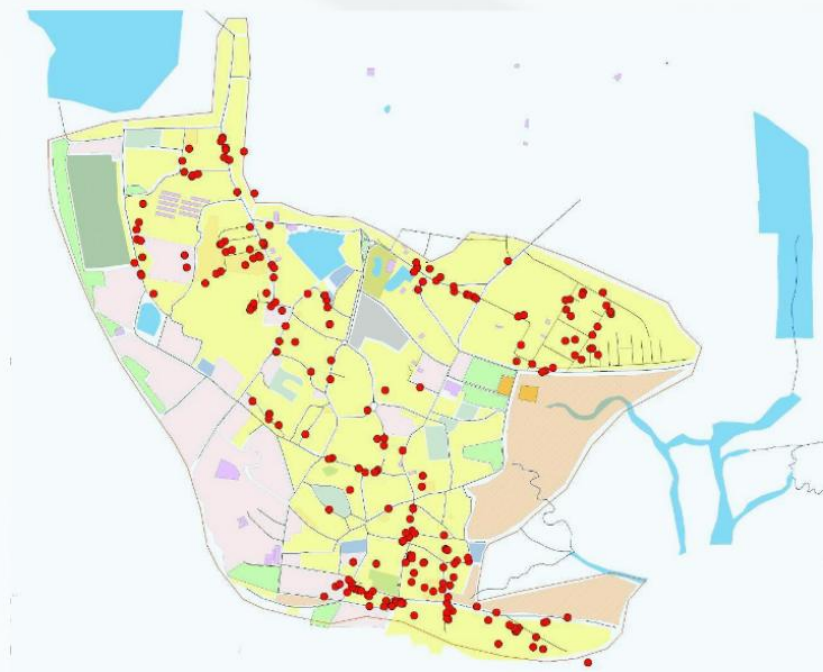




Resilience of Urban Water and Sanitation Infrastructure & Services in Coastal Towns

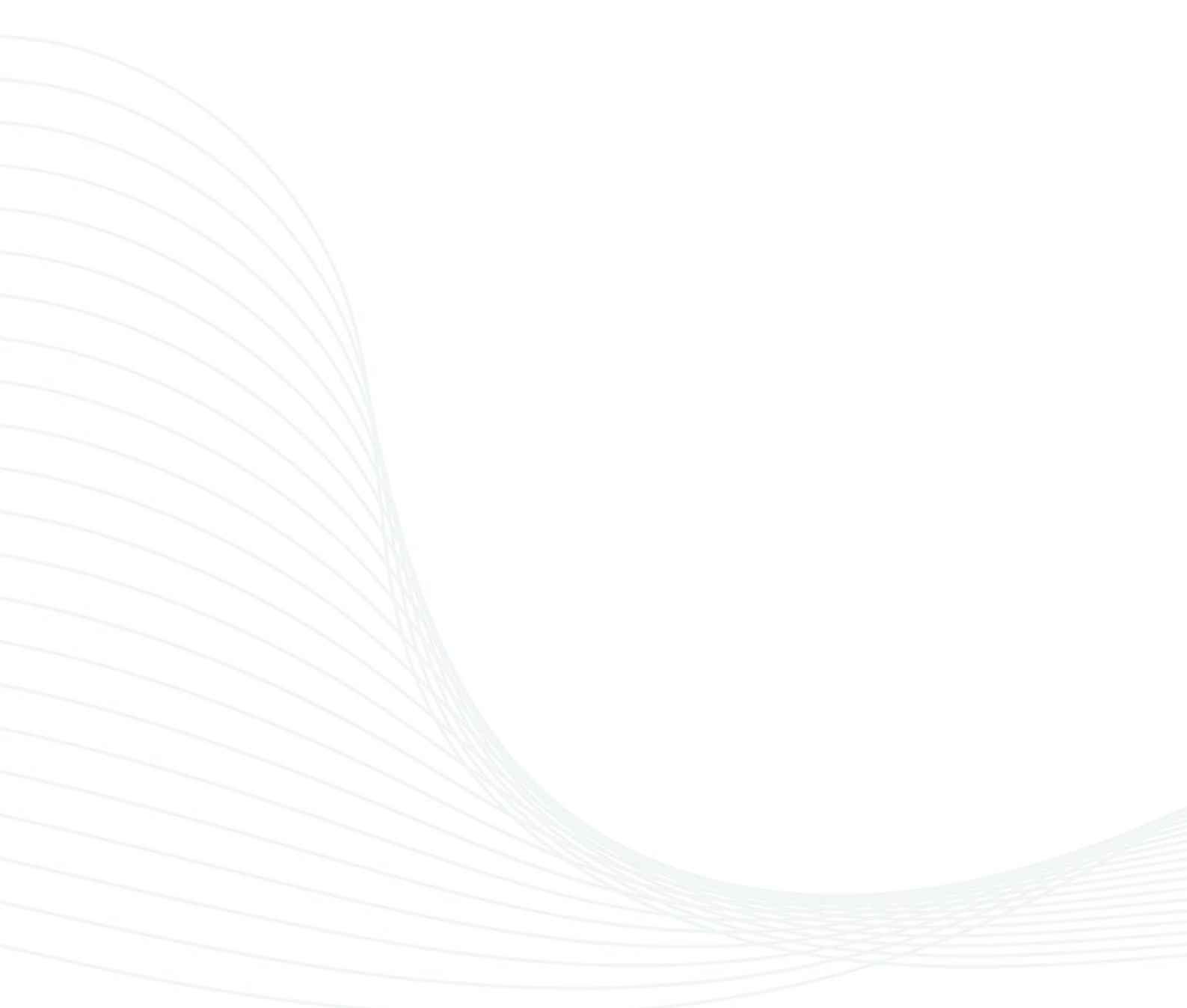
Preliminary Situational Analysis: The Alibag Pilot
Alibag, Maharashtra



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N C Narayanan

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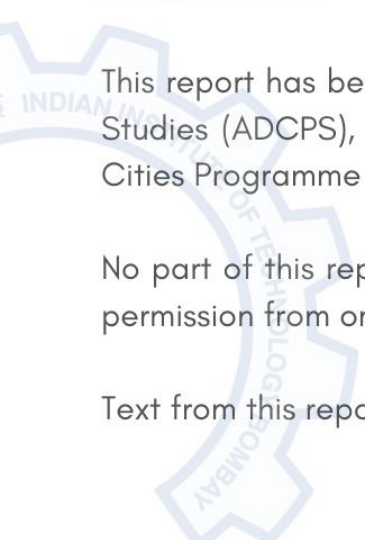


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TITLE

Resilience of Urban Water and Sanitation Infrastructure & Services in Coastal Towns:
Preliminary Situational Analysis for Alibag, Maharashtra

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PREFACE: THE ALIBAG PILOT STUDY

India's coastal regions are on the front lines of climate change. Rising sea surface temperatures in the Arabian Sea have intensified cyclonic events, while the loss of natural buffers, unregulated development, and sea-level rise continually heighten coastal exposure. Within these geographies, inadequate Water and Sanitation (WaSH) infrastructure deepens vulnerabilities, disproportionately impacting disadvantaged communities.

Against this backdrop, the 'Climate Resilient Coastal Cities' project, supported by HSBC-India, was initiated to examine the landscape of coastal vulnerability across the western states of Goa, Gujarat, Karnataka, and Maharashtra.

This document serves as the foundational pilot study for a broader situational assessment of 12 coastal towns. Focussing on Alibag, a Class-III coastal town in Maharashtra's Raigad district, this inaugural report was designed to test, refine, and establish the methodological framework used for the overarching project. Because it served as our proving ground, readers will note that the structure, depth, and exploratory scope of this report differ from the 11 subsequent town assessments.

The granular approach taken in Alibag, evaluating the intersection of climate risk, WaSH service disparities, greenhouse gas (GHG) emissions from water systems, and municipal financial sustainability, helped standardise the analytical parameters applied to the rest of the study.

Alibag presented a critical environment for this baseline assessment. Despite its ecological importance, its low elevation (approximately 0 m above sea level), tidal inlets, and proximity to the Western Ghats make it highly susceptible to saline intrusion, flooding, and storm surges, as witnessed during Cyclones Nisarga and Tauktae. The town's water and sanitation systems are under severe pressure from an ageing distribution network, high non-revenue water (NRW), and reliance on septic systems. Rapid urbanisation has widened socio-spatial disparities, leaving marginalised groups, particularly the Koli fishing community, living in the most climate-exposed and underserved zones. Furthermore, institutional weaknesses and heavy reliance on state and central grants have undermined the local council's autonomy, contradicting the spirit of the 74th Constitutional Amendment.

By analysing these local governance gaps and resilience needs, this pilot report not only provides actionable insights to strengthen Alibag's climate-adaptive infrastructure but also establishes the analytical foundation that guided the broader 12-town assessment.

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EXECUTIVE SUMMARY

India's coastal regions face growing threats from climate change, including sea-level rise, cyclones, coastal erosion, saline intrusion, and flooding. Rising sea surface temperatures in the Arabian Sea have increased the intensity of cyclonic events, while loss of natural buffers and unregulated development heighten exposure. Weak Water and Sanitation (WaSH) infrastructure and inadequate service delivery deepen vulnerabilities, especially among disadvantaged groups.

Against this backdrop, the Landscape Analysis for Four Coastal States on Climate-Resilient Water and Sanitation Infrastructure Project, supported by HSBC-India, examines 12 towns across Maharashtra, Gujarat, Goa, and Karnataka. **This report focuses on Alibag, a Class-III coastal town in Raigad district, Maharashtra, which serves as the district headquarters and lies within a high-rainfall agroclimatic zone. The study assesses Alibag's water and sanitation sector, highlighting service disparities, institutional roles, and financial sustainability. It also evaluates greenhouse gas (GHG) emissions from urban water and wastewater systems and identifies opportunities for both adaptation and mitigation. By analyzing governance gaps and resilience needs, the report proposes actionable recommendations to strengthen climate-resilient infrastructure and services**

Despite its ecological importance featuring mangroves, wetlands, and fishing villages the town is increasingly exposed to climate-driven risks, infrastructural strain, and socio-economic inequalities. Alibag's **geographical features** low elevation (around 0 m above sea level), proximity to the Western Ghats, and tidal inlets make it highly vulnerable to **sea-level rise, erosion, storm surges, and saltwater intrusion**. Cyclones Nisarga (2020) and Tauktae (2021) caused severe disruptions, damaging infrastructure, uprooting trees, and displacing over 50,000 people. Future climate projections suggest a **temperature rise of 1.1–1.28°C** and **10–30% more monsoon rainfall by 2030**, with sea levels rising **0.24–0.66 m by century's end**, intensifying risks to critical services.

Water and sanitation systems are under severe pressure. **Bulk water supply from Maharashtra Industrial Development Corporation (MIDC)** is unreliable, and the **aging distribution network** suffers from leakages, low pressure, and high non-revenue water (NRW). Poorer households, especially in low-lying areas, face inequitable access. On sanitation, most households rely on septic systems; 18% lack individual toilets. Weak desludging practices, poor public toilet coverage, and frequent flooding worsen public health risks. Waste mismanagement contributes to **greenhouse gas (GHG) emissions** from inefficient pumping and untreated sludge. Marginalized groups, particularly the **Koli fishing community**, are disproportionately affected, living in the most climate-exposed and underserved zones. Rapid urbanization has widened **socio-spatial disparities**, with wealthier areas enjoying better infrastructure while coastal, low-income settlements remain neglected. Institutional weaknesses, coupled with Alibag Municipal Council's (AMC) **heavy dependence on state and central grants**, undermine the financial sustainability and autonomy of WaSH services, contradicting the spirit of the 74th Constitutional Amendment.

Strengthening Alibag's resilience requires integrated action across water, sanitation, and governance systems. This study identifies urgent interventions to enhance climate-adaptive WaSH infrastructure, build institutional capacity, and improve financial sustainability.

KEY RECOMMENDATIONS

Water

- **Water Reduce Losses:** Cut non-revenue water through audits, leak repairs, and pipeline upgrades.
- **Diversify Sources:** Promote rainwater harvesting, recharge wells, and decentralized systems to reduce MIDC dependence.
- **Modernize Infrastructure:** Replace aging pipelines, improve pumps and storage, and ensure reliable supply.
- **Ensure Equity:** Address supply gaps and redesign distribution to serve low-income and coastal areas.
- **Build Resilience:** Establish community storage, emergency water kiosks, and contingency protocols.
- **Promote Efficiency:** Launch awareness campaigns and incentives for water conservation.

Sanitation

- **Climate-Resilient Planning:** Integrate risk assessments into sanitation design and siting.
- **Upgrade Infrastructure:** Retrofit septic tanks, toilets, and treatment plants for flood resilience.
- **Strengthen On-Site Sanitation Systems (OSS):** Enforce desludging, safe disposal, and climate-adapted septic designs.
- **Expand Treatment:** Establish resilient Faecal Sludge and Septage Treatment Plants (FSSTPs) and decentralized wastewater systems.
- **Governance & Coordination:** Foster cross-departmental collaboration and secure dedicated funding.
- **Community Engagement:** Involve local groups in planning and train staff for climate-responsive management.

Financial Sustainability

- **Boost Revenues:** Revise tariffs, expand tax base, and strengthen collection systems.
- **Improve Cost Recovery:** Rationalize tariffs and reduce operational losses.
- **Strengthen Planning:** Develop multi-year financial strategies and establish resilience funds.
- **Build Capacity:** Improve AMC's financial and technical management skills.
- **Ensure Transparency:** Link grants to performance and publish regular financial reports.

CHAPTER 1: INTRODUCTION

NEELAM RANA, ASHISH DANGI, ABHAY JUNAGHARE, UDIP PRAN DAS AND N.C.NARAYANAN

1.1 BACKGROUND

In recent years, India's coastal regions, including Alibag, have become increasingly vulnerable to climate change. Scientists predict a rise in the intensity and frequency of extreme weather events. Alibag, a coastal town in Maharashtra along the Arabian Sea, is particularly at risk due to its low elevation, which averages around 0 meters above sea level, and its proximity to the Western Ghats and dynamic tidal inlets. These geographical factors make the town susceptible to sea-level rise, coastal erosion, saline intrusion, and flooding (National Centre for Coastal Research, 2022)¹. The erosion of natural coastal defences like mangroves and sand dunes, along with unregulated coastal development, has heightened the town's vulnerability. Infrastructure such as roads and buildings has suffered, with severe monsoons and storms, like Cyclone Tauktae in 2021, causing significant damage (Rao K., 2019)².

Demographically, Alibag is home to diverse communities, including the Koli fishing community, which is socio-economically marginalized and particularly vulnerable to climate impacts. Marginalized groups often reside in the most at-risk areas, such as low-lying coastal zones, and face unequal access to services and resources (Pramanik et al., 2021)³. Rapid urbanization has strained infrastructure, leading to socio-spatial disparities in essential services like water supply, sanitation, and transportation. Wealthier neighbourhoods benefit from better infrastructure, while vulnerable coastal areas remain underserved (Khemnar, 2017)⁴.

Alibag's WASH infrastructure is under pressure due to rapid population growth, with poorer areas facing significant service shortfalls. This exacerbates socio-spatial inequalities and heightens vulnerability to climate change. Moreover, unplanned urban development has strained the town's infrastructure, worsening waste management and overburdening water and sewage systems, further increasing Alibag's vulnerability to environmental challenges (Rao K., 2019). The degradation of natural buffers and increasing climate-related events highlight the urgent need for better urban planning and sustainable resource management (Mohanty et al., 2020)⁵.

