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Urban Crisis Response

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FROM THE EDITOR-IN-CHIEF

India, currently the world's fourth-largest economy, is projected to become the third-largest by 2030, driven by strong domestic demand, structural reforms, and a youthful workforce. While this trajectory promises significant economic gains, it also highlights the urgent need to address the country's mounting urban crisis to ensure growth is inclusive and benefits all citizens. Indian cities, engines of economic activity that generate nearly 70% of the national GDP are struggling to achieve their full potential as they grapple with overlapping challenges. Rapid and unplanned urbanisation has overburdened infrastructure, resulting in housing shortages, traffic congestion, inadequate water and sanitation systems, and escalating pollution levels. Climate-related disasters such as floods and heatwaves are becoming more frequent and severe, underscoring the fragility of urban systems. At the same time, socio-economic disparities, the proliferation of informal settlements, and overstretched public services continue to deepen inequalities and compromise the quality of urban life. As population pressures mount, Indian cities face the urgent challenge of transforming into resilient, inclusive, and sustainable spaces that can support continued growth.

As per World Bank report, by 2025, around 37% of the India's population resides in urban areas, proportion that continues to rise rapidly. According to United Nations projections, by 2050, nearly 50% of India's population will be living in cities. This unprecedented pace of urbanisation is profoundly transforming economies, cultures, and societies across the globe. This year's World Habitat Day highlights the increasing challenges urban areas face as they grapple with overlapping crises, including climate change, natural disasters, conflict, forced migration, pandemics, and economic instability.

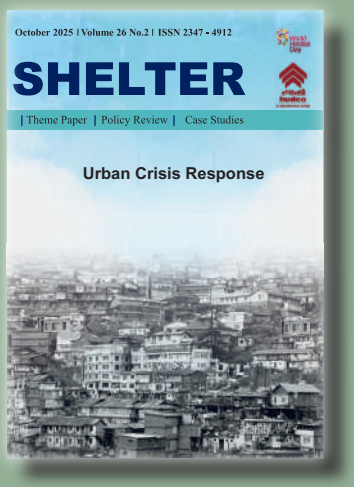
One of the most visible symptoms of urban strain is the rise of informal settlements and slums. India's slum population in 2022 is estimated to be 41.5% of total urban population (UN-Habitat Urban Indicators database) lacking adequate access to clean water, sanitation and secure tenure. These conditions expose residents to heightened risks during crises from flooding and fires to pandemics and social unrest. Cities are responsible for over 70% of global CO2 emissions while occupying just 3% of the Earth's surface (World Bank, 2021). This makes them both major contributors to and victims of climate change. Extreme weather events such as hurricanes, heatwaves, floods, and wildfires have become more frequent and intense, hitting urban centers particularly hard. Given the complexity and scale of urban crises, reactive emergency responses are no longer sufficient. Cities must shift toward proactive, integrated approaches that build long-term resilience.

The Government of India has implemented several key programmes and schemes to address the growing urban crisis caused by rapid urbanisation, inadequate infrastructure, housing shortages, and vulnerability to disasters. One of the flagship initiatives is the Pradhan Mantri Awas Yojana – Urban (PMAY-U), which aims to provide affordable housing to all urban poor, ensuring "Housing for All." This scheme focuses on slum rehabilitation, beneficiary-led construction, and credit-linked subsidies, significantly improving living conditions for millions in urban areas. Complementing housing efforts, the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) targets the enhancement of urban infrastructure, such as water supply, sewerage, urban transport, and green spaces, to improve the quality of life and build sustainable, resilient cities. Additionally, the National Disaster Management Authority (NDMA) leads India's disaster preparedness and mitigation efforts. It formulates policies and coordinates response, focusing on capacity building, early warning systems, and risk reduction. Key programmes include the National Cyclone Risk Mitigation Project (NCRMP), School Safety Programme, and Hospital Safety Programme. These initiatives strengthen resilience, enhance structural safety, and integrate disaster risk reduction into development planning to ensure effective response and a safer India.

This issue of Shelter adopts the World Habitat Day theme of "Urban Crisis Response," and underscores the importance of urgent urban responses that call for coordinated, equitable, and future-focused solutions to build resilient urban communities.

The journal features a range of articles arranged into three sections. Rinky Halder et al's paper frames India's urban crisis as a socio-ecological challenge, urging resilient planning and participatory governance via the Urban RAASTA framework for inclusive,

INSIDE



sustainable urban resilience. The paper by Shaleen Singhal et al analyses climate-urbanisation links in Indian cities, advocating resilience through technology, finance and stakeholder engagement for climate-ready urban systems.

In the policy review section, the paper by Ankit Jha et al argues that existing resilience planning has a limited understanding of service equity risks, thus reinforcing socio-spatial inequalities. The paper by Neha Lakhwan et al demonstrates the need for integrating the 6R principle in city management plan through existing best practices in Indian cities. Soumyadip Chattopadhyay et al's paper examines financing climate action in Indian cities advocating stronger revenue capacity and inclusive climate budgeting. Dr Kulwant Singh's paper underlines India's urgent urbanisation challenges, stressing resilience and sustainability as engines of prosperity, equity, and climate resilience.

The case study section features the paper by Dr. Barsha Posricha et al explores a transformative initiative in Rourkela's Naya Bazaar Leprosy Colony, where community participation and women's leadership enabled sustainable solutions, offering a scalable model for inclusive urban development. The paper by Risaal Amina Esa et al reviews Climate Risk Assessment (CRA) approaches in Indian cities' City Climate Action Plans (CCAPs), evaluating their strengths and weaknesses against defined criteria.

I thank all the contributors for an overwhelming response to this issue. I hope the readers enjoy the issue as much as we did putting it together. We value your feedback and would appreciate your comments.

THEME PAPER

POLICY REVIEW

CASE STUDIES

IN THE BOX

Two-week ITEC Training Course on "Leveraging Resilience for Future Proofing our Cities" (10th – 23rd September 2025)

HUDCO's Human Settlement Management Institute (HSMI) organised the 58th Training Course for overseas professionals on "Leveraging Resilience for Future Proofing our Cities", sponsored by the Ministry of External Affairs (MEA), Government of India, under its ITEC Programme from 10th – 23rd September 2025. The programme was inaugurated by Shri Sanjay Kulshrestha, Chairman and Managing Director, HUDCO, on September 11, 2025, in the presence of Shri M Nagaraj, Director (Corporate Planning), HUDCO and Shri Tekkam Sridhar, Senior Executive Director, HUDCO's HSMI.

58th ITEC batch of overseas professionals with Shri Sanjay Kulshrestha, Chairman and Managing Director, HUDCO and Senior Officers of HUDCO and HUDCO's HSMI

The training programme was attended by 22 delegates from 13 countries, namely the Dominican Republic, Ethiopia, Ghana, Indonesia, Iraq, Mauritius, Nepal, Nigeria, Palestine, Sri Lanka, Tunisia, Venezuela and Zimbabwe. The programme was conducted on participatory lines with deliberations and insights from the domain experts drawn from the government sector, private sector, and academia. The notable speakers invited to take the sessions included Prof. Vinod K. Sharma, Senior Professor at the Indian Institute of Public Administration (IIPA); Md. Asif Raza, Programme Manager, CITIIS NIUA; Dr. Surya Prakash, Professor and Head of Department, National Institute of Disaster Management (NIDM); Ar. Shaily Mahera, Senior Manager, GRIHA Council Fellow, TERI; Prof. Anil Kumar Gupta, Project Director, Adapt DMIR, IIT Roorkee; Dr. Barsha Poricha, Head-Technical Cell, Centre for Urban Regional Excellence (CURE); Dr. Amarnath Tripathi, Associate Professor, Jaipuria Institute of Management, Noida; Shri C.N. Jha, Building Materials and Technology Promotion Council (BMTPC) and Shri Alok Shiromany, Financing Expert, CRISIL Risk Infrastructure Solutions.

The course provided an opportunity to the participants to develop an understanding of the concepts and various aspects of disaster mitigation, adaptation and preparedness, besides social and economic resilience. The technical sessions were interspersed with visits to project sites and places of cultural and historical importance in Delhi. As part of the technical site visit, the participants were taken to see the Five-Star GRIHA-rated "Vanijya Bhawan" in New Delhi. The participants were also taken on a two-day outstation trip to Agra, where they visited Taj Mahal World Heritage Site and through a Metro ride had first hand experience of Metro Project at Agra.

FROM VULNERABILITY TO RESILIENCE : RETHINKING URBAN CRISIS RESPONSE IN INDIA

RINKY HALDER AND SFEETI PADELE

India's urban crisis reflects the intersecting pressures of inequitable urbanisation, critical gaps in infrastructure resilience, and environmental damage. This article reframes the crisis as a socio-ecological and governance challenge, proposing actionable pathways that embed resilience in urban policy, planning, and project pipelines.From a planning perspective, it emphasises risk-informed planning instruments and nature-based solutions, such as sponge retrofits, shaded public realms, and blue–green networks etc., mainstreamed into development controls and capital investment. Socially, it places equity at the core through in-situ upgrading of informal settlements, risk-informed service delivery, and co-produced mapping, transforming vulnerable sites into resilience anchors.

Drawing lessons from recent urban crises and reforms, the paper highlights how accountability gaps, fragmented institutions, weak local capacity, and limited fiscal autonomy can be addressed through resilience cells, participatory budgeting, and data-driven governance.By translating global commitments into locally actionable strategies, cities can align climate adaptation, social inclusion, and livability to deliver co-benefits across scales. The Urban RAASTA framework illustrates how national missions can connect with local leadership, shifting urban development from reactive disaster response toward anticipatory resilience building. Overall, the paper advances an integrative model where design, planning, and social equity converge to secure a sustainable urban future.

Keywords: Climate Adaptation, Disaster Risk Reduction (DRR), Inclusive Urban Transformation, Multi-Hazard Resilience, Nature-Based Solutions (NBS), Resilient Infrastructure, Sustainable Development Goals (SDGs), Urban Crisis Response, Urban Governance, Urban RAASTA, Vulnerability and Preparedness

Introduction: Understanding the Urban Crisis

More than half of the world's population now lives in cities, a figure expected to reach nearly 7 in 10 by 2050, with over 4 billion people already residing in urban areas. This unprecedented urban transition is transforming economies and societies, but it is also concentrating risks. Cities, with their dense populations and critical infrastructure, are where the converging crises of our time are felt most acutely, from intensifying heatwaves and floods to storms displacing millions each year.

More than 122 million people are forcibly displaced globally, and for the first time, displacement is predominantly urban, with more than 60% of internally displaced persons, refugees,

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and migrants seeking shelter in cities. At the same time, 1.1 billion people worldwide reside in slums or informal settlements, where insecure housing and limited services heighten vulnerability. These overlapping pressures of rapid urban growth, large-scale displacement, and deepening informality make clear that today's urban crisis is multidimensional, cutting across planning, governance, services, and leadership. Its complexity can be understood across three interlinked dimensions.

First, inclusive planning and governance remain critically weak. Only 19% of cities across 50 countries demonstrate strong civil society participation in urban planning, highlighting widespread gaps in inclusive governance. In Asia-Pacific region, land consumption has been growing faster than population, a sign of unsustainable urban sprawl that undermines compact, connected growth. At the same time, the World Cities Report 2024 highlights that cities account for 71–76% of global CO_2 emissions from energy use, making governance reform central to climate action . Weak governance and outdated master plans leave cities unprepared to accommodate displaced and vulnerable populations, fuelling exclusion, informality, and social tension instead of fostering cohesion.

Second, housing, land, and basic services are under severe strain. Globally, 1.1 billion people live in informal settlements without secure tenure or reliable access to water, sanitation, or adequate housing. In Asia–Pacific alone, the housing investment gap exceeds USD 1.5 trillion annually, reflecting the scale of unmet needs for affordable and adequate housing. Meanwhile, the urban building sector contributes 17.5% of global greenhouse gas emissions, linking inadequate housing systems with escalating climate risks. For both displaced and host communities, these deficits perpetuate cycles of poverty and vulnerability, particularly when compounded by crises such as climate extremes or pandemics like COVID-19.

Third, local leadership is indispensable yet under-resourced. Cities generate over 80% of global GDP, yet many local governments, particularly in developing regions, suffer from severely limited financial autonomy. Despite these constraints, mayors and municipal authorities have shown remarkable potential if equipped with resources and authority. Example being- Medellín, Colombia, local leadership implemented the Metro cable - a gondola-based transit system integrated with the metro network that connects hillside informal neighbourhoods with the city centre, unlocking mobility and opportunity for marginalised communities and in Paris, municipal authorities pursued an ambitious Climate Action Plan targeting full carbon neutrality by 2050, including 100% renewable energy and expansive greening and mobility reforms. Empowering cities with fiscal autonomy, institutional capacity, and participatory governance is essential if sustainable global commitments are to translate into local resilience.

India, while distinct in its trajectory, mirrors many of these global patterns at an immense scale.The pace of urbanisation has been relatively slow, about 36% of the population lives in cities today, compared to nearly 80% in Brazil or over 50% in China. Yet, in absolute terms, India hosts one of the largest urban populations in the world of over 522 million people as of 2023[12], a figure projected to cross 600 million by 2036. This dual reality of **a slower rate, but an enormous scale,** creates a unique form of crisis. Indian cities are expanding steadily, but often without the planning, infrastructure, or governance capacity needed to accommodate such numbers.

The dimensions of this urban crisis are already starkly visible. Housing insecurity is rampant: millions live in informal settlements lacking secure tenure, basic services, and resilience to extreme heat or flooding. Environmental and infrastructural stresses converge in Indian cities, where almost the entire population is exposed to unsafe air pollution levels, while congestion, unsafe streets, and transport emissions from urban mobility add further strain.

Climate shocks like heatwaves, frequent flooding, and water stress are intensifying across major urban centres, especially where infrastructure is outdated or unplanned. Governance and data systems frequently lag, with fragmented planning and weak local capacity undermining proactive crisis management. Together, these interlinked challenges- demographic surge, housing fragility, environmental degradation, mobility risks, climate stress, and governance gaps, place Indian cities at the frontline of a pressing and compounding urban crisis.

Viewed through the same three lenses as the global context - planning and governance; housing, land and services; and local leadership, the contours of India's urban crisis sharpen.

Inclusive Planning and governance remain a foundational challenge. National urban flagship missions -Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation, Swachh Bharat Mission - Urban, Pradhan Mantri Awas Yojana (Urban) designed and implemented to respond to the existing urban gaps and emerging urban realities, are functioning under a very complex sub-national institutional and implementation framework. Existing frailties in city governance, fragmented institutions, and poor infrastructure can amplify natural hazards into disasters. Chennai's 2015 floods illustrated the urgent need for risk-sensitive urban planning and coordinated emergency preparedness.

Case Study: Chennai's 2015 Floods - Inclusive Planning and Governance[15]

In December 2015, Chennai faced one of India's worst urban floods with over 500 lives lost, 1.8 million displaced and damages up to USD 7-15 billion. The disaster reflected unchecked urbanisation, encroachment of wetlands, narrowed rivers and neglected storm water systems.

In response, Tamil Nadu launched reforms including desilting 23,000 tanks, clearing 1.4 lakh culverts, pre-positioning disaster forces and removing encroachments. By the time Cyclone Vardah struck in 2016, these measures reduced casualties and improved recovery, showing that resilient planning, ecosystem protection and coordinated governance can turn disaster into preparedness.

Figure 1- Chennai Floods, 2015 (Source- NITI Aayog)

Housing insecurity and service gaps continue to undermine urban resilience. Informal settlements provide affordable shelter but often lack tenure security, basic services, and disaster preparedness, deepening the urban crisis. Mumbai highlights how unplanned urban growth in ecologically fragile zones perpetuates vulnerability and calls for inclusive housing policies.

Case Study: Mumbai's Slum Challenge - Housing & Informality[1617]

Figure 2 -Dharavi Slum, Mumbai (Source- Jonas Bendiksen)

In Mumbai, 42% of residents live in slums squeezed onto just 9% of city land. Dharavi alone houses nearly 1 million people within 2.1 sq km, with densities above 300,000 per sq km. These settlements offer affordable shelter near work centers to its residents but have no solution for challenges like insecure tenure, poor sanitation, and disaster risks. During the 2005 floods, Dharavi and other slums along the Mithi River were among the worst hit, exposing the dangers of unplanned growth. Policies like the Slum Rehabilitation Authority (SRA) and Dharavi Redevelopment Project seeks to provide in-situ housing and upgrade basic services, yet affordability and inclusivity remain challenges. Mumbai's experience illustrates how the housing-service nexus, if inadequately addressed, perpetuates vulnerability in Mumbai

Local leadership and institutional capacity determine a city or state's ability to manage crises. Odisha's experience during the 1999 Super Cyclone demonstrates how governance gaps can intensify disaster impacts and how structured reforms and community engagement strengthen regional resilience.

Cities on the Frontline - Cities are at the frontline of the global climate and development challenge, with India exemplifying this intensity. The world will continue to urbanise rapidly, with the share of urban residents rising from 56% in 2021 to 68% by 2050. This translates into an increase of 2.2 billion urban residents, living mostly in Africa and Asia. In India, this means that the health, safety and prosperity of almost a billion people will depend on how well its cities manage the compounding risks of growth, inequality and climate disruption.

Urban areas are particularly exposed due to their density, infrastructure dependence, and economic centrality. The IPCC Sixth Assessment Report (2022) identifies South Asian cities including Delhi, Ahmedabad, Mumbai and Kolkata, among the world's most climate-vulnerable, facing intensifying heatwaves, sea-level rise, and flood risks. For India, this translates into cascading disruptions: economic losses from climate-related disasters already cost billions annually, while social impacts fall disproportionately on the poor and marginalised. The World Bank (2021) estimates that South Asia could see up to 40 million climate migrants by 2050, with unplanned urban growth acting as a major driver.

At the same time, urban crises are not only about human-induced climate change. The UNESCAP Asia-Pacific SDG Progress Report and SDG gateway highlights that the Southeast Asia Region and India as country is not fully on track to achieve SDG 11, with severe data gaps masking the real depth of vulnerability. India's National Indicator Framework (MoSPI, 2025) also showcases these gaps across SDG 11 indicators :

Case Study: Odisha's Super Cyclone, 1999 - Local Leadership & Governance[1819]

The 1999 Super Cyclone devastated Odisha, killing nearly 10,000 people and affecting over 20 million. Weak preparedness, poor coordination, and lack of early warning systems magnified the disaster. In its aftermath, the state created the Odisha State Disaster Management Authority (2000), pioneering a structured framework with cyclone shelters, community preparedness, and robust early warning. These reforms transformed Odisha into a model of resilience, with cyclones like Phailin (2013) occuring later witnessing far fewer casualties. The case study shows how governance reform and community engagement can turn tragedy into resilience.

Figure 3 - Image of Odisha after Super Cyclone 1999, (Source: INDIATV)

- Safe and Affordable Housing (SDG 11.1.1): In 2022, 71.59% of India's urban population lived in slums, informal settlements, or inadequate housing, only a marginal improvement from 73.3% in 2020.

Figure 4 - National Progress of SDG 11.1 (Safe and Affordable Housing)
Source- NIF Progress Report, 2025

- Affordable and Sustainable Transport Systems (SDG 11.2): By 2020, 89.6% of urban households had "convenient access" to public transport (11.2.1), but road accident fatalities remain high. (11.2.2) with 11.38 deaths per 100,000 population in 2021.

Figure 5 - National Progress of SDG 11.2 (Affordable and Sustainable Transport Systems)
Source- NIF Progress Report, 2025

- **Inclusive and Sustainable Urbanisation (SDG 11.3.1):** The ratio of land consumption rate to population growth rate has risen sharply in India, however, the SDG 11.3.1. datasets are insufficient and unavailable to mark the progress.
- **Reduce the Adverse Effects of Natural Disasters (SDG 11.5):** India recorded 0.4 disaster-related deaths per 100,000 population in 2021 (11.5.1) a slight decline from 0.55 in 2015. Data on economic losses (11.5.2) remains insufficient.

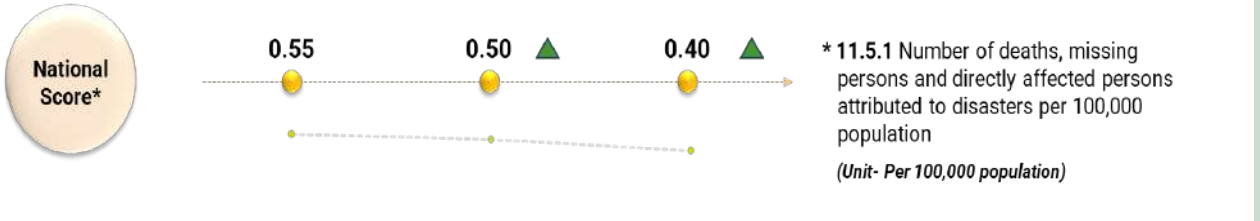


Figure 6 - National Progress of SDG 11.5.1. (Reduce the Adverse Effects of Natural Disasters)
Source- NIF Progress Report, 2025

- **Reduce the Environmental Impact of Cities (SDG 11.6.1, 11.6.2 and 11.6.3):** By 2021, 73% of municipal solid waste was processed, while 98% was collected door to door, However, air pollution remains severe, with India's annual mean PM2.5 concentration at ~75 μg/m³—over fifteen times the WHO guideline (The recommended annual PM 2.5 AQG level of μg/m³, with four interim target from- 35 μg/m³, 25 μg/m³, 15 μg/m³ and 10 μg/m³)[26].

Figure 7 - National Progress of SDG 11.6 (Reduce the Environmental Impact of Cities)
Source- NIF Progress Report, 2025

These indicators tell a stark story: India's urban crisis is not a single challenge but a web of interlocking risks. Housing deficits, climate hazards, unsafe mobility, environmental degradation, and governance gaps do not exist in isolation- they reinforce and amplify each other. Cities concentrate people, infrastructure, and economic activity, and exposure to shocks. This duality makes them the epicentre of both vulnerability and possibility.

Breaking this cycle requires moving from piecemeal recovery efforts to anticipatory resilience, integrating risk into all layers of urban development, and aligning local priorities with global commitments under SDG 11. This recognition leads us to the central question: ***what do we do to respond effectively to the urban crisis?***

Responding to Urban Crises: What Do We Do?

Despite the scale of India's urban challenges, these crises also present opportunities for transformation. Strategic investments in housing, water, sanitation, and climate-resilient infrastructure can unlock inclusive growth. To achieve this, three strategic shifts are critical.

1. Mainstream resilience into urban planning - Urban planning must move beyond a project-driven approach to platforms for resilience. India's urban housing shortage rose from approximately 18.78 million units in 2012 to 29 million in 2018 , with around 210 million people still lacking safely managed sanitation . The opportunity lies in embedding climate risk assessments, disaster preparedness, and equity safeguards into master plans, zoning regulations, and infrastructure pipelines.

Investments in affordable housing, WASH, and resilient transport can reduce vulnerabilities and generate jobs in construction, clean energy, green infrastructure, and related sectors. Frameworks like the Sendai Framework for Disaster Risk Reduction (2015–2030) and India's National Disaster Management Plan (2019) provide guidance, but municipal governments need training, financing, and data access to turn policy into action.

2. Localising the Sustainable Development Goals - The Sustainable Development Goals, particularly SDG 11 (Sustainable Cities and Communities), provide a roadmap for inclusive and resilient cities. Their power lies in localisation, where global targets become actionable benchmarks. SDG 11.1 links to slum upgrading, 11.2 to safe and low-carbon mobility, and 11.5 to preparedness for floods, heat, and storms.

National data reveal stark gaps: 71.5% of urban population live in inadequate housing (2022), road accident fatalities remain among the highest globally, land consumption exceeds population growth rate, and average PM2.5 pollution exceeds WHO norms

by fifteenfold. These deficits compound risk but also point to opportunity. Every $1 invested in WASH yields up to $4 in returns . Tools such as Urban RAASTA (Resilient & Accelerated Advancement with Sustainable & Transformative Actions) are critical here, as they translate abstract targets into diagnostics, strategies, and measurable indicators for Indian cities. In this way, global commitments become local decision-making instruments.

3. Unlock finance and partnerships for resilience - No city can respond effectively to crises without adequate resources. India will require $840 billion in urban infrastructure investment by 2036. Strengthening resilience requires blended finance, mobilising national schemes like AMRUT 2.0, PMAY, NCAP etc., together with international climate funds, municipal bonds, and private sector partnerships.

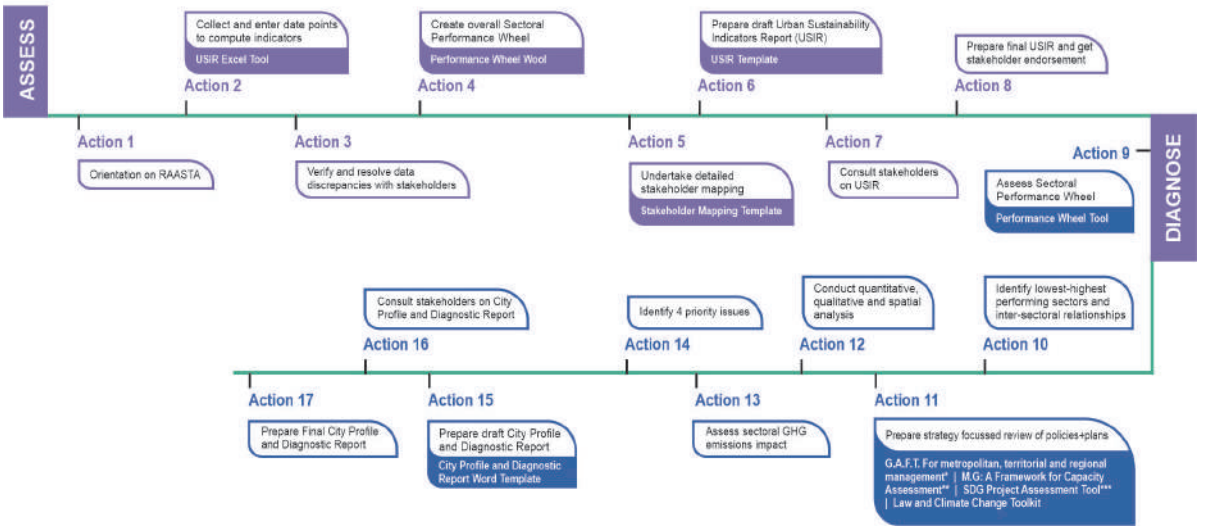
At the same time, Governance must be participatory, involving communities, youth, and civil society as partners in planning and monitoring, in line with SDG 11.3 (Global Target of- Inclusive and Sustainable Urbanisation). When effectively implemented, resilience financing can simultaneously strengthen safety nets, reduce inequality, and unlock long-term economic dividends.

4. Turning crisis into opportunity - Strategic shifts alone are insufficient, cities need tools to translate vision into action. Frameworks that integrate risk, equity, and sustainability into planning are critical. This is where the Urban RAASTA (Resilient and Accelerated Advancement with Sustainable and Transformative Actions) framework becomes critical. The Urban RAASTA framework exemplifies this approach, translating global commitments into local diagnostics and actionable strategies. It offers cities a practical pathway to move from fragmented crisis response toward systemic resilience-building.

