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Designing a Disaster Resilient Community in Flood prone zones of Srinagar, Uttarakhand.

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Abstract: *Uttarakhand, a state 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 analysing 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 towards a more resilient future for Uttarakhand and other flood-prone regions.

Keywords: - Vulnerable, Preparedness, Mitigation, Disaster Management, Flood Mitigation.

INTRODUCTION

The influence of natural disasters has risen rapidly across the globe, making the risk of disasters a concern globally. 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 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 to livestock, infrastructure as well as the local people of the region. And the erratic weather pattern of the region can aggravate the frequency and intensity of such disasters. Flash flood, along with the landslides in mountainous regions, is the most catastrophic natural disaster that causes the loss of lives and damage to infrastructure and other economic activities [1]. In the last 30 years, flood alone has contributed to about 50% of the total affected 80 million people due to natural disasters. On the economic front, flood damage is worth more than USD 11 million around the world [2].

This research dives into the concept of forming disaster resilient community that is prepared, responsive, and favorable to recover from the harms caused by the disaster first handily. This study aims to study the strategies and initiatives that could be put in action to favor Srinagar's community into becoming more resilient towards disaster. 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. The anthropogenic activities such as the construction of dams, roads, deforestation, etc., have further aggravated the disasters which have disrupted the Himalayan ecosystem in the various states such as Uttarakhand [3].

This study is done to understand the frequency and the response of the community towards disasters, and what steps should be followed to make the community more thriving and stronger toward disasters. It will focus on the following four aspects:

- **Vulnerability to Disasters:** How major factors such as geographic locations and climate changes make the region more prone to such disasters.
- **Understanding Resilience Strategies:** understanding community adaptation, preparedness towards disasters, we can learn and develop methods of response toward disasters.

- **Learning from Local Knowledge:** Disaster Management policies can be improved by involving local people learning about the self and government implemented strategies in constructing a disaster prepared society. The traditional knowledge and practices of local people can be effective in reducing disasters not only in the designated area but also similar places facing similar problems.
- **Informing Policy and Planning:** Learning the policies and strategies from resilient community can inform policies for Uttarakhand and other disaster-prone regions in India.

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 discussing about the improvement or instalment of disaster preparedness in the community. Finally learning their thoughts on what kind of information and program 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, Garhwal. The provided info is key in developing effective strategies to keep the community safe from floods.

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

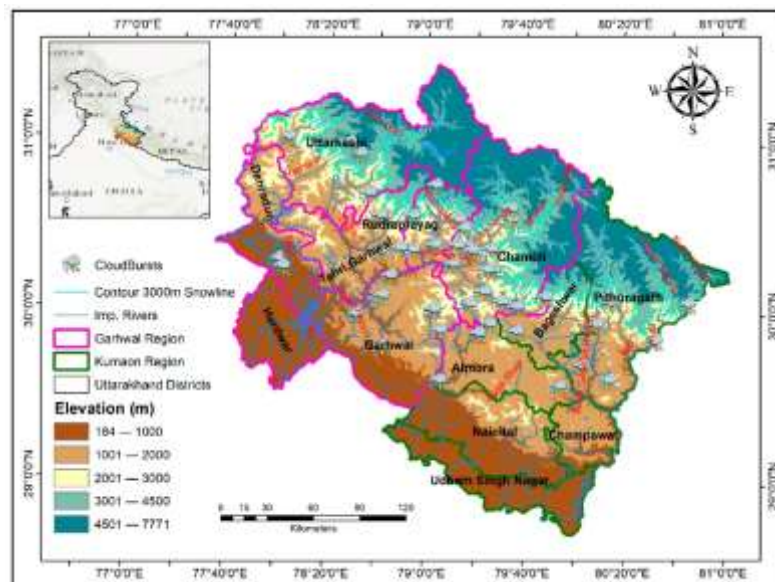


Figure 1. Map of Uttarakhand showing district, regions, and locations of cloudbursts. (source: [4])