In the following sections, the objectives are presented in the second and third sections. The third and fourth sections provide background information on the study area, including demographic profiles, climatic conditions, and vulnerabilities to climate change. The fifth section details the methodology employed in the study. The sixth section examines the spatial dimensions of climate vulnerability in Alibag, utilizing data collected from primary surveys across different localities to identify the town's most vulnerable areas. The status of water

supply and sanitation infrastructure and service delivery is discussed in detail in the seventh section. The eighth section outlines the institutional framework governing the water and sanitation sector. The ninth section assesses the financial health of the Alibag municipality. The tenth section evaluates greenhouse gas emissions from the water and sanitation sector. Finally, the concluding section summarizes the key findings and discusses their implications.

1.2 OBJECTIVES

- a. To map the status of Water and sanitation infrastructure and services in AMC
- b. To understand financial health of Alibag Municipality
- c. To map institutional framework in water and sanitation sector
- d. To assess Greenhouse Gas (GHG) emissions from water and sanitation infrastructure and services
- e. To examine socio-spatial aspect of disasters planning for Alibag municipality

1.3 METHODOLOGY

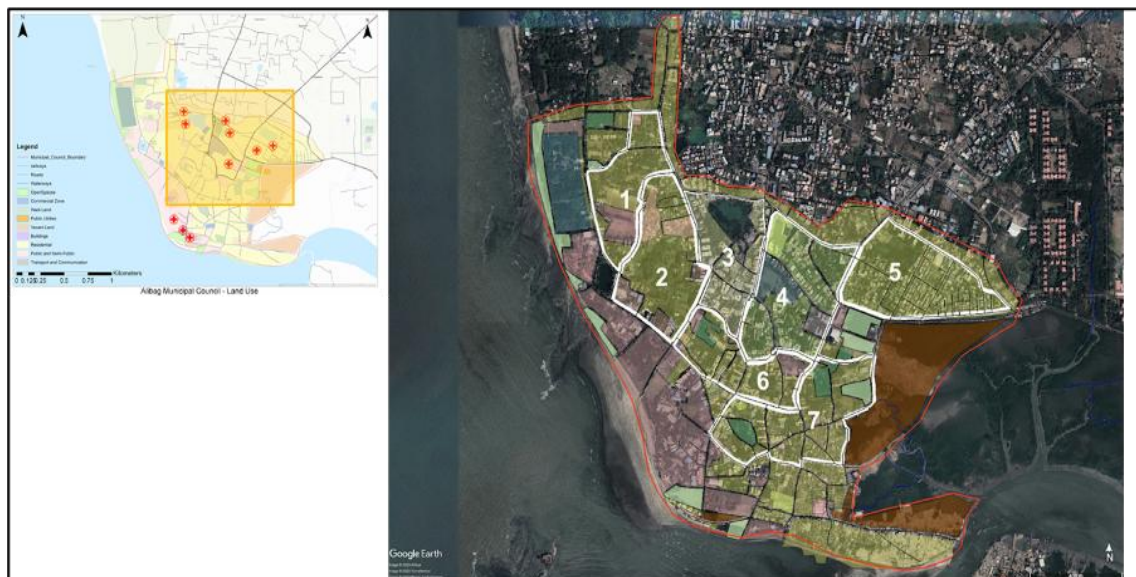
For our study of Alibag, we used a mixed-methods approach combining both primary and secondary data collection techniques. The steps taken are as follows:

1. **Desk study:** The first step involved a desk study to collect secondary data on water and sanitation infrastructure and services, map key stakeholders and understand their role in decision making process and understand the impacts of climate change on the town.
2. **Stakeholder interactions and semi-structured interviews:** The second step included stakeholder interactions with the municipality (water and sanitation department), Raigad District collector's office and disaster management authorities, MIDC, and local NGOs. Key components of the WaSH service delivery infrastructure were identified, and site visits were conducted. The purpose was to develop an in-depth understanding of the status and funding in WaSH services, and related decision-making process. The questions related to energy consumption in delivering WaSH services were asked to AMC. The interactions with the DMA helped in understanding disaster preparedness of WaSH services in the town and identify vulnerable communities. Base maps, land use map was also collected from AMC.
3. **Interactions with residents:** It was deemed necessary to understand the perspective of users (local citizens) on the status of WaSH services as well as the felt impacts of climate change, if any. Hence, the step involved recce visits to Alibag talking to locals and social workers. These steps helped in designing the questionnaire for household survey and pilot testing it. It also helped to identify site specific characteristics based on which the sampling could be carried out.

4. Household Survey: The fourth step comprised a household survey conducted in December 2023 (as part of the winter school), to assess the status of WaSH infrastructure and services and the impacts of cyclones on such services at household level. Survey was conducted in two zones which were broadly classified as ‘Alibag City’ and ‘Koliwada’ area. Survey with the help of interview schedules and questionnaires consisting of nearly 75 questions segregated into 6 broad parameters, namely, a) demography; b) socio economy (education, livelihood); c) access to WaSH infrastructure; d) disaster impacts and management; e) Hygiene; and f) Culture. Using random sampling method, a total of 321 households (HHs) were surveyed from the 14 subregions of both ‘Alibag City’ and ‘Koliwada’ area, of which, 231 HHs were from Alibag City and 90 HHs from the Koliwada area (figure 3).

Sampling for Household Survey: Based on the reconnaissance site visits, it was understood that the portions occupied by the Koli community, called the Koliwada, have distinct characteristics from the rest of the town. Hence the study area was divided into two zones: ‘City Area’ and ‘Koli Area’. Upon further examination of the site on Google Earth, a very dominant ring radial road pattern and built density patterns were visible. Based on this, these two zones were further subdivided into 7 subregions each (figure 1 and 2). Areas with apartment buildings, and public/semi-public land uses were excluded from the study area.

Figure 1 : Zoning of Alibag city



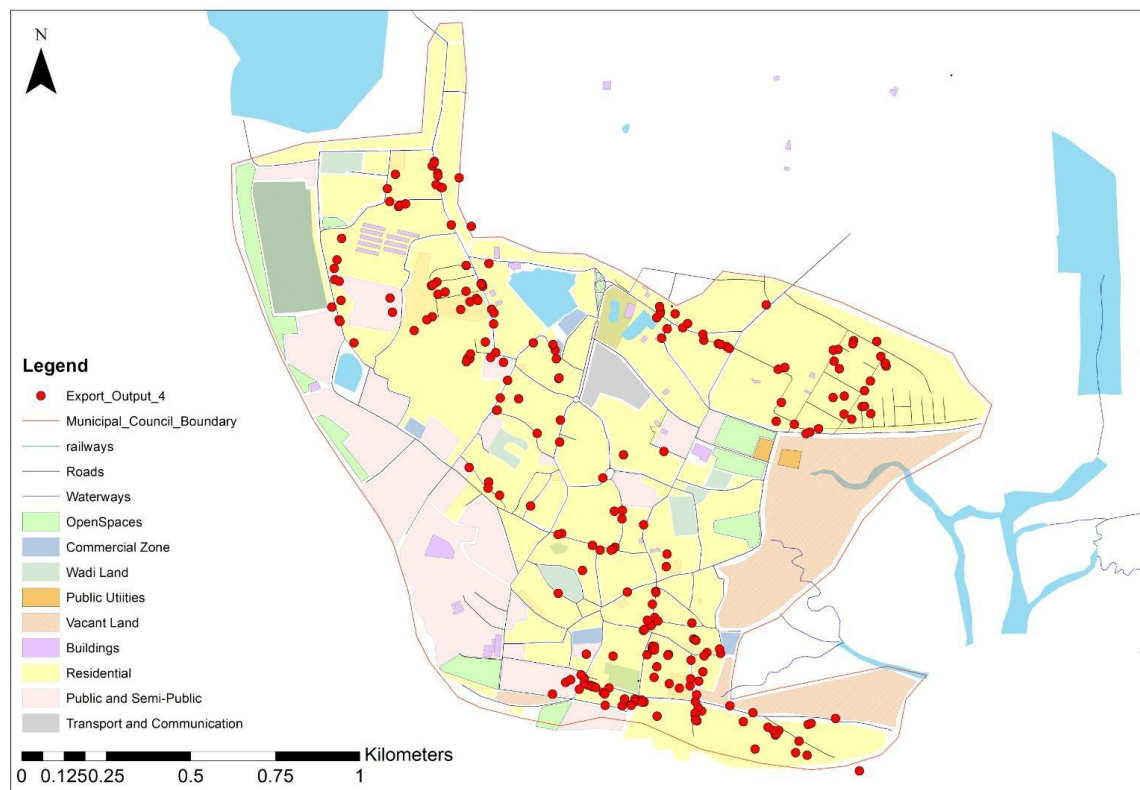
Source: Author's Illustration

Figure 2 : Zoning of Alibag Koli area



Source: Author's Illustration

Figure 3: Sample Household Survey Location



Source: Primary Survey

- 5. Mapping Activities as part of Survey:** A key aspect of socio-spatial analysis is the correlation of the socio-economic and cultural parameters with spatial parameters such as land use, elevation, built-up densities, etc. Data on these spatial parameters from the public domain such as land use tends to generalize and often fails to capture the local level differentialities of built-up heights, mixed building uses, ownership issues, etc. Ground truthing of the land use plans helps us capture these aspects for a more fine-grained analysis. Residential (with building height based on the number of storeys), commercial (Office & Retail), Green Spaces, and Vacant land were identified for the same.

CHAPTER 2: TOWN PROFILE: ALIBAG

NEELAM RANA & N.C.NARAYANAN

2.1 OVERVIEW

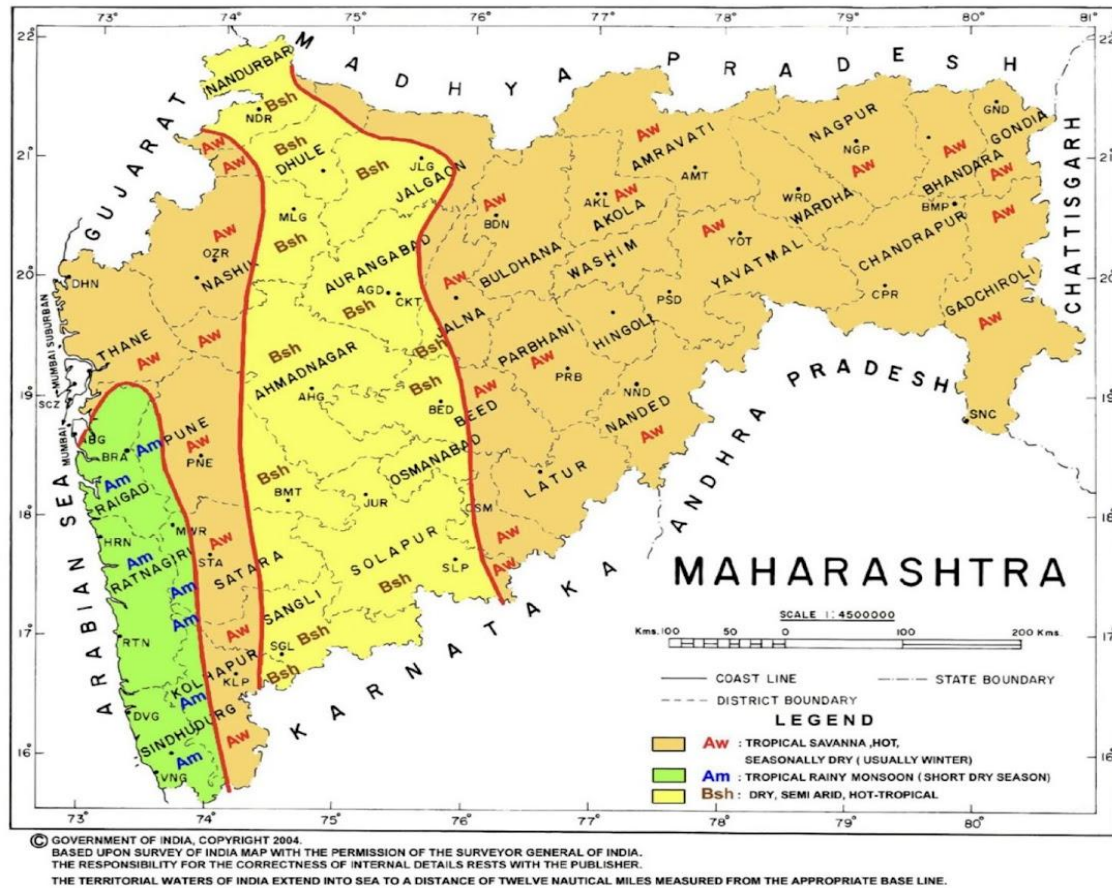
Alibag is a coastal town located in the Raigad district of Maharashtra, India. Situated on the shores of the Arabian Sea, Alibag has the following geographical coordinates: Longitude: 72° 52' 47" E, Latitude: 18° 39' 23" N. In Figure 4, the location of Alibag city within the state of Maharashtra is shown. Alibag town is the headquarters of the Raigad district and has its own municipal council. The town as part of the Raigad district is part of one of the seven agroclimatic zones in Maharashtra with very high rainfall pattern (refer figure 5). According to the Census 2011 the population of Alibag is 20,743 and the population of AMC stands at approximately 29,300 as of 2024.

Figure 4 : Alibag Map



Source: Map My India

Figure 5 : Agro-climatic Zones in Maharashtra



Source: IMD, Pune

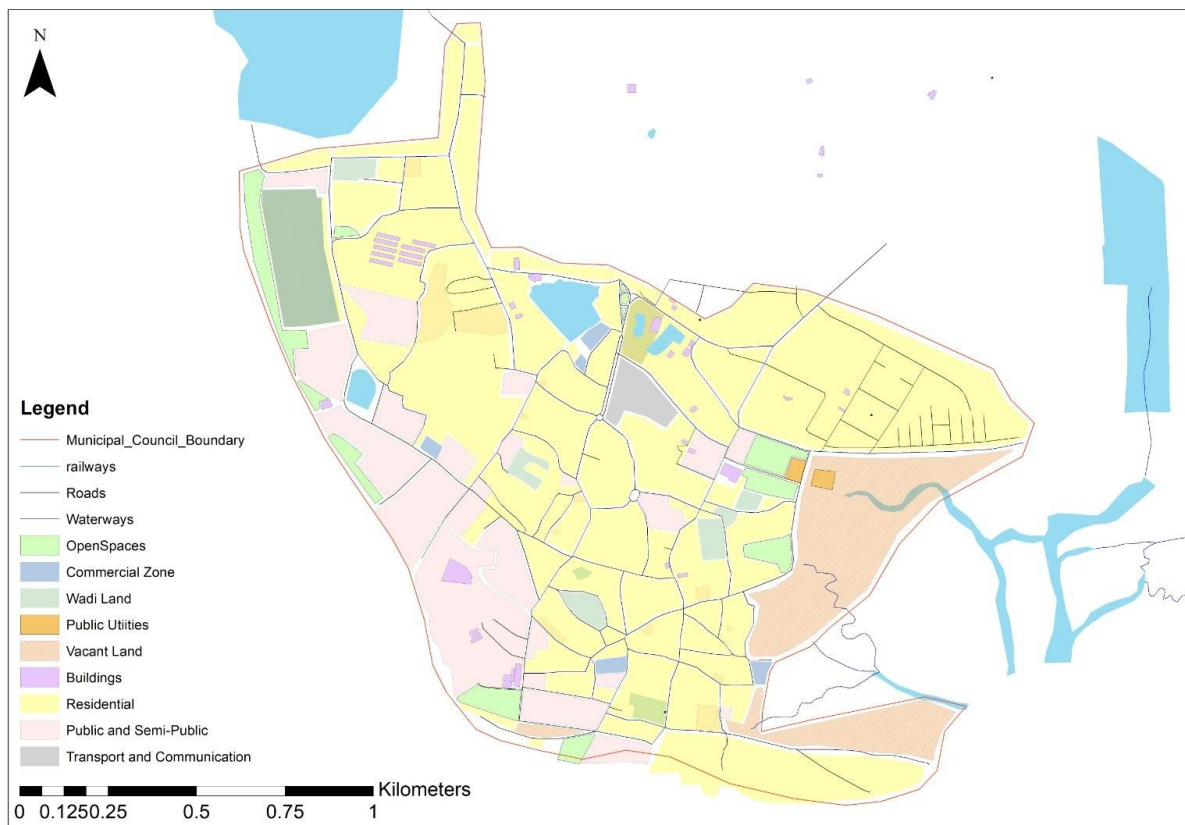
The town boasts a high literacy rate of 92.2% (Census, 2011)⁶. Alibag's population is diverse in terms of caste and tribe, with Schedule Tribe (ST) constituting 13.2% and Schedule Caste (SC) comprising 5.7% of the total population. Religiously, the town is predominantly Hindu, with 82.55% of the population following this faith, followed by Muslims at 11.06%, Christians at 0.44%, and other religious communities. When it comes to the working population, a significant majority of 89.2% of workers describe their work as main work, which involves employment or earning for more than 6 months. The agricultural sector has a modest presence, with 59 cultivators (owners or co-owners) and 31 agricultural laborers engaged in Main Work. Overall, Alibag's population and demographic profile reflect a diverse and highly literate community, with a mix of religious and caste identities, and a predominantly non-agricultural workforce (Census, 2011).

