Review Paper:

Urban Flooding in Tier-2 Indian Cities: A Qualitative Exploration of Causes, Impacts and Mitigation Strategies

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Abstract

Urban flooding has emerged as a recurring challenge in Indian cities, with even minimal rainfall events triggering waterlogging and severe disruptions. This study investigates the phenomenon of frequent urban flooding in five tier-2 Indian cities: Puri, Raipur, Ranchi, Vizag and Bhopal through a qualitative lens. Using focus group discussions (FGDs) with a cross-section of stakeholders including residents, municipal officials, urban planners and environmental activists, the study aims to generate in-depth insights into the patterns of flooding, its multifaceted impacts, perceived causes and proposed mitigation strategies. The data, collected through semi-structured FGDs and analysed thematically, reveals that unplanned urban expansion, poor maintenance of drainage infrastructure, encroachment on natural waterways and inadequate storm-water management are recurrent factors contributing to urban flooding. Participants reported substantial health risks, property damage, traffic paralysis and income loss, especially among marginalized communities.

This research adds to the limited qualitative evidence based on urban flooding in non-metro Indian contexts. By foregrounding lived experiences and stakeholder perspectives, the study offers valuable insights for localized disaster risk reduction strategies and urban policy reforms. It underscores the urgency of integrated urban planning, community-based resilience-building and proactive governance to mitigate the growing threat of urban flooding in emerging Indian cities.

Keywords: Urban Flooding, Tier-2 Cities, Disaster Risk Reduction, Focus Group Discussions, Urban Resilience.

Introduction

Urban flooding has emerged as a critical urban environmental challenge in India, with cities experiencing severe waterlogging and inundation even after short spells of rain. Traditionally associated with extreme weather events, flooding in Indian urban contexts is now increasingly linked to moderate or even light rainfall due to structural deficiencies in urban planning and infrastructure. While metropolitan cities like Mumbai and Chennai frequently dominate the discourse on urban floods[48]. Tier-2 cities such as Puri, Bhopal, Ranchi, Raipur and Vizag are now witnessing a sharp rise in urban flood incidents, despite their smaller size and relatively recent urbanization trajectories[40]. The frequent recurrence of flooding in these cities after the slightest of rain indicates a systemic failure in storm-water management, compounded by rapid and unregulated urban expansion, loss of natural drainage channels and poor governance mechanisms[17]. The consequences are multifaceted, ranging from infrastructural damage and economic losses to public health crises and social disruption, especially for vulnerable populations residing in low-lying or informal settlements[42].

Despite the growing body of research on urban flooding, there remains a lack of in-depth qualitative studies that explore localized experiences and perspectives from smaller cities. Most existing studies employ quantitative tools such as GIS mapping, rainfall-runoff modeling, or flood hazard indexing, which often overlook the live realities of affected communities and governance[34].

This study addresses this gap by adopting a qualitative approach based on focus group discussions (FGDs) across five tier-2 Indian cities. It seeks to examine: (i) the incidence and characteristics of urban flooding in these cities, (ii) the socio-economic and environmental effects on residents, (iii) the underlying causes from community and institutional perspectives and (iv) the perceived efficacy and gaps in current mitigation strategies. Through this exploratory study, we aim to provide grounded insights to inform more resilient urban planning and localized disaster risk reduction (DRR) efforts in emerging urban centers of India.

Understanding the phenomenon of urban flooding in Indian cities requires a comprehensive examination of both global and local perspectives on its causes, impacts and mitigation strategies. This review synthesizes existing scholarly work to contextualize the rising incidence of flooding, particularly in tier-2 cities, which are often overlooked in mainstream urban disaster research. It explores key drivers such as climate change, inadequate drainage systems and unplanned urban expansion, also highlighting the socio-economic and infrastructural consequences of frequent inundation. Furthermore, it critically assesses the limitations of existing flood mitigation frameworks and underscores the value of qualitative methodologies such as focus group discussions

for capturing live experiences, institutional challenges and context-specific insights essential for shaping inclusive and resilient urban planning.