Urban RAASTA: An Integrated Pathway for Resilient, Inclusive Urban Transformation

As Indian cities confront an evolving landscape of climate risk, unbalanced growth, and social vulnerability, the need for a comprehensive, actionable, and unifying planning framework has never been more pressing. Urban RAASTA , recognised and piloted under the aegis of the Ministry of Housing and Urban Affairs (MoHUA), offers exactly that: a pathway that embeds resilience and inclusion directly into how cities assess, plan, strategise, and invest.

Stages of Urban RAASTA



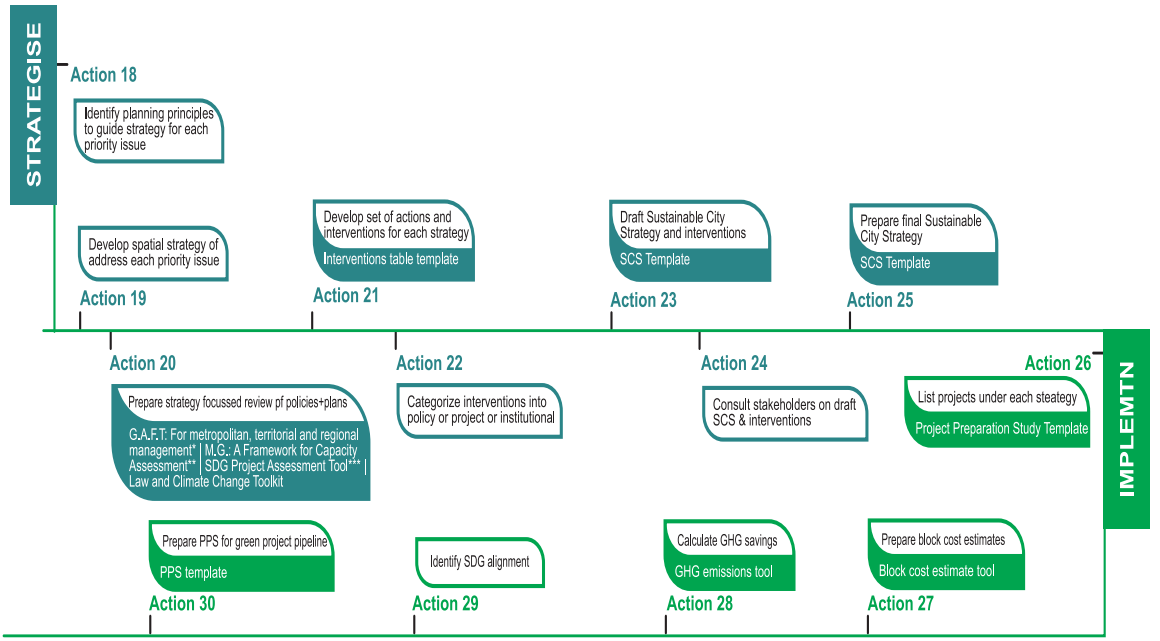


Figure 8 - Stages of Urban RAASTA

Unlike sectoral models that isolate problems, Urban RAASTA adopts an integrative approach, merging the imperatives of urban planning, affordable housing, environmental stewardship, and institutional leadership into a common lens of civic action. The framework's four-stage process - **Assessment, Diagnosis,Strategising, and Implementation**, guides municipalities from fragmented analysis to a structured investment pipeline, underscored by data-rich diagnostics and SDG-linked accountability .

1.Translating Plans into Action: Blue-Green Urbanism - Urban RAASTA has enabled cities like Jajpur and Vijayawada to reimagine master plans not as static documents, but as dynamic blue-green strategies. In Jajpur , the tool synthesised urban data and ecological analysis to prioritise waterbody restoration and reconnect green corridors, embedding heritage and low-carbon pathways into spatial policies. Vijayawada's engagement with Urban RAASTA led city planners to move beyond conventional zoning, to focusing on flood-resilient networks, integrated drainage, and green infrastructure, ensuring that post-disaster management gives way to anticipatory resilience . These cases exemplify how the RAASTA framework empowers Indian cities to translate master planning into living systems, where ecological logic is inseparable from urban growth.

Sustainable Cities Integrated Approach Project (Jajpur): The framework integrated urban data with ecological analysis to prioritise waterbody restoration, green corridor reconnection, and heritage-sensitive planning. This approach enabled the city to embed low-carbon pathways and ecological resilience directly into spatial development policies.

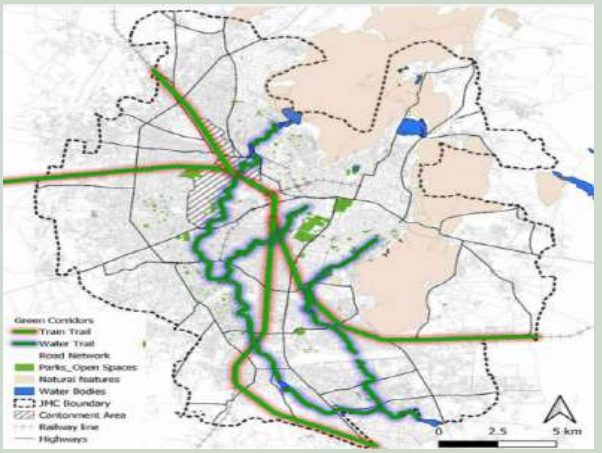


Figure 9 - Proposed eco trails across the city

Figure 10 - Proposed design with nature-based solutions for MurliPura

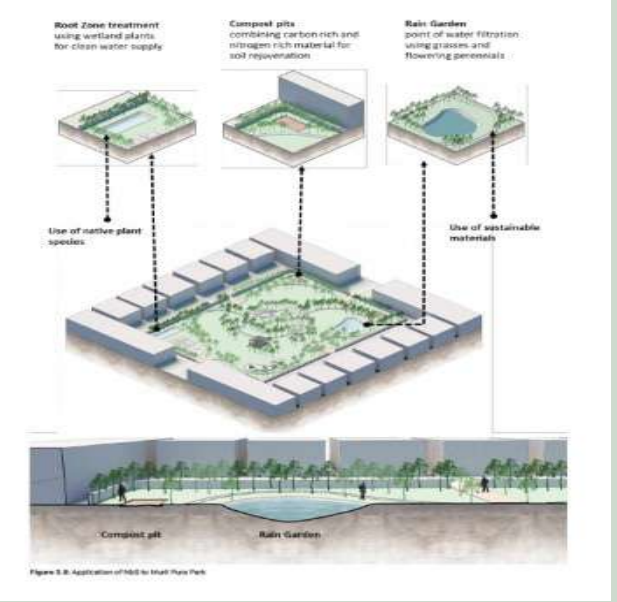


Figure 11 - Application of NBS to MurliPura Park

2. Advancing Affordable Housing and Slum Rehabilitation: Beyond Shelter - In urban India, housing interventions often struggle to rise above incrementalism. Through the RAASTA platform, cities such as Guntur and Vijayawada unlocked the capacity to link informal housing and slum rehabilitation with broader resilience goals. Using performance wheels and geospatial mapping, the framework connected vulnerabilities in informal settlements with risk factors such as heat and flooding (SDG Target 11.1). This evidence-based approach steered cities to blend housing upgrades with investments in green public spaces, walkability, and climate-adaptive infrastructure, moving beyond shelter to holistic urban improvement in line with PMAY and AMRUT priorities.

In **Guntur** and **Vijayawada**, the framework applied performance wheels and GIS mapping to connect informal housing vulnerabilities with climate risks such as flooding and urban heat (SDG Target 11.1). This evidence-based diagnosis guided investments in affordable housing upgrades, green public spaces, walkable neighbourhoods, and climate-adaptive infrastructure.

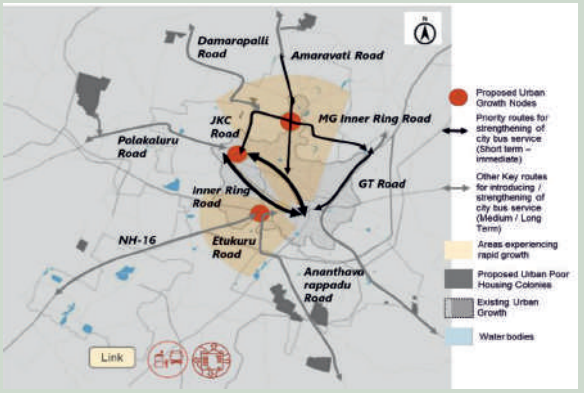


Figure 13 - Vijayawada: Slum settlements – Service Accessibility

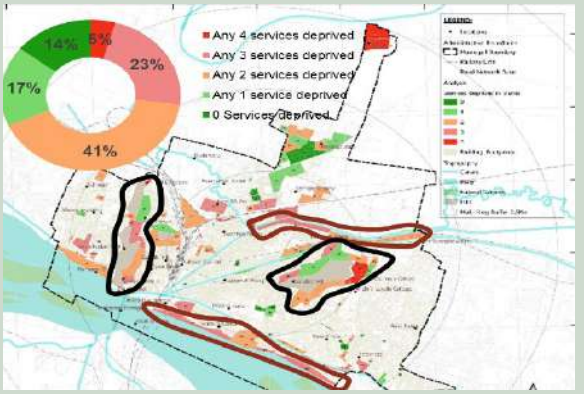


Figure 12 - Guntur: Re-densification of areas experiencing growth

By linking **PMAY (Pradhan MantriAwasYojana)** and **AMRUT (Atal Mission for Rejuvenation and Urban Transformation)** priorities with resilience outcomes, RAASTA demonstrates how housing interventions can evolve into holistic urban renewal strategies.

3. Institutional Leadership and Community-Driven Resilience - The most profound contribution of Urban RAASTA is its demonstration that resilience is as much about leadership and community engagement as it is about bricks and mortar. Across the SCIAP pilots, city mayors, commissioners, and frontline officials have led by example , championing resilience benchmarking, validating diagnostics, and rallying departments to adopt co-created strategies. Initiatives like participatory budgeting in Lucknow and Bhopal have showcased how citizens, once empowered with data and a seat at the planning table, can transform siloed interventions into a shared, accountable journey. The framework's emphasis on institutional coordination and local validation ensures that resilience is not just top-down but lived and led by the very communities it serves.

The Way Forward: From Pilots to National Scaling - In an era of compounding urban pressures, Urban RAASTA reframes crisis management as a proactive, structured, and inclusive resilience journey. It compels cities to view growth, infrastructure, environment, and equity not as competing priorities, but as deeply interconnected components of sustainable urban futures. By mainstreaming global frameworks - *the Sustainable Development Goals (SDGs), the Sendai Framework for Disaster Risk Reduction, and the Paris Agreement,* within India's local governance and policy ecosystems, the framework sets a template for bankable, measurable, and replicable action.

As climate risks intensify and urban inequities deepen, the pathway ahead is clear: **resilience must move from vision to practice**, and from pilots to scale. Endorsed and championed by MoHUA, Urban RAASTA positions Indian cities at the forefront of global urban resilience discourse, while remaining firmly grounded in local realities and community aspirations.

Pathways for Strategic Action

India's urban crisis is multi-dimensional; climate shocks, housing deficits, environmental degradation, and weak governance intersect to magnify risks. The response must shift from piecemeal crisis management to anticipatory, systemic, and inclusive resilience-building. Encouragingly, progress is already underway. National missions - PMAY(U) including ARHCs[41], AMRUT/AMRUT 2.0[42], SBM-U[43], Smart Cities Mission[44] , and NCAP[45], have created financing windows, technical standards, and delivery systems that cities can now leverage. State-level urban platforms and city dashboards are emerging as the "operating system" for transparency, data-driven decision-making, and SDG-linked accountability. Meanwhile, MoHUA's capacity-building platforms have expanded training for city leaders, planners, and engineers, accelerating the uptake of integrated urban planning practices.

Image 1- Stakeholder Validation Meetings

Building on these gains and the Urban RAASTA framework, ten strategic pathways can move cities from vulnerability to resilience:

- **Risk-Smart/Inclusive Planning & Blue–Green Systems** - Cities must integrate hazard overlays, wetlands, and floodplains into master plans to reduce exposure and safeguard vulnerable communities. Blue–green corridors and sponge-city retrofits transform streets and open spaces into buffers that absorb shocks while enhancing livability.

Global: -**UN-Habitat's City Resilience Profiling Tool:** This tool assists cities in assessing their resilience by integrating hazard overlays and promoting blue–green infrastructure, thereby enhancing urban planning and governance .

National: -**National Mission on Sustainable Habitat (NMSH):** This mission emphasises the integration of sustainable urban planning practices, including the restoration of natural habitats and the incorporation of green spaces into urban environments.

- **Resilient Homes & Essential Services** - Strengthening the housing ecosystem through in-situ upgrading, climate-safe rental housing, and design standards such as cool roofs or flood-proof plinths ensures that the most vulnerable are not left behind. Safe, affordable, and resilient services are the first line of defence against climate shocks.

Global: - World Bank's City Resilience Program: This program focuses on building resilient infrastructure, including housing and essential services, to withstand climate-induced stresses and shocks.

National: - Smart Cities Mission: This initiative aims to develop sustainable and inclusive cities by upgrading infrastructure, including housing and essential services, to improve the quality of life for urban residents.

- **Health, Mobility & Safety Nets** - Scaling Heat Action Plans[48], disaster SOPs (Standard Operating Procedures), and climate-proofing hospitals can save lives during extreme events. At the same time, shaded, universally accessible streets and robust public and non-motorised transport create safe, equitable mobility systems for all citizens.

Global: - **World Bank's Urban Resilience Framework:** This framework highlights the importance of integrating health systems, mobility infrastructure, and safety nets into urban planning to enhance resilience against various shocks.

National: - **National Urban Health Mission (NUHM):** This mission focuses on providing accessible and affordable healthcare services in urban areas, particularly for the urban poor, to improve health outcomes and resilience.

- **Finance & Institutions for Resilience** - Resilient cities require resilient financing, blending grants, climate funds, municipal bonds[49], and PPPs while improving urban local body (ULB) creditworthiness and project readiness. Building skilled city cadres ensures institutions can sustain risk-informed, resilience-focused planning and delivery.

Global: - **ADB's Urban Resilience Trust Fund (URTF):** The URTF supports projects that enhance urban resilience through financial mechanisms and institutional strengthening, focusing on physical, ecological, social, and economic resilience .

National: - **Municipal Bonds and Climate Financing in India:** The Indian government has been promoting the use of municipal bonds and other financial instruments to fund urban resilience projects, enhancing the financial capacity of urban local bodies.

- **Communities, Data & Circular Systems** -Empowering communities through ward committees and participatory planning creates ownership and accountability in resilience strategies. Coupled with open-data dashboards, resilience scorecards, and expansion of decentralised waste, water reuse, and energy-efficient systems, cities can move toward inclusive and circular urban economies.

Global: - **100 Resilient Cities (100RC) Program** focuses on building urban resilience through community engagement, data-driven decision-making, and the implementation of circular systems to address urban challenges.

National: - Atal Mission for Rejuvenation and Urban Transformation (AMRUT): AMRUT focuses on providing basic infrastructure services in cities, promoting community participation, and ensuring sustainable urban development through data-driven planning and implementation.

The implementation roadmap can be phased: Immediate steps (0–6 months) include setting up ULB-level resilience cells, rapid diagnostics, and interim guidance on high-risk zones and heat-safe work schedules. In the **short term (6–24 months),** cities must integrate risk overlays into statutory plans, roll out pipelines for housing upgrades and drainage retrofits, and operationalise dashboards with quarterly KPIs. **The medium term (2–5 years)** should focus on scaling finance, institutionalising training ecosystems, and metropolitan coordination for peri-urban and ecological management.

At the core, resilience must be mainstreamed into every investment, **housing, mobility, water, energy, or public space,** so that infrastructure doubles as protection against climate and social risks. Cities are already building momentum through MoHUA's platforms and pilots; the task now is to scale, connect, and accelerate. If India equips its local governments with finance, skills, and data, and empowers communities as co-creators, it can turn today's vulnerabilities into tomorrow's resilience pathways.

Conclusion: Navigating Crisis Towards Resilience

India stands at a decisive moment in its urban trajectory: cities are both drivers of growth and epicentres of vulnerability. The stakes are high: unmanaged urbanisation will magnify inequality, deepen climate risks, and strain governance systems. But with foresight and innovation, this same transition can become the engine of resilience and sustainable prosperity.

The Urban RAASTA pilots demonstrate that cities need not wait for disasters to act. By diagnosing vulnerabilities, aligning with SDG 11, and leveraging national missions such as PMAY(U), AMRUT, and Smart Cities, municipalities can shift from reactive crisis response to proactive resilience. Every investment, in housing, mobility, water, energy, or public space, must double as an investment in protection, equity, and sustainability. Empowered local governments, supported by data, finance, and technical capacity, and communities as co-creators, can transform India's urban risks into pathways for inclusive, resilient, and climate-ready cities.

The choice is clear: Preparedness today ensures prosperity tomorrow.

Policy Takeaway *(From Vulnerability to Resilience:* Top Moves for Decision-Makers*)*

To accelerate India's shift from crisis management to systemic resilience, policymakers must:

- **Mainstream** risk-informed planning by embedding hazard maps, climate overlays, and blue–green networks into every statutory plan.
- **Unlock** resilience financing through municipal bonds, climate funds, and PPPs while improving ULB creditworthiness and pipeline readiness.
- **Build** institutional capacity with continuous cadres of trained urban professionals and digital public infrastructure for transparent, data-driven governance.
- **Empower** communities as co-creators by institutionalising participatory planning, ward committees, and protections for vulnerable groups.

As World Habitat Day reminds us, the future of humanity is urban. Whether that future is one of escalating crises or of resilient transformation depends on the choices we make now.

Urban crisis response is not just a necessity, it is the defining opportunity of our time.

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REBOOTING URBAN RESILIENCE COMPETITIVENESS FOR CLIMATE-READY CITIES

PROF. SHALEEN SINGHAL

PRAHLAD KUMAR TEWARI

Climate Change and Urbanisation – The Interlinked Crisis

Climate change is no longer a distant environmental concern—it is a present and intensifying crisis with profound implications for ecosystems, economies, and urban societies. According to the IPCC's Sixth Assessment Report, global surface temperatures have already risen by 1.1°C above pre-industrial levels, with projections indicating a likely breach of the 1.5°C threshold within the next decade if emissions are not significantly curtailed (Figure 1). The evidence is unequivocal: atmospheric CO_2 concentrations are now the highest they've been in at least two million years, sea level rise is occurring at the fastest rate in over 3,000 years, and Arctic Sea ice extent is at its lowest in more than 1,000 years (IPCC, 2023).The Third National Communication by India to the UNFCCC confirms that the country is experiencing the full spectrum of climate impacts, including heatwaves, floods, droughts, glacier melt, and coastal erosion (PIB, 2024).

The primary drivers of climate change remain anthropogenic—fossil fuel combustion, deforestation, industrial emissions, and unsustainable consumption patterns. In India, the energy sector alone contributes over 70% of total greenhouse gas emissions, with urban areas acting as major emission hotspots (NITI Aayog, 2025). Notably, the early stages of industrialisation and urbanisation were marked by a linear economic model—extract, produce, discard—with little regard for resource efficiency or circularity. This oversight has led to massive material throughput, energy waste, and environmental degradation (World Bank, 2022; UN, 2023).

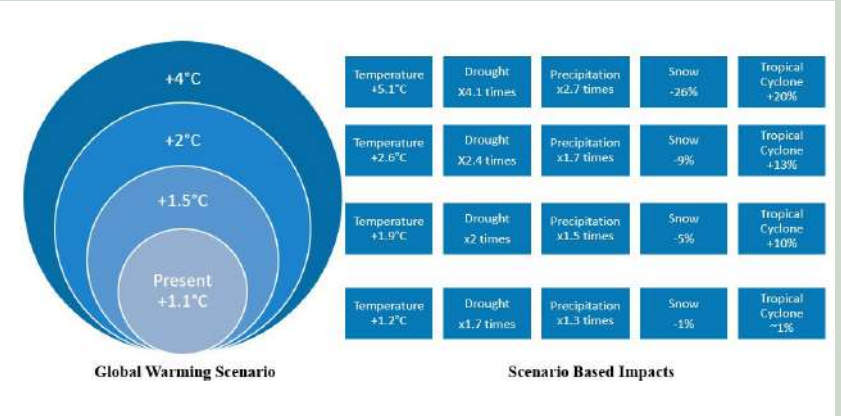

Figure 1: Worsening impact of global warming with every +0.5°C (adapted from IPCC Report, https://www.ipcc.ch/report/ar6/wg1/figures/technical-summary/ts-infographics-figure-1; and UNEP – Last Call for Climate Action: https://www.unep.org/resources/infographic/last-call-climate-action)

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Urbanisation, while a driver of economic growth, has emerged as a double-edged sword in the climate debate. India's urban population is expected to reach 600 million by 2036, placing unprecedented pressure on land, water, and infrastructure (NITI Aayog, 2025). The rise of megacities—urban agglomerations exceeding 10 million residents—has intensified emissions, congestion, and vulnerability. Cities contribute nearly 70% of global CO_2 emissions and are disproportionately exposed to climate-induced hazards such as urban flooding, heat stress, and air pollution (PIB, 2024). The air pollution, a critical urban challenge, is intricately linked to climate change. Fine particulate matter (PM2.5), largely from fossil fuel combustion and vehicular emissions, degrade air quality while accelerating warming through short-lived climate pollutants like black carbon and methane. The India Meteorological Department (IMD) and Central Pollution Control Board (CPCB) have reported increasing frequency of poor air quality days in major metropolitan cities like Delhi, with direct consequences for public health and climate resilience (CPCB2025).

Cities are not just part of the problem—they are central to the solution. Urban centers offer unique opportunities for climate action through compact planning, green infrastructure, and sustainable mobility. The adoption of resource efficiency (RE), circular economy (CE), and decarbonisation pathways can transform cities into climate resilient cities. Circular models—focused on reuse, recycling, and regenerative design—can decouple growth from resource use, reduce emissions, and enhance social well-being. The climate-urban nexus demands a paradigm shift with bold strategies, inclusive planning, and systemic reforms, cities can lead the global transition toward a low-carbon, equitable future.

Key Impacts of Climate Change on Cities

The cities in India are increasingly vulnerable to the cascading impacts of climate change. With over 35% of the population living in urban areas—and projections suggesting this will rise to nearly 50% by 2047—urban centers are facing a convergence of environmental stress, infrastructure fragility, and social inequality. Climate change amplifies these pressures, manifesting in extreme weather events, resource scarcity, and public health crises (Figure 2).

Climate-Driven Heatwaves and the Urban Heat Island Effect: Heatwaves are among the most visible and deadly manifestations of climate change in urban environments. According to the IPCC's Sixth Assessment Report and the World Meteorological Organisation, human-caused climate change has significantly increased the frequency, intensity, and duration of heatwaves since 1950. Every additional 0.5°C of global warming leads to discernible increases in extreme temperature events, with urban areas facing amplified risks due to the Urban Heat Island (UHI) effect. Heatwaves have intensified in frequency, duration, and severity across cities in India, mirroring a global trend of record-breaking temperatures. In 2025 alone, extreme heat shattered historical records worldwide. Over a 12-month period, nearly 4 billion people—roughly 49% of

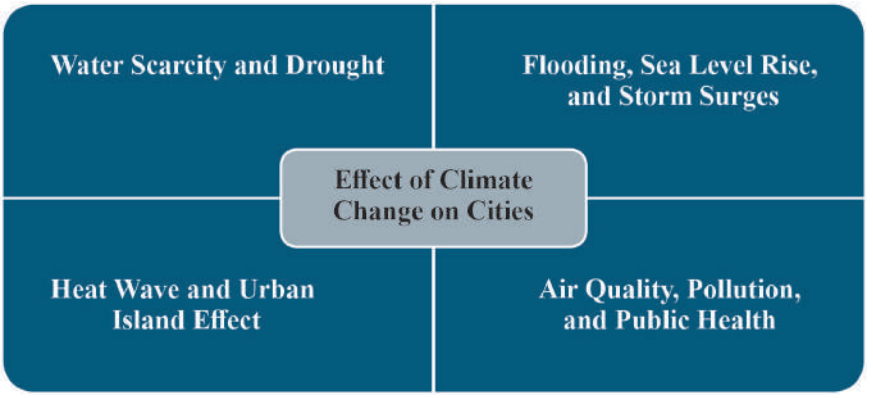

Figure 2: Key Effect of Climate Change on the Cities

the global population—experienced at least 30 additional days of extreme heat, underscoring the scale of the crisis. Scientific assessments across 195 countries and territories confirm that climate change has at least doubled the number of extreme heat days compared to a world without human-induced warming. India's experience has been particularly acute. The India Meteorological Department (IMD) reported that 2024 was the warmest year on record, with February registering the second-highest minimum temperature in 123 years and May recording the fourth-highest mean temperature ever (IMD2025). Between March and June 2024, the country endured 77 heatwave days, with severe warm nights concentrated in northern states such as Delhi, Haryana, Punjab, and Uttar Pradesh. These conditions have continued into 2025, underscoring the growing frequency and duration of extreme heat events across the region (Figure 3). This marks a sharp rise compared to previous years that indicate approximately 49 heatwave days in 2023, 43 in 2022, and 36 in 2021. The urban heat island (UHI) effect—caused by dense built environments, concrete surfaces, and lack of vegetation—exacerbates this phenomenon, making cities 3–5°C hotter than surrounding rural areas.

Prolonged exposure to high temperatures, especially those above 35°C, can rapidly escalate into life-threatening conditions. According to the National Programme on Climate Change and Human Health (NPCCHH), even short exposures of 10–20 minutes to extreme heat can impair the body's ability to cool itself, trigger heat exhaustion, and lead to organ failure. Vulnerable populations, including outdoor workers, elderly residents, and slum dwellers, face heightened risks of heatstroke and dehydration. Recognising these risks, the National Disaster Management Authority (NDMA) issued the updated guidelines for 2024, including advisories on emergency cooling, heat-health surveillance, and protection for informal workers. The Ministry of Health also directed hospitals to establish dedicated heatwave units and strengthen preparedness protocols (NDMA 2024). These measures reflect a growing institutional recognition of heat as a public health emergency and signal a shift toward proactive urban climate governance. Ahmedabad's Heat Action Plan, supported by the National Disaster Management Authority (NDMA, 2023), has become a model for other cities, integrating early warning systems, cool roof programs, and public awareness campaigns.

