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Alarming Floods in Indian Cities: Strengthening Institutional Capacities for Management

Hriday Ronak Mehta

Pandit Deendayal Energy University (PDEU), India. (email: hridayrmehta@gmail.com)

Abstract

Floods are among the most dangerous natural disasters, statistically impacting more lives and properties than any other calamity. According to the National Disaster Management Authority (NDMA), India witnessed over 400 major floods between 1953 and 2018, affecting approximately 56 million people and causing damages amounting to $100 billion. This paper discusses methods institutions in India could adopt to mitigate the effects of floods. The research methodology includes primary research through personal interactions with bureaucrats and technocrats in the field of management, as well as with staff from the National Disaster Response Force (NDRF). Additionally, secondary research comprises qualitative analyses of data, reports, and various journal papers. Findings emphasize the necessity of participative governance and inter-departmental coordination to minimize damage. Recommendations include preventive measures through infrastructure development and staff training, thorough prior licensing of industries, collaboration with meteorological departments and NGOs, standardization of rescue team procedures, and active engagement from policymakers. The roles of efficient committees and public participation are underscored, alongside the need for collaboration among technical and managerial departments—such as water, irrigation, rapid action, and medium-range weather forecasting. The paper offers a scientific approach to tackling floods and serves as a reference for policymakers, bureaucrats, and committees focused on flood prevention and management.

Keywords:

assessment of regions; bureaucracy's role in disaster management; collaboration and coordination among departments; use of forecasting for prevention; preventive infrastructure; participative governance during disasters; standardization of procedures for calamities

Introduction

Urbanization in India is occurring at an unprecedented pace. The urban population has seen a significant increase over the years, from approximately 285 million in 2001 to over 480 million in 2021, with projections suggesting that this figure will reach 600 million by 2031. This surge in urbanization has created a pressing need for essential urban services such as water supply, sanitation, housing, waste management, and transportation. As a result, cities are facing substantial financial burdens to meet these demands, with the estimated investment required for urban services exceeding $1 trillion. The consequences of this inadequacy are dire, with millions of urban dwellers facing substandard living conditions and deteriorating infrastructure, especially in slum areas that house nearly 65 million people.

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The combination of rapid urbanization, global climate change, and rising public expectations presents a formidable challenge for urban local bodies. Over 100 million people in urban areas globally are at risk of devastating floods, making it imperative to allocate necessary funds to cities capable of utilizing them effectively. Proactive urban planning can mitigate flooding risks for millions, enhancing health, education, connectivity, and urban development. However, many Indian cities are ill-prepared to cope with escalating demands for urban services, resulting in inadequate and deteriorating infrastructure. This growing disparity underscores the strain caused by rapid urbanization.

India is one of the most water-rich countries in the world, boasting 4% of the world's freshwater resources. Yet, for many cities, water availability is seasonal, and flooding is frequent and often severe. In 2021 alone, India experienced devastating floods, with over 6 million people affected and economic losses estimated at around $8 billion. Heavy rainfall in short spans without proper drainage causes urban flooding, especially when development does not adhere to planning norms ensuring rainwater runoff. Unplanned growth exacerbates the flooding situation, and despite recurrent flooding experiences, urban planning has not fully recognized the importance of preventing or minimizing flood impacts. Science and technology are insufficiently integrated with good governance to respond adequately to flood risk management. Migration in search of work is a significant contributing factor, as over 8 million people migrated to cities in 2020 alone.

Therefore, it is critically important that future urban development incorporates flood mitigation measures. Comprehensive Flood Risk Management approaches, often involving nature-based solutions, aim for equitable distribution of flood risks to prevent future catastrophic impacts while providing flood-resilient infrastructure. Local governance and community involvement can help identify where to build micro-scale flood-resilient infrastructure. However, city authorities and relevant agencies often lack a comprehensive understanding of the flood problem on the ground.

These factors call for a change in perspectives and approaches within bureaucratic structures.