Studies on Urban Flooding- Global and Indian Contexts: Urban flooding has become a critical environmental hazard worldwide, largely driven by climate change, rapid urban expansion and inadequate infrastructure[12]. Globally, cities in Asia and Africa face recurring inundation that disrupts urban life and exposes systemic vulnerabilities. In the Indian context, urban flooding has evolved from an episodic concern to a structural urban crisis as seen in the cases of Mumbai (2005), Chennai (2015) and Hyderabad (2020), where extreme rainfall events combined with poor urban planning led to widespread disruption[26]. While these large metros receive significant scholarly attention, tier-2 cities such as Puri, Raipur and Bhopal are increasingly witnessing similar challenges but are underrepresented in existing research[40].

Key Causes - Climate Change, Poor Drainage and Unplanned Urbanization: Multiple interlinked factors contribute to the increased incidence of urban flooding. Climate change has intensified rainfall variability and the frequency of extreme precipitation events[18]. At the local level, cities face institutional and infrastructural bottlenecks. Unregulated urban sprawl, reduction of green cover, encroachment on wetlands and drainage channels and absence of storm-water management systems significantly increase surface runoff[37]. Moreover, most Indian cities rely on outdated or incomplete drainage infrastructure, often clogged due to poor maintenance[15]. These factors are particularly pronounced in tier-2 cities where infrastructure growth has lagged behind urban population increases.

Impacts of Urban Flooding: The effects of flooding in urban areas are multifaceted. Physical infrastructure such as roads, housing, water supply and power systems are damaged, leading to prolonged service disruption[2]. Flooding also exposes the urban poor to health hazards including waterborne diseases and vector-borne illnesses, due to stagnant water and contamination[24].

Economically, the urban informal sector suffers significant losses due to interrupted mobility and workplace accessibility. In many cases, flooding leads to temporary or permanent displacement, particularly in informal settlements situated in low-lying or flood-prone zones[24].

Frameworks for Mitigation and Identified Gaps: Several urban flood mitigation strategies have been proposed and implemented globally. These include structural measures like improved drainage, detention basins and green infrastructure and non-structural measures like early warning systems, land-use planning and community-based disaster preparedness[47]. In India, programs such as the Smart Cities Mission and AMRUT aim to integrate urban resilience, yet their effectiveness remains uneven due to governance fragmentation, underfunding and weak inter-agency coordination[23]. Moreover, there is minimal integration of local knowledge or citizen feedback into these frameworks, making them less adaptive to localized realities in smaller cities.

Relevance of Qualitative Methods in Urban Disaster Research: While much of the research on urban flooding is dominated by quantitative approaches such as GIS mapping, hydrological modeling and spatial analytics, these tools often fail to capture lived experiences and socio-political dimensions of vulnerability[7]. In contrast, qualitative approaches such as focus group discussions and in-depth interviews provide rich, contextual insights into the causes, consequences and coping strategies related to urban flooding. This method is especially relevant for tier-2 cities where official datasets may be sparse or outdated and where governance challenges are deeply embedded in local narratives[32]. Qualitative inquiry can illuminate institutional bottlenecks, community perceptions and informal adaptive strategies that often remain invisible in technical assessments.

Focus Group Discussions

To explore the underlying causes, impacts and mitigation strategies associated with urban flooding in Indian tier-2 cities, this study adopts a qualitative, exploratory research design. Given the context-specific and experiential nature of flood vulnerability and urban governance, qualitative methods are well-suited to uncovering localized insights that may be obscured in quantitative analyses. Focus group discussions (FGDs) serve as the primary data collection tool, enabling dialogue among diverse stakeholders including residents, officials and experts in five purposively selected tier-2 cities.

Research Design: This study employs a qualitative, exploratory research design aimed at understanding the localized dynamics of urban flooding in emerging Indian cities. Qualitative methods are particularly effective for exploring complex, context-dependent phenomena such as disaster vulnerability and community response, especially where numerical data may be sparse or insufficiently descriptive[9]. Focus group discussions (FGDs) were chosen as the primary tool to elicit a diversity of perspectives and promote collective reflection among key stakeholders, allowing for the emergence of nuanced themes[28].