Urban Vulnerability to Flooding, Sea Level Rise, and Storm Surges: Climate change is intensifying

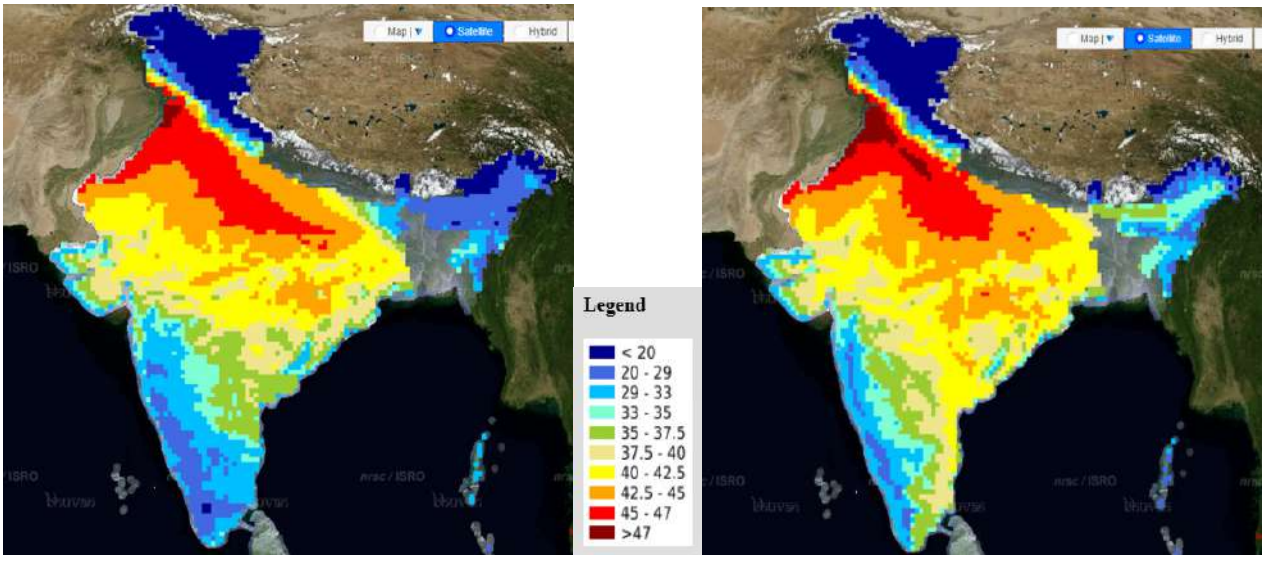

Figure 3: Heat wave condition in India during May and June of 2025 (Source:ISRO's Bhuvan Geoportal: https://bhuvan-app1.nrsc.gov.in/heatwave/)

hydrometeorological risks in urban areas, particularly through increased flooding, rising sea levels, and more frequent storm surges. According to the IPCC's Sixth Assessment Report (2021), global mean sea level has risen faster since 1900 than in any preceding century over the last 3,000 years, primarily due to thermal expansion and melting glaciers.For India, the NDMA's Urban Flood Risk Atlas (2023) identifies over 100 cities at high risk, with coastal cities facing compounded threats from sea level rise and storm surges. Urban flooding has become a seasonal crisis in cities like Mumbai, Chennai, and Bengaluru. Encroachment on wetlands, inadequate drainage, and outdated infrastructure have made urban areas highly susceptible to pluvial and fluvial flooding. Mumbai's 2005 deluge and Chennai's 2015 floods are stark reminders of the scale of urban vulnerability. Urban flooding in India has reached catastrophic proportions, with over 83 million hectares affected and 323 million people exposed to flood-related risks. In recent years, floods have damaged 64.98 million hectares of crops worth ₹88,267 crore, destroyed more than 10.5 million homes, and claimed 17,422 lives, public infrastructure losses have exceeded ₹1.49 lakh crore, underscoring the urgent need for resilient urban planning and climate-adaptive infrastructure (PIB 2023). The Maharashtra State Climate Action Plan (2024) emphasises nature-based solutions such as mangrove restoration and permeable pavements to mitigate flood risks.

Climate-Driven Drought and Urban Water Scarcity: Climate change is intensifying water stress in urban areas through altered precipitation patterns, rising temperatures, and increased evapotranspiration. According to the IPCC's Sixth Assessment Report (2021), many regions are experiencing longer and more severe droughts due to anthropogenic warming. Erratic rainfall patterns and over-extraction of groundwater have led to acute water stress in urban India. Cities like Bengaluru, Jaipur, and Hyderabad face declining aquifers and shrinking reservoirs. A significant share of urban households—estimated at over 30%—still lack access to reliable piped water, underscoring persistent service delivery gaps. Poor recycling practices and inefficient water use further aggravate scarcity. The Jal Shakti Abhiyan and AMRUT 2.0 aim to promote rainwater harvesting, wastewater reuse, and integrated water resource management(MoHUA, 2023, 2024).

Climate Change induced Rising Air Pollution, and Public Health Concerns: Climate change is increasingly recognised as a contributor to deteriorating air quality and associated public health risks in urban areas. Rising temperatures accelerate the formation of ground-level ozone and intensify particulate matter concentrations, especially during heatwaves and wildfires. According to the IPCC's Sixth Assessment Report (2021), climate change is "projected to increase ozone and PM2.5 levels in many regions," exacerbating respiratory and cardiovascular illnesses. Cities like Delhi, Kanpur, and Varanasi consistently rank among the most polluted globally. Vehicular emissions, construction dust, biomass burning, and industrial activity contribute to high levels of PM2.5 and black carbon—both harmful to health and potent climate forcers. According to the WHO estimates, air pollution contributes to over 1.8 million premature deaths annually in India, making it one of the country's most pressing public health challenges. Poor air quality exacerbates respiratory illnesses, cardiovascular diseases, and mental health disorders, especially among children and the elderly. Initiatives like the National Clean Air Programme (NCAP) and city-level air quality monitoring networks are steps toward integrated climate-health strategies.

Climate Change Risks to Urban Ecosystem

India's cities are complex ecosystems where climate risks intersect with infrastructure gaps, social inequities, and governance challenges. As climate change intensifies, several sectors of urban ecosystem namely

housing, energy, transport, waste, and public health, emerge as particularly vulnerable(Figure 4). These sectors not only bear the brunt of climate impacts but also hold the key to transformative

Over 65 million urban residents in India live in informal settlements and slums, many of which are located in hazard-prone areas such as floodplains, riverbanks, and low-lying zones (MoHUA/ NBO, 2011; NDMA, 2023). These settlements lack durable housing, sanitation, drainage, and access to health services, making them highly susceptible to floods, heatwaves, and disease outbreaks. For instance, over 40% of slum households in Delhi are exposed to recurrent flooding and waterlogging during monsoons, particularly those located near drains, riverbanks, and low-lying zones (DUSIB, 2023; Delhi SAPCC, 2023). Climate-resilient housing initiatives under PMAY-Urban and the City Investments to Innovate, Integrate and Sustain 2.0(CITIIS 2.0) Scheme aim to integrate disaster-resilient design and green building norms. The implementation of these initiatives remains uneven.

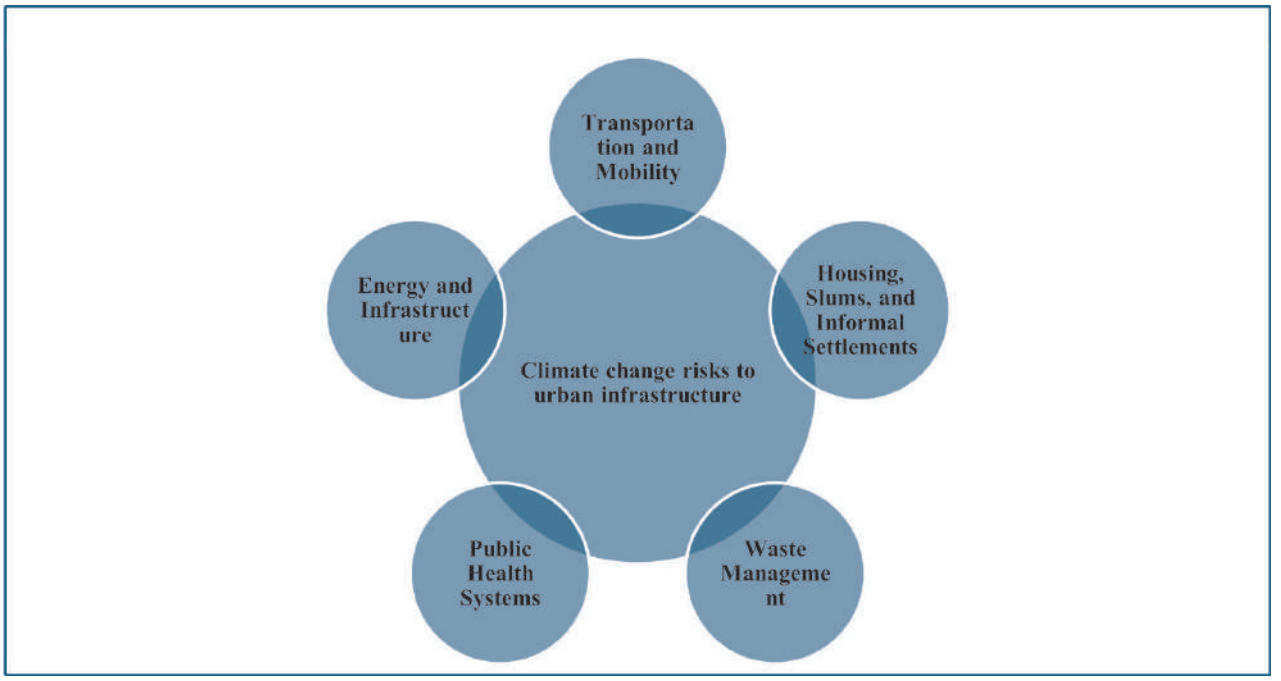

Figure 4: Key Climate Risk to Urban Infrastructure

Climate Vulnerability in Urban Housing, Slums, and Informal Settlements:

Climate Risk on Urban Energy and Infrastructure

Urban energy systems are under growing stress from rising demand and climate volatility. Cities consume over 75% of India's electricity, much of it generated from fossil fuels (NITI Aayog, 2025). Heatwaves increase peak energy demand for cooling, while floods and storms damage transmission lines and substations. Infrastructure such as roads, bridges, and drainage systems are also vulnerable to climate shocks. The State Climate Actions Plans such as State Climate Action Plan for Maharashtra, Rajasthan and Bihar emphasise the need for climate-proofing urban infrastructure through measures such as elevated roads in flood-prone areas, permeable surfaces for stormwater management, and decentralised renewable energy systems to enhance resilience and reduce emissions. Renewable energy integration, rooftop solar, and smart grids are critical to building resilience, but require financing and regulatory support.

Risk to the Transportation and Mobility: Urban transport systems are highly sensitive to climate disruptions. Flooded roads, heat-damaged rail tracks, and storm-affected airports can paralyse mobility. In Chennai, heavy rains routinely halt public transport, stranding commuters and disrupting economic activity (TN State Planning Commission, 2023). Transport is also a major

contributor to urban emissions and air pollution. According to assessments by Central Pollution Central Board (CPCB), The Energy and Resource Institute (TERI), and urban air quality models, vehicular emissions contribute up to 30% of PM2.5 levels in major Indian cities (CPCB 2022). While Ministry of Road, Transport and Highway (MoRTH's) 2024 report emphasises emission reduction strategies, these findings underscore the need for accelerated transition to cleaner transport systems. Transitioning to electric vehicles, expanding public transit, and promoting non-motorised transport are essential. The Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme and metro rail expansions are steps in the right direction.

Climate-Driven Disruptions in Urban Waste Management

India generates over 150,000 tonnes of municipal solid waste daily, much of which remains mismanaged (PIB 2023). Practices like open dumping and burning release methane and black carbon—potent short-lived climate pollutants that significantly contribute to global warming and urban air pollution Ministry of Environment, Forest and Climate Change (MoEFCC) & CPCB, 2023). Informal waste workers, who form the backbone of urban recycling, operate in hazardous conditions with minimal protection. Climate change exacerbates waste-related risks: floods spread untreated waste into water bodies, while heat accelerates decomposition and disease vectors. The Swachh Bharat Mission 2.0 and the Cities Coalition for Circularity (C-3), launched by MoHUA, promote decentralised composting, material recovery facilities, and circular economy principles. However, the integration of informal waste workers and enforcement of segregation norms remain critical gaps in achieving inclusive and effective waste management.The implementation of technological interventions such as Supervisory Control and Data Acquisition (SCADA), systems help in achieving the efficiency in water and wastewater management.

Risk to the Public Health Systems

Urban public health systems are on the frontlines of climate impacts. Rising temperatures, poor air quality, and contaminated water sources contribute to a surge in climate-sensitive diseases—heatstroke, asthma, cholera, and vector-borne illnesses. During the 2024 heatwave, over 35,000 suspected heat-related illness cases were reported across Indian cities, with informal workers and slum residents bearing the brunt of exposure due to inadequate shelter and cooling access (PIB, 2024; NPCCHH, 2024). Health infrastructure—hospitals, clinics, and emergency services—is often overwhelmed during climate disasters. Many facilities lack cooling systems, backup power, and flood-proofing. The National Health Mission and Ayushman Bharat aim to strengthen urban health systems, but climate resilience must be embedded into health policy and infrastructure design.

Rebooting City Resilience Competitiveness in a Climate-Constrained World

As climate risks intensify and urban populations swell, cities in India must transition from reactive adaptation to proactive transformation to enhance their competitiveness. The future of urban resilience competitiveness lies in reimagining cities as circular, regenerative, and inclusive ecosystems—where sustainability is embedded in every layer of planning, infrastructure, and governance. Cities across the globe are experiencing the brunt of climate change—whether through rising seas, extreme heat, or erratic rainfall. In India, urban centers are not only vulnerable but also uniquely positioned to lead climate actionand be competitive through the incentivisation of technology and innovation, inclusive policy and governance, financial support and implementation of resource efficiency and circular economy strategies (Figure 5).

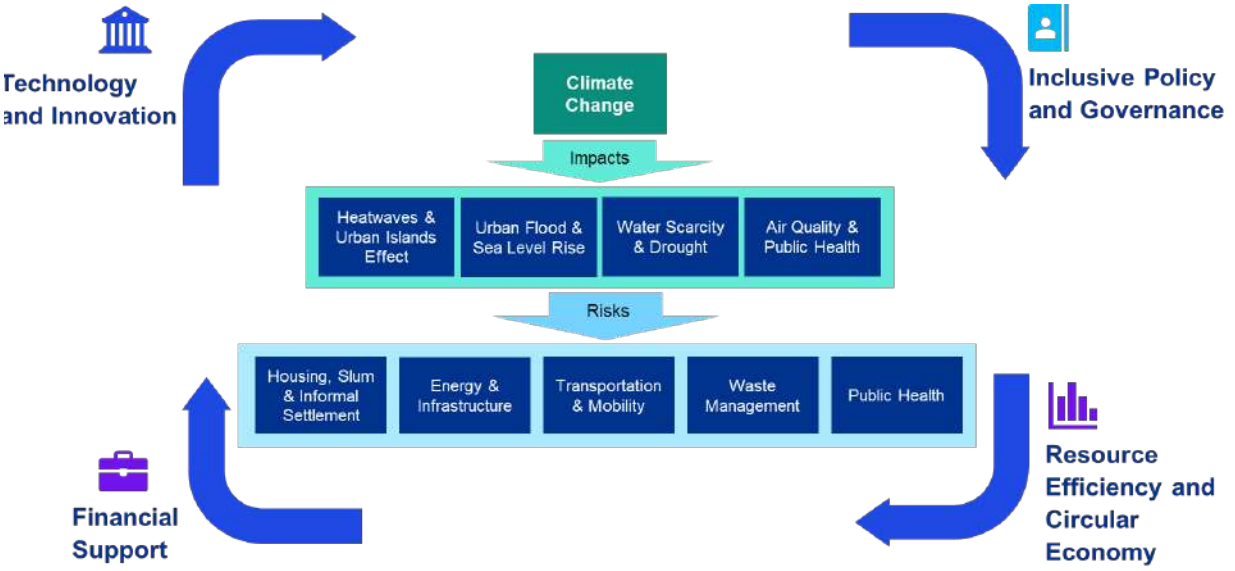

Figure 5: Strategies for Making Cities Resilient for Climate Change

Role of Technology and Innovation for Climate Resilient Cities

Technology is rapidly transforming the way cities understand, plan for, and respond to climate risks. In India, the convergence of digital infrastructure, climate data, and smart governance is opening new frontiers for urban resilience. From predictive analytics to citizen engagement platforms, innovation is no longer optional—it is foundational.

Building Smart Cities and Climate Data Integration for City Resilience

India's Smart Cities Mission (Singhal and Jain, 2020) has catalysed the integration of digital tools into urban management. Over 100 cities now operate Integrated Command and Control Centres (ICCCs), which aggregate real-time data on traffic, air quality, water supply, and emergency response (MoHUA, 2024). These platforms enable city administrators to monitor climate indicators, coordinate disaster response, and optimise resource use. The Maharashtra State Climate Action Plan (2024) identifies Mumbai as a high-risk zone for compound flooding, where high tides coincide with intense rainfall. Under the Mumbai Climate Action Plan, the city is developing nature-based solutions such as biodiversity parks, sponge zones, and green corridors to absorb excess rainwater and enhance urban resilience. Cities like Pune, Surat, and Bhubaneswar are leveraging climate data to design heat action plans, flood mitigation strategies, and green infrastructure (Singhal and Kumar, 2024). Case studiesof this interventions in India and abroad are highlighted in Table 1.

Table 1:Case Examples of Smart Cities and Climate Data Integration

Case Examples	City	Interventions
India	Mumbai	Mumbai, has developed a hyperlocal flood forecasting system integrated into the Mumbai Climate Action Plan (MCAP). It includes real-time rainfall sensors, predictive models, and citizen-sourced waterlogging data to support early warnings and targeted response
	Kochi	Kochi's Smart City initiatives include climate-responsive zoning and flood modeling using GIS and rainfall data. The city has mapped tidal flooding and sea-level rise risks to guide resilient infrastructure investments, supported by the CITIIS program.
	Bhopal	Under the Smart Cities Mission, Bhopal has developed an Integrated Command and Control Centre (ICCC) that aggregates real-time data from air quality sensors, traffic systems, and weather stations. The city uses this data to issue heat alerts, optimise traffic flow during extreme weather, and monitor pollution hotspots.

	Hyderabad	Hyderabad launched the Telangana State Climate Action Plan integrating satellite-based climate data with urban planning. The city uses remote sensing to monitor urban heat islands and flood-prone zones, feeding into its ICCC for disaster response and green infrastructure planning
Global	Barcelona	Barcelona's Urban Platform integrates climate data from IoT sensors across air quality, temperature, and energy use. The city uses predictive analytics to manage heatwaves, optimise energy consumption, and guide tree planting in vulnerable neighborhoods
	Melbourne	Melbourne's Resilient Melbourne Strategy uses climate projections and real-time data to inform urban cooling, green roofs, and water-sensitive design. The city's Urban Forest Strategy is guided by heat mapping and tree canopy analytics.
	Cape Town	Cape Town's Smart Water Management System uses climate data and consumption analytics to manage drought risk. The city's ICCC integrates rainfall forecasts, dam levels, and citizen usage patterns to trigger water-saving protocols.
	Singapore	Singapore's Smart Nation initiative includes climate-responsive urban planning using real-time data from sensors, satellite imagery, and AI models. The city's flood management system uses predictive analytics and smart drainage to prevent urban inundation.

AI, GIS, and Digital Twins for Urban Planning for Climate Resilient Cities

Advanced technologies such as Artificial Intelligence (AI), Geographic Information Systems (GIS), and digital twins are revolutionising urban planning. GIS tools help map vulnerabilities—such as heat islands, flood zones, and informal settlements—enabling targeted interventions. AI algorithms analyse climate trends, simulate risk scenarios, and optimise energy use. Digital twins—virtual replicas of urban environments—allow planners to test infrastructure performance under different climate conditions. NITI Aayog (2025) emphasises the role of digital twins in future-ready cities, especially for infrastructure stress testing and climate modeling. Recent evaluations by Zihao et al. reveal a notable disconnect in understanding how artificial intelligence can harness its data-driven capabilities to enhance urban aesthetics and planning. While AI demonstrates strong performance in technical domains, such as infrastructure optimisation, aspects like traffic flow, environmental greening, public space design, and cultural integration tend to receive lower prioritisation. This trend indicates a stakeholder inclination toward AI applications that support imaginative and transformative urban visions, rather than incremental improvements in conventional planning metrics. Many cities across globe digitised their infrastructures for real time data integrating GIS, AI to develop digital replicas for improving climate resilient and service delivery. Case examples of this interventions in India and abroad are highlighted in Table 2.

Table 2: Case Examples of Implementation of AI, GIS, and Digital Twins

Case Examples	City	Interventions
India	Kochi	Kochi is developing a Digital Twin of its urban core to simulate climate risks like flooding and heat stress. It plans to integrate satellite imagery, rainfall data, and land-use patterns to guide resilient infrastructure and zoning decisions.
	Hyderabad	Hyderabad's Climate Action Plan uses remote sensing and GIS to identify urban heat islands and flood-prone zones. These insights inform green cover expansion and stormwater infrastructure upgrades.

	Surat	Surat uses GIS-based flood modeling and real-time hydrological data to manage urban flood risks. AI-powered early warning systems feed into its Integrated Command and Control Centre, helping reduce climate-induced disruptions.
Global	Singapore	The Virtual Singapore digital twin simulates climate scenarios like sea-level rise, heatwaves, and urban flooding. It supports adaptive planning for drainage, energy use, and green infrastructure.
	Barcelona	Barcelona's smart city initiatives center on sustainable urban development, using IoT and big data to improve energy efficiency, public transportation, and mobility. A key project is the 'Sentilo' platform, which integrates a wide array of IoT sensors to deliver real-time data for city management and public services. This open-source system supports applications ranging from traffic monitoring and waste collection to air quality and noise control, enabling more responsive and efficient urban governance.
	Helsinki	Helsinki's 3D City Model integrates energy use, climate projections, and pedestrian flows to optimise zoning and reduce emissions. It supports climate-adaptive building design and green mobility planning.
	Cape Town	Cape Town's Smart Water Management System uses AI and climate data to manage drought risk. Real-time analytics on rainfall, dam levels, and consumption patterns trigger water-saving protocols.
	Rotterdam	Rotterdam's digital twin models simulate stormwater flows and flood risks in low-lying districts. AI-enhanced GIS tools guide climate-resilient design and green infrastructure investments.

Early Warning Systems for Disaster Risk Management

Early warning systems are critical to reducing disaster impacts. The India Meteorological Department (IMD, 2024) has improved forecasting accuracy for cyclones, heatwaves, and heavy rainfall, enabling timely alerts. Cities like Chennai and Mumbai have deployed flood warning systems using IoT sensors and predictive analytics to monitor water levels and drainage capacity. The National Disaster Management Authority (NDMA, 2023) promotes community-based alert systems, mobile apps, and SMS notifications to ensure vulnerable populations receive timely information. This includes Mobile apps like Sachet and Bhoomi Rashi for disaster alerts and land-related updates. SMS-based warning systems integrated with telecom providers for rapid outreach and Community-based disaster preparedness programs, especially in flood- and cyclone-prone regions, to build local response capacity. This system has been implemented in many parts of the world including Mumbai, Ahmedabad and Surat in India (Table 3).

Table 3: Case Examples of Implementations of Early Warning Systems for Disaster Risk Management

Case Examples	City	Interventions
India	Mumbai	A state-of-the-art Emergency Operations Center enables round-the-clock monitoring and rapid response, supported by Automatic Weather Stations that track real-time conditions and issue public warnings. Flow sensors placed across flood-prone zones feed into predictive models, enhancing early alerts and targeted mitigation.

	Ahmedabad	A heatwave early warning system was established, issuing graded alerts when temperatures exceeded 41°C to trigger preparedness across municipal services. The city also trained healthcare professionals to identify and treat heat-related illnesses, equipping hospitals with cooling wards and response protocols.
	Surat	After devastating floods in 2006, the city adopted a proactive resilience strategy. Supported by the Asian Development Bank and MoHUA's Smart Cities Mission, Surat developed an Integrated Flood Warning System using real-time sensors and predictive analytics.
Global	New York	Investments in green infrastructure, elevated parks, and stormwater management systems aim to reduce vulnerability. The city's ClimAID report emphasises the need for adaptive design in transportation, housing, and energy systems
	Copenhagen	After a catastrophic cloudburst in 2011, the city launched its Climate Adaptation Plan, transforming flood-prone neighborhoods into green-blue infrastructure zones. Rain gardens, permeable pavements, and elevated bike paths double as stormwater channels. The St. Kjelds neighborhood is a model of climate-responsive urban renewal, integrating resilience with aesthetics and public engagement.
	Jakarta	Jakarta's adaptation efforts include constructing sea walls, developing biopores for water absorption, and relocating coastal communities.
	Seoul	Developed storm and flood alert systems, strengthened water management infrastructure, and the creation of new urban green spaces across the city

The technology intervention adopted must be inclusive. Digital divides—based on income, gender, and geography—can limit access to life-saving information. Integrating local knowledge, ensuring multilingual platforms, and training municipal staff are essential to maximise impact. As cities grow and climate risks intensify, technology offers a powerful toolkit—but its success depends on governance, equity, and citizen engagement. Key case studies of the technological intervention implemented across globe include the following

Policy and Governance for Inclusive Urban Climate Action

Building climate-resilient cities in India demands more than technical solutions—it requires systemic governance reform and a commitment to social equity. Fragmented institutional mandates, limited fiscal autonomy, and uneven policy execution continue to hinder coordinated climate action. Urban Local Bodies (ULBs), though constitutionally empowered, often lack the authority, capacity, and resources to lead resilience efforts. Municipal functions are split across agencies, creating silos that delay integrated planning and dilute accountability. As highlighted in the World Cities Report 2024, empowering local governments with clearer mandates and climate-responsive financing is essential to unlock timely, inclusive, and place-based solutions.

Inclusive governance can democratise climate action by embedding citizen agency into urban decision-making. Citizen climate cells, participatory budgeting, and digital platforms offer scalable pathways for deeper engagement, especially when supported by institutional frameworks. The Smart Cities Mission promotes citizen involvement through Integrated Command and Control Centres (ICCCs), but the ICA-Bengaluru experience highlights that meaningful participation requires more than access—it demands trust-building, capacity development, and co-creation.

Equity and justice must be foundational to climate resilience. Vulnerable urban populations—including informal workers, migrants, and marginalised caste

groups—are disproportionately exposed to climate risks, often residing in high-hazard zones with inadequate access to essential services. Over 40% of India's urban residents live in informal settlements, many lacking piped water and drainage infrastructure (MoHUA, 2024). Women in low-income households face compounded challenges during climate events due to caregiving responsibilities and resource limitations. As highlighted in the C40 Cities report on "Powering inclusive climate action in cities", cities are on the frontlines of the climate crisis, where social and environmental vulnerabilities intersect. To achieve climate justice, urban climate strategies must embed equity across sectors—housing, health, employment, and environment—by mobilising both formal and informal governance capacities. City leaders must move beyond fragmented, sectoral approaches and adopt inclusive (Waghmare and Singhal, 2021), cross-cutting frameworks that ensure climate action benefits all residents, especially those most at risk.

The ICA pilot demonstrates that when communities are engaged through localised climate dialogues, neighborhood-level planning, and data transparency, they become active contributors to resilience strategies. However, deliberate inclusion of marginalised voices such as informal workers, women, and youth is essential to avoid reinforcing existing inequities. Initiatives like Mission LiFE and the Pro-Planet People approach aim to embed behavioral change and community participation into climate policy, but the success of three venture hinges on sustained civic partnerships and decentralised governance.

As cities move toward climate-responsive futures, inclusive governance must evolve from tokenistic consultation to transformative collaboration—where citizens are not just consulted but empowered as co-creators of urban resilience.