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

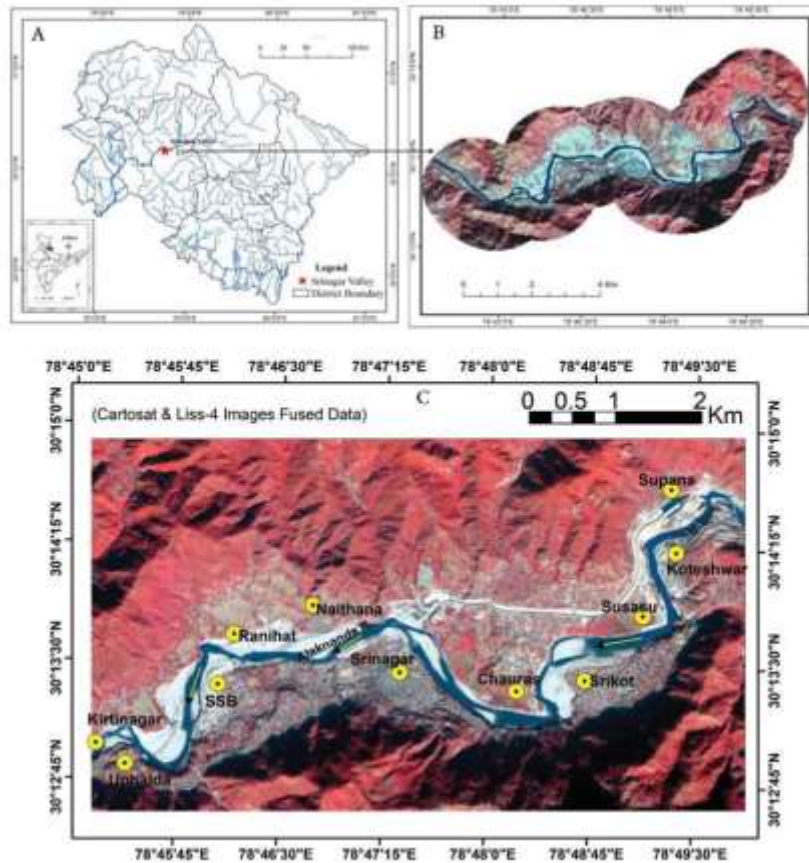


Figure 2. A) Location of the study area in Uttarakhand, B) The standard FCC of Srinagar Valley showing the Alaknanda River (LANDSAT ETM+, 2000) and C) Location of studied sites along the surveyed stretch of the river (source: [5])

1. LITERATURE REVIEW

Cities are becoming more vulnerable to flooding because of development and climate change. Despite the risk, traditional floodplains are appealing because of their amenities. This means that creating towns that are flood-resistant will require a multifaceted strategy. Using non-structural methods such as land-use regulations and financial incentives is one strategy. Flood damage can be considerably decreased with risk-informed planning, according to a Boulder, Colorado, framework test. [6]

For Pakistani and Indian flood zones, an alternative strategy emphasizes the use of inexpensive, environmentally friendly building materials like mud and bamboo. These promote independence and give communities more authority. Resilience is also influenced by social variables. Strong communal bonds aid in a community's ability to recover from calamities, according to a Taiwanese study. It is important to see disasters as social concerns that call for cooperation between people, governments, and scholars. [7]

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. To enhance cooperation, knowledge exchange, and decision-making for flood-

resilient design and planning, artificial intelligence (AI)-driven platforms are being developed. [8]

Being aware of the community is essential for readiness. Research conducted in Jakarta, Indonesia, revealed that flood risk awareness, reaction capability, and recovery ability are desired traits of communities that are flood resilient. A European study found that effective risk management requires public participation. Resilience measurement is crucial. An Indonesian study put forth a framework with an emphasis on community-based programming that uses metrics to evaluate a community's overall resilience. [9]

A disaster resilience model that incorporates technological innovation, spatial planning, mitigation, and adaptation is necessary given the unique problems faced by Jakarta. Additionally, urban planning ought to be given more consideration, with an emphasis on mitigating and responding to floods. Cities can become more flood-resilient by combining non-structural measures, social awareness, community participation, and creative design. [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 considering social factors like community spirit (Taiwan). Economic incentives and regulations can guide development away from floodplains.

Building Materials: Affordable and locally available materials like bamboo and mud can be effective for rebuilding in flood-prone areas of developing countries.

Community Engagement: Public participation is crucial for effective risk management (Europe) and community awareness is the foundation for preparedness (Jakarta, Indonesia). Studies emphasize collaboration between researchers, policymakers, and residents.

Decision-Making Tools: Cost-benefit analysis (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 using indicators can assess a community's overall resilience, including preparedness, response capacity, and recovery ability. Overall, there's no single solution. Building flood resilience requires a multifaceted approach that considers social aspects, planning, design, and community engagement.

