



Resilience of Urban Water and Sanitation Infrastructure & Services in Coastal Towns

Situational Assessment Report

VALSAD, GUJARAT

2026

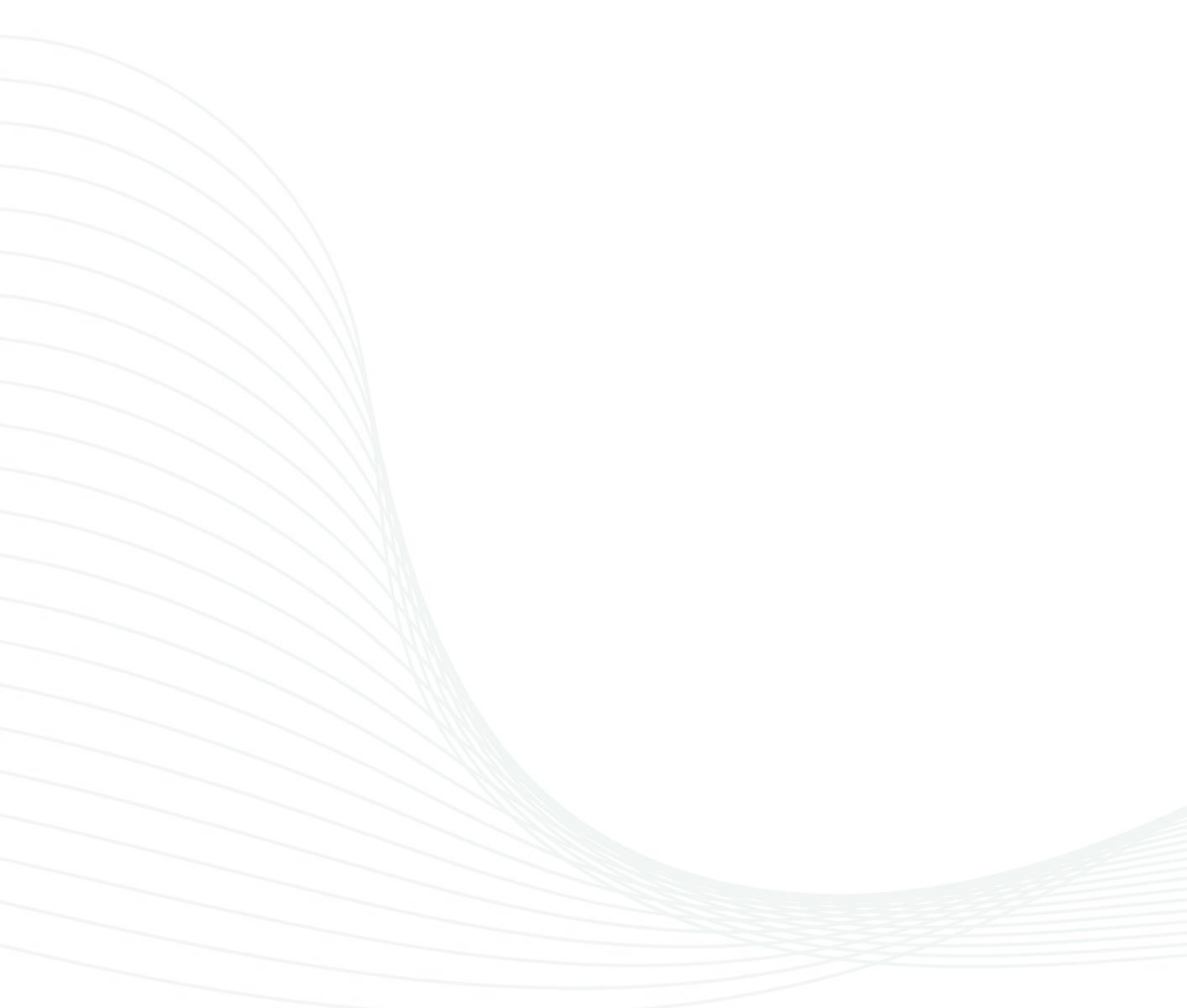


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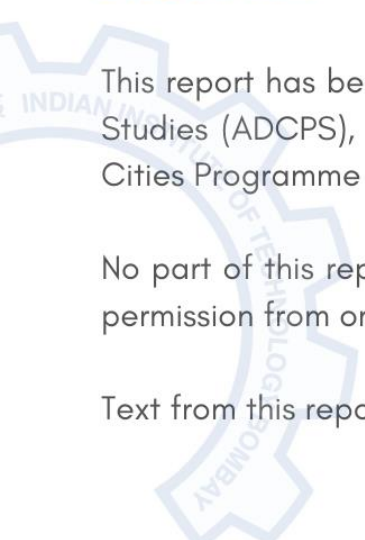


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TITLE

Resilience of Urban Water and Sanitation Infrastructure & Services in Coastal Towns :
Situational Assessment of Valsad, Gujarat.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY	i
CHAPTER 1: INTRODUCTION	1
1.1 Background.....	1
1.2 Objectives	4
1.3 Methodology	4
Town selection Criteria	4
Steps	6
Data Collection.....	7
Greenhouse Gas Emission Estimation	10
CHAPTER 2: TOWN PROFILE: VALSAD	12
CHAPTER 3: STATUS AND CHALLENGES OF WATER SUPPLY INFRASTRUCTURE AND SERVICES AT VALSAD MUNICIPAL COUNCIL.....	21
3.1 Background.....	21
3.2 Water Sources.....	21
3.2.1 Surface Water Sources	21
3.2.2 Ground Water.....	24
3.3 Water Demand & Supply.....	26
3.4 Water Infrastructure	27
3.5 Key Challenges.....	32
CHAPTER 4: URBAN SANITATION SYSTEMS IN VALSAD: STATUS, INSTITUTIONS AND CHALLENGES.....	33
4.1 Background.....	33
4.2 Sanitation Service Chain.....	34
4.3 Institutional Arrangements.....	39
4.4 Challenges and Opportunities in Sanitation Infrastructure and Services.....	41
CHAPTER 5: GREENHOUSE GAS EMISSIONS FROM WATER AND SANITATION SYSTEMS: A CASE STUDY OF VALSAD.....	44
5.1 Background.....	44
5.2 Greenhouse Gas Emissions from Water Supply	45
5.3 Greenhouse Gas Emissions from Sanitation	46
5.4 CONCLUSION AND STRATEGIC PRIORITIES	48

KEY TAKEAWAYS	48
THE WAY FORWARD	49
CHAPTER 6: PERFORMANCE AND FINANCIAL ANALYSIS OF WATER SUPPLY AND SANITATION AT VALSAD MUNICIPAL COUNCIL.....	50
6.1 Introduction.....	50
6.2 Performance Analysis: Service Level Benchmarks	50
6.2.1 Water Supply	51
6.2.2 Sewerage and Sanitation	53
6.3 Revenue Streams	55
6.3.1 Water Supply.....	56
6.3.2 Sewerage & Sanitation	62
6.4 Assessment of Finances	66
6.4.1 Water Supply.....	66
6.4.2 Sewerage and Sanitation	68
6.5 Key Financial Challenges.....	70
CHAPTER 7: RISK ASSESSMENT OF WASH INFRASTRUCTURE IN VALSAD.....	72
7.1 Background.....	72
7.2 Exposure to climate risk.....	72
7.3 Vulnerability of the WaSH Infrastructure.....	78
Adequacy of Infrastructure.....	78
Reliability, Flexibility and Redundancy	78
Infrastructure Risk Governance and Finance.....	79
CHAPTER 8: CLIMATE CHANGE INITIATIVES IN VALSAD.....	81
CHAPTER 9: SECTORAL RECOMMENDATIONS FOR ENHANCING CLIMATE RESILIENCE OF WASH INFRASTRUCUTRE AND SERVICES IN VALSAD	83
9.1 Background.....	83
9.2 Water	84
9.3 Sanitation	85
9.4 GHG Emissions.....	86
9.5 Financial Sustainability	87
9.6 Infrastructure Resilience	88
Notes & references.....	92
ANNEXURE -I: DATA GAPS	97

ANNEXURE-II: STAKEHOLDER CONSULTATION WORKSHOP ‘CLIMATE RESILIENT URBAN WATER AND SANITATION INFRASTRUCTURE SERVICES IN COASTAL TOWNS’: KEY HIGHLIGHTS AND WAY FORWARD 100

ANNEXURE-III: ABBREVIATIONS AND GLOSSARY 106

FIGURE 1 : VALSAD DISTRICT MAP.....	12
FIGURE 2 : VALSAD TALUKA MAP	13
FIGURE 3 : BUILT-UP FOOTPRINT OF VALSAD	15
FIGURE 4 : DISTRICT EXPOSURE TO WIND HAZARD.....	17
FIGURE 5 : DISTRICT EXPOSURE TO MAXIMUM SUSTAINED WINDS DURING CYCLONIC ACTIVITIES.....	18
FIGURE 6 : ANNUAL AVERAGE RAINFALL (MM) IN DISTRICTS OF GUJARAT.....	19
FIGURE 7 : FLOOD PRONE AREAS IN GUJARAT.....	20
FIGURE 8 : FLOOD VULNERABILITY, HAZARD, EXPOSURE AND RISK: DISTRICTS OF GUJARAT.....	20
FIGURE 9: DISTANCE OF AURANGA RIVER TO VALSAD CITY	22
FIGURE 10: AURANGA BASIN	22
FIGURE 11: FLOW OF AURANGA RIVER.....	22
FIGURE 12: WATER SOURCE TO VALSAD - AURANGA RIVER	22
FIGURE 13: CLARI-FLOCCULATOR AT WTP.....	28
FIGURE 14: COVERAGE OF WATER SUPPLY AT VMC.....	29
FIGURE 15 : SANITATION SERVICE CHAIN IN VALSAD	38
FIGURE 16 : CARBON AND ENERGY FOOTPRINT OF VALSAD’S WATER SUPPLY	45
FIGURE 17 : CARBON FOOTPRINT ESTIMATION OF URBAN WATER CYCLE	47
FIGURE 18: SHARE OF GRANTS VS OWN REVENUE FOR WATER SUPPLY AT VMC VALSAD.....	61
FIGURE 19: SHARE OF GRANTS VS OWN REVENUE FOR SEWERAGE & SANITATION AT VMC VALSAD	66
FIGURE 20: TREND ANALYSIS OF COST RECOVERY IN WATER SUPPLY CHARGES AT VMC.....	67
FIGURE 21: TREND ANALYSIS OF COLLECTION EFFICIENCY IN WATER SUPPLY CHARGES AT VMC.....	68
FIGURE 22: TREND ANALYSIS OF COST RECOVERY IN SEWERAGE & SANITATION CHARGES AT VMC.....	69
FIGURE 23: TREND ANALYSIS OF COLLECTION EFFICIENCY IN SEWERAGE & SANITATION CHARGES AT VMC.....	70
FIGURE 24 : DISTRICT WISE RAINFALL TRENDS IN GUJARAT DURING ENTIRE SUMMER MONSOON PERIOD FROM 1989 TO 2018.....	73
FIGURE 25: EMERGING VULNERABILITY HOTSPOTS AND EXPOSURE OF VALSAD CITY TO CLIMATE HAZARDS	75
FIGURE 26: LOCATION OF CRITICAL COMPONENTS OF THE WASH INFRASTRUCTURE IN VALSAD ADMINISTRATIVE BOUNDARY	77

TABLE 1 : TOWN SELECTION CRITERIA	5
TABLE 2 : SELECTED TOWNS.....	6
TABLE 3 : SCOPE OF EMISSIONS METHODOLOGY FOR CARBON FOOTPRINT ASSESSMENT OF THE URBAN WATER CYCLE.....	10
TABLE 4 : DENSITY OF POPULATION AND WARD-LEVEL BUILT-UP FOOTPRINT	16
TABLE 5: HYDROCHEMISTRY OF MANDVI	25
TABLE 6: HOUSEHOLD COVERAGE PLAN FOR WATER SUPPLY	26
TABLE 7: WATER SUPPLY PROJECTS AT VALSAD.....	27
TABLE 8: ANNUAL FLAT TARIFF SYSTEM AT VALSAD.....	30
TABLE 9: NEW WATER CONNECTION CHARGES IN VALSAD	31
TABLE 10 : INSTITUTIONAL ARRANGEMENTS: SANITATION SERVICES	40
TABLE 11: PERFORMANCE INDICATORS FOR WATER SUPPLY AT VMC.....	51

TABLE 12: PERFORMANCE INDICATORS FOR SEWERAGE & SANITATION AT VMC.....	53
TABLE 13: FUNDS RECEIVED BY VMC FOR WATER SUPPLY UNDER CENTRAL GOVERNMENT SCHEMES (IN INR)	56
TABLE 14: FUNDS RECEIVED BY VMC FOR WATER SUPPLY UNDER STATE GOVERNMENT SCHEMES (IN INR).....	58
TABLE 15: REVENUE INCOME FROM WATER SUPPLY AT VALSAD (IN INR).....	60
TABLE 16: FUNDS RECEIVED BY VMC FOR SEWERAGE & SANITATION UNDER CENTRAL GOVERNMENT SCHEMES (IN INR)	62
TABLE 17: FUNDS RECEIVED BY VMC FOR SEWERAGE & SANITATION UNDER STATE GOVERNMENT SCHEMES (IN INR).....	64
TABLE 18: REVENUE INCOME FROM SEWERAGE & SANITATION AT VALSAD (IN INR).....	65
TABLE 19 : WARD LEVEL ELEVATION AND VULNERABILITY TO FLOODING	76
TABLE 20 : CLIMATE CHANGE INITIATIVES IN VALSAD.....	82

PHOTO 1 : COMMUNITY TOILET IN VALSAD CITY	36
PHOTO 2 : STORM WATER DRAINAGE SITUATION AND FLOOD AFFECTED HOUSEHOLD IN VALSAD.....	37
PHOTO 3 : FLOOD AFFECTED AREA IN VALSAD CITY.....	42
PHOTO 4 : STORM WATER DRAINAGE AND SEWERAGE NETWORK	43
PHOTO 5 : STP LOCATION	43

EXECUTIVE SUMMARY

India ranks among the most climate-vulnerable countries globally, with coastal populations facing severe risks from cyclones, floods, sea level rise, and saltwater intrusion. The west coast has seen a sharp rise in Arabian Sea cyclones due to increasing sea surface temperatures, alongside mounting threats of erosion, land submergence, and tidal flooding. Weak water and sanitation infrastructure further magnifies these risks, especially for socio-economically disadvantaged groups.

Against this backdrop, the *Landscape Analysis for Four Coastal States on Climate-Resilient Water and Sanitation Infrastructure Project*, supported by HSBC-India, assesses 12 towns across Maharashtra, Gujarat, Goa, and Karnataka. This report focuses on Valsad, a Class-I city in South Gujarat, strategically located between the industrial hubs of Surat and Vapi, and increasingly exposed to climate-induced stresses.

Situated in the floodplains of the Auranga River and along the Arabian Sea, Valsad faces recurrent flooding, tidal backflow, and saline intrusion. These risks are exacerbated by its low-lying coastal topography, high rainfall, and cyclonic activity. Critical water and sanitation infrastructure—including the sewage treatment plant (STP) located in a flood-prone zone and the water treatment plant (WTP) without power backup—remains vulnerable to disruption during extreme weather events. Service delivery failures during such shocks not only limit residents' ability to adapt but also contribute to greenhouse gas emissions (GHG) from inefficient pumping systems and untreated wastewater discharge.

Despite relatively high annual rainfall and groundwater availability, Valsad struggles with fragmented water service delivery. Supply is intermittent, household connections remain limited, and non-revenue water (NRW) is high due to aging pipelines and leakages. The absence of metering, coupled with billing inefficiencies, has driven cost recovery down to just 17% in 2023–24, undermining financial sustainability. On the sanitation front, only 33% of households are connected to the sewerage network, while nearly 20% of sewage flows untreated into open drains. The new sewerage network under implementation is poorly integrated with stormwater systems, compounding flood risks during monsoons.

Institutionally, the Urban Local Body (ULB) faces capacity and resource constraints, limiting its ability to address these growing challenges. Financial sustainability remains a critical barrier, with weak revenue collection, limited planning for operation and maintenance, and heavy reliance on state and central grants. However, important initiatives such as mandatory rainwater harvesting for new buildings and solar energy installations at the STP provide a foundation for scaling resilience and low-carbon interventions.

Strengthening Valsad's climate resilience will require a multi-pronged strategy: reducing NRW through rehabilitation and metering, expanding sewerage coverage with decentralized and nature-based solutions, climate-proofing critical infrastructure, and improving cost recovery through tariff rationalization and efficient operations. Institutional capacity-building, establishment of resilience funds, and greater integration of disaster risk reduction into infrastructure planning will also be essential. Building on its locational advantages and ongoing initiatives, Valsad can transform its water and sanitation systems into resilient, inclusive, and climate-aligned urban services.

KEY RECOMMENDATIONS

Water and Sanitation

1. **Decentralize Water Management** – Promote rainwater harvesting, check dams, percolation ponds, and watershed management to localize sourcing and reduce dependence on distant sources.
2. **Strengthen Water Distribution Systems** – Upgrade pipelines with smart meters, leak detection, and real-time monitoring to cut Non-Revenue Water (NRW) and unauthorized use.
3. **Promote Wastewater Recycling and Reuse** – Encourage reuse of treated wastewater for irrigation, industry, and landscaping to close the urban water loop and reduce pressure on freshwater.
4. **Integrate Climate-Resilient Water Practices** – Expand small-scale water storage and embed climate resilience in planning to mitigate risks from erratic rainfall and flooding.
5. **Expand Sewerage Network Coverage** – Accelerate completion of ongoing sewerage works, map the network through GIS, and bridge gaps with decentralized or nature-based solutions.
6. **Enhance On-site Sanitation (OSS) and Faecal Sludge Management (FSM)** – Regularly survey OSS systems, establish a FSM plan with community septic tanks (CSTs), decentralized treatment units, and regulated desludging services.
7. **Improve Access for Low-Income Communities** – Install modular, flood-resilient community toilets and prioritize vulnerable areas in municipal funding and adaptation planning.
8. **Climate-Proof Critical Infrastructure** – Upgrade stormwater drainage and STPs with climate-adaptive designs, tidal backflow prevention, and reliable backup power (solar, generators).

9. **Build Operation & Maintenance (O&M) Capacity** – Mandate training and certification of ULB staff for STP and FSM operations; set up peer-learning platforms with other coastal cities.
10. **Reduce GHG Emissions** – Improve OSS design to cut methane and N₂O, adopt sludge-to-energy practices, improve STP efficiency, and integrate wastewater treatment into the city's climate action strategy.

Financial Sustainability

1. **Improve Cost Recovery and Collection Efficiency** – Revise user tariffs to reflect operational costs, especially electricity and staffing; strengthen enforcement of arrears.
2. **Strengthen Revenue Collection** – Upgrade billing systems, customer service, and awareness campaigns to reduce payment delays and increase willingness to pay.
3. **Control Operational Costs** – Optimize resource use, reduce energy intensity of pumping, and encourage decentralized, low-cost systems to lower long-term O&M expenses.
4. **Streamline Financial Administration** – Introduce transparent monitoring and reporting; align financial strategies with climate resilience and service delivery demands.
5. **Leverage Private Sector & Industry** – Engage Valsad's industrial sector in wastewater reuse markets and explore waste-to-energy business models for cost-sharing and revenue generation.

Infrastructure Resilience

1. **Provision for Coastal & Climate Risks** – Undertake hyperlocal risk assessments for saline intrusion, flooding, and effluent contamination; integrate early warning and monitoring systems into city planning.
2. **Localized & Contextual Infrastructure Design** – Shift from energy-intensive deep sewers to hybrid systems: decentralized CSTs, shallow sewers, faecal sludge treatment units, and modular STPs tailored for flood-prone low-lying wards.
3. **Nature-Based Solutions for Flood Management** – Use mangroves, river basin protection, and recharge ponds to manage runoff and safeguard Auranga river's drainage capacity.
4. **Risk Governance & Redundancy** – Establish SoPs, continuity plans, and ring-fenced budgets for infrastructure protection and recovery; set up a climate cell within the ULB for coordination with District Disaster Management Authority (DDMA).

5. **Community Ownership & Participation** – Encourage participatory monitoring and community-led risk governance to safeguard water resources, prevent contamination, and improve resilience of sanitation services.
6. **Mainstream Disaster Risk Reduction (DRR) into Water, Sanitation and Hygiene (WaSH)** – Mandate service benchmarks suitable for flood-prone low-lying areas; integrate DRR and CCA into all water and sanitation project designs.
7. **Integrate Alternative Energy** – Transition to solar-powered pumping and backup systems to reduce dependency on electricity and minimize service disruptions during floods and storm.

CHAPTER 1: INTRODUCTION

NEELAM RANA, PRIYAKSHI GOGOI, SUCHARITA ROY, ASHISHDANGI,
ABHAYJUNAGHARE, TEJASH ANAND AND N.C. NARAYANAN

1.1 BACKGROUND

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 among the most vulnerable countries to climate change as per the Intergovernmental Panel on Climate Change (IPCC) sixth assessment report. This is especially true for the large coastal population (171 million population in coastal districts). India is highly susceptible to cyclones and their related dangers such as storm tide, intense winds, and substantial rainfall. More than 300 extreme events have hit the country in recent decades, causing losses of more than INR 5,600 billion (Mohanty, et al., 2020)². A recent evaluation indicates that more than 75% of districts in India, including 95% of coastal districts, are hotspots for extreme events (ibid).

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)³⁴. **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 Goal (SDG) targets and amplifying inequalities** (Braks & Husman, 2013)⁵. Water and sanitation services face significant threats from climate change induced hazards, and it is crucial to comprehend and enhance the ability of water and sanitation infrastructure and services to withstand this impacts. 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)⁶. and are now exposed to climate change-related risks. This requires adopting climate-responsive policies, infrastructure planning, financing mechanisms, and institutional frameworks across all levels of governance. Such measures contribute to strengthening urban resilience—enhancing a city’s ability to absorb shocks, adapt to changing conditions, recover from disruptions, and continue to thrive.

With this understanding, a project “Landscape analysis for four coastal states on climate resilient water and sanitation infrastructure project” was initiated with funding support from HSBC. The project focuses on both adaptation and mitigation strategies to strengthen climate-

resilient urban water and sanitation infrastructure and services, with an emphasis on developing actionable policy recommendations that are grounded in local realities.

The project focuses on 12 west coastal towns of Maharashtra, Gujarat, Goa, and Karnataka. While the east coast has been more exposed to tropical cyclones, recent years show a greater number of tropical cyclones (TC) forming in the Arabian Sea (west coast)(Deshpande, et al., 2021)⁷. In recent years, the Arabian Sea has emerged as a key region for the formation of tropical cyclones, which have led to severe impacts across western coast of India(Thomas & Lekshmy, 2022)⁸. For instance, the Arabian Sea region has witnessed a 52% surge in the occurrence of cyclonic storms in the recent period (2001–2019), whereas the Bay of Bengal (east coast) has experienced an 8% decline(Deshpande, et al., 2021). Along India’s west coast, the coastal districts of Gujarat specifically have become increasingly vulnerable to tropical cyclones in recent years(Boragapu, Guhathakurta, & Sreejith, 2023)⁹. This increase in the frequency and intensity of cyclones in the Arabian Sea has been attributed to rapid rise in sea surface temperatures(Deshpande, et al., 2021). Further, west coast states are more exposed to sea level rise; every one-metre rise in sea level can inundate almost 5,763 km² of land (Woodruff, BenDor, & Strong, 2018)¹⁰. Making the west coast more susceptible to coastal flooding and cyclones is the significant loss of the complex mangrove ecosystem, which will continue to increase beyond 2100 as per UNFCC-IPCC 2023 report.

Furthermore, historically established as fishing villages and trading posts near river mouths or perched along the slopes of the Konkan and Sahyadri mountains, the coastal settlements have evolved into thriving industrial hubs, port cities, and tourist centres. The region’s undulating terrain, fragile slopes, rising sea levels, erratic weather patterns, and increasing cyclonic activity exacerbate its vulnerability. Challenges such as land submergence, wave shoaling, shoreline erosion, salt intrusion, groundwater flooding, and coastal inundation are increasingly evident. These threats contribute to environmental degradation, contamination of land and water, disruptions in essential services, and potential infrastructure failures.

The current report focuses on Valsad – Class-I city of Gujarat. Gujarat’s 1,600 km coastline, the longest in India, makes it prone to hydro-meteorological hazards like cyclones, storm surges, gusty winds, and heavy rains (Gujarat State Disaster Management Authority, 2024)¹¹.The report primarily examines the town’s adaptive capacity in the water and sanitation sector amid climate change and assesses the sector’s GHG emissions to inform the risk assessment of climate change impacts on its infrastructure and services.

Valsad city, located in South Gujarat, has seen rapid development due to its strategic location at equidistance from the two important industrial centres of Southern Gujarat - Vapi and Surat. The city has seen rapid development in the past decades. A Class I city, Valsad city serves as the

headquarter for the taluka and the district headquarters and hence is of significant administrative importance. It lies on the main interstate railway route and is also a rail head accommodating multiple railway-based functions for the region. **Valsad district is in south of Tropic of Cancer, faces heavy rainfall, cyclonic storms having a sub-tropical climate with moderately high humidity. It faces recurrent flooding due to its location in the floodplains of Auranga River and its coastal topography.**

This report examines the current status of water and sanitation services in town, highlights challenges, and identifies opportunities related to water and sanitation services, with a particular emphasis on disparities in service access, framed within the context of climate change. It maps the institutional framework governing the urban sanitation and analysis the roles of different institutions involved in service delivery—an essential step, as effective climate change measures rely on a clear understanding of institutional responsibilities. Additionally, the report presents the findings on GHG emissions associated with the urban water and wastewater cycle at the town level, aimed at identifying actionable steps the town can take to reduce its GHG emissions. These findings inform the risk assessment of water and sanitation infrastructure in the context of climate change. The study also evaluates the financial sustainability of the ULB, examining its capacity to meet current and future demands while implementing climate change adaptation and mitigation measures. Additionally, the study highlights key climate initiatives undertaken by the town's water and sanitation sector that contribute directly or indirectly to both adaptation and mitigation efforts.

The report begins with Chapter 1, which establishes the link between climate change and water and sanitation, offers a brief overview of the importance of studying west coastal towns, and introduces the study area—Valsad. It also outlines the study's objectives, the methodology adopted to achieve them, and the criteria used for town selection. **Chapter 2** presents a detailed town profile, covering demography, climate, topography, land use and land cover, as well as key climate risks highlighted in literature. **Chapter 3** focuses on the status of urban water supply in the context of a changing climate, highlighting major challenges. **Chapter 4** examines the sanitation service chain, and reviewing institutional arrangements, highlighting major challenges. **Chapter 5** *examines whether the town meets national service-level benchmarks (SLBs) in urban water and sanitation and reviews the financial health of the ULB in sustaining and upgrading these services.* **Chapter 7** examines risks to WaSH infrastructure and services. **Chapter 8** explores key climate change initiatives being undertaken at the town level. Finally, **Chapter 9** concludes the report with sector-specific recommendations.

1.2 OBJECTIVES

-
- **Conduct a comprehensive assessment** of the current state of water and sanitation infrastructure and services in the town.
- **Highlight critical issues and challenges** confronting the town's water and sanitation systems.
- **Quantify the GHG footprint** associated with the urban water and wastewater cycle.
- **Assess the financial sustainability** of the ULB in managing water and sanitation services.
- **Assess risk of water and sanitation** infrastructure of the town.
- **Propose recommendations to enhance resilience** of *water and sanitation infrastructure and services*.

1.3 METHODOLOGY

Twelve towns were selected for the study. This section outlines the criteria used for town selection and describes the steps and data collection methods employed to meet the study's objectives.

TOWN SELECTION CRITERIA

Across the four states, the study focuses on 12 selected towns (Ref. Table 2). The town selection followed a two-step process. First, a set of criteria was developed through a comprehensive literature review (outlined in Table 1). These criteria were designed to ensure diversity among the case study towns in terms of Water, Sanitation and Hygiene (WaSH) infrastructure and services, geography, demographics, and climate vulnerability, administrative status, thus enabling a more representative and contextually grounded analysis.

- **Current understanding of climate risks:** The selection process considered the known climate risks each town faces, as these are critical for assessing the vulnerability of WaSH infrastructure to climate-related hazards.
- **Variation in infrastructure and urban characteristics:** Towns were selected to reflect diversity in water and sanitation infrastructure and service levels, population size, climatic conditions, and economic activities—factors that influence exposure and adaptive capacity and GHG emissions.

- **Socio-economic profile:** Differences in socio-economic conditions lead to varied water consumption and sanitation practices. These factors are crucial for understanding a town's climate resilience and estimating GHG emissions in the WaSH sector.
- **Administrative status:** The administrative status of a town significantly influences its capacity for climate change planning and response, especially in critical sectors like water and sanitation. Towns with higher administrative status—such as municipal corporations or class-I and beyond—tend to have greater autonomy, better institutional structures, and access to financial and technical resources. They are more likely to have dedicated departments, skilled personnel, and the ability to integrate climate considerations into urban development plans.

These towns also benefit from larger budgets, greater revenue-generating powers, and enhanced eligibility for national and international funding schemes focused on climate adaptation and mitigation. In contrast, smaller towns or panchayats often rely heavily on state or district-level agencies, leading to delays in planning and implementation. Moreover, higher status towns typically have better data systems and monitoring capabilities, which are essential for assessing climate risks and emissions. Their greater political visibility further enhances their chances of being included in pilot projects or targeted policy interventions. Thus, a town's administrative status directly shapes its ability to design and implement effective, context-specific climate-resilient infrastructure and services.