Selection Criteria for Study Sites: Five tier-2 cities: Puri, Raipur, Ranchi, Vizag and Bhopal, were purposively selected based on the following criteria:

- Recurring incidents of urban flooding following even mild to moderate rainfall.
- Rapid urban expansion with a high rate of population growth and infrastructure development.
- Existence of flood-prone or low-lying residential areas, including informal settlements.

- Municipal interest and accessibility for stakeholder engagement.
- Geographic and ecological diversity representing different parts of India.

This purposive selection ensured that the study sites reflect the broader spectrum of challenges faced by rapidly urbanizing non-metro cities in India[41]. A total of 8 FGDs (1 per city) were conducted, each involving 8–10 participants. A heterogeneous stakeholder model was used to ensure diverse representation, including:

- Local residents from flood-affected neighborhoods.
- Municipal officials involved in urban planning and storm-water management.
- Environmental activists and NGO workers focusing on disaster mitigation and urban governance.
- Urban planners, civil engineers and academics with expertise in sustainable urban development.

This composition enabled triangulation of perspectives, helping validate findings across community, institutional and expert domains[35].

Data Collection and Ethical Considerations: Data were collected through semi-structured FGDs guided by a thematic protocol covering flooding events, perceived causes, impacts and mitigation strategies. Discussions were audio-recorded with informed verbal consent and supplemented by field notes capturing group dynamics and non-verbal cues. Participants were informed of their right to withdraw at any time and all data were anonymized using pseudonyms to maintain confidentiality and adhere to ethical research standards[6].

Data Analysis: The recorded discussions were transcribed verbatim and analyzed using thematic analysis, as outlined by Braun and Clarke[5]. The process followed six iterative steps:

1. Familiarization with the data
2. Generation of initial codes
3. Searching for themes
4. Reviewing themes
5. Defining and naming themes
6. Producing the final report

Thematic analysis is well-suited for identifying patterns in qualitative data, especially in social research contexts involving public service and infrastructure issues. Both inductive (data-driven) and deductive (literature-informed) coding strategies were applied to enhance analytical robustness.

Discussion

The findings are derived from the FGDs conducted across five tier-2 Indian cities, offering rich, context-specific insights into the incidence, impacts, perceived causes and mitigation practices related to urban flooding. Thematic analysis of participant narratives revealed both common patterns and city-specific variations, highlighting how even brief rainfall events can disrupt infrastructure, livelihoods and public health. The findings are organized into four key themes: the frequency and spatial variation of flooding, its multifaceted effects, stakeholder perceptions of root causes and the range of mitigation responses, both institutional and community-driven, along with their associated challenges. These insights provide a ground understanding of urban flood vulnerability in emerging Indian cities, which is often absent in technical assessments.

The discussions interpret the key findings from focus group discussions held across five tier-2 Indian cities to understand the localized dynamics of urban flooding. By comparing participant insights with existing literature and policy frameworks, the frequency and variation of flood events, their socio-economic and public health consequences, perceived root causes and the effectiveness of current mitigation efforts are examined.

Incidence of Flooding

Frequency and Triggers: Participants across all five tier-2 cities reported that flooding frequently occurs even after short durations of moderate rainfall. In cities like Puri and Vizag, as little as 20–30 mm of rain within an hour resulted in street-level waterlogging, often due to clogged or undersized drainage networks. The FGDs revealed that monsoon months (June to September) bring near-annual occurrences of urban flooding, with some areas experiencing up to five or six flood episodes per season.

These accounts align with a growing body of empirical research that documents the increasing frequency of urban flooding in Indian cities due to inadequate stormwater drainage infrastructure, urban sprawl and climate variability. For instance, Singh et al[43] found that even rainfall below 50 mm/hour can paralyze cities like Guwahati and Bhopal due to poor drainage design and maintenance. Similarly, Doshi and Garschagen[11] noted that undersized and silted drainage systems, a legacy of outdated city planning, are major contributors to urban flood vulnerability. These problems are magnified in tier-2 cities where infrastructure investment often lags behind urban expansion.

