

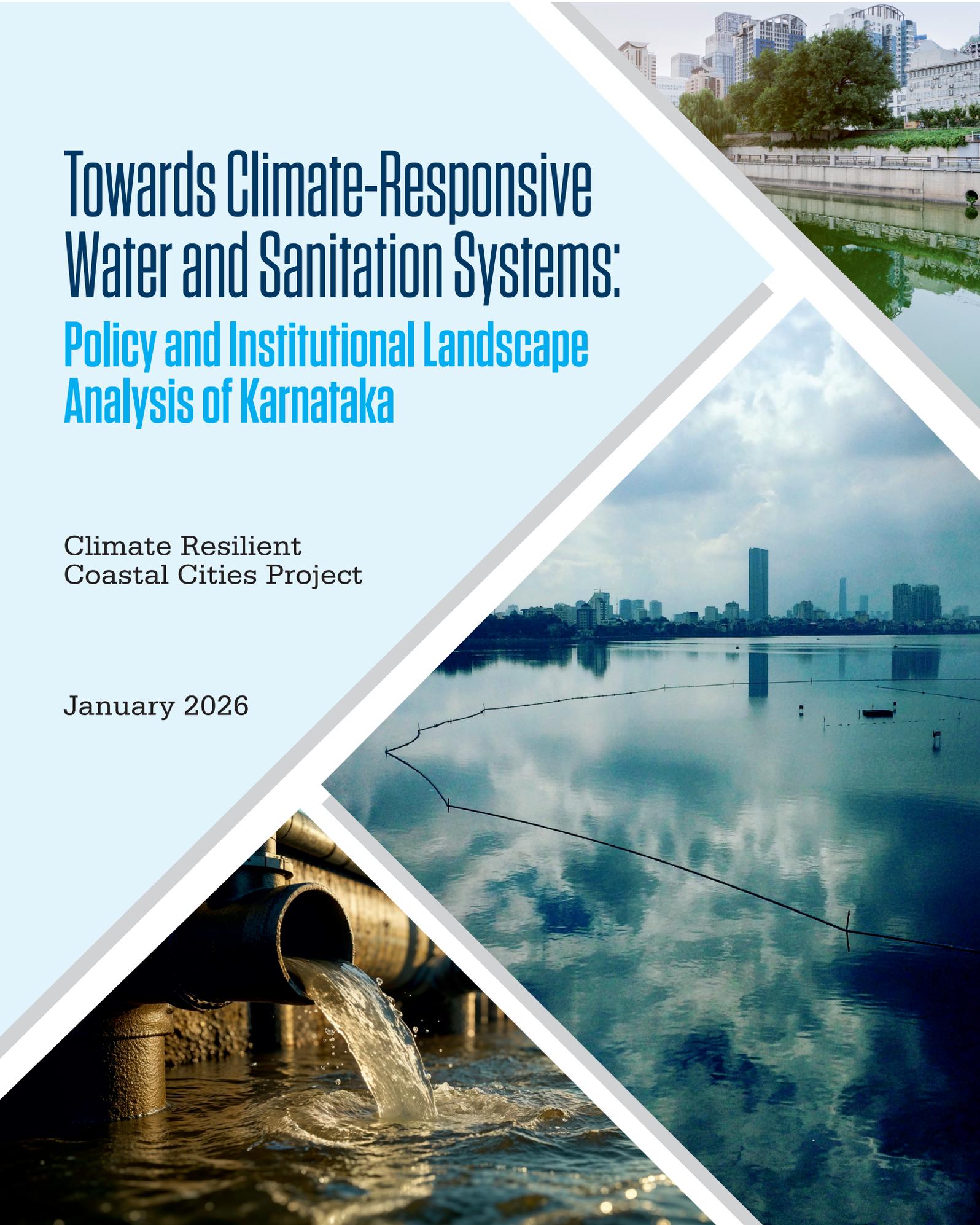
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Towards Climate-Responsive Water and Sanitation Systems: Policy and Institutional Landscape Analysis of Karnataka

Climate Resilient
Coastal Cities Project

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The collective research work undertaken through this initiative represents an important step towards advancing climate-responsive water and sanitation planning along India's west coast. The findings and recommendations presented in this report are intended to support urban local bodies and policymakers in strengthening the resilience, adaptability, and sustainability of WaSH systems.

Preface

Evidence indicates a marked increase in the frequency and intensity of cyclonic events along India's west coast, accompanied by rising sea levels, saline intrusion, and extreme rainfall. These climate-related pressures are being compounded by rapid urbanisation, population growth, and expanding economic activity in coastal cities, placing significant stress on freshwater aquifers and essential urban services such as water and sanitation. Recognising this, HSBC India, India Sanitation Coalition (ISC) at FICCI, the Ashank Desai Centre for Policy Studies (ADCPS) at Indian Institute of Technology - Bombay (IIT Bombay), and the Consortium for DEWATS Dissemination India (CDD India) formed a strategic partnership in July 2023 to address the emerging climate risks confronting coastal urban regions. This collaboration was formalised as the *Climate Resilient Coastal Cities (CRCC)* initiative in September 2023. Phase I of the initiative was implemented between September 2023 and December 2025 across four coastal states along India's western seaboard: Goa, Gujarat, Karnataka, and Maharashtra.

Within this context, the CRCC initiative focuses on strengthening the climate resilience of Water, Sanitation, and Hygiene (WaSH) infrastructure and service delivery systems-critical foundations for public health, environmental sustainability, and the long-term viability of coastal urban settlements. The initiative adopts an integrated approach that combines applied research with targeted implementation to support informed planning and decision-making. The project was guided by four interrelated objectives: (i) assessing the climate resilience of WaSH infrastructure and services in selected coastal towns; (ii) analysing the water-energy-climate policy landscape relevant to coastal urban systems; (iii) designing and implementing targeted interventions to enhance resilience in priority locations; and (iv) developing practical, scalable recommendations to strengthen system-level climate resilience.

Under the CRCC initiative, ADCPS-IIT Bombay, as the core research partner, conducted town-level situation assessment studies along with national and state policy and institutional landscape analyses. The town studies assessed the status, challenges, risks, financial sustainability, and greenhouse gas (GHG) footprint of water and sanitation systems, and proposed recommendations to enhance the resilience of such systems. These studies were carried out in twelve towns-three each in Goa (Canacona, Mapusa, and Mormugao), Gujarat (Mandvi, Devbhumi Dwarka, and Valsad), Karnataka (Karwar, Kundapura, and Mangalore), and Maharashtra (Alibag, Ratnagiri, and Vengurla). The policy and institutional landscape analysis covered the national level and the four states, with the aim of examining how urban water, sanitation, and climate change policies interact to shape broader governance and planning frameworks for resilient urban water and sanitation systems. CDD India as a research and implementation partner focused on three coastal towns in Maharashtra (Dahanu, Guhagar, and Malvan), translating assessment findings into actionable Climate Resilient Sanitation Plans (CRoSAPs) to support local implementation and decision-making.

Implementation activities under the CRCC initiative included policy consultations, capacity-building workshops, and field exposure visits for government officials and key local stakeholders, including Self-Help Groups (SHGs). These activities were jointly facilitated by CDD India, ADCPS-IIT Bombay and ISC. The initiative also enabled structured engagement with sector experts and practitioners. Complementing these efforts, CDD India led community-level mobilisation activities in the study towns, including awareness campaigns and tree plantation drives, to foster local ownership and strengthen community participation in climate resilience efforts.

India Sanitation Coalition (ISC) at FICCI has served as the anchor organisation for the initiative, leading advocacy and outreach efforts and supporting the dissemination of evidence, best practices, and policy-relevant insights. ISC has also contributed to the editorial review of the reports to enhance clarity, coherence, and accessibility. In addition, ISC has articulated the potential role of corporate actors in supporting similar climate-responsive WaSH initiatives in the future. HSBC India has provided financial support for the research, implementation, and outreach components of the initiative. In parallel, the initiative seeks to catalyse larger-scale investments in climate-resilient WaSH infrastructure by aligning with and leveraging resources already committed under the Swachh Bharat Mission (SBM) 2.0.

The findings and learnings from the initiative are being disseminated through a comprehensive suite of outputs comprising one National Report, four State Reports (Goa, Gujarat, Karnataka, and Maharashtra), and fifteen Town Reports-three each from Goa, Gujarat, and Karnataka, and six from Maharashtra. This report constitutes one of the twenty reports produced under the CRCC initiative.

It is hoped that the insights from the study will inform future policy and planning actions and investments aimed at strengthening climate-resilient water and sanitation infrastructure and services in India's coastal towns.

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Executive Summary

As part of the landscape study on climate resilient water and sanitation infrastructure for four coastal states, Karnataka's policy and institutional landscape related to water, sanitation, and climate change was examined through detailed studies from the towns of Karwar, Kundapura, and Mangaluru to identify key implementation challenges. Although Karnataka is highly urbanized and boasts strong human development indicators, the state remains vulnerable to climate risks such as droughts, floods, and coastal threats including saltwater intrusion. Smaller towns and economically disadvantaged urban areas struggle with inadequate and aging water and sanitation infrastructure, which undermines their capacity to adapt to climate impacts. Additionally, Karnataka is a significant contributor to India's greenhouse gas emissions, largely due to untreated wastewater, highlighting the urgent need for interventions. While the state has leveraged central government funds for urban development, its own allocations for urban infrastructure and climate initiatives have declined. Despite broad alignment with national policy frameworks, overlapping institutional mandates and conflicting regulations have led to fragmented governance and implementation challenges. The policy focus remains heavily toward adaptation, with mitigation efforts and infrastructure resilience receiving comparatively less attention in budgeting and program priorities. This report assesses the institutional, financial, policy, and climate resilience landscape of urban water and sanitation (WaSH) infrastructure in Karnataka, highlighting key challenges and recommendations for strengthening sectoral governance, funding, and climate action.

Finances / Programmes and Schemes

Urban water and sanitation infrastructure in Karnataka is financed through a mix of central schemes (AMRUT, SBM), state contributions, and Urban Local Bodies (ULBs) revenues. For FY 2024–25, KUWSDB proposed a budget of INR 3515.79 crore, primarily supported by central and local funds. Despite steady allocation growth since 2020, the sector remains a low priority relative to others like education and agriculture. ULBs depend heavily on property taxes but generate limited revenue from water and sewerage charges, with capital expenditure on sewerage and drainage comprising only 3–5% of total ULB capital spending.

Key Challenges:

- Low budgetary prioritization and dependence on central funding.
- Weak local revenue mobilization and volatile grant flows.
- Limited capital investment and financial autonomy at the ULB level.

Recommendations:

- Increase state investments and reduce central dependency.
- Reform ULB finances by revising tariffs, expanding tax bases, and improving collection.
- Establish stable, formula-based grant mechanisms.
- Prioritize capital spending in underfunded sanitation sectors.
- Learn from best practices of peer states.
- Empower ULBs with greater fiscal and operational authority.

Institutional Landscape

The multi-tier governance of WaSH in Karnataka suffers from fragmentation, unclear roles, and poor coordination among households, ULBs, and state agencies, undermining service delivery and climate resilience, exemplified by the case of Mangaluru.

Key Challenges:

- Weak regulation and oversight of household on-site sanitation (OSS).
- Environmental and equity issues in ULB-managed infrastructure, including user-fee barriers.
- Limited ULB engagement in large infrastructure projects and planning.
- Disconnect between environmental regulation and service delivery.
- Reactive disaster governance and limited mandates for climate resilience.
- Inadequate authority and resources for ULBs in climate adaptation.

Recommendations:

- Enforce technical standards for OSS and regulate desludging operators.
- Integrate climate-resilient design and audits in sanitation infrastructure.
- Institutionalize ULB participation and community consultation in projects.
- Strengthen municipal environmental compliance.
- Expand ULB mandates for disaster preparedness and climate-proofing.
- Provide dedicated funding and technical support to ULBs for local adaptation.

Policy Landscape

Aligned with India's Net Zero 2070 target, Karnataka has established institutional mechanisms for climate action, including State Action Plans and dedicated research bodies. Climate concerns are embedded across water management, health, and urban policies. Yet, budget allocations for climate action have slightly declined, and the state's approach strongly favours adaptation, especially in agriculture and forestry, with limited mitigation focus on urban water and sanitation.

Adaptation Challenges:

- Severe water scarcity and poor implementation in smaller towns.
- Low wastewater recycling and inconsistent rainwater harvesting adoption.
- Policy incoherence leads to costly and difficult-to-maintain systems.
- Lack of incentives for property-level compliance.

Mitigation Challenges:

- Narrow focus on energy efficiency, neglecting biological emissions.
- Limited energy recovery from wastewater treatment.
- Infrastructure gaps and weak operational monitoring.
- Disconnect between policies and local implementation.

Recommendations:

- Improve policy coherence supporting practical wastewater solutions.
- Provide financial and technical incentives for decentralized systems.
- Scale up wastewater reuse and rainwater harvesting statewide.
- Expand mitigation strategies to include emissions from sludge and sewage.
- Invest in treatment capacity and environmental enforcement.
- Promote energy recovery and enhance data and inter-agency coordination.

Resilience of Water and Sanitation Infrastructure

Karnataka's climate action plans inadequately address water and sanitation infrastructure resilience. Existing urban systems are vulnerable due to legacy design and lack of integrated, proactive resilience planning, often limited to new, externally funded projects.

Challenges:

- No dedicated resilience focus for water and sanitation in climate frameworks.

- Fragmented and inconsistent policy coverage.
- Emphasis on structural measures ignores urban wastewater systems.
- Reactive rather than proactive resilience strategies.

Recommendations:

- Explicitly prioritize water and sanitation resilience in policy and planning.
- Conduct comprehensive risk assessments of municipal infrastructure.
- Retrofit and climate-proof existing systems in vulnerable towns.
- Foster departmental coordination and fund ULB resilience capacity.
- Promote widespread adoption of climate-resilient solutions.

Coastal Areas

The National Action Plan on Climate Change lacks a dedicated coastal mission; coastal issues are addressed indirectly through the National Water Mission and state projects. Karnataka's coastal climate action plan outlines adaptation and mitigation measures but faces governance fragmentation, weak local ULB involvement, policy dilution, and siloed sectoral planning.

Challenges:

- Overlapping agency mandates causing poor coordination.
- Insufficient climate and disaster risk integration in coastal policies.
- Limited ULB capacity and engagement in coastal towns.
- Weak enforcement of Coastal Regulation Zone (CRZ) rules.
- Fragmented planning across sectors like fisheries, tourism, and housing.

Recommendations:

- Strengthen institutional coordination and ULB capacity.
- Mainstream climate resilience in land use and infrastructure planning.
- Enforce CRZ and ecological protection regulations.
- Promote cross-sectoral and integrated coastal management.
- Utilize scientific tools for hazard mapping and eco-sensitive zoning.

Overall, the study underscores the need for enhanced financial prioritization, institutional strengthening, policy coherence, and integrated climate-resilient planning to improve Karnataka's urban water and sanitation infrastructure. Empowering ULBs, promoting decentralized solutions, and integrating mitigation with adaptation efforts are critical to building



resilient, equitable, and sustainable WaSH services, especially in climate-vulnerable coastal and urban areas.

1. INTRODUCTION

Global Climate Risk Index 2021 ranks India as the seventh-most exposed and vulnerable country to climate extremes¹. With high risk of concurrent flood incidents, the country is amongst the most climate-vulnerable as per an IPCC report (Intergovernmental Panel on Climate Change , 2023). This is especially true for the nearly 171 million population in coastal districts. India is highly susceptible to cyclones and related hazards such as storm surges, intense winds, and extreme rainfall. More than 300 extreme events have occurred in the country in recent decades, causing financial losses of more than INR 5,600 billion (Mohanty, et al., 2020). A recent evaluation indicates that more than 75% of districts in India, including 95% of coastal districts, are hotspots for extreme events (Mohanty, et al., 2020).

West Coast: Increasing Climate Risks

While the east coast has faced greater exposure to tropical cyclones (TC), recent trends highlight the Arabian Sea (west coast) with increased cyclonic formations (Deshpande, et al., 2021). The Arabian Sea has emerged as a key region for the formation of tropical cyclones in recent years, that have led to severe impacts across the western coast of India (Thomas & Lekshmy, 2022). Between 2001 and 2019, the frequency of cyclonic storms in the Arabian Sea surged by 52%, while the Bay of Bengal (east coast) recorded an 8% decline (Deshpande, et al., 2021). Coastal districts of Gujarat, in particular, have become increasingly vulnerable (Boragapu, Guhathakurta, & Sreejith, 2023). This rise in the frequency and intensity of Arabian Sea cyclones has been attributed to rapid increase in sea surface temperatures (Deshpande, et al., 2021). Compounding these risks, west coast states are more vulnerable to sea level rise; every one-metre rise in sea level can inundate approximately 5,763 km² of land (Woodruff, BenDor, & Strong, 2018). The situation is further aggravated by significant loss of mangrove ecosystems, which are projected to continue declining beyond 2100, as per UNFCCC-IPCC 2023 report.

Climate Risks and Water and Sanitation Infrastructure and Services: Amplifying Inequalities

Access to basic services such as housing, improved sanitation, and safe drinking water forms the first line of defence against the potential impacts of climate change. These services are essential for enhancing people's resilience and adaptive capacity. Especially following climate hazards such as heavy rainfall, ensuring access to appropriate and reliable WaSH services plays a vital role in protecting populations from water-related diseases and flooding (Carlton, et al., 2014).

Further exacerbating the risks posed by climate change is the inadequate infrastructure and services in critical areas such as housing, sanitation, water, and public health, particularly for socio-economically disadvantaged groups (Rumbach, 2018); (Yenneti, Tripathi, Wei, Chen, & Joshi, 2016). This is particularly critical in small towns, which are already finding it challenging to provide universal access to water and sanitation services (Central Pollution Control Board ,

2021), and are now exposed to climate change-related risks. The climate change induced water stress and insecurity can increase the incidences of waterborne infectious diseases, thereby, hindering or reversing advancements made in related Sustainable Development Goals (SDG) targets and amplifying inequalities (Braks & Husman, 2013). The IPCC views universal access to WaSH, i.e., achieving SDG 6.1 and 6.2, as a critical adaptation strategy, with high confidence (Caretta, 2022) and a low-regret adaptation measure (Cutter, 2012). Further, SDG 1 (No Poverty) is found to be statistically linked to SDG 6 (Clean Water and Sanitation), as reducing poverty enhances adaptive capacity in alignment with the Paris Agreement’s adaptation goals (Pradhan, 2019) (Pradhan, 2019). Likewise, achieving SDG 3 (Good Health and Well-being) depends heavily on reliable access to water and sanitation infrastructure (Toni Delany-Crowe, 2019). The Intergovernmental Panel on Climate Change (IPCC) recognizes universal access to water, sanitation, and hygiene (WaSH)—as targeted in SDGs 6.1 and 6.2—as a critical, low-regret adaptation strategy, supported by high confidence (Caretta, 2022) (Cutter, 2012). Moreover, ensuring universal access to WaSH not only contributes directly to SDG 11 (sustainable cities and communities) but also promotes social equity and environmental sustainability.

Studies have predicted substantial economic losses across various sectors in India due to climate change (Chaturvedi, 2015) ; (Kumar & Maiti, 2024). For Mumbai, sea-level-rise-induced damage to building foundations between 2005 and 2050 is estimated at INR 1,501,725 crores (Kumar, Jawale, & Tandon, 2008). Further, a 2.5% decrease in growth rate is expected with one-degree Celsius temperature increase for India (Jain, O’Sullivan, & Taraz, 2020). Such economic losses may ensue from the diminished functionality of the infrastructure and, consequently, the provision of related services (Kreibich, et al., 2014) such as critical services like water and sanitation. For example, in Alibag (a small coastal town in Raigad district, Maharashtra) power lines were damaged, which led to the disruption of water supply. This lasted for 8 hours since the town did not have necessary alternative infrastructure to restore the power supply. In this context, IPCC underscores the importance of making WaSH infrastructure climate-resilient (Ben A. Smith, 2015); Shah et al., 2020) (Ashfaq Ahmad Shah, 2020). Resilient infrastructure systems should not only be able to absorb and resist the impacts of disasters but also ensure uninterrupted service delivery during crises. Moreover, they must recover quickly in a manner that reduces future vulnerabilities. Integrating resilience into the design, planning, and operation of water and sanitation systems is critical for safeguarding public health and ensuring sustainable service delivery in a changing climate. Further, beyond implementing new infrastructure, the expansion and replacement of existing WaSH systems offer crucial opportunities to integrate climate-resilient approaches and reduce greenhouse gas (GHG) emissions (Boholm & Prutzer, 2017), (Dickin, Bayoumi, Giné, Andersson, & Jiménez, 2020).

With this understanding, a landscape study on climate resilient water and sanitation infrastructure across four west coast states was initiated under the *Climate Resilient Coastal*

Cities project – a collaborative initiative of HSBC India, the India Sanitation Coalition (ISC) at FICCI, the Ashank Desai Centre for Policy Studies at IIT-Bombay (henceforth will be referred to as IIT-Bombay, unless specified otherwise) and CDD India. The initiative aims to (i) assess the climate resilience of WaSH infrastructure and services in fifteen coastal towns across the four states of Goa, Gujarat, Karnataka, and Maharashtra, (ii) analyse the related water-energy-climate policy landscape, (iii) design and implement town-level solutions in select locations, and (iv) propose recommendations to strengthen the resilience of WaSH systems. IIT-Bombay and CDD India were the research and implementation partners. Both partners conducted town-level assessments of existing WaSH infrastructure, with CDD-India focused on three towns in Maharashtra and translating the assessments into actionable climate resilient sanitation plans (CReSAPs), and IIT-Bombay, focused on the remaining twelve towns (three per state) within the scope of understanding the water-energy-climate policy landscape. IIT-Bombay additionally focussed on providing similar analysis and understanding at the state level (for each state) and national level.

Among the selected states, **Karnataka** ranks among India’s top four most climate-vulnerable regions (Mohanty & Wadhawan, 2021). **Maharashtra** is listed among the top three most climate-vulnerable states (ibid). Gujarat, with a **1,600 km-long coastlineⁱⁱ—the longest in India—and nearly 9.9 million people living across 40 coastal talukas**, faces heightened exposure to climate-related hazards such as sea-level rise, cyclones, storm surges, strong winds, heavy rainfall, and salinity ingress. **Goa** too is highly vulnerable, with projections indicating that a **1-meter rise in sea level could affect nearly 7% of its population**, potentially submerging key coastal areas.

The report focuses on presenting the findings for Karnataka. The state is third-largest state economy in India, contributing 8.77% to the national GDP. The state covers 1,91,791 sq. km (5.83% of India’s geographical area) and had a population of 61 million in 2011 (5.05% of India’s total) (Government of Karnataka, 2022). It is the ninth most populous state in the country with 38.67% of the population residing in urban areas, higher than the national average (as per Census 2011) (Government of Karnataka, 2022). It is currently rank at 8th most populace state in India (EMPRI, 2021). Increasing urbanization (by 4.68% over the last decade) in Karnataka is driving a higher demand for freshwater and sanitation services (Government of Karnataka, 2022). This is challenging in the context of climate change, as the state is already grappling with extreme droughts and water scarcity in certain regions.

The state is ranked among India’s top four most climate-vulnerable regions (Mohanty & Wadhawan, 2021). The state is facing severe cyclones in its coastal belt (coastal line extends for approximately 320 kilometresⁱⁱⁱ) and compounded flood events (Mohanty & Wadhawan, 2021). Further enhancing these risks is lack of basic infrastructure and services, particularly in specific regions. **Karnataka's Human Development Index improved from 0.429 in 1990 to 0.645 in 2019,**

however, the state lags behind other southern states in achieving the Sustainable Development Goals (SDGs)^{iv} (Government of Karnataka, 2022). For instance, in sanitation and water services, Karnataka scores 85, slightly above the national average of 83 but 15 points behind Goa, the best-performing state with a perfect score of 100. In poverty alleviation, the state scores 68, exceeding the national average of 60 but trailing Tamil Nadu, which leads with 86.