Table 1 : Town Selection Criteria

Key Parameters	Selection criteria		
Administrative status	Municipal Corporation	Municipal Council (A and B)	Nagar Panchayat (C and D)
City Size based on population	Class-I to Class IV		
Socio-economic profile	Capturing variability in socio-economic profile of the town population		
Climate Change Exposure and vulnerability	Low Risk/vulnerable	Medium Risk/vulnerable	High Risk/vulnerable
Sanitation Infrastructure Services Status	Only On-site Sanitation	OSS + % networked system	OSS+ % networked + Non-networked (NBS/ Conventional/ FSSTP)
Economic Contributions /Profile	Industrial, agricultural, tourism, service sectors		
State government and ULB support	Past and current partnerships, collaborations		

The above process generated a preliminary list of towns, from which the final selection was made in consultation with the State Directors of Swachh Bharat Mission-Urban (SBM-U).

Table 2 : Selected Towns

State	Town	Population (2011)	Class
Maharashtra	Alibag	20,743	Class-III
	Ratnagiri	76,229	Class-II
	Vengurla	12,392	Class-IV
Karnataka	Mangaluru	4,99,487	Class-I
	Kundapura	30,444	Class-III
	Karwar CMC	77,139	Class-II
Goa	Canacona	12,434	Class-IV
	Mormugao	94,393	Class-II
	Mapusa	39,989	Class-III
Gujarat	Dwaraka	38,873	Class-III
	Mandvi	51,376	Class-II
	Valsad	1,70,060	Class-I

STEPS

Adopting resilient infrastructure not only helps reduce the intensity of adverse consequences from disasters but also provides an opportunity to shift to lower carbon pathways. The risk of infrastructure failure during disruptive events depends on several factors, including exposure to hazards, locational limitations, technology, sensitivity of the infrastructure, its governance, access to funding, and systemic agility. The Sendai Framework for Disaster Risk Reduction identifies the resilience of critical infrastructure as key for risk reduction.

An assessment of the resilience of the WaSH infrastructure *the town has been undertaken in the context of climate change* to inform future planning and build climate-resilient WaSH infrastructure and services in the town. Guided by the Global Methodology for Infrastructure Resilience (UNDRR, 2023)¹², **a three-step, contextualized methodology has been developed**. This methodology analyses the adequacy, reliability, and flexibility of WaSH infrastructure in the face of climate change and the robustness of governance and finance to handle future risks. This **framework** enables a comparative understanding of system resilience for WaSH infrastructure across towns and cities, irrespective of the level of urbanization, population size, and local body

capacity. It helps identify trends and patterns across various classes of cities and develop a structured approach towards building resilience of WaSH infrastructure in coastal cities.

1. **Mapping the Existing Infrastructure and Services:** The existing infrastructure and services have been mapped and analysed *based on data gathered from various sources on performance, coverage, socio-spatial variability, technology, governance, key stakeholders, existing policies, climate change initiatives, financial health of the ULB, budgets, and future projects.*
2. **Identifying the Infrastructure Exposure and Vulnerability:** The climate hazards faced by the settlement has been identified based on literature review. Three critical coastal risks—flooding and inundation, storm surges and coastal erosion, and saltwater intrusion—have been considered. Satellite data has been utilized to assess land use and land cover (LULC), elevation, built-up footprints, road networks, shoreline change detection, mangrove and water bodies, storm surge locations, and flood risk zones. This data has been overlaid with information from municipal bodies on administrative boundaries, flood hotspots, population distribution, critical utility locations to identify the exposure. Primary data on water usage, sanitation practices, water quality, access disparities, socioeconomic vulnerability, behavioural practices, and exposure history collected through discussions, interviews, household surveys, and ground-truthing via transect walks and visual surveys were further collated and overlayed to identify ward level exposure and infrastructure vulnerability.
3. **Assessing the resilience:** The adequacy, flexibility and reliability of the infrastructure, its governance and financial sustainability and systemic gaps have been identified and assessed along with the exposure and vulnerability. The summary of risks to WaSH infrastructure provide insights into the resilience measures needed for the coastal town.

DATA COLLECTION

1. **Desk Based Research:** An extensive desk study was conducted to review existing literature and collect secondary data from various government sources. The study utilized secondary data and information from a range of national, state, district, and town-level sources, including the Census, National Family Health Survey, SBM-U, Central Pollution Control Board (CPCB), Performance Assessment System for urban water and sanitation (PAS) website, District Disaster Management Plans (DDMP), and the municipality website. Additionally, the

review was instrumental in mapping key stakeholders, defining their roles and responsibilities, and developing the analytical framework for various thematic studies, including GHG emission estimation.

The desk study not only informed the overall research design but also facilitated the identification of data gaps and discrepancies, which subsequently guided the development of data collection protocols as well as the planning and execution of the fieldwork.

2. **Field Work:** To address data gaps, validate secondary data, and resolve data discrepancies, the study incorporated rapid field assessments, site visits, and semi-structured interviews. These interviews were conducted with local residents, as well as district and municipal officials from the town planning, water and sanitation, sewerage, public works, and disaster management departments. These interviews were conducted with local residents, as well as district and municipal officials from the town planning, water and sanitation, sewerage, public works, and disaster management departments. Field work also involved mapping of the critical infrastructure in the water and sanitation sector.
 - **Secondary Data Collection from Town Water and Sanitation Departments:** Meetings with ULBs were conducted to collect a variety of documents, including city maps, land-use land cover maps, electricity bills, data on SLB data, SBM-U, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), along with financial reports and other relevant datasets. Detailed information on STP size, collection and treatment volumes, and water reuse was also gathered to understand the scale and performance of existing infrastructure.
 - **Semi-Structured Interviews:** In Valsad Municipal Council (VMC), we interviewed (semi-structured interviews) key ULB officials—including the Water Engineer (1), Sanitation Engineers (1), SNM-U Coordinator (1), System Operators (1) to understand the status of water and sanitation infrastructure and services, as well as to gather information on recent and past extreme events—such as floods, droughts, cyclones and heavy rainfall—and their impacts. These discussions also provided insights into the effects of climate change as experienced locally. Importantly, the interviews helped identify vulnerable areas and communities within the town, which informed the design of the rapid assessment study. We also obtained detailed information on STPs, such as their capacity, collection and treatment volumes, and water reuse practices. Furthermore, data on the number, condition, and O&M structures of community toilets (CTs) and public toilets (PTs) in the city were collected to better understand the scale and performance of the existing sanitation infrastructure.

- **Site Visits:** Site visits were conducted to validate the functioning of critical water and sanitation infrastructure, such as STP, Pumping stations, and disposal, WTPs, Elevated Level Storage Reservoir (ELSR) and Ground Level Storage Reservoir (GLSR). These visits focused on gathering information on operational status, environmental compliance, and electricity consumption. These site visits also facilitated the integration of critical infrastructure into the GIS platform for further spatial analysis.
- **Rapid Field Assessment:** The assessment process combined on-ground observations with semi-structured interviews, particularly targeting high-risk zones such as low-income neighbourhoods, low-lying areas, sites prone to extreme weather events, and densely populated clusters. These hotspots were identified through consultations with ULB officials and spatial analysis of WaSH infrastructure, highlighting zones with heightened vulnerability due to their proximity to each other. Areas characterized by both low elevation and high building density were prioritized for field investigation. Municipal officials also helped identify locations that would provide socio-demographic diversity for sampling. The interviews served to validate and triangulate data from secondary sources on WaSH systems, offering grounded insights into local infrastructure and the lived realities of residents—especially those in vulnerable communities—during events such as heavy rainfall, cyclones, and storms.

The process involved on-ground observations and in-depth conversations with residents (13#), particularly in low-income neighbourhoods and areas identified as vulnerable to extreme events during interviews with ULB officials. This approach yielded valuable insights into both the state of infrastructure and the lived experiences of residents, especially those from vulnerable communities. The emphasis was on understanding challenges related to access, affordability, and reliability of water and sanitation services in the context of climate change. Residents were asked whether they had private toilets on their premises, and if so, whether these were connected to the sewage network. For those not connected, questions focused on how and where human waste was disposed of. In cases where OSS were used, we gathered information on the type of system, frequency and cost of septic tank cleaning, service providers involved, and affordability and other challenges of these services. Additional questions covered methods of greywater disposal, sources of tap water, costs associated with water connections, and any support received from the ULB during disaster events. For households without individual toilets, we explored the alternative sanitation arrangements they relied on.

The team engaged with 13 residents across the city, carefully selecting locations to cover a range of socio-economic backgrounds. Our questions with residents focused primarily on service access and quality.

Additionally, the team visited one public toilet to assess their condition firsthand. During our rapid field assessment, we did not follow any specific strategy or have a particular reason for selecting that toilet. Instead, we visited the public toilet located in a busy areas to observe their condition and usage.

GREENHOUSE GAS EMISSION ESTIMATION

Assessing the carbon footprint of urban water systems requires a comprehensive approach that accounts for emissions across different stages of water abstraction, treatment, conveyance, distribution, and wastewater management. These emissions originate from various processes, including direct GHG releases, energy and chemical consumption in operations, and emissions embedded in materials that make up the physical infrastructure. In this estimation, emissions are classified into three broad categories: **Direct Emissions**, **Indirect Emissions**, and **Embedded Emissions as mentioned in table 3**. Each category captures different sources of carbon emissions within the urban water cycle.

Table 3 : Scope of emissions methodology for carbon footprint assessment of the urban water cycle

Category	Possible Sources of Emissions	Methodology
Direct Emissions	- Methane (CH₄) emissions from anaerobic decomposition of organic matter in wastewater. - Nitrous Oxide (N₂O) Emissions from nitrification and denitrification of nitrogen compounds wastewater - Methane (CH₄) emissions from the decomposition of organic matter in anaerobic sediments in freshwater reservoirs*	<i>2006 IPCC Guidelines for National Greenhouse Gas Inventories (2019 Refinement)</i>
Indirect Emissions	- Indirect emissions from electricity consumption - Life cycle GHG emissions associated with the chemicals used in water and wastewater treatment processes (alum, hypo, chlorine etc.)* - Emissions from diesel combustion for transportation	<i>Electricity consumption data obtained from urban local bodies and an average grid emission factor 0.716 tCO₂/MWh (FY 2022-23, Central Electricity Authority) for Indian grid used for CO₂ estimation.</i> <i>Diesel consumption for desludging trucks based on information obtained from interviewing truck operators.</i>
Embedded Emissions	- Life cycle GHG emissions associated with the materials used in the physical infrastructure. *	<i>Not estimated due to non-availability of data on material footprint.</i>
*Emissions not considered in the estimation due to non-availability of reliable activity data for the same.		

The study findings were shared during a stakeholder and expert consultation workshop held on 13th August 2025, with participation from State Public Works Departments, ULBs, and State Pollution Control Boards. The feedback and comments received have been incorporated into the town assessment reports, details of which are provided in the annexure-II. The workshop also helped define the way forward for the research team.

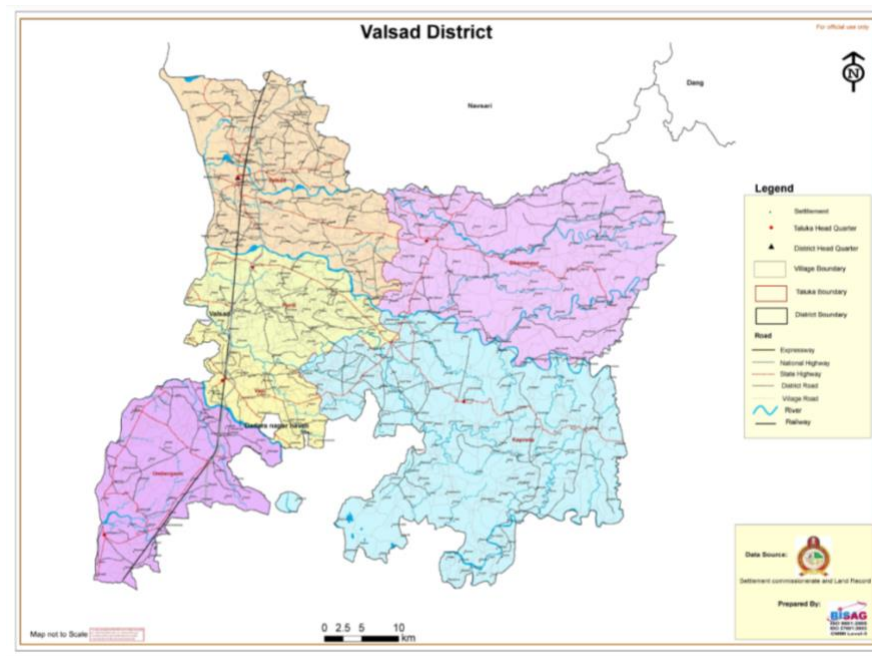
The study also identified several critical data gaps that limit comprehensive assessment and effective decision-making. These gaps, detailed in Annexure-II, highlight the need for improved data collection, systematic reporting, and stronger integration of information across institutions to better inform future planning and resilience-building efforts.

CHAPTER 2: TOWN PROFILE: VALSAD

NEELAM RANA, PRIYAKSHIGOGOI, SUCHARITA ROY, TEJASH ANAND & N.C.NARAYANAN

Valsad municipality is situated in Valsad district, spanning over 14 sq.km. It has 11 wards. Valsad city is in South Gujarat, equidistant from the two important urban centres of Southern Gujarat - Vapi and Surat. The city is a young city and has seen rapid development in the past decades, due to its strategic location close to industrial hubs of Surat and Vapi. A growing Class I city, Valsad city serves as the Valsad taluka as well as a Valsad district headquarters and hence is of significant administrative importance. It lies on the main interstate railway route and is well connected to Mumbai and Ahmedabad, two major metropolitan cities of India on the west. It is also a rail head accommodating multiple railway-based functions for the region.

Figure 1 : Valsad District Map

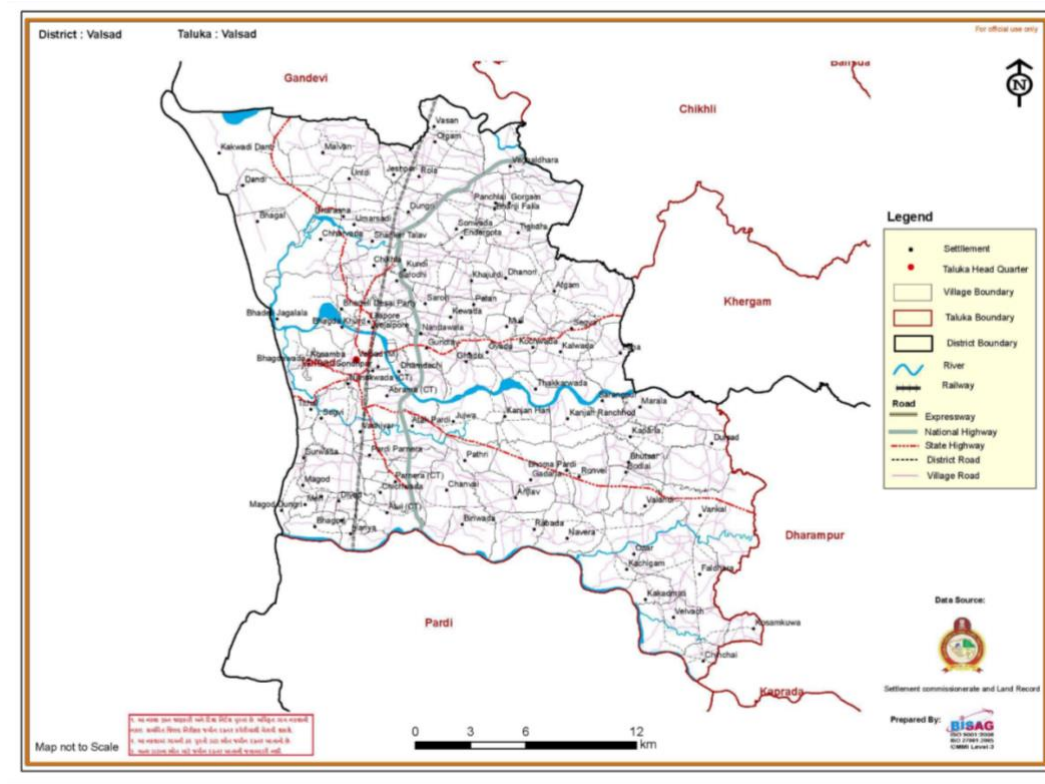


Source: Revenue Department, Government of Gujarat ¹³

Demographic Profile: The municipality had 114636 population in 2011 as per Census of India, out of this 58624 are males and 56012 females. The number of households is 26044. The Literacy rate

of the city is 83.9 %. According to census 2011, Schedule Tribe (ST) were 23380 people, while Schedule Caste (SC) were 3584. Out of the total population, about 35.06% are workers. Among this working population, 90.71% were involved in main work, while remaining were engaged in marginal work.

Figure 2 : Valsad Taluka Map



Source: Revenue Department, Government of Gujarat

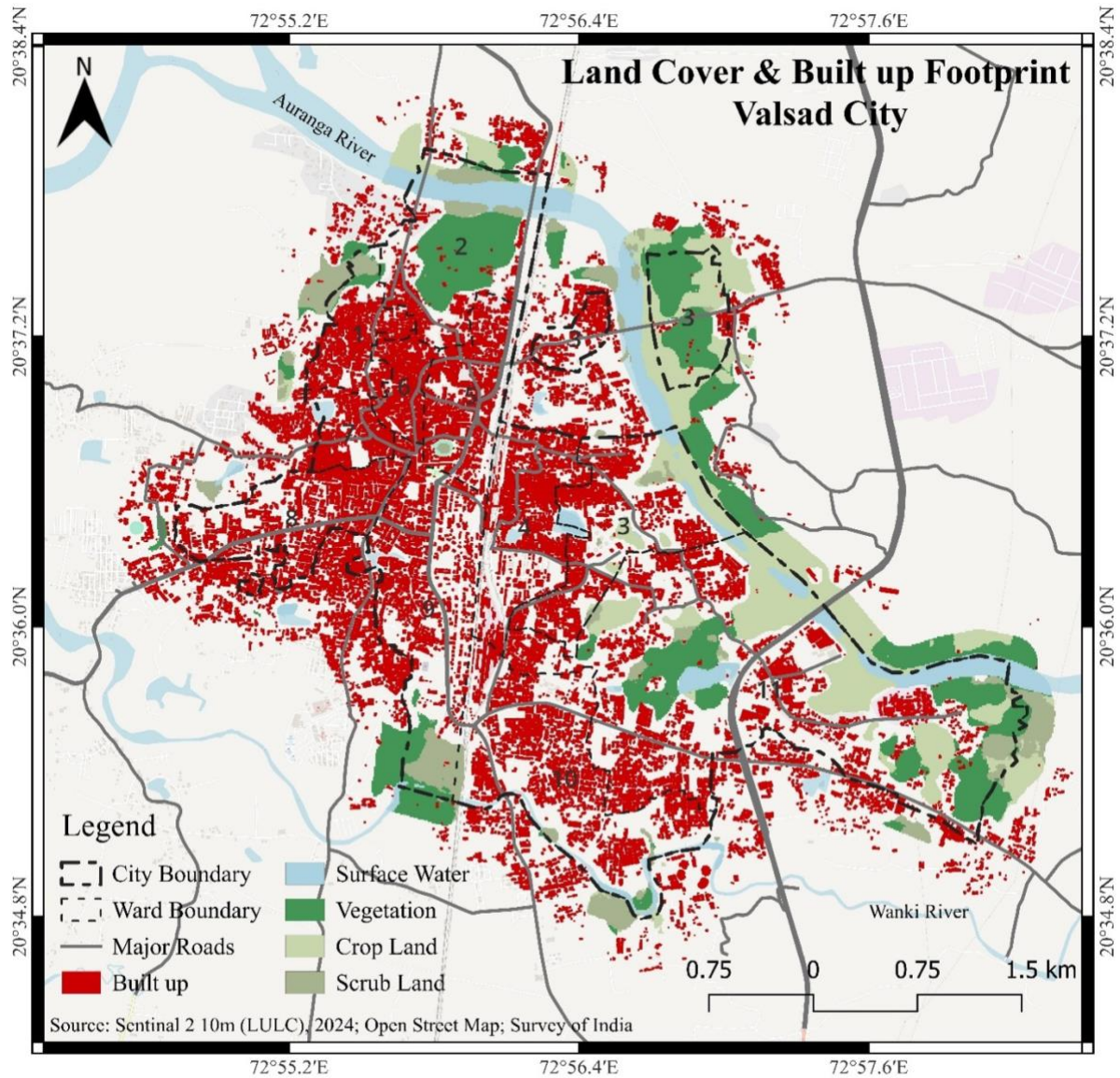
Topography: Valsad district has high variation in topography ranging from near sea levels all along western part to as high as 600m above MSL, in high relief tracks in eastern boundary. Based on topography and landforms, the main physiographic units identified in the district are narrow coastal plains having inter-tidal saline wastelands and adjoining alluvial plains in the west, and intermediate rocky table lands with contiguous high relief hill ranges in east.¹⁴

Valsad city lies in the alluvial plains in the west of the district. It is not directly connected to the sea as can be seen in Figure 3. It lies more than 3 km away from the Arabian Sea and hence is minimally affected by coastal risk drivers like storm surges, wave shoaling, shoreline erosion and rising sea level. The Wanki River flows south of Valsad and then runs parallel to the coast meeting the Auranga river at its mouth. Several smaller settlements such as Kosamba, Pali Hill, Nanakavada, Tithal, and Segvi, some of which are contiguous to Valsad, lie between the city and the sea, as is observed in Google Earth. It lies in the downstream floodplain of Auranga river basin. Auranga river is a west flowing perennial river with its catchment area comprising of the hill ranges of the Nasik district and Valsad district. The flow of the water in the rivers is more during the monsoon. The drainage is dendrite to sub-dendrite type, the low-lying flood plain near the mouth of the river is prone to overflow and flooding. This is primarily due to the sediment load and increasing annual precipitation, cyclonic weather events leading to intense precipitation, and storm surges and tidal effect in the wastelands along the coastal region due to climate change.

The city is situated on higher ground, with only 4% of its land at an elevation less than 5 m above mean sea level and more than 76 % of its land at an elevation 10 – 25 m above mean sea level. The built-up footprint of the city is towards its west and south. The low-lying areas are primarily along the banks of Auranga River, which flows along the eastern boundary of the city from south to north before meeting the sea at the west. The city has 7 non-flowing water bodies or *Talav*(AMRUT, City Water Balance Plan, 2021 – 22).

Land use and Landcover: Built up cover is the main classification for this densely developed city followed by surface water and vegetation cover along the floodplains. The residential, transportation and public land use are the main classifications for the city. A significant land is under use by the railways as Valsad serves as an important rail head in the region. Wards 1, 4, 5, 6, 7, 8 which form the western and central wards have the highest built-up cover and are the more populous wards of the city. Wards 1, 2 and 3 are the most low-lying wards with 40, 84 and 41 % land at an elevation of 10 meters above mean sea level. Due to the shallow aquifer and significant water rise seen in ground water levels post monsoon, ground water flooding along with river overflow together make these areas flood prone during monsoons. Ward 2, which is primarily of vegetated land use has only 16% of the land built up. While the population is distributed equally with each ward accommodating between 9 – 10 % of the total population (Refer Table 4), ward 6 and 7 towards the west of the city have the highest density of population and built-up land cover. The built-up footprint of the city is primarily towards its west and south, restricted by the river in the east and the north. (Refer figure 3)

Figure 3 : Built-up footprint of Valsad



Source: Sentinel 2 10m (LULC), 2024; Open Street Map; Mapusa Municipal Council

Ward no	Population	Estimated Ward Size (sq. km)	Estimated Population Density (per sq. km)	Built Area %
1	17954	0.471	38119	64%
2	17428	1.201	14511	16%
3	19857	1.859	10682	32%
4	19986	0.878	22763	57%
5	19216	0.683	28135	60%
6	18789	0.255	73682	88%
7	18961	0.282	67238	71%
8	18243	0.837	21796	61%
9	18684	1.461	12789	41%
10	19756	1.685	11725	43%
11	18977	4.387	4326	25%

Source: Census 2011 (Population) and GIS Analysis

Table 4 : Density of Population and Ward-level Built-up Footprint

Climate: Valsad district shows Heavy monsoon season precipitation (>1800 mm). The districts are Valsad recorded temperature greater than 31°C experience the highest mean annual daily maximum temperature (Government of Gujarat, 2021)¹⁵.

Disasters and Climate Change Vulnerability: Town level data on disasters and climate impacts is lacking. Hence, we relied upon district, administrative division and taluk level secondary data on disasters and climate change projections.

Extreme Temperatures

The districts of Valsad, Navsari, Surat, Bharuch, Vadodara, and parts of Tapi and Narmada have experienced significant increases in maximum temperatures, with recorded values exceeding 31°C. Observational data indicates a consistent warming trend, with the mean annual daily maximum temperature rising by approximately 1°C. Additionally, mean annual daily minimum and average temperatures have increased by about 0.1°C to 1.5°C. Despite this warming trend, several southeastern districts—including Valsad, Navsari, Dang, Surat, Tapi, Narmada, Bharuch, Vadodara, and parts of Chhota Udepur, Panchmahal, and Dahod—have also experienced a higher number of cold days in recent years, indicating increasing variability in temperature patterns.

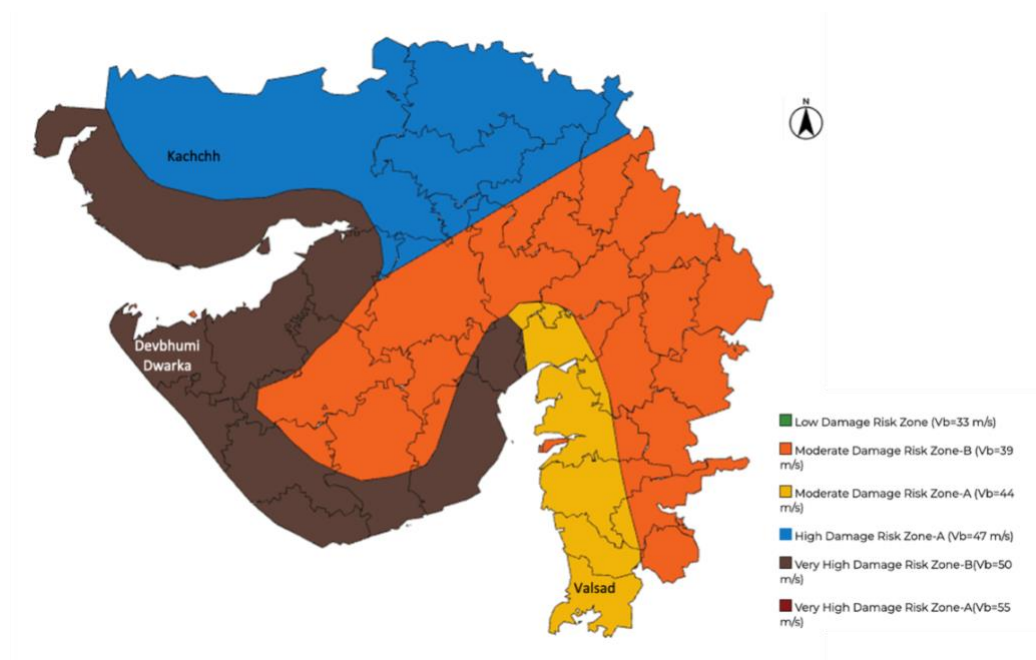
Looking ahead, climate projections suggest further temperature increases. Under the RCP 2.6 scenario, temperatures are expected to rise in the near and mid-term across the southern districts.

Similarly, under the RCP 4.5 scenario, a rise in temperature is projected in the near term for districts such as Valsad, Dang, Navsari, Surat, Tapi, Narmada, and Bharuch.

