EMBEDDING EQUITY IN URBAN CLIMATE RESILIENCE: RETHINKING SERVICE DELIVERY IN INDIAN CITIES

ANKIT JHA, SOHAM SHAH, GAURAV SAHNI, DR VISHWAS CHITALE

Climate change is turning episodic hazards into systemic service failures in Indian cities. This paper argues that existing resilience planning has a limited understanding of service equity risks, thus reinforcing socio-spatial inequalities. Using Mumbai's case, we review the IPCC hazard-exposure-vulnerability framework along with underlying political economy and climate justice perspectives to highlight how centralised infrastructure and governance mechanisms further entrench service disparities, translating climate extremes into perpetual service crises, particularly for the people living in informal settlements, informal workers and other vulnerable groups. Our study highlights the evidence that resilience planning must take an equity-first policy approach, pairing infrastructure upgrades with governance reforms and redistributive measures that prioritise the most vulnerable.

Ankit Jha, Programme Associate, The Council on Energy, Environment and Water
ankit.jha@ceew.in

Soham Shah, Research Analyst, The Council on Energy, Environment and Water
soham.shah@ceew.in

Gaurav Sahni, Senior Engagement Associate, The Council on Energy, Environment and Water
gaurav.sahni@ceew.in

Dr Vishwas Chitale, Fellow, The Council on Energy, Environment and Water
vishwas.chilate@ceew.in

Introduction

Cities under Siege: Infrastructure, Equity and Climate Pressures in Urban India

Cities are regarded as engines of economic growth, serving as hubs of innovation, industry, and trade that contribute to a nation's/region's development. These developments are underpinned by socio-economic transformations and the presence of urban systems like transportation, electricity, housing, water and sanitation, healthcare systems, etc. These urban systems are tightly interlinked, bringing people and markets together, improving living standards and unlocking new opportunities.

However, an accelerating climate crisis threatens these dynamics. Increasing frequency and intensity of climate-induced extreme events like floods, heatwaves, storms, and cyclones are overwhelming service delivery systems, compromising community well-being and threatening the overall resilience of cities (Dodman et al., 2022). According to the projections by the United Nations Department of Economic and Social Affairs (UNDESA), by 2050, nearly 70 per cent of the world's population will live in urban areas, with the bulk of growth occurring in Asia and Africa (UN DESA, 2019). This makes urban resilience a global concern that also needs to be addressed at the local level, particularly for India, given its vast population and scale of urbanisation.

In India, concentration of people, assets and infrastructure in cities makes them hotspots of vulnerability, exposing millions living in precarious conditions, particularly in informal settlements where service delivery is inadequate (Alakshendra et al., 2020). While the existing body of work on urban risks and resilience has focused on

physical vulnerabilities, research on how these risks interact with and exacerbate inequities in service delivery remains nascent. Through this paper, we seek to understand this interaction and explore the following questions -

1) How does climate change exacerbate inequities in urban service delivery?
2) What frameworks can help integrate equity into resilience planning for Indian cities?

In our analysis, we take the case of the coastal city of Mumbai which is witnessing intensifying and frequent cyclones and storms due to rising surface temperatures in the Arabian Sea, which pose new risks to its people, infrastructure and governance mechanisms.

Literature Review

Urban systems under climate stress

Urban landscapes are central to economic development, population growth, but also increasingly vulnerable to climate hazard risks (Monteiro et al., 2022). The IPCC frames risk as a function of three components - **Hazard, Exposure, and Vulnerability:**

- **Hazards:** Extreme precipitation and flooding, extreme heat, cyclones, and a rise in sea level impact the functioning and dynamics of infrastructure systems (Ikonomova & Mac Askill, 2023).
- **Exposure:** Presence of people and assets in hazard-prone areas.
- **Vulnerability:** The sensitivity[1] and adaptive capacity[2] of people and systems to extreme weather events (Sharma & Ravindranath, 2019).

Hazards such as heatwaves directly impact human health, leading to an increase in morbidity and mortality numbers, especially among the vulnerable communities (Dodman et al., 2022), while also affecting infrastructure systems like roads, railway networks and power infrastructure (Mills & Andrey, 2002). During peak summers, higher demand for cooling increases the load on the grids and causes frequent power outages (International Energy Agency [IEA], 2023). Similarly, when extreme precipitation causes floods, it puts water management systems, transportation infrastructure and other critical systems at high risk (Ferdowsi et al., 2024), which disrupts the functioning of cities (He et al., 2006).

Socio-economic vulnerabilities and Service gaps

Climate hazards interact with urban systems to expose infrastructural gaps, jeopardise vulnerable populations and trigger cascading failures that result in service disruptions and detrimental social impact (Dodman et al., 2022). However, hazards alone are not responsible in determining these adverse outcomes but are also a factor of infrastructural conditions and socio-economic contexts (Cutter et al., 2003; Leichenko & Silva, 2014). For instance, drainage systems in most Indian cities were designed for smaller populations of the time but are undersized and dated for today's megacities. Centralised water distribution systems, a recurring feature in Indian cities, create single points of failure that can halt entire supply zones. During floods, these are the worst hit, often disrupting water supplies to prevent water contamination, resulting in water insecurity, sanitation and health risks. All such structural weak points in the urban systems transform climate hazards into service crises, disproportionately affecting the vulnerable populations in cities.