The state is also a significant contributor to national total greenhouse gas (GHG) emissions (GHG Platform India, 2018). Although Karnataka accounts for about 5% of India's population (as per census 2011), it contributed 4.42% of the country's GHG emissions in 2018 (GHG Platform India, 2018)^v. The **domestic wastewater sector**, encompassing both rural and urban areas, accounted for 53.63% of total waste sector emissions (5.37 Mt CO₂e) in 2018 (GHG Platform India, 2018). Rural areas, with 62% of the state's population, contributed approximately 56% of the domestic wastewater emissions (2.88 Mt CO₂e) in 2018 (GHG Platform India, 2018). **The primary drivers of emissions in this sector are the discharge of untreated wastewater and the widespread use of septic tanks** (GHG Platform India, 2018). **The assessment, however, overlooks energy consumption in its analysis of GHG emissions from the domestic wastewater sector. Including this factor would offer a more comprehensive understanding of emissions, particularly since municipal services in Karnataka, such as public lighting and water works, account for approximately 9% of the state's total electricity consumption (~64,000 MUs), with public water works contributing around 7.1% (Central Electricity Authority, 2022). This project aims to address this gap in the analysis.**

To address the climate change related risks, the state has a Climate Change Action Plan aligned with the national climate action framework, along with several complementary policies. Recognizing the critical link between climate change and human development, Karnataka released the Human Development Index Report 2022, which outlines strategies to improve access to essential services including water and sanitation (Government of Karnataka, 2022). Additionally, the state's latest economic survey report (2023-24) highlights the alignment of its expenditures with sustainable development goals (SDGs) and climate change and efforts to achieve them (Government of Karnataka, 2024).

The findings provide insights on the policy and governance landscape in Karnataka concerning urban water, sanitation, and climate change, focusing on how these sectoral policies interact and the implications for both. This includes a review of relevant policies, programmes, and schemes to assess how they address these intersections—whether through the lens of adaptation, mitigation, or infrastructure resilience. **Particular attention is paid to how climate change impacts water and sanitation infrastructure and services (adaptation, adaptive capacity, and infrastructure resilience dimensions), and conversely, how these sectors**

contribute to climate change (mitigation dimension). This analysis draws on the Intergovernmental Panel on Climate Change (IPCC) understanding of Adaptation, Adaptive capacity, and Mitigation^{vi}. **Within the IPCC’s framework of “universal access” to WaSH the key adaptation strategies highlighted are source water protection and augmentation (through conservation), integrated urban water management, strengthened water governance, rainwater harvesting, water conservation, leak reductions and infrastructure investments for resilience (Caretta, 2022).**

This study specifically aims to identify such solutions, while drawing on insights from the town-level studies (Mangaluru, Kundapura, Karwar) that assesses their implementation status and the challenges encountered on the ground. Mitigation refers to human interventions aimed at reducing greenhouse gas (GHG) emissions or enhancing carbon sinks. Accordingly, the **study analysis focuses on identifying policies and programmes that directly or indirectly contribute to GHG mitigation.** Further, infrastructure resilience to disasters refers to the capacity of disaster-resilient infrastructure systems to withstand and absorb shocks, maintain service continuity during crises, and recover rapidly in ways that reduce future risks (CDRI)^{vii}. **Accordingly, this report also examines whether and how the state policies incorporate resilience principles into the design, planning, and operation of critical infrastructure—particularly water and sanitation systems.** The analysis also maps the roles and responsibilities of key agencies involved in water, sanitation, and climate change.

For clarity this report is organised into seven sections. Section 1 offers a brief overview of the importance of studying the west coast in relation to climate change and its impact on the water and sanitation infrastructure and services in Karnataka and vice-versa. Section 2 outlines the methodology adopted for data collection, followed by a brief profile of Karnataka in Section 3. Section 4 explores the state’s climate exposure and vulnerability, with particular emphasis on the water and sanitation sector. Section 5 examines the prevailing funding landscape across key national and state-level programmes related to urban water supply and sanitation, while highlighting major implementation challenges. Section 6 analyses the institutional framework by examining key actors across three tiers of governance and their respective roles in delivering water and sanitation services. It further explores the policy landscape at the intersection of water, sanitation, and climate change, with particular emphasis on coastal policies—highlighting the state’s adaptation, mitigation, and infrastructure resilience measures. Drawing on town-level assessments, the section also reflects on ground-level implementation and institutional effectiveness. The report concludes in Section 7 by synthesizing key insights and offering reflections to guide future planning and policy integration

2. METHODOLOGY

The study primarily relied on secondary data sources (as outlined in Table 1). A comprehensive desk-based review was conducted, systematically analysing national and state-level portals to compile an inventory of key policies and programmes related to water, sanitation, and climate change within the WaSH sector. This review also enabled the mapping of relevant stakeholders and their institutional roles in service delivery. Additionally, it provided an overview of the status of WaSH infrastructure and services in the state, as well as data on climate exposure, vulnerability, and projected impacts at the state and district levels—particularly important in the absence of such data at the town scale.

To complement the desk review, semi-structured interviews were carried out with key stakeholders and subject-matter experts to capture contextual insights on policy and institutional frameworks governing WaSH and climate change in Karnataka. The study also draws on town-level assessments conducted in Mangaluru, Karwar, and Kundapura, which included field investigations and interviews with Urban Local Body (ULB) officials and district disaster management authorities (refer Table 2). These town-level assessments provided a grounded understanding of how state and national policies are being implemented at the local level (detailed findings are presented in the respective town assessment reports).

Table 1: Data Collection Methods

SI. No.	Objective	Data Collection Method	Data Sources
1.	To understand climate change projections, impacts and vulnerability	Secondary Data through Literature Review	Government reports: state climate change action plan, vulnerability assessment reports
		Stakeholder semi-structured Interviews	Karwar, Kundapura, Mangaluru towns
2	To understand status of WaSH services in study area	Secondary Data through Literature Review, collection from ULBs	Central pollution control board (CPCB) inventory report, State government reports, non-government sources (PAS website)
3	To understand linkages between climate change and WaSH policies and implementation of these policies	Secondary Data through Literature Review	Various reports
		Stakeholder semi-structured Interviews	Municipal officials, district disaster official (Karwar, Kundapura, Mangaluru); state level experts
4	To map current institutional environment	Secondary Data through Literature Review	State government websites and reports

		Stakeholder semi-structured Interviews	Karwar, Kundapura, Mangaluru towns
5	To map current financial sources for climate change and water and sanitation	Secondary data through literature Review, collection from ULBs	Swachh Bharat Mission (urban), Ministry of Housing and Urban Affairs (MoHUA) website, Urban Development Department, government of Karnataka and other published reports

Table 2: Selected Towns

State	Town	Population (2011)	Class
Karnataka	Mangaluru MC	4,99,487	Class-I
	Kundapura TMC	30,444	Class-III
	Karwar CMC	77,139	Class-II

Study Limitations

The findings presented in this report should be viewed in consideration of a few study limitations:

Representation of Urban Areas – Three towns were examined in greater detail to illustrate local realities. While these case examples provide valuable insights, they may not fully represent the diversity of conditions across all urban areas in the state unless specified otherwise.

Differences in Research Focus – The *Climate Resilient Coastal Cities* initiative comprises a National Report, four State Reports, and fifteen Town Reports. This document represents one of the four state-level studies. This report primarily draws on research and analysis conducted by the Ashank Desai Centre for Policy Studies at IIT-Bombay. Variation in this report and other state reports (specifically, the Maharashtra State Report) is a reflection of differing research objectives of the two research and implementation partners under the initiative^{viii}.

Scope of the Report – The study focuses on selected aspects of the water and sanitation sector that are most relevant for climate resilience and service delivery. It is not intended as an exhaustive review of the entire WaSH space but highlights priority areas where policy attention can strengthen outcomes.

Data Availability – The study relies primarily on secondary research, and the extent of analysis is therefore dependent on the quality and availability of published data and literature. Wherever possible, secondary information has been supplemented with primary inputs.

3. STATE PROFILE

Karnataka is located on the western side of the Deccan Peninsula, approximately between 11.5° N and 18.5° N latitudes, and 74° E and 78.5° E longitudes. The state shares its borders with Goa to the northwest, Maharashtra to the north, Telangana and Andhra Pradesh to the east, Tamil Nadu to the southeast, and Kerala to the southwest. The Arabian Sea forms its western boundary. In the south, Karnataka is located where the Western Ghats and Eastern Ghats meet the Nilgiri Hills. It spans an area of 191,791 km², making up 5.83% of India's total geographical area.

Geographically, state is divided into four main regions: Deccan Plateau, Western Ghats mountain range, and the coastal plains. The current study focuses on the coastal region. The region is one of the 10 agroclimatic zones (Figure 1), with its own set of challenges to climate change. It stretches from the Western Ghats in the west to the Karnataka Plateau in the east. The coastal belt varies in width from 50 to 80 km and runs approximately 320 kmⁱⁱⁱ from north to south. The terrain here is marked by rivers, creeks, waterfalls, and ranges of hills and peaks (EMPRI, 2021). **The selected towns – Karwar, Kundapura and Mangaluru fall under districts of Uttara Kannada, Udupi, and Dakshina Kannada.**

Figure 1: Agro-climatic Map of Karnataka



Source: Government of Karnataka^{ix}

Demography: The state is divided into 30 districts (Figure 2) and 176 talukas, spanning 29,340 villages, and 347 cities and towns. It currently ranks as the eighth most populous state in India. According to the 2011 Census, the state's population stood at 61 million (EMPRI, 2021). The rural population, totalling 37,552,529, grew at a rate of 7.63%, significantly lower than the 12.29% growth seen between 1991 and 2001. In contrast, the urban population, at 23,578,175, saw a growth rate of 31.27%, a slight increase compared to the 29.15% recorded in the 2001 Census (EMPRI, 2021). It is primarily an agriculture state with around 61% of rural population relying on agriculture and allied activities (Ground Water Directorate ; Central Ground Water Board, South Western Region, 2023).

Figure 2: Districts of Karnataka

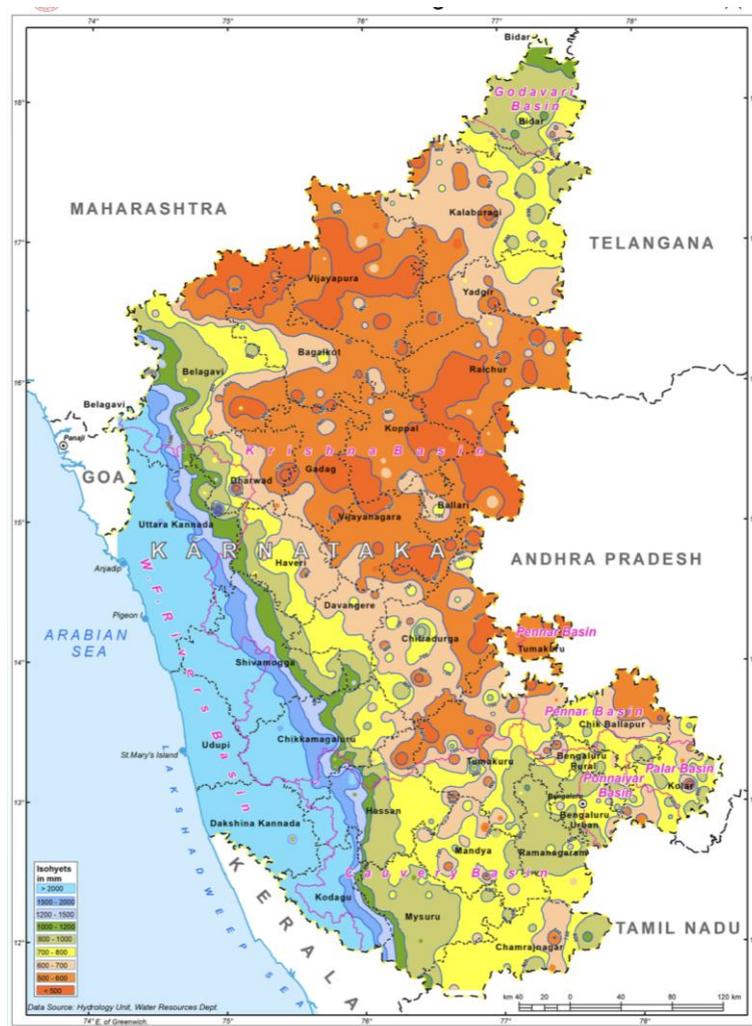


Source: <https://karnataka.gov.in/district/en> . Retrieved on 15 October 2024

Climate profile: The climate exhibits significant variation, ranging from a very humid, rainy monsoonal climate along the west coast, the Western Ghats, and Malnad regions to a warm,

semiarid, and dry climate in the eastern parts. Rainfall distribution also shows a marked contrast, with higher levels in the Western Ghats that gradually decrease towards the eastern plains. The rainfall variations across different regions are shown in Figure 3. **Coastal districts such as Uttara Kannada, Udupi, and Dakshina Kannada —where the three towns (Karwar, Kundapura, Mangaluru) selected for this study are located—recorded an average annual rainfall exceeding 2000 mm between 1992 and 2022.** In contrast, drought-prone districts like Bijapur, Raichur, and Bellary received only about 500-600 mm during the same period.

Figure 3: Annual Average Rainfall (1992-2022) in Districts of Karnataka



Source: (Water Resources Department, 2022a)

Economy: Karnataka has increased its Gross State Domestic Product (GSDP) from Rs. 22.70 lakh crore in 2022-23 to Rs. 25.01 lakh crore in 2023-24, reflecting a growth rate of 10.2% at current prices. At constant prices, the GSDP grew from Rs. 13.35 lakh crore to Rs. 14.23 lakh crore,

marking a growth rate of 6.6%. Karnataka's Gross Domestic Product (GDP) expanded by 6.6% in 2023-24, compared to India's 7.3% growth at constant prices (Government of Karnataka, 2024). In terms of share, Karnataka's GSDP accounted for 8.4% of India's total GDP in 2023-24, up from 8.3% in 2022-23. The state's per capita income reached Rs. 3,32,926, 79% higher than the national average of Rs. 1,85,854. This marks a growth of 9.3% at current prices, from Rs. 3,04,474 in 2022-23 to Rs. 3,32,926 in 2023-24. At constant prices, per capita income increased by 5.8%, from Rs. 1,75,895 to Rs. 1,86,038 (Government of Karnataka, 2024). The regional analysis in the report highlights the strong economic performance of selected towns, such as Kundapura in Udupi and Mangaluru in Dakshina Kannada, which are excelling in both per capita income and their contribution to the state GDP. For instance, Dakshina Kannada is the second-largest contributor to Karnataka's GDP in 2022-23, accounting for 5.5%, and has the second-highest per capita income in the state at Rs. 4,92,074, following Bangalore Urban district.

Water Resources: The two main river systems of the state are the Krishna and its tributaries (Bhima, Ghataprabha, Vedavathi, Malaprabha, and Tungabhadra) in the north, and the Cauvery and its tributaries (Hemavati, Shimsha, Arkavathi, Lakshmana Thirtha, and Kabini) in the south that flow eastward towards the Bay of Bengal (Water Resources Department, 2022a). Figure 4 shows river basins in Karnataka. The three selected towns in the coastal districts of Udupi, Dakshin Kannada and Uttara Kannada fall under West following river basin system.

5	North Pennar, South Pennar, Palar	932
TOTAL		107493
<p>Note: Selected towns namely Karwar, Mangaluru, Kundapura are in the coastal districts of Uttara Kannada, Dakshin Kannada, and Udipi and are part of the west flowing river system</p>		

Source: (Water Resources Department, 2022b)

In terms of ground water, state’s annual groundwater recharge is 17.74 BCM, with an annual extractable groundwater resource of 16.04 BCM (Ground Water Directorate ; Central Ground Water Board, South Western Region, 2023). **In 2022, 11.22 BCM, or 69.93%, of the extractable groundwater (16.04 BCM) is being extracted. Rainfall is the primary contributor to groundwater recharge (~17.74 BCM), accounting for 56.45%, while recharge from water conservation structures represents only 2.24%** (Ground Water Directorate ; Central Ground Water Board, South Western Region, 2023, p. 41)^x. **This highlights a significant untapped potential that could be vital for addressing the challenges posed by a growing population, urbanization, and climate change-induced droughts. This is particularly important given that the state ranks among the most water-stressed in India, with a substantial portion of its area classified as drought-prone** (Water Resources Department, 2022a)^{xi}. Detailed discussion on this is covered in next section.

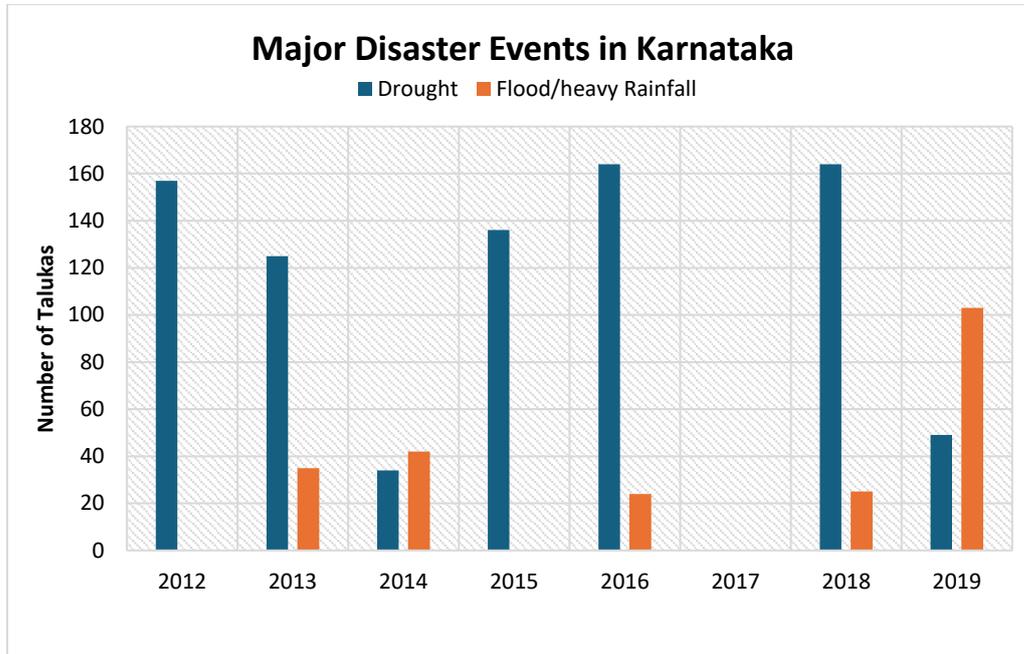
4. CLIMATE CHANGE EXPOSURE, RISK AND VULNERABILITY

Broadly, vulnerability is a function of exposure (to hazard), sensitivity, adaptive capacity (to adapt to changing circumstances), and resilience (to bounce back to the previous state). The current section highlights the status and projected exposure to climate change events, along with their potential impact on people with special focus on water and sanitation infrastructure services. The status of the water and sanitation services, at state and district level, as a function of resilience and adaptive capacity is also discussed. Since climate change exposure and vulnerability are not adequately addressed in the literature at the town level, this section focuses on the districts to which the selected towns belong to.

4.1 Climate Change and Disasters Exposure and Impact

About 80% of the State's geographical area (1,91,791 sq.km) is prone to drought, as 15 out of the last 20 years have been affected by drought conditions. Heavy rains and floods have occurred annually since 2009, with 11 out of 16 years (2005-2020) declared as heavy rain or flood-affected. Additionally, 24% of the area is vulnerable to cyclones and heavy winds, and the 359 km coastal line is at risk from sea erosion and tsunami threats (Rajan, 2022). Figure 5 illustrates the number of disaster events (floods and droughts) at the taluka level between 2012 to 2019 period. Notably, no drought events were reported in the years 2012 and 2017. These events resulted in significant losses, including damage to crops, loss of human life, harm to livestock, water schemes damages, irrigation infrastructure damages, electricity outages, and damage to roads (Karnataka State Disaster Management Authority, 2020, p. 51)

Figure 5: Number of Talukas Affected by Droughts and Floods/Heavy Rainfall in Karnataka

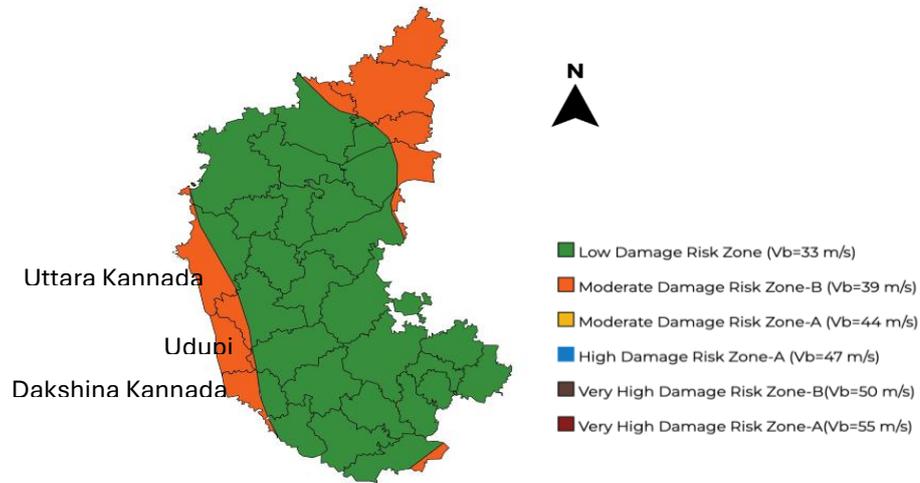


Source: (Karnataka State Disaster Management Authority, 2020)

Cyclones

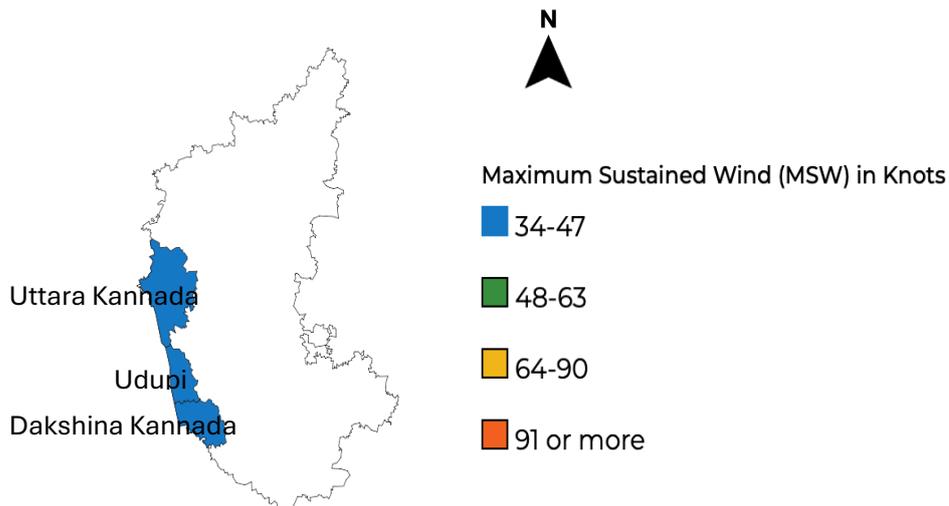
According to NITI Aayog’s Climate and Energy Dashboard, Karnataka falls within a low to medium damage risk zone for wind hazards and cyclonic activity (Figures 6 and 7) (Niti Aayog, 2025). The coastal districts of Dakshina Kannada, Udupi, and Uttara Kannada, stretching over 322 km of coastline and home to a population of 4.36 million, are at significant risk from cyclones and severe cyclones that develop in the Arabian Sea. These areas also face indirect threats from cyclones originating along the eastern coastline. Due to the dense population in these regions, they are highly vulnerable to the impacts of storm surges and powerful winds brought on by cyclonic activity (GoK, 2022). The districts (i.e., Uttara Kannada, Udupi, Dakshina Kannada) containing the selected towns (Karwar, Kundapura, Mangaluru), are classified under a moderate damage risk zone for wind hazards, with a low risk in terms of maximum sustained wind speeds (Niti Aayog, 2025).