Cyclones

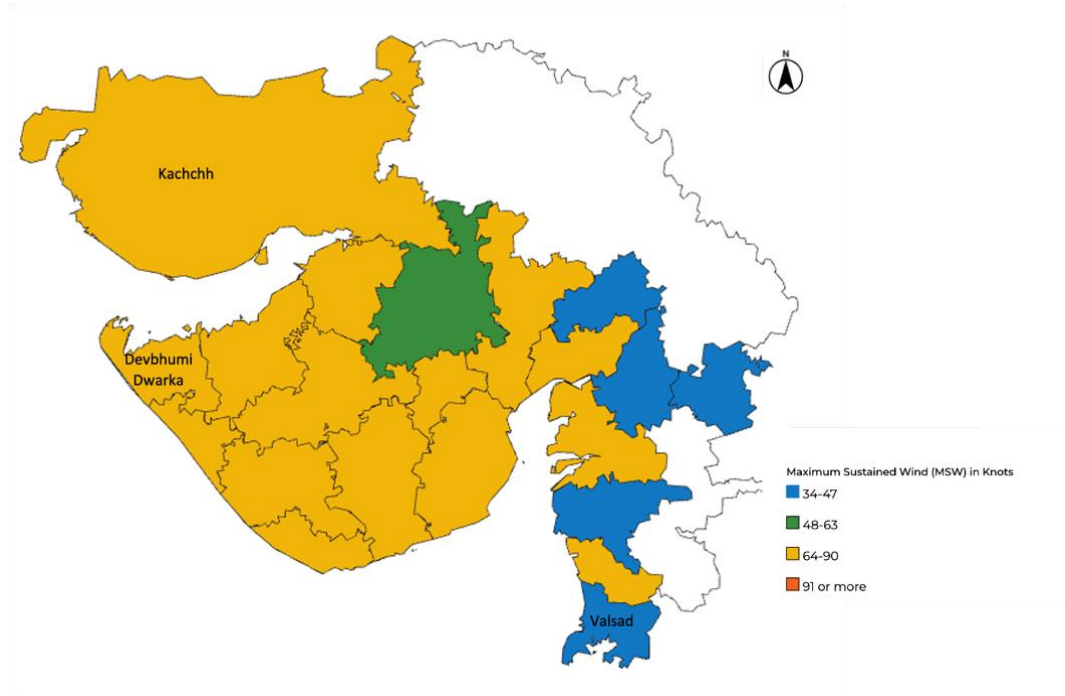
Gujarat lies within the tropical cyclone zone and, with the longest coastline in India—about 1,600 km—it is particularly susceptible to cyclones and related hazards like flooding and storm surges. As per NITI Aayog, Valsad district falls under the high maximum wind speed of 64-90 m/s and a moderate damage risk zone (Ref. Figures 4). Coastal areas in the district including Valsad town are particularly prone to cyclones and storm winds impacting infrastructure and services. For instance, Cyclone Vayu, which struck Gujarat in 2019 disrupted cargo operations at several ports, necessitating the evacuation of workers to safer locations. The cyclone also led to the suspension and cancellation of Western Railway services, and educational institutions were temporarily closed. Cyclone Biparjoy in 2023, a severe cyclonic storm, brought strong winds and heavy rainfall to Gujarat's coastal regions (Gujarat State Disaster Management Authority, 2024). In Valsad, Tauktae and Biparjoy cyclone caused severe flooding, with some buildings submerged and widespread power outages, highlighting challenges in disaster response and the gap between official claims and community experiences¹⁶.

Figure 4 : District Exposure to Wind Hazard



Source: (Niti Aayog, 2025)¹⁷

Figure 5 : District Exposure to Maximum Sustained Winds During Cyclonic Activities



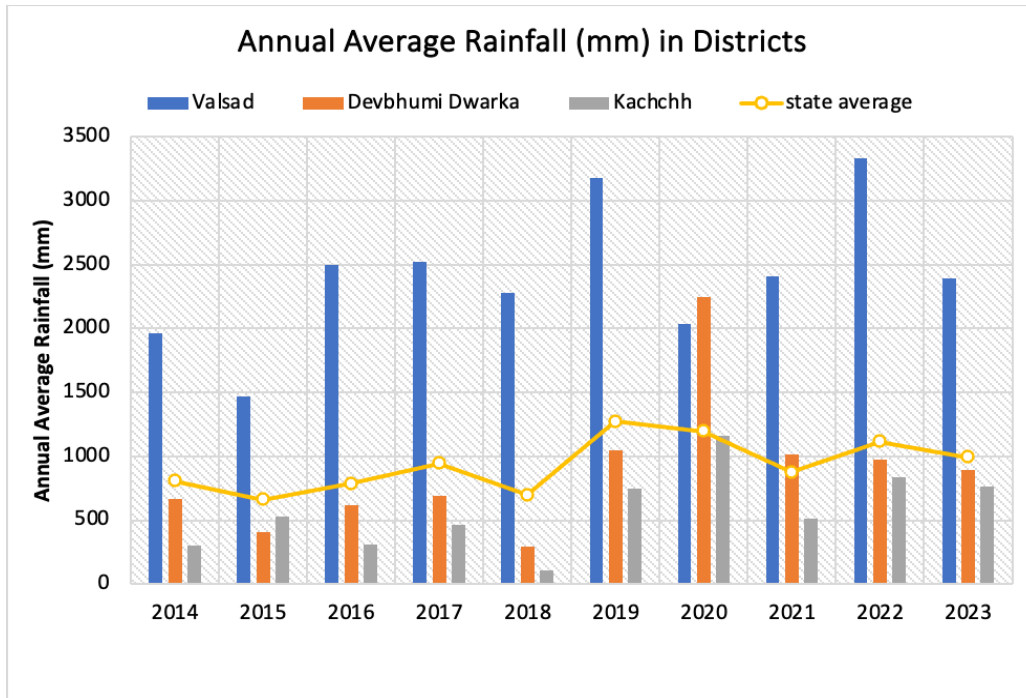
Source: (Niti Aayog, 2025)

Floods

Average seasonal rainfall has shown (refer figure 6) an increasing trend across the Saurashtra and South Gujarat regions, including Valsad. As illustrated in the figure below, Valsad consistently records one of the highest average annual rainfall levels in the state—significantly exceeding the Gujarat state average.

In addition to this overall rise in rainfall, several districts have experienced a notable increase in extreme precipitation events. Between 1951 and 2019, Valsad, Navsari, Dang, Tapi, Surat, and Narmada each recorded more than four extreme rainfall events, highlighting the growing intensity and variability of rainfall in southern Gujarat (Government of Gujarat, 2021).

Figure 6 : Annual Average Rainfall (mm) in Districts of Gujarat

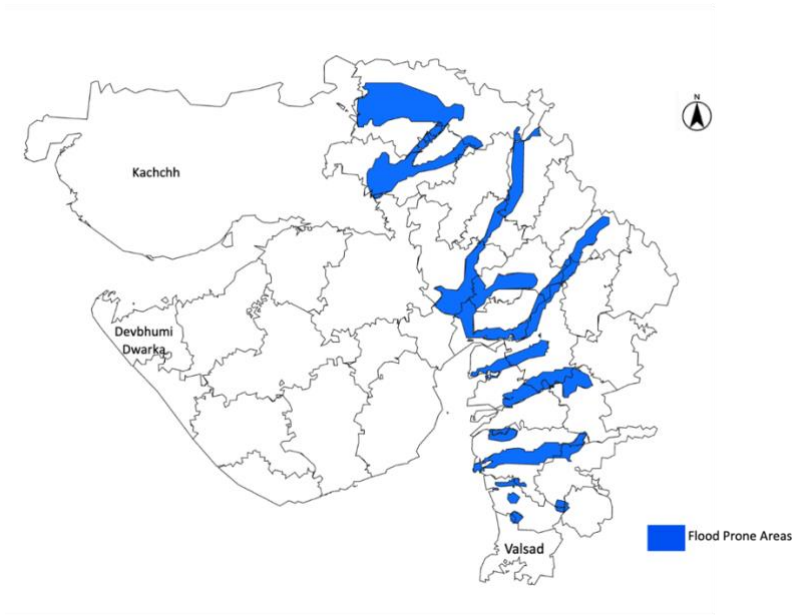


Source:(Central Ground Water Board , 2023)¹⁸.

As per Niti Aayog Valsad is not flood prone (Ref. figure 7). Similarly, according to a study by IIT Gandhinagar, the region has low exposure and flood risk; however, it exhibits moderate to high levels of hazard and vulnerability (Ref. Figure 8). Most of Gujarat's major rivers flow through extensive flat terrain before emptying into the sea. These low-lying areas in the lower river basins are particularly susceptible to flooding. Floods cause widespread damage to infrastructure such as roads, buildings, and tunnels, while also increasing soil erosion—especially affecting railway lines and water infrastructure. They further disrupt waste disposal and drainage systems. In addition to causing fatalities and injuries from its immediate effects, flooding can also heighten the risk of both communicable and non-communicable diseases due to increased stress and disruptions in regular healthcare services.

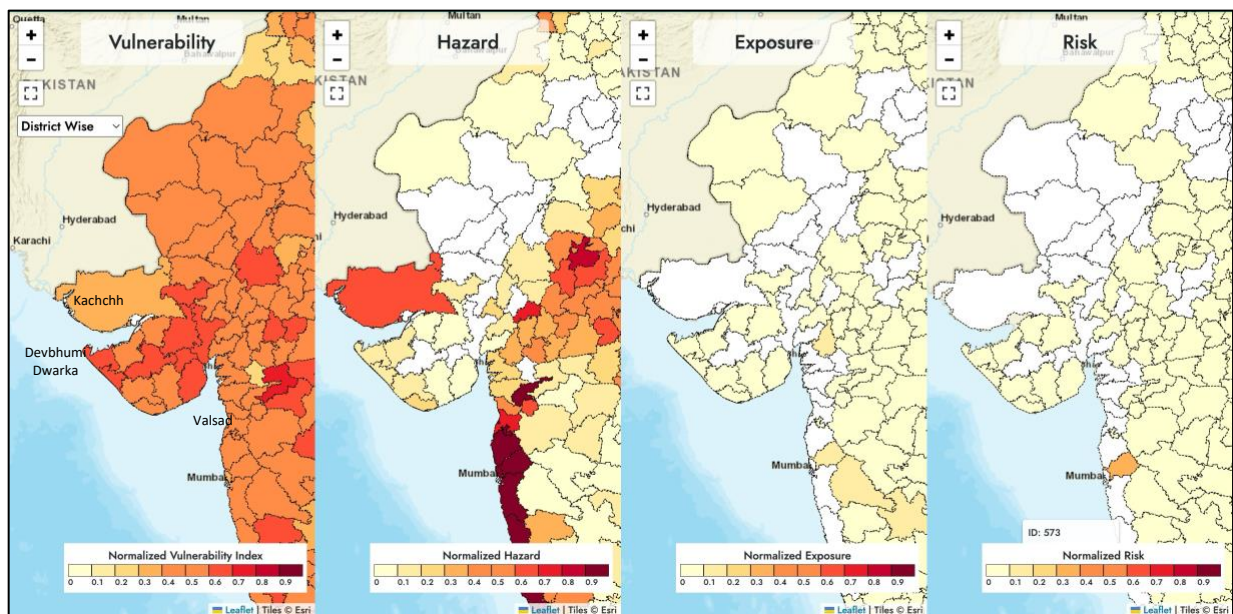
Our field observations revealed significant drainage challenges across various areas, particularly during the rainy season, with frequent flooding from heavy rains reported to adversely affect housing, sanitation, and water infrastructure.

Figure 7 : Flood Prone Areas in Gujarat



Source: Niti Aayog, 2025

Figure 8 : Flood Vulnerability, Hazard, Exposure and Risk: Districts of Gujarat



Source: IIT Gandhinagar¹⁹

CHAPTER 3: STATUS AND CHALLENGES OF WATER SUPPLY INFRASTRUCTURE AND SERVICES AT VALSAD MUNICIPAL COUNCIL

ABHAY JUNAGHARE & NC NARAYANAN

3.1 BACKGROUND

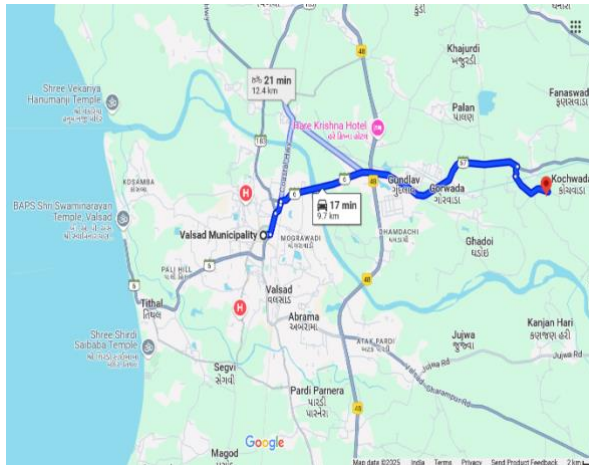
Water infrastructure and services in rapidly urbanizing coastal towns are increasingly under pressure due to the dual challenges of urban growth and climate change (Dodman, 2023²⁰; Moraci, 2020²¹; Nicholls et al., 2007²²). Coastal cities like Valsad are particularly vulnerable, as they depend on monsoon-driven surface water, groundwater aquifers, and fragile coastal ecosystems. Already facing constraints on freshwater resources, these towns are seeing rising demands for water and sanitation services while simultaneously grappling with the impacts of changing precipitation patterns, more frequent extreme weather events, rising sea levels, and saltwater intrusion (MoEFCC, 2018²³; USEPA, 2025²⁴; Datta et al., 2024²⁵; Rosińska et al., 2024²⁶). To better understand how current water management practices interact with broader environmental challenges, it is essential to assess the state of water infrastructure in these towns (Pal et al., 2023²⁷; Siddha & Sahu, 2020²⁸; Rajasree & Deo, 2020²⁹; Govindarajulu, 2020³⁰). The chapter provides status of water infrastructure and services in the town and highlights key challenges.

3.2 WATER SOURCES

3.2.1 SURFACE WATER SOURCES

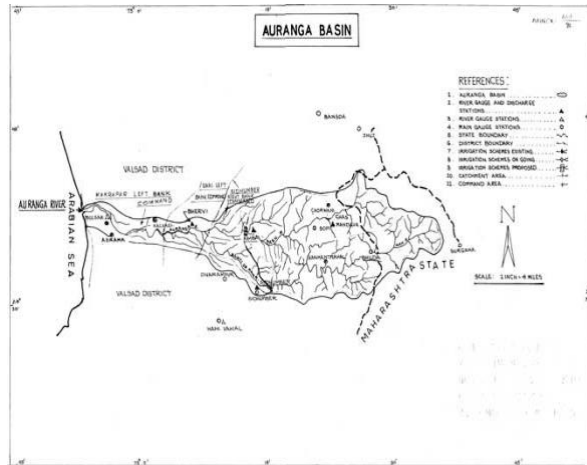
Being a coastal city, Valsad has long faced challenges in securing a sustainable and reliable water supply due to its proximity to the coast and the limited local water sources. By receiving water from the Auranga River, Valsad Municipality is able to meet the growing demand for drinking water, as well as water for sanitation and other municipal needs (Fig. 9, 10, 11, & 12). The river provides a reliable and consistent supply, which is crucial, especially during the dry summer months when local sources may not be sufficient.

Figure 9: Distance of Auranga River to Valsad City



Source: Google Maps

Figure 10: Auranga Basin



Source: WRD, Gujarat³¹

Figure 11: Flow of Auranga River



Source: Google Images

Figure 12: Water Source to Valsad - Auranga River



Courtesy: Team, IITB

The Auranga River is a west-flowing river (towards Arabian Sea) that originates near Bhervi village from the confluence of its two main tributaries, the Man and Tan rivers, both of which flow through

the Sahyadri hill ranges in Maharashtra. After the confluence, the river travels approximately 30 km before draining into the Arabian Sea. The river basin spans an area of 748 km², located between the latitudes 20° 30' and 20° 42' N, and longitudes 72° 53' and 73° 37' E, crossing through both Gujarat and Maharashtra. The basin features diverse topography, including hilltops, uplands, terraces, foot slopes, valley plains, and riverbeds. The region's climate is heavily influenced by the South-West monsoon, which accounts for 97% of the total annual rainfall, with figures ranging from 1644 mm to 2406 mm. To manage water resources more effectively, a number of storage reservoirs are proposed, including the Chasmandva Dam on the Tan River, aimed at supporting regional water storage and distribution (WRD, Gujarat).

The Auranga basin straddles both Gujarat and Maharashtra, with the majority of its drainage area located in Gujarat. The upper reaches of the basin are primarily hilly and forested, while the lower areas, around 15 km downstream from the confluence of the Tan and Man rivers, are flat and used for cultivation. The Tan River, covering a catchment area of 289 km², plays a crucial role in the hydrological system of the basin. Rainfall data from stations like Valsad highlight the basin's dependence on monsoonal rains, emphasizing the need for efficient water management. As part of a larger regional water strategy, six proposed dams, including the Chikkar and Kelwan dams, are intended to enhance water storage and facilitate water diversion through the Par-Tapi-Narmada link, providing a critical solution for sustainable water supply in the region (WRD, Gujarat).

The bulk water supply source to Valsad city is Auranga River. There are two water tapping points at the Auranga River that taps 30 Million Litres per Day (MLD) water from this source. The total bulk water tapped from all the sources at Valsad city is 28.0 MLD (AMRUT, 2025). Under AMRUT 2.0, Valsad city has awarded two contracts with a total estimated project cost of INR 6.90 Crores to rejuvenate the MOTATALAV MOGARAWADI (Lake). Previously, Valsad had multiple sources for its protected water supply. According to census 2011, the town relied on Tap water from treated source (TT), Tubewell /Borehole (TW/B) and Handpumps (HP) as protected sources for water supply. The total storage capacity from all the sources was 9.7 MLD at River Infiltration Gallery (RIG) and Pressure Tank (PT) (Census, 2011).

Valsad experiences a tropical climate with three distinct seasons: summer, monsoon, and winter. The summer season, from March to June, is characterized by high temperatures, often exceeding 40°C, with relatively low humidity. During the monsoon, from June to September, the region receives moderate to heavy rainfall due to the southwest monsoon, with annual precipitation ranging between 2,000 to 3,000 mm. This period sees a drop in temperatures, with humidity levels rising significantly, making the climate humid and warm. The winter months from October to February are cooler and more pleasant, with temperatures ranging between 15°C and 30°C, making it the most comfortable period of the year (CGWB, 2022; CGWB, 2013).

Rainfall is one of the most significant climatic variations in Valsad. The monsoon season brings a considerable amount of rain, with variations depending on the year. In some years, the rainfall can be above average, leading to waterlogging and flooding, while in other years, it might be less, causing drought-like conditions. The climate is influenced by the proximity to the Arabian Sea, which moderates the temperatures but also contributes to the high humidity levels, especially in the monsoon. As Valsad is a coastal city, the variations in temperature are relatively less extreme compared to inland areas, but the seasonality of rainfall is a critical factor in the region's overall climate patterns (CGWB, 2022; CGWB, 2013).

3.2.2 GROUND WATER

Valsad, a coastal city in southern Gujarat, depends heavily on its groundwater resources for agriculture, drinking water, and industrial use. The region experiences moderate rainfall (2,000 to 3,000 mm annually), which replenishes the groundwater supply during the monsoon season. Groundwater is primarily stored in shallow and deep aquifers, which are formed from alluvial deposits of sand, silt, clay, and gravel. Shallow aquifers, typically located within 20-30 meters from the surface, are sensitive to seasonal variations, while deeper aquifers (beyond 100 meters) offer more stable water reserves, albeit with challenges such as higher salinity and energy demands for pumping (CGWB, 2022; CGWB, 2013).

However, Valsad faces significant groundwater challenges, including over-extraction, salinity intrusion, and contamination from industrial and agricultural runoff. The increasing demand for water, has led to a declining water table and the encroachment of saline water into freshwater aquifers. To address these issues, local authorities have implemented measures like rainwater harvesting, regulating borewells, and promoting groundwater recharge programs. Effective management and conservation are critical to ensure the sustainable use of groundwater resources in the region, balancing the needs of agriculture, industry, and the local population (CGWB, 2022; CGWB, 2013).

The groundwater in Valsad, both from the Alluvium and Sedimentary areas and the Basalt area, generally maintains a slightly alkaline pH, averaging 8.21, which is within the acceptable range for drinking and agricultural use (Ref. Table 5). Electrical conductivity (EC) values (1160.5 $\mu\text{S}/\text{cm}$ on average) also fall below the WHO limit of 1,500 $\mu\text{S}/\text{cm}$, indicating that the water is not overly saline. While chloride, sulphate, and nitrate levels are within safe limits, the average bicarbonate concentration (307 mg/l) exceeds the acceptable range of 200 mg/l, which could affect soil pH and agricultural productivity due to higher alkalinity (CGWB, 2013).

Table 5: Hydrochemistry of Mandvi

Constituents	Alluvium and Sedimentary Area ³²	Basalt Area ³³	Average	Acceptable Range
pH	8.26	8.16	8.21	6.5 to 8.5
EC ($\mu\text{S}/\text{cm}$)	1167.00	1154.00	1160.50	1,500 $\mu\text{S}/\text{cm}$ (WHO 2004)
CO ₃ (mg/l)	ND	ND	0.00	200 mg/l
HCO ₃ (mg/l)	338.00	276.00	307.00	200 mg/l
Cl (mg/l)	167.00	187.00	177.00	250 mg/l and 1000 mg/l
NO ₃ (mg/l)	15.00	14.00	14.50	45 mg/l
SO ₄ (mg/l)	55.00	54.00	54.50	200 mg/L
F (mg/l)	0.58	0.39	0.49	1 mg/l and 1.5 mg/l
Ca (mg/l)	72.00	66.00	69.00	200 mg/l
Mg (mg/l)	36.00	30.00	33.00	100 mg/
Na (mg/l)	115.00	124.00	119.50	200 mg/l
K (mg/l)	6.00	9.00	7.50	10 md/l

Source: CGWB, 2013

The levels of fluoride, calcium, magnesium, sodium, and potassium in Valsad's groundwater are generally within acceptable limits, with fluoride levels averaging 0.49 mg/l, below the permissible limit of 1 mg/l. Calcium and magnesium concentrations are well within their respective limits, and sodium levels (119.5 mg/l) are also safe. However, while the overall water quality is good, the

high bicarbonate levels and potential risks from saline intrusion due to over-extraction, particularly in coastal areas, require continued monitoring. Regular assessments of these parameters will help ensure the long-term safety and sustainability of groundwater resources in the region (CGWB, 2013).

3.3 WATER DEMAND & SUPPLY

According to the 2011 Census, the population of Valsad was 1,14,636, with a total of 26,044 households and 35 slum settlements. By 2021, the population had increased to 1,74,244, with 50,026 households. The city's population density stands at 12,446 persons per square kilometre. Projections indicate that by 2025, the population will reach 2,08,678, with a total of 60,031 households and 6,486 slum households (AMRUT, 2025). The current water demand in the city is 41.3 MLD, while the available water supply is 28 MLD, creating a deficit of 13.3 MLD. According to AMRUT 2025, the city has a water treatment capacity of 33.0 MLD, of which 28.5 MLD is currently operational. Additionally, only 35,300 households have access to tap water connections in 2021, and the projected demand in 2025-26 is 60,031 households, creating a gap of 24,731 households without access to tap water connections in 2025-26 (AMRUT, 2025). Under the AMRUT 2.0 scheme, Valsad city intends to cover 10,000 HHs, while the remaining 14,731 HHs to be covered under various other schemes, as given in Table 6.

Table 6: Household coverage plan for water supply

#	Financial Year	Under AMRUT	Under other Schemes
1.	FY 2022	0	0
2.	FY 2023	750	0
3.	FY 2024	2,400	4,231
4.	FY 2025	3,350	4,500
5.	FY 2026	3,500	6,000
Total		10,000	14,731

Source: AMRUT 2.0, VMC

The city supplies 2.0 MLD water to 1,519 commercial establishments, 1.5 MLD to 1,422 slum households, 0.5 MLD to 7 industries, 1.5 MLD to 60 institutional establishments and 23 MLD water is supplied to 25,316 residential households. The average per capita water supply in Valsad is 261.07 litres per capita per day (lpcd). Future projections indicate a total water demand of 41.3 MLD, with 35 MLD required for residential households, 3.5 MLD for commercial use, 2.0 MLD for institutions, 0.8 MLD for industries, and 4 MLD for slum settlements.

Table 7: Water Supply Projects at Valsad

#	Project Name	Type	Milestone	Progress
1.	AMRUT 2.0: Redevelopment of old WTP 20.0 MLD Abrama Head Works at Valsad	Water Supply	Contract Awarded	0%
2.	Augmentation of Valsad Water Supply Scheme at Valsad	Water Supply	Contract Awarded	88%
3.	AMRUT 2.0: Reconstruction of Ramwadi Water Tank, Rakhodiya Talav Water Tank and Kalyan Bagh Water Tank	Water Supply	Contract Awarded	0%

Source: AMRUT 2.0, VMC

VMC plans to cover 10,000 additional households in phases from 2022 to 2026 (Table 7). However, the implementation of this plan has not progressed as expected, and the number of household connections remains stagnant. These initiatives remain crucial for improving water supply efficiency and addressing the city's growing water demand. Under AMRUT 2.0, the ULB has prepared 10 DPRs for several projects, out of which 10 were approved with a project cost of INR 162.22 Crores, and contracts were awarded for all 10 projects. Only one project has been completed out of the total 10 projects. Out of the 10 projects, only 3 projects pertain to water supply with a total project cost of 53.49 Crores (VMC, 2025).

3.4 WATER INFRASTRUCTURE

Water Treatment Plant: The water from Auranga River is sent to the Abrama Head Works (HW) WTP having a total designed capacity of 33.0 MLD. However, the operational capacity of the WTP is only 28.5 MLD creating an operational gap of 4.5 MLD. The projected consumption/demand for FY 2025-26 is the WTP with a total capacity of 41.3 MLD, hence creating a total operational gap of 12.8 MLD. The existing WTP is a consortium of 3 small WTPs, one of

which is recently constructed. The technology used for automatic monitoring at the recently constructed WTP is SCADA. However, the inspected WTP severely lacks manpower and is in weary condition (Ref. Figure 13).

Figure 13: Clari-flocculator at WTP

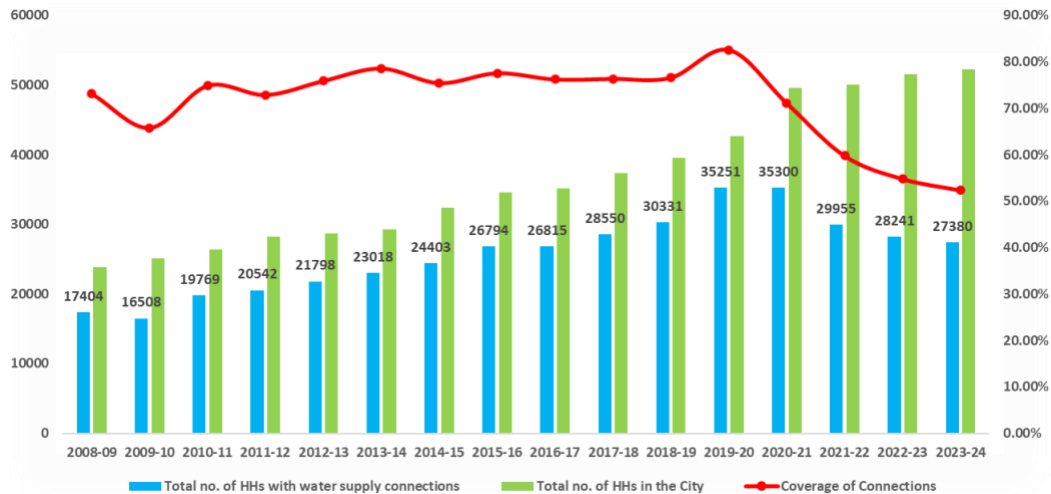


Courtesy: Team, IITB

Distribution Network of Water Supply: VMC receives a daily bulk water supply of 28.0 MLD from Auranga River. The raw water from the river flows into the Abrama Head Works (HW) WTP. After treatment, the water is discharged from the WTP outlet and stored in a GLSR, from where it is distributed to households through the city's network. The existing length of the water supply distribution network is more than 56 KM. Before being flown into the distribution tributaries, the water is temporarily stored at ELSRs and GLSRs.

Household Piped Water Supply in Valsad: The data presented reflects the coverage of water supply connections to households in VMC over a period of 16 years, from 2008-09 to 2023-24 (Ref. Figure 14). Throughout this period, there have been fluctuations in both the number of households with water supply connections and the overall percentage coverage, which can be analysed in several key phases. In the initial years (2008-09 to 2012-13), VMC exhibited a steady increase in both the number of households with water supply connections and overall coverage. For instance, in 2008-09, approximately 17,404 households had access to water, representing 73.14% of the total households in the city. This coverage gradually improved to 75.91% by 2012-13, with the number of connected households rising to 21,798.

Figure 14: Coverage of Water Supply at VMC



Source: VMC, 2025

The municipal council appears to have been making consistent progress during this period, though it did experience some fluctuations, such as a slight dip in coverage in 2010-11 (74.89%) and 2011-12 (72.89%). Between 2013-14 and 2019-20, VMC witnessed substantial growth in both population and water supply coverage. The number of households with connections increased significantly, from 23,018 in 2013-14 to 35,251 in 2019-20. This period saw the highest coverage of water connections, peaking at 82.60% in 2019-20. However, despite this apparent success, the increase in total households outpaced the expansion of connections, leading to a relative dip in coverage by 2020-21, which dropped to 71.16%. This suggests that while the council expanded water supply infrastructure, the rapid growth of the city's population may have been a challenge in maintaining high connection rates for all households.

From 2020-21 onwards, the coverage of water supply connections faced a sharp decline. By 2023-24, only 52.35% of households were connected to the water supply, a significant drop from 82.60% in 2019-20. This represents a stark reduction in both the absolute and relative coverage, with the number of connected households falling to 27,380. The drop in coverage could be attributed to several factors, such as resource constraints, delayed infrastructure expansion, or changes in administrative priorities. It could also be a result of a mismatch between the increasing number of households (which grew from 49,606 in 2020-21 to 52,304 in 2023-24) and the slower rate of expansion in water supply connections. Thus, while Valsad Municipal Council made significant strides in expanding its water supply connections in the earlier years, recent years have seen a worrying decline in coverage. This trend highlights the challenges associated with rapid urban

growth, the need for sustainable infrastructure development, and the importance of keeping pace with population demands in ensuring equitable access to essential services like water supply.

Tariff structures for Water Supply in Dwarka: The water supply in Valsad operates under a flat tariff system, where consumers are charged based on the annual water tariff. The ULB is not content with the existing low tariffs and proposed revision, however, that are yet to be approved by the local body. The annual water tariffs are as given below in Table 8.