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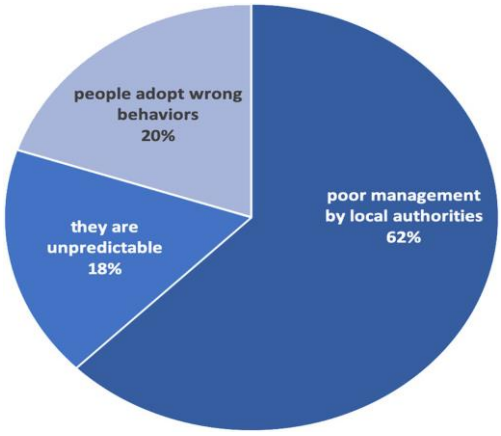
Picture 1.

Analysis of the top three reasons damages occurred in a flood



Methods

This research employs a mixed-methods approach, integrating both primary and secondary research for a comprehensive analysis of flood management in Indian cities. The primary research component involves direct interactions with key stakeholders, specifically bureaucrats and technocrats engaged in disaster management and urban planning. These interactions provide firsthand insights into challenges and opportunities in implementing flood management strategies. Discussions with personnel from the National Disaster Response Force (NDRF) are critical, offering operational perspectives on emergency response efforts during floods. These discussions capture decision-making intricacies, resource allocation, and the effectiveness of existing institutional frameworks in flood management. The qualitative data gathered will be analyzed to identify common themes and areas for improvement.

The secondary research component consists of extensive qualitative analysis of relevant literature, including academic articles, government reports, and case studies. This literature review provides a broader context of flood management in India, documenting theories, historical data, and regional experiences. By synthesizing findings from existing studies, this research will highlight best practices, knowledge gaps, and lessons learned from past flood events.

The combination of primary and secondary research methods enriches the analysis, facilitating a well-rounded exploration of institutional capacities for flood management. Integrating real-world insights with theoretical frameworks enhances the validity of findings and contributes to actionable recommendations for improving flood resilience in Indian cities. Ultimately, this methodology aims to foster a deeper understanding of the complexities involved in flood management and the institutional dynamics at play.

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Results and Discussion

Urban Floods in India

Rapid urbanization and growing economic importance are leading to extreme land-use changes in Indian cities. Urbanization primarily involves converting natural landscapes into residential, industrial, and commercial units to accommodate the influx of migrants seeking better livelihoods. These changes create urban heat islands and increase impervious surfaces, with studies indicating that the proportion of impervious surfaces in Indian cities has risen from 10% to 30% in the past two decades. Shifts in government policies toward road networks, port construction, and dam-building dry up much of the hinterland's water, leading to flash floods and catastrophic effects.

Encroachment of urban areas towards rivers and lakes diminishes watershed effectiveness, which is crucial for intercepting stormwater and recharging natural aquifers. For instance, in Mumbai, approximately 40% of the natural drainage system has been compromised

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due to unplanned urban expansion. Concrete and hard surfaces—roads, plazas, and buildings—hinder natural water movement into the soil, causing surface flooding. Urban flooding is an interaction among channels, shelters, the urban environment, and society, exacerbated by unplanned development that neglects effective anticipation and mitigation by local governments.

Causes of Flooding:

The primary causes of flooding include rainfall, poor drainage facilities, massive built-up areas, changes in land use, silting of river channels, and encroachment on riverbanks and water bodies. Rapid urbanization significantly increases vulnerability, with recent reports indicating that urban areas experience an average annual rainfall increase of 10-20%. While low-frequency floods might not severely impact rural areas, major cities are experiencing more frequent and intense floods that result in substantial human and economic losses. For example, the 2015 Chennai floods affected over 1.8 million people and caused damages estimated at $1 billion. Urban flooding emerges from complex relationships between physical and socio-economic environments, institutional planning, and design. The rapid pace of city development has posed greater challenges for local bodies and administrators, mainly due to high population growth driven by rural-to-urban migration. Poor planning has led to slum proliferation, chaotic growth, environmental degradation, and increased encroachments on water bodies, exacerbating flooding. Existing urban drainage systems, inadequately designed and managed, struggle to cope with urbanization, while replacing permeable agricultural land with built-up areas heightens runoff and flooding risks.