Figure 6: Wind Hazard in Karnataka



Source: (Niti Aayog, 2025)

Figure 7: Cyclonic Winds in Karnataka (based on wind speed data between 1891-2008)



Source: (Niti Aayog, 2025)

Droughts

According to the Drought Vulnerability Report of Karnataka (2017), nearly 80% of the state's talukas (around 140 out of 176) are drought-affected, which includes almost all areas under rainfed agriculture, supporting approximately 70 lakh farming families. From 2001 onward, the state experienced droughts of varying severity for 15 years, with only three exceptions: 2005, 2010, and 2017. The primary cause of recurring droughts is the variation in the spatial and temporal distribution of rainfall during the southwest monsoon. Data from 2015, 2016, 2018, and 2019 shows that more than half of the state's regions were affected by drought. In years of severe drought, over 70% of the state is impacted. The districts most affected by drought include Chitradurga, Kolar, Tumkur, Mandya, Chikballapura, and Bangalore Rural (Government of Karnataka, 2022).

Flooding

Flood impacts are observed in fewer talukas than drought-affected ones. Karnataka experienced severe floods in 2005, 2009, 2018, and 2019. Notably, the effects of floods are felt over a shorter period compared to droughts, with flood vulnerability being particularly high in districts with higher Human Development Index (HDI), except for Raichur. Heavy rainfall in the coastal region during 2009 resulted in crop losses and deterioration in crop quality in the Malnad districts and much of north-interior Karnataka. The most affected districts in 2009 were Raichur, Koppal, Bellary, and Gulbarga. Critical infrastructure, including roads, bridges, electrical systems, schools, hospitals, and anganwadis, was heavily damaged by floods. In 2018, floods in the Western Ghat region, especially in Kodagu district, marooned entire villages and towns.

While coastal districts in Karnataka excel in HDI, MPI, and poverty levels, they face increasing vulnerability due to direct threats from cyclones in the Arabian Sea and indirect impacts from eastern coastline cyclones. Global warming-induced erosion further heightens disaster risks. Udupi, Dakshina Kannada, and Uttara Kannada are particularly cyclone-prone. While the interior plains endure droughts and heatwaves, coastal areas struggle with cyclones and seawater intrusion (Government of Karnataka, 2022). Approximately 30% of the coastal zone experiences moderate soil erosion, with 16% facing severe erosion, especially in Dakshina Kannada and Udupi. Coastal erosion and land submergence have been observed in areas like Ankola, Bhatkal, Malpe, Mangaluru, and Gokarna (Government of Karnataka, 2022). Over 320 km of coastlineⁱⁱⁱ, home to nearly 3 lakh fishermen, is at risk from rising sea levels and inundation (ibid).

Dakshina Kannada (selected town Mangaluru in Mangaluru Taluka)

Dakshina Kannada is a highly industrialized district in Karnataka, with total area of 4,859 sq km and population 2089649, and 42 km coastal length. In terms of human development, the district performs well with an impressive sex ratio of 1018 females per 1000 males and a literacy rate of 88.62%. The district is rich in rivers. The administrative headquarters of Dakshina Kannada is

Mangaluru city, located in Mangaluru Taluka, which is also the focus of our study. The two major rivers, Netravathi and Gurupura, run through Mangaluru Taluka.

Although the district lies within the cyclone-prone region affected by storms originating from both the Arabian Sea and the Bay of Bengal, historical data indicates that cyclones here are less severe and less frequent compared to those along the eastern coast of India. Same is depicted in Niti Ayog's climate and energy dashboard (refer Figure 6). The most severe cyclone on record was in 1979, although no major damage was reported at that time. In 2019, however, the district experienced four significant cyclones in the Arabian Sea—Vaayu, Hika, Kyarr, and Maha—which led to heavy rainfall due to the cyclonic effects. Historically there have been incidences of floods in the low-lying areas along the major rivers especially Netravathi and Gurpur. Highest amount of rainfall expressed (400mm) in Mangaluru Taluka on May 29th 2018 causing Urban Flooding. Mangaluru taluka received highest annual rainfall in year 2019 (Figure 5). **Mangaluru taluka and Bantwal taluka were declared drought (mostly due to deficit of rainfall and area under sowing) hit in 2016-17 by state government** (District Disaster Management Authority, 2022).

Uttara Kannada

Uttara Kannada is one of the largest districts in Karnataka, comprising eleven talukas including Karwar taluka within which Karwar town falls. Rich in natural resources, the district is characterized by dense forests covering 88% of its land, perennial rivers, and a coastline stretching approximately 140 km (Uttara Kannada District Disaster Management Authority, 2023). From Western Ghats five medium and 13 small rivers join the sea in the District. Of these, two rivers, Kali and Sharavati have dams constructed for hydroelectric purpose. Uttara Kannada district has a tropical monsoon climate, with hot and humid conditions along the coast year-round. Temperatures rise from January, peaking around 30°C in May, occasionally reaching 38°C. The district receives an average of 2,750 mm of rainfall annually over 103 rainy days, with Karwar taluk ranking among the top five for rainfall.

Cyclones in the district are low frequency and high impact hazard. Historically, the worst cyclone to hit the district was during the year 1979. No major damage was reported during that period. On the other hands floods are high frequency and high impact phenomenon. During the 2019 floods, approximately 33 villages in Uttara Kannada district were identified as flood-prone, affecting an estimated population of around 32,000 (Uttara Kannada District Disaster Management Authority, 2023).

Karwar taluka, which receives higher annual average rainfall than the district average, had total approximately people affected were close to 7000 during 2019 floods. as per Figure 9, Karwar CMC seems to be also impacted by the floods (Uttara Kannada District Disaster Management

Authority, 2023). One can see a relation between the flood frequency and increase in annual rainfall for two talukas (Karwar and Mangaluru) in Uttara Kannada (Figure 8 and Table 3). Rainfall has increased in the range of 20% to 25% in parts of the Western Ghats districts of Udupi, and Uttara Kannada districts.

Droughts in Uttara Kannada district are high frequency and high impact hazards as compared to floods (Tables 4 and 5). The district faced many drought conditions earlier due to deficit rainfall and overexploitation of ground water resource (Uttara Kannada District Disaster Management Authority, 2023).

Table 4: Impact vs Frequency Mapping of Hazards in Uttara Kannada District, Karnataka

Events	High impact low frequency	High impact High frequency
Cyclones/Heavy Rains		
Floods		
Droughts		
Sea Erosion		

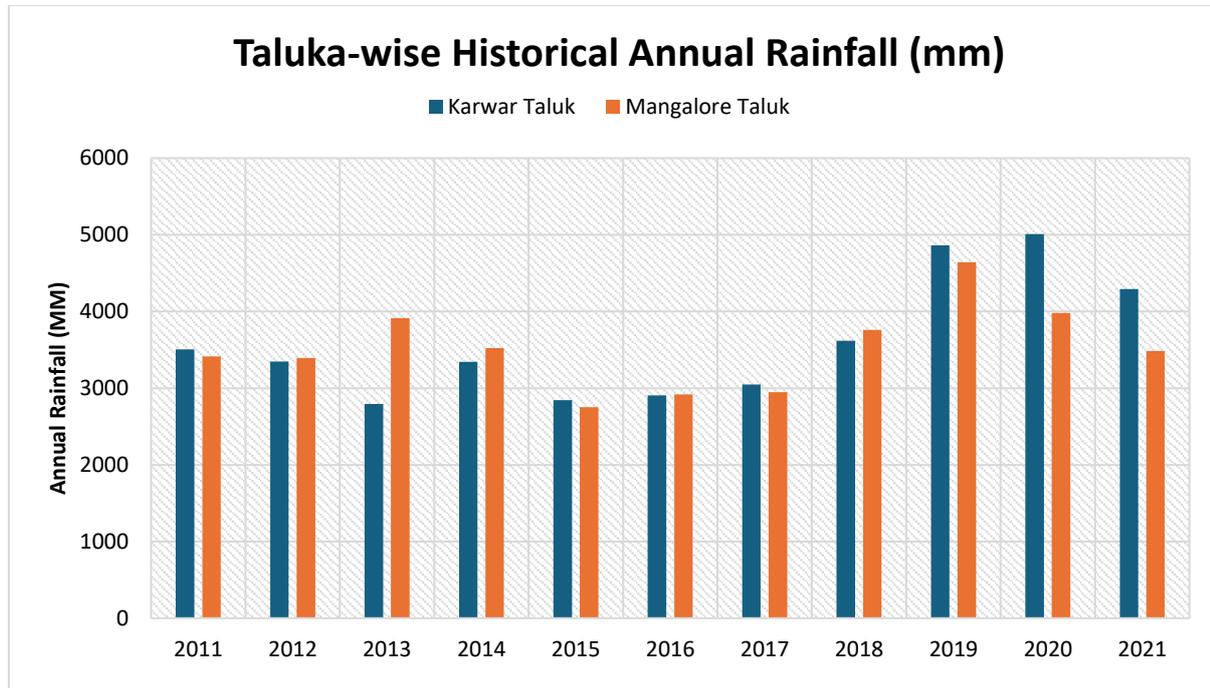
Source: (Uttara Kannada District Disaster Management Authority, 2023)

Table 5: History of Disasters in Uttara Kannada District, Karnataka

Events	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cyclones/Heavy Rains													
Floods													
Droughts													
Sea Erosion													

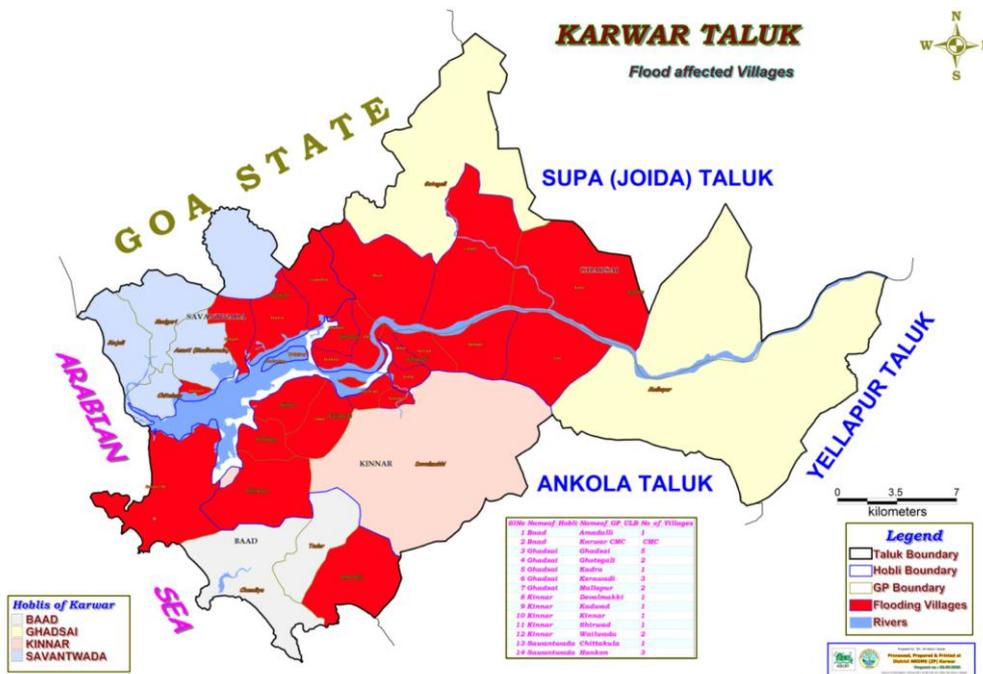
Source: (Uttara Kannada District Disaster Management Authority, 2023)

Figure 8: Historical Annual Rainfall (mm) in Karwar Taluka (Uttara Kannada), Mangaluru Taluka (Dakshin Kannada), Karnataka



Source: data from (Uttara Kannada District Disaster Management Authority, 2023)

Figure 9: Flood (2019) Affected Areas in Karwar Taluka in Uttara Kannada District, Karnataka



Source: (Uttara Kannada District Disaster Management Authority, 2023)

Udupi District

Udupi district, located on the western coast of India, lies between North Latitude 13° 8' and 14° and East Longitude 74° 30' and 75° 13'. The district has a coastline stretching nearly 100 km (Census 2011). According to the 2011 census, Udupi District has a total population of 1,177,908. The population density is 311 per square kilometre, and the literacy rate stands at 78.6%. The district experiences an average annual rainfall of 4,571 mm. In 2022, temperatures ranged from a minimum of 17.2°C to a maximum of 36°C, while in 2023, temperatures ranged from 17.6°C to 36.7°C. Groundwater in all talukas of Udupi, including Kundapura, is classified as safe, with a groundwater extraction rate of 26.92% of the annually extractable resource (11,383.58 HAM), the highest among the district's talukas. However, in 2023, three talukas—Karkala, Hebri, and Brahmavara—were declared drought-hit, while Kundapura taluka was not affected by the drought. **Kundapura town does not face any significant water shortage issues.**

Rainfall has increased in the range of 20% to 25% in parts of the Western Ghats districts of Udupi, and Uttara Kannada districts. Over the past six years, 10 villages in Kundapura taluka have been affected by floods. During the floods of 2019 and 2023, residents of Kundapura taluka had to be relocated to safer areas (District Disaster Management Authority Udupi, 2024).

Kundapura town is vulnerable to cyclone and sea erosion (District Disaster Management Authority Udupi, 2024).

4.2 Climate Change Projections

Projected monthly rainfall under the RCP 4.5 and RCP 8.5 scenarios^{xii} indicates that Udupi district will receive the highest annual rainfall, totalling 4,635.1 mm. Uttara Kannada is projected to receive 2,461.7 mm of annual rainfall, while Dakshina Kannada is expected to see 2,602.6 mm annually. In Karnataka, an increase in the number of rainy days is projected for a majority of the districts of Karnataka, under both RCP 4.5 and 8.5 scenarios. The increase in the number of rainy days is ≥ 5 days annually in 6 districts under RCP 4.5 scenario, and 22 districts under RCP 8.5 scenario.

In Karnataka, increase in the occurrence of ‘Very High’ and ‘High’ intensity rainfall events is projected, largely in the range of 1 to 2 events annually, under both RCP 4.5 and RCP 8.5 scenarios. ‘Very High’ intensity rainfall events are projected to increase in the range of 1 to 2 events annually, for 25 districts under RCP 4.5 scenario and 29 districts under RCP 8.5 scenario. **‘Drought’ years are projected to decline**, in the range of 1 to 3 years under RCP 4.5 scenario, and 1 to 4 years under RCP 8.5 scenario for Short-term (2030s), in a majority of the districts of Karnataka including Uttara Kannada and Dakshina Kannada. **No change is expected for Udupi district.**

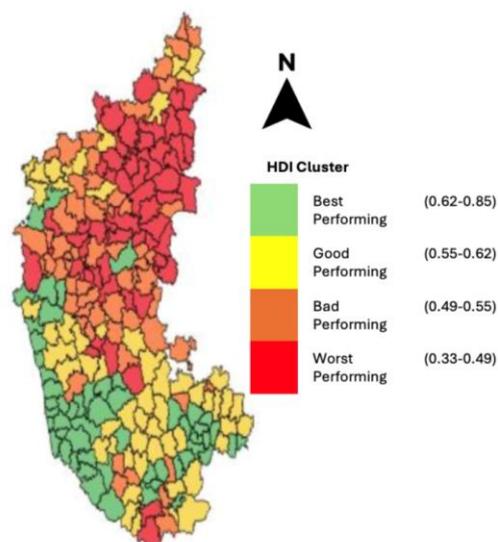
The temperature in the state ranges from 23°C - 43°C during summers and 9°C to 27°C during winters. Across the districts of Karnataka, a rise in summer maximum temperatures ranging from 0.5°C to 2.5°C is expected^{xiii}. Under the RCP 8.5 scenario, the projected warming for the 2030s (short-term) is expected to range between 0.5°C and 1.5°C across the state. **Specifically, the Western Ghats districts, including Uttara Kannada, Udupi, and Dakshina Kannada, are anticipated to experience a warming of 0.5°C to 1°C.** According to the State Action Plan on Climate Change and Human Health, 15 districts in Karnataka, excluding Uttara Kannada, Udupi, and Dakshina Kannada, are particularly vulnerable to heat waves (Government of Karnataka, 2023)^{xiv}.

4.3 Vulnerability: Socio-economic and Water and Sanitation Infrastructure and Services

Access to basic services such as housing, improved sanitation, and safe drinking water forms the first line of defence against the potential impacts of climate change. These services are essential for enhancing people’s resilience and adaptive capacity. The Intergovernmental Panel on Climate Change (IPCC) recognizes universal access to water, sanitation, and hygiene (WaSH)—as targeted in SDGs 6.1 and 6.2—as a critical, low-regret adaptation strategy, supported by high confidence. Moreover, ensuring universal access to WaSH not only contributes directly to SDG 11 (sustainable cities and communities) but also promotes social equity and environmental sustainability.

This section thus discusses status of basic services with special focus on water and sanitation services. It also highlights GHG emissions related to water and sanitation and the financial performance of the sector, both of which have significant implications for climate-resilient planning. The state's Human Development Index (HDI) has improved from 0.429 in 1990 to 0.645 in 2019. However, it still lags other southern states in achieving the Sustainable Development Goals (SDGs) (Government of Karnataka, 2022). Figure 10 illustrates the HDI across various talukas in the state, clearly showing that the talukas of Dakshina Kannada, Uttara Kannada, and Udupi districts fall under the best-performing category.

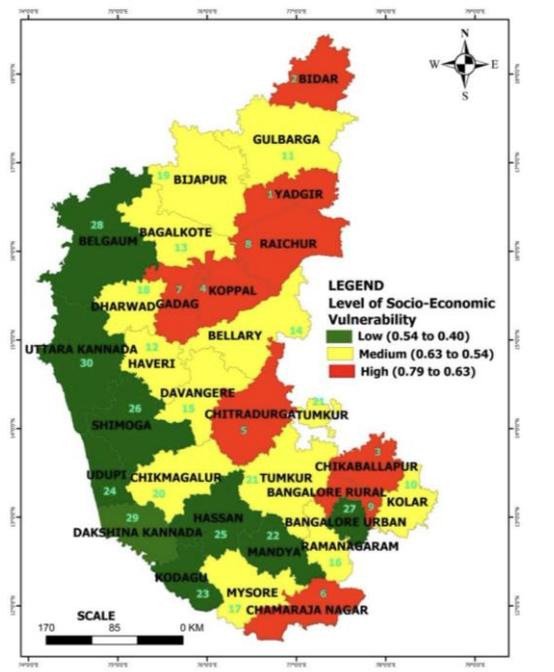
Figure 10: Taluka-wise HDI in Karnataka (2022)



Source: (Government of Karnataka, 2022)

As per State Climate Action Plan, the three districts among also fall under the low socio-economic vulnerability to climate change (Figure 11). The lowest socio-economic vulnerability district shows that Uttara Kannada (vulnerability index 0.40). The key drivers of vulnerability considered in the analysis by the study, are population density, proportion of SC/ST population (lowest for Udupi district), literacy (high for all three districts), net irrigated area (lowest for Udupi) (EMPRI, 2021).

Figure 11: Socio-economic Vulnerability Index



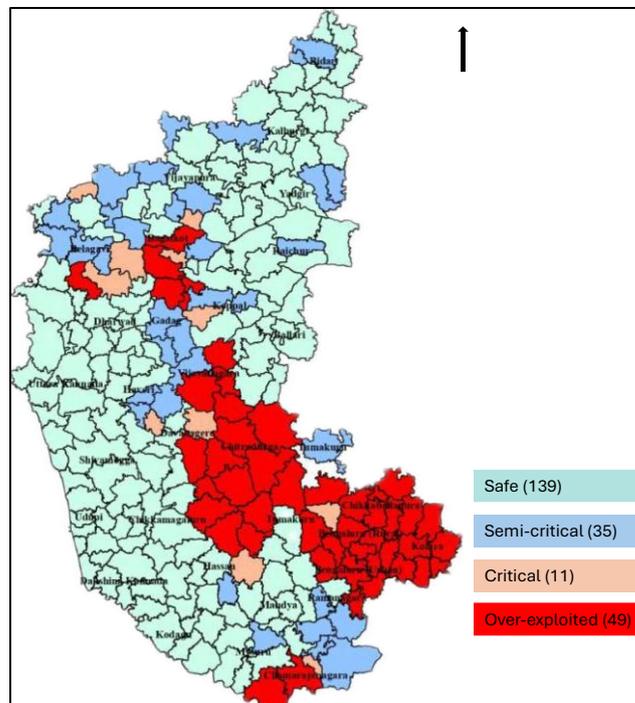
Source: (EMPRI, 2021)

Water Resources, Supply and Scarcity

The State Water Policy (2022) accords “overriding priority” to domestic water needs over irrigation, livestock, fisheries and aquaculture, hydropower, industries, ecology and other uses (Water Resources Department, 2022a, p. 8). This is reflected in National Family Health Survey (NFHS-5)-India (2019-20) survey with 90% of households in Karnataka having basic drinking water service, and 96% households use an improved source of drinking water. However, only 47 % have water piped into their dwelling, yard, or plot. Urban households (59%) are more likely than rural households (38%) to have water piped into their dwelling, yard, or plot (International Institute for Population Sciences ; ICF, 2022)^{xv}. The lack of piped water connectivity and increasing population and urbanisation translate to over exploitation extraction of ground water.

For example, there has been a 7.58% increase in annual ground water extraction, rising from 65% in 2020 to 69.93% in 2022 (Water Resources Department, 2022a). As illustrated in Figure 5, among the 234 assessment units (talukas), 49 (20.94%) are categorized as 'Overexploited,' 11 (4.70%) as 'Critical,' 35 (14.96%) as 'Semi-critical,' and 139 (59.40%) as 'Safe' (Ground Water Directorate ; Central Ground Water Board, South Western Region, 2023)^{xvi}. **The groundwater assessment units in the coastal regions, including Dakshina Kannada, Uttara Kannada, and Udupi, are classified under the safe category** (Ground Water Directorate ; Central Ground Water Board, South Western Region, 2023).