The Alibag taluka has diverse landscapes, including farms, fishing villages, and ecologically significant wetlands. These wetlands are characterized by mud flats, salt marshes, and mangrove forests. Such coastal ecosystems play a crucial role in environmental sustainability

by performing essential functions such as water purification, water storage, nutrient processing, shoreline stabilization, and supporting diverse plant and animal life (Joshi, 2021)⁷.

The Mumbai Metropolitan Region (MMR), covering an area of 6,328 sq. km., covers nine Municipal Corporations and nine Municipal Councils including Alibag. The Mumbai Metropolitan Region Development Authority (MMRDA) is tasked with ensuring balanced development across the MMR, addressing the diverse needs and challenges of its urban and rural areas. Alibag, as part of this region, benefits from the coordinated efforts aimed at improving infrastructure and promoting sustainable growth. Figure 6 illustrates the city boundary, including existing roads, waterways, open spaces, public utilities, transport, and communication networks.

Figure 6 : Alibag City Base Map



Source: author's illustration

2.2 CLIMATE CHANGE VULNERABILITY OF ALIBAG

A report "Mapping India's Climate Vulnerability: A District Level Assessment" by the Council on Energy, Environment and Water (CEEW) (Mohanty & Wadhawan, 2021)⁸ provides a broad analysis of climate vulnerability across Indian districts and states. It does mention Maharashtra as one of the top three climate vulnerable states in India.

Raigad district, of which Alibag is part of, is moderately vulnerable to drought, and Ratnagiri district which is moderately vulnerable to floods & cyclones (Mohanty & Wadhawan, 2021) ; (National Centre for Disease Control , 2022). Recent reports indicate that Alibag city is vulnerable to various natural disasters. For example, cyclone Nisarga made landfall near Alibag, Maharashtra, in June 2020, classified as a severe cyclonic storm with wind speeds of 110-120 km per hour. The cyclone caused significant damage, uprooting trees, damaging power lines, and structures, leading to widespread disruptions.

In terms of future projections, Alibag being (as part of the Konkan division) is expected to have a moderate rise in mean temperature (1.1-1.28°C) and a 10-30% increase in monsoon rainfall by 2030 (The Energy and Resources Institute, 2014)⁹. Extreme rainfall is projected to rise by 10-14%, and Konkan will see fewer additional dry days compared to other regions, with an increase of 3-5 days. This could impact agriculture and water resources, challenging equitable water access at the Urban Local Body (ULB) level, particularly with the push for 24x7 water services and 150 lpcd norms. The increase in temperature could lead to rising heat index levels which in turn could worsen heat stress, raise malaria transmission, and drive-up energy and water demand, exacerbating the urban heat island effect. Further, sea levels along Maharashtra's coastline may rise by 0.24-0.66m by the end of the century, affecting coastal cities like Alibag, Ratnagiri, and Vengurla. Sea level rise, along with storm surges and coastal erosion, could lead to saltwater intrusion into groundwater aquifers. Maharashtra's coastline faces a 25.5% erosion rate, with stable coasts in districts like Sindhudurg and Ratnagiri, though accretion is observed along Alibag region (Kankara, Murthy, & Rajeevan, 2018), (National Centre for Coastal Research, 2022)¹⁰.

CHAPTER 3: SOCIO-SPATIAL DIMENSIONS OF CLIMATE RESILIENCE IN ALIBAG

UDIP PRAN DAS, NEELAM RANA, ABHAY JUNAGHARE & N.C.NARAYANAN

3.1 BACKGROUND

Recognizing the absence of city-level studies on vulnerabilities to climate-induced disasters, a focused study was initiated. Early visits and stakeholder interactions revealed stark disparities in the basic services including water and sanitation and interconnected impacts of climate change.

Following this, a socio-spatial approach to vulnerability was followed. The approach explores how social relations and spatial configurations interact, emphasizing that space actively influences and is influenced by social dynamics (Gotham & Brumley, 2002)¹¹. Henri Lefebvre's concept of the 'Right to the City' states that urban inhabitants should have equitable access and influence over urban environments, advocating for participatory and democratic urban development (Purcell, 2014)¹².

Applying this framework to water and sanitation infrastructure in the context of climate change reveals that spatial determinants significantly shape vulnerabilities. Marginalized communities, often located in high-risk areas with inadequate infrastructure, are disproportionately affected by climate impacts (Hendricks & Van Zandt, 2021)¹³. Vulnerabilities manifest through health risks, economic disruptions, and are intensified by spatial and socio-economic inequalities (Narayan-Parker & Patel, 2000¹⁴; Few, 2007¹⁵; Kühn, 2015¹⁶). Climate events like floods and droughts exploit these vulnerabilities (Carrão et al., 2016)¹⁷. Addressing these issues involves equitable redistribution of resources and inclusive decision-making to enhance community resilience (Fitzgibbons & Mitchell, 2021)¹⁸. This approach extends Lefebvre's 'Right to the City' to emphasize equitable resource distribution and participatory adaptation strategies.

In the study, we conducted a household survey in Alibag, Maharashtra, focusing on socio-economic vulnerability related to climate change impacts. This survey, which included diverse socio-economic zones, aimed to understand how spatial and social factors intersect to influence resilience. The section discusses how marginalized communities, often situated in high-risk areas with inadequate infrastructure, face heightened vulnerabilities during climate events. This work applies Lefebvre's 'Right to the City' to advocate for more equitable resource distribution and inclusive decision-making in urban planning.

The section is divided into three subsections: the first examines the socio-economic profile of sampled households across different zones, including their access to water and sanitation services; the second captures the impact of recent cyclones on these services and people's lives

through their lived experiences; and the final subsection analyzes the overall socio-spatial vulnerability of the sample population using the weighted overlay method.

3.2 ANALYTICAL FRAMEWORK

To map the socio-spatial dimension of the climate resilience weighted overlay method was used. The method helped in identifying the most vulnerable locations in Alibag based on multiple socio-environmental criteria. Each criterion is weighted according to its relative importance to overall vulnerability, reflecting its socio-spatial impacts on public health, water and sanitation infrastructure, and climate resilience.

The key steps are:

1. **Criteria Selection:** Table 1 shows criteria pertaining to **three major layers** i.e.,
 - (a) **socio-economic layer** : house ownership, housing typology, household income
 - (b) **sanitation layer:** grey and black water management practices at household level
 - (c) **disaster impact layer:** people's perception of impact of latest cyclones on water and sanitation infrastructure and services, changes in rainfall pattern
2. **Weight Assignment:** Weights are assigned through a combination of expert judgment, socio-economic survey results, and GIS-based geospatial analysis (Table 1).
3. **Data Integration:** Spatial and empirical data are overlaid to create a vulnerability map. The resulting vulnerability map identifies hot spots (darker shaded areas) that represent higher socio-spatial vulnerability. These areas that are near to the coast and the Koliwada zone, are subject to poor sanitation practices, higher cyclone damage, and flooding risks. Such vulnerabilities are worsened by socio-economic disparities, particularly in marginalized communities with limited access to resilient infrastructure.

The weights assigned to each indicator (0.05–0.25) were derived using the **Analytic Hierarchy Process (AHP)** developed by Saaty (1980)¹⁹. Pairwise comparisons were conducted to evaluate the relative importance of each indicator with respect to climate resilience of water and sanitation infrastructure. The comparison matrix was constructed based on ground truthing, evidence from the literature on climate resilience, vulnerability assessment, and water and sanitation systems. The normalized principal characterised direction of the comparison matrix was used to obtain the final indicator weights, and the consistency of judgments was verified using the **Consistency Ratio (CR)**, ensuring that the comparisons met the acceptable threshold ($CR < 0.10$)

Table 1: Indicators to Assess Climate Resilience of Communities with Focus on Water and Sanitation Infrastructure Services in Alibag

Criteria	Description	Weight (0.05-0.25)
Socio-Economic Layer		
Housing Typology (Pucca, Semi-Pucca, Kuccha)	Assesses the type of housing structure (permanent, semi-permanent, or temporary).	0.1
Household Socio-Economic Status	Considers household income levels and resource access	0.05
House Ownership Distribution	Analyzes whether homes are owned or rented, with implications for infrastructure resilience	0.05
Water Layer		
Impact of Cyclone on Water Storage Tanks	Evaluates the extent of damage inflicted by cyclones on water storage infrastructure in Alibag, influencing water availability post-disaster	0.2
Water Sufficiency	Assesses the adequacy of water supply across different regions of Alibag, based on household perceptions and actual measurements of water availability.	0.15
Water Pressure	Analyzes the consistency and adequacy of water pressure in household taps, which affects daily usage and satisfaction with water services.	0.1
Water Quality	Measures the safety and cleanliness of drinking water in Alibag, reflecting public health implications and infrastructure effectiveness.	0.15
Sanitation Layer		
Toilet Coverage	Determines the presence or absence of individual toilets in households	0.05
Toilet connection to On-Site Sanitation Systems (OSS)	Determines whether individual households toilets connect to OSS	0.1
Presence of Septic Tank Outlets	Identifies households with septic tank outlets discharging into drainage systems or nearby water bodies.	0.25
Septic Tank Cleaning Frequency	Tracks how often septic tanks are cleaned, with infrequent cleaning posing risks to public health.	0.1
Septic Tanks with Concrete Bottoms	Maps the presence of septic tanks with concrete bottoms, which reduce groundwater contamination risks.	0.1
Cleaning Frequency of Public Toilets	Evaluates the cleanliness and frequency of maintenance of public sanitation facilities.	0.05
Bathroom Wastewater Management	Evaluates the methods used by households to dispose of grey water	0.15
Disaster Impact Layer		

Criteria	Description	Weight (0.05-0.25)
Observed Changes in Rainfall Patterns	Captures local perceptions and data on changes in rainfall over the past 10-15 years.	0.15
Impact of Cyclones (2020 and 2021)	Measures the damage caused by cyclones Nisarga and Tauktae, particularly on water and sanitation infrastructure.	0.25
Flood Impact Areas	Maps regions that suffered severe flooding due to cyclones and inadequate drainage.	0.2
People's Understanding of Cyclone Occurrence	Captures spatial distribution of residents' awareness of cyclone risks and recurrence.	0.05

3.3 FINDINGS

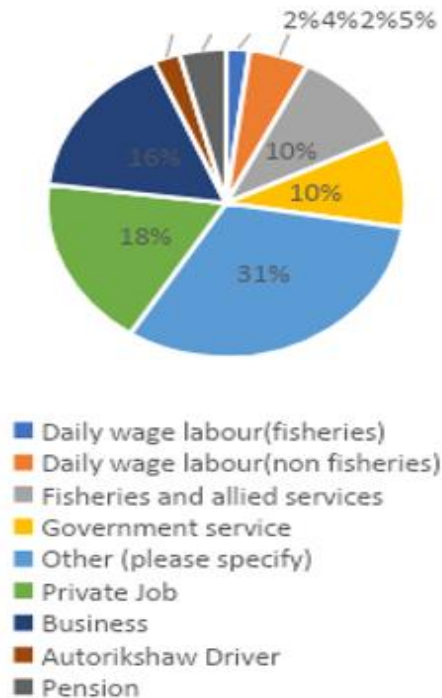
The current section discusses findings of the household survey pertaining to socio-economic layer (household income, home ownership, type of housing), status of water and sanitation services, and disaster impact layers to produce socio-spatial climate resilience map.

3.3.1 SOCIO-ECONOMIC LAYER

- Primary Source of Household Income:** Primary survey conducted reveals that the largest segment of the population in Alibag, comprising 31%, earns their livelihood through daily wage labour in non-fisheries sectors (figure 7). This indicates a significant reliance on casual labour, which suggests economic vulnerability due to the instability associated with such jobs. The second largest group, at 18%, is involved in fisheries and allied services, reflecting the community's dependency on local natural resources, potentially linked to a coastal or riverine environment. Those engaged in daily wage labour specifically within fisheries make up 16% of the population, highlighting the importance of this sector to the local economy. 10% of the households derive their income from government services, and an equal proportion from private jobs, highlighting a segment of the population that possibly enjoys more stable and formal employment conditions. Smaller fractions of the community are engaged in business (10%), driving autorickshaws (2%), and other unspecified activities (2%), with a minimal percentage (2%) relying on pensions, which may indicate a limited number of elderly or retired individuals. This income distribution provides insights into the socio-economic fabric of the community, suggesting areas where interventions could enhance economic stability and reduce vulnerability, particularly among the majority engaged in daily wage labour.

Figure 7 : Segregation of Primary Source of Household Income (percentage households)

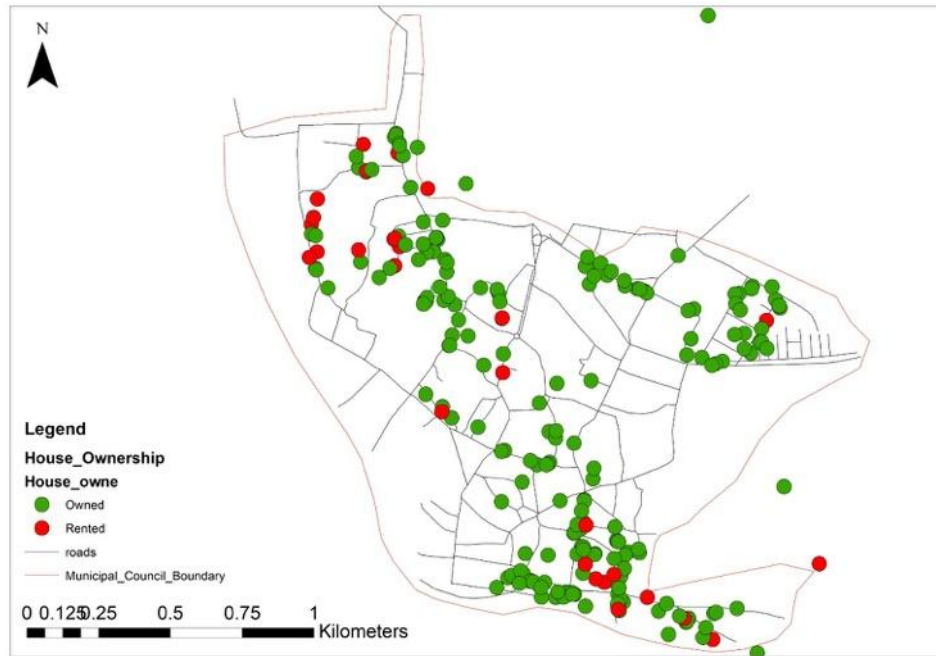
Primary Source of HH Income



Source: Authors' illustration from Primary Survey

- House Ownership:** The figure 8 illustrates the distribution of house ownership status across Alibag, categorizing properties into owned and rented. Most of the dots, marked in green, indicate a predominance of homeowner households, suggesting a stable residential community with a significant investment in property ownership. Red dots represent rented properties, clustered more towards the north western and southern part Alibag and near major roadways, possibly indicating areas with higher residential mobility or a younger demographic that prefers renting.