The archetypal sites for the hazard-infrastructure-vulnerability nexus to manifest are the informal settlements characterised by high population density, limited infrastructure and tenure irregularities (UN-Habitat, 2020). In 2022, an estimated 1.1 billion people lived in slums or informal settlements globally, whereas India's slum population was estimated at roughly 236 million in 2020[3] (Gautam & Sharma, 2024), indicating the scale of informal settlement vulnerability -

[1]defined as the degree to which the urban systems are affected by climate variability

[2]defined as the ability of the system to adjust to potential damages.

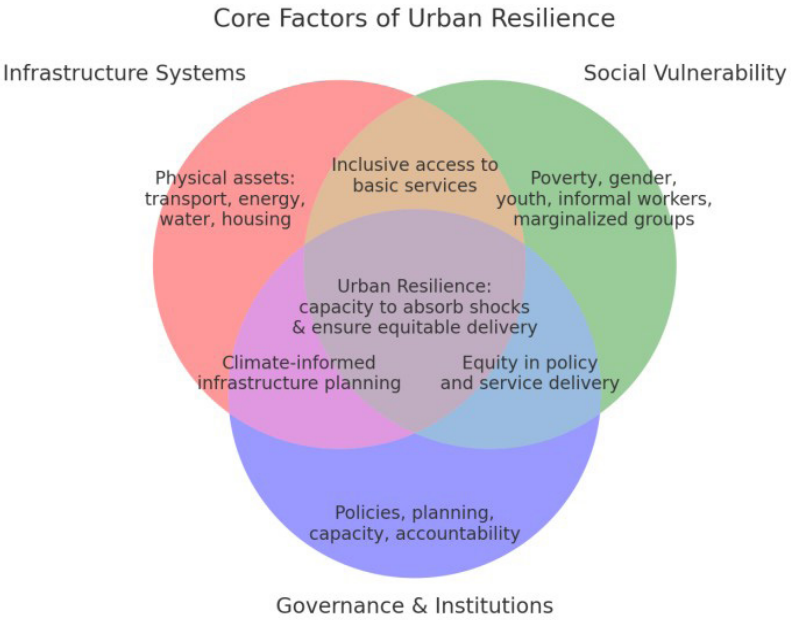
[3]The last census was held in 2011 and therefore no official figures have been provided by the Govt agencies. This data relies on projections by the UN and associated agencies.

both globally and in Indian cities. Add to that the patchy service delivery networks, which amplify this vulnerability. Research suggests that service networks like piped water connection, access to household sanitation facilities, reliable electricity, etc., are substantially low, unreliable and intermittent in areas inhabited by low-income groups or informal settlements (Satterthwaite & Mitlin, 2013). As a result, climate stressors like floods and heatwaves cause deeper marginalisation because households lack the capacity to meet these demands, leaving them with fewer coping options. This results in climate extremes increasingly translating into systemic long-term risks rather than isolated events for the vulnerable population (Alegría et al., 2024).

It is important to note that service inequity is not merely the lack of access to critical physical infrastructure, but is also reinforced by governance and planning exclusions. For instance, Indian cities like Delhi and Mumbai have informal settlements lacking legal tenure and deemed "unauthorised", resulting in them being excluded from formal service networks. As a result, there is an increasingly forced reliance on alternative service providers like private water tankers or community toilets, leading to increased risks and vulnerabilities - both from climate shocks and as a public health hazard.

Planning exclusions also augments these vulnerabilities. IPCC AR6 notes that urban adaptation plans "are rarely developed through consultation with diverse and marginalised urban communities," highlighting that infrastructure investments tend to favour formal neighbourhoods and seldom address the priorities of the poorer sections (Dodman et al., 2022). Secondly, poor integration of climate risk considerations into urban development, reactive disaster response in and around informal settlements means that when climate hazards strike, marginalised communities not only take the impact but also have to bear with slow, inequitable recovery. Literature suggests that whenever disaster strikes, recovery is prioritised in central business districts and formal neighbourhoods, while lower-income areas have to face prolonged service outages, pointing to a post-disaster service divide (Aldrich, 2012).