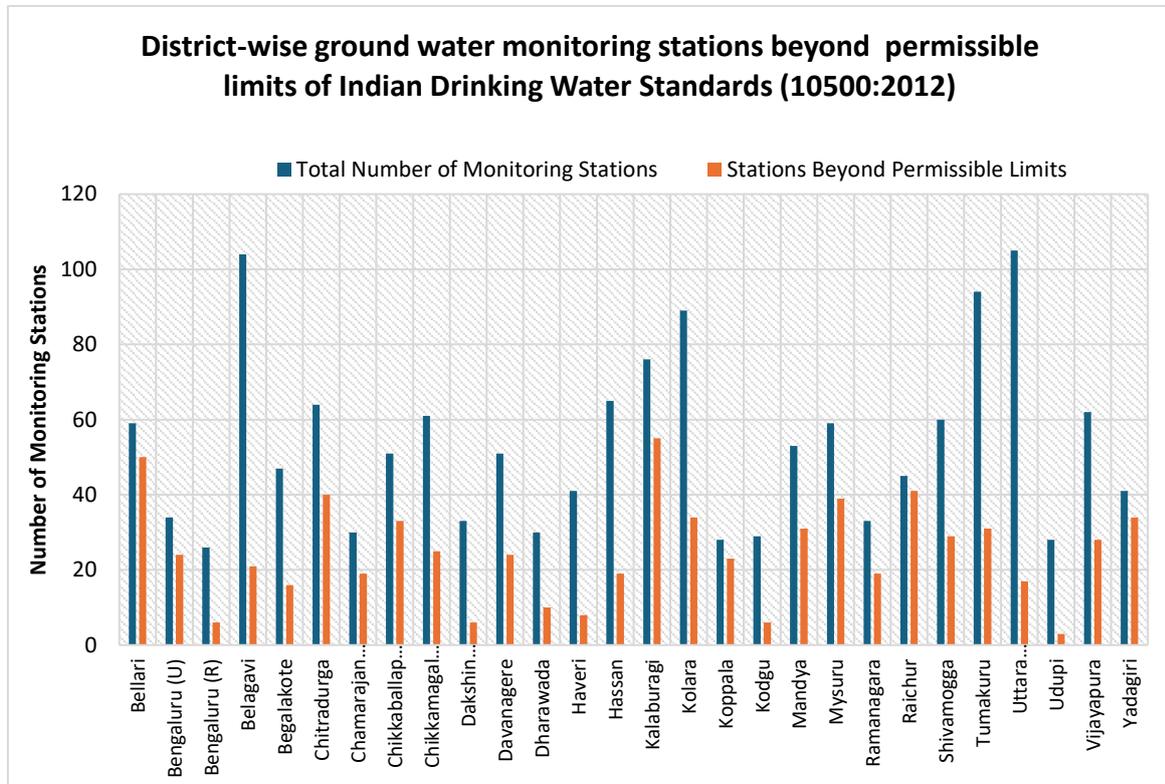
Figure 12: Status of Ground Water in Assessment Units in Karnataka



Source: (Ground Water Directorate ; Central Ground Water Board, South Western Region, 2023)

Scarcity is also a function of lack of reliable quality drinking water. The district-wise groundwater quality assessment for 2018 (Figure 13) reveals that 46% of the total monitoring stations recorded groundwater quality exceeding the permissible limits set by the Indian Drinking Water Standards (IS 10500:2012) (Ground Water Directorate, 2019). **Notably, the districts of Uttara Kannada, Udupi, and Dakshina Kannada, which encompass the three selected towns, rank among the bottom three in terms of the lowest percentage of ground water monitoring stations meeting the permissible drinking water standards (Figure 13) (ibid).**

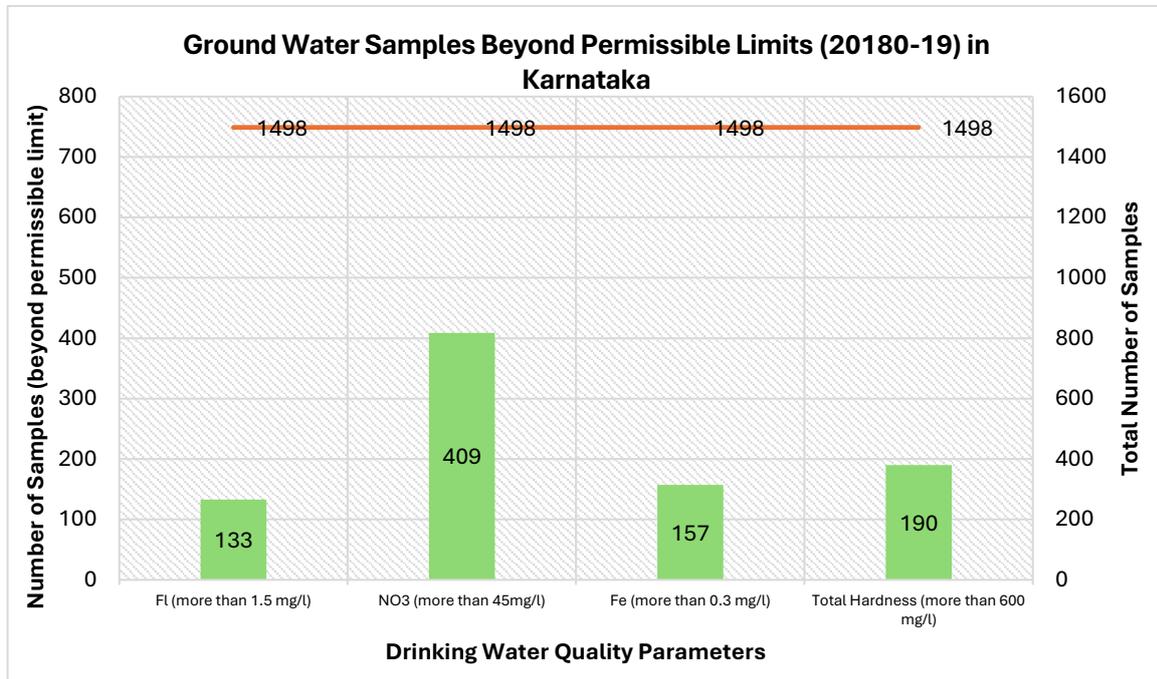
Figure 13: District wise ground water monitoring stations beyond permissible limits of Indian Drinking Water standards



Source: data from (Ground Water Directorate, 2019)

In terms of groundwater quality, a significant number of samples exceeded the permissible nitrate limit (>45 mg/L) (Figure 14) ^{xvii}, rendering them unsuitable for drinking and domestic use (Ground Water Directorate, 2019).

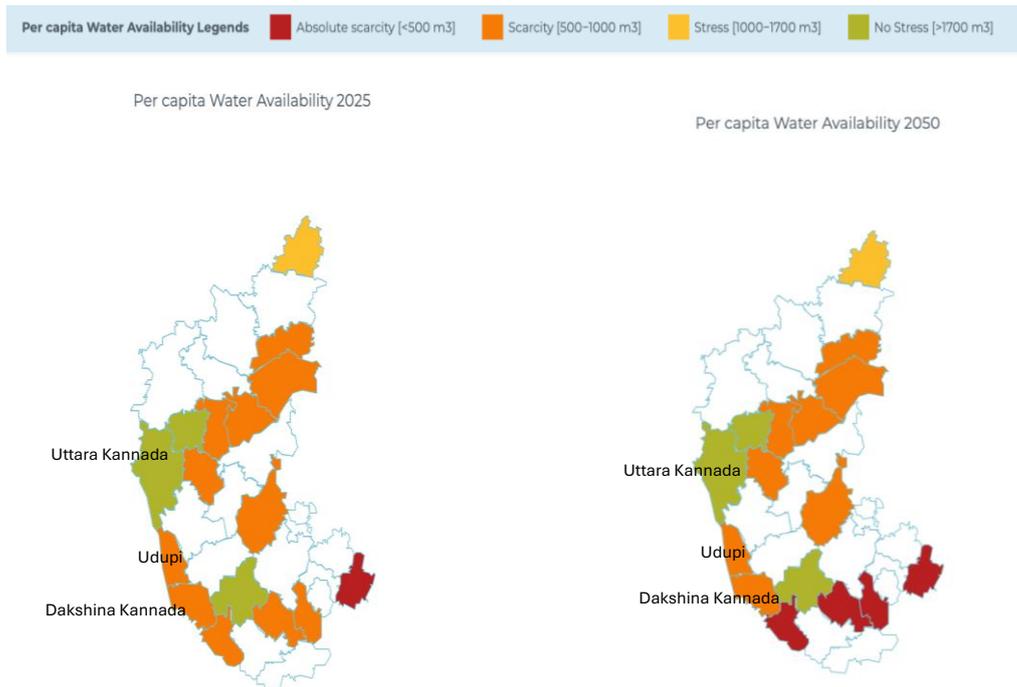
Figure 14: Ground Water Quality (Fluoride, Nitrate, Total Iron, Total Hardness) in Karnataka



Source: data from (Ground Water Directorate, 2019)

This makes state as one of the most water-stressed states in India, with large area of the State in the drought prone area as per State water policy-2022 (Water Resources Department, 2022a). **The three towns, located in the districts of Udupi, Dakshina Kannada, and Uttara Kannada are projected to fall under the scarcity category in terms of per capita water availability by 2025, while Uttara Kannada is expected to remain in the no-stress category. This status is anticipated to persist through 2050 (Figure 15).**

Figure 15: Karnataka District-wise Water Stress and Scarcity in 2025 and 2050



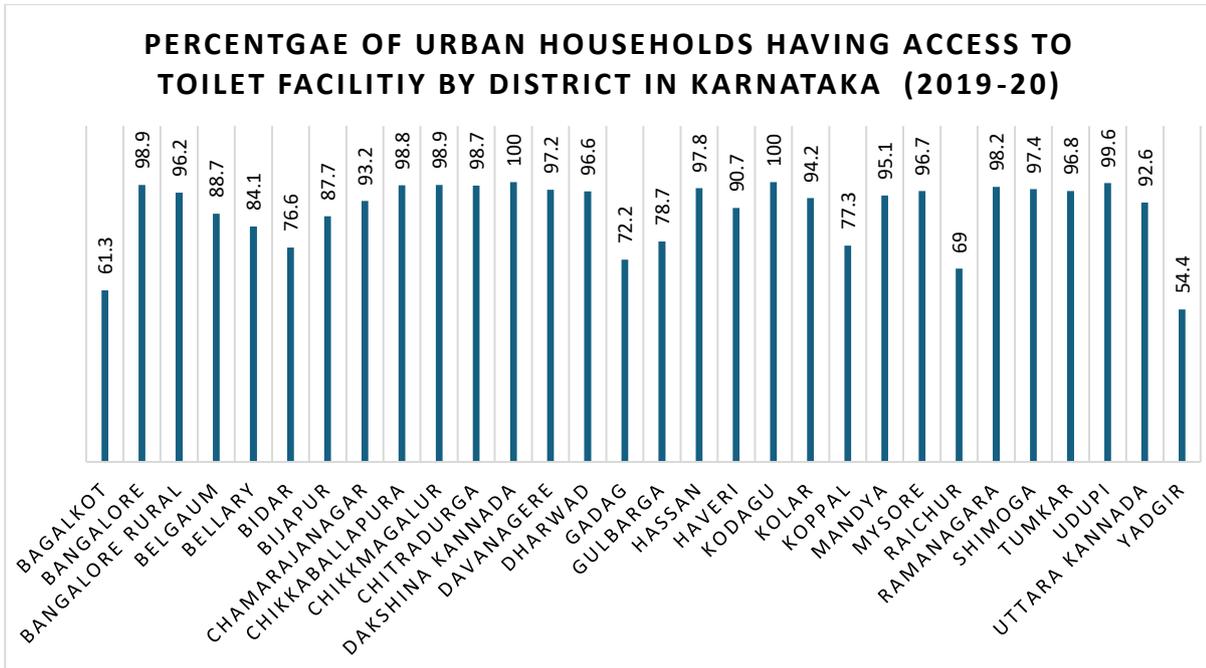
Source: (NITI Aayog , 2024)

Sanitation and Wastewater Management

As far as sanitation is considered, 18% of all households, including one-quarter of rural households, do not use a sanitation facility; they use open spaces or fields. In Karnataka, 83% of households have access to a toilet facility, with a much higher accessibility in urban areas (93%) than in rural areas (76%). Access to a toilet facility for households ranges from 76% among scheduled castes to 88% among those households not belonging to a scheduled caste, scheduled tribe or another backward class. **The access to a toilet facility in districts varies widely across the districts (Figure 16), ranging from 47% in Yadgir district to all households in Dakshina Kannada district. Interestingly, all households in urban areas have access to a toilet facility in only three districts (Dakshina Kannada, Kodagu, and Udupi).**

68.4% of the households in Karnataka have Flush/pour flush connected to piped sewer system, septic tank, or pit latrine. In urban areas around 78% of the households have Flush/pour flush connected to piped sewer system, septic tank, or pit latrine, in rural areas this percentage is 61.3% (International Institute for Population Sciences and ICF, 2021).

Figure 16: Percentage of Urban Households with Access to Toilet Facility: Districts of Karnataka (2019-2020)



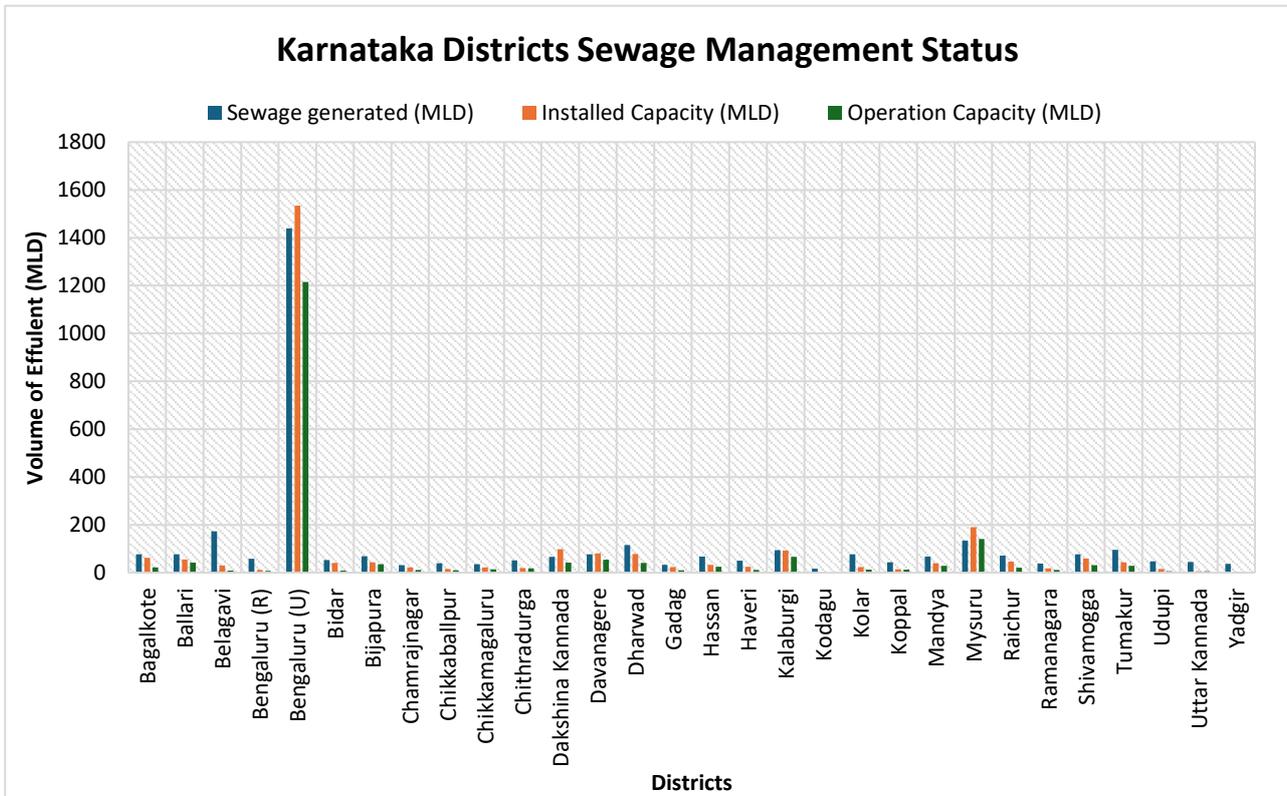
Source: data from (International Institute for Population Sciences and ICF, 2021)

Wastewater Pollution, Management and GHG Emissions

According to the Central Pollution Control Board (2021), urban centres in Karnataka generate 4,458 MLD of wastewater, with an installed sewage treatment plant capacity of 2,712 MLD (61%). However, only 1,786 MLD is treated, reflecting the operational treatment capacity. Of this treated volume, just 1,168 MLD meets (~65% of treated effluent) the environmental standards set by the state pollution control board (Central Pollution Control Board , 2021).

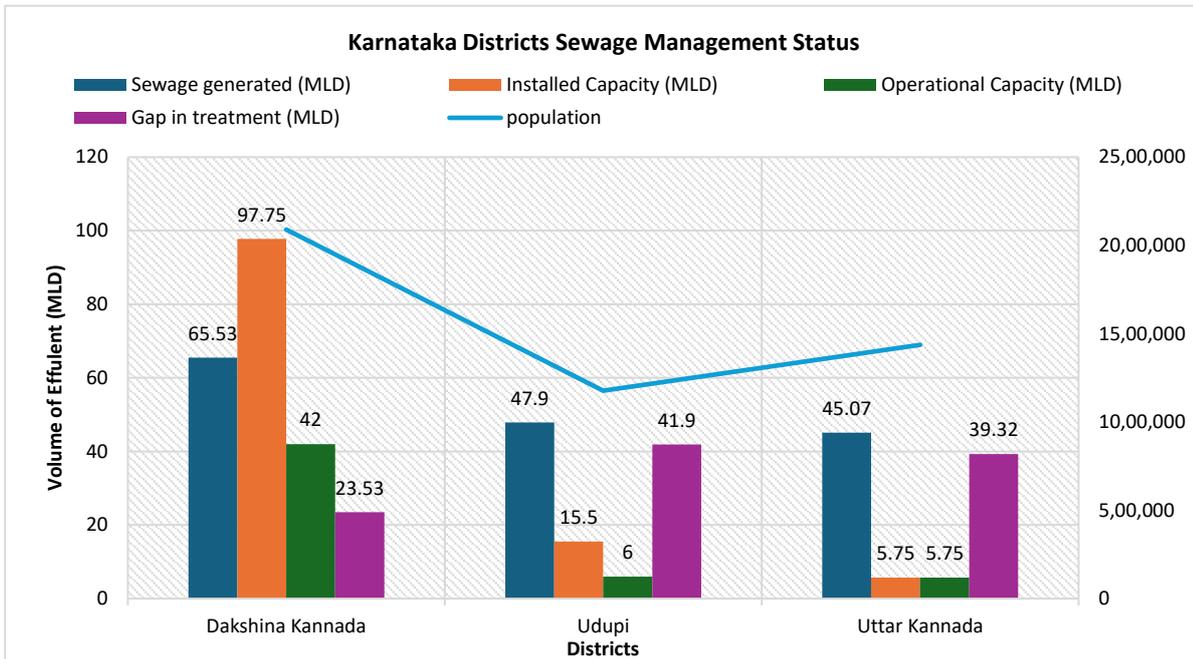
The State Economic Survey 2023 indicates that Bangalore Urban is the largest wastewater generator in Karnataka, while approximately 26 districts lack the installed capacity required to treat the wastewater, they generate (Government of Karnataka, 2024). Dakshina Kannada has exceeded its required treatment capacity, whereas Uttara Kannada and Udupi fall significantly short (Figures 17 and 18). Among the three study towns specifically, the STPs in Mangalore (Dakshina Kannada district) are not operating at full capacity due to deficiencies in the town’s sewerage system. At Karwar (Uttara Kannada district), the STP has an installed capacity of 1.5 MLD that falls short against the 5.2 MLD wastewater that is generated. While at Kundapura (Udupi district) there is neither an STP nor an FSTP. The town relies on suction trucks which are improperly discharging the liquid septage directly into manholes that release the liquid into marine and aquatic ecosystems, while the solid sludge is transported to a sedimentation pond that the research team could not locate.

Figure 17: Status of Sewage Management in Districts of Karnataka



Source: data from (Government of Karnataka, 2024)

Figure 18: Status of Sewage Management in Uttara Kannada, Dakshina Kannada, Udupi Districts of Karnataka



Source: data from (Government of Karnataka, 2024)

The state's subpar performance in provisions of wastewater infrastructure has resulted in a significant proportion of untreated wastewater being released, contributing to GHG emissions and water pollution. Discharge of untreated wastewater and use of septic tanks are the key drivers of emissions due to Domestic Wastewater sub-sector. **In 2018, domestic wastewater had a share of ~54% in the total waste sector emissions (5.37 Mt CO₂) of Karnataka (GHG platform India). Emissions from Domestic Wastewater of both rural and urban areas grew at a CAGR of 2.86% from 1.99 Mt CO₂e in 2005 to 2.88 Mt CO₂e in 2018 (GHG platform India).**

GHG Emissions in UWSS in Karnataka

Electricity consumption in public water works and sewage pumping (2022-23) = 4,729.51 million KWh; which is equivalent to 4.02 Mt CO₂e

Domestic wastewater had a share of ~54% in the total waste sector emissions (5.37 Mt CO₂) of Karnataka



Indirect GHG emissions in public water works (water and wastewater management) result from electricity consumption. The electricity consumption in the public water works amount to average 7% of the total energy consumption (63673.5 MUs) in the state between 2021-2023. The electricity consumption in public water works (water and sewage pumping) was ~ 4,729.51 million KWh in 2022-23, which is equivalent to 4.02 Mt CO₂e of GHG emissions (Government of Karnataka, 2024, p. 335).

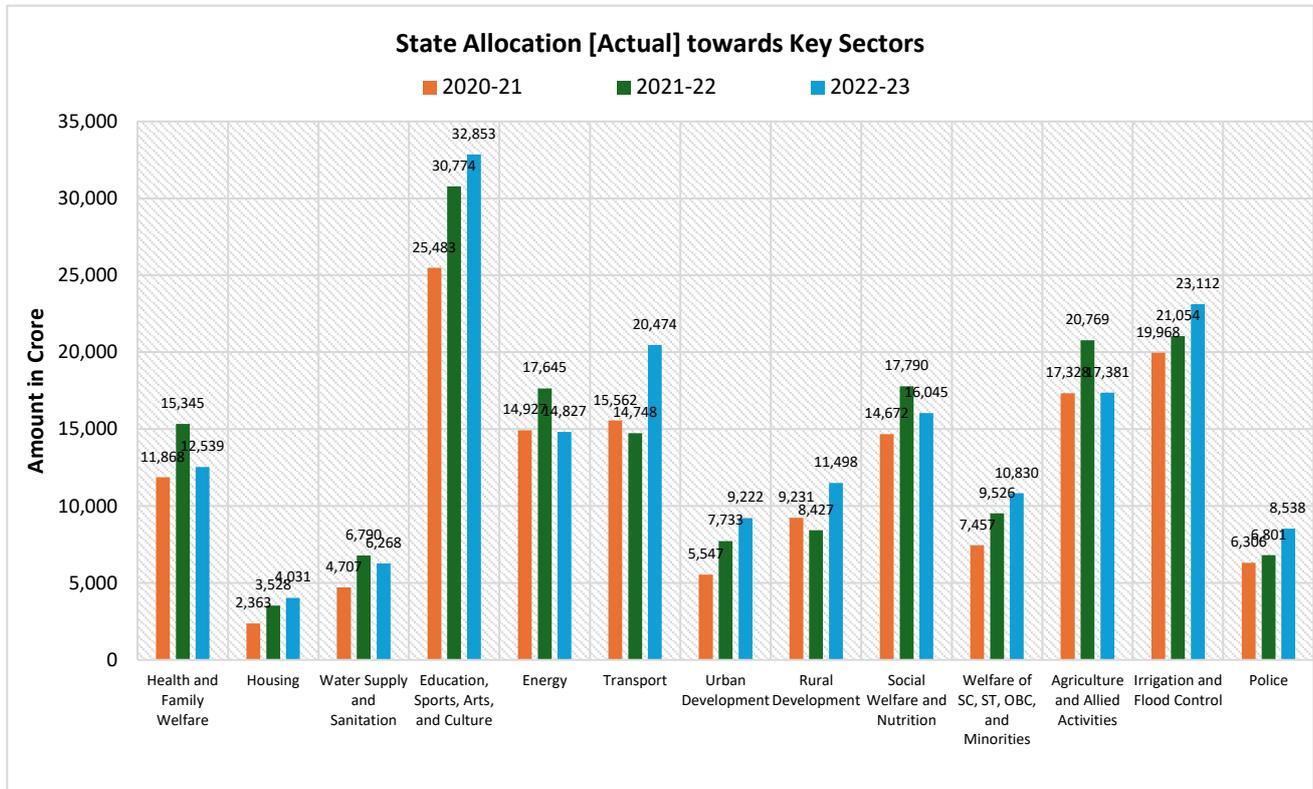
5. PROGRAMMES AND SCHEMES IN URBAN WATER AND SANITATION

For the developed of water and sanitation infrastructure and services in urban areas, the state depends upon both the centrally sponsored schemes such as the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), UIDST, and the Swachh Bharat Mission (SBM) and its own funds. The section highlights key sources of funding for the water and sanitation sector in Karnataka state.

Total Funds and Trends in Allocations

The Karnataka Urban Water Supply and Drainage Board has proposed outlay of INR 3515.79 Crore for the Financial year 2024-25, which includes total Capital outlay of INR 2988.20 Crore (from state INR 600 Crore, from Centre INR 1865.00 Crore, ULB's own contribution)^{xviii}, Revenue and Debts (INR 221.44 crore), and Deposits and Suspense accounts (INR 283.39 Crore). For Capital fundings from the Centre UIDST, AMRUT and JnNURM schemes are included (Karnataka Urban Water Supply And Drainage Board, 2024). **While the allocation to water and sanitation grew at a 10% CAGR from 2020-21 to 2022-23, the sector continues to rank among the lowest in both absolute numbers and proportion of total allocation, along with housing and urban development.** In contrast, the largest allocations were made to the education, sports, arts, culture, agriculture, irrigation, transport, and energy sectors (Figure 19).