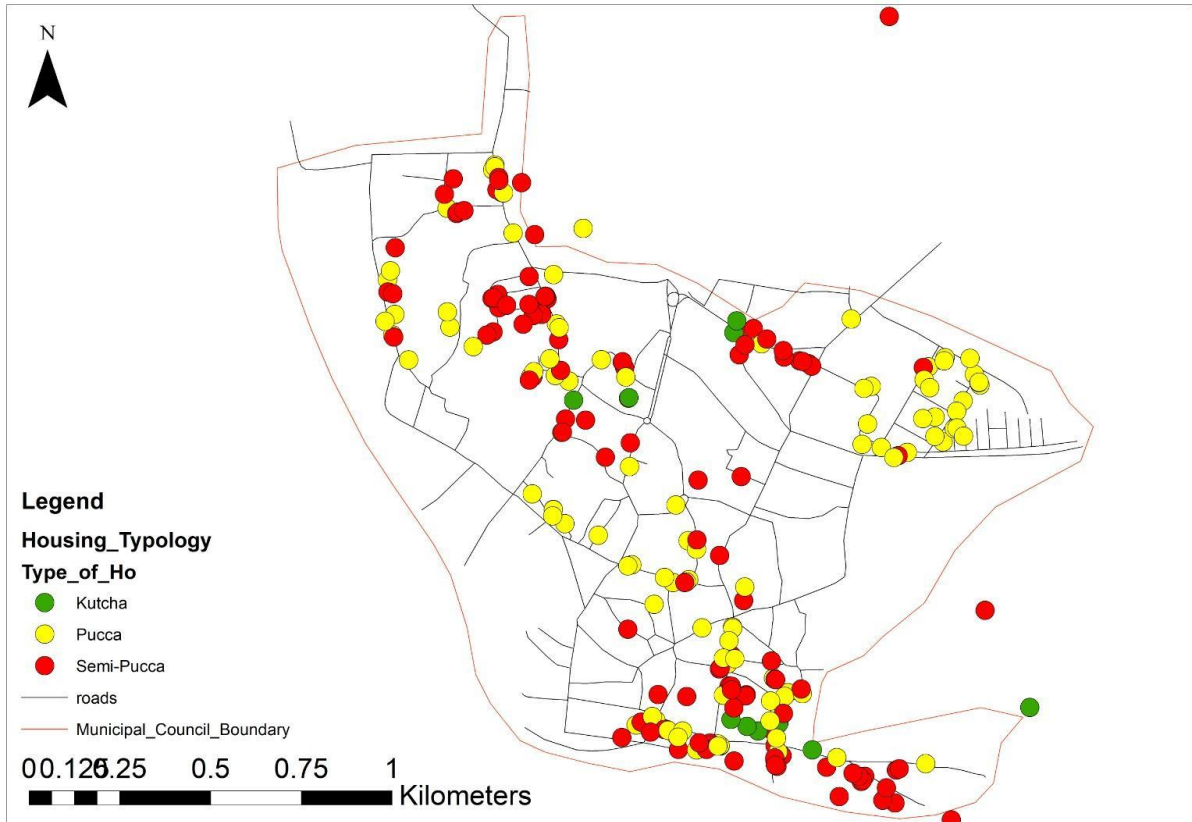
Figure 8 : Home Ownership Distribution in Study Area



Source: Authors' illustration from Primary Survey

- Type of Housing:** The figure 9 delineates the distribution of different housing types in Alibag, categorized as Pucca (permanent), Semi-Pucca (semi-permanent), and Kuccha (temporary) houses.. The dominance of Semi-Pucca houses, marked in red, indicates a transitional housing status where structures may have durable elements but lack complete resilience against environmental factors, reflecting a socio-economic stratum that is above temporary but below fully permanent dwellings. Pucca houses, shown in yellow, signify a concentration of more economically stable households that can afford robust, long-term structures, likely indicative of higher income or prioritization of durable construction in these areas. Kuccha houses, represented in orange, are fewer and suggest pockets of vulnerability where households may face higher risks during environmental adversities, pointing to lower economic stability. **Kutchha houses**, represented in green, are sparsely distributed across Alibag and indicate areas with comparatively lower socio-economic conditions. Constructed using temporary or non-durable materials, these houses are more susceptible to damage from cyclones, heavy rainfall, and flooding, highlighting higher climate vulnerability.

Figure 9: Housing Typology

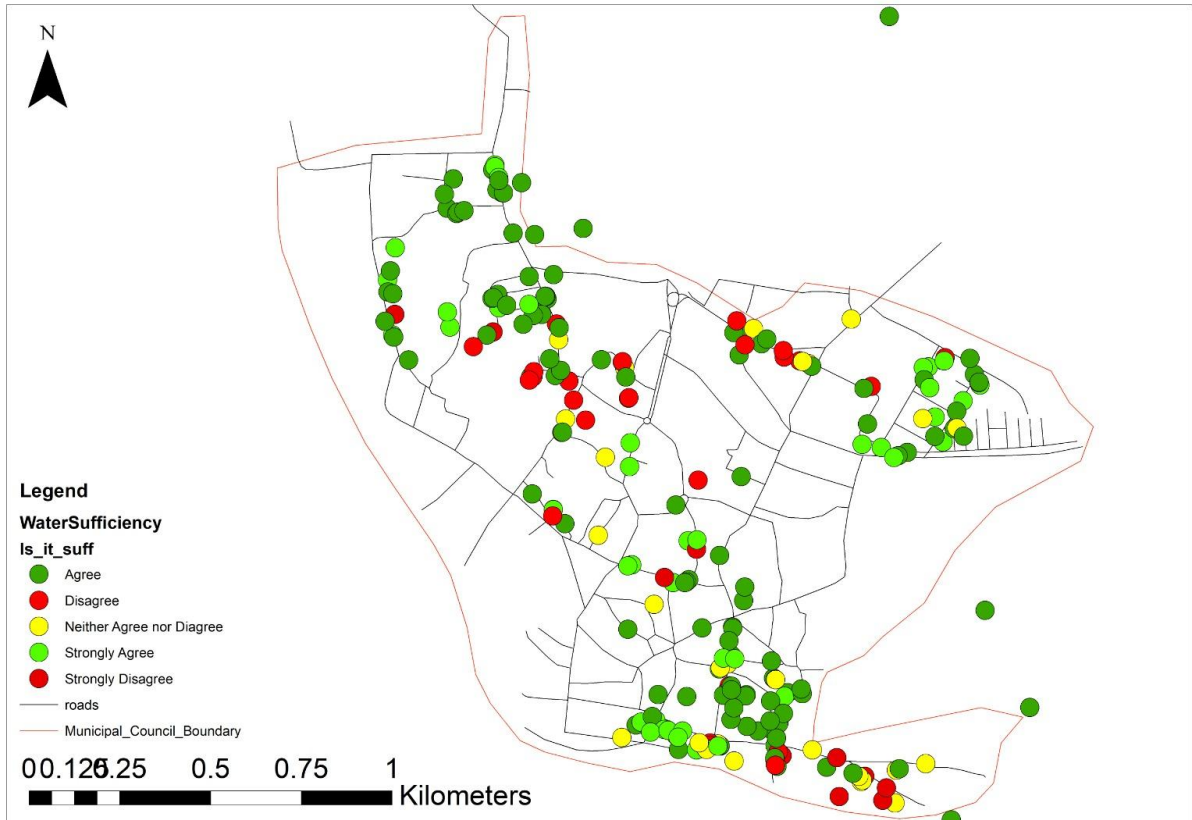


Source: Authors' illustration from Primary Survey

3.3.2 WATER SERVICES LAYER

- **Water Sufficiency:** The map (figure 10) portrays the distribution of household perceptions regarding water sufficiency in Alibag, indicated through the colour green signifying agreement (sufficient water), yellow denotes neutrality, and red represents disagreement (insufficient water). The prevalence of red and yellow dots throughout the town highlights significant disparities in water sufficiency, with these insufficiencies prominently observed in denser and economically disadvantaged areas. This pattern highlights critical issues in water resource management and distribution that aggravates social inequities and points to a need for systemic enhancements in water infrastructure. Conversely, areas with a concentration of green dots, likely more affluent regions, exhibit better water sufficiency, which may reflect disparities in access to water resources and infrastructure resilience.

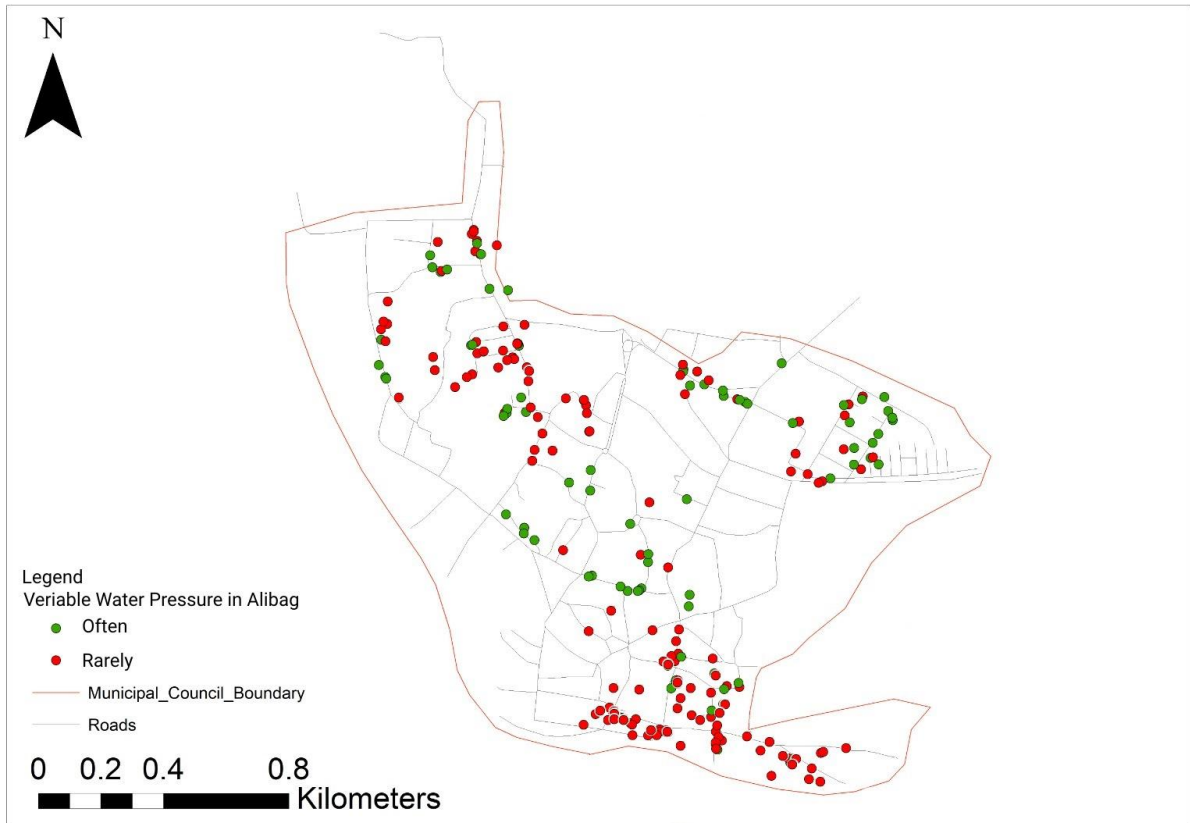
Figure 10. Spatial Distribution of Water Sufficiency amongst the households



Source: Authors' illustration from Primary Survey

- Water Pressure:** The map (figure 11) illustrates the distribution of water pressure variability in households across Alibag, categorized by red dots for areas where residents rarely experience stable water pressure and green dots for areas where stable water pressure is more commonly experienced. The significant concentration of red dots, especially in the northern, central and southern parts of the town, indicates prevalent issues with water pressure, affecting daily life and potentially indicating aging or inadequate water infrastructure. In contrast, the green dots, scattered throughout the town but notably less frequent, suggest pockets of Alibag where the water pressure is relatively reliable, possibly reflecting recent improvements or less demand on the infrastructure in those areas.

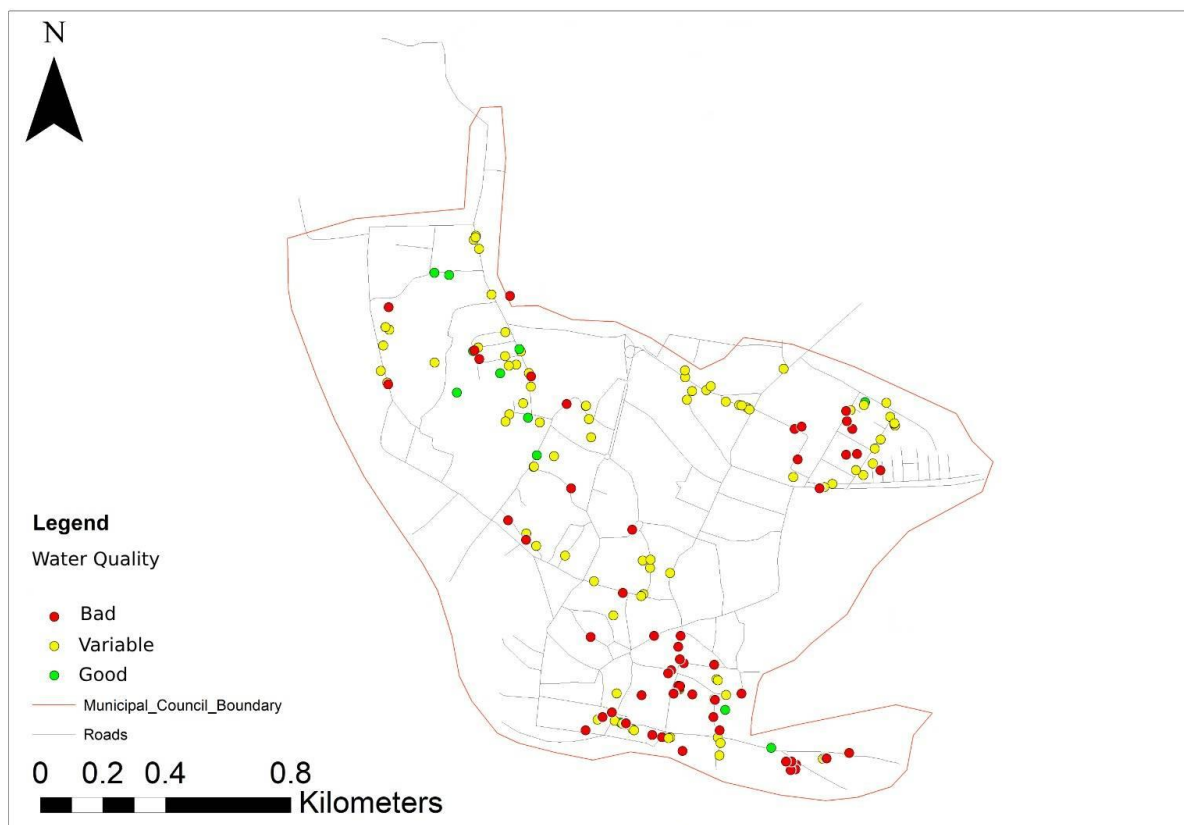
Figure 11: Spatial Distribution of variable Water Pressure amongst the households



Source: Authors' illustration from Primary Survey

- **Water Quality:** The map (figure 12) depicts the distribution of water quality across Alibag, employing a three-variable color-coded system to indicate the varying levels of water quality experienced by residents. Green dots denote areas with consistently good water quality that adheres to safety and health standards, yellow dots represent regions where water quality is variable and sometimes fails to meet these standards, and red dots indicate areas suffering from poor water quality that frequently poses health risks. The concentration of red dots are present in the more densely populated or economically disadvantaged areas. Meanwhile, the green dots, likely more prevalent in affluent neighborhoods or areas with recent infrastructure upgrades, signify regions with better access to high-quality water.