Table 8: Annual Flat Tariff System at Valsad

#	New Connection Category	Existing Annual Tariff (INR)	Proposed Annual Tariff (INR)
1.	Residential	660.00	1000.00
2.	Non-Residential	1,100.00	1700.00
3.	Institutional	1,500.00	3000.00
4.	Commercial	5,000.00	7000.00
5.	Industrial	3,300.00	5000.00

Source: VMC, 2025

To acquire a new water connection, the charges are divided into new connection fees, labour charges, and road maintenance fees against each category. The ULB has proposed revision to the existing new water connection charges, however, they are yet to be approved by the local body. The new water connection charges are as given below in Table 9.

Moreover, the sanctioned intake staff capacity at VMC is 32, however, the current working staff capacity is 68. The sanctioned Engineering staff intake is 1, and 1 Engineer is working against the intake capacity. There are no Work Inspectors/Meter Readers working in Valsad. Only 2 Electricians/Fitters are working against the intake capacity of 14. There are no linemen/ plumbers against the sanctioned intake capacity of 6, whereas, there are 64 labourers working against the sanctioned intake capacity of 8 personnel.

Table 9: New Water Connection Charges in Valsad

#	New Connections	Type of Charges	Existing Charges (INR)	Proposed Charges (INR)
1.	Residential	New Connection Fee	300.00	500.00
		Labour Charges	500.00	600.00
		Road Maintenance Fee	400.00	1,000.00
		Total	1,200.00	2,100.00
2.	Commercial	New Connection Fee	300.00	500.00
		Labour Charges	500.00	600.00
		Road Maintenance Fee	700.00	1,200.00
		Total	1,500.00	2,300.00
3.	Industrial	New Connection Fee	300.00	500.00
		Labour Charges	500.00	600.00
		Road Maintenance Fee	700.00	1,500.00
		Total	1,500.00	2,600.00
4.	Reconnection Residential Use –	New Connection Fee	300.00	500.00
		Labour Charges	500.00	500.00
		Road Maintenance Fee	600.00	1,100.00
		Total	1,400.00	2,100.00
5.	Reconnection Commercial Use –	New Connection Fee	300.00	500.00
		Labour Charges	500.00	600.00
		Road Maintenance Fee	800.00	1,500.00
		Total	1,600.00	2,600.00

Source: VMC, 2025

3.5 KEY CHALLENGES

Valsad faces several critical challenges in its water supply system. Despite exceeding the national average in per capita water supply, the city struggles with low household coverage, with only 52.35% of households connected to the water supply, far below the Central Public Health and Environmental Engineering Organisation (CPHEEO) target of 100%. The water supply is intermittent, with only 2 hours of availability per day, well below the ideal 24-hour service. Additionally, Valsad has no metered connections, hindering effective resource management and financial sustainability. The cost recovery rate is concerningly low at 17.12%, and while non-revenue water (NRW) has improved to 19.33%, it still exceeds the target. Rapid population growth has outpaced infrastructure expansion, leading to a widening gap between supply and demand. Furthermore, delays in completing key projects, staffing shortages, and the lack of approved tariff revisions further exacerbate the city's water supply issues, calling for urgent investments in infrastructure, metering systems, and revenue management.

CHAPTER 4: URBAN SANITATION SYSTEMS IN VALSAD: STATUS, INSTITUTIONS AND CHALLENGES

NEELAM RANA, PRIYAKSHI GOGOI, NC NARAYANAN

4.1 BACKGROUND

Climate risks are significantly exacerbated by inadequate infrastructure in critical, interlinked sectors such as water and sanitation **which** disproportionately affecting socio-economically disadvantaged communities (Rumbach, 2018); (Yenneti, Tripathi, Wei, Chen, & Joshi, 2016); (Central Pollution Control Board , 2021). **Climate change-induced water stress and insecurity have been linked to a rise in waterborne infectious diseases, threatening to reverse progress toward the SDGs and exacerbating existing social and health inequities** (Braks & Husman, 2013). WaSH services are essential for preventing disease outbreaks, particularly in the aftermath of climate hazards such as heavy rainfall and flooding (Carlton et al., 2014; Jones et al., 2020)³⁴³⁵. In this context, **ensuring access to safe, reliable water, sanitation, and hygiene services** is widely **recognized** as a **low-regret adaptation measure**—offering substantial benefits **regardless of the severity of future climate scenarios** (Cutter et al., 2012)³⁶. The **IPCC** highlights **universal access to WaSH**—specifically the achievement of SDG targets 6.1 and 6.2—as a **high-confidence adaptation strategy**, underscoring its central role in building climate resilience (Caretta et al., 2022)³⁷.

India has only one national-level policy dedicated to urban sanitation—the National Urban Sanitation Policy (NUSP), introduced in 2008. The policy defines sanitation as the 'safe management of human excreta, including its safe confinement, treatment, disposal, and associated hygiene-related practices.' (Ministry of Urban and Housing Affairs, 2008, p. 6)³⁸. In the context of climate change, the policy links sanitation to GHG emissions and advocates the adoption of low-energy solutions, such as decentralized or onsite wastewater treatment technologies and distributed utilities. City Sanitation Plans (CSPs) are expected to incorporate these concerns, including the impacts of climate change, diminishing water resources, and the need for energy-efficient infrastructure (ibid).

Although sanitation is not explicitly identified as a focus area in India's **National Action Plan on Climate Change (NAPCC)**, it is closely linked to climate action through missions on water, sustainable habitats, and energy. The **National Water Mission (NWM)** emphasizes water

conservation and efficiency—critical for sustainable sanitation systems, especially in water-stressed urban areas. The **National Mission on Sustainable Habitat (NMSH)** more directly addresses sanitation-related concerns, including urban waste management, wastewater recycling, and climate-resilient infrastructure, thereby contributing to both mitigation and adaptation objectives. Sanitation is also aligned with the NAPCC’s broader emphasis on **energy efficiency and GHG emission reduction**, as centralized wastewater treatment plants are significant sources of methane and nitrous oxide. Innovations such as **waste-to-energy systems** and **resource recovery from faecal sludge** further support this agenda. Additionally, **State Action Plans on Climate Change (SAPCCs)**—developed in line with the NAPCC—are increasingly acknowledging sanitation as a key sector for climate intervention, particularly in climate-vulnerable regions. Though the NAPCC predates the **SDGs**, it has gradually evolved to align with global frameworks. National programs such as **SBM** and **AMRUT** have also begun integrating climate resilience and sustainability into urban sanitation planning and implementation.

Hence, assessing the current state of sanitation services is essential for identifying infrastructure gaps, vulnerabilities, and climate-related risks. Such an assessment supports the design of proactive adaptation measures, promotes efficient resource use, and enables low-carbon development strategies. A critical component of this process is mapping existing institutional arrangements—clarifying responsibilities, particularly the role of ULB, their engagement across different governance levels, and the interdependencies among key stakeholders. This chapter seeks to address these objectives through a detailed case study of Valsad. Data collection was primarily conducted through secondary sources, supplemented by primary data gathered via semi-structured interviews with ULB officials, district disaster management officers, and residents. These interviews helped fill information gaps and validate secondary data.

The chapter is organized into the following sections: **Section two** discusses the sanitation service chain, covering all critical stages—toilet access, containment, transportation, treatment, and final disposal or end-use. **Section three** reviews the institutional framework, detailing the roles and responsibilities of various stakeholders involved in sanitation governance. **The final section** concludes the chapter by highlighting key challenges and opportunities for improving sanitation infrastructure, service delivery, and governance.

4.2 SANITATION SERVICE CHAIN

Human waste must be safely managed throughout the entire sanitation service chain, which may have different stages, including capture, containment, emptying, transport, treatment, and disposal or end use (UNICEF, 2020)³⁹ (Refer **figure 15**).

- **Capture:** This includes toilets (individual household level, community, public). The primary function of a toilet is to capture excreta while effectively separating people from the waste to ensure safety and hygiene.
 - **Toilets:** According to the 2011 Census, out of 31374 households Valsad town + Out Growth area, 320 households did not have access to individual toilets. However, as per information received from the Valsad Urban Local Body (March 2025) which is SLB 2023-24, all 52091 Properties now have individual toilet facilities. The town has been officially declared Open Defecation Free Plus Plus (ODF++) in the year 2023, in line with the SLBs set by the Government of India and the SDG Target 6.2. The field visit also revealed that, even in low-income areas, most households had toilets in their homes.

Detailed information on toilet typologies is essential—not only to evaluate the quality and adequacy of sanitation services but also to accurately estimate the GHG emissions associated with different sanitation systems. However, the most recent comprehensive assessment was conducted during the 2011 Census, and no updated data has been made available since, at the national, state, or city levels. Gathering this information would necessitate a dedicated household-level survey, which lies beyond the scope of routine assessments.

- **Community Toilets and Public Toilets⁴⁰:** According to the ULB official the city currently has 5 CTs and 7 PTs. However, there is a discrepancy in the data presented on the SBM Urban dashboard, which lists a total of 14 community toilets and 7 public toilets. When we raised this inconsistency with ULB officials, they were unable to provide any explanation for the difference.
- Information on the coverage and usage of community and public toilets is currently unavailable, as the ULB does not maintain registers or systematic records tracking user numbers or assessing whether existing facilities meet local demand. According to ULB officials, the locations for public toilets were selected strategically, based on observed footfall and the perceived need for dedicated sanitation facilities in high-traffic areas.

To assess the condition of community and public toilets, we engaged with ULB officials, who stated that these facilities are generally well maintained. To verify this, our team conducted a site visit to one public toilet. The facility was found to be clean, functional, and equipped with running tap water. Water supply to all public

toilets is provided through direct piped connections managed by the municipality. However, the ULB does not maintain formal records of cleaning schedules or maintenance activities, making it difficult to independently verify the consistency of upkeep.

Photo 1 : Community toilet in Valsad City



Source: IITB team

- **Containment:** According to data provided by the ULB, as of 2022 (SLB 2023-24), the city had a total of 50,445 properties. Of these, only 33% (16,816) properties are connected to the sewerage network, while remaining 33,629 properties relied on OSS systems equipped with septic tanks with soak pits. Field observations also revealed that while even low-income areas have been connected to the sewerage network, some locations remain uncovered. In these areas, black water (wastewater from toilets) is discharged into open drains, which then flow directly into nearby water bodies.

Understanding the typology of OSS is crucial for accurately assessing GHG emissions. We inquired with ULB officials about the availability of such data; however, they were unable to provide any. Consequently, collecting this information would require a dedicated household-level survey, which falls beyond the scope of the current project.

- **Emptying and Transport:** Currently, the city has a sewerage network connection with 9 working and 2 under construction pumping stations. As mentioned in the previous section 66% of the properties relies on septic tanks with soak pits which are emptied by a single vacuum truck owned by the ULB, with a capacity of 3000 liters. Households are charged between INR 500 within the city and 2,000 outside city per trip for septic tank cleaning services. Apart from that the city also has private operators. Field observations revealed significant drainage challenges across various areas, particularly during the rainy season, with frequent flooding from heavy rains reported to adversely affect housing, sanitation, and water infrastructure. As per the ULB officials, the wastewater from CT and PT gets collected in the sewerage network.

Photo 2 : Storm Water Drainage Situation and Flood Affected Household in Valsad

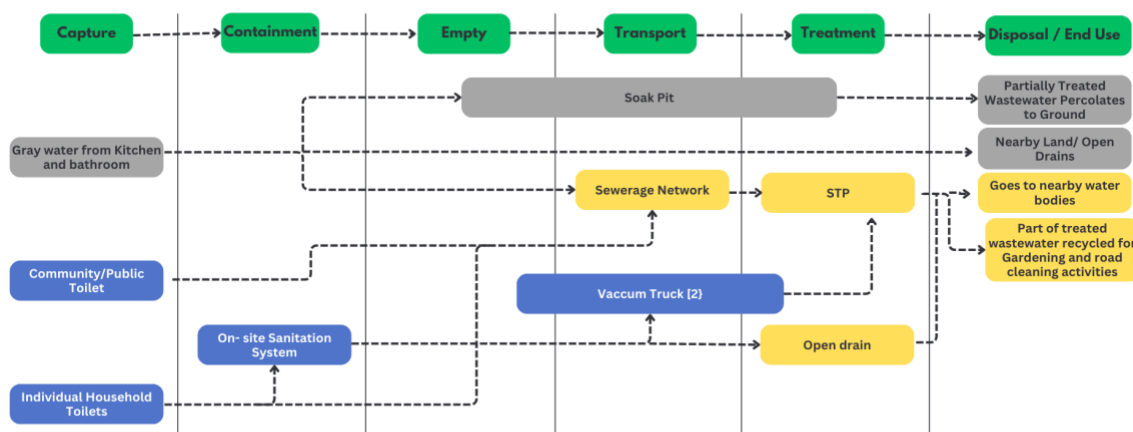


Source: IITB team

Field visits revealed considerable variation in **greywater management practices** across households. While some homes channel greywater into separate soak pits, others discharge it into nearby open drains. **The city has a pucca stormwater drainage network extending over 91 km, covering approximately 68.94% of the total 132 km road length as of 2023–24**, according to SLB data. However, beyond this coverage figure, there is a lack of secondary data on the drainage network's typology or its potential GHG emissions. Assessing these aspects would require in-depth technical studies, which are beyond the scope of the current study.

- Treatment:** According to the SLB 2023–24 report, the town generates 20.1 MLD of wastewater and has a 20.20 MLD Sequencing Batch Reactor (SBR) technology-based STP, commissioned in 2020. Even though the ULB officials claim that all the wastewater is being directed to the treatment plant, field visits to the STP revealed insufficient wastewater inflow for effective treatment. Since the majority (66.67%) of the properties (according to SLB 23-24) rely on the OSS system, it is highly likely that a significant portion of the wastewater is not reaching the treatment plant for processing.
- End-use Disposal (Septage and Sludge Management)** ⁴¹: The city currently lacks a dedicated Faecal Sludge and Septage Treatment Plant (FSSTP). Instead, it relies on 1 vacuum truck owned by the ULB. The septage collected by these trucks is transported to the STP.
- Recycling and Reuse:** The treated wastewater from the STP is currently being recycled and reused for road cleaning and gardening activities. Additionally, there is a memorandum of understanding (MoU) in place to sell this treated wastewater to private chemical companies in the city that require hard water. The team visit to the STP revealed that the treated sludge has not been utilized for any purpose.

Figure 15 : Sanitation Service Chain in Valsad



Source: Authors' Illustration

4.3 INSTITUTIONAL ARRANGEMENTS

This section explores the institutional arrangements for sanitation governance, highlighting the roles of various departments, agencies, and organizations involved in delivering sanitation infrastructure and services (refer table 10). It underscores the pivotal role of ULBs in disaster governance and their broader responsibilities within India's multi-level governance framework.

Sanitation is constitutionally a state subject, with ULBs designated as the primary entities responsible for water supply and sanitation services under the 74th Constitutional Amendment Act. However, in practice, sanitation governance involves a complex multi-stakeholder framework spanning national, state, and city levels.

At the household level, neither ULB nor other institutions are actively involved in enforcing standards for toilets or OSS. For larger establishments, compliance mechanisms exist through building plan approvals managed by state-level agencies like Gujarat Urban Development Company (GUDC) and Gujarat Urban Development Mission (GUDM).

At the ULB level, smaller sanitation interventions like *PT and CT* are primarily the ULB's responsibility, with independent decision-making power in key areas such as land selection, technology choice, *O&M*, and funding. Under the SBM 1.0, capital funding was provided for all CTs and PTs, supplemented by the ULB's own revenue resources. The O&M of CTs is managed directly by the ULB, while the O&M of PTs has been outsourced to private vendors, who recover costs through user charges.

ULBs serve as nodal agencies for delivering sanitation services, but their involvement in large-scale infrastructure projects such as STPs is often constrained. The funding for such projects largely comes from central government schemes like AMRUT- 1.0, with the selection of technology, approval, and implementation overseen by state-level agencies such as the GUDC and GUDM. This centralized approach limits the autonomy of ULBs, making them dependent on higher tiers of government for both financial resources and critical decision-making in infrastructure development

Furthermore, in terms of disaster management, the ULB does not have a dedicated disaster response team in the ULB. But they work with *DDMA* and coordinate with multiple departments to mobilize staff, equipment, and resources for rapid response. The ULB initiates pre-monsoon preparedness activities approximately 60 days before the rainy season, focusing on flood mitigation and community safety. They thoroughly clean and desilt underground drainage (UGD) systems and stormwater networks to prevent blockages and ensure efficient water flow. Community canters near low-lying areas are identified as temporary shelters and stocked with essential supplies, including food kits, medical provisions, potable water, and sanitation facilities, to accommodate displaced residents during emergencies. During the monsoon months of June, July, and August, water quality

testing is intensified to monitor safety. The Ornaga River becomes a River after merging of two rivers called Kaam and Maan. At this junction, an early warning monitoring system has been installed by the DDMA. When the water level rises and the ULB gives warnings to the city. This operation is managed by the DDMA.

Table 10 : Institutional Arrangements: Sanitation Services

Intervention	Technology Selection	Land	Capital	Technology Provision	Technology implementation	O&M	O&M Funding
Toilets	HH	HH	HH	Local vendors/Mesons	Local Vendors/Mesons	HH	HH
OSS	HH	HH	HH			HH	HH
						Septage removal by vehicles of ULB	
CT	ULB	ULB	ULB	ULB	ULB	ULB	ULB
			Central Government [SBM 1.0]				
PT	ULB	ULB	ULB	ULB	ULB	Sulabh international	Pay and Use by the Agency
			Central Government [SBM 1.0]				
STP	GUDM	ULB	Central Government [AMRUT 1.0]	GUDM	GUDC	GUDC	GUDC
Sewerage network	GUDM	ULB	Central Government [AMRUT 1.0]	GUDM	GUDC	GUDC	GUDC

Source: (Rana, Gogoi, & Narayanan, Forthcoming)⁴²

4.4 CHALLENGES AND OPPORTUNITIES IN SANITATION INFRASTRUCTURE AND SERVICES

It is clear that the town is not fully meeting several of the SLB norms set by the Government of India. The challenges outlined below are key barriers to achieving the required service levels, but they also present valuable opportunities in provision of equitable and affordable sanitation services to all.

- **Inadequate Infrastructure and Services:** The city has only 33% of its properties connected with the sewerage network. The insufficient coverage and integration of the sewerage network may result in a substantial proportion of untreated sewage being released into open drains and local water bodies. This not only poses serious environmental and public health risks but also highlights broader challenges in urban wastewater management, such as slow network expansion and the reliance on stormwater drains for sewage conveyance. However, as per the ULB officials, the citywide sewerage network is under construction. Currently, approximately 80% of the sewerage connections are integrated with the stormwater drainage system, which directs the wastewater to the STP. However, the remaining 20% of sewage is discharged directly into open drains and eventually flows into nearby water bodies without undergoing primary treatment. The officials further indicated that the ongoing development of the sewerage network, running parallel to the stormwater drainage system, is expected to resolve this issue upon completion.
- **Integrating Climate Resilience and Disaster Risk Planning in Infrastructure Planning for Coastal and Low-lying Areas:** The city, classified as a low-lying and flood-prone area, is traversed by the Oranga and Waki rivers before they meet the sea. During the flood, many residents experienced water entering their homes, even though their foundations were built at considerable heights. In some cases, houses were nearly submerged, prompting people to seek refuge with relatives or in higher-rise areas. Residents noted challenges with water and sanitation during this period. To manage stormwater runoff, local authorities have mapped and upgraded discharge lines to ensure efficient drainage of rainwater into the rivers. While this has helped mitigate flooding caused by heavy rainfall, officials report that the major challenge of tidal backflow persists. During periods of high tidal waves, seawater flows back and stagnates in the low-lying areas of the city, even in the absence of rainfall. This underscores the urgent need for protective infrastructure, such as sea walls, barriers, or barrage systems, to prevent seawater intrusion during such events. Moreover, seawater intrusion presents a potential risk to both ground and surface water quality, particularly in terms of salinity. This situation highlights the complex challenges faced by coastal cities, which must simultaneously manage the risks of both riverine and coastal flooding.

Photo 3 : Flood Affected Area in Valsad City



Source: IITB Team

Similarly, ULB officials have stated that the STP is in a low-lying area near the river due to the lack of alternative land for its construction. Although the STP is enclosed by a wall, during periods of heavy rainfall and flooding, the river water can rise to the level of the wall. When this occurs, floodwaters may reach the STP, causing untreated wastewater to overflow and potentially flow back into the city, leading to significant nuisances and serious public health risks. This situation highlights the urgent need for climate-proofing infrastructure, ensuring that essential facilities like sewage treatment plants are designed to withstand extreme weather events and rising flood risks. Flooding, heavy rainfall, or strong winds can lead to power outages, disrupting critical services such as water supply. Our interactions with ULB officials revealed that while the STP is equipped with a power backup system, the water treatment plant does not have such provisions. In the event of power failures, the ULB arranges for tanker water supply to ensure that residents continue to have access to water. Given the essential nature of water services, it is recommended that the ULB install reliable power backup systems, such as generators or solar-powered solutions, at the water treatment plant to ensure uninterrupted water supply during extreme weather events.

Photo 4 : Storm Water Drainage and Sewerage Network



Source: IITB team

Photo 5 : STP Location



Source: STP Location Plotted on Google Earth Map

CHAPTER 5: GREENHOUSE GAS EMISSIONS FROM WATER AND SANITATION SYSTEMS: A CASE STUDY OF VALSAD

ASHISH DANGI⁴³ AND NC NARAYANAN

5.1 BACKGROUND

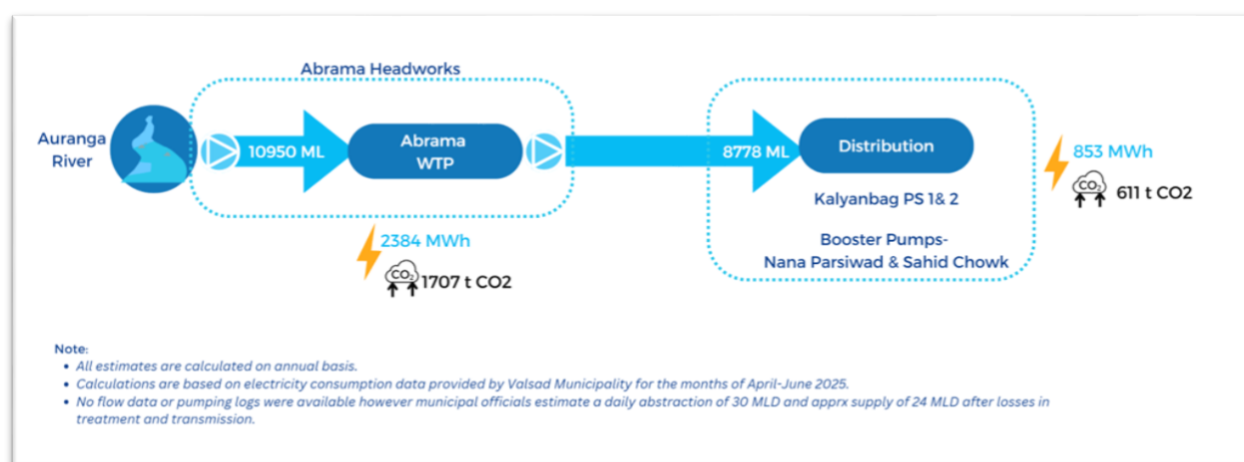
The water sector is not just a victim of climate change; it is also a significant contributor to GHG emissions. Energy is a key input in the management of the urban water services. Conventional water and wastewater systems are energy dependent systems that contribute to indirect carbon emissions and water withdrawals for energy generation. Similarly, wastewater treatment processes emit methane and nitrous oxide, potent GHGs that further drive climate change. As local water availability declines, cities increasingly depend on energy-intensive alternatives such as long-distance water transfers and advanced treatment technologies, driving up energy use and carbon emissions. This, in turn, exacerbates climate change, intensifying the very impacts these measures aim to address. By examining the entire water cycle including sourcing, treatment, distribution, wastewater management, and the associated material and energy flows, this chapter highlights the critical linkages between water, sanitation, and climate resilience. Understanding these connections is essential for developing a sustainable and adaptive urban water management strategy.

As cities strive to meet rising water demands, they are often locked into a cycle of increasing energy consumption and emissions. The push for climate resilience must therefore consider not only how water systems are impacted by climate change but also how they contribute to it. This chapter assesses the carbon footprint of existing water and wastewater management practices in VMC, highlighting the energy dependencies and emissions associated with each stage of the water cycle. By quantifying these emissions, the assessment aims to provide insights into the trade-offs between different management strategies and explore opportunities for decarbonising urban water systems. A shift towards more energy-efficient practices, integration of renewable energy, and nature-based solutions can help mitigate emissions while ensuring long-term water security. Understanding these dynamics is essential in designing sustainable water management systems that align with both climate adaptation and mitigation goals.

5.2 GREENHOUSE GAS EMISSIONS FROM WATER SUPPLY

The energy-intensive nature of water supply—spanning extraction, treatment, conveyance, and distribution—results in substantial indirect GHG emissions, primarily from electricity use. Additionally, household-level pumping, purification, and heating contribute to the carbon footprint, although such household level energy use is not accounted for here. Emissions related to treatment chemicals, construction materials, and logistics also remain outside the scope of this estimation due to data constraints. Furthermore, scientific studies suggest that freshwater reservoirs may also release direct GHG emissions due to anaerobic decomposition of organic matter in sediments⁴⁴. However, these are excluded from this analysis given methodological limitations. This section focuses solely on electricity-related emissions across key components of the water supply chain, as shown in Figure 16.

Figure 16 : Carbon and energy footprint of Valsad's water supply



Source: (Dangi & Narayanan, forthcoming)⁴⁵

The Valsad municipal water supply system sources raw water from the Auranga River through the Abrama Headworks. An estimated 30 MLD is abstracted daily, of which approximately 24 MLD is delivered after treatment and transmission losses.

The energy consumption profile of the system shows two major emission-intensive stages:

- **Abstraction, Treatment and Conveyance at Abrama Headworks:** Annual electricity consumption is 2,384 MWh, resulting in approximately 1,707 tonnes of CO₂ emissions. This represents the most energy-intensive stage of the system.

- **Distribution through pumping stations and boosters** (Kalyanbag PS 1 & 2, Nana Parsiwad, and Sahid Chowk): Annual energy use amounts to 853 MWh, corresponding to 611 tonnes of CO₂ emissions.

Together, the Valsad water supply system consumes about 3,237 MWh annually, emitting ~2,318 tonnes of CO₂.

The emission intensity of the system is therefore directly tied to the losses between abstraction (30 MLD) and supply (24 MLD) equivalent to 20% system losses. These inefficiencies mean that a substantial portion of energy-related emissions are associated with water that never reaches end users. As demand continues to rise, without efficiency gains the system risks being locked into a cycle of higher pumping, higher treatment loads, and escalating emissions. Targeted actions such as reducing water losses, upgrading pumping infrastructure, and integrating renewable energy can lower the carbon intensity of supply while securing long-term resilience.

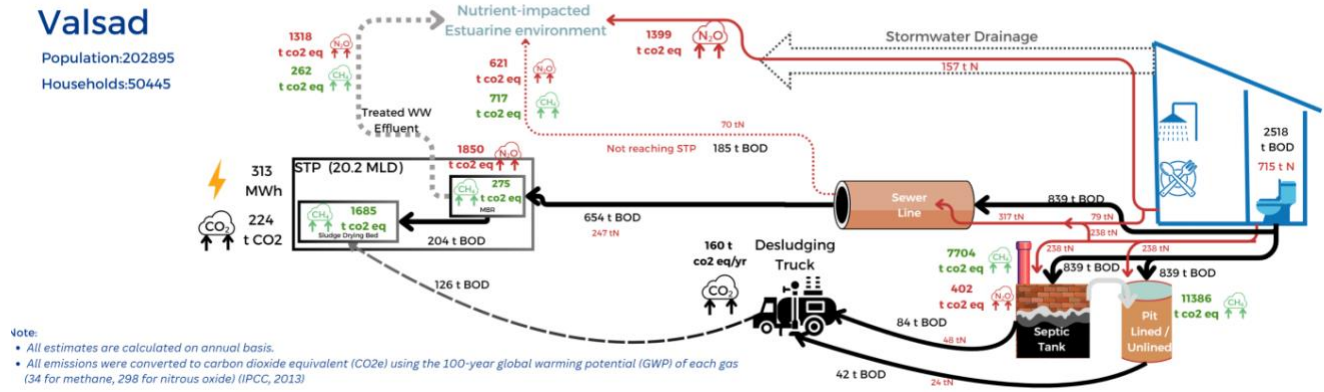
5.3 GREENHOUSE GAS EMISSIONS FROM SANITATION

Energy plays a crucial role across the sanitation service chain, particularly in the treatment and transportation of wastewater and sludge, leading to indirect GHG emissions linked to electricity consumption. Wastewater treatment plants alone are estimated to account for 3% global electricity consumption⁴⁶. With the rise in sewage generation and treatment capacity, the energy and carbon footprint of wastewater is likely to increase dramatically in the near future in the absence of interventions. For example, domestic wastewater emissions increased by 400% between 2000-2014 in China due to growth in WWTPs⁴⁷. With the increased variability posed by climate change the emission in WWTPs could further increase⁴⁸. Additionally, biological degradation of the organic matter present in sewage and grey water across the containment, transport, treatment and discharge pathways in a sanitation service chain results in direct methane (CH₄) and nitrous oxide (N₂O) emissions. Direct emissions in wastewater treatment are significant at ~1.57% of global GHG emissions⁴⁹.

An assessment of the carbon footprints is thus important for understanding not only its implication for sustainability of the sanitation systems but also for energy security and climate mitigation due to growing evidence on rising emissions.

