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Urban Crisis Response



REBOOTING URBAN RESILIENCE COMPETITIVENESS FOR CLIMATE-READY CITIES

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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).

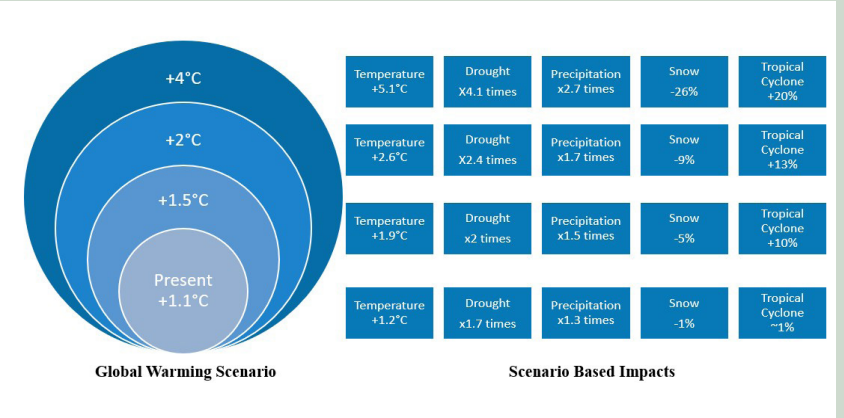

Figure 1: Worsening impact of global warming with every +0.5°C (adapted from IPCC Report, https://www.ipcc.ch/report/ar6/wg1/figures/technical-summary/ts-infographics-figure-1; and UNEP – Last Call for Climate Action: https://www.unep.org/resources/infographic/last-call-climate-action)

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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

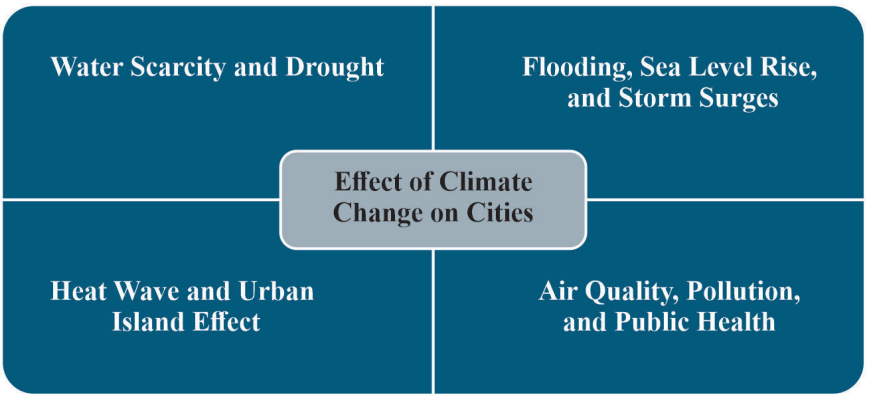

Figure 2: Key Effect of Climate Change on the Cities

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

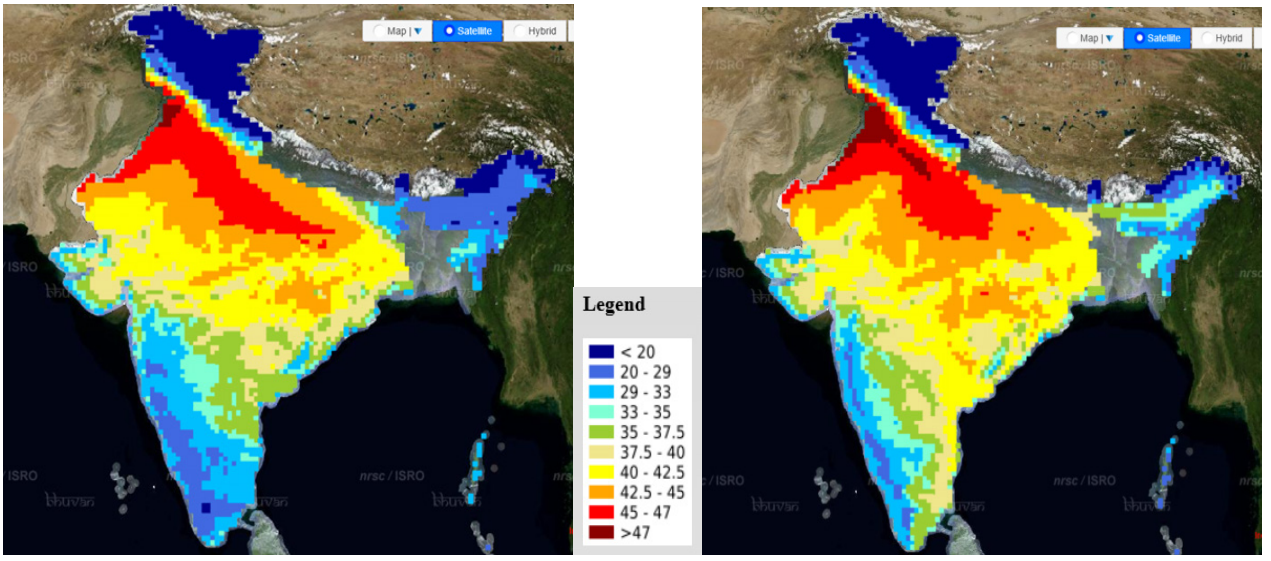

Figure 3: Heat wave condition in India during May and June of 2025 (Source:ISRO's Bhuvan Geoportal: https://bhuvan-app1.nrsc.gov.in/heatwave/)