India's urban future must be intersectional recognising how poverty, gender, caste, and geography shape vulnerability. Long-term resilience will depend on empowering local institutions, mobilising inclusive finance, and embedding justice into every layer of urban climate governance (Table 4).

Table 4: Case Examples of Aligning Policies and Governance for Addressing Climate Change

Case Examples	City	Interventions
India	Rajkot	Rajkot aligned its local governance with national climate goals (Solar City, Smart Cities Mission), enabling integrated planning for energy efficiency and heat resilience.
	Srinagar	Srinagar strengthened its urban governance to address climate-sensitive planning in a fragile Himalayan ecosystem. Institutional reforms enabled better coordination for flood mitigation and inclusive service delivery.
	Delhi (NCT)	Delhi's participatory budgeting and ICCC integration allow real-time climate alerts and responsive service delivery. Civil society engagement ensures that vulnerable communities are included in climate planning.
Global	Durban	Durban's Municipal Climate Protection Programme embeds climate resilience into city budgeting and planning. Community consultations ensure that adaptation strategies reflect local vulnerabilities.

	Seoul	Seoul's 2050 Climate Action Plan integrates carbon neutrality goals with climate adaptation targets by using the Vulnerability Assessment Tool (VESTAP), developed by the Ministry of Environment. VESTAP evaluates exposure, sensitivity, and adaptive capacity using district-level climate and socio-economic data, and incorporates IPCC's RCP 4.5 and 8.5 scenarios.
	New York	The City faces coastal threats. Sea-level rise of up to 3.5 feet by 2080 could inundate critical infrastructure and shoreline communities. The city has responded with robust climate action plans, including the NYC Panel on Climate Change and the Climate Resiliency Design Guidelines. (NYSDEC, 2024).
	Phoenix, Arizona,	The city's Climate Action Plan also includes electrified transport, zero-waste goals, and water conservation pledges. Scientific research from the Heat Resilience and Performance Centre informs policy, making Phoenix a model for heat adaptation.
	Barcelona	Barcelona's inclusive zoning and citizen assemblies prioritize climate justice. Vulnerable groups are engaged in adaptation planning, ensuring equitable access to cooling infrastructure and green spaces.
	Los Angeles	LA's Green New Deal embeds equity into climate governance through legally binding resilience targets. Community platforms ensure that frontline neighborhoods receive priority in adaptation investments.
	Lima	Lima's legal framework for climate governance integrates climate into urban codes and mandates inclusive planning. Civil society co-produces resilience strategies, especially for flood-prone and underserved areas.

Implementation of Resource Efficiency (RE) and Circular Economy (CE) Strategies

As climate change intensifies, cities must transition from linear consumption models to regenerative systems that reduce emissions, conserve resources, and build resilience. The circular economy (CE) offers a transformative framework to decouple urban growth from resource depletion by designing out waste, extending product lifecycles, and regenerating natural systems. When paired with resource-efficient practices, CE interventions can significantly mitigate climate risks—especially in energy, construction, transport, and waste sectors.

In India, the Ministry of Housing and Urban Affairs (MoHUA, 2024) launched the Cities Coalition for Circularity (C-3) to embed CE principles across urban domains such as construction, solid waste, water management, and mobility. Cities like Indore and Pune are pioneering circular models in decentralised waste processing, green building codes, and reuse of construction and demolition waste, demonstrating scalable pathways for low-carbon urban development. Cities across globe are embracing RE and CE to tackle climate stress (Table 5).

Table 5: Cities across globe are embracing RE and CE to tackle climate stress

Case Examples	City	Interventions
India	Indore	Decentralised composting, biogas plants, and advanced recycling systems for plastics, e-waste, and construction debris. Processing over 1,000 metric tons daily of waste to energy
	Pune	Implemented zero-waste wards, local recycling loops, and green building initiatives. Around 62% of all waste collected is recycled
Global	Amsterdam	Committed to becoming fully circular by 2050, integrating CE into housing, textiles, and food systems
	San Francisco	The city is also prioritising nature-based solutions, including habitat restoration, expanded access to green spaces, and improved biodiversity. Efforts to address tree equity—particularly in underserved neighborhoods—are closely linked to community health and environmental justice outcomes
	Toronto	The city plans to introduce an emissions performance standard to cap building emissions and ensure residents benefit from decarbonisation. Stakeholders are accelerating deep energy retrofits for aging and low-quality housing to cut emissions and improve living conditions. To support this, new financial tools—such as low- or no-interest loans and sustainability-linked options—are being developed. Technologies like heat pumps and thermal storage are also being deployed to create efficient, localised energy networks that promote energy autonomy and resilience
	Copenhagen	Uses circular procurement and energy-efficient retrofitting to reduce emissions in public buildings.
	Singapore	Promotes water circularity through its NEWater program, recycling wastewater into potable supply.
	San Francisco	Achieved over 80% landfill diversion through aggressive recycling and composting mandates.

In the Indian context, resource-efficient practices such as energy-efficient building design, low-carbon materials, and urban mining are gaining traction. The GIZ-supported Urban Cooling Program and CITIIS 2.0 projects are helping cities integrate CE into climate adaptation strategies, while Mission LiFE encourages behavioral shifts toward sustainable consumption.

By aligning circular economy interventions with climate goals, cities can reduce greenhouse gas emissions, lower resource footprints, and foster inclusive green jobs. The future of urban climate resilience lies in designing cities that not only consume less—but regenerate more. Resilient cities prepare for shocks; regenerative cities go further by restoring ecological balance and enhancing community well-being. Regenerative urbanism integrates nature-based solutions—such as urban forests, biodiversity corridors, and permeable surfaces—with social infrastructure like inclusive public spaces and community-led planning. The Tamil Nadu Urban Greening Policy (2023) and Surat's Biodiversity Park under CITIIS 2.0 exemplify how Indian cities are beginning to embrace regenerative design. These models prioritise long-term health, equity, and climate stability.

Access to Climate Finance for Implementing Adaption and Mitigation Plans

Climate finance is a critical enabler for cities to mitigate and adapt to the growing impacts of climate change. Cities receive a disproportionately small share of global climate finance despite being highly vulnerable to climate impacts and central to mitigation efforts. According to UN-Habitat's World Cities Report 2024, cities are responsible for over 70% of global carbon emissions and house the majority of climate-vulnerable populations, yet they struggle to access adequate climate finance due to institutional, fiscal, and capacity constraints (UN-Habitat, 2024). In India, the challenge is particularly acute. The World Bank estimates that climate-related damages in Indian cities could reach $30 billion annually by 2070, driven by flooding, heat stress, and infrastructure failure (World Bank, 2025). However, most Urban Local Bodies (ULBs) lack the fiscal autonomy, creditworthiness, and technical capacity to access long-term, affordable finance for climate-resilient infrastructure.

Indian cities face structural barriers in accessing climate finance. Municipal functions are often fragmented across departments, and ULBs depend heavily on state and central transfers, which are not always aligned with local climate priorities. Moreover, the lack of bankable climate projects and limited capacity to navigate complex funding mechanisms further restricts access. To address these challenges, India has developed multiple pathways for climate finance. These include multilateral instruments such as the Green Climate Fund (GCF), Global Environment Facility (GEF), and Adaptation Fund, as well as national schemes like the National Adaptation Fund for Climate Change (NAFCC), Smart Cities Mission, and AMRUT 2.0. Development banks have also stepped in: the Asian Development Bank (ADB), in partnership with the Green Climate Fund, launched the India Green Finance Facility, a $200 million concessional fund aimed at supporting clean energy and resilience projects (ADB, 2024).

Bridging the climate finance gap requires a multi-pronged strategy. Blended finance models that combine public, concessional, and private capital can help de-risk investments and attract larger flows. Credit enhancement tools, such as partial guarantees and risk-sharing facilities, are essential to improve the bankability of urban climate projects. Capacity building for ULBs is equally important. Cities must be equipped to prepare climate investment plans, conduct risk assessments, and apply directly for multilateral funding. Decentralised access to finance, supported by institutional reforms and transparent governance, can empower cities to act swiftly and effectively. Programs like the India Green Finance Facility and the Climate Resilience Cities Program under the Ministry of Housing and Urban Affairs (MoHUA) are steps in the right direction, but scaling them will require stronger intergovernmental coordination and sustained political commitment (PIB, 2024; MoHUA, 2024).

Financing remains a major barrier. Indian cities rely heavily on state transfers, with own-source revenues contributing less than 0.5% of GDP (NITI Aayog, 2023). While schemes like AMRUT 2.0 and the Smart Cities Mission have introduced climate-sensitive components, funding is often short-term and project-based. Access to global climate finance is constrained by complex eligibility and weak proposal pipelines. Recent proposals for municipal green bonds and blended finance models show promise but require stronger uptake and institutional support.

Conclusion

Climate change and its association with urbanisation, identified as part of the 'grand challenges' and one of the prominent 'wicked problems', require a systemic top-down and bottom-up approach. This paper reiterates the significance of impacts and risks of climate change in context of the cities in India. The paper advocates for revisiting the approach towards enhancing the urban resilience competitiveness through impetus on technological advancement, inclusive governance, targeted

financial assistance, and emphasis on integrating and implementing resource efficiency and circular economy strategies in cities. The shift towards a newer approach calls for co-production of knowledge and its systemic operationalisation through proactive engagement of key stakeholders. The urgency to strengthen the interface between-innovation in science and technology; data driven policy and governance; and efficient practice and implementation, is vital to realise the shared goal of climate-ready cities.

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PRAGATI

PRAGATI (Pro-Active Governance And Timely Implementation) is a distinctive, integrated, and interactive platform. Developed in-house by the Prime Minister's Office (PMO) team in collaboration with the National Informatics Centre (NIC), it was officially launched on March 25, 2015. This robust system promotes e-transparency and e-accountability through real-time interaction and information exchange among key stakeholders.

The platform is designed to address public grievances while simultaneously monitoring and reviewing major programmes and projects initiated by the Government of India, as well as those flagged by State Governments. It uniquely integrates three cutting-edge technologies: digital data management, video conferencing, and geo-spatial technology.

Moreover, PRAGATI fosters a novel approach to cooperative federalism by bringing together Secretaries of the Government of India and Chief Secretaries of the States on a single platform. This enables the Prime Minister to engage in discussions with relevant Central and State officials, equipped with comprehensive information and the latest visuals depicting ground-level realities. Such an initiative is unprecedented in India and marks a significant step forward in e-governance and good governance.

Inputs by: A.K. Jain, Ex-Commissioner (Planning), Delhi Development Authority

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

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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.

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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.

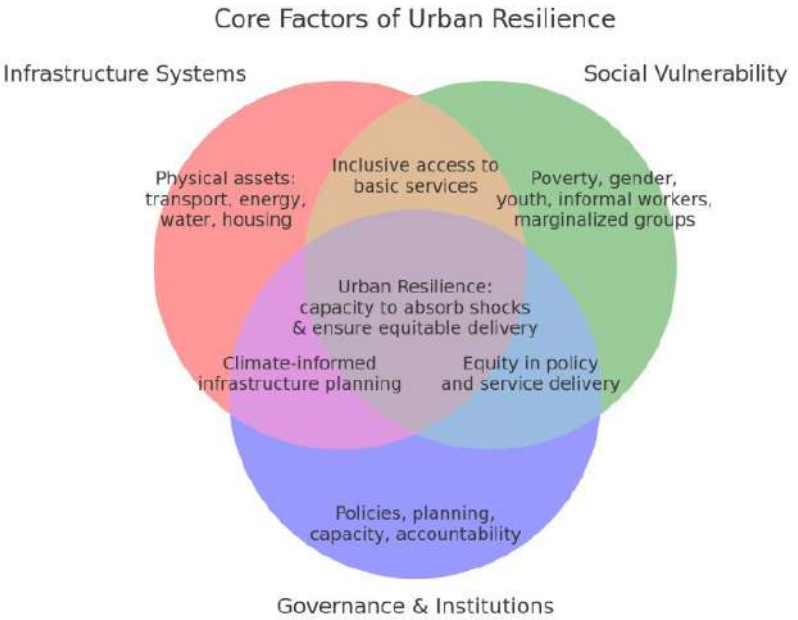
[3]The last census was held in 2011 and therefore no official figures have been provided by the Govt agencies. This data relies on projections by the UN and associated agencies.

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.

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FROM LINEAR TO CIRCULAR: STRENGTHENING URBAN RESILIENCE IN WATER, ENERGY, AND WASTE THROUGH THE 6R PRINCIPLES

NEHA LAKHWAN, SONIA GROVER AND GIRIJA K BHARAT

Cities are regarded as the growth engines of nations, as they are not only centres of innovation, economic activity, and job creation but also contribute to national GDP and productivity exponentially. Despite their economic vibrancy, cities continue to grapple with the issues of solid waste management, public hygiene, air pollution, and crumbling infrastructure underscoring the necessity for sustainable development and efficient urban management. Climate change has compounded these issues and unless ***climate adaptation, mitigation and resilience actions*** *are strengthened, the growth of these urban agglomerations will be stunted.*

Cities also have the dubious distinction of consuming 75% of global energy produced and account for approximately 70% of global greenhouse gas emissions, primarily from the burning of fossil fuels in buildings, transportation and industry. The ***greenhouse gas (GHG) emissions from wastewater systems and landfills also significantly contribute to urban air pollution,*** *alink that is often under-recognised. To close this gap, cities must design* ***integrated business models*** *that extend beyond carbon to holistically address all three sectors, maximising the use of existing resources while reducing emissions.*

This paper demonstratesthe need for integrating the 6R principle (Reduce, Reuse, Recycle, Recover, Redesign, and Restore) in city management plan through existing best practices in Indian cities.

Introduction

As per UN reports 68% of the global population is expected to live in cities by 2050 (World Urbanisation Prospects, 2018, UN DESA). India is no exception to the global urbanisation trend. As per projections, about 60% of Indians would live in cities by 2050. Cities are expected to generate up to 70% of new jobs in India, contributing about 70% t o the country's GDP and drive a near four-fold increase in per capita income by 2030.But India's urbanisation opportunity is jeopardised by severe gaps in urban public infrastructure, services, poor air quality, water contamination and scarcity to name a few. The challenge for policy makers and urban planners is to augment and improve the delivery of services through processes and programmes that limit global warming to 1.5 degree centigrade or in other words to incorporate mitigation and adaptation strategies that expand the approach from a carbon reduction limited model to a holistic one that protects air, water and material cycles together. The policy, markets, and finance have

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heavily favoured carbon mitigation in the energy sector, via emissions trading, clean energy transitions, carbon credits, and related mechanisms. These instruments have delivered momentum. But water and solid waste system scentral to public health, climate resilience, and equity—have not benefited from equivalent policy or investment (Climate Policy Initiative, 2022).This imbalance persists despite clear evidence that wastewater systems and landfills are significant and often under-recognised sources of greenhouse gases (IGSD, 2024). In India, for example, methane emissions from organic waste in landfills and untreated wastewater are increasingly identified as potent and addressable climate drivers (NIUA)

Reframing urban resilience through the 6R principles—Reduce, Reuse, Recycle, Recover, Redesign, Restore offers cities a practical path forward. This approach complements carbon action, while tying together air-quality goals, water security, and materials management. It also creates opportunities for municipal revenue, public trust, and co-benefits like flood mitigation, heat stress reduction, and enhanced public spaces (C40, 2023; UN-Habitat, 2024).

The 6R Framework in Urban Context

Continuous and increasing extraction of the natural resources is leading to their depletion and also exacerbates their scarcity concerns for the future (Ellen MacArthur Foundation, 2013). The reckless disposal ofwaste comprising of plastics, electronic waste, industrial waste, etc contaminates land, water and air which is a serious threat to environmental sustainability and urban resilience. It also leads to health issues, deteriorates quality of life and also increases vulnerability to deleterious impacts of climate change. This is mostly attributed to the linear mindset which is only focused on economic growth and has consequential environmental impacts like pollution, dwindling biodiversity and degrading urban resilience.

The concept of a circular economy is emerging as a solution which has multiple benefits including climate resilience which is promoted by minimising waste generation by maximising resource efficiency. This approach creates a balance where natural resources are conserved and waste generation is minimised (Kirchherr et al., 2017). In this approach, the products circulate within a closed- loop system which is more like waste serving as an input for other processes and products. Circular economy hinges on restorative approaches prioritising system optimisation over individual components. At its essence, the circular economy is built on diverse circular strategies, typically organised within various multi-R frameworks (Khajuria, A., & Verma, P., 2025). To enhance circularity, R strategies can be applied to various products and/ or services that can be used either independently or in combination with other "R's" (Zorpas 2024). Applying these principles helps cities minimise resource consumption, extend product lifespans, encourage innovation, and promote environmental restoration.

Six Rs Application in the Urban Context

Reduce: minimising resource use and waste generation through efficient design, optimised transportation systems and low-impact lifestyles. Cities can achieve this by implementing green buildings which reduce dependence on energy and fresh water.

Reuse: repurposing the waste into other useful purposes or products. At city scale it includes reuse of old buildings, reuse/ recycle of treated waste water.

Recycle: involves collecting and processing urban waste like plastics, metals, and organics so that these materials can be reintroduced into manufacturing and construction. Cities are setting up recycling stations etc as part of urban services to collect recyclables.

Recover: retrieving energy or resources from waste that cannot be recycled, such as through waste-to-energy plants, biogas production, or material recovery facilities.

Redesign: means rethinking products, infrastructure, and systems for greater sustainability. Using eco-friendly materials, modular construction, and circular design principles.

Table-1: 6 Rs, Circular Economy, and Climate Resilience

R Principle	Circular Economy Role	Climate Resilience Benefit
Reduce	Limits resource input/waste output	Cuts emissions, lessens stress on systems
Reuse	Extends product lifespans	Reduces demand for new materials
Recycle	Keeps materials in use	Prevents landfill, curbs pollution
Recover	Harnesses energy/resources from waste	Offsets fossil fuels, manages waste
Redesign	Innovates for sustainability	Builds resilient infrastructure
Restore	Regenerates ecosystems/resources	Improves adaptive capacity, buffers hazards

Restore: focuses on rehabilitating and enhancing urban ecosystems, including greening of public spaces, restoring wetlands, rivers, and biodiversity corridors. Restoring urban ecosystems helps to mitigate climate change impacts, improve water and air quality in cities.

These 6Rs support urban sustainability at individual and collective scale. It creates a loop where resources, spaces and infrastructure are optimally used and reused ensuring cities become resilient and liveable for future generations.Table-1 presents how these Rs play crucial role in circular economy and climate resilience.

Sectoral Applications of the 6Rs

Energy Sector: Carbon-Centric Progress

The energy sector has been the centre-piece of global and national climate policy, reflecting its direct link with fossil fuel consumption and carbon dioxide emissions. Over the past two decades, countries have invested heavily in emission reduction strategies, ranging from large-scale renewable energy deployment to improved energy efficiency in industry, buildings, and transport. Market-based mechanisms such as carbon credits, cap-and-trade systems, and emission trading schemes have created structured pathways to decarbonisation, while compliance frameworks including carbon taxes in some countries have added further pressure to reduce emissions (Winkler et al., 2025).This policy ecosystem has been reinforced by the private sector, where large energy companies, driven by both regulatory obligations and reputational pressures, have invested in innovation and efficiency. Instruments such as Clean Development Mechanisms (CDM), carbon offset markets, and voluntary carbon schemes have provided additional financing routes, attracting international investments and scaling technologies that were once considered niche (Carbon Market Watch, 2024). Simultaneously, complementary tools such as Carbon Contracts for Difference (CCfDs) and targeted subsidies have further reduced risks for early adopters of renewable and low-carbon solutions (Reuters, 2025).

However, the strength of these frameworks has also revealed an imbalance. The intense focus on the energy sector has created a narrative where carbon is often treated as the sole metric of assessing climate progress, overshadowing emissions that arise from water and waste systems. While mitigation focused energy sector reforms have generated structured markets, high visibility, and strong innovation incentives, the same progress has not been mirrored in adaptation especially in water and waste management. The other reason private investment in mitigation measures focuses on energy efficiency and clean energy. The adaptation remains poorly funded. The mitigation is seen mostly through the lens of energy and not carbon capture like forestation, nature-based solutions (NbS), etc(Climate Policy Initiative, 2024).These sectors remain fragmented, publicly managed, and under-funded, with limited market-driven momentum or financial mechanisms to encourage innovation (Climate Policy Initiative, 2024).

The contrast is striking: energy transitions are visible in falling

renewable costs and widespread adoption, while wastewater treatment and solid waste systems continue to struggle with aging infrastructure, high operational costs, and methane emissions from poorly managed landfills and untreated effluents. Without comparable policy instruments and financial incentives, water and waste remain the "silent contributors" to urban greenhouse gasescritical but often left behind in the broader climate discourse (Climate Policy Initiative, 2022).

Water Sector: Lagging Progress

Water sector holds an immense potential in circular economy; however, it's still a lagging sector and its potential has not been completely tapped. Treated wastewater represents a key resource in the sector, enabling reuse, recycling, and opportunities for resource recovery. In this regard, Decentralised Wastewater Treatment Plants (DWTPs) can help bridge the infrastructural gap created by centralised wastewater treatment plants and expanding population. Cities like Bangalore, have the largest number of decentralised treatment plants to ensure wastewater is treated and reused within the premises. These systems are increasingly vital in cities for promoting climate resilience because they offer flexibility, efficiency, local water reuse, and sustainable urban growth. Some of the advantages offered by the DWTPs for enhancing climate resilience in the cities include:

- Less vulnerability to disruption in supply chain or system failure of centralised systems during extreme weather conditions.
- Reduced dependence on infrastructure brings benefits like lower maintenance and energy demand thus lowering urban carbon footprint.

The safe reuse of treated water (SRTW) is one of the promising approaches but the scale of reuse of treated water is still very limited. This treated water has many potential end uses in cities such as construction, dust suppression, horticulture, industrial processes, flushing, etc. The sustainable management of wastewater offers an ample opportunity that align with circular economy approaches and can help build sustainable cities.

Solid Waste Sector: Untapped Potential

Among the three pillars of urban resilience - air, water, and waste, the solid waste sector holds considerable potential for climate action. According to the Ministry of Housing and Urban Affairs' report *Circular Economy in Municipal Solid & Liquid Waste*, India currently generates approximately 1.45 lakh metric tonnes of MSW per day, of which about 35% is dry waste. (SBM Urban)

When not segregated or treated in scientific ways, the organic portion decomposes anaerobically in landfills, producing methane, a greenhouse gas with much higher warming potential than carbon dioxide. The Fourth Biennial Update Report (BUR-4), summarised by NIUA, shows that the waste sector in India emitted about 76 $MtCO_2e$ in 2019, which is 226% of $MtCO_2e$ emitted in 1994. Of which, 22.69% comes from solid waste disposal. In 2020, landfills produced 912 Gg of methane from 51,527 kt of MSW, and open incineration contributed 178 Gg of CO_2(NIUA,2025).

Recasting solid waste management through a circular economy framework can help reduce reliance on landfills and unlock environmental, economic, and health benefits. Recovery of dry waste (plastics, paper, metals, glass), better segregation, composting of organics, and capturing methane from landfills are among the scientifically validated interventions. MoHUA's document underscores that dry waste recovery at a large scale could significantly raise resource recovery value (MoHUA, 2021).

In short, the solid waste sector clearly embodies the Recover, Recycle, and Redesign dimensions of the 6R framework. With enforceable policy, improved infrastructure for waste processing, and community participation, waste can shift from being a climate burden toward becoming a resource in India's climate resilience and circular economy strategy.

Case Study: Surat – Circular Economy in Action

Surat has positioned itself as a frontrunner in integrating circular economy principles into urban

service delivery, particularly in the **reuse of treated wastewater** and the **segregation and recycling of municipal solid waste**. The Surat model shows how cities can simultaneously advance sustainability, generate municipal revenues, and reduce environmental pressures.

Revenue Generation from Treated Wastewater

Surat Municipal Corporation (SMC) has set up **Tertiary Treatment Plants (TTPs)** for recycling sewage water/ waste water for industrial reuse. Together, these plants supply 115 MLD of treated wastewater daily to the Pandesara and Sachin industrial estates, thereby leading to a saving of an equivalent quantity of freshwater. This initiative generates over ₹140 crore in annual revenue, while at the same time conserving water for nearly 800,000 residents(Community Connective Cities, 2023).

Waste Segregation and Resource Recovery

SMC has scaled up **door-to-door waste collection and segregation**, supported by **Material Recovery Facilities (MRFs)** that process dry waste, reducing the dependency on landfill sites.MRF reduces the burden on landfill-site, saving on transportation/ conveyance cost while generating royalties from the sale of recyclables (Community Connective Cities, 2023). Plastic waste collection has also been integrated with Extended Producer Responsibility (EPR) programs—such as with SUMUL Dairy, which collects and recycles nearly 150,000 milk pouches daily (Community Connective Cities, 2023). The plastic is repurposed for road construction, fabric manufacturing, PET bottle to yarn conversion and some recycled plasticis converted into pellets which is sold as a raw material leading to resource optimisation and additional revenue generation.

In addition to plastics, the organic waste generated is processed into compost, fertilizers, and Bio-CNG. The bio-methanation plant at Agricultural Produce Market Committee (APMC) alone produces around 2,200 kg/day of Bio-CNG, besides organic fertilizer, creating both environmental and economic benefits (Community Connective Cities, 2023)for the area. The city also recycles construction and demolition (C&D) waste into usable building materials, further extending the circular economy approach. The dry waste is converted in to Refuse Derived Fuel (RDF) reducing dependence on alternative fuel.

Towards a Circular Economy City

Surat's integrated approach has diversified municipal revenue streams. While the **largest share comes from treated wastewater reuse**, revenues are also derived from the sale of treated waste water, compost, Bio-CNG, recycled plastic and other recyclables. Simultaneously, the city has also undertaken **urban beautification projects** using recycled materials, and reclaimed a former dumpsite into an **Ecological Park,** improving the air quality and adding to the city's green cover (Community Connective Cities, 2023).

Lessons for Replication

Surat offers replicable lessons for Indian cities:

- **Prioritise treated wastewater reuse** as a revenue stream and water conservation measure.
- **Strengthen segregation at source** to maximise recovery of plastics, organics, and C&D waste.
- **Promote decentralisation,** such as Organic Waste Converters (OWCs) run by Resident Welfare Associations (RWAs).
- **Embed circularity in procurement,** mandating the use of recycled materials.
- **Engage communities and the informal sector** to ensure ownership and long-term sustainability.

By treating wastewater as a financial resource and reimagining waste as an economic input, Surat demonstrates that circular urban models can deliver **environmental gains, fiscal stability, and resilience** beyond decarbonising the habitat.

Key Enablers and Deterrents

The key enablers for implementing the 6R framework (Reduce, Reuse, Recycle, Recover, Redesign and Restore) in the urban context in building climate-resilient cities include strong political

will, stable financial stream, participatory approach, inter-sectoral coordination, education, awareness and skill development. These elements can bring the much-needed transition in urban governance by changing the course from linear to circular economy (Prendeville, Cherim, &Bocken, 2018).

On the other hand, there are some deterrents also which impede this transition. It includes fragmented governance and regulatory approach, insufficient funding, limited public awareness, and entrenched behavioural patterns that resist change.