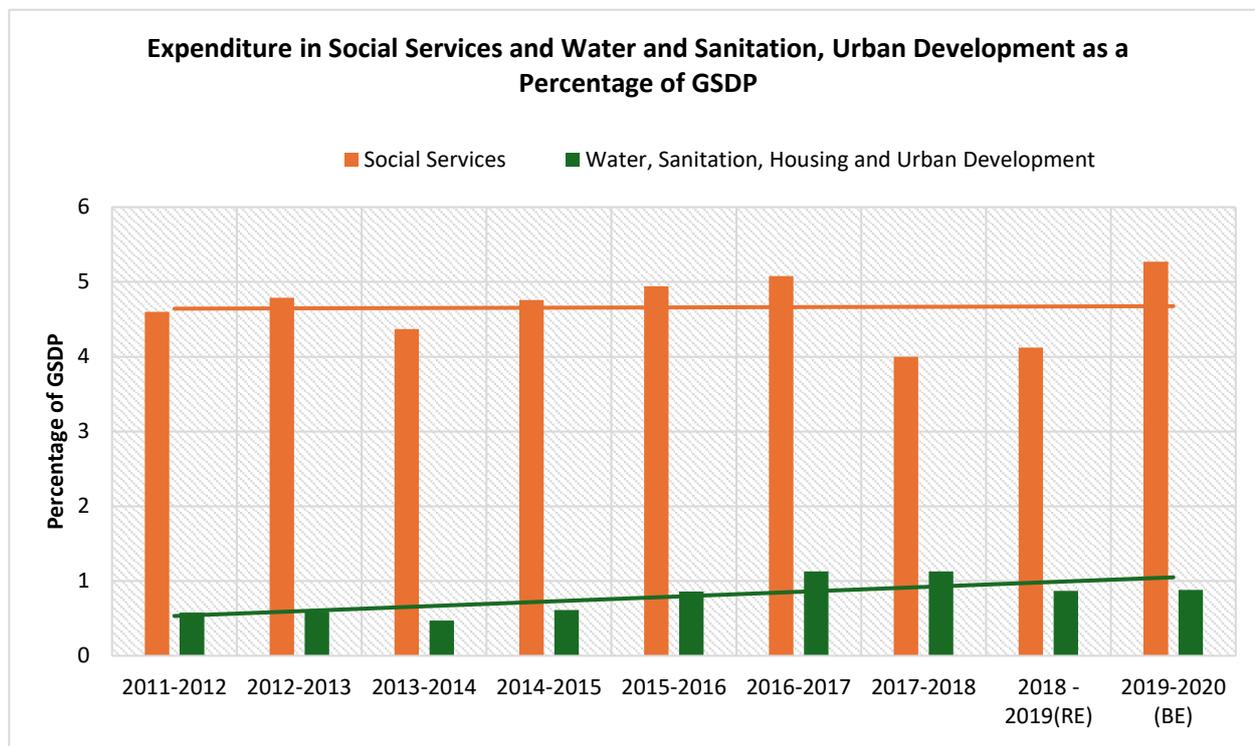
Figure 19: State Allocation towards Key Sectors including Water and Sanitation (2020 to 2023)



Source: data from (PRS Legislative Research , 2024)

The expenditure on social services as a percentage of Gross State Domestic Product, particularly in the water and sanitation, housing, and urban development sectors, has grown at a comparable rate (Figure 20). This increase became especially evident after the 2014-2015 period, largely driven by the central government's Swachh Bharat Mission (SBM).

Figure 20: Expenditure in Social Services and Water and Sanitation, Urban Development as a Percentage of GSDP



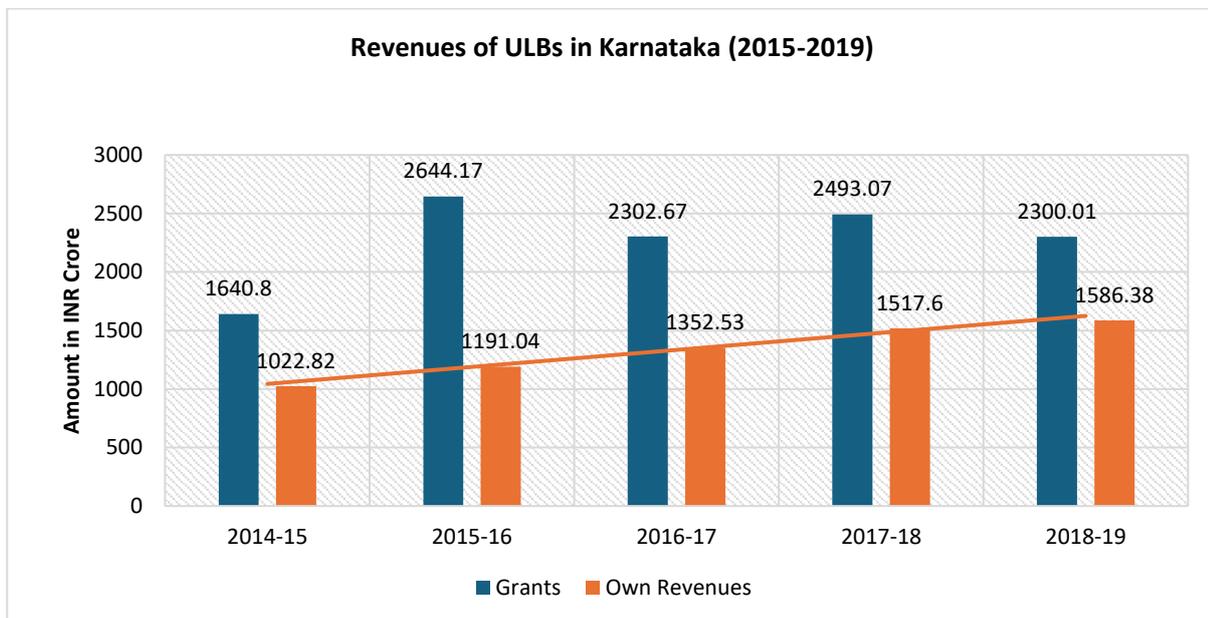
Source: data from (Jacob & Chakraborty, 2020)

ULB Funds

The total resources of ULBs can be classified under four major categories: (i) Own resources: tax revenue (property tax, vacant land tax, water benefit tax, advertisement tax, sewerage benefit tax, tax on animals, and taxes on carriages and carts), non-tax revenue (user charges, betterment charges, development charges, sale and hire charges, water supply and sewerage donations, market fees, trade licensing fees, parking fees, layout/building approval fees, slaughterhouse fees, and birth and death registration fees) and other receipts; (ii) Assigned/shared revenues : taxes levied and collected by the State government and shared with or passed on to the local bodies such as Entertainment tax, professional tax, surcharge on stamp duty, entry tax, and motor vehicles tax;(iii) Grants: Central and State Finance Commission grants, central and state grants under various programmes and schemes such as Smart Cities Mission, Swachh Bharat Mission, Atal Mission for Rejuvenation and Urban Transformation; and (iv) Loans from State and Central governments, banks and borrowings through municipal bonds.

The recent CAG report highlights a steady upward trend in the Urban Local Bodies' (ULBs) own resources to their total financial resources between 2014 and 2019, as evidenced in Figure 21 (Comptroller and Auditor General of India, 2020). However, grants to ULBs do not follow a clear trend. There is a sharp increase of 38% post-2014-15 (likely due to SBM), followed by a sudden decline of 15% in 2016-17, an 8% rebound, and another 8% decrease thereafter.

Figure 21: Funding Sources to ULBs in Karnataka

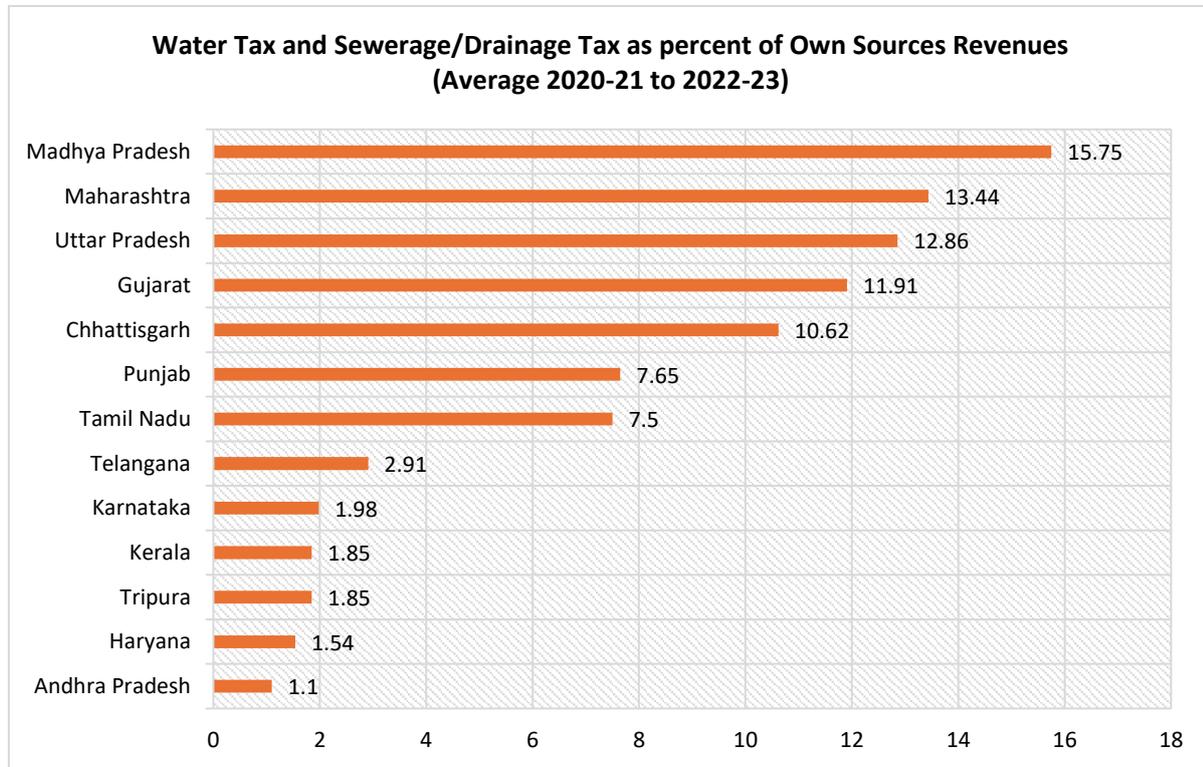


Source: data from (Comptroller and Auditor General of India, 2020)

As part of the own revenue, the property tax remains a main contributory sector across different cities in India (Department of Economic and Policy Research, 2024). This is true for Karnataka ULBs as well (ibid).

A comparison across states (Figure 22) reveals that, Karnataka performs poorly in terms of the share of water and sewerage/drainage taxes as a percentage of its own revenue sources, especially when compared to Southern states (Tamil Nadu and Telangana) and Western states (Maharashtra and Gujarat) with higher HDI (see, Government of Karnataka, 2022, pp. 28,51,58,253).

Figure 22: State-wise share of Water Tax and Sewerage/Drainage Tax as percent of Own Sources Revenues (Average 2020-21 to 2022-23)

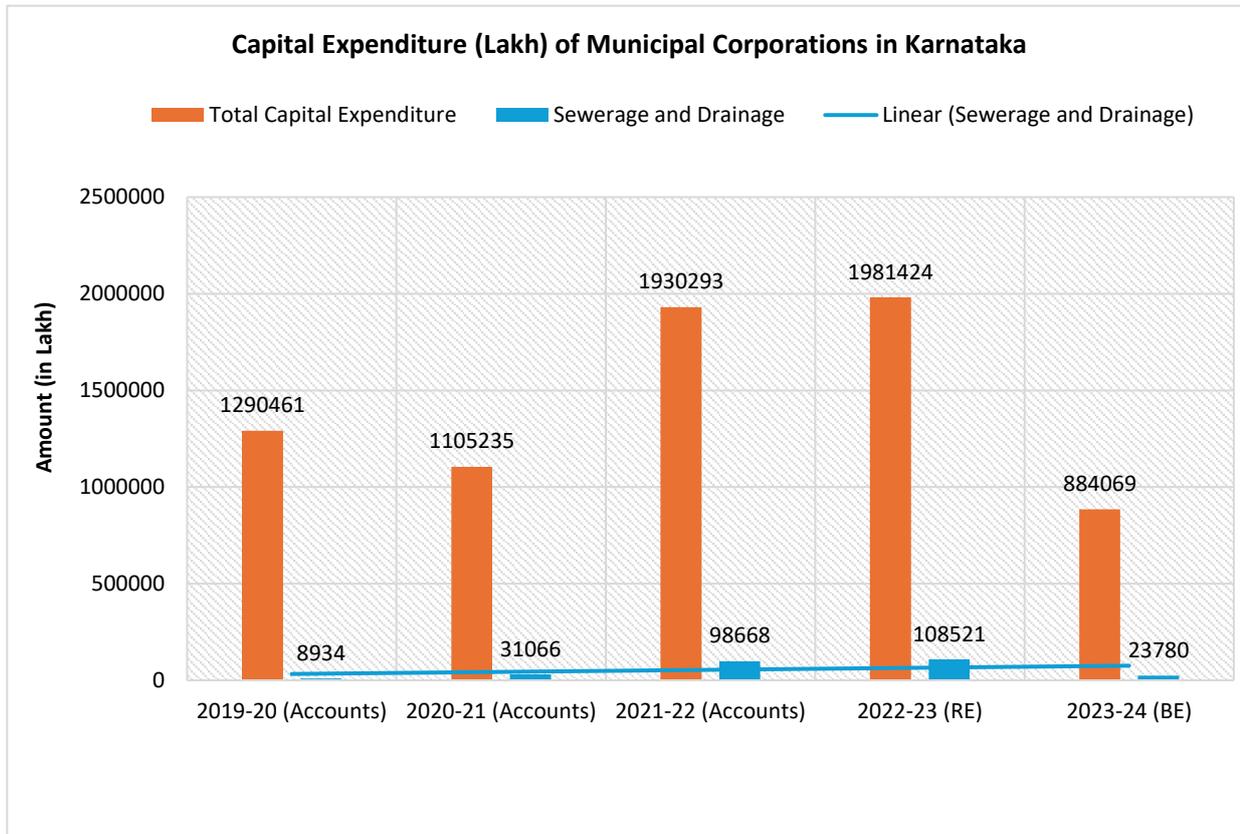


Source: data from (Department of Economic and Policy Research, 2024)

Expenditure In Water and Sewerage at ULB level

Figure 23 shows that between 2019 and 2022, capital expenditure in the sewerage and drainage sector of municipal corporations in Karnataka has steadily increased. However, this sector still accounts for only 3-5% of total capital expenditure.

Figure 23: Capital Expenditure (Lakh) in Sewerage and Drainage Sector at Municipal Corporation level In Karnataka



Source: data from (Department of Economic and Policy Research, 2024)

6. STATE POLICY AND INSTITUTIONAL LANDSCAPE IN CLIMATE CHANGE AND WATER AND SANITATION

The climate change and water and sanitation sectors are governed by multiple institutions, each with distinct mandates and policy frameworks. Understanding these institutions is essential for identifying key stakeholders — including those responsible for financing, technology selection, infrastructure development, and policy implementation — as well as for assessing overlaps, and coordination challenges. This understanding is critical to enhancing resilience in the water and sanitation sectors.

This section is organised into two parts: The first part presents a comprehensive review of the current governance landscape at the state level. The second part examines relevant policies related to water and sanitation, climate change and disaster management, with a focus on identifying implementation challenges at the town level.

6.1 Institutional Landscape

6.1.1 State Level

Water is a concurrent subject, while sanitation falls under the State List. Under the 74th Constitutional Amendment Act, Urban Local Bodies (ULBs) are primarily responsible for the delivery of water supply and sanitation services. However, in practice, the governance of these services operates within a complex, multi-stakeholder, and multi-level framework.

According to the 7th Schedule of the Constitution of India, water is a state subject and the state has the prerogative to take decisions about the available water resources within the state jurisdiction. The central ministry of housing and urban affairs (MoHUA) formulates the policies, rules or laws and the states have the authority to adopt the policies in their respective states. The Central Public Health Environment and Engineering Organisation (CPHEEO) is the technical arm of the Ministry of Housing and Urban Affairs (MoHUA), which formulates and defines the service level benchmarks (SLBs) for water supply and sewerage. CPHEEO also drafts the manuals, guidelines, and policies that are applicable to all municipalities in the country. However, the state makes policies within the national policy framework.

The Central Pollution Control Board (CPCB), under the Ministry of Environment, Forests, and Climate Change, sets environmental pollution standards that State Pollution Control Boards (SPCBs) enforce. Urban local bodies and state water and sewerage boards must comply with

these standards. As per the three-tier structure of governance in India, the state approves the central policies or centrally sponsored schemes and the ULB implements the action plans based on the policies and guidelines, such as the Atal Mission for Rural and Urban Transformation (AMRUT). The state sponsored schemes are driven by the state urban development department (UDD). Thus, the source of grants for AMC is mainly the central and state schemes.

The design and construction of sanitation facilities involve a network of institutions: ULBs are responsible for operation and maintenance (O&M) and construction at the city level, while in smaller towns, ULBs handle only O&M, with the Public Health Engineering Department (PHED) taking charge of construction. Additionally, the standards for the design and construction of onsite sanitation systems (OSS) and sewerage/water supply infrastructure are governed by distinct organizations: the CPHEEO and the Bureau of Indian Standards (BIS), respectively. Further, energy-related aspects of water and sanitation sector fall under the purview of the Ministry of Power and the Karnataka Renewable Energy Limited (KREDL), with programs like MEEP, while renewable energy generation from sanitation facilities is overseen by the Ministry of New and Renewable Energy (MNRE) through various central bioenergy programs.

At the state level, various departments, agencies, and organizations are involved not only in the provision of water and sanitation infrastructure and services but also in broader climate change governance and disaster management (refer to Table 6). The Environmental Management and Policy Research Institute (EMPRI) functions as the State Nodal Agency for Climate Change, providing technical support for research, training, and capacity-building programmes, and has developed the State Climate Change Action Plan.

The Urban Development Department (UDD) oversees policy implementation and funding of major urban infrastructure schemes, enforcing national programmes such as the Swachh Bharat Mission (Urban), AMRUT, Smart Cities Mission, and the Jal Shakti Abhiyan, including its “Catch the Rain” campaign. It is also responsible for approving and monitoring infrastructure execution through agencies like the Bangalore Water Supply and Sewerage Board (BWSSB), promoting rainwater harvesting, and managing urban planning and governance across various Urban Local Bodies (ULBs) under the Karnataka Municipal Corporations Act (1976) and Karnataka Municipalities Act (1964). Within the UDD, the Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC) acts as a financial intermediary for externally aided projects and government schemes across sectors such as water supply, roads, drainage, solid waste, and stormwater management. KUIDFC also plans, finances, and implements urban infrastructure projects under state and national programmes, including the Smart Cities Mission, the Karnataka Integrated Urban Water Management Investment Programme (Jalasiri), and the Karnataka Urban Water Supply Modernization Project (KUWSMP), which is piloting 24x7 water supply in selected towns.

The Department of Water Resources is responsible for the development and management of surface water resources for irrigation and drinking water, with a mandate to formulate integrated, science-based policies and programmes. Key projects under its purview include the Yettinahole Integrated Drinking Water Supply Project. Complementing this, the Groundwater Directorate and the Karnataka Groundwater Authority regulate groundwater development and management by notifying and de-notifying areas, registering drilling agencies and users, issuing No Objection Certificates (NOCs) and extraction permits, and implementing the Karnataka Groundwater (Regulation and Control of Development and Management) Act and Rules (2011–2012) through district-level committees.

Environmental governance is further supported by the Department of Forest, Environment and Ecology, which regulates activities under environmental laws such as the Environment Protection Act and ensures the sustainable management of forests and ecological resources. The Karnataka State Pollution Control Board (KSPCB) enforces environmental standards within the national framework, monitors pollution, and manages consent mechanisms to ensure that solid, liquid, and air pollution are properly treated and regulated across user categories. In the domain of energy, the Karnataka Renewable Energy Development Limited (KREDL) serves as the State Nodal Agency for implementing Karnataka’s renewable energy and solar policies within the broader national framework. Disaster risk governance is led by the Karnataka State Disaster Management Authority, which develops disaster management plans, promotes proactive and people-centric risk governance, and integrates climate change adaptation through a multi-stakeholder approach. Its mandate is to strengthen the state’s capacity to mitigate, prepare for, respond to, and recover from natural and human-made disasters.

Table 6: Key National and State Government Agencies in Urban Water and Sanitation and Climate Change

S. No.	Institution/Department	Main Role
1	Ministry of Housing and Urban Affairs	Formulates policies, rules, laws for urban development in India
2	Central Public Health Engineering and Environmental Organisation	Technical wing of MoHUA serves as advisory body to Ministry for WaSH
3	Ministry of Jal Shakti	Responsible for development water resources, and providing quality drinking water and sanitation facilities, recently started Bureau of Water Efficiency on similar lines of BEE
4	Central ground Water Board	Scientific organisation under DWR RGDR, develops and disseminates technologies for sustainable groundwater management.
5	Ministry of Environment Forest and Climate Change	Plans, promotes, coordinates, and oversees the implementation of environmental and forestry conservation programmes.
6	Central Pollution Control Board	Statutory board established to control water and air pollution in India
7	Ministry of Consumer Affairs and Food and Public Distribution	Formulates plans, policies and programs for consumer protection, welfare, and food security.
8	Bureau of Indian Standards, Ministry of Consumer Affairs, Food & Public Distribution	Formulates standards, markings, and certifications for goods to ensure quality and safety.

9	Ministry of Finance	Entrusted with formulation of budget, offering policy advice, and review of government programs. Accountable for finance, governance and financial management through funds, grants, and procurements.
10	Central Finance Commission	Recommends the distribution of tax revenues between the Union and the States and amongst the States themselves.
11	Member of Parliament Local Area Development Scheme	A scheme for Lok Sabha and Rajya Sabha MPs to suggest public work worth Rs5 crore in their constituency.
12	Ministry of New and Renewable Energy	Policies and schemes on renewable Energy from urban Waste, solar power
13	Ministry of Power	Bureau of Energy Efficiency (BEE), Energy Conservation Act
STATE		
1	Environmental Management and Policy Research Institute (EMPRI)	<ul style="list-style-type: none"> • State Nodal Agency for Climate Change. • Provides technical support for climate change research, training, and capacity building programmes. • Developed state climate change action plan
2	Urban Development Department (UDD)	<ul style="list-style-type: none"> • Oversees policy implementation and funding of urban infrastructure schemes. • Enforces national programmes like Swachh Bharat Mission (Urban), AMRUT, Smart City Mission, and Jal Shakti Abhiyan including Jal-Shakti Abhiyan-Catch the rain • Approves and monitors infrastructure execution through state water and sanitation agencies like Bangalore Water Supply and Sewerage Board (BWSSB). • Promotes Rainwater Harvesting (RWH). • Manages urban planning and governance across various Urban Local Bodies (ULBs) as per the Karnataka Municipal Corporations Act (1976) and Karnataka Municipalities Act (1964).
	Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC)	<ul style="list-style-type: none"> • Falls under the Urban Development Department. • Acts as a financial intermediary for externally aided projects and government schemes, covering sectors such as water supply, roads, drainage, solid waste, and stormwater management. • Plans, finances, and implements urban infrastructure projects under national and state programmes/schemes like Smart Cities Mission, Karnataka Integrated Urban Water Management Investment programme (KIUWMIP) “Jalasiri,” Karnataka Urban Water Supply Modernization Project Brief (KUWSMP) 24x7 water supply project at selected locations.
3	Department of Water Resources	<ul style="list-style-type: none"> • State department • Develops and manages surface water resources for irrigation and drinking water. • Responsible for formulating integrated and science-based water management policies and programmes. • Key projects pertaining to drinking water are Yettinahole Integrated Drinking Water Supply Project
4	Groundwater Directorate and Karnataka Groundwater Authority, Government of Karnataka	<ul style="list-style-type: none"> • Implements uniform regulations for groundwater development and management across the state. – • Notifies/de-notifies areas to regulate groundwater use. - Registers drilling agencies and existing users in notified areas. • Issues No Objection Certificates (NOCs) and extraction permits for commercial, industrial, and entertainment purposes. • Implements the Act and Rules (2011–2012) through district-level committees.
5	Department of Forest, Environment and Ecology	<ul style="list-style-type: none"> • Performs regulatory functions under various environmental laws, including the Environment Protection Act, and ensures sustainable management of forest and ecological resources.
6	Karnataka State Pollution Control Board (KSPCB)	<ul style="list-style-type: none"> • Setting and enforcing environmental standards within the broader national environmental framework • Monitoring and regulation of pollution • Responsible for consent management mechanisms (ensuring solid, liquid and air pollution is properly treated and managed by different types of users)
7	Karnataka Renewable Energy Development Limited (KREDL)	<ul style="list-style-type: none"> • Functions as the State Nodal Agency for implementing Karnataka’s solar and renewable energy policies within the national policy framework on renewable energy
8	Karnataka State Disaster Management Authority	<ul style="list-style-type: none"> • Nodal agency in disaster management • Responsible for development disaster management plans

		<ul style="list-style-type: none"> • Functions in promoting proactive disaster risk governance and climate change adaptation which is a people-centric approach and a multi-stakeholder approach in order to enhance state's capability to Mitigate, Prepare, Respond and Recover from all natural and manmade disasters
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Source: Collated from respective organisation websites

6.1.2 Town Level

While schemes and projects are implemented at the urban local level, their planning, funding, and oversight often involve coordination across multiple tiers of government. **The roles and responsibilities of stakeholders—from households to state-level institutions—are illustrated through the case of Mangaluru (refer Table 7).** In the context of increasing climate risks and heightened vulnerability of urban systems, effective governance of water and sanitation infrastructure becomes a critical component of climate adaptation and disaster resilience. However, the **institutional landscape across different levels of government—from households to urban local bodies (ULBs) and state-level agencies—remains fragmented, with uneven responsibilities and limited coordination.**

At the household level, the construction and maintenance of sanitation infrastructure—such as toilets and on-site sanitation systems (OSS)—remain the responsibility of individual families. For faecal sludge management, households typically rely on vacuum trucks, mostly operated by private vendors. However, the absence of regulatory oversight over the design, construction, and environmental performance of toilets and OSS systems poses serious concerns. Poorly constructed systems risk groundwater contamination, ineffective waste containment, and vulnerability during climate events such as flooding—thereby undermining broader public health and environmental goals.