In recent years, Indian cities have grappled with climate-induced shocks with increasing temperatures and extreme rainfall events that have put the larger masses at risk. The heatwaves of 2024 in India were among the worst in recent times. Heatwatch (2024) reported that 37 Indian cities experienced temperatures above 45 degrees Celsius between March and June 2024, dramatically increasing the heat exposure of urban residents. In 2023, Delhi witnessed one of the worst floods in 63 years, displacing over 15000 people - mostly farming communities along the Yamuna river. More recently, on 19th August 2025, Mumbai



Equity as a Pillar of Urban Resilience

Fig.1: Core factors of Urban Resilience
WSource: Author's Visualisation

[4]The Hindu. (2025, October 10). Mumbai rains: Extreme rainfall intensified by climate change and multiple weather systems, warn scientists and climate experts. https://www.thehindu.com/news/cities/mumbai/mumbai-rains-extreme-rainfall-intensified-by-climate-change-and-multiple-weather-systems-warn-scientists-climate-experts/article69954721.ece

recorded 800 mm of rainfall in just four days, surpassing the monthly average of 560.8 mm and paralysed the functioning of India's financial capital[4] . These incidents illustrate how climate shocks can cause a hazard-service failure chain. The burden of these failures (power outages, transport collapse, water cuts) falls hardest on slum dwellers, informal workers, women and other vulnerable groups. This evidence implied that climate shocks interact with existing service inequities, making the design and delivery of urban infrastructure an urgent imperative, especially from a governance perspective.

India's urban governance framework has tried to address these intersectional challenges through programs like Smart Cities Mission (SCM) and Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and Swacchh Bharat Mission-Urban (SBM-U), aiming to modernise infrastructure to meet current demands. Yet their implementation underplays the dynamics between climate change and equity considerations. Take sanitation and water access, for instance. Though SBM-U expanded access to sanitation facilities, it struggled to ensure equitable benefits, particularly for women's sanitation security (Dandona, 2025). A Praja Foundation (2025) report highlights a stark contrast in Mumbai's context, where slum households receive only 45 LPCD water per capita per day compared to 135 LPCD for non-slum households, forcing them to rely on private service providers. The report also notes the neglect towards public sanitation, as it found that most community toilets lack running water or power, and only one in four toilet seats is reserved for women. These statistics highlight evident disparities and indicate how unequal baseline service delivery leads to differentiated vulnerabilities and reduced capacity to cope with climate shocks. In the absence of distributive justice in urban planning and service delivery, resilience measures risk reinforcing such inequities rather than reducing them. In the next section, we attempt to analyse this interaction using IPCC risk framing and political-economy perspectives.

Conceptual Framing

For our analysis, we combine the IPCC's hazard–exposure–vulnerability framing with climate-justice and political-economy perspectives to capture how adaptation and infrastructure investments are distributed across social groups, asking who benefits from it and who bears the costs. While the IPCC triad helps in tracking the cascading effects of climatic extremes through infrastructure networks to produce service interruptions, it doesn't provide insights into why some communities recover faster than others. For this, we looked into the political economy and climate-justice scholarship. Using David Scholsberg's three dimensions of justice (Schlosberg, 2004), i.e. distributive (who gets resources and protection), procedural (who takes part in decision-making), and recognitional (whose needs and rights are acknowledged), reveals how governance, land markets and institutional practices channel adaptation benefits. Evidence suggests that adaptation actions often channel benefits towards affluent districts, promoting "green gentrification", catalysing capital-driven development and real estate for affluent groups (Anguelovski et al., 2018; García-Lamarca et al., 2019; Peroni & Pappalardo, 2024), thus underscoring the need for policies that prioritise resource allocation and risk buffers for vulnerable neighbourhoods. These complementary lenses reveal that infrastructural and technical robustness alone is not sufficient to build resilience but is also underpinned by social and political contexts. We argue that equitable urban resilience requires fair allocation of resources and infrastructure services enabled by participatory planning and decision making, while explicitly recognising the groups' based rights and needs on the lines of age, gender, occupation, and income. Together, these principles ensure that resilience planning can shift away from a myopic focus on technical and physical robustness to one centred on fairness, participation and positive socio-economic outcomes.

Methodology

The analysis presented in this paper synthesises secondary data from peer-reviewed research, policy reports and briefs and international frameworks. In the process of understanding the intersections of urban service delivery and climate change, we did a systematic review of global assessments like IPCC AR6 WGII Report and UN-Habitat guidelines along with scholarly literature on climate risks to urban services and settlements, For our case study, we reviewed India's national urban policies like the Smart Cities Mission (SCM), Swacch Bharat Mission - Urban (SBM-U), Atal Mission for Rejuvenation

and Urban Transformation (AMRUT), National Urban Policy Framework (NUPF). Additionally, we looked at the state and city climate action plans. To supplement our hypothesis and make recommendations, we also looked at grey literature emerging from think tanks and policy research institutes.

Using the IPCC risk framing, we developed an integrated conceptual framework bringing together interactions between -

1. climate hazards (floods, heat, heavy precipitation, storms and cyclones) with infrastructural fragility (inadequate or outdated drainage, power grid, water network, sanitation facilities, etc.) that interact to determine service delivery
2. social vulnerability that shapes and affects exposure and the capacity to cope in the event of climate-induced challenges
3. governance measures meant for service provision and their role in enabling adaptation for communities

The analysis does not include primary fieldwork or new data; rather, we collate and interpret existing findings to assess how climate change may deepen service inequities in Mumbai. The learnings that have helped in finalising the recommendations come from ongoing projects in the state, however, not limited to them, and are also supported by our own analysis of the existing literature.