Key Enablers

- **Political will:** Political will plays the most important role and catalyses other enablers. City governments can endorse circular economy targets and plans which can drive the urban transformation through the 6R approach.
- **Financial Commitment:** Stable stream of funding is also important for this transformation. Funding in the form of various PPP models not only ensure public participation but also reduces risk due to private party involvement.
- **Community Participation and Engagement:** The participatory approach is vital in the environment sector; the active involvement of citizens, local organisations and grassroot movement helps drive bottom-up adoption of 6R practices while also creating a sense of ownership and belonging about the initiative amongst the local communities.
- **Capacity Building and skill development:** It is of paramount importance that there should be investment in capacity building where cities equip their residents with the knowledge, skills, and attitudes needed to make informed decisions and take actions that contribute to a healthier environment and a more sustainable future. In addition, skilled workforce is also needed that can take up designing, implementation and management of sustainable systems. The impetus should be on building of green work force.
- **Inter-sectoral coordination and Interdisciplinary Networks:** Effective coordination amongst government departments, NGOs, and private sector actors bridges the gap between disciplines and sectors, enabling co-creation and innovative solutions for circularity.
- **Young Leaders, Ecopreneurs and Front-line Champions:** Local leaders and technical experts mobilise resources and manage projects that exemplify the 6R framework in action (e.g., circular construction, waste-to-energy facilities). Start-ups should be promoted and incentivised to promote 6R strategies.
- **Policy Advocacy:** Think tanks and research organisations should be engaged in evidence-based policy advocacy and contribute to the development of effective environmental regulations, ensuring that efficient and equitable policies are upheld.
- **Awareness, Education, and Behavioural Change:** Public events, mass awareness programs are needed to facilitate the behavioural changerequired formoving towards 6R approaches and climate resilience. Well-designed curricula of circular economy at school and higher educational institutes can help foster behavioural change.
- **Formal Authorities and Legal Basis:** Legal mandates and regulations empower city governments to enforce 6R compliance in industries and public services.
- **Promoting experimental approaches** Living labs/ Incubation Centres can play a vital role in faster transition to circularity from a linear approach.

Key Deterrents

- Fragmented governance and regulatory framework without clear mandates, clearly defined roles and responsibilities can hinder the integration of the 6R framework.
- Unstable financial commitments or inconsistent budget allocations can create gaps in implementing circular practices.

- Limited awareness and public participation poses challenges and causes circularity to be kept aloof from local convention, leading to drop in adoption and thereby making these practices bereft of legitimacy or impact.
- Resistance to change among both citizens and businesses due to habit and preference for linear models could impact the transition. This is where role of incentives and education comes into picture
- Insufficient technical capacity due to limited availability of technical skills and know-how regarding circular technologies and materials across city departments poses operational barriers.

These enablers and deterrents provide a strategic roadmap for urban policymakers and practitioners aiming to leverage the 6R framework for climate resilience and circular urban economies.

6. Conclusion and Way Forward

At present, urban policy frameworks remain overly **carbon-centric**, with disproportionate emphasis on the energy sector. While carbon mitigation through renewable energy and efficiency is indispensable, such a narrow focus overlooks critical sources of emissions and vulnerabilities from wastewater systems, landfills, and degraded ecosystems. This imbalance underscores the urgency of shifting toward **integrated approaches** that treat air, water, and waste as interconnected systems. An integrated resilience strategy recognises that reducing methane from landfills, reusing treated wastewater, or restoring wetlands can be as impactful as carbon mitigation measures, while also providing co-benefit of health, livelihood, and equity.

The **way forward requires coordinated, multi-stakeholder action** anchored in governance innovation and resource efficiency. To operationalise this vision, the following policy directions are essential:

1. **Policy and regulatory support:** Strong legal frameworks and compliance mechanisms are needed to mandate segregation, promote reuse of treated wastewater, and incentivise material recovery, thereby mainstreaming the 6Rs into everyday governance.
2. **Institutional integration:** City governments should establish cross-sectoral planning mechanisms that unify energy, water, and waste management under the 6R framework. Integrated municipal policies can prevent duplication, close resource loops, and maximise co-benefits.
3. **Financing circularity:** Dedicated green finance streams, public private partnerships, and incentives for ecopreneurs must be scaled to unlock investments in circular technologies and infrastructure. Revenue models, as demonstrated by Surat's wastewater reuse, show that resource efficiency can strengthen both resilience and fiscal sustainability.
4. **Community engagement and awareness:** Citizen participation must be institutionalised through awareness campaigns, school curricula on circular economy and incentives for segregation and reuse. Social ownership is critical to sustaining behavioural change and ensuring inclusivity.
5. **Capacity development and skill enhancement:** Investments in technical training, skill-building, and knowledge networks are vital in creating a green workforce capable of designing, implementing, and maintaining circular systems across sectors.

The 6R framework for urban resilience serves as the foundation for transitioning cities away from a linear, extractive model toward a regenerative, circular pathway that simultaneously reduces vulnerabilities and enhances adaptive capacity. There is a need for cities to move towards institutionalised collaborative participatory governance that provides a clear pathway for transforming into circular, resource-efficient, and resilient economic ecosystem. Policymakers, businesses, and

citizens must jointly act to embed circularity into city management, ensuring urban systems integrate environmental protection, economic efficiency, and social equity into their core governance agenda and are prepared not only for present challenges but also for the uncertainties of the future.

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Indore Achieves IGBC Green City Platinum: A Benchmark for Sustainable Urban India

Indore has recently achieved the IGBC Green City Platinum Certification, making it the first city in Madhya Pradesh and among only three Indian cities to earn this elite recognition. The certification—awarded jointly to Indore Smart City Development Limited (ISCDL) and the Indore Municipal Corporation (IMC)—came after a rigorous six-month evaluation of multiple sustainability criteria.

Criteria evaluated included water resource management, energy efficiency, smart waste management, e-governance, green cover, and sustainable planning. Indore outperformed many peers on metrics such as cleanliness, air quality, water management and waste disposal. The award ceremony saw the Platinum certification being handed to the city's key administrators by senior officials associated with CII and IGBC.

This achievement underscores Indore's growing role as a model for sustainable urban development and green growth. It reflects strong institutional commitment, comprehensive policy interventions, and tangible progress in environmental management. With this recognition, Indore joins an exclusive lineup of Indian cities already certified at Platinum level, reinforcing its status as a benchmark for ecological governance and green infrastructure.

TOWARDS SUSTAINABLE CITIES: CHALLENGES AND POLICY PRIORITIES FOR FINANCING CLIMATE ACTION IN INDIA

SOUMYADIP CHATTOPADHYAY

Indian cities require massive investment, about 1.95 percent of GDP, for meeting climate-resilient and low-carbon infrastructure and service needs between 2021 and 2050. This paper discusses the prospects and problems of financing climate actions in Indian cities. Revenue generation from city governments' own sources is quite insignificant and use of land based financing instruments is limited. Cities depend heavily on urban schemes and grants to finance climate action plans. There are examples of cities innovatively utilising such schemes to create climate friendly housing and waste management. Yet, prioritisation of projects with short term climate mitigation prospects, absence of functional coordination among the implementing actors and inability of cities in arranging the matching contributions constrain city governments' access and utilisation of grant. This paper argues for strengthening the own source revenue generation capacity of ULBs and tapping the revenue potential of land based financing instruments. Financially empowered cities can better access scheme funds and mobilise resource through various tools including green bonds. This paper also emphasises on the preparation of climate budget to identify climate projects and to track their expenditure requirements and revenue generation prospects. Equally important is to prepare city climate plans and budgets with special focus on the people who are exposed to multiple risks.

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Introduction

India is urbanising at a fast space with it's cities becoming more vulnerable to climate change. Proliferations of diverse economic activities and increasing demand for urban infrastructure have serious environmental implications, e.g., in terms of their ecological footprint and greenhouse gas (GHG) emissions. Changes in urban landscape coupled with high population density pose threats of heat accumulation and increase in anthropogenic activity that affect crucial climate parameters like rainfall and pollution. In recent times, incidences of heat waves, floods, variations in precipitation and water stress have become more frequent in urban India. There has been deterioration in public health and greater chance of spread of diseases due to overcrowded and cramped living conditions. As per the 2021 Global Climate Risk Index, India has emerged as seventh most affected country by climate-related extreme weather events and climate change cost is estimated to be 2.8 percent of

GDP (MoHUA, 2023). Although India emits lower GHGs per capita compared to global averages, Indian cities account for two thirds of per capita emission, albeit with significant inter-city disparities (Downes and Shah, 2022). Vulnerability of the Indian cities to adverse climate risks is evident from the Cities Readiness Report 2023 that identified 21 major Indian cities including Delhi, Bengaluru, Chennai and Hyderabad heading towards zero groundwater levels. Moreover, 18 smart cities and 124 Atal Mission for Rejuvenation and Urban Transformation (AMRUT) cities are prone to high risk of flooding (MoHUA, 2023).

Existing problems of inadequate provision of urban basic services including housing, pollution and depletion of natural resources have compounded the impacts of climate change. Urban poor living in the informal settlements are hard hit by climate induced shocks in conjunction with their limited access to essential urban services. Climate change events also impact livelihood opportunities of the urban poor that are subjected to climate cycles. Further, there are large variations in the nature of climate risks faced by the cities depending on their local geography and climatic characteristics.

As part of international climate commitment, India's Nationally Determined Contributions (NDCs) placed stronger focus on building climate resilient cities. The NDCs have been updated in 2022 with commitment towards reducing emissions intensity of its GDP by 45 percent by 2030 from 2005 level, achieving about 50 percent cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030. Adoption of a set of proven low-carbon measures could potentially reduce urban emissions from buildings, transport, waste and materials for infrastructure by 89 percent in 2050 (Coalition for Urban Transitions, 2021). This also would aid India's long-term goal of becoming net-zero by 2070. Indian cities require massive investment to the tune of $2.16–2.41 trillion, equivalent to 1.95 percent of GDP, for meeting climate-resilient and low-carbon infrastructure and service needs between 2021 and 2050 (World Bank, 2025). The same investment needs is estimated to increase to 2.48 percent of GDP by 2070. Current levels of capital investment in urban infrastructure are significantly lower than future investment needs. Between 2011 and 2018, total capital expenditure in urban infrastructure is averaged at 0.6 percent of GDP (Athar et al., 2022). Against this background, the present paper discusses the prospects and problems of financing climate actions in Indian cities.

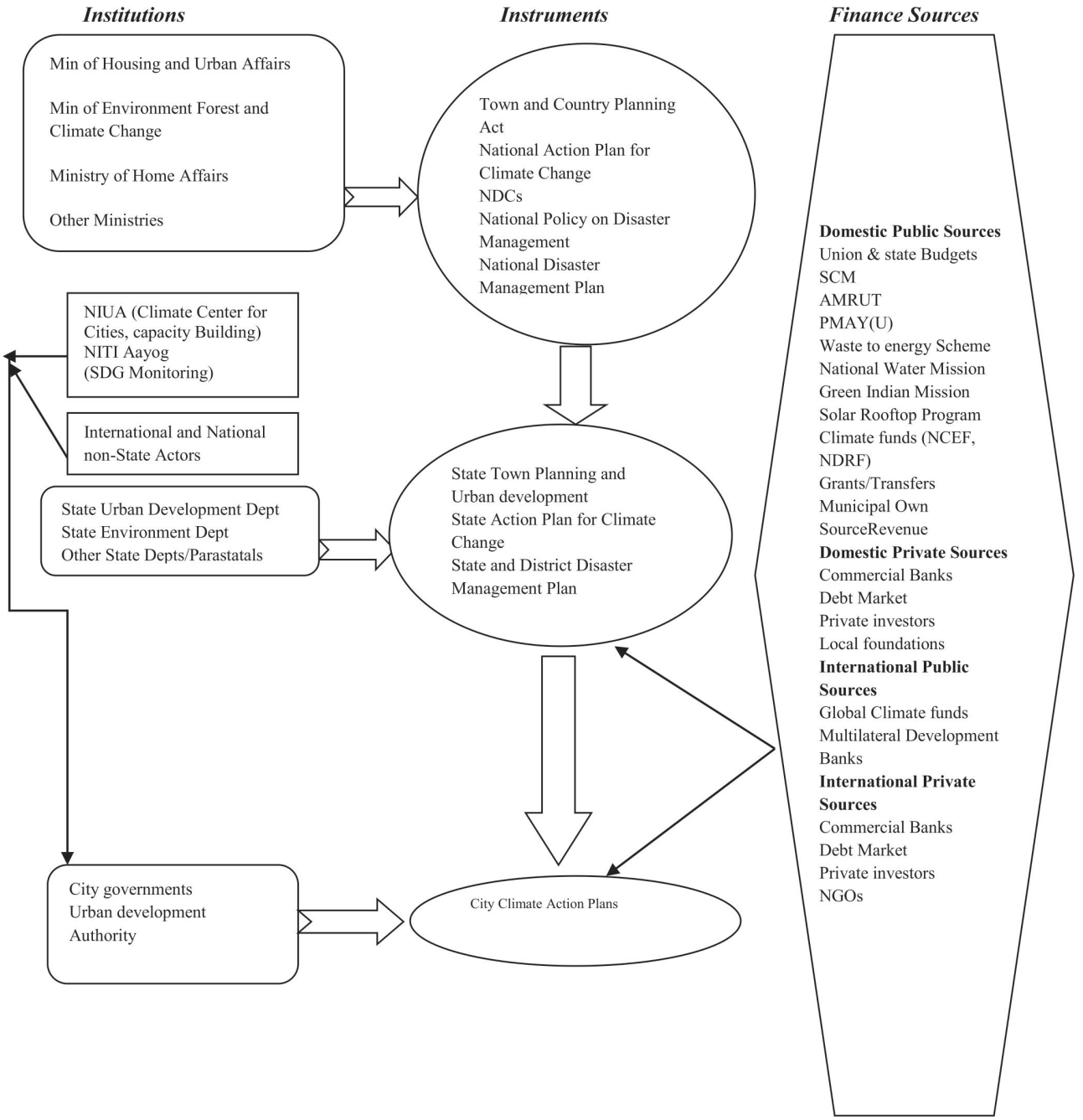
Climate Planning Architecture in Indian Cities

In India, climate planning framework is multilayered (Figure 1). National Action Plan for Climate Change (NAPCC) is implemented through eight missions aiming to balance efficient as well as innovative climate actions with the nation's development challenges. At the state level, many state governments have prepared State Action Plan for Climate Change (SAPCC) to negotiate with the contributors to and consequences of climate change. India's "Nationally Determined Contributions" (NDCs) pledge to facilitate sustainable urban development through measures likes provision of urban basic services, access to clean energy, electric mobility and so on – all of which entails climate mitigation and adaptation co-benefits. The National Mission on Sustainable Habitat (2021-2030) provides for city climate action plan in the form of annual energy audit for all urban services, integration of climate norms into urban planning, provision of public transport systemsand installation of 100 percent energy-efficient streetlights to address disparate climate risks including

heat, floods, extreme rainfall, cyclones and storm surges, water scarcity, etc. National Disaster Management Authority also provides guidelines and capacity building for issues related to urban climate change. In addition, NITI Aayog monitors the city level progress of sustainable development goals (SDGs).

Of late, the city governments have attempted to manage climate change issues through their development plans. For example, the Brihanmumbai Municipal Corporation (BMC) has prepared the Mumbai Climate Action Plan 2022 to identify the city's vulnerabilities (e.g., in terms of urban flooding, urban heat, air pollution etc.) and strategise plans to address them. The plan also provides for a 'Climate Cell' to coordinate the plan implementation. Rajkot Municipal Corporation has also prepared a Climate Resilient City Action Plan with yearly break-up of financial costs and benefits of two or three climate related projects.

Figure 1: Climate Planning and Finance Landscape in urban India



The state level parastatals and state governments' department working in the areas of environment and disaster management play a crucial role in formulation of city level climate action plans. International and national non-state actors, focused on climate change issues, also provide technical support to the city governments' climate responses. Moreover, the Ministry of Housing and Urban Affairs (MoHUA) has introduced Climate Smart Cities Assessment Frameworks to ensure consistency of city climate action plans to national priorities. The Ministry has also supported the establishment of Climate Centre for Cities (C-Cube) at the National Institute of Urban Affairs to provide advisory and technical support to prepare city-based climate action plans.The Centre liaisons with international forums, e.g., the Global Covenant of Mayors for Climate and Energy (GCoM) and the European Union (EU) to plan city specific climate solutions.

About 75 percent of the climate action plans in Indian cities are financed by the central and state governments through their multiple urban development missions and schemes while own source revenue of the cities covers 15 percent of cost of urban infrastructure (World Bank, 2025). The role of City governments is primarily limited to implementation of various central and state schemes for provision of urban infrastructure services. There are target oriented schemes like the Pradhan MantriAwasYojana (Urban) (PMAY-U) for provision of 1.12 crores houses in cities; Swachh Bharat Mission (Urban) (SBM-U) to make the cities garbage free with broad implications for climate mitigation and adaptation. Attempts have been made to integrate the local climate concerns in implementation of some of these schemes. Some city plans emphasise on the improvement of centralised water and sanitation networks or provision ofbetter solid waste management while others plan for relocation of untenable informal settlements or development of disaster warning systems. In addition, funds from private sources – domestic and international – account for a smaller proportion of urban climate finance (Figure 1). Cities can access these private funds by entering into collaborations with accredited international implementing organisations including UN agencies and development banks (MoHUA, 2025).

Imperative for Strengthening Revenue Generation

Financial sustainability of city development plan in general and climate action plans in particular depends on revenue available to meet city governments'ever expanding responsibilities. During 2007-08 to 2017-18, municipal revenue hovered around 1 per cent of GDP. In 2023-24, revenue receipts of 232 municipal corporations accounted for 0.6 percent of GDP. This is in stark contrast to the fiscal performance of cities in OECD and EU countries with municipal revenue contribution of 7.5 percent in their GDP (OECD, 2024). In 2016-17, grants/transfers from higher level of governments accounted for about 25 percent of total revenue and the corresponding percentage figures increased to about 40 percent during 2019-20 to 2023-24. Between 2020-21 and 2022-23, municipal corporations' median financial autonomy ratios (ratio of own source revenue to total revenue expenditure of municipal corporations)remained below 0.5(RBI, 2024). Inadequacy of own source revenue of more than half of the municipal corporations in financing even half of their revenue expenses seriously jeopardises the prospect of financing climate action plans on a sustainable basis.Theoretically, the "principle of subsidiarity" argues for assignment of public policy and it's implementation to the lowest level of government with the capacity to achieve the objectives. The, functional and financial empowerment of city governments can foster their accountability and responsiveness, brightening the prospect for provision of urban services in line with the climate concerns.

Property tax contributes about 64

Notes: First three time points are related to 201 municipal corporations and rests are based on 232 municipal corporations.
RE – Revised estimates
BE – Budget estimates
Source: Report on Municipal Finance RBI (2022, 2024)

percent to the own tax revenue of the municipal corporations (RBI, 2024). However, the revenue collections from property tax roughly constitute 0.15 percent of the gross domestic product (GDP) in India. This is far below the corresponding level of 3 to 4 percent contribution to GDP in case of the developed countries, like Canada and US. Urbanisation induced wealth generation can be better appropriated by using property tax in the cities. Yet, property tax remains relatively inelastic with respect to tax base and tax rate.

In India, tax bases are inaccurate and do not present a true picture without any scope for periodic updation. Valuations based on annual rental value or capital value method or unit area method does not correspond to economic benefits arising out of urbanisation. A study of 36 largest Indian cities indicates inefficient collection of property tax (Mathur, 2009). Although 88 percent properties were in the tax roll in those cities, only 63 percent of the assessed properties paid the taxes which resulted in effective coverage ratio of only 56 percent. Visibility of property tax coupled with limited prospect of inter-connecting revenue accrued and expenditure incurred at the local level reduces the acceptability of this tax amongst the local people. Consequently, property tax as a revenuegenerating tool remains grossly underutilised thereby impacting the revenue generation capacity of the cities.

Of late, Indian cities have reported positive growth of non-tax revenue, comprising of fees and user charges.However, full potential of non-tax revenue are yet to be tapped owing to lack of political will and peoples' dissatisfaction with availability of urban basic services. Sincere efforts must be put in place to emphasise appropriate pricing of urban services and to link revenue proceeds from fees to higher expenditure by ULBs thereby resulting in improvement in service delivery.

Exploring the Potentials of Land Based Finance Instruments

In general, Indian cities are experiencing prohibitive increase in land values on account of agglomeration economies, changes in government policies and improvement in provision of infrastructural facilities. Public finance theories strongly argue for leveraging urban land values to finance urban infrastructure projects. Efficiency of land taxes emanates from their non-distortionary effect on investment choices (Dye and England, 2010). Land taxes also adhere to the equity principle as it recovers a part of the unearned increase in land and property valuefrom public investment. Given the inadequacy of conventional taxing instruments and prevalence of revenue deficits at the city level, it is imperative to explore land based financing mechanisms for providing resilient urban infrastructure services.

Broadly, three categories of land based finance instruments are utilised in different cities across the world– (a) land-based taxes; (b) development financing tools and (c) land value capture methods (Vyas et al., 2020). Apart from property tax and stamp duty, land based taxes include vacant land tax and land value gain tax based on capital value of idle land held beyond a pre-specified period and gains in land values between two time points respectively. Development financing tools encompass different variants of development impact fees and contributions from the existing developers to provide infrastructural facilities required for new developments. Betterment charges, transfer of development rights and tax increment financing are bracketed under land value capture methods as these instruments aim to capitalise land value increments for supporting infrastructure development and spatial planning that lead to such increments.

In Indian cities, use of land based financing instruments for revenue generation has been limited (Ahluwalia and Mohanty, 2014). Few cities have experimented with variants of land based instruments. For example, Greater Hyderabad Municipal Corporation (GHMC) first introduced impact fees with the provision for utilisation of fees to back city decongestion plan involving road widening, construction of over bridges, flyovers, modern lighting and development of parks - all of which have direct implications

for climate action plan[1] . Many countries including USA use impact fees to raise funds for mitigating the adverse climate impacts of city development. State law in USA mandates imposition of impact fees against any new development including roadways, water treatment and distribution facilities; wastewater collection and treatment facilities; storm waterdrainage; street lighting; local parks and protection of environmental resources. In case of Mumbai, an estimated 10 percent impact fees on the cost of new construction has the potential of financing about half of the planned infrastructure development (Vyas *et al.*, 2020).

GHMC collects betterment charges for granting building permissions in order to generate funds for provisioning of internal amenities such as water supply, sewerage, drainage, roads and parks. Development charges are also imposed for any changes or development of land use/building with the mandated use of 85 percent of the proceeds for implementation of the provisionsinthe master plan. In case of development layouts violating the norms of allocating 40 percent of the total land for roads and open spaces, GHMC charges open space contribution to finance the provision of parks, greening and plantation. Rainwater harvesting charges are also imposed on new developments without any provision for rainwater harvesting. Moreover, GHMC levies a vacant land tax (VLT) at 0.5 percent of prevailing land registration values. Apart from revenue generation, the VLT also checks land speculation and promotes sustainable land use as per the spatial planning norms.

In practice, among the Indian cities, GHMC have managed to utilise a variety of land related fees and charges. The Per Capita Land Based Financing Charges (PCLBFC) at 2011-12 prices have increased from ₹ 563.29 in 2015-16 to ₹953.99 in 2019-20. Covid induced disruptions have led to fall in PCLBFC during 2021-21 to 2023-24. In 2024-25, GHMC is budgeted to collect ₹893.61 per capita from LBFC.

Other Indian cities and urban development authorities have also attempted to generate revenue from similar sources. For example, in case of Chennai, the second master plan of Chennai Metropolitan Development Authority has the provision for charging premium on additional floor space index of land plots subject to road width and escrowing the revenue for infrastructure development of the adjoining areas. Bengaluru allows a cess of 10 percent for residential buildings and 20 percent for commercial buildings against Floor Area Ratio (FAR) up to 4.0 within 500m radius on either side of the alignment of the metro route. A part of the cess proceeds is earmarked for financing growing demand of urban infrastructure from rapid urban growth. Charges for regularising unauthorised developments are commonly imposed in many Indian cities. Although these charges augment the own source revenue of the cities, but also have detrimental climate impacts as they incentivise non-adherence to planning norms through regularisation of violations of prescribed norms.

Importantly, the land-based financing mechanisms in Indian cities are constrained by two serious problems. First, majority of these instruments lack legal backing in blatant violation of constitutional mandate of 'no tax can be levied without the authority of law' and are introduced through

1. Notes: In GHMC, LBFC includes VLT, layout charges, building permit fess, development charges, betterment charges, impact fees, open space contribution, rainwater harvesting, compounding fees, building penalization charges and layout regularization charges.
2. Notes: Gross State Domestic Product (GSDP) deflator (ratio of GSDP at current to constant prices for all the time points under consideration) of Telangana is used to deflate the revenue data.

Source: Author's calculations based on year-wise GHMC budget documents

[1]In particular, GHMC uses city level infrastructure impact fees on buildings on height above 15 meter for infrastructural improvement and impact fee on commercial building on major roads leading to increased traffic flow for infrastructural development as well as decongestion plan.

government executive orders (Gandhi and Pathak, 2016). Quite often, any such impositions of charges entail legal challenges and consequently undermine their revenue generating potential[2]. Second, the effectiveness of the land based financing instruments depends on the extent to which they are used for improving urban infrastructure in general and for meeting climate objectives in particular. However, climate related spending is not being separately accounted in municipal budgets which, in turn, make tracking of climate related investments extremely difficult[3,4] .

Role of Government Schemes in Financing Climate Actions

The Climate Smart Cities Assessment Framework (CSCAS) has identified five sectors for streamlining climate informed development and these are urban planning and green cover; energy and green building; mobility and air quality; water management and waste management. Funds under different schemes are available to the state and city governments to finance sectoral activities. One mission scheme often serves multiple sectors – for example, funds under the AMRUT 2.0 can be used for all sectors except waste management. SBM 2.0 addresses the waste management related climate actions. PMAY – (U) provides fund for sustainable habitat. Some schemes – for example, Solar City Programme under the National Solar Mission contains explicit climate objectives of deployment of solar heater and photovoltaic technology in cities. During 2015 to 2022, implementation of five schemes/ projects (SBM-U, AMRUT, SCM, PMAY-U and metro rail projects) and CPWD initiatives contributed to cumulative mitigation of GHG emissions of upto 119 million tones of CO2 (MoHUA, 2025).

The implementation of different government schemes at the city level presents useful policy insights. City governments innovatively maneuver the scheme objectives to pursue climate action as per local needs (Bhradwaj and Khosla, 2020). For example, Rajkot developed low-carbon public transit using JNNURM funds in form of Bus Rapid Transit System. In case of housing, PMAY-U guidelines specify home area for beneficiaries along with subsidy amount as well as mode of financial assistances under four verticals. The city officials of Rajkot very creatively incorporated some design elements including rainwater harvesting, passive ventilation and extra shading in housing plan under PMAY-U scheme to address climate concerns. Coimbatore not only used a part of SCM funds to redevelop seven city lakes as their core strategy towards making the city water secure, but these redevelopment plans also facilitated biodiversity and sustainable housing by integrating initiatives like upgradation of public spaces, provision of cycle lanes into such plans. Acknowledging the pressing local housing needs and local capacity constraint, Rajkot city government set up adedicated cell for speedy implementation of PMAY-U. All these attest the importance of providing right incentives to the city officials for creatively incorporating climate concerns within the framework of urban schemes/projects.