The **figure 17** below presents the energy consumption and carbon emissions associated with wastewater management in Valsad. The flow diagram underscores how every link in the town's urban wastewater chain feeds the climate problem.

Figure 17 : Carbon footprint estimation of Urban Water Cycle



Source: (Dangi & Narayanan, forthcoming)⁴⁵

- **Toilet use in Valsad** releases **2518 t BOD** and **715 t N** per year in wastewater, setting the stage for substantial methane (CH₄) and nitrous-oxide (N₂O) generation downstream.
- **Centralised treatment:** Valsad's 20 ML d⁻¹ sewage-treatment plant uses **313 MWh** releasing **224 t CO₂** for treating about one-third of the total wastewater generated. Direct emission from aerobic treatment amount to **275 t CO₂-eq CH₄** plus **~1850 t CO₂-eq N₂O**. Sludge handling at the STP results in an additional **1685 t CO₂-eq CH₄**. Almost **30 % of the load** (185 t BOD and 70 t N) **never reaches the treatment plant**. That bypassed organic matter decomposes anaerobically, emitting an extra **~717 t CO₂-eq CH₄** and **~621 t CO₂-eq N₂O** in the estuarine environment.
- **On-site sanitation:** Household pits and septic tanks handle far more waste than the central sewers. Leaky, unlined pits release an estimated **11 400 t CO₂-eq of CH₄** each year; traditional septic tanks add another **7 700 t CO₂-eq CH₄** plus **~400 t CO₂-eq N₂O**. These figures dwarf the CO₂ from electricity, showing why faecal-sludge governance is pivotal in coastal towns.
- **Desludging logistics add a small but visible slice:** Vacuum-truck fleets that ferry sludge to the treatment plant emit **~160 t CO₂ yr⁻¹**. While minor compared with biological

emissions, this load will rise if desludging frequency increases without cleaner fuels or smarter routing.

- **Nutrient leakage drives N₂O from coastal waters.:** Grey-water and treated effluent deliver **>150 t N per year** to the estuary, producing **2717 t CO₂-eq of N₂O**. Capturing or polishing these flows would cut both eutrophication and climate impacts.

Our results illustrate that the urban water systems are climate actors in their own right. In Valsad the largest mitigation wins lie in leakage control, sealed or upgraded on-site tanks, routine sludge removal coupled with biogas and nutrient recovery. Addressing those hotspots converts a fragmented, energy-hungry network into an integrated, climate-resilient water cycle.

5.4 CONCLUSION AND STRATEGIC PRIORITIES

The assessment of Valsad Municipal Council's (VMC) water and sanitation infrastructure paints a clear picture: the town's urban water cycle is a highly active, localized climate driver. From the high-energy demands of abstraction at the Auranga River to the massive fugitive emissions released into local estuaries, Valsad's water management practices require a paradigm shift to align with climate resilience and mitigation goals.

KEY TAKEAWAYS

- **The On-Site Methane Burden:** Decentralized sanitation is by far the largest climate actor in Valsad's water sector. Leaky, unlined pits and traditional septic tanks collectively generate over 19,500 tonnes of CO₂-eq in methane and nitrous oxide annually. These biological emissions vastly overshadow the carbon footprint of the town's electricity consumption.
- **The Climate Cost of Water Loss:** Valsad pumps and treats 30 MLD of water but only delivers 24 MLD. This 20% physical loss means that a substantial portion of the 3,237 MWh of electricity consumed annually—and the resulting 2,318 tonnes of CO₂—is expended on water that never reaches the end user.
- **Treatment Bypass and Sludge Emissions:** While Valsad has a 20 MLD centralized sewage treatment plant, nearly 30% of the network load bypasses treatment entirely, degrading anaerobically in the estuarine environment to produce over 1,300 tonnes of CO₂-eq. Furthermore, unmanaged sludge at the STP adds an additional 1,685 tonnes of CO₂-eq in methane.

- **Estuarine Nutrient Leakage:** The discharge of grey-water and treated effluent deposits over 150 tonnes of nitrogen into coastal waters annually. This nutrient overload not only causes localized eutrophication but generates 2,717 tonnes of CO₂-eq of N₂O, proving that downstream ecological impacts carry heavy climate penalties.

THE WAY FORWARD

To break the cycle of escalating water demands driving higher emissions, Valsad must transition from an energy-hungry, fragmented network to an integrated, low-carbon water cycle. Strategic priorities should focus on system efficiency, strict faecal-sludge governance, and nutrient recovery:

1. **Seal and Upgrade On-Site Sanitation:** The absolute highest mitigation priority is overhauling decentralized sanitation. Transitioning from leaky pits to safely sealed containment and optimizing desludging schedules will immediately curb the town's massive fugitive methane footprint.
2. **Plug the 20% Water Loss:** VMC must implement aggressive Non-Revenue Water (NRW) reduction strategies. Repairing transmission leaks between the Abrama Headworks and the distribution network will immediately reduce the treatment load, lower electricity consumption, and cut the 2,318-tonne CO₂ footprint without requiring new infrastructure.
3. **Optimize Centralized Treatment and Sludge:** The 20 MLD STP must be optimized to capture the 30% bypassed load. Furthermore, incorporating anaerobic digestion for sludge handling could capture the 1,685 tonnes of CO₂-eq currently lost to the atmosphere, converting a climate liability into a biogas energy asset to power the plant.
4. **Protect Coastal Waters with Nutrient Polishing:** Implementing nature-based solutions, such as constructed wetlands, to polish STP effluent and intercept raw grey-water can naturally strip nitrogen before it reaches the estuary. This will simultaneously mitigate over 2,700 tonnes of N₂O emissions and protect the local coastal ecosystem.

Securing Valsad's water future means recognizing that every drop pumped, leaked, or discharged has a carbon price. By targeting these specific emission hotspots, the municipality can build a water system that is both operationally efficient and fundamentally climate-resilient.

CHAPTER 6: PERFORMANCE AND FINANCIAL ANALYSIS OF WATER SUPPLY AND SANITATION AT VALSAD MUNICIPAL COUNCIL

ABHAY JUNAGHARE⁵⁰ AND NC NARAYANAN

6.1 INTRODUCTION

This chapter analyses the performance analysis against the SLBs for urban water supply and sanitation by the Ministry of Housing and Urban Affairs (MoHUA). This chapter analyses the revenue streams and grants available to The performance and financial health of VMC water supply and sanitation is constrained by systemic inefficiencies and fiscal dependence. Despite progress in per capita supply and water quality, the absence of metering and limited continuity of supply weaken accountability and revenue generation (VMC, 2025). Rising operational costs, particularly electricity and staffing, have outpaced user charges, leading to declining cost recovery and growing arrears (VMC, 2025). Heavy reliance on central and state grants further undermines financial autonomy, highlighting the urgent need for tariff rationalization, improved billing, and diversification of revenue streams (VMC, 2025). This chapter is chiefly bifurcated into two sections, viz., the performance analysis followed by financial analysis of the water and sanitation sector at VMC.

6.2 PERFORMANCE ANALYSIS: SERVICE LEVEL BENCHMARKS

The performance⁵¹ of the water utility and sewerage & sanitation in Ratnagiri can be assessed based on the performance indicators. These nine performance indicators known as the SLBs for urban water supply and sewerage and sanitation in India were proposed by the then ministry of urban development (now MoHUA) These SLBs are able to ascertain the inefficiencies in the urban water supply system (UWSS) and sewerage & sanitation besides providing the corrective measures that are vital to achieve sustainable water supply and sewerage & sanitation. The SLBs can be distinguished into four major indicator groups, viz., access, quality of water supply and treated used water, financial viability and environmental sustainability that further fits into the dimensions of social, economic and environment. Increasing urbanization, unplanned floating tourist population

and changing consumption patterns have stressed the existing water supply and sewerage & sanitation infrastructure of the town.

6.2.1 WATER SUPPLY

The water supply performance at VMC can be evaluated using various indicators, which are compared to the CPHEEO benchmarks, the India average, and the gaps in performance (Ref. Table 11). The key areas assessed include coverage of connections, per capita water supply, metering, non-revenue water, continuity of supply, water quality, customer complaints, cost recovery, and efficiency in charge collection. The coverage of water supply connections in VMC stands at 52.35%, which is way below the CPHEEO benchmark, indicating that nearly half of the total households in the city does not have a functional household tap connection (FHTC). When compared to the India average (70%), VMC still significantly exceeds this, offering comprehensive coverage. The gap of -47.65% indicates that VMC has achieved universal coverage, which is a positive indicator of equitable water supply distribution within the city. VMC provides 140.82 litres per capita per day (lpcd), which surpasses the CPHEEO benchmark of 135 lpcd, though slightly above the India average of 114 lpcd. This is a good sign, indicating that the city is providing sufficient water per person compared to national standards. The gap of 5.82 lpcd is minimal, and it suggests that while the city meets the required benchmarks, there may be scope for further optimization, especially for efficient water distribution and conservation.

Table 11: Performance Indicators for Water Supply at VMC

#	Water Supply	Calculations	Benchmark	India Average*	2023-24**	Gaps
1.	Coverage Connections	(Total no. of HHs with water supply connections)/(Total no. of HHs in the City)	100%	70.00%	52.35%	-47.65%
2.	Per capita supply (lpcd)	(Water supplied)/(Population served)	135 lpcd	114 lpcd	140.82	5.82 lpcd
3.	Metering of connections	(No. of metered connections + No. of metered Public Standposts)/(Total no. of connections + Total no. of Public Standposts)	100%	22.00%	0.00%	-100.00%

4.	Non-revenue water (NRW)	(Total water produced) - (Total water sold)/(Total water produced)	15%	31%	19.33%	-4.33%
5.	Continuity of water supply (hours)	Average hours of water supply	24 hours	2.7 hours	2.00	22 hours
6.	Quality and treatment	(Number of samples that meet the specified potable water standards)/(Total number of water supply related complaints received)	100%	95%	98.58%	-1.42%
7.	Redressal of customer complaints	(Total number of complaints redressed)/ (Total number of water supply related complaints received)	80%	89%	85.95%	5.95%

Source: * CPHEEO Guidelines for 24x7 WSS (Drink from Tap), Dec 2021; **Valsad Municipal Council, 2025

Metering is a crucial indicator for assessing the efficiency and sustainability of water supply systems. VMC's performance here is concerning, with a complete lack of metered connections, registering at 0% metering, compared to the CPHEEO benchmark of 100%. The India average is similarly low, with only 22% of connections metered. This reveals a significant gap (-100%) in VMC's approach to metering, indicating a lack of accountability, potentially leading to water wastage and financial losses due to unmeasured consumption. NRW which is the difference between water produced and water sold, stands at 19.33% for VMC, significantly below the CPHEEO benchmark of 15%. However, this is a marked improvement over the India average of 31%, suggesting that VMC is performing relatively better in reducing water losses, though there remains a gap of -4.33% when compared to the ideal target. Addressing NRW is critical to improving operational efficiency and reducing wastage. One of the most pressing issues for VMC is the continuity of water supply, where the average supply is only 2 hours per day, far below the CPHEEO benchmark of 24 hours. This is a critical gap of -22 hours, reflecting a major shortcoming in the availability of water to residents. The India average (2.7 hours) is slightly better, but it still indicates that water availability in VMC is significantly below standard, suggesting infrastructure challenges and potential management issues that need to be addressed urgently.

Water quality, as measured by the number of samples meeting potable water standards, is relatively high in VMC, with 98.58% of samples meeting the standards. While this is slightly below the CPHEEO benchmark of 100%, it is still quite high and far better than the India average of 95%.

The gap of -1.42% indicates that VMC's water quality is generally acceptable, but there is still room for minor improvements in treatment processes or monitoring. Customer complaints are effectively managed in VMC, with 85.95% of complaints being redressed, compared to the CPHEEO benchmark of 80%. This indicates that VMC has a fairly efficient system for addressing grievances related to water supply. However, the gap of 5.95% suggests that there could be minor improvements in response times or in resolving complaints more comprehensively. Hence, VMC performs well in certain areas, such as per capita supply and water quality, there are significant gaps in other critical areas like coverage of connections, extent of metering, continuity of water supply, and non-revenue water.

6.2.2 SEWERAGE AND SANITATION

The performance of sewerage and sanitation at VMC can be evaluated based on several critical indicators, which are compared against the CPHEEO benchmarks (Ref. Table 12). These indicators reflect key aspects such as toilet coverage, sewage network services, treatment capacity, and customer service. Below is a detailed analysis of VMC's sewerage and sanitation performance for 2023-24, highlighting gaps in comparison to the ideal benchmarks. VMC has achieved an impressive 99.59% coverage for households with access to individual or community toilets, nearly reaching the CPHEEO benchmark of 100%. The gap of -0.41% is minimal, indicating that nearly all households have access to sanitation facilities within walking distance. This is a positive reflection of VMC's progress in improving public health and sanitation infrastructure. The slight shortfall may be due to a small number of underserved households, which could be addressed through further targeted intervention. VMC has made limited progress in expanding its sewage network, with only 32.15% of households having a direct connection to the sewage network, which is far below the CPHEEO benchmark of 100%. This represents a significant gap of -67.85%, suggesting that a large portion of the city's population remains without a functional connection to the sewage system. This indicates major challenges in infrastructure development, and a more focused effort is required to extend sewage services to all households, particularly in underserved or newly developed areas.

Table 12: Performance Indicators for Sewerage & Sanitation at VMC

#	Sewerage and Sanitation Indicators	Calculations	Benchmarks	2023-24*	Gaps
1.	Coverage of Toilets	(Total number of HHs with access to individual or community toilets within walking distance in the city)/ (Total number of HHs without individual or community toilets within walking distance)	100%	99.59%	-0.41%

2.	Coverage of Sewage Network Services	(Total number of HHs with direct connection to the sewage network)/ (Total number of HHs in the city)	100%	32.15%	-67.85%
3.	Collection Efficiency of the Sewage Network	(Wastewater collected)/ (Total water supplied + Estimated water use from other sources)	100%	44.55%	-55.45%
4.	Adequacy of Sewage Treatment Capacity	(Treatment plant capacity)/ (Total water consumed + Total number of HHs with direct connection to sewage network)	100%	0.10%	-99.90%
5.	Quality of Sewage Treatment	(Number of samples that pass specified secondary treatment standards)/ (Total number of wastewater samples tested in a month)	100%	0.00%	-100.00%
6.	Extent of Reuse and Recycling of Sewage	(Wastewater recycled or reused after appropriate treatment)/ (Wastewater received at STPs)	20%	0.00%	-20.00%
7.	Efficiency in Redressal of Customer Complaints	(Total number of complaints redressed within the month)/ (Total number of sewage-related complaints received per month)	80%	74.98%	-5.02%

Source: VMC, 2025

The efficiency of the sewage network in VMC is measured at 44.55%, which is significantly lower than the 100% target established by CPHEEO. The gap of -55.45% highlights inefficiencies in wastewater collection, which could be linked to the underdeveloped sewage network, as a large portion of households are not connected to the system. Improving network coverage, maintenance, and operational processes would be critical to increasing collection efficiency and ensuring that a greater proportion of wastewater is effectively collected and treated. VMC's sewage treatment capacity stands at a mere 0.10% of the required capacity, compared to the CPHEEO benchmark of 100%. This is a staggering gap of -99.90%, indicating a severe shortfall in the capacity to treat wastewater. The inadequacy of sewage treatment infrastructure suggests that VMC may be relying on outdated or insufficient treatment facilities, or that the infrastructure has not kept pace with population growth and urbanization. To address this, VMC would need to invest significantly in upgrading or expanding its STPs to meet current and future demands. The quality of sewage treatment in VMC is alarmingly low, with no wastewater samples passing the specified secondary

treatment standards. This reflects a gap of -100% compared to the CPHEEO benchmark of 100%. The absence of compliant treatment processes indicates that VMC's sewage treatment plants may not be operational or are failing to meet required standards. This could result in untreated or inadequately treated wastewater being discharged into the environment, posing significant health and environmental risks. Immediate upgrades to treatment infrastructure and adherence to treatment standards are necessary to improve this critical aspect of sanitation.

VMC has made no progress in the reuse or recycling of sewage, with a recorded value of 0%, compared to the CPHEEO benchmark of 20%. The gap of -20% highlights missed opportunities for sustainable water management and resource conservation. Sewage recycling and reuse can help reduce pressure on freshwater resources and enhance the city's resilience to water scarcity. VMC should prioritize the development of sewage treatment plants that focus on recycling and reuse of treated wastewater for non-potable uses such as irrigation, industrial processes, and landscaping. VMC's performance in redressing customer complaints related to sewerage stands at 74.98%, slightly below the CPHEEO benchmark of 80%. This results in a gap of -5.02%, indicating that while VMC addresses most complaints, there is room for improvement in customer service efficiency. Enhancing response times, improving complaint management systems, and increasing public awareness about grievance redressal processes could help close this gap and improve public satisfaction with sanitation services.

6.3 REVENUE STREAMS

This section analyses the revenue streams and grants available to VMC for water supply and sewerage & sanitation. The revenue sources include central government grants, state government grants, and their own revenue sources. Here, the ratio of grants to own revenue sources is analysed to identify the percentage availability of each source for water supply and sewerage & sanitation. The assessment of financial health of the water utility and sewerage & sanitation is performed here by examining the capital receipts, capital expenditure, revenue expenditure, & revenue receipts from the city municipal budget statements. The water and sanitation budgets are created from the municipal budget to analyse the revenue streams. This helps assess VMC's preparedness to meet current and future demands for water supply and sewerage & sanitation infrastructure and services, and to enhance climate resilience of its residents. These actions ultimately contribute to improved public health outcomes and more sustainable urban environments. This section is structured in four subsections viz., 1) funds received from central government schemes, 2) funds received from state government schemes, 3) VMC's own revenue, and 4) Ratio of grants to own revenue at Valsad for water supply and sewerage & sanitation.

6.3.1 WATER SUPPLY

Central Government Funds

The analysis of the central government funds received by VMC for water supply from 2009–10 to 2023–24 highlights a shift in funding sources and trends (Ref. Table 13). Initially relying on the 12th and 13th Finance Commissions, VMC saw a notable increase in funding under the 13th Finance Commission in 2013–14, followed by a consistent flow from the 14th and 15th Finance Commissions after 2014. The 14th FC provided substantial allocations between 2016–17 and 2019–20, while the 15th FC became a dominant source after 2020, with the highest allocation in 2023–24.

Table 13: Funds received by VMC for Water Supply under Central Government Schemes (in INR)

Year	AMRUT 1.0	AMRUT 2.0	12th Finance Commission	13th Finance Commission	14th Finance Commission	15th Finance Commission	Local Area Development Scheme - MP	U.I.D.S.S. M.T Water Supply Scheme Grant
2009-10	0.00	0.00	10000000.00	0.00	0.00	0.00	0.00	0.00
2010-11	0.00	0.00	0.00	22369968.00	0.00	0.00	100000.00	13728184.00
2011-12	0.00	0.00	0.00	12345792.00	0.00	0.00	0.00	4974539.00
2012-13	0.00	0.00	0.00	11612521.00	0.00	0.00	0.00	13860000.00
2013-14	0.00	0.00	0.00	55866897.00	0.00	0.00	0.00	0.00
2014-15	0.00	0.00	0.00	0.00	16986678.00	0.00	5000000.00	0.00

2015-16	0.00	0.00	0.00	4303209 9.00	0.00	0.00	0.00	0.00
2016-17	2526868. 00	0.00	0.00	0.00	8319021 9.00	0.00	0.00	0.00
2017-18	1174879 3.00	0.00	0.00	0.00	6217720 5.00	0.00	0.00	3714151. 00
2018-19	9800000. 00	0.00	0.00	0.00	7192814 4.00	0.00	0.00	0.00
2019-20	1240513 69.00	0.00	0.00	0.00	9718975 0.00	0.00	750000.0 0	0.00
2020-21	9560652 7.00	0.00	0.00	0.00	0.00	4625636 3.00	1000000. 00	0.00
2021-22	0.00	0.00	0.00	0.00	0.00	4849201 3.00	0.00	0.00
2022-23	1889389 7.00	0.00	0.00	0.00	0.00	1217524 3.00	0.00	0.00
2023-24	1614243 6.00	7045854 0.00	0.00	0.00	0.00	8228066 2.00	0.00	0.00
Total	2787698 90.00	7045854 0.00	1000000 0.00	1452272 77.00	3314719 96.00	1892042 81.00	6850000. 00	3627687 4.00

Source: Budget Documents, VMC

Additionally, funding through the AMRUT scheme gained importance from 2016–17, peaking in 2019–20, and AMRUT 2.0 emerged in 2023–24. Older schemes like UIDSSMT and MP Local Area Development (LAD) gradually ceased or became negligible. Over the 15-year period, the total central funding amounted to approximately ₹106.83 crore, reflecting a transition from project-based grants to more predictable, formula-driven transfers. This evolution signals a maturation of India's urban financing model, with VMC becoming more dependent on structured funding mechanisms like Finance Commissions and AMRUT for water supply projects.

State Government Funds

The analysis of state government funding for water supply to VMC from 2009–10 to 2023–24 reveals a fragmented and scheme-driven funding approach, with significant reliance on the Urban Development Package-88 (UDP-88) and its sub-categories (Ref. Table 14). UDP-88 provided substantial funding in certain years, notably ₹12.07 crore in 2016–17 and ₹36.5 crore between 2014–15 and 2017–18, signalling a period of focused state investment in urban water infrastructure. However, the funding remained episodic, with limited year-to-year continuity, making long-term planning difficult.

Table 14: Funds received by VMC for Water Supply under State Government Schemes (in INR)

Year	UD P-88 Dist ing uish ed Ide ntity	UD P-88(201 4- 15)	UD P-88(201 5- 16)	UD P-88(201 7- 18)	UD P-88(201 1- 22)	UD P-88(201 9- 20)	UD P-88(202 0- 21)	UD P-88(201 8- 19)	UD P88 (20 16- 17)	UD P88 (20 22- 23)	UD P88 (20 23- 24)	Loc al Are a Dev elo pm ent Sch eme – ML A	Nag ar Nan dan van Yoj ana	Gra y lake Dev elo pm ent Gra nt	NS DP Gra nt	Dist rict Pla nni ng Boa rd Gra nt	Wat er Con serv atio n Gra nt Sch eme (Ret urn)
2009-10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2010-11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	252 077 2.00	250 000 0.00	393 403 1.00	0.00	0.00
2011-12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2012-13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250 000 0.00	0.00
2013-14	0.00	437 500 0.00	750 000 0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	250 000 0.00	0.00
2014-15	0.00	131 250 00.00	410 660 36.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	230 000 0.00	0.00
2015-16	0.00	556 981 08.00	0.00	0.00	0.00	0.00	0.00	0.00	556 981 08.00	0.00	0.00	0.00	0.00	0.00	0.00	250 000 0.00	0.00
2016-17	106 599 99.00	808 964 .00	167 805 50.00	0.00	0.00	0.00	0.00	0.00	245 700 00.00	0.00	0.00	0.00	0.00	0.00	0.00	248 046 8.00	0.00
2017-18	106 599 99.00	0.00	262 500 00.00	360 860 25.00	0.00	0.00	0.00	0.00	367 700 00.00	0.00	0.00	0.00	0.00	0.00	0.00	250 000 0.00	0.00

2018-19	167 107 86. 00	0.0 0	0.0 0	598 237 2.0 0	0.0 0	0.0 0	0.0 0	112 331 00. 00	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	250 000 0.0 0	400 000 0.0 0
2019-20	0.0 0	0.0 0	0.0 0	143 796 6.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	249 567 4.0 0	0.0 0
2020-21	0.0 0	0.0 0	0.0 0	165 392 5.0 0	0.0 0	882 850 0.0 0	0.0 0	822 976 0.0 0	975 875 .00 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	250 000 0.0 0	0.0 0
2021-22	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	892 996 8.0 0	575 215 0.0 0	100 908 65. 00	264 409 6.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0	0.0 0
2022-23	0.0 0	0.0 0	0.0 0	373 987 8.0 0	316 043 21. 00	783 724 9.0 0	498 977 5.0 0	344 117 5.0 0	0.0 0	109 533 50. 00	0.0 0	509 760 0.0 0	0.0 0	0.0 0	0.0 0	500 000 0.0 0	0.0 0
2023-24	0.0 0	0.0 0	0.0 0	0.0 0	164 677 46. 00	0.0 0	182 530 74. 00	0.0 0	0.0 0	255 534 88. 00	0.0 0	362 700 .00 0	0.0 0	0.0 0	0.0 0	210 000 0.0 0	0.0 0
Total	380 307 84. 00	740 070 72. 00	915 965 86. 00	489 001 66. 00	480 720 67. 00	255 957 17. 00	289 949 99. 00	329 949 00. 00	120 658 079 .00	365 068 38. 00	0.0 0	546 030 0.0 0	252 077 2.0 0	250 000 0.0 0	393 403 1.0 0	293 761 42. 00	400 000 0.0 0

Source: Budget Documents, VMC Valsad

Other schemes like the MLA Local Area Development Scheme, District Planning Board, and Water Conservation Grants contributed modestly but inconsistently. Although total state contributions exceeded ₹59 crore, the lack of predictable, formula-based transfers, unlike central government funds, hindered the development of a coherent, sustained water supply infrastructure. To improve water resilience, VMC would benefit from a more consolidated, multi-year, programmatic support model from the state government.

Own Revenue

VMC's water supply revenue structure is highly skewed, with the Special Water Tax constituting a dominant 77.55% of the total ₹32.1 crore generated over 15 years, highlighting the council's reliance on a single tax source (Ref. Table 15). This heavy dependence on the Special Water Tax makes VMC's revenue vulnerable to policy changes or inefficiencies in collection. Other revenue streams, such as the General Water Tax, water connection fees, tanker charges, and dam rent, remain underutilized or inconsistent, suggesting untapped potential for growth.

Table 15: Revenue Income from Water Supply at Valsad (in INR)

Year	Special Water Tax	General Water Tax	Water connection Fee	Water tanker charge	Dam rent and sand revenue	Misc. Expenditure	Road maintenance fee/ Construction Completion Fee
2009-10	7901690.00	1826513.00	380700.00	0.00	0.00	1271025.00	774533.00
2010-11	10674876.00	1543897.00	418600.00	0.00	774125.00	0.00	1284915.00
2011-12	13650488.00	1465192.00	841075.00	885245.00	39375.00	0.00	591155.00
2012-13	16041457.00	1069606.00	874200.00	3398763.00	1010000.00	0.00	604600.00
2013-14	16799366.00	1208079.00	668000.00	2092661.00	5000000.00	0.00	282780.00
2014-15	16095819.00	1151190.00	337600.00	0.00	0.00	0.00	194600.00
2015-16	16642194.00	1399912.00	622500.00	179537.00	1500000.00	0.00	301300.00
2016-17	17474351.00	1483674.00	1316800.00	0.00	1510490.00	0.00	665900.00
2017-18	17177444.00	1549843.00	510300.00	0.00	1414200.00	0.00	285000.00
2018-19	18224164.00	1544362.00	400005.00	0.00	1522600.00	0.00	227800.00
2019-20	18159317.00	1631295.00	523200.00	4800.00	1500000.00	0.00	288802.00
2020-21	18570807.00	1632342.00	613300.00	0.00	1514000.00	0.00	328000.00
2021-22	18726092.00	1698907.00	435000.00	0.00	2000000.00	0.00	350800.00
2022-23	22591409.00	3026147.00	465600.00	0.00	2500000.00	0.00	346201.00
2023-24	20236612.00	2808547.00	225100.00	0.00	3524305.00	0.00	238200.00
Total	248966086.00	25039506.00	8631980.00	6561006.00	23809095.00	1271025.00	6764586.00

Source: Budget Documents, VMC Valsad

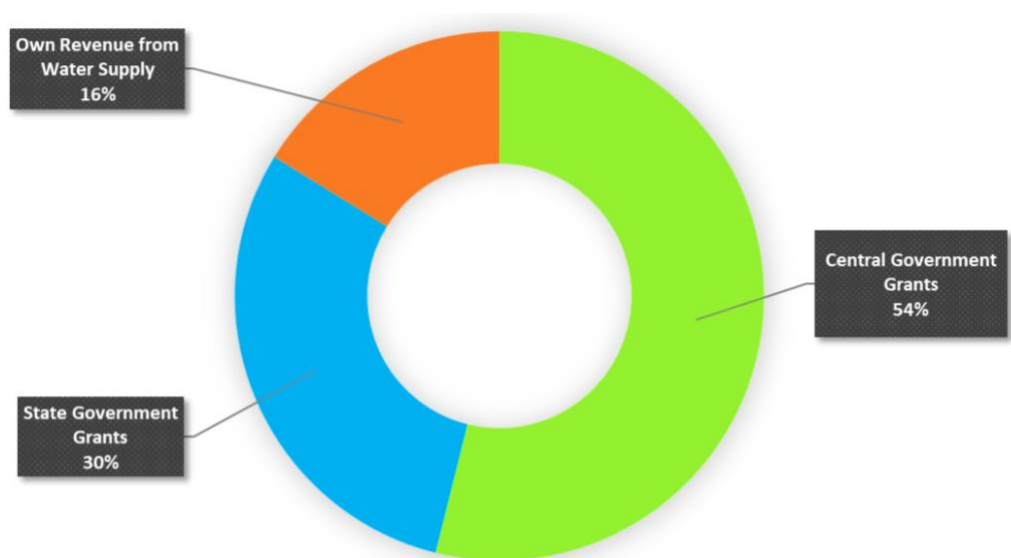
Notably, water connection fees and tanker charges have fluctuated, and the contribution from minor sources like road maintenance fees and miscellaneous income is negligible. Despite moderate revenue growth, VMC's fiscal base is narrow, and the structure is not aligned with urban expansion

or inflation. To enhance financial autonomy, VMC needs to diversify its revenue model by revising tariffs, expanding services, improving compliance, and adopting digitized collection systems.