Findings

Intensifying urban climate risk: Cities are under severe stress as a consequence of a rapidly changing climate. These risks are pronounced for people living in hazard-prone areas, especially informal settlements. Mumbai, a low-lying coastal megacity in India, is a peculiar case in point. The city experiences extreme heat, cyclones and floods every year. In the last decade, Mumbai saw 15 additional very warm nights per summer, suggesting a higher exposure to climate hazards that are defined by population density, building density and Gross Domestic Product (Prabhu et al., 2025). As per projections, under RCP 2.6, mean temperatures are expected to rise by approximately 1.5-2°C by the end of the century, whereas under RCP 8.5, an increase of 4.5-5°C is anticipated. Additionally, the number of days exceeding 35°C annually is projected to increase by 20–30 days under RCP 2.6 and by more than 40 days under RCP 8.5 (Mumbai Climate Action Plan, 2022). Similarly, rains have become highly erratic as witnessed in 2025, where July was the driest since 2015, and August 2025 recorded higher rains than average[5]. In 2024-2025, the city faced heightened storm and cyclone risks along with sea-level rise threats with models projecting Mumbai as one of the most flood-prone coastal cities under a high-emission scenario (Chakrabortty et al., 2025). These risks are further magnified by the fact that more than half of Mumbai's population lives in informal settlements that lack green spaces, follow haphazard planning and have densely clustered physical structures. Data suggests that the city houses approximately 5.2 million people or 18.1 per cent of India's total slum population[6] . In Greater Mumbai, 46 per cent of households occupy dwellings with temporary roofing materials (Census of India, 2011)[7] . Research suggests that informal settlements are particularly exposed to climate events due to both limited or no access to risk-reducing infrastructure and limited adaptive capacity, with communities facing disproportionate impacts as they lack access to basic services and social safety nets (Dodman et al., 2022; Satterthwaite et al., 2018). In a systematic literature review, it was found that informal settlements in the Global South face the highest risks: floods (cited in 44% of studies), temperature changes (41%), storms (31%), and sea-level rise (30%) amongst others (Hussainzad & Gou, 2024). Further, when hazards strike, centralised systems are the most at risk of disruption, affecting service delivery for the low-income areas and informal settlements. In the long term, this manifests as systemic risk resulting in the compromised well-being and delayed recovery of the communities (Hallegatte et al., 2019). Further, hazards compound with ageing or undersized infrastructure, causing cascading failures across service systems that have now become

[5]https://www.thehindu.com/news/cities/mumbai/mumbai-rains-extreme-rainfall-intensified-by-climate-change-and-multiple-
[6]weather-systems-warn-scientists-climate-experts/article69954721.ece

[7]https://www.orfonline.org/expert-speak/maharashtra-housing-policy-2025-promise-pitfalls-and-the-price-of-inaction

[8]https://censusindia.gov.in/census.website/data/census-tables

a defining feature of urban vulnerability in times of climate change (Dodman et al., 2022).

Socio-economic realities shape vulnerability: Socio-economic contexts shape vulnerability by determining access to services and adaptive capacity.Poverty, informality, gender and other inequities intersect with hazards to amplify exposure and produce differentiated vulnerabilities. For example, during heatwaves, women and informal workers, especially outdoor gig workers in agriculture, construction, and street vendors, work in precarious conditions, exposing them to heat-related health hazards. Venugopal et al. (2016) found that the outdoor workers with heavy workloads reported reduced productivity and higher rates of heart-related illness, especially within the informal sector, where protections are scarce. This amplifies their vulnerability by eroding both health and livelihoods. The International Labour Organisation (2019) and Lancet Countdown detail labour and health losses associated with heat and climate extremes, underlining the human costs of service failures (Romanello et al., 2022). For instance, the gendered impacts of heatwave further exacerbate differentiated vulnerabilities. Women often report higher rates of heat related illnesses, sleep disruptions and income erosion as the 20% average gender pay gap widens further during these times which aggravates health and livelihood risks[8] . Similarly, informal settlements that exhibit a lower baseline in access to quality service delivery experience longer service disruptions and slower recovery efforts, leading to what can be referred to as 'post-disaster service divide'.

Despite this evidence, most climate and labour policies overlook the urban poor, providing them with little buffer against the climate crises in terms of livelihood, income or housing safety. A recent review of India's climate policies found that around 80% of the policies omit climate risks and two-thirds overlook the migrant community, with a handful integrating adaptive social protection (Apparaju et al., 2025).

As a result, millions of people are left without any formal policy support on heat protection, livelihood support and recovery pathways when a hazard strikes. We find that service delivery in legacy urban systems is unequal, with skewed distribution, and climate shocks widen this gap further, reducing the resilience of urban communities.