However, close scrutiny of some of the project implementation processes raise policy concerns and this, in turn, constrains their replication in other cities as well as their effectiveness in addressing climate concerns. Often, in order to fast track scheme implementation, the projects with short term outputs with limited climate mitigation prospects are prioritised. For example, Coimbatore's lake restoration project focused on creation of public spaces at the cost of neglecting local concerns of biodiversity and water security which are, nonetheless, essential for mitigating long term ecological risks (Bhradwaj and Khosla, 2020).

[2]In Mumbai, the High Court ruled the imposition premium charges for additional FSI as illegal. Consequently, the state legislature amended the Maharashtra Regional and Town Planning Act to reintroduce similar charges.

[3]Surat Municipal Corporation is an exception with earmarking of ₹ 0.35 crores in line item for climate change in it's annual budget (World Bank, 2025).

[4]A study of budget documents of six Indian cities attributed only 2 to 3 percent of total spending to climate related activities (World Bank, 2025).

The climate risks in Indian cities are strongly interlinked, requiring coordinated approach across sectors. Multiple entities operate at the city level to plan and manage urban services with implications on climate mitigation and adaptation. For example, water supply project in Coimbatore is implemented by the state parastatal and the city government. However, in the absence of functional coordination, these institutions have failed to respond to local groundwater depletion problems at the cost of ensuring equitable allocation of water. In addition, low implementation capacity of the city government has led to under-utilisation of scheme funds. In case of SCM and AMRUT, cities could utilise only about one fifth of the cumulative cost of approved projects (World Bank, 2025). Creation of special purpose vehicles or engagement of private service providers in some cases have emerged as the typical policy response. Newly created institutions and their actors lack accountability and offer techno-centric solutions to climate crisis. Hardly any attempts are made to facilitate community engagement or to leverage local knowledge in the preparation of climate action plans.

All the urban schemes focus on creation of bankable projects for financing urban services in a sustainable fashion. AMRUT provides for one-third of the project cost as grant for cities with a population of above 10 lakh while for cities/towns with population up to 10 lakh, the grant amount is half of the project cost. State Governments /city governments are required to arrange balance fund through their own revenue or resorting to innovative financing mechanisms including private investment and market borrowing. City governments differ in terms of their ability to generate own source revenue and to leverage innovative sources of financing and, consequently, their ability to access and absorb funds under urban schemes. So, given significant dependence on scheme funds, smaller cities find it more difficult to plan climate actions.

The tied component of finance commission grants has gradually increased over time. Under the 15thFinance commission, the share of tied component for the urban local bodies is 72.6 percent for 2021-26 (Gupta et al., 2025). For million plus cities, the grants are fully tied with one third of the grant being linked to performance in improving city air quality while the rest is linked to achieving the Service Level Benchmarks (SLBs) in water supply, sanitation and solid waste management. There is provision of 40 percent untied grants for the non-million plus cities for addressing their urban serviceneeds. The rest of the grant is tied with half earmarked for improving sanitation and solid waste management while the other half for supporting and strengthening provision of drinking water, rainwater harvesting and water recycling. Some of the conditionalities like state notification of floor rates of property tax and constitution of State Finance Commission and Action Taken Report on its recommendation are beyond the purview of the city governments. In contrast, conditionalities, for example, in the form of regular audit of accounts and reporting of performance of SLBs are partly justified for improving the city activities. Even, this requires the city governments to plan for services for which they lack complete autonomy in planning and implementation. So, these conditionalities are likely to impact the access and utilisation of grant and this, in turn, further limits the city governments' plan for climate actions.

Mobilising Private Resources through Green Bonds

Inadequacy of public resources necessitates exploration as well as mobilisation of private resources to meet the climate goals in Indian cities. Globally, green bonds have emerged as an innovative financing mechanism to fund climate resilient development. Between 2014 and 2023, India has raised an estimated $43 billion through issuance of green bonds and the domestic power sectors accounts for 80 percent of these bonds with implications for attaining SDG 7 (clean energy) (Srinivasan et al., 2023). As per the Securities and Exchange Board of India(SEBI) regulations (2008), proceeds from the green bonds could be utilised for funding environmentally friendly projects including sustainable water and waste management, efficient

and green building, renewable and sustainable energy, public transportation, sustainable land use and biodiversity conservation. In 2022, Government of India issued two tranches of sovereign green bonds of about $2 billion to mobilise resources for green infrastructure projects aiming to decarbonise the economy.

Some of the Indian cities have experimented with green bonds to support investments in climate mitigation. Between 1997 and 2023, 14 cities and two state development authorities for 23 cities have mobilised $490 million through municipal and green bonds for augmentation of water supply projects and development of sewage treatment system (CWAS, 2024). Of late, there has been a resurgence of municipal bond market in India as about two-fifths of the bond proceeds accumulated during 2017 to 2023. This can be attributed to introduction of new SEBI regulations[5] and fiscal incentives from the central government[6] . In addition, the annual budget 2023-24 encouraged fund mobilisation via municipal bonds with special focus on green and pooled bonds. SEBI has also issued new guidelines that came into effect from 1st April 2023 comprising of revised disclosure norms required for green debt securities. Appointment of a third party reviewer is mandated to track and monitor the use of green bond proceeds for environmentally sustainable investment.

A few cities like Ghaziabad, Ahmedabad, Vadodara and Indore have issued green bonds (Table 1). Success of these cities critically depended on their strong financial performances, track record of fundraising, strong repayment structure and external technical support. For example, Indore Municipal Corporation (IMC) demonstrated continuous growth of revenue generation from non-tax sources during 2017 to 2023 supported by growth of revenue grant and assigned revenue from the state government. Utilisation of fund for development of civic amenities and infrastructure projects improved service delivery and economic performance of the IMC. In case of Ghaziabad Nagar Nigam(GNN), own source revenues (house tax, water tax and sewer tax) and grants from State Finance Commission were escrowed that resulted in a structured payment mechanism for meeting bonds repayment obligations. Ahmedabad Municipal Corporation(AMC) received technical support for listing of bonds from Merchant Bankers Tipson and State Bank of India Capital Markets. The green bond experiences of these three cities highlight the potential of municipal bonds in generating adequate climate finance that remains woefully inadequate.

Table 1: Issuances of Municipal Green Bonds

Name	Amount (in ₹ crore)	Interest	Tenure (in years)	Credit Rating	Purpose
AMC (2024)	200	7.9 %	5	AA+	Waste Management, water supply, cleaning of Sabarmati Front
GNN					
(2021)	150	8.1%	Long term	AA	Construction of tertiary sewage treatment plan
IMC					
(2023)	244	8.25%	Long term	AA+	Solar power plant

[5]SEBIRegulations 2015 defined regulatory status of municipal bond with the provisions for listing them either on BSE or NSE and continuous information disclosure as well compliance of the issuers.

[6]AMRUT 2.0 provides for financial incentives in the form of an annual lump-sum grant-in-aidfor 10 cities on first-come, first-serve reward for municipal bond issuances at a rate of ₹13 crore per ₹100 crore of bonds issued, with a ceiling of a maximum of ₹200 crore of bonds.

VMC					
(2024)	100	7.90%	5	AA+	Construction of sewage treatment plan and advanced pumping station

However, majority of the Indian cities are unable to leverage full potential of green bonds. Apart from the problem of weak financial health and lack of capacity of the city governments, non-availability of financial information and other service performance indicators constrains the municipal bond issuances. Credit rating agencies assess (a) legal and economic framework(e.g., municipal elections, city-level decision-making process, functional domain, financial powers, economic and social profile of the cities); (b) operational effectiveness and policy framework related to capacity building, reforms and orientation and (c) financial health (e.g. own source revenue generation capacity, dependence on government grants, operating revenue surplus and deficits) to rate the city governments' creditworthiness. Any rating below 'A' indicates lower credit ratings and higher default risks. Among the 500 AMRUT cities, only 36 cities have secured investment grade rating of A- and above. The, high cost of borrowing makes rest of the cities unattractive to the private investors. Overall, the success of green bonds is fundamentally linked to annual revenue surpluses and clear prioritisation of green infrastructure needs.

Conclusion

Amidst the everlooming challenge of climate change, Indian cities present opportunities for sustainable urban transformation. Quite a few Indian cities have embarked on the pathways of climate resilient urban future, necessary not only for stimulating economic growth but also to improve quality of life. Indian cities require massive investment to build low-carbon and resilient infrastructure. Strengthening own source revenue generation capacity of the cities has now become a necessity rather than a choice. The focus should be on improving the property valuation method; expanding the tax base and instilling efficiency in tax collection and management to harness the potential of Property Tax(PT) as one of the primary sources of revenue. Land based financing

instruments have immense revenue generating potential that needs to be tapped to plan and finance climate action plans. It is also indeed crucial to utilise non-tax revenue sources and attendant political resistance as well as peoples' resentment by improving delivery of urban services.

It would be then much easier for the financially empowered cities to arrange matching contributions required under urban schemes. Experiences of cities like Rajkot and Coimbatore exemplify the potential of apparently non-climate schemes like PMAY-U and SBM-U in creating climate resilient housing and waste management systems. Creativity and agency of the city bureaucracies emerged as the key enabling factors in these cities (Bhardwaj and Khosla, 2020) and efforts must be made to replicate these initiatives at a larger scale. Bigger cities should also tap the new opportunities emerging with green bonds. Preparation of climate budget must be prioritised at the city level to identify climate projects or programs with climate co-benefits and to track expenditure requirements and revenue generation prospects of such projects. Cities need institutional support for climate budgeting from the state governments. Tamil Nadu Urban Infrastructure Financial Services Ltd (TNUIFSL) has provided technical support to Coimbatore city government for preparing complex climate projects. As part of the C40 Cities Climate Leadership Group, Brihanmumbai

Municipal Corporation (BMC) has sought guidance from Oslo city government for preparing a separate climate budget[7]. Climate budgeting would support cities in fulfilling stringent requirements of validation of green projects and monitoring of bond proceeds necessary for green bond issuance. Strategic and coordinated urban climate approaches across levels of government are required to ensure that climate solutions can be sustained equitably over time. Equally important is to prepare community centric city climate plans and budgets as urban poor/ marginalised section of the city are impacted most by climate related events. Meaningful peoples' participation would facilitate data driven, evidence based climate action plans in Indian cities.

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Notes: AMC – Ahmedabad Municipal Corporation; GNN – Ghaziabad Nagar Nigam
IMC – Indore Municipal Corporationl; VMC – Vadodara Municipal Corporation
Effective interest rate is 5.9 % following the government of India's
₹ 20 crore incentives
@ GNN received ₹ 19.5 crore
Source: Author's compilation

[7] Mumbai Climate Action Plan integrates it's climate targets into city budget with aim to allocate resources for financing climate action initiatives.

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PM GatiShakti National Master Plan

The PM GatiShakti National Master Plan (PMGS-NMP) was inaugurated on 13th October 2021 to establish multimodal connectivity infrastructure across various economic zones. With an aims to improve the ease of living and doing business, reduce disruptions, and accelerate project completion while ensuring cost efficiency, PM GatiShakti represents a transformative strategy for economic growth and sustainable development, driven by seven engines of economic transformation, seamless multimodal connectivity, and logistics efficiency: Railways, Roads, Ports, Waterways, Airports, Mass Transport, and Logistics Infrastructure. All seven engines, further supported by the complementary functions of Energy Transmission, IT Communication, Bulk Water & Sewerage, and Social Infrastructure, will collectively advance the economy.

The plan has been crafted as a Digital Master Planning tool by BISAG-N (Bhaskaracharya National Institute for Space Applications and Geoinformatics) and is developed on a dynamic Geographic Information System (GIS) platform, which incorporates data on the specific action plans of all Ministries and Departments into a comprehensive database. Dynamic mapping of all infrastructure projects, with real-time updates, will be provided through a map created by BISAG-N. This map will utilize open-source technologies and will be securely hosted on MEGHRAJ, the cloud service of the Government of India. It will leverage satellite imagery from ISRO and base maps from the Survey of India. The extensive database of ongoing and future projects from various Ministries has been integrated with over 200 GIS layers, thereby enhancing the planning, design, and execution of infrastructure projects with a unified vision.

Inputs by: A.K. Jain, Ex-Commissioner (Planning), Delhi Development Authority

CRISIS IN URBAN INDIA: THE ROAD AHEAD

DR KULWANT SINGH

Thirty years ago in 1995 only about a quarter of India's population lived in cities, yet the challenges of housing, infrastructure, and basic services were already pressing. Today, more than 36% of Indians now live in cities, and by 2050 this share will exceed 50%. Cities generate nearly two-thirds of national GDP, making them vital to India's development trajectory. Yet, the core concerns identified in 1995 remain relevant—housing shortages, inadequate services, weak governance—now overlaid with new challenges of environmental stress and climate change.

Progress Made, Gaps Persist

Much progress has been achieved. Housing programmes such as Pradhan Mantri Awas Yojana–Urban has delivered millions of units. Sanitation coverage has improved under Swachh Bharat Mission–Urban. Metro systems, digital governance platforms, and the Smart Cities Mission have reshaped urban infrastructure and service delivery. Awareness of sustainability has grown, reflected in green building codes, renewable energy initiatives, and circular economy pilots.

Yet, the gaps remain stark. Informal settlements still house a significant share of urban residents. Water scarcity, untreated wastewater, and overflowing landfills continue to undermine public health. Urban local bodies remain financially and institutionally weak despite three decades since the 74th Constitutional Amendment. And climate risks—heatwaves, droughts, and floods—now magnify existing vulnerabilities.

The Sustainability Imperative

The adoption of the Sustainable Development Goals (SDGs) in 2015 has provided a global framework for action, with SDG 11—"Make cities inclusive, safe, resilient, and sustainable". For India, this goal is not aspirational; it is essential. Without resilient and sustainable cities, the national development agenda cannot succeed. The coming decade must therefore prioritise:

Integrated planning that links housing, mobility, environment, and livelihoods. Affordable and green housing that meets diverse needs while reducing ecological footprints. Strengthened local governments with real financial autonomy and capacity. Climate resilience built into urban design, infrastructure, and community preparedness. Citizen participation to make urban development inclusive and accountable.

India's urbanisation has been accelerating but national and state policies are yet to fully grapple with its implications. In 1991, only about 25% of India's population lived in cities. Today, as we mark World Habitat Day 2025, the figure has crossed 36%, with projections suggesting that by 2050, more than half of India's population will live in urban areas (1). Cities have become the engines of growth,

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contributing more than 65% of GDP (2), but they are also the arenas where multiple crises—old and new—intersect. The pressing challenges across themes such as housing and shelter, provision of urban services, basic services for the urban poor, finance for urban development, urban land development, urban planning and management, and institutional development.

In Urban India, it is important to review what has changed, what has persisted, and what lies ahead in the pursuit of resilient and sustainable urban development, particularly in the context of the Sustainable Development Goals (SDGs), and most importantly SDG 11 on "Sustainable Cities and Communities."

The Shifting Landscape of Urbanization

The last three decades have seen profound changes in India's urban trajectory:

- **Demographic and Spatial Growth:** India has added nearly 250 million new urban residents since 1995. Metropolitan cities have expanded into mega-urban regions, while small and medium towns have grown rapidly, often without adequate planning. Peripheral growth around cities such as Delhi, Bengaluru, and Hyderabad has transformed rural hinterlands into urban sprawl (3).
- **Economic Transformation:** Urban India has become a hub of innovation, services, and manufacturing. Information technology, financial services, and new digital economies have flourished in cities, even as traditional manufacturing belts struggle with pollution and infrastructure deficits (4).
- **Migration and Informality:** Migration from rural areas continues to shape urban demography. However, much of this growth has been absorbed into the informal sector, both in employment and in housing, leading to persistent challenges of slums, informality, and exclusion (5).

Housing and Shelter: Persistent Shortages, New Approaches

In 1990s, housing shortages were already acute, particularly for the urban poor. Three decades later, the demand-supply gap persists, though the policy framework has evolved considerably.

- **From Sites-and-Services to PMAY-Urban:** Earlier strategies such as sites-and-services schemes have been supplemented and, in some cases, replaced by initiatives like Pradhan Mantri Awas Yojana–Urban (PMAY-U), launched in 2015, which has sanctioned over 12 million houses(6). Yet, issues of affordability, location, and quality remain.
- **Growth of Informal Settlements:** Slums continue to house a significant proportion of the urban population. While slum improvement and in-situ rehabilitation have gained traction, tenure insecurity and inadequate financing have limited their success (7).
- **Future Directions:** Moving forward, affordable rental housing, cooperative models, and sustainable construction technologies will be critical to meet the diverse needs of urban residents while reducing ecological footprints (8).

Infrastructure and Basic Services: Expanding Access, Uneven Outcomes

Access to urban services has improved since 1995, but progress has been uneven and sustainability remains a concern.

- **Water and Sanitation:** Urban water supply coverage has expanded, but many cities face chronic shortages due to groundwater depletion, leakages, and climate variability (9). Sanitation has improved under Swachh Bharat Mission–Urban, but wastewater treatment capacity lags far behind, with most sewage still untreated (10).
- **Solid Waste Management:** From near neglect earlier, solid waste management has become a national priority, with segregation, recycling, and waste-to-energy projects being promoted. However, most cities still struggle with open dumping and landfill overflows (11).
- **Urban Transport:** Metro rail networks have transformed mobility in several metros,

yet most medium and small towns lack reliable public transport. The growing dominance of private vehicles has worsened congestion and air pollution (12).

- **Energy:** Urban electrification is now near universal, but high reliance on coal and fossil fuels undermines sustainability. Initiatives on rooftop solar, energy efficiency, and electric mobility are promising but remain nascent (13).

Finance, Governance, and Institutions: Experiments in Decentralization

The 74th Constitutional Amendmentlaid the groundwork for democratic decentralisation, but its effective implementation has been uneven.

- **Finance:** Urban local bodies remain financially constrained, with limited revenue autonomy. Central schemes such as Smart Cities Mission and AMRUT have provided resources, but dependence on state and central transfers persists (14). Municipal bonds and PPPs have made a modest beginning, yet scale and consistency are lacking (15).
- **Governance:** While city governments have taken on new roles in planning and service delivery, overlapping jurisdictions, weak capacity, and inadequate accountability hinder outcomes (16).
- **Institutional Innovations:** The past three decades have seen experiments in urban renewal missions, special purpose vehicles, and technology-enabled governance. These have improved service delivery in pockets but have not always ensured inclusiveness (17).

Environmental Pressures and Climate Change

There has been growing awareness of environmental sustainability and climate resilience over time.

- **Air and Water Pollution:** Indian cities rank among the most polluted countries in the world (18). Despite stronger regulations, vehicular emissions, construction dust, and industrial discharge continue to degrade air and water quality.
- **Climate Vulnerability:** Cities are increasingly exposed to climate-induced disasters—flooding in Mumbai, Chennai, and Bengaluru; droughts in Hyderabad and Jaipur; and deadly heatwaves across northern India (19). Unplanned expansion into wetlands, riverbeds, and floodplains have amplified risks (20).
- **Sustainability Agenda:** Green building codes, renewable energy promotion, and nature-based solutions such as urban forests and wetland restoration are emerging responses, but scaling them up remains an urgent priority (21).

From Crisis to Resilience: Aligning with SDG 11

The adoption of the 2030 Agenda and the SDGs has provided a new framework for urban development. SDG 11—"Make cities inclusive, safe, resilient, and sustainable"—resonates strongly with India's current challenges (22).

- **Inclusiveness:** Ensuring affordable housing, equitable services, and opportunities for marginalised groups.
- **Safety:** Addressing vulnerabilities to disasters, crime, and public health emergencies.
- **Resilience:** Enhancing adaptive capacities of cities to climate risks, through resilient infrastructure, early warning systems, and community preparedness.
- **Sustainability:** Reducing ecological footprints by promoting energy efficiency, circular economy practices, and sustainable mobility.

The Road Ahead: Towards Sustainable Urban Futures

As India enters the next phase of urbanisation, the challenge is no longer simply one of crisis management. It is about steering urban growth toward resilience and sustainability. Several priorities emerge:

1. **Integrated Urban Planning:** Move away from sectoral silos to holistic planning that integrates housing, mobility, environment, and livelihoods.
2. **Strengthening Local Governments:** Enhance financial autonomy, capacity, and accountability of urban local bodies.
3. **Affordable and Green Housing:** Promote housing that is not only affordable but

also resource-efficient and climate-responsive.

4. **Smart and Sustainable Infrastructure:** Focus on universal access to water, sanitation, transport, and energy, leveraging both technology and community participation.
5. **Climate-Resilient Cities:** Embed resilience in city master plans, adopt nature-based solutions, and mainstream disaster risk reduction.
6. **People-Centric Development:** Involve citizens, communities, and civil society organisations in planning, monitoring, and implementation.

Conclusion

Many of the challenges including unplanned urbanisation have added new dimensions in urban crisis like climate change, environmental stress, and global sustainability commitments and have made the agenda even more urgent.We need to actively build resilience and sustainability into the DNA of Indian cities.

The question today is not whether India can urbanise—this is inevitable—but whether it can do so in a manner that is inclusive, resilient, and sustainable. Aligning national and local policies with the SDGs, particularly SDG 11, provides a valuable roadmap.

The stakes could not be higher. India's urban future will determine the country's overall development trajectory. If managed well, our cities can become engines of prosperity, inclusion, and climate resilience. If neglected, they risk becoming epicentres of inequality, environmental degradation, and vulnerability.

If India succeeds, its cities will not only overcome crisis but also emerge as beacons of sustainable urban futures. If it fails, the costs—in human, economic, and environmental terms—will be immense. The next decade will be decisive.

On this World Habitat Day, let us reaffirm the commitment to transform India's cities into spaces of dignity, opportunity, and sustainability—for present and future generations alike

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REBUILDING LIVES WITH DIGNITY: A CASE STUDY OF INCLUSIVE SANITATION AND LIVELIHOOD SOLUTIONS IN NAYA BAZAAR LEPROSY COLONY, ROURKELA, ODISHA

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In Rourkela's industrial landscape, the Naya Bazaar Leprosy Colony has long faced isolation, poor infrastructure, and persistent stigma. This case study highlights a transformative initiative by CURE, Tata Trusts, and the Rourkela Municipal Corporation, which empowered residents to co-create sustainable solutions in water, sanitation, and livelihoods. Through community participation and women's leadership, the project turned systemic exclusion into resilience and self-reliance. The experience offers a scalable model for inclusive urban development across India.

1. Introduction: Reimagining Dignity and Inclusion

"So many NGOs came here, clicked photos, and left-but no one ever returned to change our lives. For us, the biggest curse was the lack of sanitation and livelihood. We didn't ask for sympathy; we asked for dignity."

-Umesh Nayak, *Settlement Pradhan, Naya Bazaar Leprosy Colony*

In the fast-paced industrial growth of Rourkela, a city in Odisha, the Naya Bazaar Leprosy Colony remains a living paradox, a forgotten community existing in the shadows of urban progress. Established over 50 years ago to house leprosy-affected persons displaced from their homes, the colony has long lived in isolation -geographically, socially, and economically infrastructure was virtually non-existent.

Today, approximately 70 families, totalling 156 individuals, live in this low-income settlement. Many came from neighbouring states of Jharkhand, Bihar, Bengal, Chhattisgarh, and Odisha, seeking refuge from stigma and poverty.

Today, approximately 70 families, totalling 156 individuals, live in this low-income settlement. Many came from neighbouring states of Jharkhand, Bihar, Bengal, Chhattisgarh, and Odisha, seeking refuge from stigma and poverty. Lacking formal inclusion in urban governance, the residents confronted harsh realities of mud-built homes vulnerable to floods and heat, unsafe sanitation, irregular water supply, and little opportunity for dignified livelihoods.

This case study chronicles the transformative journey of Naya Bazaar, enabled by an active collaboration between the Centre for Urban and Regional Excellence (CURE), Tata Trusts, and the Rourkela Municipal Corporation (RMC). More than just an infrastructure upgrade, the initiative empowered

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the community to co-create sustainable solutions in water, sanitation, and livelihoods.

2. The Context: A History of Systemic Neglect and Stigma

Rourkela, known for housing one of India's largest steel plants, stands as a symbol of industrial progress and economic growth. Yet, in sharp contrast to this narrative of development, the Naya Bazaar Leprosy Colony remained isolated and neglected. Established over 50 years ago to provide shelter to persons affected by leprosy, the settlement struggled with systemic exclusion. By 2015, it was characterised by crumbling infrastructure, unsafe sanitation, irregular water supply, and a lack of dignified livelihood options. Stigma surrounding leprosy further deepened their marginalisation, making access to education, healthcare, and public spaces fraught with fear and discrimination. The colony reflected a harsh reality where urban progress bypassed the most vulnerable, highlighting the urgent need for solutions rooted in inclusion, dignity, and sustainable empowerment. Most homes were constructed with mud walls and tin roofs, inadequate to provide shelter against the monsoon and scorching summer heat. Sanitation infrastructure was virtually non-existent.

Residents of the Naya Bazaar Leprosy Colony had no choice but to resort to open defecation or makeshift, unsafe sanitation options, as functional toilet facilities were either inadequate or completely absent (Ref: Figure- 1). The only available community toilet blocks were poorly designed, lacked water supply and electricity, and failed to offer privacy or safe menstrual hygiene management, especially for women. As a result, many avoided using these facilities altogether, exacerbating the practice of open defecation. Waste disposal was equally haphazard, household and human waste were often dumped in nearby drains or open areas, leading to severe groundwater contamination. This not only polluted local water sources but also posed significant health risks to the community, contributing to waterborne diseases like diarrhoea and cholera. Moreover, poor drainage infrastructure meant that during the monsoon season, large parts of the colony became waterlogged. Stagnant water turned into breeding grounds for mosquitoes, further exposing residents to vector-borne diseases such as malaria and dengue. These unsanitary conditions perpetuated a vicious cycle of ill-health, reinforcing both poverty and exclusion, and leaving residents trapped in a landscape of vulnerability with no. dignified, sustainable alternatives.

Figure 1:Water and Sanitation Condition Before Intervention (Toilet Infrastructure and open well)

A Web of Livelihood Vulnerabilities

Economic insecurity was pervasive across the Naya Bazaar Leprosy Colony, with livelihoods deeply intertwined with stigma and exclusion. Of the approximately 70 families, around 30–35 depended entirely on temple-based alms, making their survival reliant on the unpredictable generosity of others rather than stable or dignified income sources. The remaining families sought work in menial and often exploitative jobs such as street sweeping, utensil washing, or daily wage labour in nearby factories, construction sites, or small industrial units. These roles offered no job security, benefits, or formal recognition, and wages were meagre, barely enough to meet basic needs.

For many men and women affected by leprosy, the fear of being recognised as "untouchable" added another layer of vulnerability. As a coping strategy, many took up night-time labor, working under the cover of darkness to avoid public exposure, which they feared could lead to harassment, social isolation, or further discrimination. This not only affected their physical health due to irregular hours but also restricted access to more stable or organised employment opportunities.