ULBs are primarily responsible for small- and medium-scale sanitation infrastructure such as community toilets (CTs) and public toilets (PTs). They hold decision-making authority over key aspects like land allocation, technology choice, capital budgeting, and operations and maintenance (O&M). Programmes like the Swachh Bharat Mission (SBM) have supported capital investments for constructing PTs; however, questions remain about the environmental compliance and climate resilience of these structures. In many instances, O&M responsibilities are outsourced to private vendors, who recover costs through user fees—a model that can compromise equitable access in low-income and vulnerable communities, particularly during post-disaster recovery phases.

When it comes to large-scale infrastructure such as sewerage networks and sewage treatment plants (STPs), ULBs have limited influence. The preparation of Detailed Project Reports (DPRs),

infrastructure design, and project implementation are driven by state-level agencies—such as the Karnataka Urban Infrastructure Development and Finance Corporation (KUIDFC). Capital funding is often secured through multilateral or bilateral financing agencies such as the Asian Development Bank (ADB). The centralization of decision-making in these projects marginalizes local perspectives, potentially overlooking contextual needs related to climate risks and service vulnerabilities. Moreover, environmental monitoring and compliance—crucial for long-term sustainability—also remain with state agencies, distancing accountability from local institutions and communities. ULBs’ involvement in disaster planning and governance remains minimal. Interviews with local officials reveal that their responsibilities are largely reactive and confined to the provision of essential services—such as water and sanitation—during the relief phase of a disaster. They have little or no role in upstream disaster preparedness, risk assessment, or long-term recovery planning. This reactive posture limits the ability of ULBs to integrate WaSH concerns within broader frameworks of urban climate resilience, leaving towns particularly vulnerable to future climate-induced shocks.

Table 7: Town-level Institutional Arrangements in Sanitation Services: A case of Mangaluru

Intervention	Technology Selection	Land	Capital	Technology Provision	Technology implementation	O&M	O&M Funding
Toilets	Household	Household	Household	Local masons/private vendors	Local masons/private vendors	Household	Household
	Household	Household	Household			Household	Household
On-site Sanitation Systems						Septage removal by vehicles of ULB	
Community Toilets	ULB	ULB	ULB	ULB	ULB	ULB	ULB
			Central Government (15th Finance Commission and SBM 1.0)				
Public Toilets	ULB	ULB	ULB	ULB	ULB	ULB (13 are maintain by the ULB) + 13 are maintained by different club committees in pay and use basis	ULB (own revenue for 13PT)
			Central Government (15th Finance Commission and SBM 1.0)				
Sewerage Network	State (KUIDFC)	ULB	State (IFIs)	State (KUIDFC)	State (KUIDFC)	ULB	ULB
Sewage Treatment Plant (4)	State (KUIDFC)	ULB	State (IFIs)	State (KUIDFC)	State (KUIDFC)	ULB	ULB
Note: HH = Households; ULB = Urban Local Body; IFIs = International Financial Institutions							

Source: Ashank Desai Centre for Policy Studies, IIT-Bombay

The three study towns found that the ULBs have a constrained role in infrastructure development, particularly when it comes to large-scale, capital-intensive projects such as sewerage networks and sewage treatment plants. Their reliance on state and central governments, as well as international financial institutions (IFIs), for capital funding restricts their decision-making authority across key stages—from project conception and planning to design and execution. This over-dependence not only undermines the intent of the 74th Constitutional Amendment Act, which seeks to empower ULBs with functional and financial autonomy, but also hampers locally responsive governance.

The issue is further compounded in the context of climate change and disaster risk planning. Despite being at the frontline of climate-related vulnerabilities—such as urban flooding, cyclonic events, and water scarcity—ULBs often lack the institutional authority and resources to proactively plan for climate resilience. Climate adaptation infrastructure, which includes stormwater drains, resilient sewage systems, and green infrastructure, requires long-term planning and flexible financing—areas where ULBs have little say due to top-down planning processes and externally imposed conditionalities. In many cases, climate and disaster resilience strategies are embedded in large infrastructure programs governed by state-level agencies or IFIs, with little room for tailoring to local ecological and social contexts. Furthermore, disaster management responsibilities assigned to ULBs are often limited to post-disaster relief efforts, such as restoring water supply and sanitation services, rather than engaging in pre-disaster risk reduction, infrastructure climate-proofing, or community-based resilience planning.

This marginalization of ULBs weakens the responsiveness and effectiveness of urban climate and disaster governance. For climate-resilient urban sanitation systems to take root, it is imperative to enhance ULBs' institutional capacity, provide them with dedicated and flexible funding streams, and ensure their active involvement in strategic planning processes.

6.2 Policy Landscape

This section presents the findings from a comprehensive review of policies within the climate change, urban water supply, and sanitation (UWSS) sectors, along with related areas such as energy, disaster governance and environmental governance. It examines how adaptation, mitigation, and the resilience of UWSS infrastructure and services, are addressed across these sectoral policies. Additionally, the chapter incorporates field findings from work conducted

in three selected towns in Karnataka—Mangaluru, Karwar, and Kundapura—to assess the adoption and effectiveness of state-level policies and measures at the local level.

Aligning with the national commitment of ‘Net Zero target by 2070’ in COP26 in 2021, the Government of Karnataka has taken various measures in various sectors including urban water and sanitation (see annexure -I). The state showcases its commitment to climate change concerns through establishments of state action plans, nodal agency for climate change (Environmental Management and Policy Research Institute, Department of Forest, Ecology and Environment), institute responsible for research on climate change and capacity building (Karnataka Strategic Knowledge Centre for Climate Change).

The review highlights that the integration of climate change concerns at the policy level is emphasized in water resources management (state water policy, public health sector through State Action Plan on Climate Change and Human Health-2023), in human development index assessment and sustainable development studies, and buildings (through Karnataka Municipalities Model Building Byelaws 2017, Karnataka state pollution control Board’s Consent mechanisms). However, it is concerning that the total annual budget allocated for climate actions (both direct and indirect) has declined by 0.13% as a percentage of

- Climate change- water and sanitation concerns are addressed (explicitly or implicitly) in climate change policies, water policies, ground water policies, buildings, energy, environmental governance, disaster management, human health, and human development index studies.
- Sectoral policies primarily focus on adaptation measures—both intended and unintended—in the Urban Water Supply Systems (UWSS) sector, while mitigation measures, mostly unintended, play a secondary role.
- Efforts to enhance the resilience of UWSS infrastructure receive comparatively limited attention.
- This focus is also evident in the state funding pattern and schemes

the overall budget between 2017-18 and 2019-20 (EMPRI, 2021). The review highlights that policies across various sectors primarily focus on adaptation measures—both intended and unintended—in the Urban Water Supply Systems (UWSS) sector, while mitigation measures, mostly unintended, play a secondary role. However, efforts to enhance the resilience of UWSS infrastructure receive comparatively limited attention. This is also evident in the budget allocations and number of schemes. A total of 103 schemes have been identified by the State CC action plan, with the budget favouring the agricultural, forestry, fisheries, while urban sector remain largely neglected. Of the total schemes, 57.30% are focused on adaptation, rather than mitigation efforts. Furthermore, mitigation schemes do not address the urban water and sanitation sector's needs. (EMPRI, 2021).

This adaptation focus is understandable, considering that none of the towns in the state currently meet the Service Level Benchmarks (SLBs) for water supply and sewerage connections. Additionally, the state is one of the most drought-affected in India, as highlighted in the previous section. Interactions with the Ministry of Housing and Urban Affairs (MoHUA) and various think tanks reinforced these insights, highlighting the lack of robust policy evidence to support the development of mitigation-focused strategies in water and sanitation service.

6.2.1 Policies and Programmes with Mitigation Focus

GHG emissions from the UWSS sector can be classified as either direct or indirect, arising from electricity consumption and biological processes.

The review of state policies reveals that mitigation efforts in the municipal UWSS sector primarily focus on reducing electricity consumption and improving energy efficiency, with limited attention given to generating energy (from sewage management interventions). Mitigation efforts related to biological processes—such as the safe confinement, transportation, treatment, and disposal of grey and black water—fall under environmental pollution and governance. These processes also play a crucial role in ensuring access to services that contribute to public health and environmental well-being. This description of the array of policy options highlights the diversity of organizations, processes, and tools involved in mitigation efforts, emphasizing the critical need for policy coherence across different levels policy implementation.

Energy Efficiency

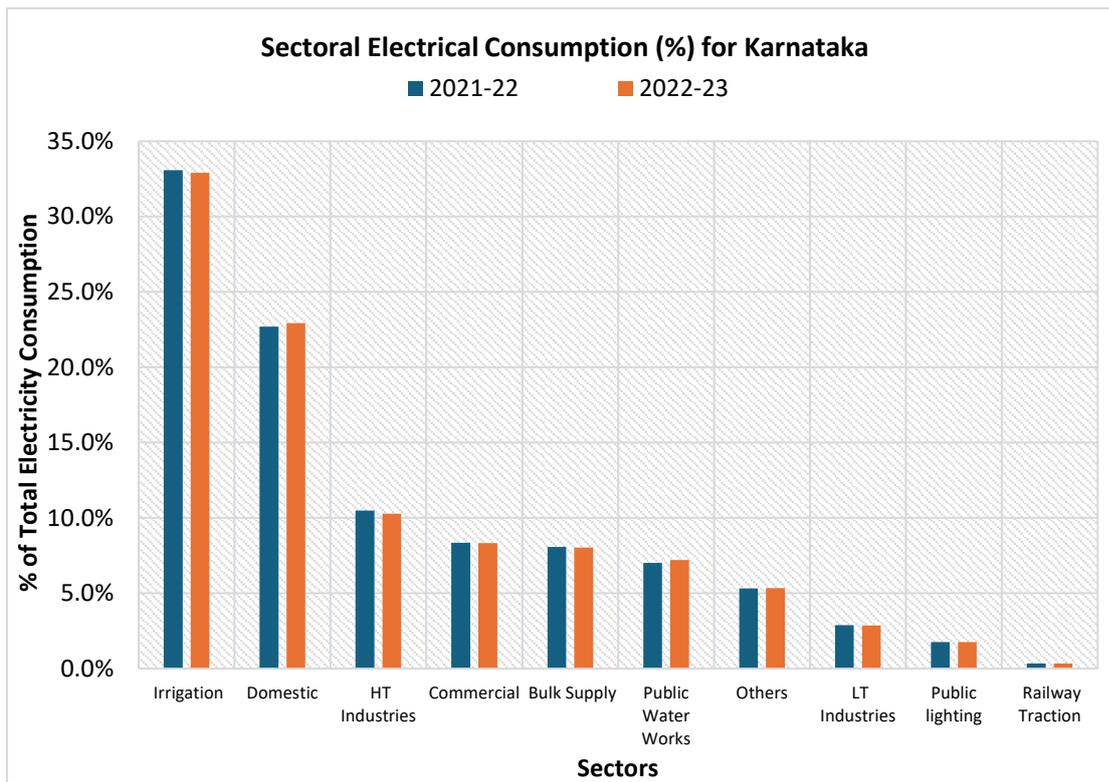
Municipal services in Karnataka—specifically public lighting and public water works—account for approximately 9% of the state's total electricity consumption (~64,000 MUs), with public water works being the primary contributor at around 7.1% (Central Electricity Authority, 2022) – see Figure

24. These figures are notably lower than the national average, where municipal services (including public lighting and water and sewerage pumping) represent 17% of electricity

- Municipal services (lighting and public water works) are responsible for 9% of the state's total energy consumption
- Public water works consumes 7.1% of the total electricity
- Municipal services have 21% energy saving potential
- State Energy Conservation and Energy Efficiency Policy 2022-2027 sets targets
- Expected to conserve 744 million kWh of electricity reducing CO2 emission of around 6,10,080 tonnes

consumption in India for the 2020-21 period (Bureau of Energy Efficiency ; Alliance for an Energy Efficient Economy, 2024, p. 8). However, the share of public water works in Karnataka's total electricity consumption is significantly higher than the national average of 2.0% for 2021-22 (Central Electricity Authority, 2023)

Figure 24: Sectoral Electrical Consumption in Karnataka



Source: (Central Electricity Authority, 2022)

The state has a huge energy saving potential (21%) in municipal services (lighting and public water works) (Table 8) and water savings, thereby reducing operational costs for the ULB and enhancing the quality of services (Government of Karnataka, 2022).

Accordingly, the state has set energy saving targets in various sector including municipal services as part of its Energy Conservation and Energy Efficiency Policy 2022-27 (Table 8).

Table 8: Energy Saving Potential in Different Sectors in Karnataka

Consumer Category	Consumption excluding losses - 2019-20 (MU)	Saving Potential (MU)	Energy Saving Potential (%)	Energy Saving Target (2022-27)
Domestic	14556	2912	20.0%	4%
Commercial	13828	2628	19.0%	3%
Industries (LT and HT)	7278	728	10.0%	2%
Agriculture	21833	6551	30.0%	3.50%
Municipal Services (Street lighting and public water works)	15283	3210	21.0%	6% for street lighting and 3% in public water works
Total	72778	16029		

Source: (Government of Karnataka, 2022)

If the state is able to meet its energy efficiency targets, **it is expected to conserve 744 million kWh of electricity reducing CO2 emission of around 6,10,080 tonnes** and capacity addition of around 454 MW in medium term. Furthermore, these practices contribute to GHG emissions mitigation and can aid in mitigating the urban heat island effect, prevalent in many Indian cities (Bureau of Energy Efficiency ; Alliance for an Energy Efficient Economy, 2024). **The state’s commitment to energy efficiency across sectors set by the Energy Conservation and Energy Efficiency Policy (2022-27) were cemented by the establishment of the State Energy Efficiency Action Plan (SEEAP) and state level steering committee. The state has also assigned budget to authorities for energy efficiency activities in municipal services (Ministry of Power, 2024). Additionally, state has “matching” allocated funds against State Energy Conservation fund (SECF) (Ministry of Power, 2024). Additionally, assessment tools such as water and energy audits**

- Key Initiatives: Energy Conservation and Energy Efficiency Policy (2022-27), State Energy Efficiency Action Plan, Municipal Energy Efficiency Programme
- Institutions: State Designated Agency, State steering committee
- Dedicated budget allocations for energy efficiency in municipal services
- Assessment Tools: Water and energy audits have been recommended for DESCOM, ULB
- Detailed Project Reports (DPRs) for public water works to include energy efficiency standards for water pumps

have been recommended in various state-level frameworks, including the State Action Plan for Climate Change and Human Health (Karnataka-2023), the Karnataka State Water Policy-2022, and the State Energy Efficiency Action Plan. These documents emphasize that state authorities, DESCOMs, and ULBs should conduct regular water and energy audits of their services to enhance efficiency. Furthermore, as part of the State Energy Efficiency Action Plan, the Detailed Project Reports (DPRs) for water works are required to include energy efficiency (EE) standards for water pumps.

As the only state with an active, Energy Conservation and Energy Efficiency Policy, Karnataka has made substantial progress in these sectors, as well as in municipal services and agriculture. With all these efforts, the state ranks (score of 86.5 out of 100) as the top-performing state in the SEEI 2023. In municipal services, the state scored 10 out of 11 (maximum), with improvement of 35.91% from SEEI 2021-22 (Ministry of Power, 2024).

Within the UWSS sector, the MEEP (national Programme for Energy Efficiency) stands out as a key initiative. Karnataka is one of 13 states that have mandated the use of BEE 4/5 star-rated energy-efficient pump sets for drinking water supply and sewerage systems across cities, towns, and Gram Panchayats. A total of 18 towns in the state have made notable progress in installing energy-efficient pump sets (see Figure 25).

Additionally, the State Designated Authority for Energy Conservation and Efficiency successfully replaced conventional water pumps with energy-efficient star-rated pumps at all government hospitals in Mysuru and Chamarajanagar districts (Taluka/Hobli). Furthermore, KREDL completed the replacement of conventional lighting (bulbs and tube lights) and ceiling fans with energy-efficient alternatives in 130 government schools during the 2022-23 period (Bureau of Energy Efficiency, 2023).

Furthermore, as part of the State Energy Efficiency Action Plan, the Detailed Project Reports (DPRs) for water works are required to include energy efficiency (EE) standards for water pumps. However, in the selected towns (Mangaluru, Karwar, Kundapura), interviews with the ULB officials revealed that the DPRs focused exclusively on energy efficiency in lighting, with no mention of EE standards for water pumps.

Figure 25: Energy efficient pumps installed under MEEP in Karnataka (as of 11 October 2024)



Source: (Energy Efficiency Services Limited, 2024)

At the building sector level, key policies include the Karnataka Municipalities Model Building Byelaws 2017, the Energy Conservation Building Codes, Eco Niwas Samhita 2020, and the Karnataka Energy Conservation and Energy Efficiency Policy 2022-27, and national programmes like Smart Cities Mission. These policies primarily focus on energy efficiency measures in water systems (chilling and heater facilities), appliances, lighting, and building materials, while there is limited attention to energy efficiency in wastewater management interventions. The State Action Plan on Climate Change and Human Health also calls for the greening of health facilities, including water and sanitation improvements.

Generating Energy from UWSS

The Karnataka Renewable Energy Policy 2022-2027 aims to create an "ecosystem for sustainable and green energy development in the state". While the policy focuses on key areas for "decarbonizing sectors," it does not explicitly mention climate change or establish a direct connection with the UWSS sector. At the municipal level, the policy addresses waste-to-energy projects using "urban waste," but it does not specifically mention energy generation from sewage treatment plants. Energy generation from STPs remains largely

unexplored in most Indian cities. Field observations from Mangaluru, Karwar, and Kundapura reveal that this option has not been considered by the respective municipalities.

Mitigation from biological process

Mitigation efforts related to biological processes—such as the safe confinement, transportation, treatment, and disposal of grey and black water—fall under both the urban development sector and environmental pollution and governance. Within the urban development sector, the provision of toilets, on-site sanitation systems, underground networks, sewage treatment plants (STPs), and FSTPs are addressed through schemes like SBM Urban, AMRUT, and state government funding. However, the state has only 61% of the required treatment capacity to handle its 4,458 MLD of wastewater, with operational compliance further lacking—only 1,168 MLD meets the standards. This highlights a significant infrastructure shortfall, which leads to the release of untreated and partially treated sewage contributing to pollution and GHG emissions. The state has 9 FSTPs with a combined installed capacity of 264 KLD, which further helps in managing the methane emissions from septic tanks.

In terms of environmental governance, key policies include the consent mechanism by KSPCB and Karnataka municipal building bye-laws, which mandate that domestic, commercial, and industrial properties of certain sizes and water consumption install decentralized (non-network) wastewater management systems. However, our studies in Bengaluru and Mangaluru show that proper (environmental) monitoring of these systems after installation is often lacking^{xix}. Furthermore, the adoption of non-network solutions diminishes operational GHG emissions by lowering the energy required for transporting water and wastewater over shorter distances. However, the need to meet stringent 10 mg/l BOD standards has led to the installation of relatively expensive technologies in cities like Bengaluru, resulting in higher energy consumption, increased electricity bills, and eventual abandonment of the systems by the owners.

6.2.2 Policies with Adaptation Focus

Most policies at the intersection of climate change and water and sanitation are focused on adaptation strategies. This is evident in the State Action Plan, which emphasizes inclusive, sustainable development through climate-resilient, low-carbon pathways. The plan primarily focuses on adaptation, a priority that is reflected in the budget allocation, with a significant portion dedicated to adaptation projects and sectors.

Most policies either intentionally or unintentionally, focus on interlinked issues of: (i) water scarcity and water security, (ii) improved and equitable access to improved drinking water and improved sanitation services, and (iii) human and environmental health.

The policies addressing water scarcity and security primarily suggest adaptive measures such as rainwater harvesting, groundwater recharge, improving water use efficiency across sectors, regulating groundwater withdrawal, and promoting the recycling and reuse of treated wastewater. These measures are particularly relevant as Karnataka is one of the most water-stressed states in India, with a significant portion of the state being drought-prone, as outlined in the State Water Policy-2022 (*discussed in fourth section of this report*).

The key policies addressing water scarcity and security issue are Karnataka State Action Plan on Climate Change Version 2.0 – 2021, State Action Plan for climate change and human health, Karnataka- 2023, Karnataka State Water Policy-2022, Karnataka Ground Water (Regulation for protection of sources of drinking water) Act, 1999 (Karnataka Act 44 of 2003) , The Karnataka Ground Water (Regulation and Control Of Development And Management) Act, 2011, The Karnataka Ground Water (Regulation and Control Of Development And Management) Act, 2012, Karnataka Municipalities Model Building Byelaws 2017, Consent Mechanism by KSPCB, Policy for Urban Wastewater Reuse :Enabling Environment for Urban Wastewater Reuse-2016, and at national level, Guidelines To Regulate And Control Ground Water Extraction by Ministry of Jal Shakti, Jalshakti Abhiyan-catch the rain-2025, and Smart cities missions. The policies and programs directly addressing access to improved drinking water and sanitation services include state government funding and national funding programmes like SBM (Urban) and AMRUT.

The current requirement under various policies (Policy for Urban Wastewater Reuse: Enabling Environment for Urban Wastewater Reuse-2017, Service Level Benchmarks) to recycle and reuse treated sewage is 20%. However, our field experience and data on Service Level Benchmarks (SLBs) from towns like Karwar, Kundapura, and Mangaluru suggest that there is significant potential for improvement in meeting this standard. Further, policies and programs addressing wastewater and sewage recycling offer dual benefits: freshwater savings, and an additional revenue stream for utilities. For instance, Bengaluru (Bruhat Bengaluru Mahanagara Palike), is one of the largest sewage generators in the state, produces 1,440 MLD of sewage. If treated efficiently, this could yield 1,153 MLD of usable water for non-potable purposes. With a cost of Rs. 300 per 1,000 litres, treated wastewater could generate an annual revenue of Rs. 346 crore for the Bangalore Water Supply and Sewerage Board (Government of Karnataka, 2024). Currently, around 35% of the revenue for the Bangalore Water Supply and Sewerage Board (BWSSB) comes from treated effluent reuse, with the funds reinvested to improve and expand treatment capacity (Gupta, Chaturvedi, Kashyap, & Bassi, 2024). However, wastewater recycling at the property level (under policies

like the Karnataka Municipalities Model Building Byelaws 2017, the Consent Mechanism by KSPCB, and national guidelines to Regulate And Control Ground Water Extraction In India) offers a solution for environmental pollution, but it also places a burden on property owners in terms of energy consumption. This has, in some cases, led to the abandonment or dysfunction of decentralized wastewater systems, as observed in Bengaluru and Mangaluru. Furthermore, property owners receive no incentives to comply with these policies, which further discourages adherence and maintenance of decentralized wastewater systems. While the Karnataka Municipalities Model Building Byelaws-2017 encourages the use of natural treatment systems in decentralized wastewater management, the high discharge standards set by KSPCB under its consent mechanisms make it necessary for property owners to install costly and energy-intensive treatment systems, leading to a preference for conventional, expensive solutions over natural treatment options^{xx}. This reflects a clear case of policy inconsistency between departments (pollution control and urban development), resulting in horizontal policy incoherence and conflicting trade-offs.

