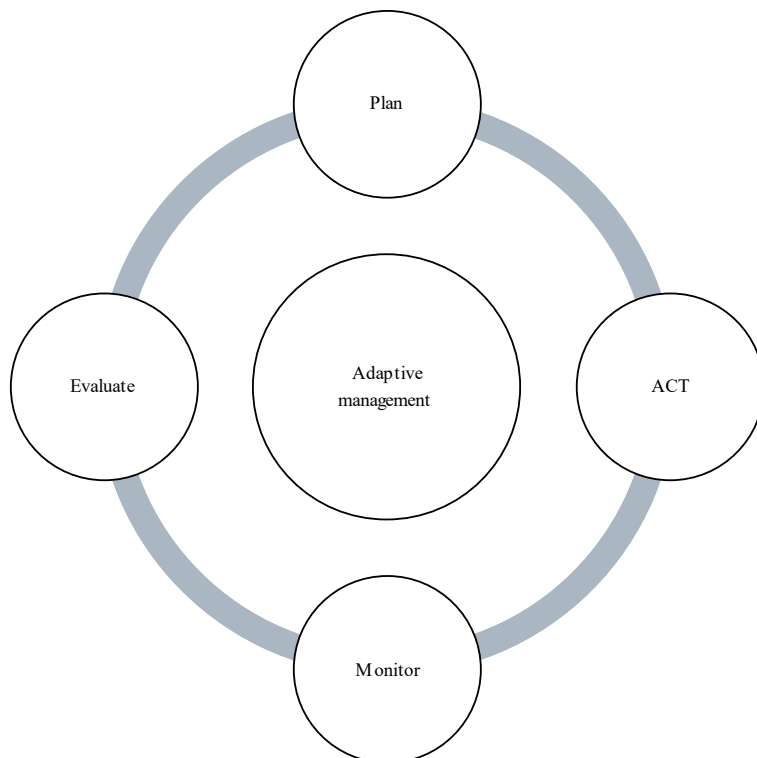


Figure 7. Adaptive management process.

Consider the 2013 Kedarnath Flood as an example. The devastation was so massive that the revival of the pilgrimage route was expected to take several years. The focus was not just on rebuilding the basic infrastructure that was washed away, but also on making it more durable and sustainable for the future.

- *Development:* Rebuilding after a disaster is a time-consuming process, particularly because of financial constraints. The government raises funds from the public and private sectors, with various relief funds established to aid the various sectors of Uttarakhand.

However, the revival goes beyond just rebuilding, a systematic approach may include:

1. *Planning:* Define the desired outcome for Srinagar (conceptual modeling), evaluate Srinagar's current state (Site Assessment), and estimate the financial resources required for the restoration project (Cost Estimation).
2. *Construction and implementation:* Focus on projects requiring minimum remodeling, as they likely require fewer interventions. Extensive engineering projects have high uncertainties.
3. *Performance assessment:* Throughout the restoration process (potentially lasting several years), progress was continuously monitored to ensure adherence to the action plan.
4. *Adaptive management:* Employing Adaptive management principles, meaning being flexible and adjusting restoration plans based on what is learned during the process (Figure 7).

CONCLUSION

Flood mitigation involves long-term measures to reduce the impacts of floods. These can be structured or unstructured. Flood defense structures are built to safeguard people and property from the direct impact of floods; they are not meant to completely stop floods, but ultimately provide the desired level of safety. These structures can be built longitudinally along the river, transversely across the river, or even as a combination of both. The characteristics of the defense structure depend on terrain, river characteristics, and available materials. After a major flood in 2013, 1000 crore worth of defense structures were built. The effectiveness of flood defense structures depends on various factors such as planning, desired safety levels, and local materials.

Although some structures built after 2013 showed success, this does not guarantee complete protection from future floods. While helpful in the short term, it may not be effective. They can fail during massive floods or unplanned development in floodplains. Considering the different characteristics of rivers in various terrains, a more proactive approach to flood risk management is required. The true effectiveness of these structures can be determined only during actual floods.

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