Ratio of grants and own revenue

A critical analysis of the water supply funding for VMC reveals a heavy reliance on external grants, which constitute 84% of the total funding. Central government grants make up the majority at ₹106.83 crore (54%), followed by state government grants at ₹59.31 crore (30%) (Ref. Figure 18). This dependence exposes VMC to risks associated with shifts in national or state policies and the unpredictability of project-based funding. In contrast, VMC's own revenue is limited, contributing just ₹32.1 crore (16%) of the total, with the Special Water Tax as the primary source.

Figure 18: Share of grants vs own revenue for water supply at VMC Valsad



Source: VMC, 2025

Over time, the ratio of own revenue to grants has declined significantly, from exceeding grant funding in earlier years to averaging just 19.32% over the 15-year period, highlighting stagnant local revenue generation mechanisms. This trend underscores a grant-driven fiscal structure that weakens municipal self-reliance and limits financial autonomy. To ensure long-term sustainability, VMC must reform its revenue generation strategy, including tariff rationalization, improved billing

and collection, and tapping into underutilized revenue streams, to reduce its dependency on external grants and enhance operational efficiency.

6.3.2 SEWERAGE & SANITATION

Central Government Funds

Central funding for sanitation in VMC has primarily come from the 13th, 14th, and 15th Finance Commissions, which together contributed ₹67.59 crore, with the 14th FC being the largest contributor at ₹33.15 crore (Ref. Table 16). These formula-based grants allowed flexibility in their use, although they were not earmarked specifically for sanitation, leading to potential misalignment in how funds were allocated. Notably, VMC did not record any central funding under SBM 1.0, and the later allocation under SBM 2.0 in 2023–24 was modest, suggesting underleveraging of central flagship sanitation programs.

Table 16: Funds received by VMC for Sewerage & Sanitation under Central Government Schemes (in INR)

Year	SBM 1.0	SBM 2.0	12 th Finance Commissio n	13 th Finance Commissio n	14 th Finance Commissio n	15 th Finance Commissio n	Local Area Developme nt Scheme – MP
2009-10	0.00	0.00	10000000.00	0.00	0.00	0.00	0.00
2010-11	0.00	0.00	0.00	22369968.00	0.00	0.00	100000.00
2011-12	0.00	0.00	0.00	12345792.00	0.00	0.00	0.00
2012-13	0.00	0.00	0.00	11612521.00	0.00	0.00	0.00
2013-14	0.00	0.00	0.00	55866897.00	0.00	0.00	0.00
2014-15	0.00	0.00	0.00	0.00	16986678.00	0.00	5000000.00
2015-16	0.00	0.00	0.00	43032099.00	0.00	0.00	0.00
2016-17	0.00	0.00	0.00	0.00	83190219.00	0.00	0.00
2017-18	0.00	0.00	0.00	0.00	62177205.00	0.00	0.00
2018-19	0.00	0.00	0.00	0.00	71928144.00	0.00	0.00
2019-20	0.00	0.00	0.00	0.00	97189750.00	0.00	750000.00
2020-21	0.00	0.00	0.00	0.00	0.00	46256363.00	1000000.00

2021-22	0.00	0.00	0.00	0.00	0.00	48492013.00	0.00
2022-23	0.00	0.00	0.00	0.00	0.00	12175243.00	0.00
2023-24	0.00	34289580.00	0.00	0.00	0.00	82280662.00	0.00
Total	0.00	34289580.00	10000000.00	145227277.00	331471996.00	189204281.00	6850000.00

Source: Budget Documents, VMC Valsad

Additionally, the Local Area Development Scheme (MP) provided only ₹68.5 lakh over 15 years, highlighting sanitation's lower priority in local political agendas. While central grants have been crucial for infrastructure, the lack of targeted sanitation initiatives and delayed participation in SBM indicate missed opportunities for structured improvements in sanitation. VMC's funding structure would benefit from more proactive alignment with national sanitation missions and strategic earmarking of untied grants to address critical sanitation needs.

State Government Funds

VMC receives state grants for sewerage and sanitation from various schemes, with UDP-88 being the largest contributor, providing over ₹54 crore in cumulative funding (Ref. Table 17). These grants focus on different aspects of sanitation, such as infrastructure development (UDP-88), sewer connections (Swarna Jayanti Mukhyamantri Jan Bhagidari Yojana), and cleanliness campaigns (Clean Gujarat 2.0). However, the funding pattern shows significant fluctuations over time, often due to changing political priorities, administrative delays, or budget cycles, creating challenges for consistent project implementation and long-term planning.

While infrastructure-related grants are substantial, funding for public hygiene programs and facilities, like cleanliness drives and pay-and-use toilets, is limited and irregular, suggesting that softer aspects of sanitation may not always receive sufficient attention. Local Area Development Scheme (MLA) grants contribute modestly to specific needs, but overall, the unpredictability of funding and the imbalance between infrastructure and behavioural sanitation programs can undermine the effectiveness of VMC's sanitation efforts. To improve, VMC would benefit from more stable funding flows, a stronger focus on hygiene programs, and better alignment with local political priorities.

Table 17: Funds received by VMC for Sewerage & Sanitation under State Government Schemes (in INR)

Year	UDP-88 Distinguished Identity	UDP-88(2014-15)	UDP-88(2015-16)	UDP-88(2017-18)	UDP-88(2021-22)	UDP-88(2019-20)	UDP-88(2020-21)	UDP-88(2018-19)	UDP-88(2016-17)	UDP-88(2022-23)	UDP-88(2023-24)
2009-10	0	0	0	0	0	0	0	0	0	0	0
2010-11	0	0	0	0	0	0	0	0	0	0	0
2011-12	0	0	0	0	0	0	0	0	0	0	0
2012-13	0	0	0	0	0	0	0	0	0	0	0
2013-14	0	4375000	7500000	0	0	0	0	0	0	0	0
2014-15	0	13125000	41066036	0	0	0	0	0	0	0	0
2015-16	0	55698108	0	0	0	0	0	0	55698108	0	0
2016-17	10659999	808964	16780550	0	0	0	0	0	24570000	0	0
2017-18	10659999	0	26250000	36086025	0	0	0	0	36770000	0	0
2018-19	16710786	0	0	5982372	0	0	0	11233100	0	0	0
2019-20	0	0	0	1437966	0	0	0	0	0	0	0
2020-21	0	0	0	1653925	0	8828500	0	8229760	975875	0	0
2021-22	0	0	0	0	0	8929968	5752150	10090865	2644096	0	0
2022-23	0	0	0	3739878	31604321	7837249	4989775	3441175	0	10953350	0
2023-24	0	0	0	0	16467746	0	18253074	0	0	25553488	0
Total	38030784	74007072	91596586	48900166	48072067	25595717	28994999	32994900	120658079	36506838	0

Year	UDP-88(2023-24)	Local Area Development Scheme - MLA	SM/JY (Sewer Connection Grant)	Pay and Use Toilet (Clean Toilet)	Cleanliness Cess Grant	Nagar Nandanvan Yojana	Clean Gujarat 2.0	NSDP Grant	District Planning Board Grant	Mahatma Gandhi Sanitation Grant	Sanitation Campaign Grant
2009-10	0	0	0	0	5010542	0	0	0	0	0	0
2010-11	0	0	0	2400000	0	2520772	0	3934031	0	0	0
2011-12	0	0	0	0	0	0	0	0	0	0	0
2012-13	0	0	0	0	0	0	0	0	2500000	0	0
2013-14	0	0	0	3818000	15970382	0	0	0	2500000	5500000	2500000
2014-15	0	0	0	35269100	0	0	0	0	2300000	0	0
2015-16	0	0	0	1775700	6044385	0	0	0	2500000	0	10415200
2016-17	0	0	0	2485000	6208774	0	0	0	2480468	0	0
2017-18	0	0	0	0	6261805	0	0	0	2500000	0	0
2018-19	0	0	0	1900000	6038627	0	0	0	2500000	0	0
2019-20	0	0	0	0	0	0	0	0	2495674	0	0
2020-21	0	0	0	0	0	0	0	0	2500000	0	0
2021-22	0	0	0	0	0	0	0	0	0	0	0
2022-23	0	5097600	0	0	0	0	0	0	5000000	0	0
2023-24	0	362700	43765750	0	0	0	0	0	2100000	0	0
Total	0	5460300	43765750	47647800	45534515	2520772	0	3934031	29376142	5500000	12915200

Source: Budget Documents, VMC Valsad

Own Revenue

VMC generates the majority of its sewerage and sanitation revenue through Sewerage Tax (36.76%), Special Cleaning Tax (28.93%), and Sanitation User Charges (31.03%), together accounting for nearly 96% of its income (Ref. Table 18). Sewerage Tax has been the most consistent and stable source, showing steady growth over the years, while Special Cleaning Tax has experienced some fluctuations, including years with zero revenue. Sanitation User Charges have

seen significant growth since 2019-20, reflecting a shift towards user-pay models for sanitation services.

Table 18: Revenue Income from Sewerage & Sanitation at Valsad (in INR)

Year	Sewerage Tax	Special Cleaning Tax	Sanitation User Charges	Toilet Cleaning Charges	Sewer Connection Fee	Pay and Use Toilet Rent
2009-10	5552905.00	5442787.00	0.00	195810.00	257755.00	0.00
2010-11	5007077.00	4593183.00	0.00	295910.00	391420.00	0.00
2011-12	5839315.00	5456530.00	0.00	298550.00	214525.00	306200.00
2012-13	6630185.00	5920669.00	0.00	322400.00	515310.00	392600.00
2013-14	7312097.00	6199883.00	0.00	375200.00	498785.00	302000.00
2014-15	6821102.00	0.00	0.00	356900.00	242045.00	332200.00
2015-16	6965187.00	6208774.00	0.00	176300.00	218405.00	362400.00
2016-17	7085925.00	6261805.00	0.00	239900.00	213640.00	392600.00
2017-18	6895443.00	0.00	0.00	0.00	115730.00	241600.00
2018-19	7212764.00	6405276.00	0.00	275451.00	146426.00	0.00
2019-20	7208119.00	6394627.00	16728512.00	17900.00	112795.00	100.00
2020-21	7732179.00	6320535.00	15661855.00	77100.00	98495.00	0.00
2021-22	6697210.00	6560597.00	16053163.00	69000.00	623292.00	0.00
2022-23	8323661.00	8319832.00	20694548.00	43350.00	439744.00	0.00
2023-24	7614492.00	6915396.00	17721090.00	0.00	23792.00	0.00
Total	102897661.00	80999894.00	86859168.00	2743771.00	4112159.00	2329700.00

Source: Budget Documents, VMC Valsad

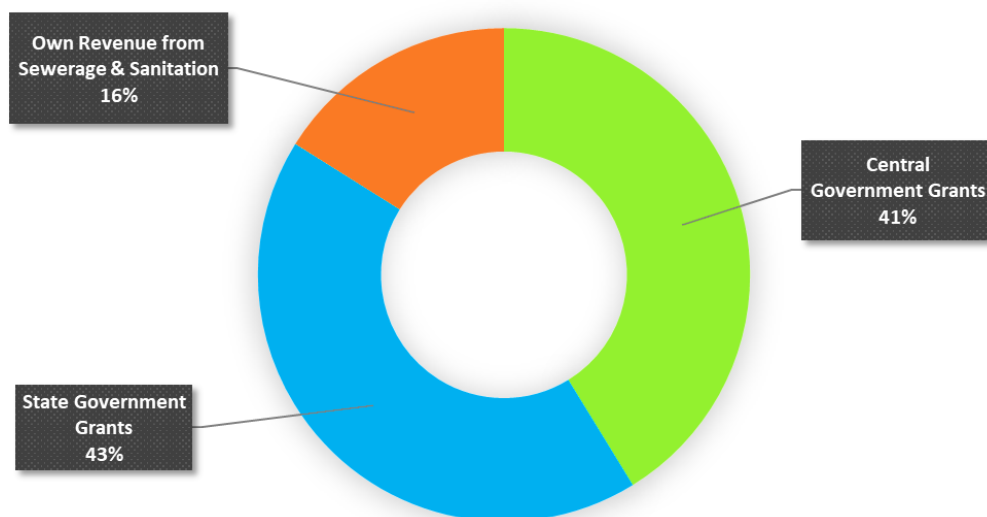
However, revenue from Toilet Cleaning Charges, Sewer Connection Fees, and Pay and Use Toilet Rent remains relatively low, suggesting these areas are underutilized. To improve its financial sustainability and service delivery, VMC could focus on expanding revenues from connection fees and pay-per-use services, enhancing collection efficiency, and promoting more equitable user-based funding mechanisms. This approach would help ensure more consistent funding and potentially improve sanitation outcomes.

Ratio of grants and own revenue

The funding structure for sewerage and sanitation at VMC relies heavily on external grants, with central and state government grants comprising 84% of the total funds, 41% from the central government and 43% from the state (Ref. Fig. 19). This highlights VMC's dependence on federal

and state support, especially for large-scale infrastructure and modernization projects. In contrast, own revenue contributes only 16% of the total funding, reflecting limited local capacity or strategy in generating sustainable funds for sanitation services.

Figure 19: Share of grants vs own revenue for Sewerage & Sanitation at VMC Valsad



Source: Budget Documents, VMC Valsad

Over time, the ratio of own revenue to grants has fluctuated, with a significant decline from 2013-14, where it dropped below 15%, indicating VMC's increasing reliance on government grants. However, since 2019-20, the ratio has slightly improved, reaching 30-45%, suggesting efforts to enhance local revenue generation. Despite these improvements, VMC's financial autonomy remains constrained, and strengthening own revenue mechanisms is crucial for enhancing fiscal resilience, ensuring stable funding, and reducing dependence on external grants for long-term sustainability.

6.4 ASSESSMENT OF FINANCES

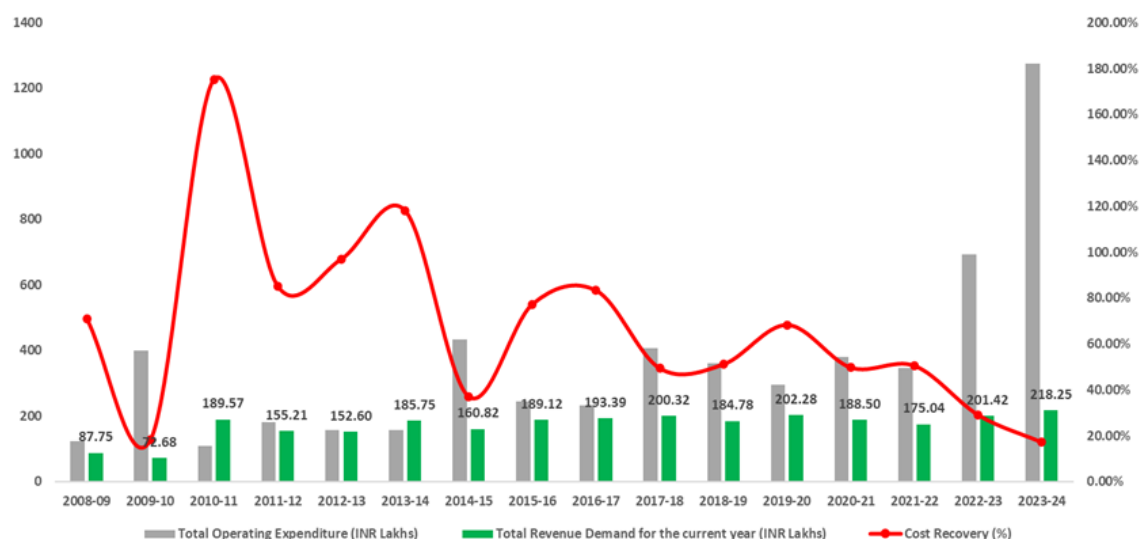
The upcoming sections analyse the trends from the SLBs for water supply and sewerage & sanitation at VMC.

6.4.1 WATER SUPPLY

The analysis of cost recovery for water supply at VMC from 2008-09 to 2023-24 reveals significant fluctuations in the financial sustainability of the system (Ref. Figure 20). In the earlier

years, VMC experienced varying levels of cost recovery, with a sharp drop to 18.18% in 2009-10, followed by a remarkable improvement to 175.20% in 2010-11.

Figure 20: Trend analysis of cost recovery in water supply charges at VMC



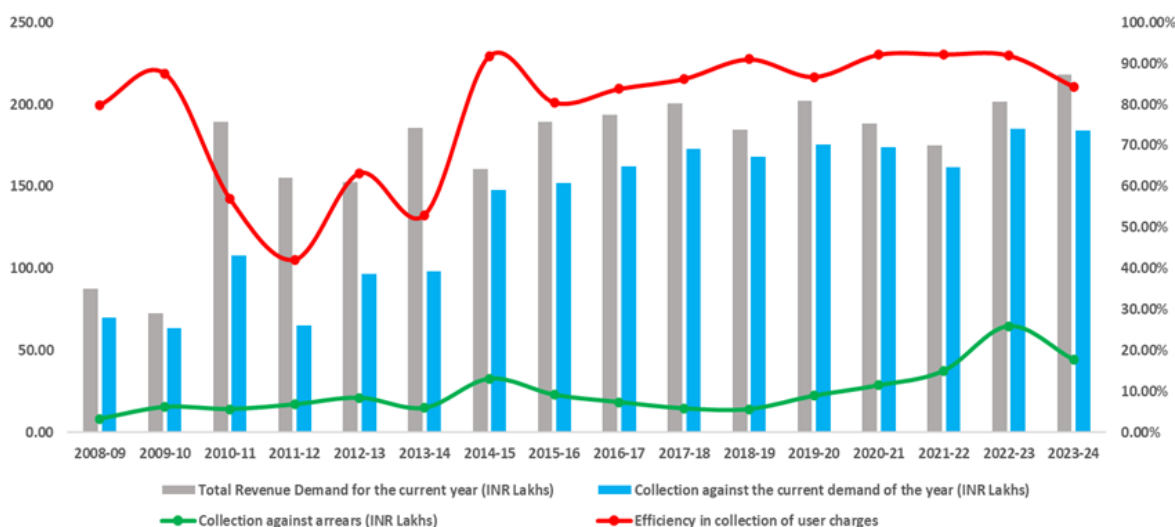
Source: VMC, 2025

However, from 2011-12 to 2017-18, recovery rates stabilized but remained inconsistent, ranging from 37% to 96%. In the more recent years (2018-19 to 2023-24), cost recovery sharply declined, reaching just 17.12% by 2023-24, suggesting serious financial difficulties. This decline is attributed to rising operational costs, especially electricity charges, and insufficient revenue generation from user charges. Despite earlier improvements, VMC's financial performance in water supply is increasingly unsustainable, highlighting the need for better management of operating expenses, regular tariff adjustments, improved revenue collection, and a stronger strategy for addressing arrears to ensure long-term viability.

The analysis of collection efficiency for water supply charges at VMC from 2008-09 to 2023-24 shows significant fluctuations in the council's ability to collect revenue (Ref. Figure 21). In the early years, collection efficiency was highly variable, dropping to as low as 42.05% in 2010-11, indicating challenges in billing, payment collection, or managing arrears. However, from 2012-13

onwards, VMC made substantial improvements, with collection efficiency peaking at 92.14% in 2020-21, suggesting better management practices and improved customer service.

Figure 21: Trend analysis of collection efficiency in water supply charges at VMC



Source: VMC, 2025

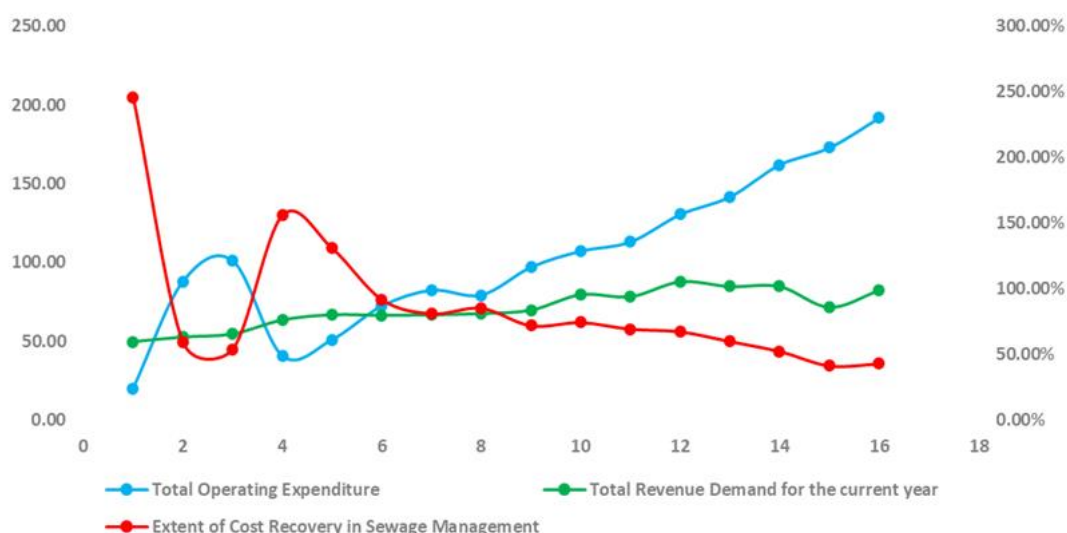
Despite this success, in the most recent years (2022-23 and 2023-24), collection efficiency declined slightly, to 91.96% and 84.32%, respectively, possibly due to increasing arrears or emerging financial constraints. While still relatively high, this decline indicates that VMC faces challenges in maintaining optimal collection rates, underscoring the need for better arrears management and enhanced billing systems to sustain financial stability moving forward.

6.4.2 SEWERAGE AND SANITATION

The analysis of cost recovery for sewerage and sanitation at VMC from 2008-09 to 2023-24 reveals significant fluctuations, indicating financial instability in the sewage management system (Ref. Figure 22). In the early years, VMC achieved unusually high-cost recovery, reaching 245.72% in 2008-09, due to low operating costs and high revenue generation. However, this unsustainable performance declined over time, with cost recovery dropping to 59.70% by 2009-10 and

fluctuating between 59% and 90% for the following years, driven by rising operating expenses and stagnant revenue.

Figure 22: Trend analysis of cost recovery in sewerage & sanitation charges at VMC



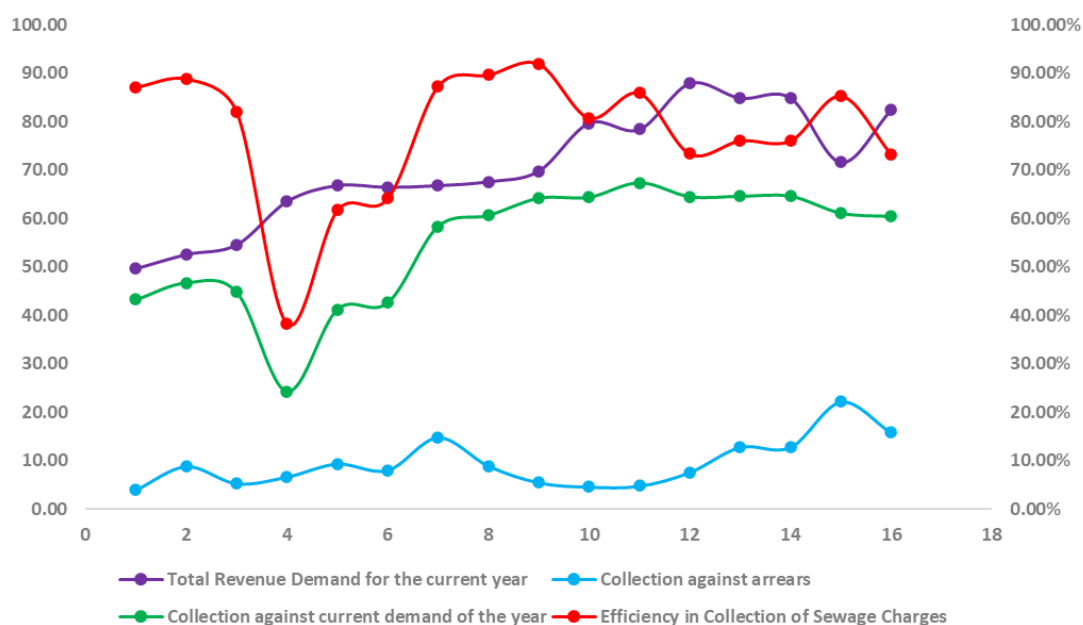
Source: VMC, 2025

The most recent years saw a further decline, with cost recovery reaching just 42.99% by 2023-24, highlighting a growing gap between operating costs and revenue from user charges. This decline is attributed to rising maintenance, staff, and contractor costs, along with persistent arrears. To restore financial sustainability, VMC may need to increase user charges, improve collection efficiency, and control operational costs.

The collection efficiency for sewerage and sanitation services at VMC from 2008-09 to 2023-24 shows significant fluctuations, reflecting varying levels of success in collecting dues (Fig. 23). In the early years, VMC maintained relatively high efficiency, with 87.16% in 2008-09 and 88.87% in

2009-10. However, a sharp decline occurred in 2011-12, falling to just 38.28%, likely due to challenges with arrears and reduced payment compliance.

Figure 23: Trend analysis of collection efficiency in sewerage & sanitation charges at VMC



Source: VMC, 2025

Collection efficiency improved from 2012-13 to 2017-18, peaking at 91.95% in 2016-17, but declined again in the years following, with a slight recovery in 2022-23 to 85.35%, before dropping to 73.27% in 2023-24. These fluctuations highlight issues in managing arrears, ensuring timely payments, and maintaining consistent collection efforts. To improve long-term efficiency, VMC may need to enhance arrears recovery, enforce stricter payment compliance, and potentially revise payment structures to boost revenue collection stability.

6.5 KEY FINANCIAL CHALLENGES

The key financial challenges for water supply at VMC are the significant fluctuations in cost recovery and collection efficiency. Over the years, VMC has faced difficulty matching rising operational costs, especially in areas like electricity and outsourced staffing, with its revenue from water charges, leading to a decline in cost recovery, which dropped to just 17.12% by 2023-24. This issue is compounded by persistent arrears, inefficient revenue collection systems, and inconsistent

tariff adjustments. Although collection efficiency showed improvement in the past, recent years have seen a decline, dropping to 84.32% in 2023-24, pointing to challenges in managing arrears and maintaining consistent payment rates. To address these issues, VMC needs to focus on controlling operational costs, revising tariff structures, improving collection practices, and implementing effective arrears management strategies to ensure long-term financial sustainability of the water supply system.

The key financial challenges for sewerage and sanitation services at VMC are marked by fluctuating cost recovery and collection efficiency. Despite a strong start with high-cost recovery in the early years, the system has struggled with a consistent decline in cost recovery, dropping to just 42.99% by 2023-24, primarily due to rising operating expenses, including staff, contractor, and maintenance costs, which have outpaced revenue growth. Similarly, collection efficiency has been inconsistent, with sharp declines during certain years, especially in 2011-12 and 2019-20, reflecting issues with arrears, reduced payment compliance, and administrative inefficiencies. Though there have been some improvements in collection efficiency in recent years, such as in 2022-23, challenges persist in managing arrears and ensuring timely payments. To improve financial sustainability, VMC needs to enhance revenue collection practices, address arrears more effectively, and control operational costs.

CHAPTER 7: RISK ASSESSMENT OF WASH INFRASTRUCTURE IN VALSAD

SUCHARITA ROY, TEJASH ANAND AND NC NARAYANAN

7.1 BACKGROUND

Urban infrastructure today faces dual pressures: rapid urbanization and extreme natural events driven by climate change. The World Risk Report 2016 highlights that inadequate infrastructure amplifies losses to life and property while increasing the likelihood of disasters arising from extreme natural events. Resilient infrastructure, by definition, refers to systems capable of absorbing, rebounding, and adapting to hazards and shocks to ensure continuity and safety. This chapter captures the exposure and vulnerability of the WaSH infrastructure of Valsad in Gujarat. The situational analysis has been based on the detailed sectoral analysis undertaken by sectoral teams and captured in Chapters 3 (Water), 4 (Sanitation), and 6 (finances). The resilient assessment of the WaSH infrastructure captures the contextual risks and gaps in the systems.