The rainwater harvesting policies provide both adaptation and mitigation co-benefits, including freshwater savings and improved energy efficiency. As decentralized systems, they are less energy-intensive compared to traditional water distribution networks – also recognised in the State Climate Change Action plan. Additionally, the costs are shared by users, reducing the financial burden on utilities. At the national level, programmes such as the Jal Shakti Abhiyan and its *Catch the Rain* campaign focus on 148 districts identified by the Central Ground Water Board (CGWB). As in previous years, the initiative includes five key interventions including Water conservation and rainwater harvesting (Government of India, 2009). As of July 2025, Madhya Pradesh topped the list with a total of 32,463 various types of water conservation structures. Karnataka ranked fourth among the top five states, with 23,341 structures, following Madhya Pradesh, Rajasthan, and Tamil Nadu. Gujarat, with 4,788 structures, stood at 10th position, while Maharashtra ranked 12th with 4,280 structures. Goa was among the bottom three states. However, when considering only rainwater harvesting structures, Karnataka ranked 8th with 1,015 such structures (status from 22-03-2025 to 28-07-2025) (Ministry of Jal Shakti, 2025). **The study in the three selected coastal towns shows that the RWH is not a prominent practice in smaller towns (with populations under 50,000), such as Karwar and Kundapura. In contrast, it is being implemented to some extent in larger urban centres like Mangaluru and Bengaluru.**

6.2.3 Policies with Resilient UWSS Infrastructure Focus

The state's primary guidance document for climate action, the State Climate Change Action Plan, overlooks the crucial issue of resilience of water and sanitation infrastructure to climate change. The plan mainly focuses on climate resilience in sectors such as agriculture, forests,

livestock, fisheries, biodiversity, and communities, leaving water and sanitation resilience underemphasized. While the plan references the UN 2030 Agenda for Sustainable Development and the adoption of climate-sensitive technologies to preserve biodiversity and enhance resilience, it does not specifically address the resilience of technologies or infrastructure within the water and sanitation sector.

Key policies and programs addressing resilience of the water and sanitation infrastructure are Karnataka State Disaster Management Plan (KSDMP) 2021-2022, Karnataka State Water Policy-2022, the State Action Plan for Climate Change and Human Health (2023), and the State Climate Change Action Plan, the Smart Cities Mission. These policies approach drinking water and sanitation services from the perspectives of adaptation, resilience (particularly for people), and preparedness and response, positioning them as priority sectors for recovery in emergencies.

For instance, the Karnataka State Disaster Management Plan (KSDMP) 2021-2022 connects climate change, disaster management, and the Sustainable Development Goals (SDGs). As part of structural measures, the Disaster Management Plan emphasizes the need to integrate Disaster Risk Reduction (DRR) into water management strategies to minimize the impacts of water-related hazards. Key focus areas for mainstreaming DRR include building resilient infrastructure. The plan also asserts that all development sectors must incorporate disaster risk management principles and that public investments should factor in disaster risk considerations. Additionally, it calls on relevant authorities to formulate guidelines for the safe construction of public works in flood-affected areas. In terms of non-structural measures, the plan proposes the establishment of flood zones and infrastructure planning for resilience. Similarly, the Karnataka State Water Policy-2022 **addresses non-structural measures like climate-resilient infrastructure planning and risk mapping (specifically flood zoning). However, its focus is primarily on dam safety, with no mention of resilience of municipal water and wastewater infrastructure.**

At city level, the Smart Cities Mission encourages cities to incorporate risk resilience into their proposals by assessing the impact of each project on the environment and its ability to withstand disasters. Field experience in Kundapura, Mangaluru, and Karwar suggests that much of the water and wastewater infrastructure, developed in earlier times, did not incorporate disaster-related concerns or prioritize climate-proofing. However, the upcoming infrastructure reports, particularly those funded by International Financial Institutions (IFIs), now require Urban Local Bodies (ULBs) to integrate disaster risk and climate change considerations into their infrastructure and service proposals.

6.2.4 Policies and Programmes for Coastal Areas

There is no dedicated national mission for coastal areas and climate change under the National Action Plan on Climate Change (NAPCC). However, the National Water Mission addresses climate change impacts on coastal regions as part of its broader mandate.

“A National Water Mission will be mounted to ensure integrated water resource management helping to conserve water, minimize wastage and ensure more equitable distribution both across and within states. The Mission will take into account the provisions of the National Water Policy and develop a framework to optimize water use by increasing water use efficiency by 20% through regulatory mechanisms with differential entitlements and pricing. It will seek to ensure that a considerable share of the water needs of urban areas are met through recycling of waste water, **and ensuring that the water requirements of coastal cities with inadequate alternative sources of water are met through adoption of new and appropriate technologies such as low temperature desalination technologies that allow for the use of ocean water**” (Ministry of Jal Shakti , 2021, p. 8). Key concerns included are saltwater intrusion due to sea level rise, which significantly impacts groundwater quality and access to drinking water. **Coastal regions, along with drought-prone areas, flood-prone areas, regions with deficient rainfall, and areas classified as over-exploited, critical, or semi-critical in terms of groundwater development and water quality, have been prioritised under the mission. Strategies for these priority areas include:** Improving water use efficiency by 20%, for which the Ministry has established the Bureau of Water Efficiency (BWE); Assessing the impacts of climate change on water resources; Maintaining a comprehensive water database in the public domain; **and** Publishing the **Composite Water Management Index (CWMI)** to track and promote effective water management practices.

In 2011, the Ministry of Environment, Forest and Climate Change (MoEF&CC) established the **National Centre for Sustainable Coastal Management (NCSCM)** as an autonomous institution to support coastal protection, conservation, rehabilitation, and policy guidance. NCSCM promotes the **Integrated Coastal Zone Management (ICZM)** approach using science-based decision support systems and by facilitating collaboration among communities, government bodies, and national and international institutes. To implement this integrated approach, the Government of India launched the **Integrated Coastal Zone Management Project (ICZMP)** under the **CRZ and IPZ Notifications (2011)**. The project has enabled key activities such as **hazard line mapping, identification of eco-sensitive areas, and delineation of sediment cells** along the entire Indian coastline, laying the groundwork for climate-resilient coastal planning and governance. For implementing the provisions of the **CRZ Notification, 2011**, the **Karnataka State Coastal Zone Management Authority** was constituted. Its mandate includes protecting and improving the coastal environment, controlling pollution, and examining proposals for changes in CRZ classifications. The Authority is also empowered to investigate

and review violations under the **Environment Protection Act** and **CRZ regulations** within Karnataka.

The State Action Plan on Climate Change (2021) outlines both mitigation and adaptation strategies for the state’s coastal zones, which are increasingly vulnerable to climate impacts. Key challenges affecting the water and sanitation sector in coastal areas include salinity intrusion, which depletes groundwater resources. Additionally, coastal water quality is deteriorating, with toxic algal blooms emerging primarily due to the discharge of untreated sewage and industrial effluents. According to the action plan, these issues are being addressed through the installation of Sewage Treatment Plants (STPs) and Common Effluent Treatment Plants (CETPs), with oversight from the State Pollution Control Board (SPCB), Coastal Zone Management Authorities, local NGOs, and fisheries institutions. Furthermore, coastal erosion, sedimentation caused by heavy inland rainfall, and mangrove degradation pose significant challenges, managed by the Coastal Zone Management Authority (CZMA) and the Forest Department. To address these challenges and build resilience, the plan proposes the promotion of effluent treatment infrastructure, mangrove replantation, the development of safe housing for coastal communities beyond the hazard line, identification of low-lying salinized lands for integrated agri-fish culture, and targeted erosion control measures at vulnerable sites.

However, a recent study highlights the **insufficient integration of climate change and disaster risk considerations in coastal governance planning** (C, Sinha, & Bisaria, 2024). The study finds that **efforts to incorporate climate adaptation and mitigation strategies into policy documents and coastal management frameworks remain weak and fragmented**. The coastal governance in India is governed by a complex web of central and state-level laws that address different sectors (e.g., fisheries, environment, urban development, environmental pollution, biodiversity conservation). This disjointed framework leads to overlapping responsibilities, coordination failures, and limited synergy between agencies—hindering the development and implementation of integrated local-level coastal plans. Moreover, our town-level studies in Mangaluru, Karwar, and Kundapura corroborate these findings, revealing limited involvement of Urban Local Bodies (ULBs) in disaster and climate change planning and governance, as well as a general lack of awareness about ongoing climate change initiatives. Further, **CRZ rules are among the most frequently violated environmental legislations in India**. Moreover, there has been ongoing dilution of policies related to ecological protection and conservation, further weakening coastal resilience. Even though, climate risks affect multiple sectors—such as housing, transport, fisheries, and tourism—yet coastal planning often occurs in silos. Although initiatives like the NAPCC, operational linkages remain weak and uncoordinated. Despite rhetorical acknowledgement of climate change, concrete measures for climate resilience—such as risk-informed land use, nature-based solutions, or infrastructure retrofitting—are scarcely embedded in coastal governance practices.

7. Recommendations

Karnataka's policy and institutional landscape was examined through a grounded assessment in the towns of Karwar, Kundapura, and Mangaluru to understand how water, sanitation, and climate change policies interact, and to identify key policy, institutional, and implementation challenges. **This section presents an analysis of these challenges and offers targeted recommendations under key themes: financial programmes and schemes, institutional frameworks, and the broader policy landscape.**

Karnataka is one of India's most urbanized states with high Human Development Index (HDI) and low MPI, yet it remains highly vulnerable to climate risks like droughts, floods, storms, and cyclones. While coastal districts benefit from higher HDI reducing socio-economic vulnerability, they face specific threats such as saltwater intrusion and coastal erosion. Smaller towns and urban poor areas suffer from poor water and sanitation infrastructure, aging systems, and low service quality, weakening their resilience to climate impacts. Karnataka is also a significant contributor to India's greenhouse gas emissions, primarily due to untreated or partially treated domestic wastewater, requiring substantial funding. Although the state has accessed central funds for urban water and sanitation, its own urban development budget and climate change allocations have declined, raising concerns. State policies broadly align with national climate and water frameworks, but overlapping institutional roles and conflicting regulations—such as between building bylaws and pollution control rules—cause implementation challenges and policy fragmentation. This lack of horizontal coherence hampers effective climate adaptation and mitigation. Nonetheless, Karnataka is progressively linking climate change with sectors like health, energy, environment, water, and sanitation. However, current policies emphasize adaptation over mitigation, and infrastructure resilience remains a secondary priority, reflected in budgetary and programmatic focus.

7.1 Financial Programmes and Schemes

In Karnataka, the development of urban water and sanitation infrastructure is funded through a mix of **centrally sponsored schemes**—such as AMRUT, UIDSSMT, and SBM—and **state and ULB-level contributions**. For FY 2024–25, the Karnataka Urban Water Supply and Drainage Board (KUWSDB) proposed a budget of **INR 3515.79 crore**, with **INR 2988.2 crore as capital outlay**, largely supported by **central funding**, ULB contributions, and **INR 600 crore from the state**. Despite a **10% CAGR in allocations from 2020–21 to 2022–23**, water and sanitation continue to receive **low priority** relative to sectors like education, agriculture, and energy. The rise in allocations post-2014 is linked to the **Swachh Bharat Mission**, yet the sector's share

remains low in the broader state budget. Urban Local Bodies (ULBs) rely on four primary revenue streams: **own revenue, assigned/shared taxes, grants, and loans/borrowings**. Property tax is the **main own-source revenue** across Karnataka ULBs, but **revenues from water and sewerage taxes are low compared to other high-HDI states**. While capital expenditure in sewerage and drainage has increased since 2019, it still represents only **3–5% of total capital expenditure** at the ULB level.

Key Challenges

1. **Low Sectoral Priority:** Water and sanitation continue to receive **minimal budgetary allocations**, both in absolute terms and as a proportion of total expenditure.
2. **High Dependence on Central Schemes:** Karnataka's infrastructure funding is **heavily reliant on central schemes**, making it vulnerable to policy shifts at the national level.
3. **Inadequate Local Revenue Generation:** ULBs **underperform in mobilizing water and sewerage-related taxes**, especially when compared with peer states like Tamil Nadu, Gujarat, and Maharashtra.
4. **Volatile Grant Trends:** **Grants to ULBs** have shown inconsistent trends, with sharp fluctuations between 2014 and 2019, affecting planning and stability.
5. **Low Capital Investment at ULB Level:** Sewerage and drainage sectors form a **very small proportion (3–5%)** of ULBs' capital expenditure despite urban service delivery pressures.
6. **Limited Financial Autonomy:** Continued reliance on state transfers and central schemes undermines **ULBs' financial autonomy and planning capacity**.

Key Recommendations

1. **Enhance State Investment:** Increase Karnataka's **own allocations** to water and sanitation to reduce dependence on central schemes.
2. **Reform ULB Finances:** Improve **local revenue generation capacity** by revising water and sewerage tariffs, expanding the tax base, and improving collection efficiency.
3. **Stable Grant Mechanisms:** Establish **predictable and formula-based transfers** from the state to ULBs to enable better planning and service delivery.
4. **Targeted Infrastructure Spending:** Prioritize capital expenditure in underfunded sectors like **sewerage, stormwater drainage, and wastewater treatment**.
5. **Inter-State Learning:** Adopt **best practices** from better-performing states (Tamil Nadu, Maharashtra) for tax design, billing systems, and financial management.
6. **Empower ULBs:** Strengthen institutional capacity and devolve **greater fiscal and operational authority** to ULBs for planning and implementing WSS projects.

7.2 Institutional Landscape

While water and sanitation (WaSH) schemes in Karnataka are implemented at the urban local level, their planning, financing, and oversight span multiple tiers of government. However, this multi-level governance landscape is **fragmented**, with **unclear roles, uneven responsibilities, and limited coordination** among stakeholders—ranging from individual households to Urban Local Bodies (ULBs) and state-level agencies. The case of Mangaluru illustrates how these institutional gaps can compromise climate resilience and service delivery.

Key Challenges

1. **Weak Regulatory Oversight at the Household Level:** Households are responsible for constructing and maintaining toilets and on-site sanitation (OSS) systems, and often rely on private vacuum truck operators for faecal sludge removal. However, the absence of regulation over the **design, construction, and environmental safety** of these systems leads to significant risks—such as **groundwater contamination**, ineffective containment, and vulnerability during climate events like flooding.
2. **Environmental and Equity Concerns in ULB-Managed Infrastructure:** ULBs manage small- and medium-scale sanitation infrastructure, such as community and public toilets. Though programmes like the **Swachh Bharat Mission (SBM)** have supported capital investments, many structures lack environmental safeguards or **climate-resilient designs**. Moreover, outsourcing O&M to private vendors who recover costs through user fees can **exclude low-income users**, particularly in post-disaster scenarios.
3. **Limited ULB Role in Large-Scale Infrastructure Projects:** ULBs have **minimal involvement** in planning large-scale sanitation infrastructure like sewerage networks and sewage treatment plants (STPs). These projects are centrally driven by state agencies like **KUIDFC**, often funded by international agencies (e.g., ADB), with little space for local consultation. This approach risks **overlooking local needs**, particularly those arising from site-specific **climate vulnerabilities**.
4. **Disconnected Environmental Monitoring and Accountability:** Environmental regulation—including pollution control, treatment compliance, and discharge monitoring—is primarily handled by state-level bodies like the KSPCB. This separation between implementation (ULBs) and regulation results in **weak accountability** and delayed corrective action.
5. **Reactive and Marginalised Role in Disaster Governance:** ULBs' involvement in disaster governance is typically **reactive**, limited to restoring water and sanitation services post-disaster. They have **no formal mandate** for conducting risk assessments, preparing resilience strategies, or integrating WaSH concerns into long-term climate planning.

6. **Limited Authority and Resources for Climate-Resilient Planning:** Despite being on the frontlines of **climate-related impacts**—such as urban flooding, water scarcity, and cyclonic events—ULBs **lack the institutional authority, planning autonomy, and financial flexibility** to develop long-term climate adaptation strategies. Critical investments in climate-resilient infrastructure, such as stormwater drains, green spaces, and climate-proof sanitation systems, are typically embedded within top-down programmes led by state agencies or international financial institutions (IFIs), with little room for **local adaptation**. ULBs are further sidelined by externally imposed project designs and conditionalities, limiting their capacity to tailor interventions to local ecological and social contexts.

Recommendations

1. Develop and enforce **technical standards for OSS systems** and build ULB capacity to monitor compliance. Regulate and register private desludging operators to ensure safe handling, transport, and disposal of faecal sludge.
2. Mandate **environmental audits** and integrate **climate-resilient design standards** into all publicly funded sanitation facilities. Strengthen ULBs' regulatory and contract management capacity.
3. Institutionalise ULB engagement in **project planning and DPR preparation**. Make **community consultation** a mandatory step in large infrastructure projects to ensure contextual and climate-responsive solutions.
4. Measures to ensure **environmental compliance** at the municipal level for wastewater and faecal sludge management.
5. Amend the institutional mandate of ULBs to include **disaster preparedness, climate-proofing of sanitation infrastructure, and risk-informed service delivery**. Provide technical support and incentives for integrating WaSH into local disaster management plans.
6. Strengthen ULBs by granting **dedicated climate adaptation mandates**, providing **flexible, untied funding** for local infrastructure, and ensuring their **active participation in state- and donor-led planning processes**. Foster local innovation in green and hybrid infrastructure to support context-sensitive resilience.

7.3 Policy Landscape

Aligning with India's national commitment to achieve Net Zero emissions by 2070, as announced at COP26 in 2021, the Government of Karnataka has taken several initiatives

across various sectors, including urban water and sanitation. The state has demonstrated its institutional commitment through the establishment of the State Action Plans on Climate Change, the designation of the Environmental Management and Policy Research Institute (EMPRI) as the nodal agency for climate change, and the creation of the Karnataka Strategic Knowledge Centre for Climate Change, which focuses on research and capacity building.

Climate change concerns have been integrated into a range of state-level policies, including water resource management, public health (via the State Action Plan on Climate Change and Human Health, 2023), human development assessments, sustainable development frameworks, and building regulations such as the Karnataka Municipalities Model Building Byelaws (2017) and the Karnataka State Pollution Control Board's consent mechanisms. However, despite this multi-sectoral attention, there has been a marginal decline in the total annual budget allocated to climate actions—both direct and indirect—as a percentage of the overall state budget, dropping by 0.13% between 2017–18 and 2019–20.

The review of the state's climate-related initiatives reveals a strong focus on adaptation, including within the urban water supply and sanitation (UWSS) sector, while mitigation remains largely incidental and secondary. Among the 103 schemes identified in the State Climate Change Action Plan, over 57% are adaptation-focused, with the majority of funding allocated to agriculture, forestry, and fisheries, and only limited attention to urban sectors. Mitigation strategies, where present, fail to specifically address the needs of the urban water and sanitation sector.

This adaptation-oriented approach is not entirely surprising, given the state's context. Karnataka is one of the most drought-prone states in India, and none of its urban areas currently meet the Service Level Benchmarks (SLBs) for water supply and sewerage connections. The urban water and sanitation systems face chronic service deficits, which are compounded by climate risks such as water scarcity, urban flooding, and heat stress. Interactions with the Ministry of Housing and Urban Affairs (MoHUA) and various national think tanks further reinforce the lack of robust policy evidence and planning frameworks to support mitigation strategies specific to urban water and sanitation services.

7.3.1 Adaptation

Most policies at the intersection of climate change and water and sanitation in Karnataka predominantly focus on **adaptation strategies**, emphasizing inclusive, sustainable development through climate-resilient, low-carbon pathways. This adaptation focus is reflected in budget allocations, with significant funding directed towards adaptation projects and sectors.

Key Challenges

1. **Water Scarcity and Security:** Karnataka faces severe water stress and drought conditions. Policies emphasize adaptive measures such as rainwater harvesting, groundwater recharge, water-use efficiency, and wastewater recycling. However, actual implementation, especially in smaller towns, remains limited.
2. **Access to Improved Water and Sanitation:** While national and state programs like SBM (Urban) and AMRUT support improved access, many urban areas do not meet standards for wastewater recycling. For example, only 20% treated sewage recycling is mandated, but towns like Karwar, Kundapura, and Mangaluru fall short of these benchmarks.
3. **Policy Inconsistencies and Implementation Barriers:** There is notable **horizontal incoherence** between policies—for instance, between pollution control regulations demanding strict, costly wastewater treatment and urban development policies encouraging decentralized, natural treatment systems. This results in energy-intensive, expensive systems that property owners struggle to maintain, leading to abandonment in cities like Bengaluru and Mangaluru.
4. **Limited Incentives for Compliance:** Property owners face no clear incentives to comply with wastewater reuse or treatment policies, discouraging uptake and maintenance of decentralized systems.
5. **Uneven Rainwater Harvesting Adoption:** Although rainwater harvesting (RWH) policies offer adaptation and mitigation co-benefits, their adoption is inconsistent—widely practiced in larger cities (Mangaluru, Bengaluru) but not prominent in smaller coastal towns.
6. **Potential Yet Underutilized Wastewater Reuse:** Cities like Bengaluru generate vast amounts of sewage, which if treated properly, could supply substantial non-potable water and generate revenue. Currently, only about 35% of BWSSB's revenue is from treated effluent reuse, highlighting untapped potential.

Key Recommendations

1. **Strengthen Policy Coherence:** Align pollution control and urban development policies to support cost-effective, energy-efficient wastewater treatment solutions that are practical for property owners and local contexts.
2. **Enhance Incentives and Support:** Provide financial or technical incentives for property owners to adopt and maintain decentralized wastewater treatment and reuse systems.
3. **Scale Up Wastewater Recycling:** Promote wastewater reuse aggressively, especially in larger cities, to conserve freshwater, reduce pollution, and create revenue streams for utilities.

4. **Expand Rainwater Harvesting:** Encourage wider adoption of RWH, particularly in smaller towns, through awareness campaigns, technical support, and integration into urban planning.
5. **Focus on Implementation and Monitoring:** Improve monitoring and enforcement of existing policies to ensure water recycling targets are met and systems remain functional and sustainable.
6. **Promote Integrated Water Security Approaches:** Combine adaptive measures such as rainwater harvesting, groundwater recharge, and wastewater reuse in an integrated strategy to address Karnataka's severe water stress effectively.

7.3.2 Mitigation

Karnataka has made significant strides in addressing greenhouse gas (GHG) emissions from the Urban Water and Sanitation Systems (UWSS) sector, primarily through energy efficiency improvements. Karnataka leads in municipal energy efficiency, ranking **#1 in SEEI 2023** (score: 86.5/100), with a **35.9% improvement** from the previous cycle. The state has mandated **BEE 4/5-star-rated pump sets** for water and sewerage systems, with **18 towns already adopting** these technologies. Tools such as **water and energy audits** are integrated into major policies (State Water Policy 2022, Climate Change and Health Plan 2023, SEEAP). The state has allocated **matching funds to the State Energy Conservation Fund (SECF)** and budgeted for municipal energy efficiency actions. However, major **gaps remain in policy coherence, infrastructure coverage, and mitigation of biological processes**. The state's mitigation efforts are mainly targeted at reducing electricity consumption, with **limited focus on energy generation from wastewater** or comprehensive biological process management.