3. RESEARCH METHODOLOGY

Srinagar Garhwal, Uttarakhand a drastic improvement for its flood preparedness. To understand the arsenal of the locality and how well-equipped the community is and 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. Asking localities about their property types and whether it has been affected by flooding in the past. Asked them to share their level of awareness about risks and the typical warning system. The survey also studies the community's preparedness, exploring the designated evacuation routes and opportunities to participate in flood drills.

The particular interest behind the survey was to learn the community perspective on the biggest challenges community faces during flood. Is it the lack of evacuation plan? Difficulties getting higher ground due to limited transportation? Perhaps the need of improvement in flood warning systems.

To learn the community perspective on the biggest challenges Srinagar's community faces during flood, we utilized a quantitative approach to gather data from the residents of Srinagar, Garhwal. The survey employs a mix of closed-ended and open-ended questions to capture the 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 experience of people with floods, including frequency and water depth.

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

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

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

2. RESULTS

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

3.1 Flood Awareness and Community Engagement:

While a moderate level of flood awareness exists (30%), there's a clear need to bridge the 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.

3.2 Enhancing Flood Warning Systems:

Local media remains the primary source of flood warnings (56%), underlining the importance of collaboration between disaster management authorities and media outlets. Expanding outreach through government websites, 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 timely warnings reach all residents, regardless of their access to technology.

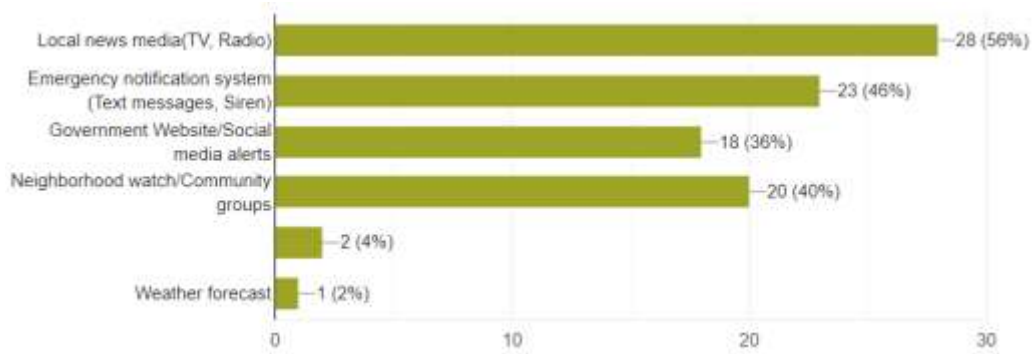


Figure 3. Flood warnings received by the community. (source: [Author])

3.3 Evacuation Planning and Drills:

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

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 for dealing with the stress of a flood event. Additionally, incorporating training on 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.

3.4 Addressing Transportation and Supply Challenges:

Difficulty accessing transportation during floods 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 ground with accessible routes. Limited access to emergency supplies (57%) requires a multi-pronged approach. Stockpiling essential supplies (food, water, medication) in accessible locations throughout the city and establishing partnerships with local NGOs for pre-disaster resource allocation can ensure residents have the supplies they need to weather the storm. (Figure 4)

3.5 Prioritizing Infrastructure Investment:

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

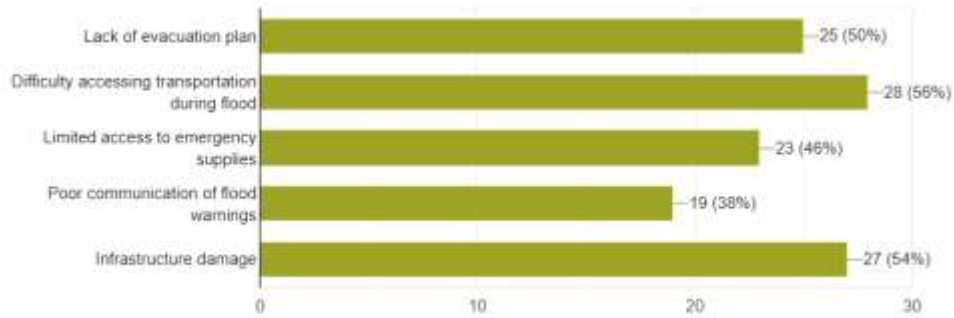


Figure 4. Biggest challenges your community faces during floods. (source: [Author])