Women, in particular, bore the heaviest burden. Most were engaged in low-paid, home-based activities such as small-scale tailoring or weaving, often working without formal contracts, social security, or any financial safety net. A significant number also participated in irregular informal work, including daily wage labour or assisting in family-based economic activities. With no access to credit, vocational training, or institutional support, these women remained trapped in a cycle of poverty, unable to transition into more stable livelihoods.

The intersection of disease-related stigma and economic marginalisation created a compounded vulnerability where access to sanitation, health services, and dignified work remained out of reach, reinforcing dependence on charity or exploitative labour. This systemic exclusion perpetuated not just economic precarity but also a loss of dignity and agency for the residents of the colony.

The Invisible Barrier: Stigma

Leprosy, a disease long misunderstood as highly contagious and morally tainted, imposed a silent but unyielding wall of stigma around the residents of Naya Bazaar Leprosy Colony. Misconceptions about the disease fueled fear and discrimination, isolating the community from mainstream society.

Children in the colony bore the brunt of this stigma early on. Many faced harassments and bullying in local schools, where classmates and sometimes even teachers treated them with suspicion or outright hostility. Several families withdrew their children from school altogether, fearing public shame or worse, believing that their children would never be accepted. This not only cut off opportunities to acquire formal education but also perpetuated a cycle of illiteracy and poverty.

Adults, too, encountered systematic exclusion. Employers in both the formal and informal sectors refused to hire individuals from the colony once their condition or background became known. Even menial jobs, which should have provided some financial relief, were often closed to them. Social occasions, festivals, and community gatherings became spaces of exclusion rather than belonging. The constant fear of recognition forced many to work at night or in the shadows, not by choice, but by necessity, further entrenching their isolation.

Accessing healthcare presented its own set of challenges. Despite being a basic human right, many health facilities hesitated to treat residents of the colony. Healthcare workers, themselves products of societal fear and misinformation, often refused treatment or provided substandard care. Many residents avoided visiting clinics altogether, fearing humiliation or outright rejection. Pregnant women, children, and the elderly suffered in silence, unable to access routine medical check-ups or critical interventions.

The stigma extended beyond the individual, it was structural, socially embedded, and self-reinforcing. It robbed residents of

their dignity, blocked their access to opportunity, and deepened their vulnerability. Leprosy was not merely a health condition in Naya Bazaar; it was a social sentence, one that marginalised an entire community from the promise of urban progress.

As Umesh Nayak remarked:

"*We were not just poor; we were unwanted. The walls between us and the rest of the city were not built with bricks, but with fear.*"

3. The Intervention: A Holistic, Community-Centric Approach

CURE recognised early on that lasting change in Naya Bazaar Leprosy Colony could never be delivered through infrastructure alone. Installing toilets or connecting taps was necessary, but insufficient. The real challenge lay in addressing the layers of social exclusion, stigma, and disempowerment that kept the community marginalised. The intervention was therefore built on a simple but powerful idea - empowering residents as active co-creators of their future, not passive recipients of charity.

The initiative was structured around three interdependent pillars:

A. Community Engagement and Ownership

B. Sustainable Infrastructure and Design Innovation

C. Livelihood Inclusion and Capacity Building

Trust as the Foundation

The first phase of the intervention deliberately focused on low-barrier, participatory activities that could engage the whole community and nurture trust. Settlement clean-up drives brought men and women together to reclaim shared spaces, turning neglected corners into symbols of collective action. Fruit tree plantations done in collaboration with children and elders became more than a forestation drive; it represented growth, hope, and a stake in the future (Ref: Figure- 2).

Wall art campaigns transformed barren, stigmatised walls into vibrant visual narratives of dignity and resilience, while child-friendly play areas provided safe spaces for children to simply be children, free from fear of discrimination. These small but visible steps were critical in sparking dialogue, breaking down fear, and encouraging residents to imagine their own role in shaping change.

Listening Deeply, Designing Together

Using Participatory Learning and Action (PLA) tools, CURE facilitated a structured yet organic process of problem identification and solution co-creation. Activity mapping, stakeholder mapping, focus group discussions, and door-to-door interactions opened space for residents to share real life experiences that were often too painful or were best left hidden from public scrutiny.

Key interactions revealed the deeply personal dimensions of exclusion:

- A young mother shared how she routinely avoided attending school functions because of the absence of private, safe sanitation facilities, a decision that left her feeling isolated from her child's educational life.

Figure 2: Community Participation Contribution on Settlement Development

Figure 3: PLA tools exercise for data and information collection

- An elderly man recounted his nightly anxiety at having to queue for a broken, dark public toilet, risking falls and harassment.
- A teenage girl spoke candidly about staying home from school during menstruation, as discussing such a topic was taboo, and no safe alternatives were available.

These powerful testimonies became the bedrock of the project's design strategy. The solutions did not emerge from technical manuals but from lived-in experiences, rooted in dignity and pragmatism. Every technical intervention—from improved tap designs to accessible ramps—was directly shaped by community input, ensuring relevance, ownership, and sustainability.

This holistic, community-centric approach reframed the intervention not as an external aid project, but as a shared journey towards reclaiming rights, safety, and agency.

A. Co-Creation: Designing Solutions From Within

At the heart of the Naya Bazaar transformation was a powerful belief: sustainable solutions are born from lived experiences, not external prescriptions. From the very beginning, the project fostered genuine co-creation, where residents became active designers of their own future, rather than passive recipients of aid.

Through regular community meetings, focused group discussions, and interactive workshops, CURE encouraged residents to voice their most pressing sanitation and livelihood challenges and propose practical solutions based on day-to-day realities (Ref: Figure- 3). The ideas that emerged were simple yet deeply insightful, reflecting a nuanced understanding of local needs:

- Hooks and Soap Stands in Toilets: Residents emphasised the need for practical touches—hooks to hang clothes or bags and dedicated soap stands—to make toilet usage more convenient, especially for women managing daily chores and menstrual hygiene.
- Handwashing Stations Outside Homes: Recognising that hygiene was more than a matter of infrastructure, residents suggested small, accessible handwashing points near their homes to foster regular hygiene practices (Ref: Figure- 5).
- Improved Tap Designs and Ventilation Cut-Outs: Poorly designed taps and suffocating toilet interiors had discouraged usage. The community's input led to user-friendly tap fixtures and ventilated toilet designs that addressed both comfort and safety.
- Peak-Hour Usage Schedules: To tackle overcrowding, residents proposed schedules for toilet usage, especially during early mornings and evenings, reducing conflicts and wait times without creating rigid bureaucratic structures.

CURE, in close collaboration with technical experts, translated these community-driven ideas into climate- resilient, sustainable designs that blended innovation with practicality (Ref: Figure- 4):

Figure 4: Co-Design Exercise with Settlement Groups

Figure 5 Programme Implementation

- **Solar Lighting:** Recognising the safety concerns during night-time usage, solar-powered lights were installed. This solution not only enhanced safety but also minimised dependence on an unreliable municipal power supply, particularly critical during monsoons or outages.
- **Rainwater Harvesting (RWH) and Decentralised Wastewater Treatment Systems (DEWATS):** These systems addressed two key challenges-unreliable water supply and untreated wastewater discharge. By harvesting rainwater and treating greywater locally, the design reduced groundwater extraction and prevented environmental contamination, creating a more sustainable, circular water system.
- **Universal Accessibility Measures:** Ramps, grab bars, non-slip flooring, and disabled-friendly washbasins ensured that elderly residents, differently abled persons, and pregnant women could use sanitation facilities safely and with dignity.
- **Landscaping and Wall Art:** The project went beyond functionality. Community-led wall art campaigns and landscaping efforts turned dilapidated spaces into vibrant, prideful places, symbolising resilience and ownership rather than neglect.

Women emerged as powerful leaders throughout the co-creation process. Their voices were pivotal in pushing for:

- **Privacy Enhancements:** Women insisted that toilet designs account for privacy, especially during menstruation or caregiving, advocating for enclosed cubicles and lockable doors.
- **Improved Menstrual Hygiene Management (MHM):** Simple but critical demands such as provision of disposal bins, availability of sanitary napkins, and discreet facilities were incorporated based on women's direct input.

- **Better Handwashing Access and Safe Waste Disposal:** Women identified strategic locations for handwashing stations and safer waste disposal methods, directly influencing the layout and operational design.

This leadership was formally recognised by the Rourkela Municipal Corporation (RMC), which institutionalised women's involvement by entrusting them with the operation and maintenance (O&M) of two community toilet complexes (CTCs) outside the colony. This marked a critical shift: gender equity was not an afterthought but embedded in the solution's very structure.

By making residents, especially women the architects of their own dignity, the project reframed sanitation and livelihood challenges as opportunities for empowerment, agency, and sustainable change.

B. Multi-Stakeholder Convergence: Strengthening Systemic Solutions

The transformation of Naya Bazaar Leprosy Colony was never the effort of a single organisation or a one-off intervention. Its success lay in a powerful convergence of multiple stakeholders each playing distinct yet complementary roles working together toward a shared vision of dignity, inclusion, and sustainability.

Rourkela Municipal Corporation (RMC): The Institutional Anchor

The RMC played a pivotal role by providing essential infrastructure support and policy backing. Beyond merely constructing facilities, RMC recognised the need for long-term sustainability and accountability. Importantly, it institutionalised the leadership role of women from the community in the operation and maintenance (O&M) of sanitation infrastructure. This formal recognition transformed women from informal caretakers into accountable service providers, empowering them with both responsibility and legitimacy.

Water and Health Departments: Technical Backbone

Recognising systemic service gaps in water supply and sanitation, the Water and Health Departments actively collaborated in the initiative. They provided technical guidance for the implementation of decentralised solutions such as Rainwater Harvesting (RWH) and Decentralised Wastewater Treatment Systems (DEWATS), ensuring these innovations were not just conceptual but practically viable. Their involvement bridged the gap between policy and ground-level implementation, strengthening the technical integrity of the solution.

Child and Women Development Department: Enhancing Social Services

The Child and Women Development Department played a critical role in improving early childhood care and nutrition services. By enhancing the management of Anganwadis (government-supported child care centers), the department ensured that the children in the colony had access to quality nutrition and early education. This intervention addressed an often-overlooked dimension of vulnerability, particularly the compounded disadvantages faced by young girls and children born into marginalised families.

CURE: The Facilitator and Integrator

As the project's facilitator, CURE acted as a neutral intermediary bridging gaps, ensuring dialogue, and providing technical inputs. Its role went beyond coordination; it translated community voices into actionable designs, ensured alignment across government departments, and nurtured accountability at every level. By embedding participatory processes into the project's DNA, CURE enabled residents to steer solutions, while making certain that no stakeholder operated in isolation.

Community-Based Organisations (SHGs): Grassroots Drivers of Change

Self-Help Groups (SHGs) within the community assumed active, hands-on responsibility. They managed the operation and maintenance of the Community Toilet Complexes (CTCs), coordinated household waste collection, and drove hygiene awareness campaigns. Leveraging their established grassroots networks, the SHGs

became the project's frontline actors, maintaining a culture of collective ownership and day-to-day functionality. Their local knowledge ensured that solutions remained practical, relevant, and community-centred.

C.A Unified Model for Sustainable Change

This multi-stakeholder convergence did more than just align actors, it prevented fragmented, unsustainable interventions that often plague urban development. Instead of piecemeal charity or short-term infrastructure projects, the approach created an integrated model where the community, government, and civil society each had clear responsibilities and shared accountability. The model was in harmony with national goals such as the Swachh Bharat Mission-Urban (SBM-U), demonstrating that systemic inclusion is not only possible but replicable.

Together, these roles forged a holistic, sustainable pathway, turning Naya Bazaar from a site of exclusion into a living example of participatory urban resilience.

D. Tangible Outcomes: From Exclusion to Empowerment

The journey of the Naya Bazaar Leprosy Colony was not just about plans on paper or infrastructure alone, it was about real, visible change that residents could touch, use, and take pride in.

Today, the settlement stands transformed, a powerful testament to what community-led action can achieve. At the heart of this transformation are two upgraded, user-friendly Community Toilet Complexes (CTCs), no longer neglected structures but functional, climate-resilient facilities that reflect the community's active involvement in their design and upkeep. Far from being isolated projects, these CTCs are managed by the community itself, particularly by women who now hold formal roles as sanitation stewards, instilling a sense of ownership and accountability.

Universal accessibility features have been thoughtfully integrated, ensuring that elderly residents and differently-abled individuals can use the facilities with safety and dignity. Simple additions such as ramps, grab bars, and non-skid flooring have made a world of difference in enabling equitable access, breaking down physical and social barriers that previously excluded the most vulnerable.

Solar-powered lighting now illuminates the CTCs, dramatically improving security after dark. Where once residents feared using public facilities at night due to unsafe, poorly lit surroundings, they now feel reassured. This not only enhanced safety but also reduced dependency on the irregular municipal power supply, lowering costs and promoting sustainability.

A key innovation was the introduction of rainwater harvesting systems. By capturing and storing rainwater, the colony now enjoys a more reliable water source, particularly crucial during dry spells when municipal supply was erratic. This system reduces the strain on groundwater and limits the environmental impact of unsafe discharge, contributing to a circular, sustainable water solution.

Together, these tangible outcomes reflect a broader shift; from exclusion, vulnerability, and neglect to empowerment, dignity, and resilience. They are not just technical achievements but symbols of a community reclaiming its voice and agency, demonstrating that sustainable change is possible when infrastructure caters to the need of communities.

Women's Leadership and Empowerment: Redefining Roles, Reclaiming Power

In Naya Bazaar Leprosy Colony, change was not delivered from the outside, it was nurtured from within. At the heart of this transformation were nine remarkable women who stepped into leadership roles, shifting the narrative of marginalisation to one of empowerment.

Two Jal Sathis (Water Stewards) now manage the delicate task of ensuring reliable water distribution and the upkeep of critical water infrastructure. Their work guarantees that the community has access to safe water, a fundamental need that was once unreliable and unsafe.

Two Swachhata Sathis (Sanitation Stewards) take charge of household waste collection, hygiene promotion, and the operation and maintenance

(O&M) of the Community Toilet Complexes (CTCs). These women became trusted figures, connecting with households, providing hygiene education, and ensuring that waste did not accumulate in public spaces.

A Swachh Supervisor coordinates sanitation activities across the settlement, stepping in to resolve conflicts, monitor maintenance schedules, and liaise with government bodies. Her role has created a formal channel of accountability, allowing the community to manage its sanitation systems sustainably.

Two women further stepped into Anganwadi roles, as a Caretaker and a Worker, dedicating themselves to the health, nutrition, and early education of the colony's youngest residents. Their presence strengthened the link between sanitation, nutrition, and child development, crucial in a context of chronic deprivation (Ref: Figure- 6) .

Two women led community sanitation outreach, becoming local champions who organised hygiene awareness campaigns and encouraged behavioural change.

For many, these roles were not just jobs, there were pathways to dignity. From marginalised household members who were once invisible in public life, they emerged as community role models, challenging gender norms, and demonstrating that leadership is earned through action and commitment.

Livelihood Transformation: From Survival to Sustainable Dignity

Economic exclusion had long been a silent burden in Naya Bazaar. At the start of the project, 35 men relied solely on begging, a survival strategy born out of exclusion, not choice. Today, that number has dramatically reduced.

Ten men now hold formal, dignified positions with the Rourkela Municipal Corporation (RMC), employed as street sweepers and settlement upkeep workers.

This shift marks a profound economic transformation. These men no longer face the indignity of begging but contribute to the very cleanliness and order of the city they were once excluded from. Their children, once shadowed by the stigma of begging, now dream of formal education and steady work.

Meanwhile, 30 women have come together to form Self-Help Groups (SHGs), taking collective responsibility for managing CTC operations not just within Naya Bazaar, but in neighbouring settlements as well. They earn a stable income by managing sanitation services, turning what was once an unrecognised chore into a respected profession.

This transition represents more than improved incomes—it's a break from the cycle of inter-generational poverty, where dignity and opportunity are no longer distant ideals but experienced by residents daily.

Figure 6 Mushroom Cultivation by Settlement Groups

E. Replication and Institutionalisation: A Model That Scales

The tangible, systemic success of the Naya Bazaar initiative did not go unnoticed. Recognising its potential, the Rourkela Municipal Corporation formally committed to replicating the model in five other leprosy colonies across the city.

What began as a focused pilot project evolved into a scalable, replicable model. It demonstrated that sustainable change lies in blending community agency with systemic government support—where local knowledge drives design, women lead management, and institutions provide the scaffolding for long-term impact.

Naya Bazaar is no longer a forgotten settlement. It is a story of resilience, a beacon of inclusive urban development, and a powerful example of how dignity can be restored through collective action.

4. Lessons and Reflections: Charting a New Path

Inclusion is Not Charity but Justice

One of the most powerful lessons from Naya Bazaar is that true development is never about charity, it's about justice. For decades, the community lived in the shadows of neglect, seen as passive recipients of aid or invisible burdens. The project turned that notion on its head by positioning residents as co-creators of solutions. Their lived experiences, often dismissed by outsiders, became the foundation for practical, effective interventions. Whether it was a mother's insight into privacy needs or a young man's suggestion for handwashing stations, these contributions proved that dignity is fundamental to any development intervention.

Women's Leadership is Non-Negotiable

Transforming power dynamics was not incidental; it was deliberate. Embedding women in formal leadership roles fundamentally altered the way decisions were made and implemented. Women moved from the margins to the center, as Water Stewards, Sanitation Supervisors, and Anganwadi Workers responsible for managing critical infrastructure and outreach. This leadership did more than provide jobs. It shattered patriarchal barriers, instilled a sense of agency, and proved that women are not just beneficiaries of development, they are its driving force.

Systems Matter

Sustainability requires structure. The project's alignment with the Swachh Bharat Mission-Urban (SBM-U) and integration into municipal planning were critical moves. By formalising roles for Self-Help Groups (SHGs) and linking community processes with government frameworks, the initiative avoided common pitfalls of fragmentation and myopic outlook. Instead of a collection of isolated interventions, it became a coherent, accountable system. Community members could now engage with RMC as equal partners, not as supplicants, creating a foundation for long-term sustainability.

Voices of Change

Umesh Nayak: A Leader Empowered

"We used to feel abandoned. Today, we are partners. We decide, we act, and we manage. This project didn't just give us toilets; it gave us pride."

Meera Devi: From Margins to Leadership

"*I never imagined I would manage a sanitation facility. Now, I help others understand the importance of hygiene. Women in our colony see me as an example.*"

Ravi Kumar: From Begging to Dignified Work

"*Begging was a survival tactic, not a choice. Today, I work for the municipality, sweeping streets with respect. My children now dream of more than survival.*"

Sustainability is a Collective Responsibility

Perhaps most striking was the shift in mindset; from dependency to ownership. From the maintenance of Community Toilet Complexes to household waste management, residents became active custodians of their environment. The success of the initiative was not measured solely in infrastructure upgrades but in the pride with which women managed sanitation facilities, men performed formal street sweeping, and children played in clean, safe spaces. The community's collective sense of responsibility ensured that improvements were not temporary gifts but lasting achievements, driven by shared purpose rather than external aid.

5. Conclusion: A Model for the Future

The transformation of Naya Bazaar Leprosy Colony is more than a success story, it's a blueprint for inclusive, sustainable urban development. By placing community voices at the center, fostering multi-stakeholder collaboration, and institutionalising women's leadership, the project proved that systemic exclusion is not inevitable.

Today, Naya Bazaar stands as a vibrant, self-sustained community. It is no longer defined by stigma, poverty, or neglect, but by resilience, dignity, and agency. The initiative demonstrates that when development is rooted in equity and participation, it delivers more than services—it restores hope, identity, and a future shaped by those who live it.

This model of systemic inclusion offers a powerful example for cities across India and beyond, showing that lasting change emerges when communities are trusted as equal partners, not passive beneficiaries.

National Highway for Electric Vehicles (NHEV)

India's heightened emphasis on electric mobility is set to revolutionise its transportation and energy sectors. At the forefront of this initiative is the National Highway for Electric Vehicles (NHEV), an e-highway pilot program endorsed by the Government of India; initially backed by the Ministry of Commerce & Industry to transform highways into E-Highways. This initiative aims to convert the nation's national highways and expressways into electric highways (e-highways), establishing a 5,500 km e-highway network along the Bharatmala and Sagarmala routes from Delhi to Kanyakumari via the Mumbai and Kolkata corridors by 2027. The program is not merely a standalone mobility project but functions as a comprehensive initiative that aspires to develop charging infrastructure, deploy a fleet of electric trucks and buses, and create world-class e-highway infrastructure capable of providing automatic backup within 30 minutes in the event of a vehicle shutdown.

It has conducted technical trials on three pilot corridors, specifically Delhi-Agra (Yamuna Expressway – 2020) and Delhi-Jaipur (NH48 – 2022), as well as Chennai-Trichy (NH 179B 332 KM), out of the twelve national corridors proposed by the Ministry of Power for electrification in its guidelines and standards dated December 14, 2018, to be converted into E-highways. The program is being financed through a hybrid public-private partnership (PPP) model, referred to as annuity hybrid e-mobility (AHEM).

The advancement of e-highways must now take precedence to achieve critical national objectives, such as reducing logistics costs, decarbonising surface transport, and lowering the oil import bill.

INFORMING CITY CLIMATE ACTION PLANNING THROUGH ROBUST DATA-DRIVEN RISK ASSESSMENTS

RISAAL AMINA ESA, SOHAM SHAH, GAURAV SAHNI, DR PUSHP BAJAJ

Indian cities are at high risk to climate-induced hazards such as floods, heatwaves and water scarcity, whose impacts are compounded by poor urban planning and unregulated urban expansion. City Climate Action Plans (CCAPs) serve as strategic roadmaps to reduce greenhouse gas (GHG) emissions and adapt to the adverse impacts of climate change. The robustness and long-term effectiveness of CCAPs are highly dependent on the quality, scope and comprehensiveness of climate risk assessments. Scientific and data-driven Climate Risk Assessment (CRA) is, therefore, the first and most critical step in developing and implementing context-specific and effective adaptation strategies. Although a variety of methodologies have been adopted for climate risk assessment, a comparative analysis of their scope and effectiveness remains limited in the literature. This article addresses this gap by undertaking a systematic review of existing CRA approaches embedded within CCAPs across Indian cities and evaluating their respective strengths and weaknesses based on a set of defined criteria. Additionally, the article discusses current institutional and technical barriers in conducting robust risk assessments and proposes essential elements of an ideal CRA, highlighting the urgent need to shift towards more granular, integrated and comprehensive methodologies that incorporate interdependencies, governance and socio-economic dimensions of vulnerability. Strengthening such approaches will be crucial in enabling Indian cities to enhance adaptive capacities, make risk-informed planning decisions and ultimately work towards a more climate-resilient urban future.

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Introduction

The Government of India launched the National Action Plan on Climate Change (NAPCC) in 2008 to promote sustainable development while addressing the impacts of climate change in the country (Ministry of Environment, Forest and Climate Change 2021). In 2009, the Government directed all States and Union Territories to formulate their State Action Plans on Climate Change (SAPCCs), identifying local vulnerabilities while aligning with national priorities and international commitments. Recent disruptions in societies and urban systems caused by intensifying extreme weather events, have highlighted that climate change is not only a national or state-level issue but a hyperlocal challenge that requires enhancing the role of non-state actors and strengthening multilateral governance to accelerate climate action (Chitale et al. 2024).

Cities are pivotal to India's economic growth, contributing significantly to the nation's GDP. However, they are also major contributors to greenhouse gas emissions and are increasingly

vulnerable to the impacts of climate change, including heatwaves and flooding. Rapid urbanisation and increasing migration from rural areas tourban centers intensify their exposure to climate-related risks, making the need for comprehensive planning and resilience-building strategies necessary.

Since the launch of the Smart Cities Mission and the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) Mission in 2015, urban areas in India have received significant attention, enhancing efforts to develop plans that address both climate adaptation and mitigation challenges. This involves integrating climate action measures into urban systems, both human and natural, as a proactive response to climate change. The City Climate Action Plan (CCAP) is a comprehensive action plan or a roadmap that describes how cities will adjust to recent or anticipated climate events and strive towards low greenhouse gas emissions (Tuts et al. 2015). City action planning, as defined by National Institute of Urban Affairs (NIUA), is a process designed to build climate resilience. This involves creating a robust framework to identify and implement climate actions, including both mitigation and adaptation strategies (Panwar 2021).

Why is CRA critical for urban resilience?

Indian cities experience distinct seasonal challenges: extreme heat in summer, urban flooding during monsoons and air pollution in winter. According to the Census 2011, India's urban population is rapidly expanding, with 53 cities exceeding a million residents. At this current growth rate, the urban population is estimated to reach 607 million by 2030, and it is estimated that by 2050, 50 per cent of the country's population (877 million) will be living in urban areas (NITI Aayog 2022). In this regard, infrastructure development is crucial for urban growth, it encourages an environment conducive to economic prosperity and an improved standard of living for the urban population.

Infrastructure comprises the physical structures, facilities, networks and assets that provide critical services for social and economic activities, including water supply systems, power grids, transportation networks, healthcare facilities and financial services (UNDRR 2023). Given the increasing vulnerabilities highlighted by climate change, a rigorous **Climate Risk Assessment (CRA)** is essential to enable systematic, evidence-based urban resilience planning and ensure that cities can respond effectively to current and future climate challenges. It also improves public awareness and creates a stronger call for action (Lesnikowski et al. 2015).

Effective analysis involves the following key steps:

- **Hazard Mapping:** Identify and map various hazards, including floods, heatwaves, droughts, cyclonic storms, and storm surges.
- **Vulnerability Mapping:** Highlight communities and systems that are exposed to these hazards and factors that make them vulnerable.
- **Adaptive Capacity Mapping:** Assess the ability of existing systems, governance structures and financial mechanisms to respond effectively

Without a comprehensive CRA, cities risk investing in infrastructure that may fail to perform effectively under climate stress. The assessment must eventually inform actionable strategies and targeted recommendations to mitigate the risks and enhance resilience. The upcoming IPCC Special Report on Cities is expected to play a pivotal role in strengthening awareness and driving more comprehensive policy and action on both mitigation and adaptation in cities (Simpson et al. 2025).

While CRAs at the country level lay the groundwork for national adaptation strategies, these are often inadequate in informed decision-making at the municipal level. This is because national-level assessments often overlook local vulnerabilities, stakeholders' priorities and context-specific risks. CRAs conducted at the municipal level are better suited to capture community needs and localised climate risk evidence. Nevertheless, there are very limited systematic municipal risk and vulnerability assessments (Hübner and Finkbeiner 2025).

Within India, there have been considerable efforts in city-level climate action planning in recent years, particularly in metropolitan areas, with populations exceeding one million. A major milestone was achieved in 2022 when Mumbai became the first city in India to launch a dedicated and comprehensive City Climate Action Plan. The plan assessed the city's climate vulnerabilities, inventoried its greenhouse gas emissions and laid out strategies to strengthen resilience. As of December 2024, around 41 Indian cities have either completed or are in the process of preparing their own CCAPs, indicating a growing recognition-of and collective commitment-to tackle climate-related challenges (MoHUA 2024).