Flooding Due to Migration:

Rapid urbanization puts immense pressure on cities to meet the needs of a growing population. Development is often haphazard, with master plans frequently modified to facilitate random construction without adequate infrastructure considerations. Economic activities attract labor, stretching urban facilities to their limits and causing chaotic growth. This unplanned development pressures existing infrastructure, leading to drainage system failures, waterlogging, and disrupted normal life. For instance, Delhi's population surged from 8.2 million in 2001 to over 20 million in 2021, resulting in chronic flooding during monsoon seasons. Factors contributing to flooding include land use patterns, drainage networks, poorly designed drains, and land encroachments. The financial burden of survival and chaotic urban growth are primary contributing factors. Creating well-planned satellite towns may effectively tackle flooding caused by migration.

Preventive Infrastructure:

Systemized city planning is essential for disaster management. Infrastructure development should include:

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1. Disaster Water Harvesting: Directing drains to artificial underground tanks can help utilize excess floodwater for various purposes, particularly effective in semi-urban areas. The Rainwater Harvesting scheme in Tamil Nadu, which implemented over 400,000 rainwater harvesting systems, has demonstrated the effectiveness of this strategy.
2. Special Bureaucratic Channels: Empowered committees should make swift decisions based on assessments of flood-prone areas to operate floodgates and centralized drainage gates, preventing waterlogging. The formation of the Mumbai Flood Control Authority is an example of a proactive approach to managing urban flood risks.
3. Direction of Excess Water: Approximately 30% of geographical areas face regular flooding during the monsoon. Developing artificial infrastructures like canals and, if necessary, dams can help direct excess water toward irrigation-requiring areas. The construction of the Kosi embankment in Bihar aimed to control flooding along the Kosi River has helped protect over 2 million people.
4. Monitoring Changes: Integration of new technologies like Geographic Information Systems (GIS) and Remote Sensing (RS) in urban planning is essential. These tools can aid in real-time monitoring of flooding risks. For instance, the Ahmedabad Urban Development Authority has implemented GIS technology for better urban planning, resulting in a significant reduction in urban flooding incidents.
5. Standardized Emergency Operations Protocols: Preparedness and responsiveness during floods require clear guidelines for local governance and coordination with relevant agencies. Establishing standardized procedures can enhance collaboration and efficiency during emergencies. In Kerala, the standardized approach to flood management in 2018 led to a quicker response and minimized damages, showcasing the efficacy of well-coordinated efforts.
6. Capacity Building: Training local governance bodies and stakeholders in disaster management is crucial for effective response. Implementing regular training programs can enhance the capacity to handle flood events. For example, the Uttarakhand State Disaster Management Authority conducts annual training for local officials, leading to improved response times during flood emergencies.

Financing Disaster Prevention

Disaster prevention, as is established, is a long-term and investment-heavy approach. Preventive infrastructure, being expensive, also comes with a no-profit or no direct benefit prejudice. Therefore, policymakers are often hesitant to invest in the disaster prevention approach, preferring instead a "disaster fixation" approach. According to the World Bank (2021), every $1 invested in disaster prevention saves $4 in post-disaster recovery. Moreover, India's

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annual economic loss from disasters, particularly floods, has been estimated at around ₹60,000 crores (approximately $8 billion), demonstrating the importance of preventive spending (Central Water Commission, 2019).

1. National Disaster Management Fund (NDMF): The National Flood Commission of 1980 advocated for the use of preventive infrastructure in flood-prone areas. The commission report recommended allocating a certain part of the National Disaster Management Fund (NDMF), which currently stands at ₹1,000 crores annually (NDMA, 2019), for preventive approaches to disaster management. However, much of this fund is still allocated to post-disaster relief, limiting the proactive building of flood-resistant infrastructure.
2. Cess**:** A potential source of revenue could be the levying of a cess (special tax) on goods and services, specifically for the construction of preventive civil structures. For instance, a "disaster preparedness cess" of 1% on luxury goods could generate billions of rupees each year, contributing significantly to the budget for preventive measures.
3. Donation-based Programme: The government and NGOs may collaborate to raise donations or crowdfund specific civil structures. The Prime Minister's Disaster Relief Fund, which raised ₹11,000 crores in 2020 alone (PMO, 2020), serves as an excellent example of this model. This model could be extended further for preventive measures instead of just relief.