Variations across Cities: Although flooding was a common experience across all cities, there were marked variations in triggers and intensity. For instance, Puri and Vizag, both located on relatively flat terrain and influenced by coastal systems, suffered rapid flash floods. In contrast, Ranchi and Raipur experienced slower but more persistent waterlogging due to blocked runoff and terrain-related drainage stagnation. These differences reflect both natural topography and variations in urban infrastructure investment. The observed differences in flooding patterns are consistent with past insights such as coastal cities like Puri and Vizag face heightened flood risks due to these combined factors[10] and

inland cities, characterized by undulating terrains, experience slower yet more persistent waterlogging[27].

Effects of Flooding

Damage to Property and Infrastructure: Flooding led to consistent reports of damage to roads, culverts, boundary walls and residential buildings, particularly in informal settlements. Focus group participants in Ranchi and Bhopal noted that repeated flooding has caused structural weakening of homes, destruction of household items and electrical hazards. These findings align with broader research on urban flooding in India, such as, urban pluvial floods have significantly affected infrastructure and livelihoods in Indian cities, with informal settlements being particularly vulnerable due to inadequate infrastructure and poor housing conditions[43] and informal settlements often suffer the most due to their location in high-risk areas and lack of resilient infrastructure[44].

Public Health Impacts: Health effects were prominent in all cities, particularly due to the mixing of floodwater with sewage and garbage. FGDs revealed increased cases of gastrointestinal infections, skin diseases and mosquito-borne illnesses such as dengue and malaria, particularly during peak monsoon periods. Stagnant water was cited as a breeding ground for vectors and a direct threat to public hygiene. These findings align with broader research on flooding, such as, incidence and transmission of infectious diseases during and after floods[1], increased risk of communicable diseases following natural disasters, particularly floods[38], skin infections resulting from prolonged exposure to floodwaters[33] and health vulnerabilities like typhoid fever, malaria, diarrhea and dengue[45].

Mobility and Economic Disruption: Participants consistently mentioned disruption to everyday mobility including the breakdown of public transport and impassable roads. In commercial zones, particularly in Raipur and Vizag, shopkeepers and daily wage earners reported substantial income losses during flood events. School and office attendance also suffered, revealing a broad socioeconomic impact.

As per past insight, a modest flooding of 1.3% of road segments can lead to an 8% temporal expansion of the entire traffic network, with increased travel times persisting for weeks after floodwaters recede, which extend beyond the immediate flood zones[36]. Similarly, flood-induced disruptions can lead to substantial income losses, as commercial activities are halted and access to workplaces is impeded[47] and increased flooding correlates with decreased school attendance and learning outcomes in India[21].

Perceived Causes

Inadequate Drainage Systems: Across all five cities, the primary cause of flooding was identified as obsolete or insufficient drainage systems. Residents reported that drains were either blocked, poorly maintained, or terminated without proper outlets. In Puri and Bhopal, existing drainage infrastructure was designed decades ago and has not kept pace with urban expansion. These findings are consistent with insights from past research such as, across India, many cities rely on colonial-era drainage systems designed for much lower rainfall intensities[20] and with changing climate patterns and increased urbanization, these systems are inadequate, leading to frequent urban flooding[50].

Encroachment on Water Bodies: Participants highlighted encroachment on natural drainage paths, wetlands and low-lying floodplains. In cities like Vizag and Raipur, storm-water that historically drained into natural channels is now obstructed by residential colonies and commercial development. As per insights from past research, land-use changes, particularly the conversion of natural floodplains into built-up areas, have reduced the cities' flood absorption capacity, creating hotspots of urban vulnerability[29]. Further, encroachment on natural drainage channels, wetlands and low-lying floodplains and unregulated urban expansion has significantly disrupted hydrological flows, leading to surface runoff accumulation and frequent waterlogging during rainfall events[8].