A Comparative Analysis of CRA Approaches in CCAPs

The following section reviews the various approaches to climate risk assessment adopted in existing CCAPs across India. It offers a comparative analysis based on multiple parameters, highlighting key trends, methodological strengths and existing gaps.

Seven CCAPs were reviewed here – corresponding to Ahmedabad, Thane, Udaipur, Solapur, Nasik, Chhatrapati Sambhaji Nagar, Bengaluru, Leh, Jamnagar and Junagadh cities – which capture diverse geographical, hydrometeorological and socio-economic contexts. Among these CCAPs, four broad patterns or models were identified, which are referred to here as Models A, B, C and D.

Model A - The Climate Risk and Vulnerability Assessment (CRVA) here is based on the "Net-Zero Climate Resilient CITIES" framework (NIUA n.d) developed by ICLEI- Local Government for Sustainability. In this model, risk assessment is carried out semi-quantitatively, with risks identified from climate trends and projections. The risks are then analysed as a product of likelihood and consequence. For vulnerability assessment, areas exposed to extreme hazards are mapped spatially. The adaptive capacities of vulnerable groups and actors are then assessed qualitatively by combining individual scores to generate an adaptive capacity index, categorised as low, medium, or high. This approach has been applied in the CCAPs of Ahmedabad (in Gujarat), Thane (in Maharashtra) and Udaipur (in Rajasthan) (Ahmedabad Climate Resilient City Action Plan, 2023)

Model B - In this model, the Climate Change Risk Assessment (CCRA) guidance document developed by C40 Cities and the Climate Hazard Vulnerability Assessment (CHVA) Framework developed by WRI India were used to assess risk. Here, GIS-based analysis of hazard, exposure of area and population vulnerable to surface flooding and land surface temperature has been conducted. The vulnerability analysis of various indicators is description-based. The cities of Solapur, Nashik and Chhatrapati Sambhaji Nagar, in Maharashtra, followed this approach in their CCAPs (WRI India, 2024)

Model C - The approach in this model builds on that of Model B, combining two frameworks: the Climate Change Risk Assessment (CCRA) framework developed by C40 and the Climate Hazard Vulnerability Assessment (CHVA) framework of WRI India. While it shares similarities with Model B, it is slightly more advanced in scope and application. In the risk assessment, hazards are analysed for both likelihood and magnitude and represented spatially based on the order of priority. The vulnerability assessment incorporates demographic and socio-economic parameters under sensitivity, infrastructure and accessibility-related parameters under adaptive capacity, which are then spatially mapped. This model is seen in the Bengaluru Climate Resilient Action Plan (BCAP).

Model D - This model is based on the Climate Smart Cities Assessment Framework (CSCAF) introduced by the Ministry of Housing and Urban Affairs (MoHUA) of the Government of India. It includes spatial hazard assessment, impact assessment and risk assessment. However, no explicit vulnerability assessment was incorporated in this model. Cities such as Leh, Jamnagar and Junagadh have adopted this approach.

Table 1 summarises the key insights emerging from the comparative analysis of the CRA methodology in the seven CCAPs analysed here. Importantly, these CCAPs predominantly assess climate risks at a granular

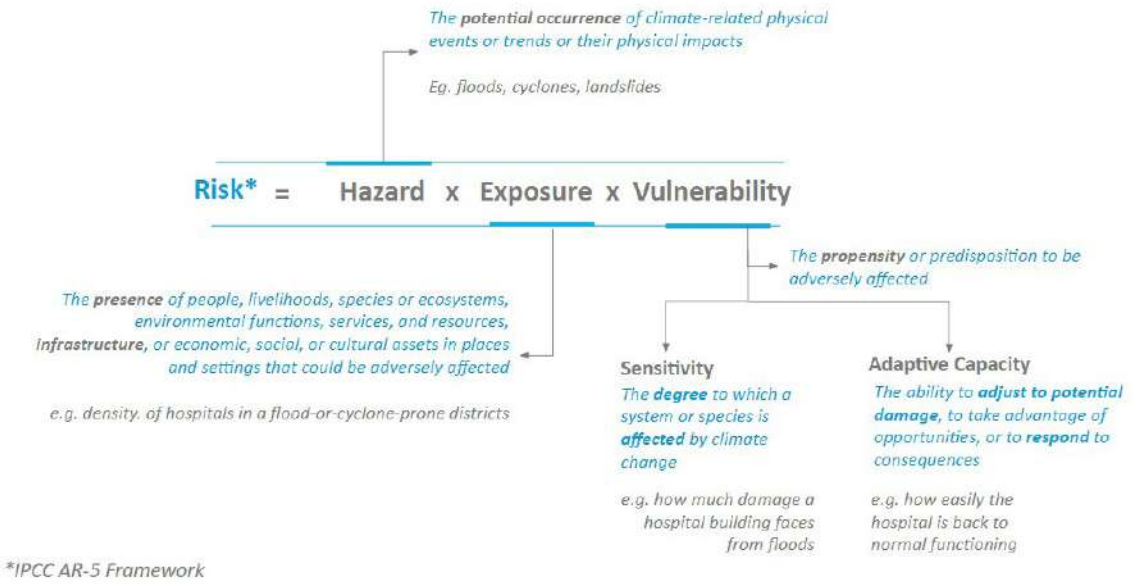

Figure 1: Calculation of Risk Assessment as per IPCC AR5 Assessment Report

level based on the identified frameworks, making planning more actionable. Bengaluru, for instance, goes further, as exposure to hazards was conducted at the sub-city level and vulnerability was assessed at the ward level and then aggregated at the zone level.

However, across these four models, there is limited integration of the widely recognised and comprehensive definition of climate risk provided by the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2022), which defines climate risk as a function of hazard, exposure and vulnerability (see Figure 1). Wherein, vulnerability is further described as a combination of sensitivity and adaptive capacity (IPCC, 2014).

Model C incorporates this partially at a conceptual level, while Model A reduces risk to a product of likelihood and consequence. The vulnerabilities associated with the fragilities of the urban systems were calculated through a qualitative exercise, based on consultations with key officials of the municipal corporation.

Certain elements stand out, like the use of Heat Index Analysis ("feels like" temperature which includes relative humidity) for extreme heat in cities such as Ahmedabad, Bengaluru and Solapur, where heat stress hotspots have been mapped. This indicator captures thermal comfort by reflecting how temperature is perceived by the human body when ambient relative humidity is combined with air temperature. Additionally, in Solapur, multi-hazard spatial overlays were used to identify exposed zones, enabling more comprehensive planning.

Vulnerability assessments across the reviewed cities rely on a mix of qualitative approaches and spatial hotspot mapping. For example, in Model A (see Figure 2), adaptive capacity of fragile urban systems is addressed qualitatively through a scoring method and ranked as low, medium or high. It is unclear whether any quantitative data-driven metrics were used to arrive at the rankings. Qualitative perception-based scores may introduce subjectivity and potential bias. This method also assumes that all three dimensions contribute equally to adaptive capacity, whereas in practice, their relative importance may vary depending on context. Model C takes an advanced approach by including socio-economic, geographic sensitivity indicators and adaptive capacity indicators such as access to infrastructural amenities and services, which are geospatially mapped with zone-level priority rankings (See Figure 3). In contrast, Model D observed in Leh for instance, has conducted ward-wise flood risk assessment and groundwater level mapping. No vulnerability assessment was conducted in this model.

ASSOCIATED ACTORS	CAPACITY TO RESPOND (A)	"RESOURCES AVAILABLE (B)	CAPACITY TO ACCESS INFORMATION (C)	ADAPTIVE CAPACITY SCORE (A*B*C)	ADAPTIVE CAPACITY
Ahmedabad Municipal Corporation	3	2	3	18	High
Traffic Police Department	3	2	3	18	High
City Police Department	3	2	3	18	High
Regional Transport Office (RTO)	3	2	3	18	High
Gujarat Pollution Control Board (GPCB)	2	2	2	8	Medium
Government health care facilities	3	2	3	18	High
Private hospitals	3	3	2	18	High
Contractors/private sector players managing urban infrastructure services for AMC	3	3	2	18	High
Vulnerable people (elderly, children, women, people with special needs)	1	1	1	1	Low
Uneducated persons	2	1	2	4	Low
Slums	1	1	1	1	Low
Rag pickers and people working at dump sites	1	1	1	1	Low
Street vendors	1	1	1	1	Low
Pedestrians, cyclists, commuters using two-wheeler	1	2	2	4	Low
Residents Welfare Associations	3	2	1	6	Medium
NGOs / charitable Institutions	2	3	2	12	High

Figure 2: In Ahmedabad's Net-Zero Climate Resilient City Action Plan (ICLEI South Asia, 2023), the adaptive capacities of fragile urban systems are assessed qualitatively using a scoring method, where the product of three functions determines a ranking of low, medium, or high.

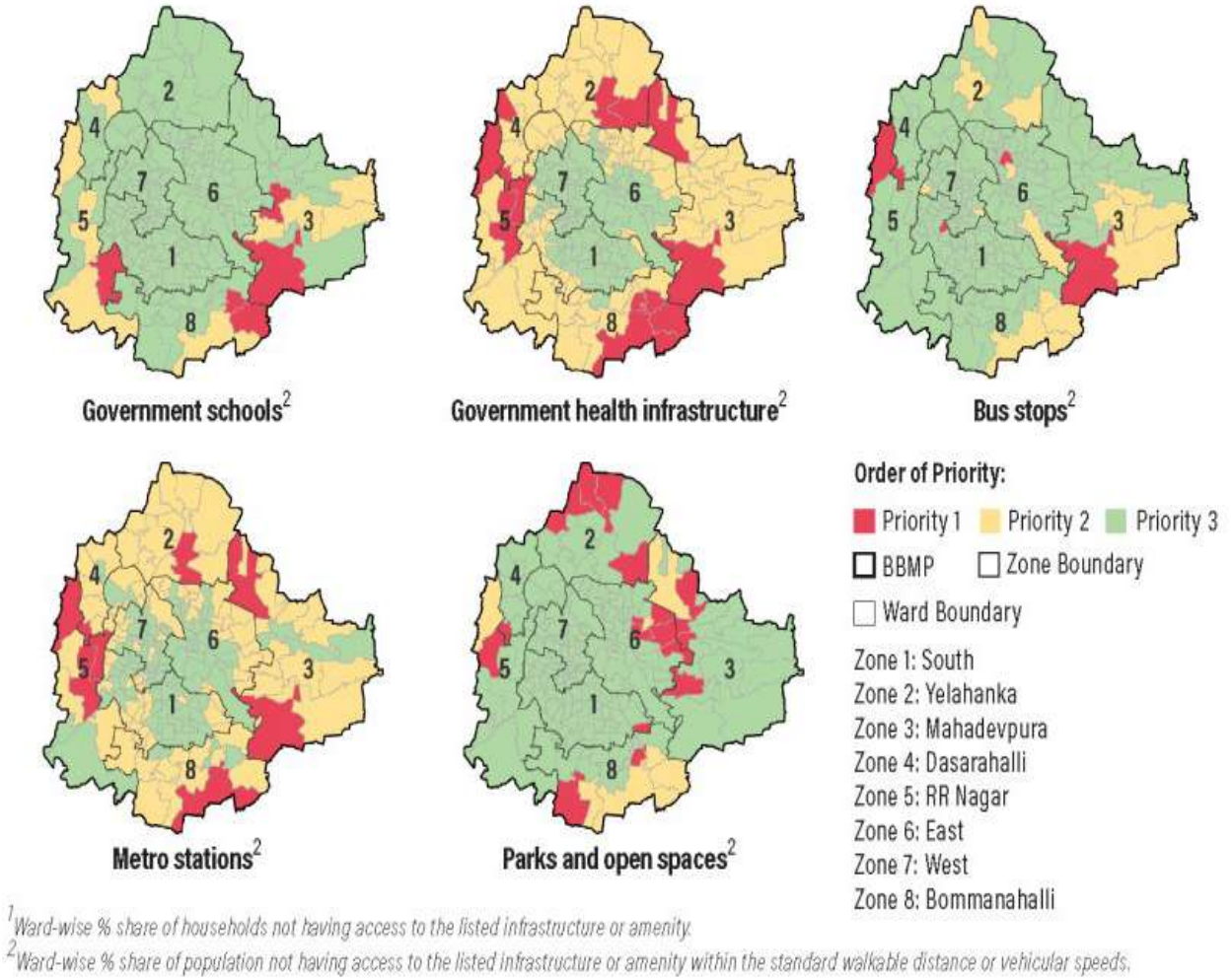

Figure 3: Adaptive capacity indicators geospatially mapped with zone-level priority rankings in Bengaluru Climate and Resilience Action Plan. Source: WRI India analysis using Census 2011, Built footprint from WSF 2019 and amenities from BBMP 2022

Accounting for differential vulnerability is essential as climate risks disproportionately affect marginalised groups.This ensures that the adaptation strategies are equitable, inclusive, and effective. The CCAPs reviewed demonstrate varying degrees of integration, from just listing vulnerable populations, slums and informal settlements, and informal workers and incorporating them in the vulnerability assessment as sensitivity indicators. It is notable that by including Scheduled Tribe and Scheduled Caste populations in its sensitivity analysis, the Bengaluru Climate and Resilience Action Plan highlights the intersection of social inequities and climate risks.

While all CCAPs adopt participatory approaches through multi-stakeholder consultations at different stages of the risk assessment's development process, engagement with vulnerable groups and local communities remains limited. In conclusion, the climate risk and vulnerability assessment methodologies in city climate action plans are largely dominated by spatial overlays, which undoubtedly capture where risks are concentrated but do not elaborate on the why and how.

Table 1: The table below summarises a comparative analysis of 7 city climate action plans (CCAPs).

Parameters City Climate Action Plans	Hazards Considered	Spatial Scale	Extent of IPCC AR Concept Integration	Key Elements of Risk Assessment	Key Elements of Vulnerability Assessment	Inclusion of Differential Vulnerability	Standout Features
Thane (2021) Knowledge partner ICLEI South Asia	Flooding, heat, sea-level rise, and air pollutionW	Qualitative risk assessment and ward-level vulnerability assessment	No	The risks associated with the fragilities of the urban systems were calculated through a risk assessment exercise conducted based on consultations with the key officials. The risk score for each fragile urban system is defined as a combination of the likelihood and consequences of an event.	Spatial mapping of vulnerabilities. Adaptive capacities of the fragile urban systems are qualitatively determined by ranking them as low, medium or high.	Inclusion of urban poor	Affected wards have been identified, listed and spatially mapped.
Ahmedabad (2023) Knowledge partner ICLEI South Asia	Extreme heat, urban flooding, and air pollution	Qualitative risk assessment and ward-level vulnerability assessment	No	Qualitative risks identified from climate trends and projections are analysed simply as a product of likelihood and consequence	Areas vulnerable to extreme heat hotspots and locations of slums and vendors exposed to extreme heat mapped spatially. The adaptive capacities of vulnerable groups and actors have been assessed qualitatively by multiplying individual scores to yield an adaptive capacity score categorised into low, medium and high adaptive capacities.	Spatial mapping of slums and vendors vulnerable to extreme heat risk and urban flood risk	Employs Heat Index Analysis (Feels like temperature) as one of the indicators for extreme heat.
Udaipur (2024) Knowledge partner ICLEI South Asia	Extreme heat and urban flooding	Qualitative risk assessment and ward-level vulnerability assessment	No	The risk status of the climate fragility statements is assessed by estimating the likelihood of occurrence of these impacts and consequence of the impacts on urban systems and populations.	The vulnerable population and wards for urban heat and floods for each fragile urban system have been identified.	Only vulnerable populations by age, income group are mentioned, but not added to maps or calculations	Vulnerable wards for urban heat and floods for each fragile urban system have been identified and mapped, followed by a consolidated vulnerability map.
Solapur (2024) Knowledge partner WRI India	Urban heat, air pollution, waterlogging, drought and groundwater depletion	Ward-level granularity for vulnerability and hotspot mapping	Yes conceptual basis only	Multi-hazard spatial overlay to identify zones exposed to multiple risks	Description-based vulnerability analysis of various indicators under subcomponents of accessibility, demography and adaptive capacity.	Mapping of the differential vulnerability of slums, informal workers, and low-income populations	Multi-hazard analysis
Bengaluru (2023) Knowledge partner C40 and WRI India	Urban flooding, urban heat, thunderstorms and lightning, drought and air pollution	Exposure to hazards at the sub-city level (zones); Vulnerability conducted at the ward level (198 wards) and aggregated at the zone level (8 zones)	Partial integration: risk defined as a function of hazard, exposure and vulnerability Climate risk is bifurcated into climate hazard assessment and impact assessment, which includes exposure and vulnerability	Hazards were analysed for likelihood and magnitude.	The vulnerability analysis conducted consists of various demographic and socio-economic parameters as part of sensitivity, and infrastructure and accessibility-related parameters as part of adaptive capacity. Analysis done at ward/zone level with maps and priority rankings	Various indicators under sensitivity and adaptive capacity are spatially mapped. Identifies vulnerable groups: slum dwellers, SC/ST communities, low-income households, informal workers, the elderly, and women.	Incorporates the scheduled tribe and scheduled caste populations in the sensitivity component of vulnerability Multi-hazard analysis Order of priority framework for hazard, sensitivity, and adaptive capacity. Equity and inclusivity lens.

Parameters City Climate Action Plans	Hazards Considered	Spatial Scale	Extent of IPCC AR Concept Integration	Key Elements of Risk Assessment	Key Elements of Vulnerability Assessment	Inclusion of Differential Vulnerability	Standout Features
Mumbai (2022) Knowledge partner C40 and WRI India	Extreme heat, extreme rainfall, flooding and waterlogging, cyclones and storm surges,, landslides, air pollution	Ward-level	Based on IPCC AR5 concepts of hazards, exposure, sensitivity and adaptive capacity	GIS-based analysis of hazard exposure	Vulnerability indicators were identified; the highest and lowest vulnerable wards were identified, but the analysis is descriptive. Not bifurcated into sensitivity and adaptive capacity	Inclusion of informal settlements	Integration of sea-level rise and cyclone modelling
Leh (2024) Knowledge partner National Institute of Urban Affairs and Global Covenant of Mayors	Floods and water scarcity	Ward-level risk maps for floods and water scarcity	No	Flood risk assessment at the ward-level and groundwater level mapped	No vulnerability assessment.	Notes inequities in water access, dependence on tourism and seasonal migration. Identifies 7% of the population in low groundwater recharge zones. However, limited attention to gender, caste or occupational differentiation.	Modelling uses two climate scenarios from the IPCC Sixth Assessment Report's Shared Socioeconomic Pathways: SSP2-4.5 (Middle of the Road) and SSP5-8.5 (Fossil-Fueled Development), focusing on changes in temperature and precipitation by 2060 and 2100.

Moving Towards Comprehensive Risk Assessment Methodologies

By addressing the specific methodological gaps identified, we can outline the essential steps to develop an ideal Climate Risk Assessment for resilient cities.

Integrating Risk Components

A robust CRA methodology lays down the foundation for developing an effective and efficient CCAP, such as that outlined by the Intergovernmental Panel on Climate Change (IPCC) AR5 Report. This framework defines risk as a function of three interlinked elements:

Risk = Hazard × Exposure × Vulnerability

The value of this approach lies in recognising that these dimensions do not operate in isolation but interact to shape actual risk. A high-intensity hazard may not necessarily translate into severe risk if exposure is low or if the region possesses strong adaptive capacity. In contrast, even moderate-level hazards can lead to high risk if vulnerable groups or critical infrastructure are directly exposed. In other words, hazards refer to climate-related physical events or trends or their physical impacts (IPCC 2014), exposure is defined by the sheer presence of urban systems, which includes the people, assets and systems that could be affected, and vulnerability captures their sensitivity, which is the degree to which a system is affected by climate variability or change, and their adaptive capacity which is the ability of the system to adjust to potential damage, take advantage of opportunities, or respond to consequences. It is the interplay of these components, rather than their independent assessment, that provides a realistic picture of urban climate risk and allows cities to prioritise adaptation measures effectively.

Need to Incorporate Future Projections of Climate Hazards

Many existing approaches to climate risk assessment depend mainly on historical and recent data, which restricts a city's preparedness to hazards already experienced. Without incorporating future climate projections, the risk assessment would serve only as an exercise in disaster mapping rather than a forward-looking climate action plan. For the assessment to drive

climate action, it must assess hazards through three crucial layers:

- Historical Data - provides a baseline of extreme weather events and identifies long-term trends
- Recent Data - captures current conditions and immediate challenges that the city faces
- Future Projections (based on climate models) - anticipate the scale and intensity of potential hazards such as extreme heat, erratic rainfall and sea-level rise, enabling cities to plan proactively for future climate risks.

The analysis should also include human-centric indicators of hazard, such as an analysis of the heat stress (which includes the compounding effect of humidity), which essentially maps people's thermal comfort. This can be seen in the Ahmedabad and Bengaluru CCAPs. In addition, adopting a multi-hazard approach can help identify areas exposed to multiple hazards in the city, resulting in more integrated and efficient planning.

Understanding 'Exposure' of Urban Systems as an Interconnected System

Urban systems such as water supply, energy, transportation, healthcare and communications are deeply interconnected and interdependent. However, conventional approaches often treat these systems in isolation, focusing only on the direct risks to individual components. This overlooks the possibility of cascading risks, where disruption in one system can trigger breakdowns in others. For instance, a plan may assess the flood risk to substations or power lines but fail to account for the resulting impacts on hospitals and critical care facilities that depend on electricity. Therefore, it is essential to map all the essential urban systems present in the city to form a comprehensive understanding of the interconnected urban landscape. For instance, the first New Zealand National Climate Change Risk Assessment 2020 (NCCRA) identified ten priority risks across natural, human, economy and built environment domains, and included the effect of cascading impacts and descriptions of dependencies between these risks.(Lawrence, Blackett, and Cradock-Henry 2020)

Socio-economic dimensions of vulnerability

Cities are home to a diverse population whose ability to cope with climate impacts varies widely depending on factors such as income, housing conditions, social status, age, gender and access to essential services. To capture this complexity, vulnerability assessments should adopt a quantitative indicator-based approach that can capture the differential vulnerability of the population groups and is focused on two key elements: Sensitivity (the degree to which populations or systems are affected by climate hazards) and Adaptive Capacity (the ability to respond, cope and recover from impacts).

Challenges in Climate Risk Assessments

Despite the growing emphasis on systematic risk assessments in the CCAPs, several challenges persist. These challenges arise at each stage of the assessment process, limiting the accuracy, granularity and policy relevance of findings.

Hazard Assessment

A key limitation lies in the granularity of available climate data. The Indian Meteorological Department (IMD) currently provides long-term climate data at a 12 km × 12 km resolution which is insufficient for meaningful local-level risk assessments. . As a result, city-level variability is represented by only a handful of data points, which fails to capture microclimatic differences and intra-city variations that are essential for accurate hazard mapping.

Exposure Assessment

Institutional capacity poses a significant challenge. Municipal corporations, already stretched by day-to-day operational priorities, often lack the capacities necessary to build and maintan long-term data repositories. This gap is compounded by limited technical expertise, especially in mapping interdependencies across urban systems. Targeted

capacity building is, therefore, crucial to equip officials with the specialised skills needed to integrate climate resilience lens into urban planning.

Vulnerability Assessment

In India, the last official national-level census was conducted in 2011, since then the country has experienced rapid urbanisation, change in the extent of informal settlements and significant demographic and socio-economic shifts over the last 15 years. Importantly, some municipal corporations have addressed this gap by conducting city-level censuses or periodic socio-economic surveys. These localised and more recent datasets provide the granularity needed to capture current vulnerabilities, making them invaluable for producing assessments that are relevant and precise.

Takeaways and Recommendations

Based on the analysis and review of existing CCAPs, the following recommendations and key takeaways aim to strengthen local-level climate risk assessments for informed decision-making in India.

1. A standardised framework, such as the IPCC model, should be adopted to ensure consistency and comparability across CCAPs. Assigning differential weights to indicators of exposure, sensitivity, and adaptive capacity would further improve analytical rigour by highlighting their relative importance in shaping climate risk in different contexts.
2. State governments and municipal corporations should establish unified data platforms that require departments such as water, energy, transport, health and planning to share and frequently update information in standardised formats.
3. Risk assessments must also integrate socio-economic and differential vulnerabilities as indicators so that the most at-risk communities are adequately represented.
4. A dedicated capacity-building programme for municipal officials can strengthen technical expertise needed to mainstream climate resilience into urban governance.

Implementing these recommendations would make climate risk assessments more rigorous, inclusive, and actionable. By strengthening data systems and investing in institutional capacity, city-level climate action planning can evolve from technical analyses into strategic roadmaps for building climate-resilient urban future in India.

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Z Morh Tunnel

The Z-Morh Tunnel links Gangangir and Sonamarg in the Ganderbal district of Jammu and Kashmir. The tunnel is engineered to accommodate up to 1,000 vehicles per hour, with a maximum speed limit of 80 km/h. It extends over a distance of 6.5 km, complemented by an additional 6.05 km of access roads. The bi-directional, two-lane roadway, measuring 10 metres in width, is constructed at an elevation of 2,637 metres (8,652 feet) above sea level, utilising the New Austrian Tunneling Method (NATM). It ensures year-round access to Sonamarg, effectively replacing the Z-turn road that is susceptible to avalanches. Additionally, a parallel escape tunnel, measuring 7.5 metres in width, is incorporated for emergency situations and can also serve as a railway tunnel.

Inputs by: A.K. Jain, Ex-Commissioner (Planning), Delhi Development Authority

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आवास के अतिरिक्त इन्फ्रास्ट्रक्चर का वित्तपोषण

हडको, एक एनबीएफसी-आईएफसी, जो आवासीय वित्तपोषण के अतिरिक्त अपने क्षितिज का विस्तार करते हुए, सुदृढ़ इन्फ्रास्ट्रक्चर परियोजनाओं को वित्तीय सहायता देने की प्रतिबद्धता के साथ विकसित भारत के उद्देश्य को प्राप्त करने के लिए परामर्श एवं क्षमता निर्माण सेवाओं के माध्यम से योगदान दे रहा है।

प्रमुख ताकत

- पैन इंडिया उपस्थिति और सरकारों के साथ सुदृढ़ संबंध
- न्यूनतम एनपीए और परिसंपत्ति की बेहतरीन गुणवत्त
- सर्वश्रेष्ठ क्रेडिट रेटिंग: घरेलू-एएए, अंतर्राष्ट्रीय-संप्रभ
- फ्लैगशिप मिशनों के प्रभावी कार्यान्वयन को पूरक बनान
- मजबूत वित्तीय अनुपात और लाभप्रदत
- क्षमता निर्माण और परामर्शी सेवाओं के माध्यम से मूल्य संवर्धन

उपलब्धिया

- नवरत्न का दर्जा प्राप्त
- एचएफसी से एनबीएफसी - आईएफसी में परिवर्तन
- एमएमआरडीए तथा अमरावती स्टेट कैपिटल डेवलपमेंट जैसे प्रतिष्ठित परियोजनाओं हेतु फंडिंग
- धारा 54 ईसी और जीरो कूपन बॉन्ड्स के अंतर्गत पूंजीगत लाभ कर छूट बॉन्ड जारी करने की अनुमति
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- अंतर्राष्ट्रीय उधार के माध्यम से वैश्विक उपस्थिति में वृद्धि

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