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

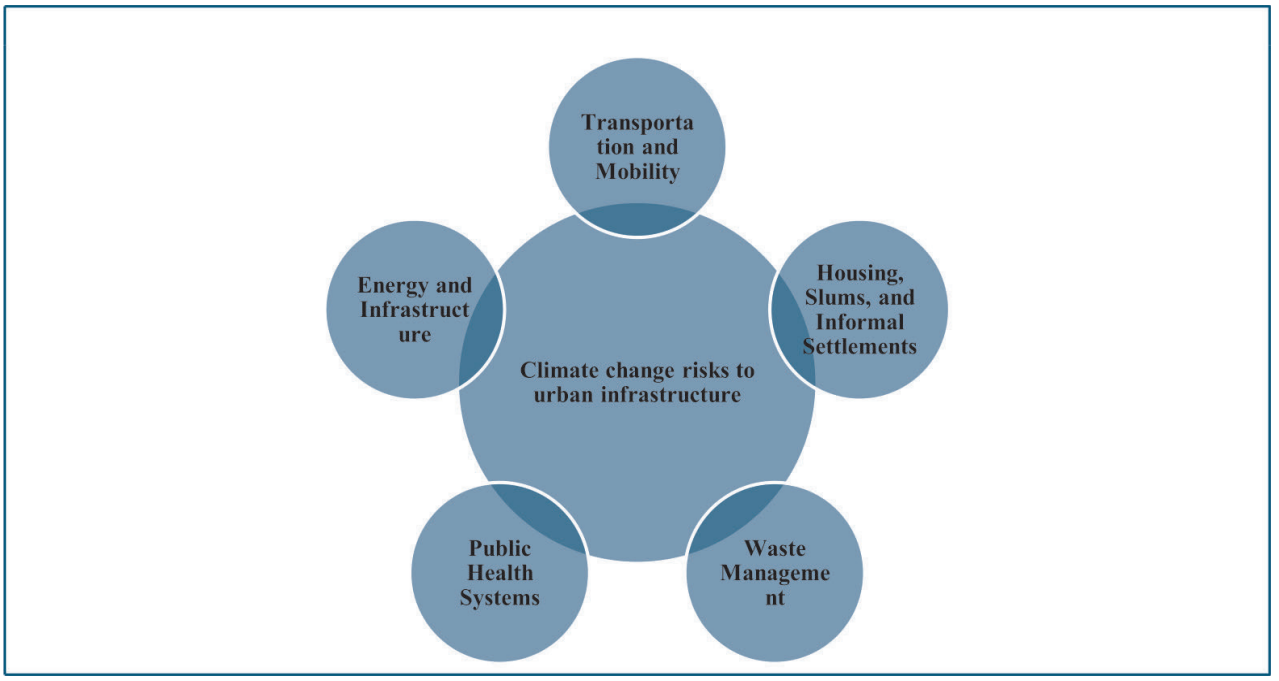

Figure 4: Key Climate Risk to Urban Infrastructure

Climate Vulnerability in Urban Housing, Slums, and 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.

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).

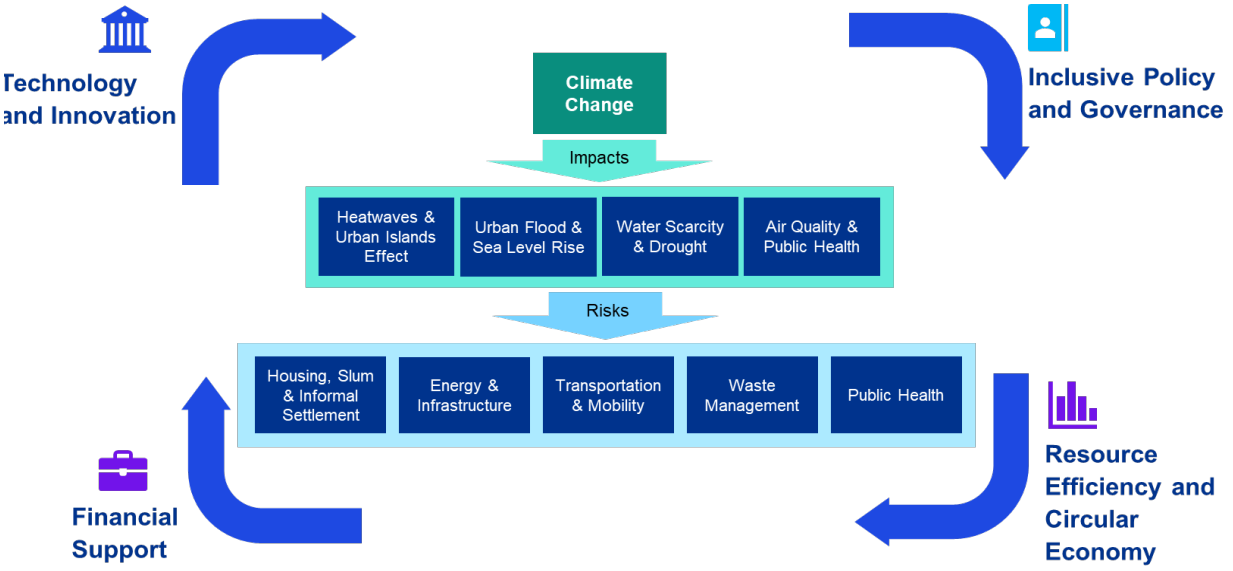

Figure 5: Strategies for Making Cities Resilient for Climate Change

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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