Equity as a function of governance: The resilience of urban communities and their adaptive capacity is a critical function of governance. Limited capacities, implementation and institutional gaps often drive inequitable outcomes. Fragmented governance, legal exclusion of informal settlements, complex land tenure, limited disaster response, weak participatory planning processes and lack of disaggregated monitoring of equity indicators accentuate inequities. Despite the 74th Constitutional Amendment, India's urban climate governance remains highly centralised, leaving little room to capture local risks and or tailor interventions for the urban poor. For example, in Mumbai, governance fragmentation is a challenge for resilience planning. Multiple agencies, including the Municipal Corporation of Greater Mumbai (MCGM), Mumbai Metropolitan Region Development Authority (MMRDA), Slum Rehabilitation Authority (SRA), and state-level bodies, often have overlapping or competing mandates (Tandel & Gandhi, 2012). This often hinders integrated planning and slows coordinated response to climate shocks. The 2022 Mumbai City Climate Action Plan suggested using a multi-sectoral approach to address the intersectional challenges but implementation gaps persist, with limited integration of informal settlements into adaptation strategies. While climate budgeting has caught the attention of Indian cities, it still needs a higher degree of decentralisation for it to fructify for resilience building.

In sum, literature consistently advocates for a more robust governance mechanism that prioritises equity-driven urban planning aimed at inclusive resilience building. This is to be done by building 'bottom-up' and addressing gender, age and class differences for effective people-centric resilience.

Discussion

Increasing climate variabilities mean more frequent and severe hazards with recent incidents highlighting the urgency of climate action. For instance, during 2024 monsoons Mumbai experienced multi-day extreme precipitation exceeding 200-300 mm leading to flooding and overload on service networks. Since cities aggregate population, critical infrastructure and economic activities in very

[8]https://www.orfonline.org/expert-speak/the-gendered-impact-of-heatwaves-and-water-crisis-in-india

small areas, these hazard events induce multi-system failures, making it necessary to treat them as stress tests of urban service infrastructure and governance mechanisms. Cities with poor service delivery networks and governance mechanisms are far more likely to see climate shocks turn into long-term, unequal impacts.

These hazard induced impacts reveal deep gaps in planning, disproportionately affecting the marginalised sections along the lines of income, class, gender, age and occupation who often remain invisible in conventional planning frameworks. Mumbai exemplifies how these effects are amplified in informal settlements, home to around 9-10 million people living in substandard housing vulnerable to floods, heat and sea-level rise.

The vulnerabilities extend further across gender and age as women and youth bear as their employment patterns shape exposure and determine coping capacity. Women are traditionally tied to caregiving roles and have limited access to sanitation and safe shelter during disasters, while youth face the consequences in terms of lost learning and livelihood opportunities.

Together, these observations point to three foundational tenets for inclusive resilience: equity-first planning, which recognises differentiated vulnerabilities; decentralised, anticipatory infrastructure and service design; and inclusive participation of marginalised groups, including women and youth, in decision-making.

Based on these tenets, this paper proposes a framework anchored in five interdependent pillars:

1. Planning using a participatory approach to influence priorities as seen in Mumbai's Ambojwadi settlement where community-led vulnerability mapping informed local flood response[9] .
2. Design to account for climate risks across informal settlements in order to reduce exposure and service gaps through nature-based solutions like Argentinian slums, adaptable to Mumbai[10].
3. Access to address entrenched disparities in access to critical services especially in high-risk areas with temporary housing.
4. Capacity to mainstream the voices across age, gender, income and occupation groups
5. Governance to broaden the scope of decision-making towards a more polycentric, multi-level system, decentralised enough to tackle the climate crisis at the local level, as piloted in Mumbai climate budgeting and ward-level participatory processes in cities like Pune, Maharashtra.

We hypothesise that by embedding socio-economic equity in urban system planning, we can improve resilience outcomes by addressing the weakest links in these systems such as heat related burden on informal outdoor workers (2.3 times higher adverse outcomes for exposed workers)[11] . Moving away from the traditional approach of treating equity as a consequence of service delivery, we must consider it a prerequisite for resilience, as ensuring that there is no lag in service delivery, especially for the marginalised, who are often left behind during shocks.

We illustrate this using practical examples built on the theoretical framing discussed in the previous section. First, decentralisation of urban systems like neighbourhood-level water tanks, micro-grids for energy or decentralised waste management systems ensures that in times of shock and failures, the system stays alive and ensures service provision. Second, through inclusive governance and participatory planning, communities and governments can build co-operation to deal with crises and accelerate recovery, reducing the likelihood of prolonged inequities. Third, targeted investments in highly vulnerable settlements like slums can reduce service gaps and improve baseline resilience, reducing the risk of domino effects on urban system service delivery.