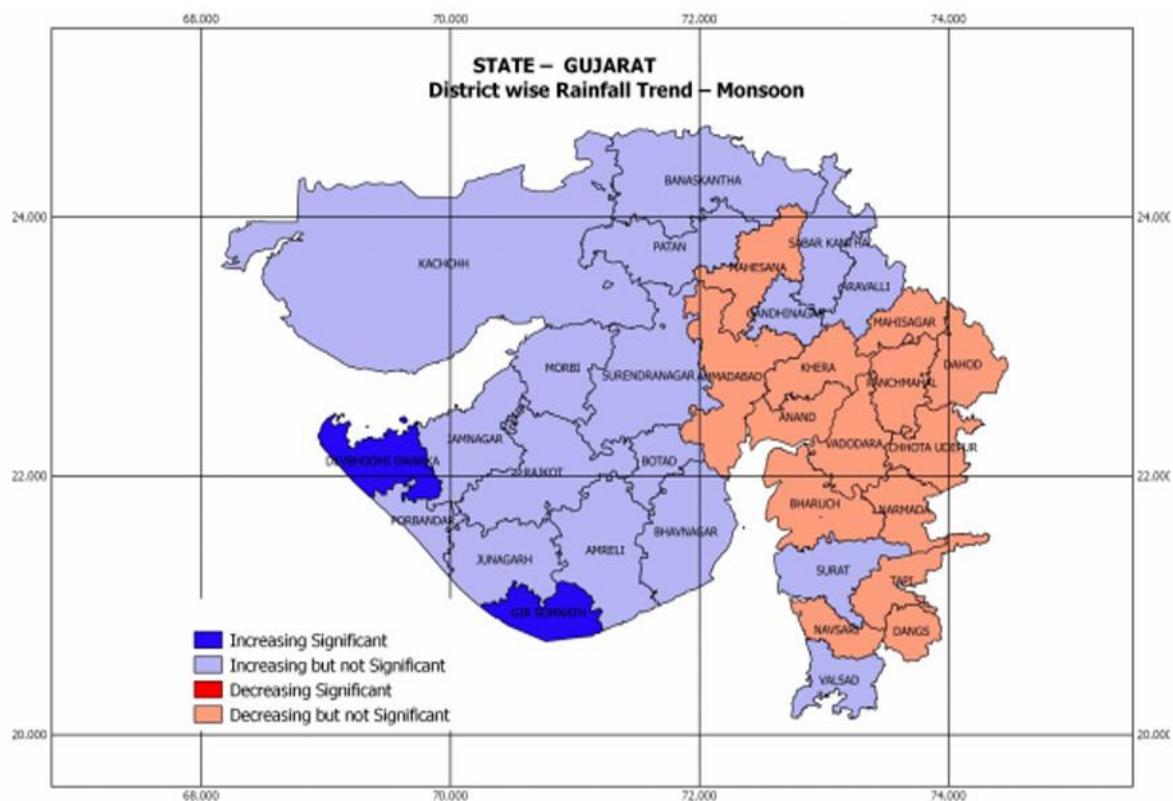
7.2 EXPOSURE TO CLIMATE RISK

Valsad district is in south of Tropic of Cancer, comes under heavy rainfall areas of South Gujarat, having sub-tropical climate with moderately high humidity. Valsad district receives much of its rainfall from the south-west monsoon during the period between June & September; its maximum intensity being in the month of July & August. Total rainy days ranges from 40 to 55 days / year (refer figure 24). Valsad lies in high damage risk zone for the wind hazard and exposed to maximum sustained winds of magnitude 34 – 47 knots (63 – 87 kmph) as per the Cyclone Occurrence Map of India (BMPTC, 2019). Tropical cyclones produce torrential rainfall leading to flooding, damaging winds, storm surge and coastal flooding near the coast within the storm path which can result in severe damage to critical infrastructure.

Over the years, there has been a significant increase in the frequency of rainy days and in the heavy rainfall days from June to September in Valsad district. The future projections suggest that the greenhouse gas-induced warming will increase global monsoon rainfall; according to the long-term trend (2081-2100), the effect on monsoon rainfall change will show asymmetry, inducing a

more significant increase in monsoonal rainfall in the northern hemisphere compared to rains in the southern hemisphere. There is high positive variation in the western portion of India. These are high indicators of the increasingly erratic nature of rainfall over India in the long-term trend. The conditions that Gujarat is facing are indicators of the extreme situation that will occur in the future, and extreme rainfall in a lesser number of days will create flood-like situations within the state and hinder mobility.⁵²

Figure 24 : District wise rainfall trends in Gujarat during entire summer monsoon period from 1989 to 2018



Source: Map is sourced from GIDM (GIDM , 2022)

The depth to ground water level ranges within 5 – 10 m below ground level and a water fluctuation of 2 – 4 m rise measured pre-monsoon and post-monsoon for the year 2021. The Total Dissolved Solids (TDS) level for Valsad city is less than 2500 mg per litre with shallow water levels. The water quality in general is good. The ground water in major part of the district is suitable for domestic, irrigation and industrial purpose.⁵³

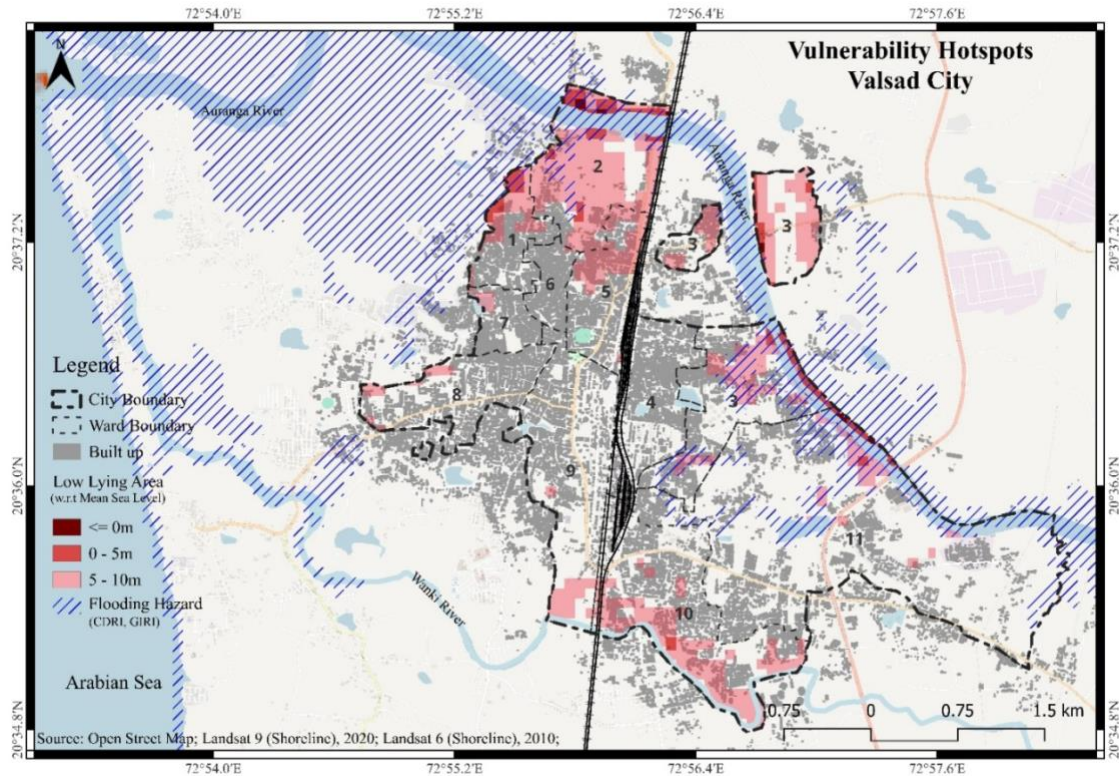
Traditionally drought-prone districts like Jamnagar, Rajkot, Surat, and Valsad have witnessed a shift towards extreme floods and storm surges in the last decade. These changing patterns are due to microclimatic changes that are triggered by local climate change drivers such as land-use-surface change, deforestation, encroachments upon wetlands and water bodies. Their unpredictability makes disaster management harder and places severe strain on the state's economy.⁵⁴

As per media reports from 26 Aug 2024 heavy rain lashed south Gujarat over two days, prompting several hundred people to relocate to safety in Valsad and Navsari districts. Continuous rainfall over 48 hours flooded low-lying areas, disrupting daily life and halting traffic. Vapi taluka in Valsad district recorded the highest rainfall in the state, with 326 millimetres in 24 hours.⁵⁵ During field studies, residents engaged with to capture ground information reported chronic issues of flooding during heavy rains, at various locations, and damages incurred thereby to their housing, sanitation, and water supply.

Valsad city faces the most critical risk of urban floods due to intense precipitation as well as river flooding due to overflow in floodplains. Lying in the alluvium floodplain of the Auranga river, the city is surrounded by rivers, streams, and lakes, the chronic flooding of the city indicates the need for protection and rejuvenation of these systems to enhance these systems. While the city is not directly exposed to coastal risks like storm surges or coastal inundation, the increasing intensity of impact of tropical cyclones, and strong winds, intense rainfall events in the region originating from the Arabian Sea are linked to climate change—have heightened the city's vulnerability to flooding and inundation.

The digital elevation mapping undertaken for the purpose of the study (refer Figure 25) and the flood hazard mapping based on 10 years⁵⁶ reflects the wards along the riverbank of Auranga and Wanki river are low lying and prone to river flooding. These include Ward 1, 2, 3 and 5 in the north & northwest of the city near the Auranga river flood plain and in ward 10 towards its south near the Wanki river flood plain. A critical exposure of population is observed in ward 1 and 5 due to the population density and the low elevation and would need prioritised action to ensure reliable WaSH services during the increasing flood like situations faced during monsoons. Ward 1 is in the flood plain of the Auranga river and hence can be prone to flooding from runoff as well as river inundation, whereas ward 5 has a *talab* or non-flowing water body which serves as a natural runoff reservoir and can be prone to flooding during heavy precipitation in the absence of without adequate protection and rejuvenation. Elevation and surface slope of the area, distance from the stream, and drainage area are some of the parameters used to predict the flood inundation. For this study, Digital Elevation Model has been used for identification of the low-lying areas which can be prone to flooding (Refer Figure 26). Land areas with elevation below 10 m above sea level has been considered as areas highly vulnerable to flooding for inland cities like Valsad.

Figure 25: Emerging vulnerability hotspots and exposure of Valsad city to climate hazards



Source: Open Street Map; Landsat 9 (Shoreline), 2020; Landsat 5 (Shoreline), 2010; Mapusa Municipal Council; SRTM DEM

Though Valsad has comparatively lesser area (less than 25%) below 10 m elevation classified as low-lying zones, these areas have habitation which are affected by the flooding due to overflow of water in flood plains particularly in wards 1, 2, 4, 5 and 10. Wards 1, 4, and 5 also accommodate significant population of Valsad (Refer Table 19).

Flooding occurs when floodplains are encroached obstructing flood ways, reducing natural flood storage and there is increase in built up surfaces resulting in major runoffs overwhelming drainage and the already compromised conveyance systems. Runoffs often overwhelm the sewerage systems where they escape resulting in “combined sewerage overflow” which is common across most Indian cities. The existing capacity of sewerage is not equipped for such elevated flows and leads to widespread contamination of land and water during flood like situations⁵⁷. Land use surface in urban settlements is made of roofs, streets and others paved surfaces and can be estimated from the built-up footprint of the city. Runoff flows through impervious surfaces to the storm-sewers or

towards the natural conveyance regime of the ecosystem. It also changes the hydrologic cycle, increasing the overland flow, reducing groundwater flow and with peak discharge increases the flood frequency.

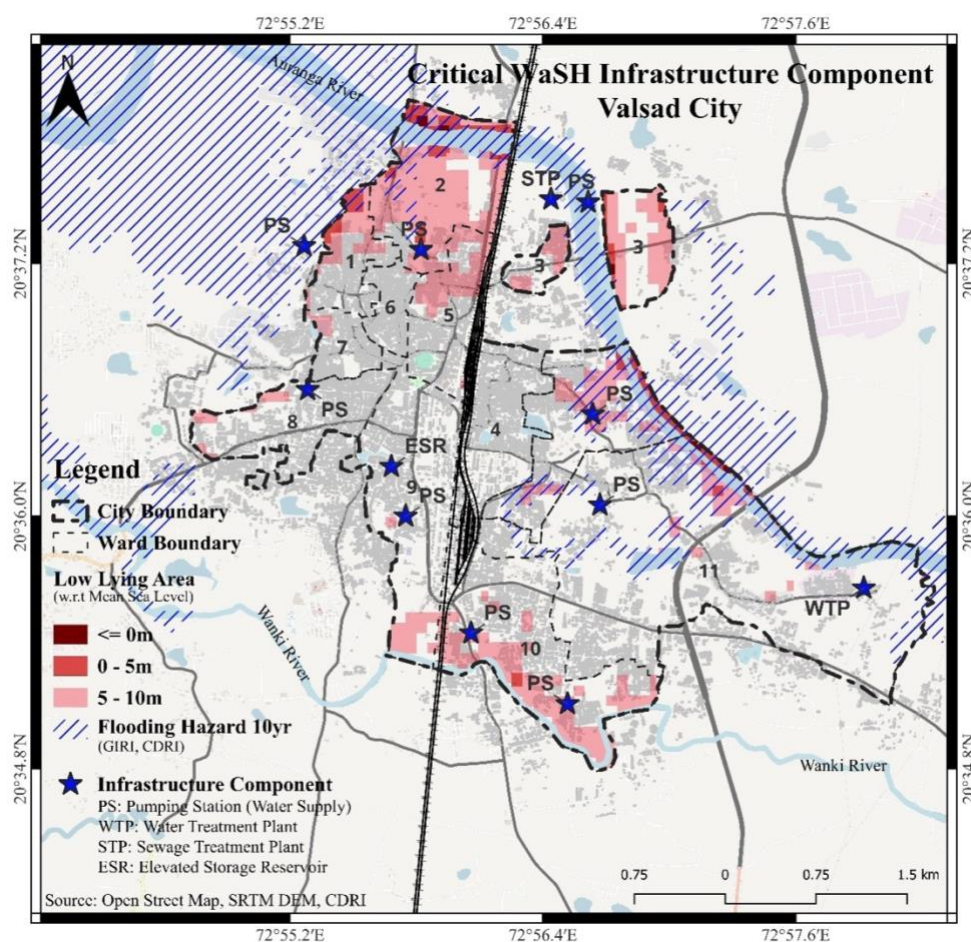
Table 19 : Ward Level Elevation and Vulnerability to Flooding

Ward	Ward Population	% Built up	Very High (<5m above MSL)	High (<10m above MSL)	Low (>10m above MSL)
1	17954	64%	11%	40%	60%
2	17428	16%	22%	84%	16%
3	19857	32%	7%	41%	59%
4	19986	57%	0%	0%	100%
5	19216	60%	0%	36%	64%
6	18789	88%	0%	1%	99%
7	18961	71%	0%	10%	90%
8	18243	61%	0%	7%	93%
9	18684	41%	0%	7%	93%
10	19756	43%	1%	36%	64%
11	18977	25%	2%	8%	92%

Field exploratory studies captured the lived experiences of the communities; it revealed that Wards 3 and 5 are at substantial risk due to both exposure and socio-economic vulnerability in some pockets.

These vulnerable households' resort to open defecation as they lack access to either household sanitation or community toilets and access to treated water is through community taps. These households live in slum-like conditions. During flood-like situations, water levels rise to 3-5 feet and do not recede for 6-7 hours, sometimes persisting for up to 2 days. This forces socio-economically vulnerable households to relocate, often near the railway tracks at higher elevations until the area is drained and liveable. Ward 3 is less densely populated and not a contiguous ward. The STP is in Ward 3. (Refer figure 19)

Figure 26: Location of critical components of the WaSH Infrastructure in Valsad administrative boundary



Source: Open Street Map; Landsat 9 (Shoreline), 2020; Landsat 5 (Shoreline), 2010; Mapusa Municipal Council; SRTM DEM, GPS tagged locations through field visits

7.3 VULNERABILITY OF THE WASH INFRASTRUCTURE

The vulnerability of the WaSH infrastructure analyses the status of the infrastructure with respect to its adequacy, reliability, and risk governance. Adequacy has been investigated respect to coverage of the services, suitability of technology, safety of infrastructure based on its age. Reliability of the services has been studied based on data where available on outages, response and recovery including contingencies and redundancies, ownership and accountability and provision of monitoring and regulation of the systems. The infrastructure risk governance looks at the financial stability and safeguards, autonomy in decision making, and jurisdictions regarding preparedness and recovery in the context of disasters.

ADEQUACY OF INFRASTRUCTURE

The WaSH infrastructure of Valsad is not adequate for the city or resilient to climate risks. The coverage of treated water supply in Valsad is currently inadequate in terms of quantity of water tapped, treated, and supplied and the section of population serviced by the same. Half the population, is without access to safe and treated water supply (Refer Chapter 3 and 4)

There is a large deficit between demand and supply. One fifth of the water tapped is lost in transmission (non-revenue water). Water supply is intermittent and available for around 2 hours. The city's sanitation infrastructure is in a transitioning phase, with one third of the city serviced by underground sewerage networks, and two thirds dependant on-site sanitation systems with intermittent desludging services offered at a cost. The transitioning from individual pits to centralized sewerage systems requires capital-intensive investments and extensive stakeholder management and administrative capacities. The STP is currently operating much below its design capacity. The STP, located at the northeastern end of the city, could lose its operational efficiency due to underutilisation. Located in a low-lying elevation the STP is also prone to exposure from flooding.

RELIABILITY, FLEXIBILITY AND REDUNDANCY

Enhancing flexibility in water systems is critical for ensuring reliable services during disruptive events. Flexibility is the ability of an infrastructure asset or system to perform the desired function based on specified requirements over time without interruption or degradation. Redundancy is key to ensuring that water systems continue to operate smoothly, even in the event of component failures. The water treatment facility has been observed to be in a beleaguered state.

Groundwater contamination can pose a challenge, for cities facing annual flooding, as for Valsad. With a significant dependence on ground water, contamination of ground water is an emerging concern due to recurrent flood like situation. Currently some vulnerable households resort to open defecation during flood like situations when they are forced to evacuate their habited locations due

to rising water. (as reported during field interactions). Long networks of centralised sewerage are not only difficult to maintain for undulating and low-lying terrains but can be unfeasible due to corrosion, leakages, reverse flows, and need for frequent uphaul. Valsad is dependent on multiple pumping stations to maintain adequate pressure in its water supply system. This increases the energy intensity and dependency of the system and possibility of outages during cyclones or other shock events. Increasing cyclonic storms and intense winds can damage overhead electrical networks, impacting pumping and treatment facilities. For a city with 2/3rd households still using traditional pits, in the absence of regulated desludging, the contamination of land and water resources due to chronic flood like conditions is inevitable. The city depends on private service providers for desludging however these are unregulated.

INFRASTRUCTURE RISK GOVERNANCE AND FINANCE

Effective governance is essential for resilient infrastructure. This involves the policies, frameworks, norms, processes, and tools that public bodies use to plan, decide on, implement, and monitor the entire lifecycle of public infrastructure. In the context of resilience, governance transformation may include progressive decision-making, regular updates to codes and standards, comprehensive regulatory frameworks, and dedicated risk and resilience funding.

The municipal corporation has been unable to pace the expansion of water supply connections with its growing population. The coverage percentage has declined in recent years.

Cost recovery for sewage management in VMC is currently not enough to enable infrastructure management and new infrastructure development. In recent years, the council has faced significant increases in staff-related expenses, contractor costs, and maintenance costs, which have outpaced the growth in revenue from user charges. The WaSH infrastructure of the city is struggling to keep pace with the growing needs as well as the adverse impacts of the climatic shock events. VMC is responsible for the management and maintenance of all municipal water works and the construction or acquisition of new works as obligatory functions in water supply services for the city. The role of ULB, in this model of development of sanitation infrastructure, is limited to smaller sanitation interventions and funded through SBM.

The funding for all other larger infrastructure development is through central government schemes like Atal Mission for Rejuvenation and Urban Transformation (AMRUT), with the selection of technology, approval, and implementation overseen by state-level agencies such as the GUDC and GUDM. The direct engagement of state agencies in city infrastructure development creates unclear asset ownership and accountability resulting in gaps in services and provisions.

VMCs role is limited to operation and maintenance of the facilities. At the household level, VMC is not engaged in the design, construction, or enforcement of standards for toilets and OSS system. This gap is especially concerning for a chronically flooded city like Valsad—exposed to annual flood and cyclone season and dependent on OSS for sanitation.

The treatment of wastewater is currently inadequate and not meeting standards. Risk Governance of WaSH is influenced by not only multiple development agencies and stakeholders but also disaster management institutions with preventive and preparatory actions being part of the Disaster Management Plans, often at district level, for the coastal towns. And the role of local bodies, enablers of risk governance at local level have limited roles and mandates. IPCC has pointed out that governance arrangements, in many contexts, too fragmented across administrative boundaries and sectors to provide integrated responses to the increasing and cascading risks from climate-related changes in the ocean and/or cryosphere (high confidence). Intensifying cooperation and coordination among governing authorities across scales, jurisdictions, sectors, policy domains and planning horizons can enable effective responses to change in the ocean, cryosphere and to sea level rise (high confidence).⁵⁸. The disaster risk governance has been defined as the system of institutions, mechanisms, policy and legal frameworks and other arrangements to guide, coordinate and oversee disaster risk reduction. The Commissioner of Relief (COR) is the at the centre of the risk governance and declares a disaster and strategizes the action to be taken and is supported by and municipal commissioners (municipal corporations), district collectors, state EOCs and non-state stakeholders. At a district level the District Collector anchors the district disaster management plan.⁵⁹. The role of the local authorities, as defined in the SDMP, is to aid in disaster management activities, ensure training of resources to be readily available for use in the event of a disaster, ensure that all constructions conform to the standards and carry out relief, rehabilitation and reconstruction activities in the affected area within its jurisdiction.

Though infrastructure repairs and reconstruction post disaster are the responsibility of the local body, it has limited role in its selection, designing and implementation. This is a significant gap in risk governance of infrastructure which often leads to disrupted services has been observed in the malfunctioning and state of disrepair observed in STPs and WTPs post disaster where the re - operationalising has often taken many months due to paucity of funds and need for external experts.

CHAPTER 8: CLIMATE CHANGE INITIATIVES IN VALSAD

NEELAM RANA, PRIYAKSHI GOGOI, NC NARAYANAN

This section outlines key climate-related adaptation and mitigation efforts observed in Valsad town, based on field insights.

Environment Management Planning

Valsad district has developed a comprehensive *Environmental Management Plan (EMP)* that integrates climate resilience into urban governance. This EMP includes strategic focus areas such as sewage management, a *zero liquid discharge* policy for industries, and a rainwater harvesting action plan—all of which contribute directly or indirectly to both *climate change adaptation and mitigation*. (Government of Gujarat, 2019).

Adaptation Efforts

With rainfall levels significantly above the state average—especially compared to arid districts like Kachchh and Devbhumi Dwarka—officials in Valsad have emphasized the need to harness this water resource efficiently. A key adaptation strategy is the **mandatory implementation of rainwater harvesting systems** for all new buildings over the past decade.

To operationalize this, property owners are required to obtain approvals from the **Town Planning Cell (TPC)** of the ULB before construction. The TPC ensures compliance with municipal by-laws related to rainwater harvesting, fire safety, and underground sump construction. Final inspections are conducted by the ULB before an **Occupancy Certificate** is issued. Rainwater harvesting is particularly crucial given that the town relies primarily on surface water from the **Auranga River**, and is located far from the coast (about 1,500–2,000 miles), thereby not facing saline water intrusion risks. Despite the mandate, **actual on-ground adoption remains limited**. Constraints include lack of space on individual plots, high installation costs, and the absence of state-level subsidies. Residents highlighted that although many homes have wells, the water is typically not potable and households often purchase drinking water instead.

Additionally, groundwater extraction is strictly regulated. As of 2019, the municipality had **89 borewells**, none of which had been granted permission for groundwater extraction—demonstrating a preventive adaptation approach to protect local aquifers (Government of Gujarat, 2019).

Mitigation Efforts

On the mitigation front, the ULB has taken steps to **reduce its carbon footprint** by transitioning to renewable energy. Solar panels have been installed at the city's **STP**, generating annual electricity savings of approximately ₹1 lakh. These efforts not only reduce operational costs but also contribute to **long-term emissions reductions**. However, **infrastructure resilience remains a challenge**. The **WTP** lacks backup power, meaning that during flood-induced power outages, the municipality resorts to supplying water via tankers—a short-term solution that highlights the need for more robust mitigation planning. The ULB is also initiating a **carbon accounting process**, collecting data on electricity usage and calculating associated emissions. These assessments are intended to inform future strategies focused on **improving energy efficiency** and identifying the scale of renewable energy integration needed to meet local sustainability targets.

Table 20 : Climate Change Initiatives in Valsad

Initiative	Relevance	Status
Environmental Management Plan	Broad climate adaptation and mitigation	- Developed by Valsad district - includes sewage management, - zero liquid discharge policy for industries, - a rainwater harvesting action plan
Mandatory Rainwater Harvesting for New Buildings	Adaptation – water conservation	- Enforced for over 10 years - building plans must be approved by the Town Planning Cell - ULB inspects before issuing Occupancy Certificate
Public Adoption of Rainwater Harvesting	Adaptation – effective use of rainfall (higher than state average)	- Common practice encouraged, - actual adoption is low due to space constraints, high cost, and lack of subsidies
Groundwater Regulation	Adaptation – groundwater protection	89 borewells in the municipality - none have extraction permissions
Solar Panels at STP	Mitigation – renewable energy and cost savings	- Operational - saves approx. ₹1 lakh/year in electricity costs
Carbon Footprint Monitoring	Mitigation – emissions reduction and planning	ULB is collecting electricity usage data, calculating emissions, and exploring energy efficiency and renewable energy strategies

CHAPTER 9: SECTORAL RECOMMENDATIONS FOR ENHANCING CLIMATE RESILIENCE OF WASH INFRASTRUCTURE AND SERVICES IN VALSAD

NEELAM RANA,,PRIYAKSHI GOGOI, SUCHARITA ROY, ASHISH DANGI, ABHAYJUNAGHARE, TEJASH ANAND & N.C. NARAYANAN

9.1 BACKGROUND

The previous chapter of this report analysed the status of water and sanitation infrastructure and services, and their interaction with climate change. It also examined the financial sustainability of ULB and identified both direct and indirect climate change initiatives currently underway at the town level. Key challenges and gaps were highlighted as part of this assessment.

Valsad, a coastal town in Gujarat with high annual rainfall, faces compounding challenges from climate change, including frequent flooding, tidal backflow, and seawater intrusion due to its low-lying geography near rivers and the Arabian Sea. Despite relatively high per capita water availability, service delivery remains fragmented and inequitable, marked by limited household connections, intermittent supply, high NRW, and no metering. These inefficiencies have contributed to a significant drop in cost recovery to just 17.12% in 2023–24, weakening the system's financial viability. On the sanitation front, only 33% of properties are connected to the sewer network, while 20% of sewage is discharged untreated into open drains. Infrastructure projects—such as the new sewerage network—remain poorly integrated with stormwater systems, leaving the town vulnerable to climate shocks. Critical facilities like the STP are located in flood-prone zones, and the WTP lacks power backup, making both systems susceptible to disruption during extreme events. These service delivery failures not only limit residents' ability to adapt to climate risks but also contribute to greenhouse gas emissions from inefficient energy use and untreated wastewater. However, the ULB has taken promising steps—such as installing solar panels at the STP and promoting rainwater harvesting, mandatory in new buildings for over a decade. These measures, while beneficial, need to be scaled up through financial reforms, tariff rationalisation, NRW reduction, infrastructure climate-proofing, and incentives to boost rainwater harvesting uptake.

Strengthening both mitigation and adaptation efforts in Valsad is essential for building a resilient, inclusive, and climate-aligned urban water and sanitation system.

Building on these insights, the following section presents town-level recommendations for strengthening the water and sanitation sectors, with a focus on enhancing climate resilience and service delivery.

9.2 WATER

To enhance water security and climate resilience in Gujarat's small and medium towns, the following policy measures are recommended:

1. Decentralize Water Management

- Promote *rainwater harvesting* and *watershed management* techniques to localize water sourcing.
- Reduce *dependence on distant water sources*, enhancing local water self-sufficiency.

2. Strengthen Water Distribution Systems

- Upgrade infrastructure using *smart meters*, *leak detection systems*, and *real-time monitoring tools*.
- Focus on *reducing NRW* and improving overall *supply efficiency*.

3. Promote Wastewater Recycling and Reuse

- Encourage *local-level reuse* of treated wastewater for *non-potable applications* such as irrigation and industrial use.
- Reduce pressure on freshwater sources and close the urban water loop.

4. Build Institutional and Community Capacity

- Equip *ULBs* with *data-driven tools* for more informed decision-making.
- Support *community-based water management systems* to foster local engagement and shared accountability.

5. Integrate Climate-Resilient Water Practices

- Increase *storage capacity* through small-scale infrastructure like *check dams and ponds*.

- Mitigate risks from *erratic rainfall patterns* and climate variability by embedding resilience into water planning.

9.3 SANITATION

1. **Expand Sewerage Network Coverage**
 - a. Accelerate completion of the citywide sewerage network under construction.
 - b. Address untreated sewage discharge by extending network coverage to cover currently unconnected areas and/or install decentralized nature-based solutions to bridge service gaps.
 - c. Accelerate replacement of aging sewer lines and conduct GPS mapping of the sewer network.
2. **Enhance On-site Sanitation Systems and Faecal Sludge Management**
 - a. Survey and monitor the functional status of OSS Systems.
 - b. Ensure proper design, maintenance, and monitoring of OSS.
 - c. Develop and implement effective faecal sludge management plan.
3. **Improve Access to Water and Sanitation in Low-Income Communities**
 - a. Provide shared community toilets with modular, flood-resilient designs in underserved settlements.
 - b. Mandate inclusive service delivery in city-level climate adaptation and urban development policies.
 - c. Prioritize vulnerable areas in municipal planning and funding.
 - d. Install decentralized nature-based solutions to bridge service gaps.
 - e. Engage local communities in design and management to promote ownership and upkeep.
4. **Climate-Proof Critical Infrastructure**
 - a. Map Storm water drainage (network length, typology etc) on GIS platform
 - b. Upgrade stormwater drainage systems using climate-adaptive designs, prioritizing flood-prone and low-lying areas.
 - c. Integrate flood risk assessments into all new infrastructure projects.
 - d. Develop protective infrastructure such as sea walls, barriers, or barrage systems to prevent tidal backflow and seawater intrusion.
 - e. Climate-proof essential facilities—including the sewerage network and STPs—to withstand flooding and extreme weather events
 - f. Install reliable power backup systems (generators, solar-powered solutions) at water treatment plants and STPs to ensure uninterrupted operation during power outages.
5. **Build Capacity for O&M of Sewage Treatment Plants**
 - a. Mandate training standards and certification programs for ULB staff.