Figure 12: Spatial Distribution of variable Water Quality amongst the households

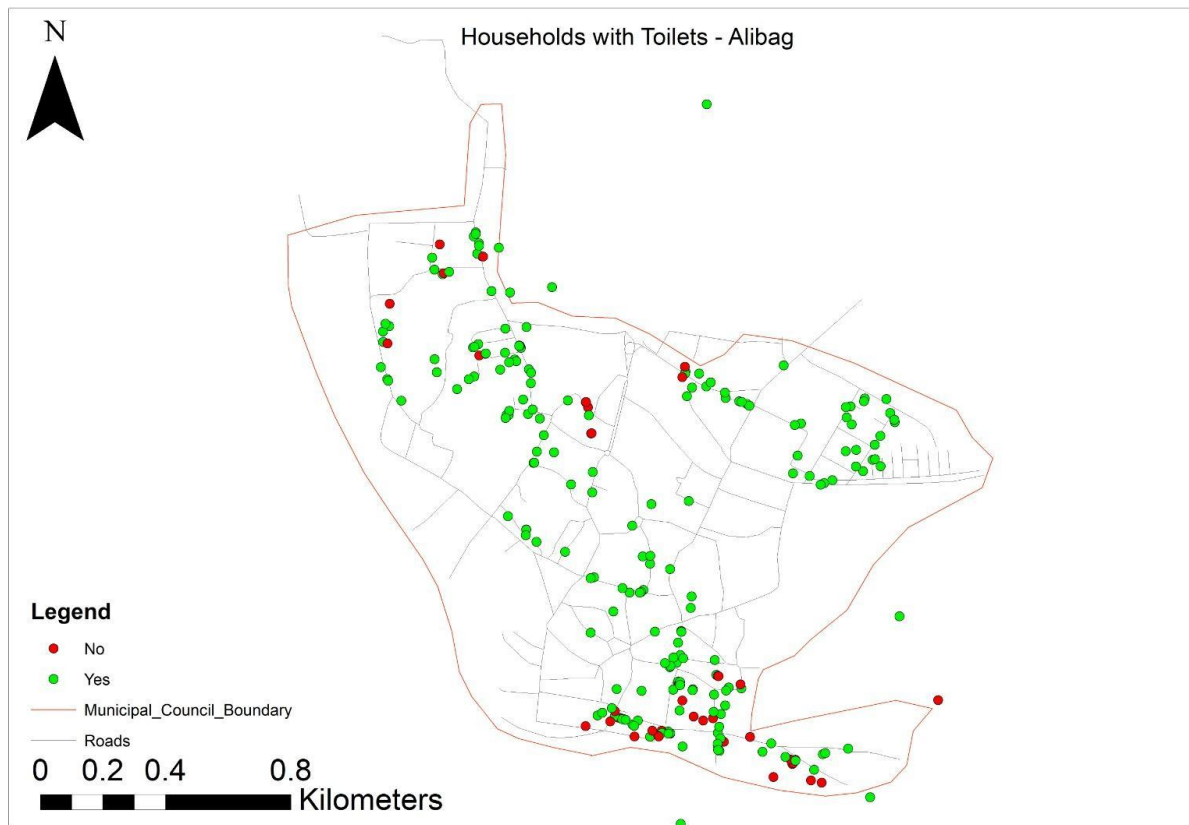


Source: Authors' illustration from Primary Survey

3.3.3 SANITATION LAYER

- Toilet Presence:** The map (figure 13) displays the distribution of households in Alibag with and without toilet facilities, signified by red and green dots, respectively. The presence of red dots indicates a substantial number of households lacking basic sanitation infrastructure, particularly concentrated in densely populated and economically weaker areas like Koliwada. This deficiency highlights significant public health risks, exacerbates social inequities, and suggests systemic neglect in urban planning and resource allocation. The pockets of green dots, primarily located in more affluent areas, reflect better access to sanitation, highlighting disparities in infrastructure development and maintenance.

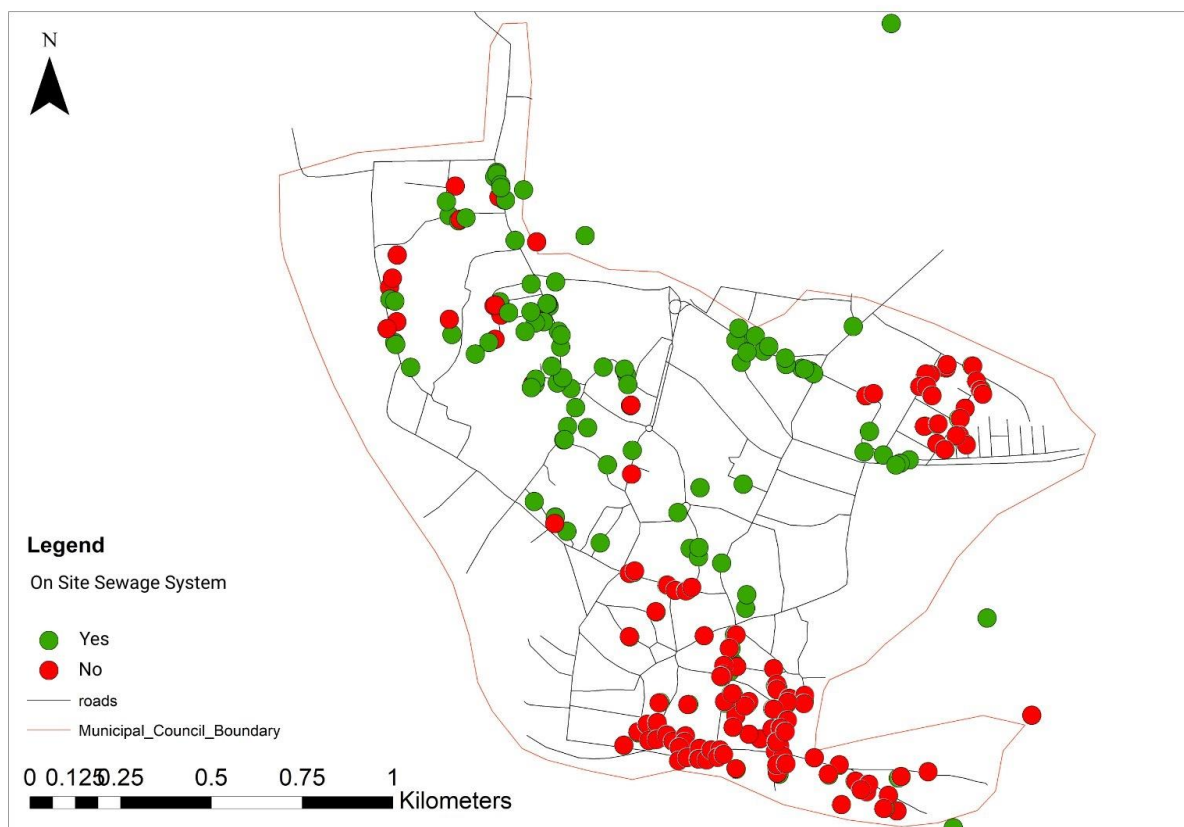
Figure 13: Spatial Distribution of Sample Households with and without Toilets



Source: Authors' illustration from Primary Survey

- On Site Sanitation Systems:** Figure 14 illustrates the spatial distribution of households connected to on-site sanitation systems (OSS) across the sampled areas of Alibag. Households connected to OSS (green) are predominantly concentrated in the central and north-western parts of the town, indicating relatively better sanitation infrastructure. In contrast, households not connected to OSS (red) are clustered mainly in the southern and eastern areas, suggesting spatial disparities in sanitation service provision. These areas may rely on alternative or inadequate sanitation arrangements, increasing the risk of environmental contamination and public health concerns, particularly during periods of heavy rainfall and flooding.

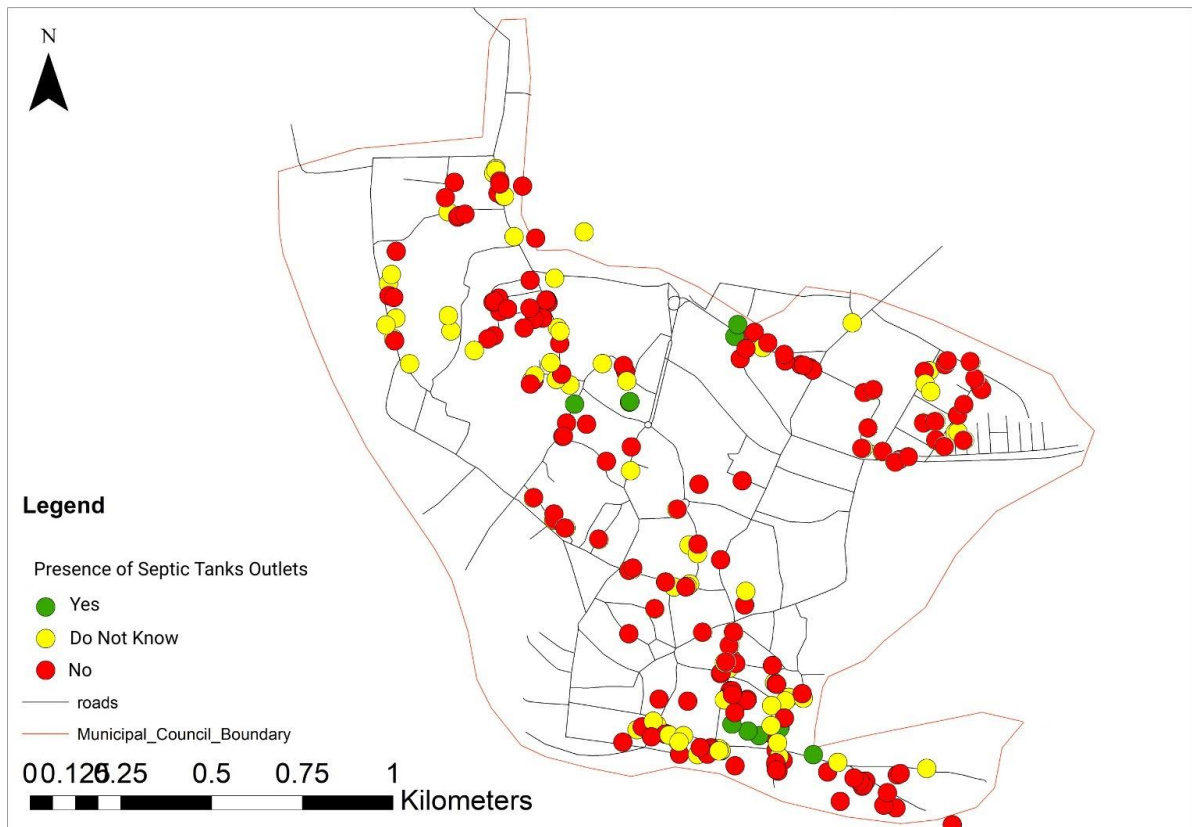
Figure 14: Individual Household Toilets Connected with Onsite Sanitation Systems Across Sample Households in Alibag



Source: Authors' illustration from Primary Survey

- Presence of Septic Tank Outlets:** The distribution of septic tanks with outlet presence in Alibag, as indicated by the map (figure 15), highlights the town's waste management infrastructure. The presence of outlets suggests a significant portion of septic systems are designed to discharge effluent into nearby water bodies or drainage systems, potentially increasing environmental and public health risks. This practice, while initially cost-effective, poses long-term challenges such as water pollution and the spread of waterborne diseases, particularly in densely populated or low-lying areas susceptible to flooding.

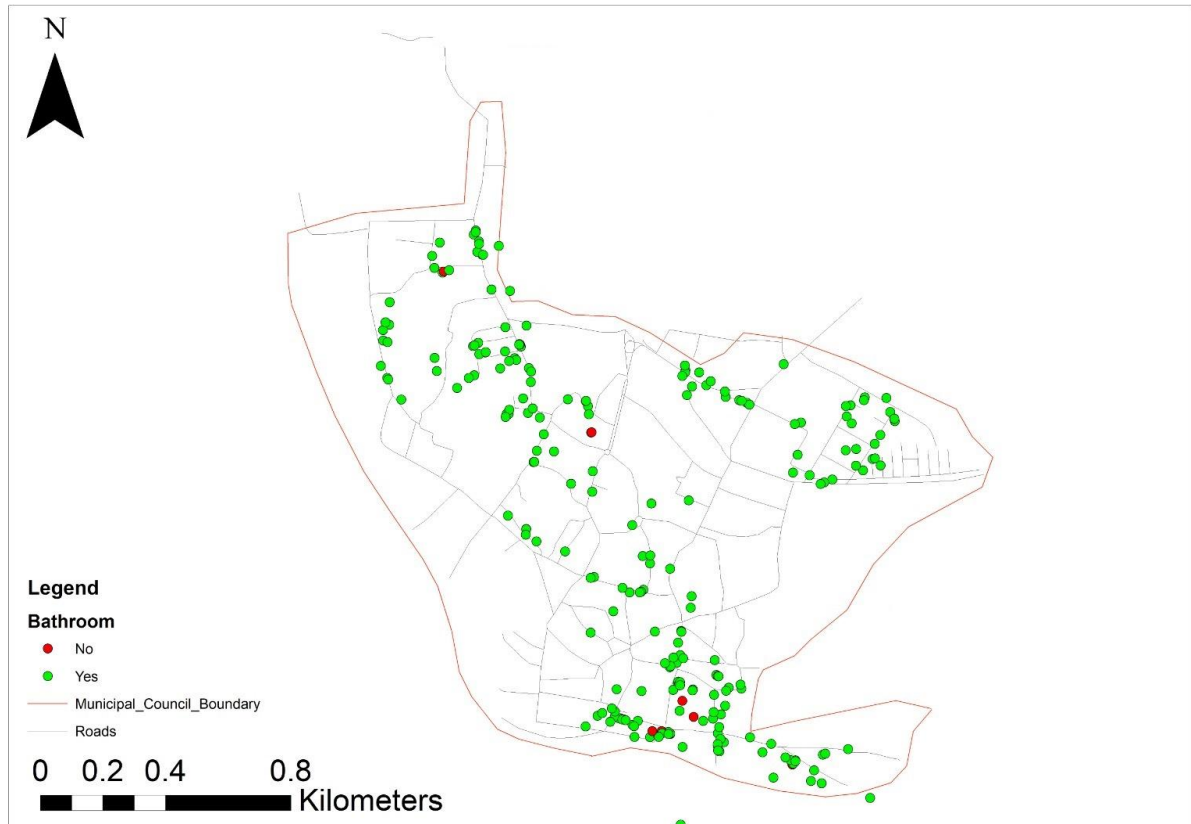
Figure 15 : Onsite Sanitation Systems with Outlets in Sample Households in Alibag



Source: Authors' illustration from Primary Survey

- Presence of Bathroom:** Figure 16 shows that the vast majority of sampled households across Alibag have access to bathrooms (green), indicating high coverage of basic sanitation facilities. Only a small number of households without bathrooms (red) are scattered across the town, with slight clustering in the southern and central areas. Although bathroom access appears to be nearly universal, the absence of these facilities in a few households points to localized sanitation gaps that may affect hygiene, public health, and climate resilience, particularly during extreme weather events. The findings suggest that future interventions should focus on these underserved pockets to achieve universal access to safe sanitation facilities..