Key Challenges

1. **Narrow Mitigation Focus:** Current mitigation strategies focus almost exclusively on improving **energy efficiency in municipal services** (particularly water pumping and street lighting), with **little integration of biological process emissions**—like those from wastewater treatment—into climate planning.
2. **Limited Energy Recovery from Wastewater:** The **Karnataka Renewable Energy Policy (2022–2027)** does not explicitly link to the UWSS sector. Energy generation from sewage treatment plants (STPs)—a crucial area for emissions reduction—remains **largely unexplored**, including in towns like Mangaluru, Karwar, and Kundapura.
3. **Infrastructure and Environmental Compliance Gaps:** Karnataka treats only **61% of its 4,458 MLD** of wastewater, and just **1,168 MLD complies** with required environmental standards. This leads to the discharge of untreated sewage, contributing to **water pollution and GHG emissions**.

4. **Lack of Operational Monitoring:** While decentralized wastewater treatment is promoted through building bye-laws, **monitoring of these systems is weak**, especially in cities like Bengaluru and Mangaluru. Moreover, the use of high-energy-consuming technologies to meet stringent discharge norms has led to system **abandonment due to high operational costs**.
5. **Disconnect Between Policies and Local Implementation:** Despite strong state-level frameworks (e.g., Energy Conservation and Energy Efficiency Policy 2022–27, State Energy Efficiency Action Plan), **local-level integration is uneven**. For example, Detailed Project Reports (DPRs) in selected towns cover lighting efficiency but **exclude energy-efficient water pumping**, despite state mandates.

Recommendations

1. **Broaden the Scope of Mitigation Strategies:** Integrate **biological process emissions**—from faecal sludge and sewage treatment—into climate mitigation frameworks. Establish **clear targets and incentives** for methane capture, nutrient recovery, and bioenergy generation from STPs.
2. **Enhance Infrastructure and Environmental Compliance:** Invest in **expanding treatment capacities**, particularly in underserved towns. Strengthen **environmental monitoring and enforcement** mechanisms for both centralized and decentralized systems.
3. **Strengthen Local Implementation:** Ensure that **DPRs and municipal project plans** incorporate **energy and water efficiency standards** across all relevant components, including pumps, treatment facilities, and sludge transport.
4. **Promote Energy Recovery and Circularity:** Link the **renewable energy and urban sanitation** sectors explicitly in state policies. Promote **waste-to-energy pilots** from sewage sludge and co-treatment facilities.
5. **Improve Data and Coordination:** Build **robust data systems** for tracking emissions, energy use, and compliance in the UWSS sector. Enhance **inter-agency coordination** between environmental regulators, energy agencies, ULBs, and utilities.

7.3.3 Infrastructure Resilience

The State Climate Change Action Plan of Karnataka largely overlooks the critical issue of resilience in water and sanitation infrastructure to climate change impacts. While the plan emphasizes climate resilience across sectors like agriculture, forests, and biodiversity, it underemphasizes or omits strategies for strengthening water and sanitation systems against climate risks.

Key Challenges

1. **Lack of Focus on Water & Sanitation Resilience:** The primary climate action framework does not specifically address the resilience of water and sanitation infrastructure or technologies, creating a significant policy gap.
2. **Fragmented Policy Coverage:** Although other policies and plans—such as the Karnataka State Disaster Management Plan (KSDMP) 2021-2022, Karnataka State Water Policy-2022, State Action Plan on Climate Change and Human Health (2023), and the Smart Cities Mission—touch on adaptation, resilience, and disaster preparedness, these efforts are often limited in scope and focus specifically with respect to Water and Sanitation sector.
3. **Structural vs Non-Structural Measures:** Disaster management emphasizes structural measures like flood zoning, resilient infrastructure planning, and safe construction guidelines, mainly targeting water management and dams. However, municipal water and wastewater infrastructure resilience remains inadequately addressed.
4. **Legacy Infrastructure Vulnerability:** Existing water and wastewater systems in cities like Kundapura, Mangaluru, and Karwar were generally not designed with disaster risk or climate-proofing in mind, leaving the m vulnerable to climate shocks.
5. **Reactive Rather Than Proactive Planning:** Most disaster resilience measures are being integrated only in upcoming infrastructure projects, often those funded by International Financial Institutions (IFIs), rather than through proactive retrofitting or comprehensive resilience strategies at the local level.

Key Recommendations

1. **Explicitly Prioritize Water and Sanitation Resilience:** Integrate climate resilience measures specific to water and sanitation infrastructure within the State Climate Change Action Plan and other key policy documents.
2. **Comprehensive Infrastructure Risk Assessment:** Conduct systematic risk mapping and vulnerability assessments for municipal water and wastewater infrastructure, beyond dam safety, to inform climate-proofing strategies.
3. **Retrofit and Upgrade Existing Systems:** Prioritize the climate-proofing of legacy water and sanitation infrastructure, especially in vulnerable urban areas, to reduce disaster risk and service disruptions.
4. **Strengthen Policy Integration:** Enhance coordination between disaster management, water resources, and urban development departments to mainstream disaster risk reduction principles in all water and sanitation planning and investments.

5. Capacity Building and Funding for ULBs: Equip Urban Local Bodies with technical capacity and dedicated funding to incorporate resilience into existing and new water and sanitation infrastructure.
6. Promote wider adoption of climate-resilient water and sanitation infrastructure across the state.

7.3.4 Coastal Areas

The National Action Plan on Climate Change (NAPCC) lacks a dedicated mission for coastal areas, though the National Water Mission addresses coastal climate impacts as part of its broader water management mandate. Key concerns include saltwater intrusion from sea-level rise, threatening groundwater quality and drinking water access in coastal zones. The mission prioritizes coastal and other vulnerable regions, aiming to improve water use efficiency by 20%, assess climate impacts on water resources, and promote transparent water management through data and indices. The Ministry of Environment, Forest and Climate Change established the National Centre for Sustainable Coastal Management (NCSCM) to support integrated coastal zone management (ICZM). The Government of India's Integrated Coastal Zone Management Project (ICZMP) has enabled scientific coastal hazard mapping, eco-sensitive area identification, and sediment cell delineation to support climate-resilient coastal governance. At the state level, Karnataka's Coastal Zone Management Authority oversees coastal protection, pollution control, and enforcement of Coastal Regulation Zone (CRZ) rules. Karnataka's State Action Plan on Climate Change (2021) outlines mitigation and adaptation for vulnerable coastal zones, focusing on challenges like salinity intrusion, deteriorating water quality due to untreated sewage and industrial effluents, coastal erosion, sedimentation, and mangrove degradation. Proposed interventions include sewage and effluent treatment plants, mangrove restoration, erosion control, safe housing beyond hazard zones, and integrated agri-fish culture on salinized lands.

Key Challenges

1. **Fragmented and Overlapping Governance:** Coastal governance is fragmented across multiple central and state agencies with overlapping mandates in fisheries, environment, urban development, pollution control, and biodiversity conservation, causing poor coordination and inefficiencies.
2. **Weak Integration of Climate and Disaster Risk in Planning:** Climate change adaptation and mitigation are insufficiently embedded in coastal policies and management frameworks, limiting effective resilience-building.

3. **Limited Local-Level Engagement:** Urban Local Bodies (ULBs) have minimal involvement or awareness regarding climate and disaster risk governance in coastal towns like Mangaluru, Karwar, and Kundapura.
4. **Policy Dilution and Enforcement Gaps:** CRZ rules face frequent violations; ecological protection policies are weakened, undermining coastal resilience.
5. **Siloed Sectoral Approaches:** Despite climate risks impacting sectors like housing, transport, fisheries, and tourism, coastal planning remains fragmented without integrated, cross-sectoral strategies.

Key Recommendations

1. **Strengthen Institutional Coordination:** Develop integrated frameworks to improve synergy among central and state agencies, fostering cohesive coastal climate governance.
2. **Enhance Local Governance Capacities:** Build capacity and awareness in ULBs for active participation in climate adaptation, disaster risk reduction, and coastal resilience planning.
3. **Embed Climate Resilience in Coastal Planning:** Mainstream risk-informed land use planning, nature-based solutions, and climate-proof infrastructure retrofitting into coastal policies and development projects.
4. **Improve Enforcement and Policy Integrity:** Reinforce compliance with CRZ regulations and ecological protection laws to safeguard coastal ecosystems and communities.
5. **Promote Cross-Sectoral Approaches:** Facilitate integrated coastal management that addresses interconnected sectors and their vulnerabilities to climate impacts.
6. **Leverage Scientific Tools and Data:** Utilize hazard mapping, eco-sensitive zone delineation, and sediment cell analyses to inform evidence-based decision-making for coastal resilience.

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Annexure – I: Sectoral Policies Linking Climate Change and Water and Sanitation

Sl. No.	Policy /Programme Name	Organization	Purpose	Measures
Climate Change				
1	Karnataka State Action Plan on Climate Change Version 2.0 - 2021	Environmental Management and Policy Research Institute (EMPRI)	Inclusive sustainable development through climate-resilient, low-carbon pathways	<ul style="list-style-type: none"> • Primary concern in UWSS - Water scarcity and security • Adaptation forward measures <ul style="list-style-type: none"> ○ Rainwater harvesting ○ Ground water recharging ○ Ground water regulation • Mitigation (low carbon pathways) concerns <ul style="list-style-type: none"> ○ UWSS doesn't receive attention ○ Water harvesting suggested as both adaptation and mitigation measure
2	EMPRI		Nodal Agency for climate change	NA
3	Karnataka Strategic Knowledge Centre for Climate Change	Department of Environment and Climate Change, Government of Karnataka	NA	NA
4	State Action Plan for climate change and human health, Karnataka- 2023	National Programme on Climate Change & Human Health, Ministry of Health and Family Welfare Government of India	Climate change direct and indirect impacts on health.	<p>Water and sanitation infrastructure and Services are viewed from adaptation, and resilient angle</p> <p>Primary concern – resilience of health sector and people</p> <ul style="list-style-type: none"> • Energy and water efficient health care facilities (HCF) • Water conservation in HCF • Rainwater harvesting <p>Adaptation</p> <ul style="list-style-type: none"> • Rainwater Harvesting System in health care facilities • Assessment tool Water audit of the health care facilities <p>Relief Measures</p> <ul style="list-style-type: none"> • Provision of sanitation facilities in relief camps <p>Mitigation Measures</p> <ul style="list-style-type: none"> • EE in health sector • Set goals to achieve this • Assessment tool: Energy audit of the health care facilities <p>Institutional Framework</p> <ul style="list-style-type: none"> • Propose state level Institutional Framework within National Health Mission of NAPCC • State governing body, state task force on environmental health, state environmental health cell
Water and Sanitation				

5	Karnataka State Water Policy-2022	Water Resources department, Government of Karnataka	"Facilitate the water security and optimal utilisation of the State's water resources for health, food, energy, environment and other societal purposes".	<ul style="list-style-type: none"> • Primary concern – water security and optimization of water resources - adaptation perspective • Adaptation Measures <ul style="list-style-type: none"> ◦ Overall Framework - IWRM ◦ Water use efficiency in all sectors ◦ 24*7 water supply ◦ Rainwater harvesting ◦ Ground water regulation ◦ Recycling and reuse of treated wastewater for non-potable uses including agriculture, industries ◦ Water audit and accounting for state • No explicit mention of Mitigation • No mention of energy efficiency in water systems • Sanitation does not figure • Climate resilient infrastructure planning focusses only on Dam safety. Risk mapping (Flood zoning)
6	Karnataka Ground Water (Regulation for protection of sources of drinking water) Act, 1999 (Karnataka Act 44 of 2003) The Karnataka Ground Water (Regulation and Control of Development and Management) Act, 2011,2012 Karnataka Ground Water (Regulation and Control of Development and Management) (Amendment) Bill, 2024 and 2011,2012	Government of Karnataka	Priority for drinking water and for protection of drinking water sources in the State; to bring a general legislation to control indiscriminatory exploitation of ground water especially in the notified areas in the State.	<p>Measures</p> <ul style="list-style-type: none"> • Institutional mechanism constitution of the Karnataka Ground Water Authority • restriction and regulation of extraction of ground water in the notified area; • specification of the minimum distance between the bore wells dug for the purpose of irrigation; • declaration by notification any areas as draught hit areas;
Urban Development				
7	Karnataka Municipalities Model Building Byelaws 2017	Government of Karnataka		<ul style="list-style-type: none"> • Makes a connection between climate change (footprint) and building construction • Talks about Climate Resilient Construction • location, design and construction of septic tank shall conform to requirements as notified by the Government. <p>Measures</p> <ul style="list-style-type: none"> • STP establishments for properties with certain sizes • Wastewater recycling • Rainwater harvesting made mandatory for properties of specific sizes • Urges promotion of Natural treatment systems • Energy and water use efficiency • Waste management • Environmental management plan to be developed <p>Building plan approval process to consider</p> <ul style="list-style-type: none"> • STP establishments for properties with certain sizes • Wastewater recycling • Rainwater harvesting made mandatory for properties of specific sizes • Urges promotion of Natural treatment systems • Energy and water use efficiency • Waste management • Environmental management plan to be developed

					<ul style="list-style-type: none"> • Ground water recharge • Environmental Cell to be established at the state level
Environmental Governance					
8	KSPCB Notification: Consent Mechanism for setting up industries and establishments (notification No.KSPCB/798/COC/2016-17/1425, dated: 15-06-2016. (https://kspcb.karnataka.gov.in/consent-management/categorisation-rog#ORANGE1))	Karnataka State pollution control board			<p>Primary concern water pollution. Both Mitigation, Adaptation and ecological linkages</p> <ul style="list-style-type: none"> • Introduces Consent mechanism for pollution management for residential properties as well • STP establishment in different residential commercial and industrial properties of certain sizes and wastewater volume generators
9	State and central pollution control board standards	Karnataka state pollution control board and Central Pollution Control Board, Government of India			<p>Primary concern water pollution. Both Mitigation, Adaptation and ecological linkages</p>
10	Policy for Urban Wastewater Reuse: Enabling Environment for Urban Wastewater Reuse-2016	Urban Development Department, Government of Karnataka		<p>Aims to establish an enabling environment for the reuse of municipal wastewater to maximize efficient resource use, protect the environment, address water scarcity, and enhance economic output.</p>	<p>Primarily an adaptation concern with mitigation co-benefits</p> <p>It makes the connect with climate change impacts on water resources. It makes a clear connect between “reduced energy consumption associated with production, treatment and distribution of freshwater” (page 2). By 2020, 20% of all STW is targeted for reuse across the state (in domestic sector), in accordance with regulatory standards like SLBs, National Power Tariff Policy 2016; [to be increased to [50%] by 2030]. Advocates reuse of treated wastewater.</p>
Energy Sector					
11	Karnataka energy conservation and energy efficiency policy 2022-27	Gazatted Notification (policy Directive), Government of Karnataka		<p>Energy security to give impetus to economic activities</p>	<p>Focus areas - agriculture, municipal, industries, commercial and domestic. Also makes mandatory use of EE technology in housing projects. Creates demands to create carbon Cess, green funds or climate funds</p>
12	Karnataka Renewable Energy Policy 2022-2027. Notification No: ENERGY/209/VSC/2021	Energy Department, Government of Karnataka		<p>To continue Karnataka State's position as a preferred investment destination in the RE sector and create an ecosystem for sustainable and green</p>	<p>Talks about energy generation. At municipal level, waste to energy projects from urban waste; no explicit mention of wastewater or sewage treatment plants</p>

			energy development in the State.		
13	State Energy Efficiency Action Plan	Karnataka Renewable Energy Development Limited (KREDL), Government of Karnataka	To provide a roadmap for the state to achieve its energy efficiency goals.	Municipal sector (lighting and water pumping efficiency) figures out in a major way. In water and sanitation sector talks about current efforts in EE in water pumping, sewage treatment.	
14	Energy Conservation Building Codes (ECBC), Energy Codes for Residential Buildings Karnataka (Eco Niwas Samhita 2020)	Government of Karnataka		Energy Efficiency Perspective and Environmental impact of buildings. Calls for energy efficiency measures but mostly related to water component.	
Disaster Management					
15	Karnataka State Disaster Management Plan (KSDMP) 2021-2022 volume-I and II	Government of Karnataka		Views climate change as a “threat multiplier” for impacts from natural hazard and “human induced vulnerabilities”. Talks about strengthening efforts to mainstream DRR into water management and reduce the likely impacts of water-related hazards. Key focus areas for mainstreaming DRR includes resilient infrastructure. Doesn't specify which sector. The plan views sanitation and drinking water as after preparedness and response - emergency function and as one of the prioritizing sectors for recovery.	
National					
Urban Water and Sanitation					
16	Guidelines to regulate and control ground water extraction in India	Ministry of Jal Shakti, Government of India	To have sustainable management of water resources in the country	NOC for GW extraction to be given on following conditions <ul style="list-style-type: none"> Residential apartments/ Group Housing Societies where ground water requirement is more than 20 m3/day. Installation of Sewage Treatment Plants shall be mandatory for all residential apartments/ Group Housing Societies where ground water requirement is more than 20 m3/day. Installation of digital water flow meter (conforming to BIS/ IS standards) in all abstraction structure(s) shall be mandatory for all Residential Apartments and Group Housing Societies pay ground water abstraction charges for the quantum of ground water proposed to be extracted water audit for industrial and commercial areas in over-exploited assessment units, use of ground water for construction activity shall be permitted only, if no treated sewage water is available within 10 km radius of the site. 	
17	SBM-Urban and AMRUT	Ministry of Housing and Urban Affairs (MoHUA), Government of India		Adaptation forward as infrastructure and services provision in water and sanitation is necessary step for building resilient communities against CC. Funds for extending and establishing water and sanitation (including septage and faecal) infrastructure in urban areas.	
Energy Sector					
18	Bureau of Indian Standards on design, construction, installation of septic tanks (IS 2470 (Part 1): 1985) and CPHEEO guidelines	Ministry of Consumer Affairs, Food and Public Distribution, Government of India		Primary concern water pollution. Both Mitigation, Adaptation and ecological linkages	

19	Municipal Energy Efficiency Programme (MEEP)	Energy Efficiency Services Limited (public sector entity under Ministry of Power, Government of India)		Mitigation forward as it promotes adoption of energy efficient pumps in water and sanitation infrastructure
Urban Development				
20	Smart Cities Mission Statement & Guidelines 2015, GoI	Ministry of Housing and Urban Affairs (MoHUA), Government of India	To promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment through the application of 'Smart' solutions.	Essential features of the SCPs wastewater recycling and storm water reuse, sanitation including solid waste management, rainwater, harvesting, smart metering, Energy efficiency in buildings. Talks about risk resilience by evaluating city proposals on "What is the impact of the proposal on the environment and resilience from disasters"?

Source: Ashank Desai Centre for Policy Studies, IIT-Bombay

Endnotes

ⁱ Global Climate Risk Index 2021. Who suffers Most from Extreme Weather Events? Weather-related Loss Events in 2019 and 2000 to 2019 <https://www.germanwatch.org/en/19777>

ⁱⁱ The coastline length of Gujarat referenced in this report is based on sources reviewed and compiled by the author. During report finalization, the official coastline length of Gujarat was revised to 2340.62 km as per the Press Information Bureau (PIB), Government of India, Delhi vide press release dated 04 December 2025, (Release ID: 2198800). <https://www.pib.gov.in/PressReleaseDetailm.aspx?PRID=2198800®=3&lang=1>

ⁱⁱⁱ The coastline length of Karnataka referenced in this report is based on sources reviewed and compiled by the author. During report finalization, the official coastline length of Karnataka was revised to 343.3 km as per the Press Information Bureau (PIB), Government of India, Delhi vide press release dated 04 December 2025, (Release ID: 2198800). <https://www.pib.gov.in/PressReleaseDetailm.aspx?PRID=2198800®=3&lang=1>

^{iv} SDG-1 (End Poverty), SDG-2 (Zero Hunger), SDG-3 (Good Health and Well Being), SDG-4 (Quality Education), SDG-5 (Gender Equality), SDG-6 (Clean Water and Sanitation), SDG-7 (Clean and Affordable Energy), and SDG-16 (Peace, Justice and Strong institutions).

^v The energy sector was the major contributor (80%) to state's net GHG emissions (130.65 Mt CO₂e) in 2018. Energy sector considers fuel combusted for captive electricity generation (auto-producers) and direct fuel combustion (industrial energy). The waste sector (including solid waste and domestic wastewater) contribution to the net GHG emissions declined from 5% in 2005 to 3% in 2018. However, in absolute terms, emissions from the waste sector increased from 4.11 Mt CO₂e in 2005 to 5.37 Mt CO₂e in 2018 (GHG Platform India, 2018).

^{vi} As per IPCC, Adaptation is understood as adjustments in human systems in response to actual or expected climate impacts, aimed at moderating harm or capitalizing on beneficial opportunities. Adaptive capacity refers to the ability of systems, institutions, and individuals to adjust to potential damage, seize opportunities, or respond effectively to consequences.

^{vii} CDRI. <https://lexicon.cdri.world/topic/240> Retrieved on 23 July 2025.

^{viii} The *Climate Resilient Coastal Cities* initiative was rolled out in September 2023. Project partners include - Funding Partner: HSBC; Communication, Outreach, and Advocacy Partner: India Sanitation Coalition (ISC); Research Partner: Ashank Desai Centre for Policy Studies (IIT-Bombay); Research and Implementation Partner: CDD India.

^{ix} Department of Water Resources. Government of Karnataka. <https://waterresources.karnataka.gov.in/storage/pdf-files/Maps/AGRO%20ZONES.pdf>. Retrieved on 17 Sep. 24

^x Water conservation structure excludes canals, tanks, ponds.

^{xi} Water stressed condition = Annual per-capita water availability of less than 1700 cubic meters; water scarcity condition = annual per-capita water availability below 1000 cubic meters. (Ministry of Water Resources, 2020).

^{xii} Representative Concentration Pathways (RCPs) are used by the IPCC to describe different GHG concentration trajectories and their associated climate outcomes by 2100. RCP 2.6 represents a very low emissions pathway with strong mitigation, limiting global warming to around 1.5–2°C above pre-industrial levels. RCP 4.5 is an intermediate scenario with moderate mitigation, leading to stabilization of emissions and approximately 2.4–

3°C warming by the end of the century. RCP 8.5 reflects a high-emissions pathway with minimal climate action, resulting in continued reliance on fossil fuels and warming of 4°C or more.

^{xiii} Short term changes (2030s) relative to the historical period of 1985–2015, under two climate change scenarios: RCP 4.5 and RCP 8.5.

^{xiv} Heat wave is considered if the maximum temperature of a station reaches at least 40°C or more for plains, 37°C or more for coastal stations and at least 30°C or more for hilly regions. Specific criteria is: heat wave = departure from the normal is 4.5°C to 6.4°C; Severe heat wave = departure from the normal is > 6.4°C. For plains only, heat wave = when the actual maximum temperature ≥ 45°C ; Severe heat wave = when the actual maximum temperature ≥ 47°C.

^{xv} Nearly 36% of households in Karnataka live in a Kutchha house and almost all (99%) households have electricity (International Institute for Population Sciences ; ICF, 2022)

^{xvi} Safe = ≤ 70% ground water extraction; > 70% ground water extraction and 90% ground water extraction; > 90% ground water extraction and 100% ground water extraction; >100% ground water extraction (Ground Water Directorate ; Central Ground Water Board, South Western Region, 2023).

^{xvii} Drinking water specification-IS10500: 2012 for Nitrate = 45 mg/l (acceptable limit), No Relaxation (permissible limit); Fluoride = 1.0 mg/l (acceptable limit), 1.5 mg/l (permissible limit); Total Iron = 0.30 mg/l (acceptable limit), Relaxation (permissible limit); Total Hardness = 200 mg/l (acceptable limit), 600 mg/l (permissible limit).

^{xviii} From State Capital: Funds from Government of Karnataka, Internal Extra Budgetary Resource (IEBR); ULB contribution; RDPR share; Other beneficiaries. For Capital fundings from the Centre UIDST, AMRUT schemes are included.

^{xix} The insights on Bengaluru are drawn from Ashank Desai Centre for Policy Studies (IIT-Bombay) earlier work conducted by a PhD student (Rana, 2021).

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