- b. Establish peer-learning platforms with other cities to share knowledge and best practices.
- 6. **Empower ULBs**
 - a. Grant ULBs maximum administrative and decision-making authority as per the 74th Constitutional Amendment Act.
 - b. Enable ULBs to make context-specific decisions specifically technology selection to address local challenges effectively.

9.4 GHG EMISSIONS

1. **Reduce Distribution Losses:**
 - a. Prioritise **leakage detection and repair** to reduce NRW and avoid unnecessary energy use and emissions.
 - b. Address **unauthorised water use** through better monitoring and enforcement.
2. **Ensure proper design and maintenance of OSS:**
 - a. **Seal and upgrade household pits and septic tanks** to reduce methane (CH₄) and nitrous oxide (N₂O) emissions.
 - b. Promote **FSM** reforms to reduce emissions from unlined and poorly maintained systems.
3. **Enhance Sludge Management:**
 - a. Adopt **routine desludging practices** with biogas recovery to reduce biological emissions.
 - b. Improve **desludging logistics** by transitioning to **cleaner fuels** and **smart routing** of vacuum trucks.
4. **Improve Wastewater Treatment Coverage and Efficiency:**
 - a. Increase the **wastewater capture rate** to ensure more of the organic and nutrient load reaches the STP.
 - b. Expand **nutrient removal and polishing** systems to cut eutrophication and **N₂O emissions** in estuarine environments.

5. **Optimise Centralised STP Operations:**

- a. Improve **energy efficiency** of sewage treatment processes.
- b. Explore **sludge-to-energy technologies** to offset emissions from current aerobic treatment.

6. **Mitigate Nutrient Leakage:**

- a. Prevent nutrient-rich effluents from entering coastal waters by investing in **greywater treatment** and **effluent reuse systems**.

7. **Integrate Climate Action into Urban Water Planning:**

- a. Recognise that the urban water cycle is a **significant contributor to GHG emissions** and must be managed as part of the city's climate strategy.
- b. Shift the focus from treatment plants alone to the **entire water-wastewater chain**, from source to discharge.

9.5 FINANCIAL SUSTAINABILITY

To address the persistent financial challenges in water supply and sanitation, VMC should prioritize the following actions:

1. **Improve Cost Recovery and Collection Efficiency**

- Regularly **adjust user tariffs** to reflect rising operational costs, particularly those related to electricity and outsourced staffing.
- **Increase user charges** in the sanitation sector to better align with actual service delivery costs.

2. **Strengthen Revenue Collection and Arrears Management**

- Implement **stricter payment enforcement mechanisms**.
- Enhance **billing systems and customer service** to reduce payment delays and disputes.
- Launch **targeted awareness campaigns or incentive schemes** to promote timely payments.

3. **Control and Rationalize Operational Costs**

- Explore **cost-cutting measures** in both water supply and sanitation services—especially in staffing and contractor-related expenditures.
- **Optimize resource use** to manage rising electricity and maintenance costs.

4. **Streamline Financial Administration**

- **Improve the efficiency of financial management systems**, with regular monitoring and reporting.
- Periodically **review and revise financial strategies** to ensure long-term sustainability and better alignment with service demands and climate resilience goals.

9.6 INFRASTRUCTURE RESILIENCE

Provisioning for emerging climate risks:

There is need for local risk assessments and information generation regarding critical coastal risks and around creeping disasters like saltwater intrusion or risks like effluent contamination, increasing frequency of outages in systems, etc to prevent infrastructure damage and undertake risk mitigation plans to safeguard the infrastructure and the city. Many climate risks are very local phenomena, like saline intrusions, changes in local water bodies, risk to critical infrastructure due to flooding etc. District level disaster management plans cannot capture local risks adequately to inform resilience planning at local level.

IPCC in its policy recommendations in the Sixth Assessment Report mentions that some coastal accommodation measures, such as early warning systems and flood-proofing of buildings, are often both low cost and highly cost-efficient under current sea levels (high confidence). There are no alerting systems for failures due to inefficiency, energy outages, or creeping disasters. Information flow is top-down, missing ground intel and early warnings. For coastal towns like Mandvi, multiple sudden local risks can result in disruption and delink the settlement from the district and the state. Alerts at local level can give the local administration time to react adequately. It also helps in generating real time and current database for decision making.

Safe sanitation—defined by adequate sewage containment, conveyance, and treatment—remains inadequate, and Valsad can benefit from the integration of less capital intensive and decentralized solutions. The diverse technology base provides an opportunity for hybrid sanitation solutions planned and designed based on zonation. "Waste watersheds" and "sanitation zones" identified through socio-spatial zoning, participatory mapping, and a weighted analysis of geomorphological and hydrological indicators (Narayanan, Ray, Gopakumar, & Argade, 2018) could support the

design of sustainable WaSH systems to ensure adequacy in service delivery. IPCC recommends that coastal challenges can be eased using locally appropriate combinations of decision analysis, land-use planning, public participation, diverse knowledge systems and conflict resolution approaches that are adjusted over time as circumstances change (high confidence).

Community ownership of the systems can reduce secondary risks like environmental degradation, contamination, and health challenges. Active participation at the local level and ecological awareness is critical for managing coastal risks like shoreline erosion, saline intrusions, land, and water contaminations and for safeguarding of coastal water resources from contamination. Service benchmarks need to be re-evaluated for recurring flood prone settlements with positive ground water zones of LECZ. For e.g. service benchmark for per capita water can load the water positive, heavy precipitation zones like Valsad with unmanageable and varying volumes of wastewater due to combined sewage overflows, necessitating over design facilities. Backflow and overflow of sewerage networks compound the flood hazard faced by Valsad.

System designs like centralized sewerage networks in LECZ often need energy intensive pumping systems to ensure conveyance velocity. Energy based pumping dependent systems increase the risk of system failure or disruptions. Alternative energy sources should be integrated into formal systems. Infrastructure Safety and Resilience Plans for large- infrastructure components need to be provisioned as a critical component of disaster management plans with ring fenced infrastructure protection and risk governance budgets.

Contextualizing infrastructure design and technological solutions

Valsad has a healthy shallow aquifer with good water quality as per the reports from CGWB, 2021. Hence while Valsad district, faces scarcity of water due to fluctuations pre and post monsoon water levels due to multiple geomorphological and aquifer characteristics, Valsad city is water surplus city and has the opportunity of diversified sourcing of water from ground water and flowing and non-flowing surface water resources. With increasing annual rainfall witnessed over the last couple of years in South Gujarat district due to climate change, Valsad city located in the shallow aquifer zone and alluvial flood plain with good ground water, has adequate water sources.

Distributed sourcing for low lying areas and smaller decentralised water treatment and distribution systems can be explored to service the low-lying areas which can reduce the need for pumping stations which is an energy intensive system which can also prove unreliable during shock events like storms or heavy precipitation events due to its dependency on electricity supply and manpower.

Off-grid decentralized systems also offer redundancy. Technology choices that are capital and energy intensive, and not designed for low lying and undulating topography, repeated inundations of considerable levels, for over 4 months in a year, intense precipitation and storm events and high-water tables, increase the susceptibility of the infrastructure systems and the risk to the settlement.

There is a need to explore system design which allows compartmentalisation with zone/ area level controls for shutting down conveyance systems in case of flooding; and for safe containment of sewage decentralised systems for containment through scientifically designed CST and conveyance and treatment through decentralised Faecal Sludge Treatment and Management (FSTM) solutions.

Innovative decentralized, distributed, hybrid and intermediate system designs integrated with centralized systems can plug the gaps in coverage effectively. Intermediate solutions such as CST and decentralized shallow sewer systems should be considered as less capital-intensive and safer alternatives for handling sewage in low lying wards. For more dense wards or newly developing areas, the operation and management of small primary-level sewage treatment facilities could offer an opportunity for modular scaling of systems.

The river Auranga also plays a significant role in the drainage of the water shed and it is important to ensure that the sediment load downstream is managed to increase its capacity to drain increased runoff. Protection and preventive measures on river basin and surface water reserves enable the ecosystems natural balance to adapt to the varying volumes of rainfall and runoffs.

CGWB in its ground water report for Valsad identifies Nature-based Infrastructure Systems for managing runoffs and flooding offers sustainable solutions for managing floods and ensuring equitable coverage of services. The artificial recharge structures like Percolation Tanks/ Ponds, can be identified as suitable for soft rock aquifer in the region.⁶⁰ Preventive measures to manage the runoff and control the volume of water flowing down the river during monsoon, undertaken upstream, can benefit the taluka as well as the district.

Risk governance of Infrastructure

WaSH infrastructure development - as an integrated sector - for larger cities like Valsad will require strategic planning, multi-agency coordination, risk governance and innovative investment and financial planning capacities.

There is a need to develop a clear regulatory jurisdiction of local authority to integrate DRR and CCA, a dedicated climate cell, process integration of organizational learning at local level or

evaluation of the outcomes from its actions. Risk information systems integrated with alerting systems and community generated information can help build evidence for informed planning. Currently, the absence of redundancy (backup) plans, clear SoPs for continuity of interconnected services and emergency/ contingency/ repair funds for repairs increases the vulnerability in infrastructure in Valsad. There is need to evaluate the systemic risks and contingent liabilities, adopt redundancy and continuity planning and establish protocols for infrastructure recovery post crisis.

VMC shall need to collaborate closely with the District Disaster Management Authority to develop a river management plan which can reduce the impact of flooding for the city and the adjoining settlements due to increasing volumes of rainfall faced by the Valsad taluka and the Auranga river basin.

There is scope in to regularise and engage the private sector services and offerings into the WaSH infrastructure. For a city which experiences annual flooding and disruption of services and dilapidation of critical components, regulating and partnering with private services in water distribution, desludging services, and treatment of sludge needs to be explored. Water tankers and desludging service operators play a key role in filling missing gaps during disasters. This can also help in cost sharing and reduced operational expenses.

For larger establishments and newer developments, mandatory building plan approval ensures compliance with relevant regulations and standards. For Valsad, a city which has a thriving industrial sector, commercial and industrial establishments can be a potential stakeholder in infrastructure development. Local infrastructure development can benefit from business models in waste-to-energy and wastewater markets. Mangalore has a proven business model of MSEZL which has successfully established a wastewater market based on industrial requirement. Valsad could explore such models since it also has a significant industrial sector in the city and nearby. There is currently no provision or scope for disaster resilience investment planning by local bodies in cities like Valsad. Access to investment tools, resources, and processes to avoid, reduce, and transfer risk is needed. Current resilience measures are dominated by post-disaster response and recovery activities. There is no provision for a ring-fenced budget for DRR-related initiatives at a local level. There is an absence of safeguards to protect infrastructure maintenance budgets. For cities like struggling with financial sustainability, DRR and CCA mainstreaming will require funding support.

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ANNEXURE -I: DATA GAPS

The project design necessitated a comprehensive review of secondary data sources pertaining to the water and sanitation sector and climate change across various levels—national, state, district, and town. This exercise highlighted several significant data gaps, which are detailed below.

Water

1. **Inadequate Granular Water Consumption Data:** Household-level water consumption is not metered in many areas; bulk metering data (number of connections × billed consumption) does not accurately capture per capita usage or disparities across income groups or geographies (e.g., slums vs. apartments).
2. **Unaccounted for Water (UFW) and NRW:** Accurate estimation of transmission and distribution losses is hampered by the absence of metering at intermediate system points and outdated infrastructure records, making it difficult to precisely attribute inefficiencies or quantify water losses.

Sanitation

1. ***Typology of Individual Household Toilets and On-site Sanitation Systems***
Understanding the typology of individual household toilets and on-site sanitation systems is essential for assessing current levels of access to sanitation infrastructure and determining whether these constitute improved sanitation services. This information is a key indicator for tracking progress towards the SDGs and is relevant for climate adaptation frameworks. Additionally, it plays a critical role in estimating GHG emissions from the sanitation sector. However, the last comprehensive assessment of household toilet typologies was conducted during the 2011 Census, and no updated data is currently available from national, state, or city-level sources. The National Family Health Survey-5 (2019–2020)^{ixi} provides district-level data on access to improved sanitation facilities, defined as the “population living in households that use an improved sanitation facility.” However, disaggregated data at the town or municipal level is not available. Collecting such data would require a detailed household-level survey.
3. ***Operational Status of Community and Public Toilets:*** Community and public toilets are intended to serve populations without access to individual sanitation facilities, as well as the floating population in public spaces. The operational status of these facilities—including

aspects such as functionality, availability of water supply, and cleanliness—is a key requirement under the ODF+ certification framework. According to MoHUA guidelines, ULBs are mandated to conduct regular audits of these facilities. However, data on the coverage and adequacy of community and public toilets and operational status is not available with the ULB.

4. **Data on Storm Water Drainage:** The role of stormwater drainage systems in urban resilience is well recognized. However, the data available at the town level is limited to information on overall coverage and does not provide details on the typology of the drainage systems—such as whether they are open or closed, underground or surface-level, mapped or unmapped, or man-made or natural. A comprehensive understanding of these aspects would require detailed studies.
5. **Integrated role of Sewerage Network, Creeks, and Nallahs:** It is essential to determine whether natural and man-made water bodies—such as creeks and nallahs—are integrated into the town's wastewater and stormwater management systems, and to clarify their functional roles, whether they carry greywater, blackwater, stormwater, or a combination of these. Equally important is evaluating the degree of interconnection between these natural channels and engineered infrastructure. However, such information is not available through secondary data sources, and ULBs does not maintain a detailed sewerage network map.

GHG Emissions

1. **Groundwater Use Estimation Uncertain:** There is no systematic monitoring of groundwater abstraction volumes, especially from private borewells and tankers. The growing reliance on groundwater is not reflected in official supply data, resulting in underestimation of its energy and carbon footprint.
2. **Missing Real-Time Energy Consumption Data:** Energy data for various components (pumping, treatment, household-level usage) are often estimated based on assumed intensities (MWh/MLD) due to a lack of sub-metering across the water supply system.
3. **Limited Data on On-Site Sanitation Systems:** There is no centralized inventory of septic tanks, pits, or their design standards. Emission estimates rely on assumed containment types, desludging frequencies, and containment conditions, introducing uncertainty in CH₄ and N₂O emissions from faecal waste.

4. **Industrial and Tourism Sector Use Opaque:** Water and wastewater usage and discharge data from hotels, industries, and large commercial establishments are often not disaggregated or reported, masking the full impact of tourism and commercial activity on urban emissions.
5. **Stormwater and Greywater Flows Untracked:** Greywater is often discharged into storm drains without treatment or monitoring, leading to nutrient loading and emissions not captured in inventories.
6. **Sanitation GHG Methodology Limitations:** Emission estimates are based on global default emission factors and standard GWP values (IPCC 2013), which may not reflect local climatic, operational, or containment-specific variables.

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ANNEXURE-II: STAKEHOLDER CONSULTATION WORKSHOP ‘CLIMATE RESILIENT URBAN WATER AND SANITATION INFRASTRUCTURE SERVICES IN COASTAL TOWNS’: KEY HIGHLIGHTS AND WAY FORWARD

Programme Highlights

On **13th August 2025**, the **Stakeholder Consultation Workshop on Climate Resilient Urban Water and Sanitation Infrastructure Services** was held at **VMCC, Room No. 21, Indian Institute of Technology Bombay, Mumbai, Maharashtra**, in a **hybrid format** accommodating both in-person and online participation. The workshop brought together **policymakers, experts, practitioners, and project partners** from Maharashtra, Goa, Gujarat, and Karnataka to discuss challenges and opportunities in enhancing the resilience of water and sanitation systems in coastal towns. It provided a platform to **share project findings, examine policy and governance frameworks, and explore strategies for integrated, climate-responsive urban infrastructure planning**, fostering dialogue aimed at strengthening the adaptive capacity of urban water and sanitation services.

The workshop commenced with **registration from 9:00 AM to 9:30 AM**, followed by a **welcome address by Prof. NC Narayanan, Ashank Desai Centre for Policy Studies, IIT Bombay**, at 9:30 AM, who set the context for the discussions ahead. This was followed by an overview of the project by **Mr. Romit Sen, HSBC-India**, highlighting the objectives, scope, and significance of the Landscape Analysis for Climate Resilient Coastal Cities.

From **9:55 AM to 10:50 AM**, the **project highlights** were presented. Prof. NC Narayanan began with an overview of the background, tracing the history of water and sanitation research conducted by the lab, which laid the foundation for the HSBC project. He highlighted the rationale for the project, the significance of the West Coast, and why this region was chosen.

This was followed by a presentation on the **Urban Water-Energy-Climate Nexus** by Mr. Ashish Dangi, which outlined the research framework and underscored the interconnections between water, energy, and climate. Subsequently, **Dr. Neelam Rana** presented on **Policy, Governance, and Finances in WaSH and Climate Change**, providing a comprehensive overview of the current landscape, key challenges, and potential opportunities for enhancing climate resilience. The presentation highlighted that policies remain largely focused on **adaptation**, which is appropriate in a developing country context where ensuring access to basic services such as water and sanitation continues to be a priority. The session emphasized the importance of generating evidence on GHG reductions in the WaSH sector to inform mitigation policies. The session concluded with a **discussion and Q&A**, allowing participants to clarify key aspects of the study and share preliminary observations.

The session was followed by **tea and town-level poster presentations from 10:50 AM to 11:25 AM**, enabling participants to engage directly with the project team and explore data, findings, and visual insights from individual coastal towns.

State-wise discussions were held from 11:25 AM to 12:45 PM, moderated by domain experts:

- **Karnataka:** Mr. Vishwanath S, BIOME Environmental Solutions
- **Goa:** Mr. Depinder Kapur, National Institute of Urban Affairs (NIUA)
- **Maharashtra:** Ms. Lubaina Rangwala, World Resources Institute (WRI)
- **Gujarat:** Prof. Ajay Deshpande, IIT Bombay

These sessions facilitated a deep dive into state-specific and town-specific challenges, opportunities, and lessons learned from local implementation of urban water and sanitation systems, including climate and disaster resilience considerations.

From **12:45 PM to 1:15 PM**, participants gained practical insights from **field implementation in three coastal towns of Maharashtra—Malvan, Dhanu, and Guhagarh**. The session was presented by **Mr. Irfan from the Centre for DEWATS Dissemination (CDD), India**, highlighting on-the-ground experiences, key challenges in service delivery, and innovative approaches adopted to enhance the resilience of water and sanitation infrastructure in smaller towns. Additionally, Mr. Irfan showcased the **vulnerability assessment tool developed by CDD-India as part of the project**, which aids in evaluating climate and disaster risks to water and sanitation infrastructure at the local level.

After the **lunch break**, the **Feedback and Way Forward Session** was held from **2:15 PM to 4:15 PM**. This session brought together **key partners and experts**, including Mr. Amit Mishra (India

Sanitation Coalition), Mr. Irfan (CDD India), Mr. Romit Sen (HSBC India), Mr. Vishwanath S, Mr. Depinder Kapur (NIUA), Ms. Lubaina Rangwala (WRI), and Prof. Ajay Deshpande (IITB), who discussed ***actionable recommendations, capacity-building needs, and strategies for future collaboration***. The session also featured contributions from ***state and city representatives***, such as **PWD officials from Goa, CO Vengurla, MPCB officials, and officials from Mangaluru and Karwar**, whose feedback, suggestions, and observations provided valuable insights and guidance for the project team.

The workshop concluded with a **vote of thanks from 4:15 PM to 4:30 PM**, followed by **high tea at 4:30 PM**, marking the close of a productive day of knowledge sharing, deliberation, and collective strategizing for climate-resilient urban water and sanitation infrastructure in coastal towns.

Key Discussion Points

1. Maharashtra

During the Maharashtra session, several observations and recommendations were shared. Ms. Lubaina Rangwala emphasized that climate financing currently favors large cities, while small and medium-sized towns remain underserved. She highlighted the need to make tier-3 cities future-ready, through cross-sectoral and networked thinking, incremental funding, and decentralized options that generate co-benefits, particularly for coastal livelihoods.

Mr. Irfan from CDD shared insights from work in Malvan, Dhanu, and Guhagarh, emphasizing the importance of source strengthening in smaller towns and accounting for tourism's impact on local water, sanitation, and solid waste management systems. He noted technical and financial gaps in implementing infrastructure plans and suggested the development of localized, climate-resilient treatment systems.

Alibag, Vengurla, and Ratnagiri: While no specific sectoral recommendations were recorded for these towns, the general discussion reinforced the importance of focusing on smaller towns with limited service delivery infrastructure.

2. Karnataka

Mr. Vishwanath S highlighted the potential of treated wastewater for groundwater recharge, emphasizing co-benefits in cost savings, water conservation, energy savings, and climate change mitigation. He noted that political and operational challenges often limit the functionality of STPs and stressed the need to incorporate these challenges into reports.

Groundwater recharge in coastal towns was flagged as challenging due to high salinity levels. Discussions around financial sustainability highlighted discrepancies in cost recovery, with **Mangaluru** and Kundapura achieving over 95%, whereas Karwar had not yet reached the 50% mark. Mr. Vishwanath S also underscored the low level of service delivery and the need for adaptation-focused interventions.

Karwar: The Commissioner noted that STPs frequently stop functioning due to drought, monsoon flooding, and high tides, which cause corrosion in metal components. It was recommended to replicate models from Mangaluru and Kundapura, including engaging private vendors for utility management.

Mangaluru Officials highlighted that STPs are outdated, with end-of-life expected by 2026, and suggested adopting modern sewerage network techniques to detect and fix missing connections. Pricing and cost recovery remain a challenge, with reported O&M losses of INR 15–16 crore, although updated data indicates higher recovery.

3. Goa

PWD officials shared that Goa relies heavily on deep borewells and has implemented a 100% metering system with annual tariff increases of 5%. Non-revenue water (NRW) is estimated at 25%, with 15% attributable to manual errors. Initiatives include smart metering (3,000 units in Panaji), free water up to 16m³, and slab-wise tourism tariffs. They aim to supply 24×7 water and are planning energy audits to optimize energy use per cubic meter.

Mr. Vishwanath S and Goa, PWD officials noted that energy audits for water supply are underway, but GHG emissions are not currently a primary focus for the state. Challenges include high turbidity in raw water and local religious constraints on supply timing. Officials emphasized the need for unified platforms for dialogue and knowledge-sharing to improve WASH infrastructure performance.

Mapusa: The town sources water primarily from the Sal River, with a high water table and salinity concerns. Financial challenges were noted regarding one-time settlement schemes for water revenue, which were not continued after 2021–22.

4. Gujarat

Prof. Ajay Deshpande highlighted models for small and medium towns to assess WASH systems and evolve into climate-resilient cities. He recommended standards for abstraction and infrastructure and suggested policy advocacy measures. Ms. Nagma Modi, representing Valsad town, noted severe waterlogging and flooding in coastal areas of Valsad, requiring immediate attention. Mr. Depinder Kapur explained methods used to estimate population growth and future water demand for planning purposes.

5. Expert Panel Comments and General Observations

Across states, several general observations emerged. Prof. Satish Agnihotri suggested triaging ODF data with health metrics to identify towns where sanitation systems are failing or where positive outcomes can be studied. Mr. Vishwanath S emphasized the need to ring-fence water utilities and upgrade tariffs to achieve economies of scale. Prof. Ajay Deshpande recommended differential vulnerability assessments, highlighting that ULBs often lack the capacity to interpret complex assessments. Updated CRZ regulations were noted as an important tool for empowering ULBs.

Lubaina stressed the need for future-ready cities, equitable distribution of climate finance to smaller towns, and community awareness. Vishwanath S highlighted low-cost technologies and the importance of understanding groundwater extraction and aquifer potential. Mr. DepinderKapur underscored the need to consider both sewer-connected and non-sewered decentralized systems as viable solutions.

PWD officials from Goa noted ongoing energy audits, while Gujarat representatives stressed the importance of industrial wastewater management in Valsad and policy-led sewage treatment.

Way Forward

In the ***short term***, the team will incorporate the suggestions and feedback received, including additional town- and state-specific information, into the respective reports. In the ***medium term***, the team plans to develop research papers, publications, and other outreach and communication materials in collaboration with advocacy and implementation partners, namely the ***India Sanitation Coalition (ISC)*** and ***CDD-India***, aiming to achieve broader recognition and secure buy-in from government stakeholders and the academic community. In the ***long term***, the team aims to engage governance stakeholders and local academic institutions through targeted capacity-building exercises, leveraging the forthcoming toolkit designed to assess and enhance the resilience of water and sanitation infrastructure and services in coastal towns across India

ANNEXURE-III: ABBREVIATIONS AND GLOSSARY

AMRUT Atal Mission for Rejuvenation and Urban Transformation

CCA Climate Change Adaptations

CPCB Central pollution Control Board

CPHEEO Central Public Health and Environmental Engineering Organisation

CST Community Septic Tank

CDRI Coalition for Disaster Resilient Infrastructure

DDMA District Disaster Management Authority

DDMP District Disaster Management Plan

DM District Magistrate

DMC Dwarka Municipal Council

DRR Disaster Risk Reduction

ELSR Elevated Level Storage Reservoir

FSSTP Faecal Sludge and Septage Treatment Plant

GIRI Global Infrastructure Risk Model and Resilience Index

GLIS Geographic Information System

GSR Ground Level Storage Reservoir

IFIs International Financial Institutions

IPCC Intergovernmental Panel on Climate Change

LPCD Litres Per Capita per Day

LULC Land Use Land Cover

MLD/ KLD	Million Litres per Day/ Kilo Litres per Day
MMC	Mandvi Municipal Council
MSL	Mean Sea Level
NbIS	Nature-Based Infrastructure Solutions
NRW	Non-Revenue Water
ODF	Open Defecation Free
OSS	On Site Sanitation Systems
O&M	Operation and Maintenance
RIS	Risk Information Systems
SBM	Swachh Bharat Mission
SBR	Sequence Batch Reactors
SLBs	Service Level Benchmarks
SoP	Standard operating Procedure
STPs	Sewage Treatment Plants
UNDRR	United Nations Office for Disaster Risk Reduction
VMC	Valsad Municipal Council
WTP	Water Treatment Plant
WaSH	Water, Sanitation, and Hygiene

Term	Definition
Adequacy	Making available in a universal and equitable manner which is sufficient, acceptable and affordable for all.
Basic Infrastructure	Infrastructure that provides essential services to individuals, households, communities, and businesses and includes water, drainage, sanitation networks, local road, river, and rail networks, health and education facilities, post-harvest processing and storage facilities etc. (CDRI, 2023) ⁶²
Climate Adaptation	Adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change (UNFCCC, https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/introduction).
Exposure	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected. (UNDRR)
Flexibility	Ability of an infrastructure asset or system to perform the desired function based on specified requirements over time without interruption or degradation. (CDRI, 2023)
Grey Infrastructure	Engineered physical structures that underpin energy, transport, communications (including wireless and digital), built form, water and sanitation, and solid-waste management systems and that protect human lives and livelihood. (CDRI, 2023)
Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources. (UNDRR)
Infrastructure	CDRI has defined infrastructure as “Individual assets, networks and systems that provide specific services to support the functioning of a community or society” (CDRI, 2023)
Infrastructure Governance	Infrastructure governance can be understood as the policies, frameworks, norms, processes and tools used by public bodies to plan, make decisions, implement and monitor the entire life cycle of public infrastructure. (OECD)
Infrastructure Resilience	Infrastructure systems and networks, the components, and assets thereof, and the services they provide, that can resist and absorb disaster impacts, maintain adequate levels of service continuity during crises, and swiftly recover in such a manner that future risks are reduced or prevented. (CDRI, 2023)
Nature based Infrastructure Solutions	Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, and resilience and biodiversity benefits (UNEP, 2022c).

ODF	A city / ward can be notified/declared as ODF city/ ODF ward if, at any point of the day, not a single person is found defecating in the open (Ministry of Housing and Urban Affairs, 2020) ⁶³
ODF+	A city / ward / work circle can be notified/declared as SBM ODF+city/SBMODF+ward/SBMODF+work circle if, at any point of the day, not a single person is found defecating and/ or urinating in the open, AND all community and public toilets are functional and well maintained (Ministry of Housing and Urban Affairs, 2020)
Redundancy	Alternative or back-up means created within an infrastructure system to accommodate disruption, extreme pressures, or surges in demand. (CDRI)
Reliability of services	The ability of the system to maintain its required capacity and performance during a given period under stated conditions or disastrous events. (CDRI, 2023)
Resilience	The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. (AR6, IPCC)
Sensitivity	The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. (AR6, IPCC)
System Resilience	The resilience of social, economic, territorial and environmental systems, at all scales, that conditions the ability of infrastructure assets and the services they provide to resist and absorb disaster impacts. (Definition adopted in CDRI Biennial Report)

⁶²CDRI. (2023). Map Viewer. Retrieved from Global Infrastructure Risk Model and Resilience Index, Measuring Risk and Resilience in Infrastructure Solutions: <https://giri.unepgrid.ch/map>

⁶³Ministry of Housing and Urban Affairs. (2020). Declaring your City/Town SBM ODF+ and SBM ODF++ Toolkit for Urban Local Bodies. New Delhi: Government of India.



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