3.6 Promoting Home Mitigation Measures and Financial Assistance:

A significant portion of residents (58%) lack home mitigation measures. Educational programs promoting 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 wider adoption of these measures, making homes more resilient to floodwaters. (Figure 5)

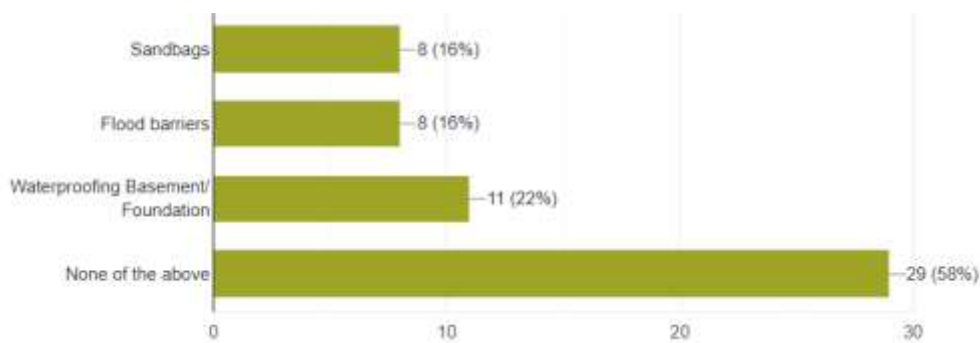


Figure 5. Flood mitigation measure. (source: [Author])

3.7 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, building a network of support during floods. The 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 take an active role in preparedness. Programs could include topics like floodproofing homes, creating emergency plans, and assembling disaster kits. Additionally, engaging local youth in community outreach programs can ensure the knowledge and skills needed for preparedness are passed on to future generations, fostering a culture of long-term resilience. (Figure 6)

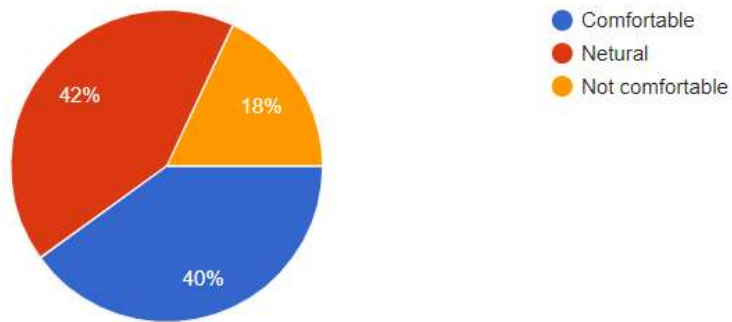


Figure 6. *Discussing Flood-preparedness with your neighbors.* (source: [Author])

3. DISCUSSIONS

Advantages and Current Methods:

Social Networks and Traditional Knowledge: The importance of social networks and traditional customs that 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 handled proactively. The survey should, however, demonstrate how well these mechanisms serve the entire community, especially the residents of high-risk locations.

Areas for Improvement: Transportation and Evacuation preparations: The survey can point out 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 also essential to evaluate how adequate transportation is.

Awareness of Flood Risk and Drills: Programs for education can be more effectively tailored if the existing degree of local understanding of flood dangers is known. Low participation in readiness drills indicates that more interesting and approachable activities are required.

Floodproofing Techniques and Mitigation Strategies: The survey's findings can be used to determine how commonplace floodproofing techniques are among households. It's also critical to ascertain how comfortable the neighborhood feels talking to each other about preparedness measures. This may open the door for group efforts to develop mitigation techniques.

Creating a More Robust Srinagar, here are some important tactics for creating a more resilient Srinagar based on the strengths and shortcomings that have been 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. Test these systems frequently and run educational programs to help people understand what warnings mean.

Enhancing Transportation and Evacuation Plans: Work together with the community to create thorough evacuation plans that include assembly locations and well-marked routes. Make sure 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, locally-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 the residents, including the elderly and children, that mimic real-life situations.

Encouragement of Community Mitigation Strategies and Floodproofing Measures: By offering financial incentives and technical support, promote floodproofing measures at the home level. Arrange seminars on building methods that withstand flooding and distribute details on easily accessible materials for floodproofing. Collaborate with the community to determine and put into action 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 including representatives from the government, local businesses, and people. This group can serve as the driving force behind 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 overly damages caused by disasters one should be well prepared to face them. An efficient disaster management plan is convenient for combating disasters and making Srinagar ready to face any unexpected disasters.