Evidence from the Global South supports our hypothesis. A multi-country review from the Global South spanning South Africa, Tanzania, Kenya, Bangladesh, Indonesia, India, Nigeria, Thailand, and Fiji reveals that "community-based adaptation strategies represent essential pathways to building equitable

[9]https://www.ceew.in/how-mumbai-is-responding-to-floods-climate-change-story

[10]https://weadapt.org/knowledge-base/cities-and-climate-change/nature-based-solutions-for-climate-change-adaptation-and-resilience-in-urban-informal-settlements-insights-from-kenya-and-argentina

[11] https://pmc.ncbi.nlm.nih.gov/articles/PMC11773483/

and sustainable flood resilience in informal settlements" (Bhanye, 2025). We also see several examples from India where these mechanisms have yielded positive results. Swacch Bharat Mission - Urban attempted to fund community toilets and solid waste projects, including unauthorised settlements, paving the way for reimagining how sanitation services are delivered. Some Indian states like Maharashtra and Kerala have implemented participatory budgeting at the ward level, where communities vote in budget allocation (Menon & Hartz-Karp, 2019). This is an example of decentralised governance to build local adaptive capacity, making it a practical resilience strategy. As diverse groups get involved in decision-making, inclusive planning and resource allocation can prevent service and recovery delays to build resilience that is sustainable and just. In the following section, we provide recommendations to translate these principles into concrete, implementable measures for all critical stakeholders.

Recommendations

Integrate climate risk in all urban policies: In order to address the issue of hazards turning into systemic risks, national and municipal governments should mandate a multi-hazard assessment along with social vulnerability assessments using disaggregated indicators to monitor equity outcomes. While indices such as the Social Vulnerability Index, Livelihood Vulnerability Index or UN-Habitat's Indicators disaggregate equity dimensions, their application in Indian cities remains limited. The Census data is disaggregated to some extent but it doesn't account for climate change related indicators and is also a 10-year survey making it difficult to be used for dynamic planning.

Empower local governance: Strengthen local governments by devolving more planning and decision-making authority to ward-level bodies to tackle challenges at the local levels. Dedicated funds must be created for decentralised development plans, service security, and asset management. Institutionalising participatory governance along with strengthening the engagement of non-state actors must also be encouraged to make planning more inclusive, responsive and accelerate climate action at sub-national levels.

Invest in resilient infrastructure: In order to ensure equity in service delivery, resilient infrastructure must be scaled up, considering the ills of climate-induced hazards like floods and heat. Development Plans should account for equity in city planning, budget, infrastructure projects, etc. Expansion or upgrading services to informal settlements should be prioritised to reduce the risks to urban poor/ low-income groups and improve their resilience. Committing to long-term funding for urban resilience must be at the heart of policies. To meet this, climate finance and private investment must be tapped through green bonds, blended finance and Public Private Partnerships.

Social measures to reduce inequity: Adaptive social protection must be embedded in policies and infrastructure schemes. Labour laws must consider the perils of climate change to human well-being and therefore aim to safeguard outdoor workers and their livelihoods. Different vulnerable groups, like women, youth, and informal workers, should actively engage in dialogue during the planning process.

Future Research Directions

For future research, we suggest conducting a more longitudinal study to understand how service equity and resilience interact and evolve over time. This will be helpful in tracking the long-term outcomes of policy interventions from an urban resilience planning perspective. For instance, a study on the effectiveness of heat action plans or whether slum upgrades help reduce flood-related losses and damage. To understand the socio-economic outcomes, participatory research with vulnerable groups could help gauge which policies improve service delivery and how to refine them for greater efficiency.

A comparative study across Indian cities or within city wards (e.g. Mumbai) could help understand the dynamics between governance and socio-economic contexts in influencing community resilience. It would be interesting to learn more about a more informed assessment of the interface between political economy and equity access across India's municipal governance systems.

We also recommend the development of an index that collects disaggregated data - by income, gender, class, age, etc.- and assesses them against climate hazards and service disruptions to develop a more granular understanding of how natural shocks affect equity.

We believe that this evidence will help policymakers guide

their efforts in scaling effective, inclusive adaptation strategies which look beyond infrastructure and delve into more intersectional challenges of equity access and solving differential vulnerabilities.

Limitations

Our analysis sticks to a systematic review of secondary literature, policy documents and civic reports rather than an extensive on-field data collection, therefore underrepresenting localised contexts. Much of the evidence comes from literature on service delivery equity and climate change, which may be limited. While we have taken Mumbai as a case study to illustrate our hypothesis, we acknowledge that there is heterogeneity across Indian cities that have not necessarily been captured in our analysis. We also faced data-related challenges during our review and analysis. Municipal service metrics like ward-level Litre Per Capita Per Day (LPCD), information on water service network and access, etc., are inconsistent, making it difficult to measure the real scope of the problem and come out with precise recommendations. Finally, with a rapidly changing climate hazard profile, policies and laws are being iteratively updated, meaning some of the future initiatives may not be captured in our study. These factors point to the need for a more targeted and longitudinal evaluation of policies and their impact.