Institutional Capacities for Flood Management

Institutions should be established with clear standard operating procedures (SOPs), preset hierarchies, and a standard flow of command and jurisdiction. Flood management requires cooperation between multiple stakeholders engaged in planning, policymaking, and program implementation. Effective institutional capacity is essential because studies have shown that urban flooding affects more than 15 million people annually in India (Mukherjee & Saha, 2021).

a. National Government and Provincial Coordination**:** Institutions within district, state, or provincial and national governments must prepare flood prevention and emergency preparedness plans and implement flood protection measures. For example, the Kerala government, after the devastating 2018 floods, established the *Rebuild Kerala Initiative*, which focused on resilient infrastructure and institutional reforms, proving that coordinated action can help mitigate future disasters (Lal & Kaur, 2020).
b. Drainage and Water Authorities**:** Land drainage and utility service authorities have responsibilities to maintain and improve drainage systems, pump stations, and water management. It is crucial to mention that inadequate drainage systems caused 25% of flood-related damages in Mumbai's 2005 floods, costing the city ₹5,000 crores in damages (Jain & Sinha, 2019).

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c. Local Municipalities**:** Local municipalities control land use and regional planning. Rebuilding institutional structures to handle long-term aspects of water management, urban infrastructure planning, and other urban development planning are relevant when addressing urban flooding. For instance, rapid urbanization has resulted in unplanned growth in cities like Delhi and Kolkata, which are now classified as high-risk flood zones due to inadequate urban drainage systems (Kumar & Singh, 2019).

Government Agencies and Policies

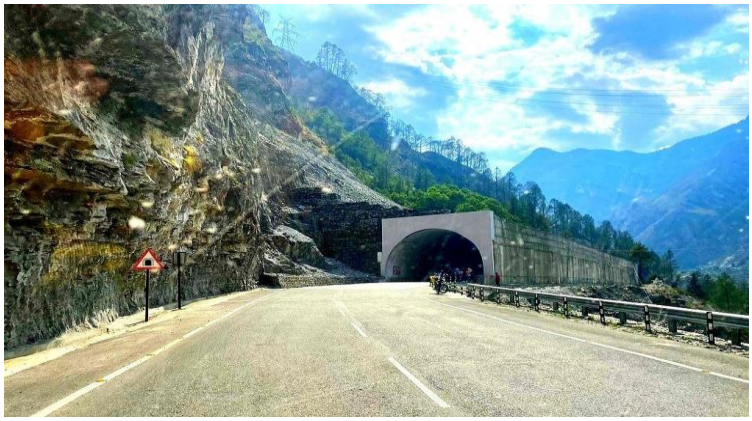
The institutional reforms of municipal corporations failed to address environmental or waste management issues significantly. For instance, the failure to manage waste effectively resulted in blocked stormwater drains during the 2017 floods in Chennai, which cost the city approximately ₹15,000 crores (Ghosh & Singh, 2021). Such instances highlight how a lack of disaster-preventive infrastructure exacerbates flood damage.

Policymakers prioritize infrastructure like roads and buildings without adhering to environmental norms. This reactive response to flood problems often stems from fragmented governance structures. The Government of India has initiated policies such as the *Atal Mission for Rejuvenation and Urban Transformation (AMRUT)*, which aims to improve urban services, but the pace of implementation is slow and underfunded.

Additionally, policies that drive up land values and encourage spatial shifts often overlook drainage needs, leading to flooding issues. For instance, excessive construction along the Yamuna floodplains in Delhi has restricted the river's natural flow, causing recurrent flooding (Srinivasan & Sinha, 2020). The establishment of an *Urban Reset Mechanism*, which addresses restrictive land-use policies and strengthens local institutions, is a potential solution for sustainable urban management.

Picture 2.

Depiction of haphazard construction without taking environmental and geological reports into consideration



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Role of Non-Governmental Organizations

Non-Governmental Organizations (NGOs) play a vital role in participatory governance. Studies show that communities with active NGO participation experience 30% less damage during disasters (Mukherjee & Saha, 2021). NGOs can build capacities for citizen action, particularly in disaster awareness programs. For instance, *SEEDS India*, an NGO, has launched several awareness campaigns in Odisha, leading to better community preparation and reduced disaster impacts in flood-prone areas.