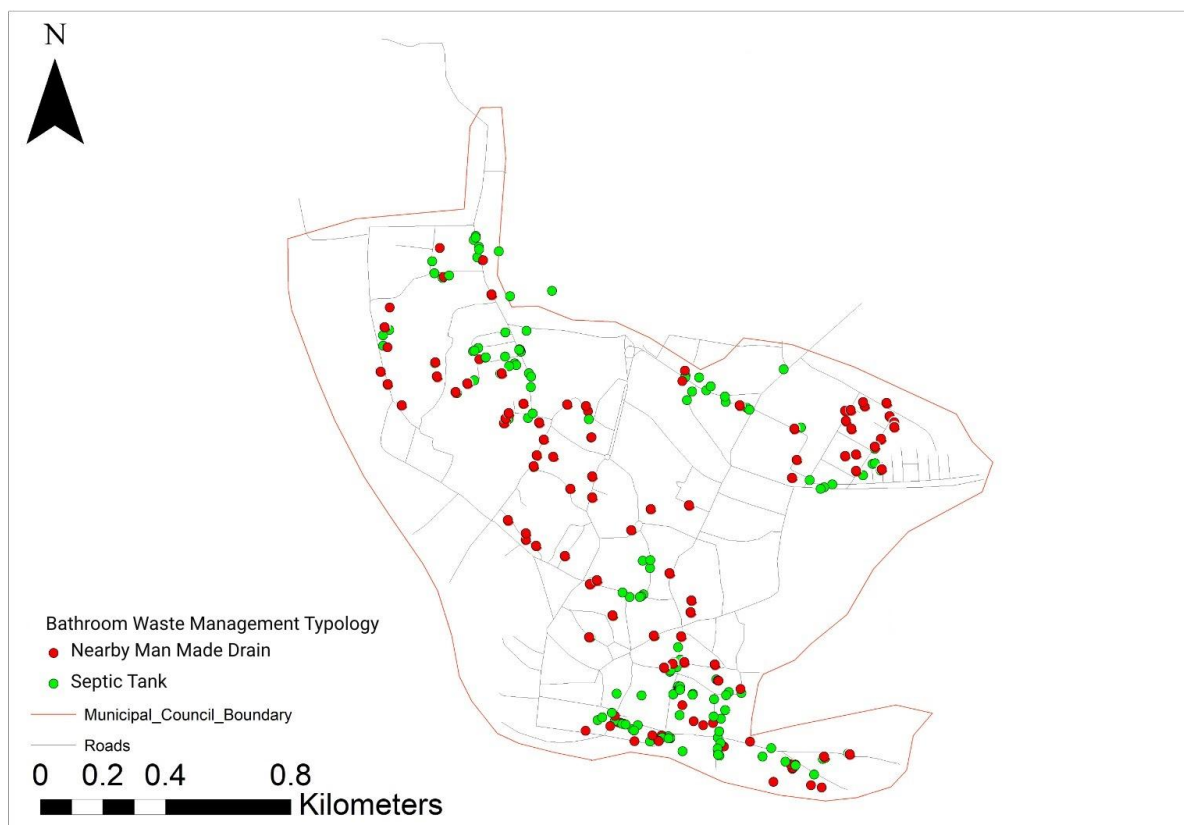
Figure 16: Distribution of Sample Households with Bathrooms



Source: Authors' illustration from Primary Survey

- **Bathroom Wastewater Management:** Predominantly, households, marked in red, using nearby man-made drains for wastewater disposal reflect a reliance on localized and often rudimentary solutions, which may not be uniformly effective across different regions (figure 17). The presence of dedicated pits and direct release onto the land, marked in green, highlights a lack of comprehensive wastewater management systems, potentially leading to severe environmental contamination and public health risks. This fragmented approach to wastewater management indicates systemic infrastructural inequities, where more affluent areas might have better access to man-made drainage systems, while poorer regions resort to environmentally harmful practices due to lack of alternatives.

Figure 17: Bathroom Wastewater Management Typology

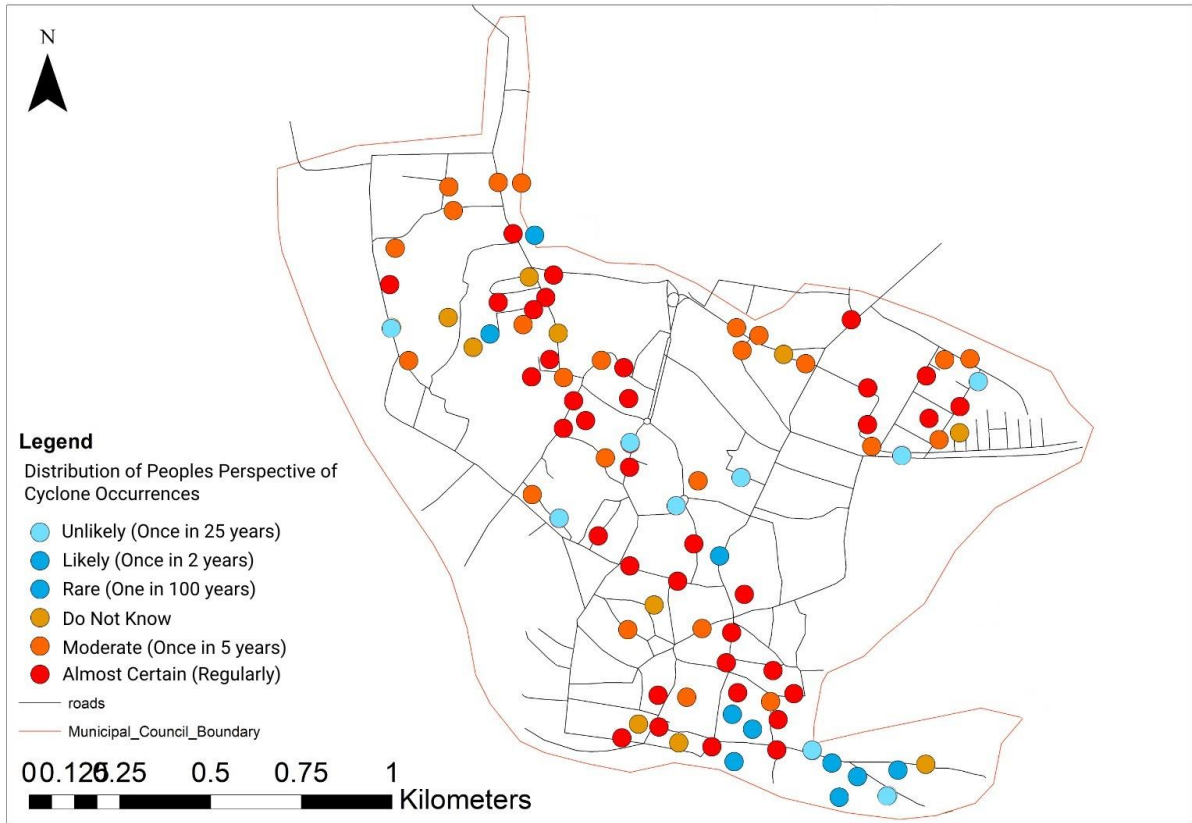


Source: Authors' illustration from Primary Survey

3.3.4 IMPACT OF CYCLONE ON HOUSING, WATER AND SANITATION INFRASTRUCTURE AND SERVICES

- People's Understanding of Cyclone Occurrences:** The spatial distribution of people's understanding of cyclone occurrences in Alibag reveals significant disparities in perception, reflecting varying degrees of awareness and preparedness across different areas. Most respondents in economically affluent areas and regions with higher literacy rates tend to view cyclones as likely (once in 2 years) or almost certain (regularly), indicating a heightened awareness likely influenced by access to information and previous experiences (figure 18). In contrast, less affluent regions and areas with lower educational attainment often perceive cyclones as unlikely (once in 25 years) or rare (once in 100 years), demonstrating a gap in awareness and possibly a lower level of preparedness.

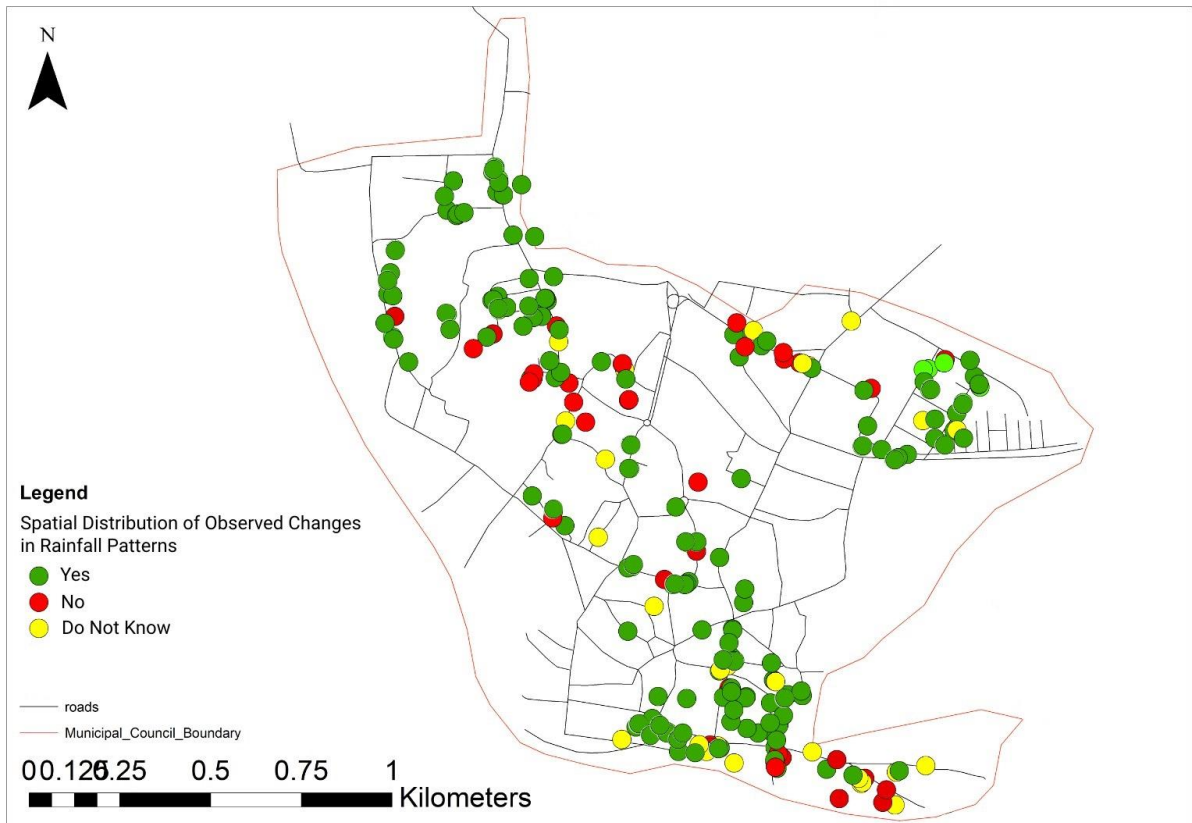
Figure 18: Distribution of Peoples Perspective of Cyclone Occurrences



Source: Authors' illustration from Primary Survey

- Observed Changes in Rainfall Patterns Over the Last 10-15 Years :** The spatial distribution of observed changes in rainfall patterns over the last 10-15 years in Alibag, as analysed from primary data collection, indicates significant variability across different regions (Figure 19). Most residents noted an increase in both the intensity and unpredictability of rainfall, aligning with broader trends observed in the Konkan coast region. Southern areas, reported more severe impacts, including frequent flooding and waterlogging, due to their low-lying topography and inadequate drainage systems. In contrast, northern parts experienced relatively fewer issues, benefiting from better natural drainage and slightly elevated terrain.

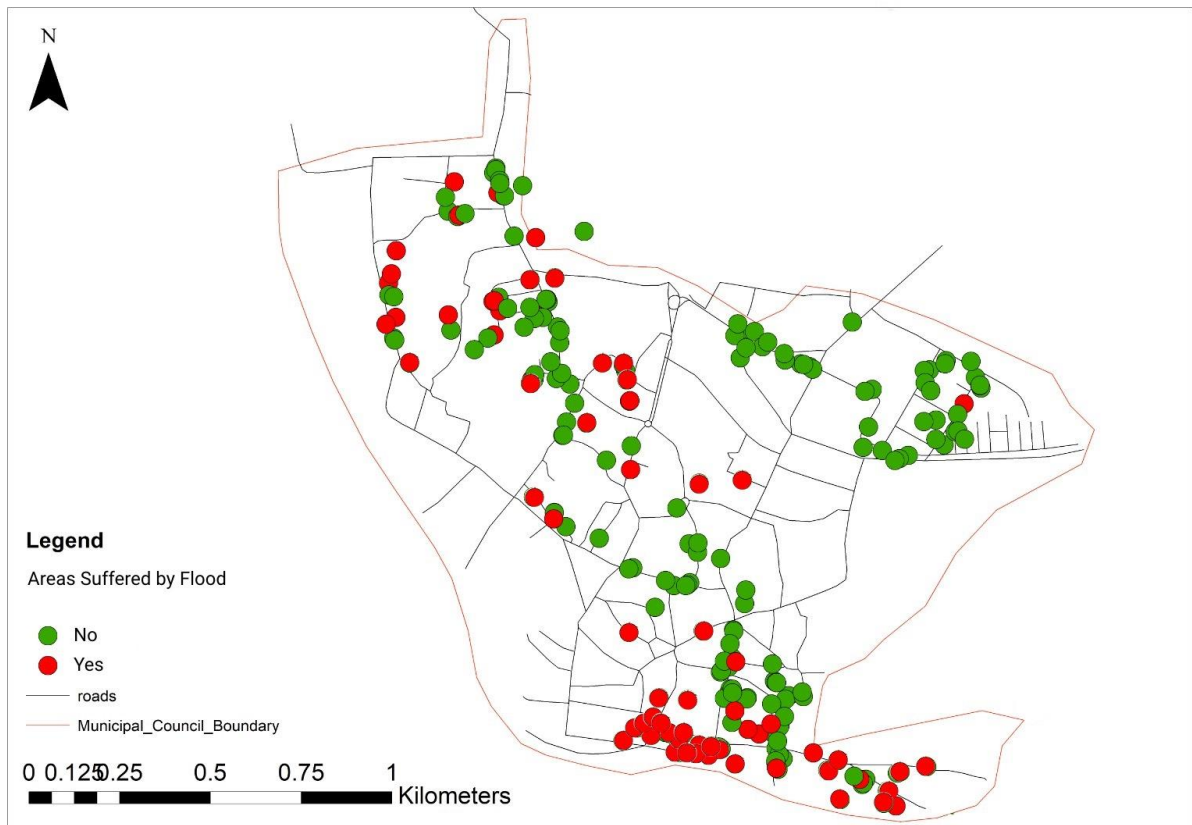
Figure 19: Spatial Distribution of Observed Changes in Rainfall Patterns; Source - Primary Survey



Source: Source: Authors' illustration from Primary Survey

- Flooding:** The map (figure 20) details the spatial distribution of flooding in Alibag. Areas close to the coastline, such as the central and southern parts of Alibag, experienced the most severe flooding due to their proximity to the sea and lower elevation. In contrast, the northern and inland areas, which are situated at a relatively higher elevation and farther from the immediate coastal impact, faced comparatively less severe flooding. These areas primarily experienced strong winds and heavy rains but did not suffer the extensive waterlogging and infrastructural damage seen in the coastal regions.