Lack of Urban Planning Enforcement: A recurring theme was weak regulatory enforcement**.** Residents described unauthorized constructions, violations of building codes and developments approved without proper drainage assessments. Many expressed concern that municipal authorities allowed growth in flood-prone zones without adequate risk assessment.

Weak regulatory enforcement has been a significant factor contributing to urban flooding in Indian cities. Residents have reported unauthorized constructions, violations of building codes and developments approved without proper drainage assessments, particularly in flood-prone zones[3]. Such practices have exacerbated flood risks by obstructing natural water flow and overwhelming existing drainage infrastructure[13,14].

Civic Governance Challenges: Civic response to flood management was widely criticized. Complaints about unresponsive municipal helplines, lack of transparency, poor coordination among departments and seasonal desilting rather than year-round maintenance surfaced across all FGDs. These findings resonate with broader critiques of urban governance in Indian secondary cities[4].

Mitigation Practices and Gaps

Current Responses by City Governments: Although some municipal corporations have initiated desilting drives, drain covers and mobile flood alerts, participants widely described these measures as reactive. For instance, apps launched in Bhopal and Puri were acknowledged but criticized for delayed responses and limited community outreach. While some cities have initiated measures like desilting drains and

deploying pumps, these are often reactive rather than preventive. Reports recommend proactive planning and infrastructure development to manage urban flooding effectively[16].

Community Coping Mechanisms: Communities have developed local coping strategies such as raising plinth levels, installing makeshift barriers and forming neighborhood groups to manage water ingress. In Ranchi and Raipur, residents shared how they dug temporary drainage channels or installed pumps to redirect water, underscoring the informal resilience that arises in the absence of institutional support. Residents have adopted various coping strategies such as elevating homes and creating informal drainage channels. However, these measures are often insufficient without institutional support. Community involvement is essential for effective flood management[31].

Suggestions from Participants: Participants suggested the revival of old water bodies, construction of sustainable urban drainage systems (SUDS) and stricter enforcement of land use zoning. Many emphasized the need for participatory planning involving local communities in flood-prone areas, particularly during the design of municipal plans. The suggestions align with insights from past research such as, reviving traditional water bodies as a critical step in restoring natural drainage pathways[46], incorporation of green roofs, permeable pavements and bio-swales for controlling storm-water runoff[25], enforcement of land use zoning regulations to avoid flood-prone development[30] and participatory planning involving local communities, where local engagement led to more accurate identification of vulnerabilities and context-specific mitigation strategies[39].

Barriers to Effective Mitigation: Key barriers identified included political interference in urban planning, lack of inter-agency coordination, insufficient budget allocations and low civic engagement. Participants frequently noted that flood management only becomes a priority post-disaster and that there is little long-term planning or evaluation of drainage adequacy. The findings resonate with insights from past research such as recurring concern, political interference, (where short-term interests often override long-term urban planning goals)[22]. Lack of coordination between municipal bodies, urban development authorities and disaster management agencies severely restricts integrated flood response[19]. Budget constraints in flood management receives funds only after major flooding events[30].

Conclusion and Implications

The findings of this study offer critical insights for urban policymakers, planners and disaster management authorities working to address the growing challenge of flooding in India's tier-2 cities. The recurrence of floods after minimal rainfall highlights the urgent need to redesign urban drainage systems, integrate land-use planning with flood risk assessment and protect natural water channels from encroachment. Furthermore, the health consequences of stagnant floodwater, especially in low-income neighborhoods, point to the need for proactive healthcare provisioning and sanitation strategies. Effective urban flood management must move beyond reactive engineering fixes and adopt a holistic, community-inclusive approach that emphasizes early warning systems, participatory planning and climate resilience.

This study contributes to the emerging body of qualitative urban flood research by centering stakeholder experiences and highlighting the governance gaps and opportunities for reform. Ultimately, strengthening institutional coordination and embedding flood resilience into city planning are essential in safeguarding livelihoods, infrastructure and well-being in India's rapidly urbanizing secondary cities.

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