NGOs can contribute in several key capacity-building areas:

- Organization: NGOs can help communities set up disaster response committees, enabling quick mobilization in times of crisis.
- Legal-related Needs**:** Many NGOs assist communities in understanding their legal rights in disaster situations, helping them access government aid and compensation more effectively.
- Quantitative and Qualitative Capacity Needs: NGOs often provide training on collecting and analyzing data related to local environmental risks, empowering communities to make data-driven decisions.

National Disaster Response Force (NDRF)

Established under the National Disaster Management Act of 2005, the NDRF is a quick action response team with personnel from the reserve forces and the army. The NDRF has grown from 8 battalions in 2006 to 12 battalions today, with a total of around 12,000 personnel (NDMA, 2020). Despite this, coordination with important agencies like the Indian Meteorological Department (IMD) remains a challenge, limiting their operational effectiveness. During the 2020 Assam floods, the NDRF struggled to coordinate with local NGOs, which had better access to on-the-ground information (Barlow, 2020).

Role of Pollution Control Board

The role of the Pollution Control Board in flood management cannot be overstated, especially considering the direct link between pollution and the clogging of drainage systems. For instance, the indiscriminate disposal of solid waste has choked over 70% of Mumbai's drains, exacerbating flood risk during the monsoon season (Saha & Gupta, 2021). A stronger focus on waste management, especially the regulation of industrial waste discharge into rivers, would mitigate urban flooding significantly.

Role of forecasting:

The Indian Meteorological Department (IMD) plays a critical role in flood management through accurate weather forecasting, early warning systems, and hydrometeorological monitoring. By predicting heavy rainfall, cyclones, and riverine floods, the IMD helps authorities

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and communities prepare in advance, reducing the risk to lives and property. Utilizing technologies such as Doppler radars, satellite-based observations, and numerical weather prediction models, the IMD provides timely and localized flood alerts. Despite these advancements, challenges remain in the form of infrastructure gaps, localized forecasting limitations, and the increasing unpredictability of extreme weather events due to climate change. Improved inter-agency coordination and communication are essential to further enhance its effectiveness in managing floods.

Conclusions

Urban flooding in India poses a significant challenge that necessitates a multifaceted approach to flood risk management, particularly as urbanization and climate change continue to intensify. The findings of this study underscore the urgent need for efficient governance frameworks that prioritize participatory approaches, collective ownership, and collaborative efforts among various stakeholders. Establishing robust institutional capacities to address flood risks requires a paradigm shift in how urban areas are planned and managed.

A critical aspect of effective flood risk management lies in fostering cooperation between government bodies, local communities, and non-governmental organizations (NGOs). The active involvement of all stakeholders enhances the understanding of local flood risks and the development of context-specific strategies that cater to the unique needs of different urban environments. Policymakers must prioritize data-driven decision-making and continuous evaluation of flood management practices. The integration of innovative technologies, such as GIS and remote sensing, into urban planning processes can facilitate real-time monitoring and enhance the resilience of urban infrastructure against flooding.

Moreover, ongoing training and capacity-building initiatives for local governance bodies and disaster response teams are essential. The establishment of standardized protocols for emergency response and recovery can ensure a more coordinated and effective approach during flood events, minimizing losses to life and property. The experiences from previous flooding incidents highlight the importance of learning from past mistakes and adapting strategies accordingly.

In conclusion, addressing the complexities of urban flooding in India requires a holistic and adaptive approach that recognizes the interconnectedness of urbanization, climate change, and effective governance. A collaborative effort, rooted in community engagement and informed by scientific research, can pave the way for resilient urban spaces that can withstand and recover from future flooding events. As urban areas continue to grow, the integration of flood risk

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management into broader urban planning efforts is not just a necessity but a moral imperative. The future of Indian cities depends on our ability to embrace proactive strategies that ensure safety, sustainability, and the well-being of urban populations.

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