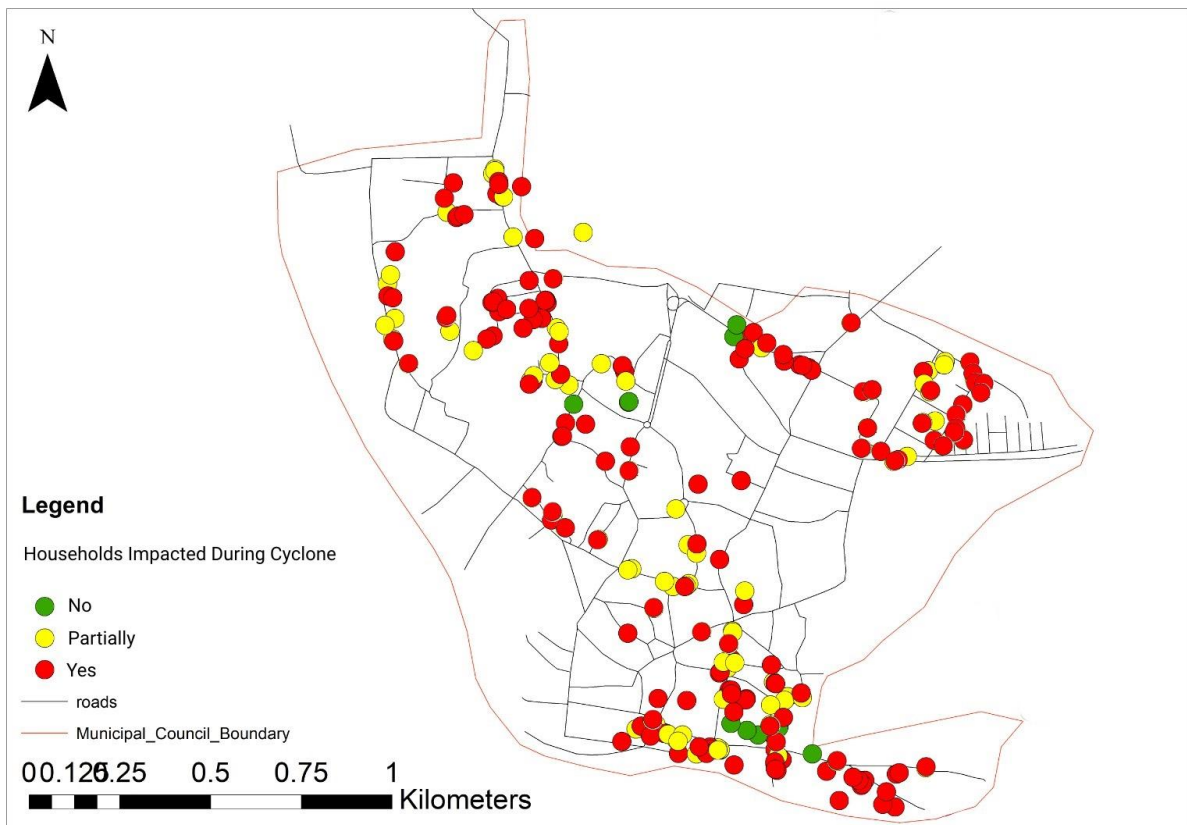
Figure 20: Areas Suffered by Flood



Source: Source: Authors' illustration from Primary Survey

- **Households impacted during the Cyclones 2020, 2021:** The coastal regions and low-lying areas experienced the most severe impact due to their proximity to the sea and lower elevation, making them more susceptible to storm surges and flooding. According to stakeholder meetings held at Alibag, Cyclone Nisarga in 2020 caused substantial damage to homes near the coasts, where high winds and heavy rainfall led to the destruction of roofs and infrastructure. Inland areas and those with better infrastructure and drainage systems, such as the central parts of Alibag town, experienced relatively less damage (figure 21).

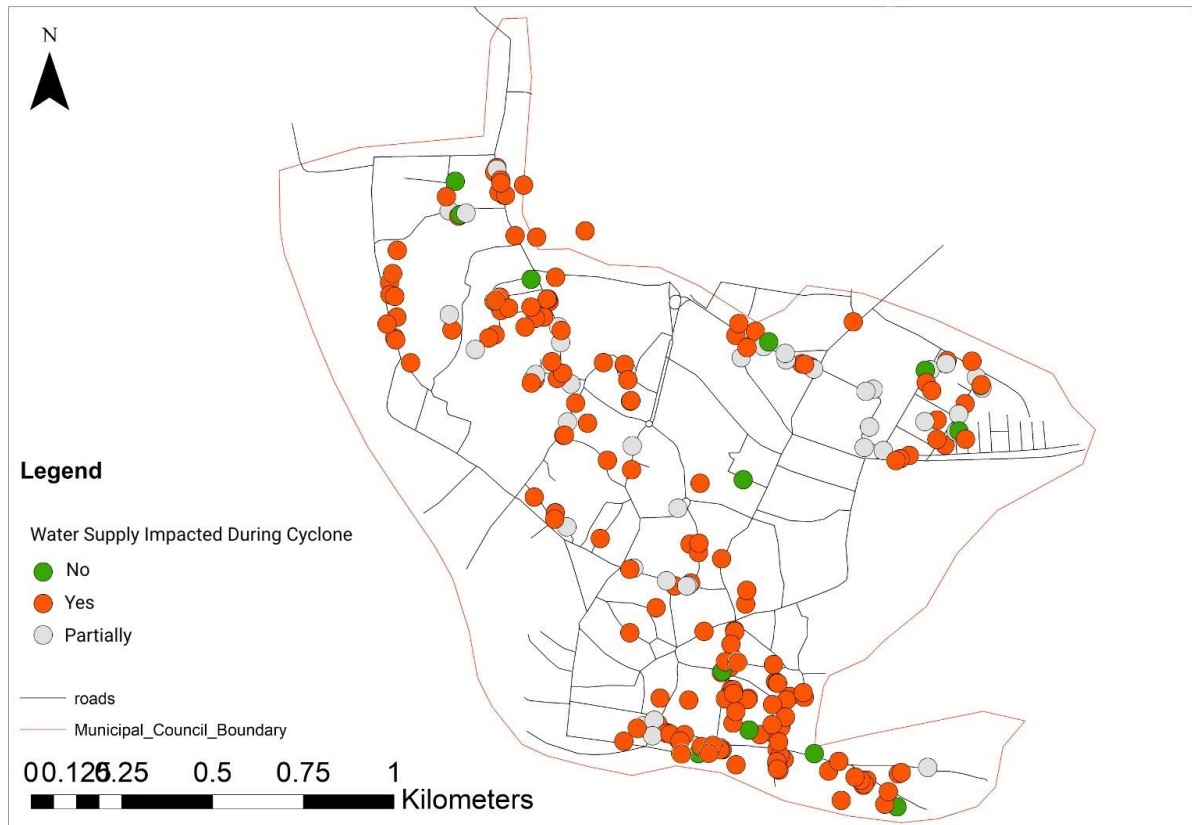
Figure 21: Households Impacted During Cyclone



Source: Source: Authors' illustration from Primary Survey

- Impact on Water Supply During the 2020 and 2021 Cyclones:** The cyclones Nisarga in 2020 and Tauktae in 2021 severely disrupted water supply systems in Alibag, highlighting the vulnerabilities in urban infrastructure amidst extreme weather events. The cyclones caused significant damage to water pipelines and storage facilities, leading to prolonged water shortages for many households. The concentration of septic tanks, soak pits, and varied waste management systems indicate areas of high vulnerability where water infrastructure was particularly compromised (figure 22). The map indicates that a majority of sampled households (orange) experienced disruptions to water supply during cyclones, with affected households distributed across almost all parts of Alibag. A smaller proportion reported partial impacts (grey), while only a few households (green) remained unaffected. This widespread disruption highlights the vulnerability of Alibag's water supply infrastructure to extreme weather events and highlights the need for resilient water distribution systems and disaster preparedness measures.

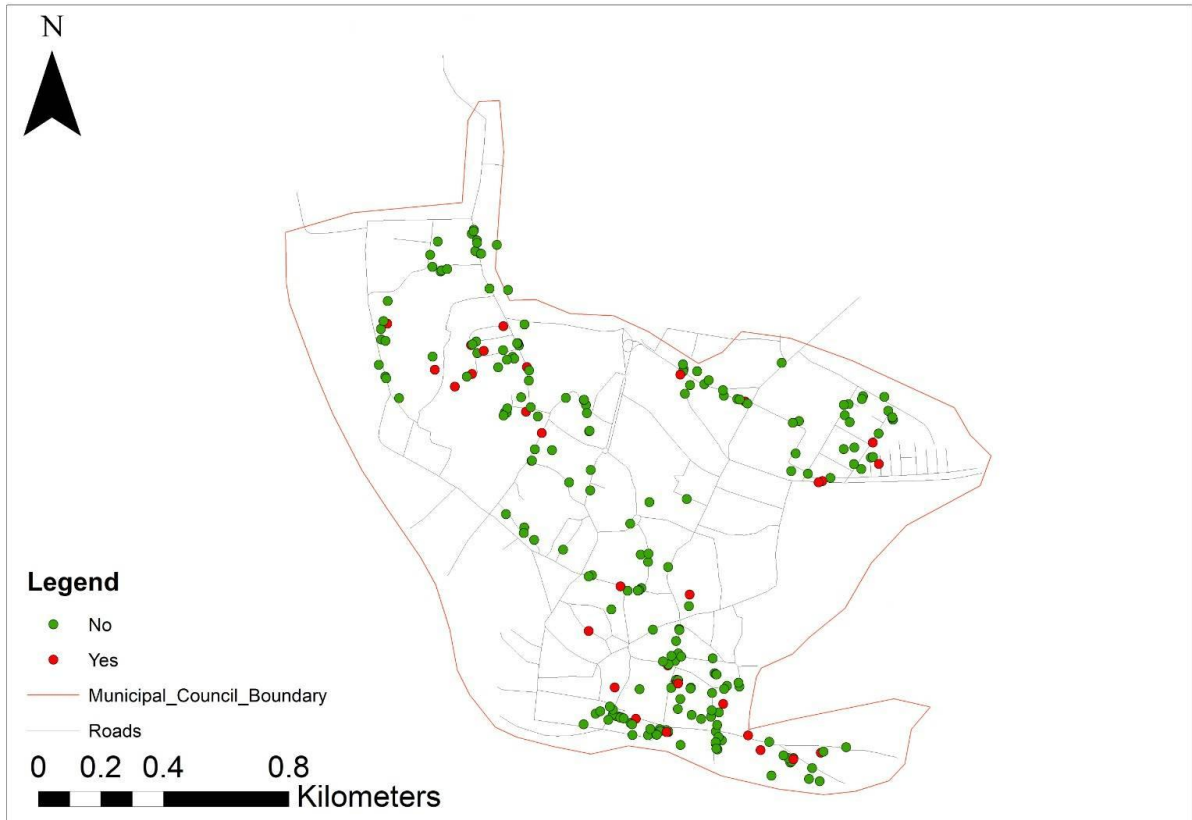
Figure 22: Water Supply Impacted During Cyclones



Source: Authors' illustration from Primary Survey

- **Impact of cyclone on water storage tanks:** This map (figure 23) displays the distribution of overhead water tanks in Alibag that were impacted by cyclones, indicated by red and green dots for affected and unaffected tanks, respectively. The presence of red dots across the town suggests that the cyclonic impacts were widespread, affecting various neighbourhoods irrespective of their socio-economic status. This widespread distribution of red dots states the vulnerability of Alibag's water infrastructure to natural disasters and highlights the need for reinforced resilience measures and maintenance strategies to mitigate such impacts.

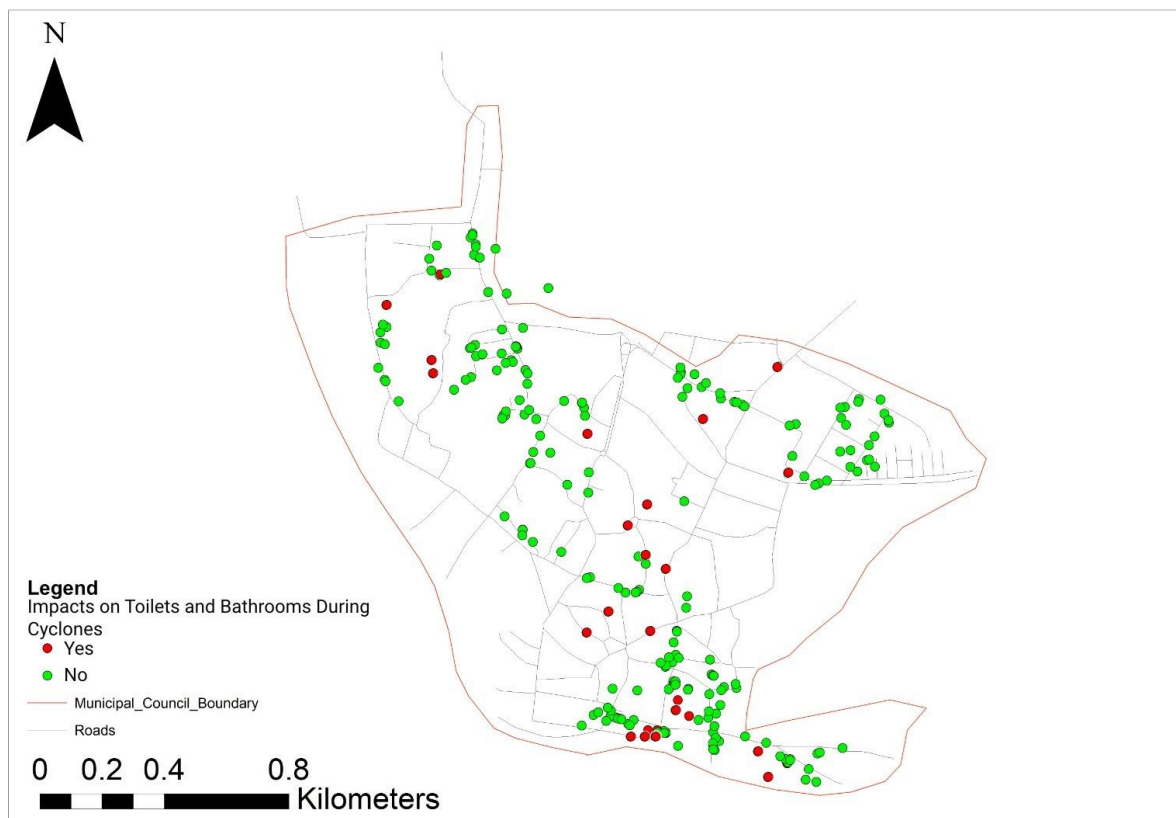
Figure 23. Spatial Distribution of Water Storage Tanks impacted in cyclone



Source: Authors' illustration from Primary Survey

- **Impacts of Cyclone on Toilets and Bathrooms:** The map reveals the spatial impact of cyclones Nisarga (2020) and Tauktae (2021) on household toilets and bathrooms, indicating significant disruption. The inundation from these cyclones led to extensive flooding and damage to septic tanks, soak pits, and waste management systems, particularly in lower-lying and densely populated areas. This disruption caused toilets and bathrooms to become non-functional, creating sanitation crises and increasing health risks. The maps show clusters of affected areas where infrastructure was most vulnerable (Figure 24).

Figure 24: Impacts on Toilets and Bathrooms During Cyclones



Source: Authors' illustration from Primary Survey

3.4 WEIGHTED OVERLAY ANALYSIS : SOCIO-SPATIAL DIMENSION OF CLIMATE RESILIENCE

The layers discussed in the previous sections were integrated using the *Weighted Overlay Analysis* to give the spatial distribution of climate resilience across different regions of Alibag.