References

- *Aldrich, D. P. (2012). Social capital in post-disaster recovery: Towards a resilient and compassionate East Asian community. In Y. Sawada & S. Oum (Eds.), Economic and welfare impacts of disasters in East Asia and policy responses (pp. 157–178). ERIA Research Project Report 2011-8, Jakarta: ERIA.*
- *Alegría, A., Poloczanska, E., Loeschke, S., et al. (2024). Towards an IPCC atlas for comprehensive climate change risk assessments. npj Climatic Action, 3, 108.https://doi.org/10.1038/s44168-024-00193-3*
- *Alakshendra, A., Kumar, A., & Mehta, S. (2020). Interlinkages between urbanization and climate change: Identifying and understanding the challenges and the prospects. Journal of Regional and City Planning, 31, 285–300. https://doi.org/10.5614/jpwk.2020.31.3.4*
- *Anguelovski, I., Irazabal, C., & Connolly, J. (2018). Grabbed urban landscapes: Socio-spatial tensions in green infrastructure planning in Medellín. International Journal of Urban and Regional Research, 43. https://doi.org/10.1111/1468-2427.12725*
- *Apparaju, A., Surampally, S., Singh, C., Ranjit, N., Patil, S., & Poonacha, P. (2025). Internal migration and climate resilience in India: Are current policies and interventions providing adaptive social protection? Indian Institute for Human Settlements.*
- *Ahmad Ferdowsi, F., Piadeh, F., Behzadian, K., & Mousavi, S.-F. (2024). Urban water infrastructure: A critical review on climate change impacts and adaptation strategies. Urban Climate, 58.*
- *Bhanye, J. (2025). A review study on community-based flood adaptation in informal settlements in the Global South. Discover Sustainability, 6, 595.https://doi.org/10.1007/s43621-025-01449-6*
- *Brian Mills & Andrey, J. (n.d.). Climate change and transportation: Potential interactions and impacts. [Journal details not available].*
- *Chakrabortty, R., Ali, T., Atabay, S., et al. (2025). Impact of climate change scenario on sea level rise and future coastal flooding in major coastal cities of India. Scientific Reports, 15, 28689.https://doi.org/10.1038/s41598-025-13394-5*
- *Chitale, V., Sahni, G., Rijhwani, V., Sharma, P., Maharjan, A., & Ghorpade, A. (2024). Enhancing the role of non-state actors in strengthening multilateral governance for accelerating climate action (T20 Policy*

Brief). T20 Brasil.https://www.t20brasil.org/media/documentos/arquivos/TF06_ST_05__Enhancing_the_role66fc045c468ae.pdf

- *Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). Social vulnerability to environmental hazards. Social Science Quarterly, 84, 242–261.*
- *Dandona, K. (2025, April 11). Swachh Bharat Mission-Urban: A critical analysis. Impact and Policy Research Institute (IMPRI).*
- *Dodman, D., Hayward, B., Pelling, M., Broto, V., Chow, W., Chu, E., Dawson, R., Khirfan, L., McPhearson, T., Prakash, A., Zheng, Y., Ziervogel, G., Archer, D., Bertolin, C., Brail, S., Cartwright, A., Chester, M., Colenbrander, S., Dhar, T., & Westman, L. (2022). Cities, settlements and key infrastructure. In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 907–1040). Cambridge University Press. https://doi.org/10.1017/9781009325844.008*
- *Emal Ahmad Hussainzad, & Gou, Z. (2024). Climate risk and vulnerability assessment in informal settlements of the Global South: A critical review. Land, 13(9), 1357.https://doi.org/10.3390/land13091357*
- *Francesca Peroni, & Pappalardo, S. E. (2024). Climate justice in future cities: Geographical perspectives for inclusive urban resilience and adaptation. Landscape and Urban Planning, 244, 104998.https://doi.org/10.1016/j.landurbplan.2023.104998*
- *García Lamarca, M., Anguelovski, I., Cole, H., Connolly, J., Argüelles, L., Baró, F., Loveless, S., Pérez del Pulgar, C., & Shokry, G. (2019). Urban green boosterism and city affordability: For whom is the 'branded' green city? Urban Studies, 58, 1–21. https://doi.org/10.1177/0042098019885330*
- *Gautam, A., & Sharma, H. R. (2024). Lives of slum dwellers: Evidence from a field survey in Ludhiana. Vol. 59, Issue No. 40, 5 Oct, 2024.*
- *Hallegatte, S., Rentschler, J., & Rozenberg, J. (2019). Lifelines: The resilient infrastructure opportunity. World Bank.http://hdl.handle.net/10986/31805*
- *He, J., Valeo, C., & Bouchart, F. J. C. (2006). Enhancing urban infrastructure investment planning practices for a changing climate. Water Science and Technology, 53(10), 13–20. https://doi.org/10.2166/wst.2006.292*
- *IMPRI. (2025). Swachh Bharat Mission-Urban: A critical analysis. Impact and Policy Research Institute.*
- *International Energy Agency. (2023). Keeping cool in a hotter world is using more energy, making efficiency more important than ever. IEA, Paris.https://www.iea.org/commentaries/keeping-cool-in-a-hotter-world-is-using-more-energy-making-efficiency-more-important-than-ever*
- *International Labour Organization. (2019). Working on a warmer planet: The impact of heat stress on labour productivity and decent work. Geneva: ILO.*
- *IPCC. (2022). Climate change 2022: Impacts, adaptation and vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press.*
- *Leichenko, R., & Silva, J. A. (2014). Climate change and poverty: Vulnerability, impacts, and alleviation strategies. Wiley Interdisciplinary Reviews: Climate Change, 5(4), 539–556.*