- **Pre-Disaster:** Prioritizing minimal damage to life, property, and the environment. And to reduce any potential loss such methods involve planning and implementing various schemes, even incorporation of early warning mechanisms is crucial for preparedness before disaster strikes.
- **Preparedness:** The responsive stage focuses on being ready to face a disaster that has already been visited. It involves government officials and residents working together to respond effectively. Public education and awareness programs focusing on how to react to specific disasters like floods are crucial at this stage.
- **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 warning seriously. This emphasizes the need for timely warning to reach vulnerable areas to minimize damage.

- **Response and Relief:** This stage involves various activities like 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 are launched by the authorities.
- **Post-Disaster Stage:** emphasizing on the importance of “building back better” after a disaster. This stage includes providing aid, rehabilitation, and reconstruction, but also taking steps to minimize damage if similar disaster strikes again. This might include improved tracking systems and more thorough and systematic planning.
- **Renewal/Resurgence:** The revival stage goes on beyond just rebuilding. The focus here is to create a sturdier and more sustainable infrastructure compared to what existed before, that includes building Roads and essential facilities. However, there’s an emphasis on ensuring these developments are built responsibly and don’t encroach on nature.
Take 2013 Kedarnath Flood as an example. The devastation was so massive that revival of the pilgrimage route was expected to take years. The focus was on not just rebuilding the basic infrastructure that was washed away, but also making it more durable and sustainable for the future.
- **Development:** Rebuilding after a disaster is a time-consuming process, especially due to the financial constraints. The government raises funds from public and private sectors, with various relief funds established to aid various sectors of Uttarakhand.

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

- a) **Planning:** Define the desired outcome for Srinagar (Conceptual modeling), evaluate Srinagar’s current state (Site Assessment), Estimate the financial resources required for the restoration project (Cost Estimation).
- b) **Construction and Implementation:** Focusing on projects requiring minimum remodeling, as they likely require less interventions. Extensive engineering projects carry higher uncertainty.
- c) **Performance Assessment:** Throughout the restoration process (lasting potentially several years), continuously monitor progress to ensure adherence to the action plan.
- d) **Adaptive Management:** Employing Adaptive management principles, meaning being flexible and adjusting restoration plans based on what’s learned during the process. (Figure 7)

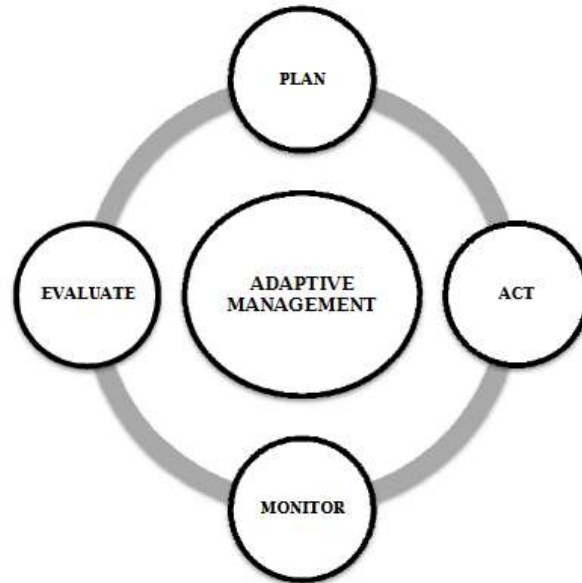


Figure 7. Adaptive management process. (source: [Author])

4. CONCLUSION

Flood mitigation involves long-term measures to reduce the impact of floods. These can be structured as well as non-structured. Flood defense structures are built to safeguard people and property from direct impact of floods, they are not meant to totally stop floods but ultimately provide the desired level of safety. These structures can be built longitudinally along the river or transversely across the river, or even a combination of both. The character of the defense structure depends on the terrains, 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 like planning, safety levels desired, and local materials.

While some structures built after 2013 showed success, this doesn't guarantee complete protection from future floods. While helpful in the short term, might not be effective. They could fail during massive floods or due to unplanned development in floodplains. A more proactive approach to flood risk management is needed, considering the different characteristics of rivers in various terrains. The true effectiveness of these structures can only be judged during actual floods.

Acknowledgement

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