- *Menon, S., & Hartz-Karp, J. (2019). Institutional innovations in public participation for improved local governance and urban sustainability in India. Sustainability Earth, 2, 6.https://doi.org/10.1186/s42055-019-0013-x*
- *Monteiro, A., Ankrah, J., Madureira, H., & Pacheco, M. O. (2022). Climate risk mitigation and adaptation concerns in urban areas: A systematic review of the impact of IPCC assessment reports. Climate, 10, 115.*
- *Mills, B., & Andrey, J. (n.d.). Climate change and transportation: Potential interactions and impacts.*
- *Mumbai Climate Action Plan. (2022, March). Mumbai Climate Action Plan, March 2022.*
- *Praja Foundation. (2025, May). The status of civic issues in Mumbai.*
- *Prabhu, S., Sukesh, K. A., Mandal, S., Sharma, D., & Chitale, V. (2025). How extreme heat is impacting India: Assessing district-level heat risk. Council on Energy, Environment and Water, New Delhi.*
- *Romanello, M., Di Napoli, C., Drummond, P., Green, C., Kennard, H., Lampard, P., Scamman, D., Arnell, N., Ayeb-Karlsson, S., Berrang Ford, L., Belesova, K., Bowen, K., Cai, W., Callaghan, M., Campbell-Lendrum, D., Chambers, J., van Daalen, K. R., Dalin, C., Dasandi, N., Dasgupta, S., Davies, M., Dominguez-Salas, P., Dubrow, R., Ebi, K. L., Eckelman, M., Ekins, P., Escobar, L. E., Georgeson, L., Graham, H., Gunther, S. H., Hamilton, I., Hang, Y., Hänninen, R., Hartinger, S., He, K., Hess, J. J., Hsu, S.-C., Jankin, S., Jamart, L., Jay, O., Kelman, I., Kiesewetter, G., Kinney, P., Kjellstrom, T., Kniveton, D., Lee, J. K. W., Lemke, B., Liu, Y., Liu, Z., Lott, M., Lotto Batista, M., Lowe, R., MacGuire, F., Odhiambo Sewe, M., Martinez-Urtaza, J., Maslin, M., McAllister, L., McGushin, A., McMichael, C., Mi, Z., Milner, J., Minor, K., Minx, J. C., Mohajeri, N., Moradi-Lakeh, M., Morrissey, K., Munzert, S., Murray, K. A., Neville, T., Nilsson, M., Obradovich, N., O'Hare, M. B., Oreszczyn, T., Otto, M., Owfi, F., Pearman, O., Rabbaniha, M., Robinson, E. J. Z., Rocklöv, J., Salas, R. N., Semenza, J. C., Sherman, J. D., Shi, L., Shumake-Guillemot, J., Silbert, G., Sofiev, M., Springmann, M., Stowell, J., Tabatabaei, M., Taylor, J., Triñanes, J., Wagner, F., Wilkinson, P., Winning, M., Yglesias-González, M., Zhang, S., & Gong, P. (2022). The 2022 report of the Lancet Countdown on health and climate change: Health at the mercy of fossil fuels.*
- *Satterthwaite, D., & Archer, D., Colenbrander, S., Dodman, D., Hardoy, J., & Patel, S. (2018). Responding to climate change in cities and in their informal settlements and economies.*
- *Satterthwaite, D., & Mitlin, D. (2013). A future that low-income urban dwellers want, and can help secure. Human Settlements Working Paper Series: Poverty Reduction in Urban Areas, 38. International Institute for Environment and Development.*
- *Schlosberg, D. (2004). Reconceiving environmental justice: Global movements and political theories. Environmental Politics, 13(3), 517–540.https://doi.org/10.1080/0964401042000229025*
- *Sharma, J., & Ravindranath, N. H. (2019). Applying IPCC 2014 framework for hazard-specific vulnerability assessment under climate change. Environmental Research Communications.*
- *Tandel, V., & Gandhi, S. (2012). Understanding issues related to polycentric governance in the Mumbai Metropolitan Region. Public Finance and Management, 12. https://doi.org/10.2139/ssrn.2127521*
- *Venugopal, V., Chinnadurai, J. S., Lucas, R. A. I., & Kjellstrom, T. (2016). Occupational heat stress profiles in selected workplaces in India. International Journal of Environmental Research and Public Health, 13(1), 89.https://doi.org/10.3390/ijerph13010089*