This map (figure 25) highlights regions where multiple vulnerabilities intersect. The areas with darker shades represent high-risk zones where inadequate sanitation infrastructure, cyclone impacts, poor wastewater management, and social-economic disparities combine to heighten the risk of public health crises, infrastructure collapse, and environmental degradation. On the other hand, lighter regions indicate better resilience, possibly due to more robust infrastructure, better-managed sanitation systems, and higher socio-economic capacity to adapt to environmental challenges.

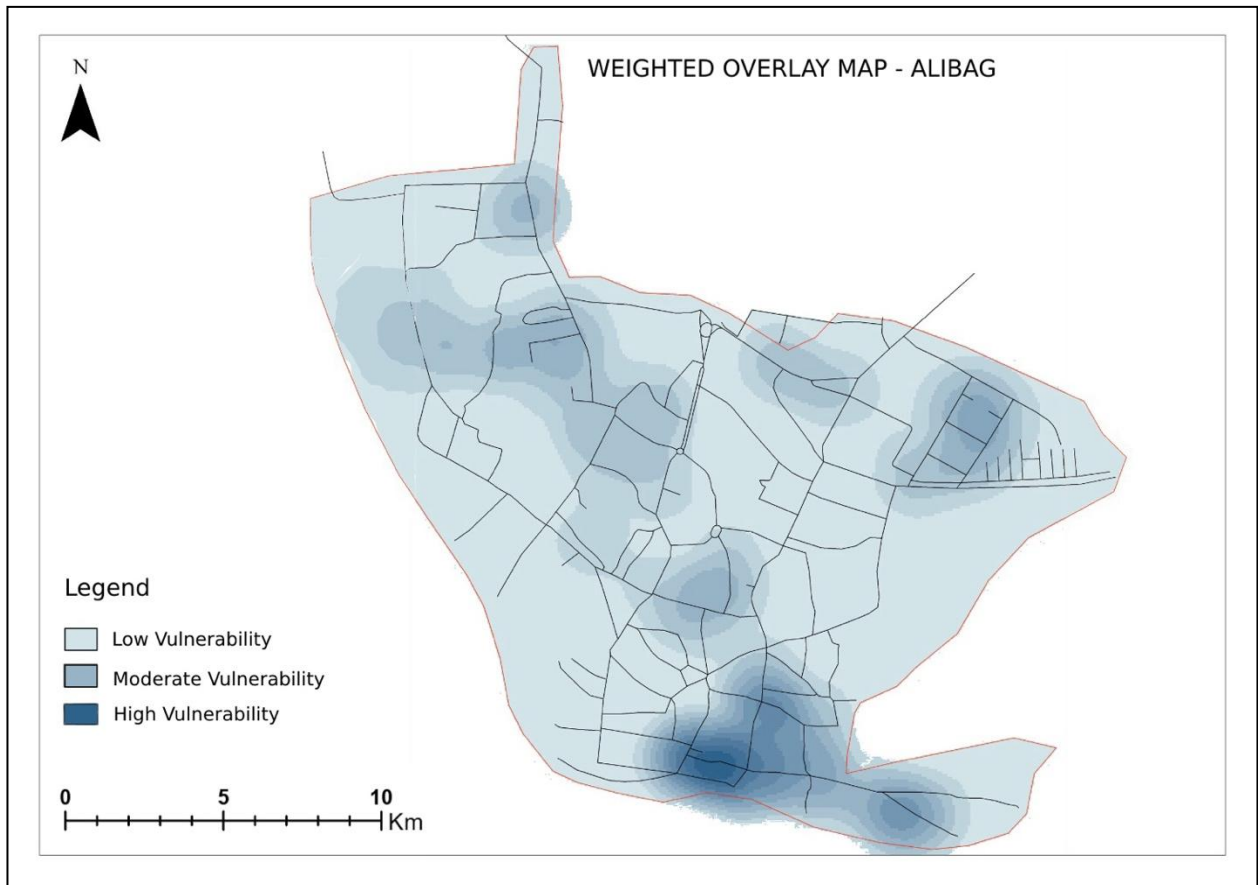
- **Darker Shaded Areas (Higher Vulnerability Zones):** The regions in darker shades correspond to the areas that are most vulnerable due to a combination of factors:
 - *Cyclone Impact (High Weight: 0.25):* These darker areas likely correspond to regions that experienced significant damage during cyclones Nisarga and Tauktae. As we discussed earlier, cyclones caused widespread damage to water supply systems, sanitation infrastructure, and housing in low-lying coastal regions. The darker zones are possibly coastal areas prone to frequent storm surges and infrastructure failure.
 - *Septic Tank Outlets (High Weight: 0.25):* Areas with poorly managed septic tanks and direct outlets into drainage systems are marked as high-risk. The presence of these outlets significantly increases environmental and public health risks, especially during floods or heavy rainfall, when water contamination is likely. These regions also correlate with the spatial distribution of inadequate wastewater management practices that we analyzed previously.

- **Moderately Shaded Areas (Moderate Vulnerability):**
 - *Rainfall Variability (Moderate Weight: 0.15):* These regions likely experience increased rainfall variability, leading to waterlogging and stress on infrastructure. The map reflects the regions where local data showed changes in rainfall patterns over the past decade, contributing to periodic flooding and infrastructure strain.
 - *Wastewater Management and Septic Tank Cleaning (Moderate and Low Weights: 0.15 and 0.10):* Areas with improper wastewater management practices, such as releasing wastewater directly onto the land or into natural drains, are more vulnerable. Regions that have infrequent septic tank cleaning also face heightened sanitation risks, which exacerbates their vulnerability during extreme weather events like cyclones.

- **Lighter Shaded Areas (Lower Vulnerability Zones):**
 - *Housing Typology and Ownership (Moderate and Low Weights: 0.10 and 0.05):* The lighter shaded areas in the map indicate regions where housing is more resilient (e.g., Pucca houses) and where households are more likely to own their property, leading to better infrastructure investments. These areas are less vulnerable as they likely have better access to sanitation, clean water, and more resilient housing that can withstand environmental hazards.

- **Spatial Distribution of Public Awareness and Social Vulnerability (Low Weights: 0.05):**
The socio-economic factors, such as people's understanding of cyclone risks and general socio-economic status, also play a role in the vulnerability of these regions. Areas with lower awareness or lower socio-economic standing might be more vulnerable but contribute a smaller weight in the overall analysis.

Figure 25: Weighted Overlay Map, Highlighting the Spatial Distribution of Vulnerable Locations in Alibag



Source: Authors' illustration from Primary Survey

3.5 CONCLUSION

The chapter discusses the socio-spatial dimensions of climate resilience in Alibag, employing an analytical framework based on the 'Right to the City' to highlight the necessity of equitable access to urban resources for enhancing resilience. It articulates how vulnerabilities are not only a product of social inequalities but are also deeply entrenched in the spatial distribution of populations and their proximity to essential infrastructure. The analysis identifies high-risk areas or "hot spots" characterized by inadequate water and sanitation infrastructure, which predominantly affects marginalized communities in Koliwada area. Insights from a comprehensive household survey highlight the socio-economic disparities that intensify these vulnerabilities, with marginalized groups such as those in Koliwada experiencing greater risks during climate events due to poor infrastructure.

A weighted overlay method in GIS is applied to integrate various socio-environmental criteria and map out the regions within Alibag that exhibit the highest vulnerabilities. The section closes with recommendations aimed at mitigating these vulnerabilities through infrastructure improvements, equitable distribution of resources, and community involvement in planning processes. These recommendations advocate for a participatory approach to urban planning that ensures all community members, especially those from vulnerable groups, have a say in the development and implementation of resilience strategies. This approach not only aims to reduce the immediate impacts of climate events but also strengthens the overall adaptive capacity of urban systems in Alibag.

CHAPTER 4: STATUS AND CHALLENGES OF WATER SUPPLY INFRASTRUCTURE AND SERVICES AT ALIBAG

ABHAY JUNAGHARE & NC NARAYANAN

4.1 BACKGROUND

Five climate-related hazards that may threaten water and sanitation services in small towns of low- and medium-income countries are: floods, droughts, windstorms, storm surges, and sea-level rise (Howard et al., 2021)²⁰. Alibag is experiencing every hazard except drought at different scales. A severe cyclonic storm NISARGA made landfall near the town on 3rd June 2020 (Press Information Bureau, 2020)²¹. Cyclonic wind and rain crippled water and electricity supply for weeks (Primary Survey, 2024)²². Sea level rise induced by global climate change directly threatens the coastal aquifers, leaving them vulnerable to saltwater ingress (Abd-Elaty et al., 2022²³; Cantelon et al., 2022²⁴). Our field survey confirmed the saltwater intrusion in dugwells of Koliwada locality of the city.

Being a coastal city, Alibag attracts plenty of tourists that boosts the economy of the city. The inadvertent increase in floating population places more pressure on the existing city water supply system. Yet, the coastal city is vulnerable to the risks associated with climate variations, especially its WaSH infrastructure is susceptible to climate change (Patil & Deo, 2020²⁵; Sanchez & Govindarajulu, 2023²⁶). Besides having a peculiar geography, Alibag does not have a perennial surface water source. Hence the city is dependent upon the bulk water supply received from MIDC. Thus, Alibag is facing the dual challenge of urban water supply management and water security (Acharya, 2021²⁷; Cook & Bakker, 2012²⁸).

This section on water and sanitation infrastructure in Alibag city delineates the existing status and challenges faced by the city regarding water supply and sanitation. The section discusses the source of water supply to the city and treatment & distribution. The last section deals with the national flagship missions, schemes and guidelines, and financial health of AMC as well as the institutional framework for water and sanitation at different levels within the three-tier governance structure in India.

4.2 WATER SOURCES

AMC, according to the 18 functions from the 12th schedule of the 74th CAA, is the statutory body entrusted with water supply and sanitation services provisioning to the city. The daily bulk water supply received by AMC from MIDC is 6 MLD. The total storage capacity of the city is 1.47 million Liters (Census of India, 2011)²⁹. The current sections discuss the functional

aspects of the water supply system at Alibag, i.e., source for water supply, distribution network, till the confluence of the domestic water to used water.

Alibag town does not have its own surface or groundwater water source. It is dependent on MIDC scheme for the bulk water supply that is originally intended for Rashtriya Chemicals and Fertilizers (RCF) industrial water provisioning. AMC purchases bulk treated water from MIDC that is lifted from River Amba Dam located approximately 53 KM away (Figure 26). Since 1981, AMC has been totally dependent on treated water procured from MIDC.

Figure 26 : Bulk Water Supply to Alibag City



Source: IIT team

4.3 WATER INFRASTRUCTURE

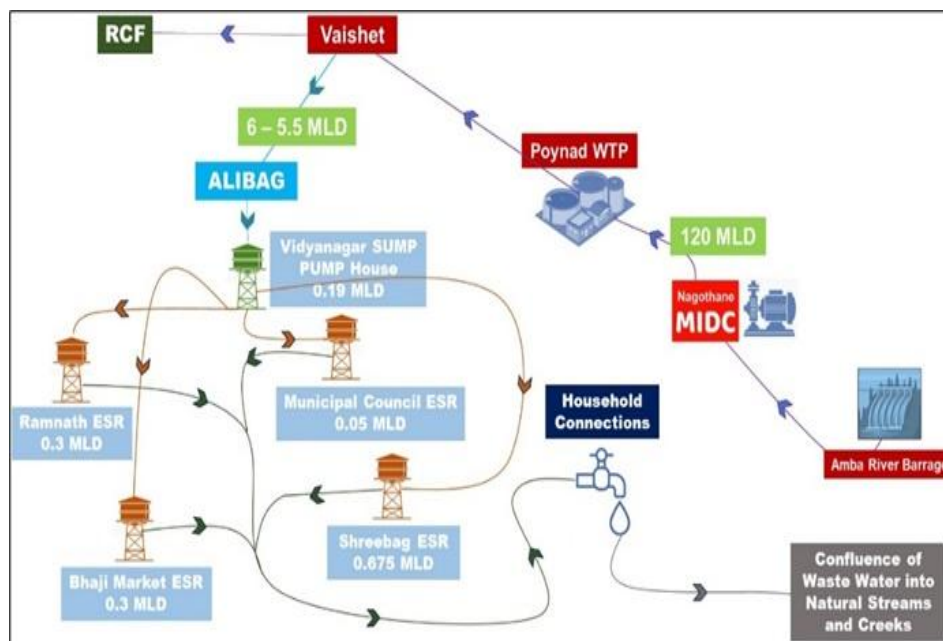
Water Treatment Plant (WTP)

Alibag does not have its own WTP. The raw water is treated at Poynad WTP by MIDC before it reaches the Vidyanagar master balance reservoir (MBR). About 6 MLD treated drinking water reaches different city ESRs and to distribution networks. The water supply department of AMC conducts regular quality checks by randomly taking samples to assess the quality of drinking water supply. Nearly 300 samples are tested annually at a third-party testing laboratory. The quality checks are essential at Alibag due to the susceptible age-old distribution network, where the prevalence of E. Coli must be zero colony forming units (CFU). However, as per the field survey conducted by IITB during December 2023, the city residents are satisfied with the quality of water supplied by the AMC (Figure 18).

Water Supply Network

The total length of the piped distribution network in the city is nearly 26 KM (Primary Survey, 2024). The current distribution system at AMC comprises water gravity mains, MBR at Vidyanagar, 4 elevated storage reservoirs (ESRs), and the distribution tributaries. Around 120 MLD water is supplied to RCF by MIDC, out of which, 6 to 5.5 MLD water is diverted to Alibag city. Four different elevated storage reservoirs cater to six water supply zones in the city. The schematic representation below shows the source to distribution network to the city and besides the elevated storage reservoirs with their water storage capacities (Figure 27).

Figure 27 : Water Distribution at Alibag



Source: Authors' Analysis and illustration

The existing water distribution network in the city is old and fragile and requires a lot of repair and maintenance (based on field observations). AMC has decided to replace this aging distribution network and prepared a detailed project report (DPR), which is yet to be approved by the state urban development department (UDD). The revision in the distribution network is essential especially for the old ESRs and rusty pipelines. A new tender is floated by AMC to build three new ESRs and revamp the existing distribution network.

4.4 WATER DEMAND, SUPPLY AND QUALITY OF SERVICES

Table 2 shows the gaps identified for water supply at AMC. The indicators for per capita city water availability and water access to urban households were found satisfactory as per the data. The coverage gap of -7.50% against the benchmark of 100% suggests that while AMC is close to full coverage, there are still areas without connections. Addressing these remaining gaps could ensure universal access and improve service equity. The data suggests that AMC is delivering more water per person than the standard, which can be beneficial in terms of water availability and customer satisfaction. While the higher per capita supply is positive, it may also indicate inefficiencies in water management or distribution that should be examined to avoid wastage and ensure sustainable use of resources. The metering of connections at AMC is considerably below the benchmark, indicating a significant gap in monitoring and billing accuracy. Effective metering is crucial for managing water resources, billing, and reducing non-revenue water (NRW). As per the data, AMC performs better than both the national average and the benchmark for NRW, with a rate of 13% compared to the 15% benchmark. This indicates that AMC is relatively effective at minimizing water losses. The better performance of the NRW implies a healthy water distribution network. However, AMC has recently floated a tender to revise the existing old distribution network.

There is intermittent water supply at Alibag with an average supply of only 2-hours per day compared to the 24-hour benchmark. This suggests severe issues with water supply reliability and coverage. AMC has continuously monitored and maintained high standards to ensure adequate quality of water supply to safeguard public health and confidence. AMC exceeds the benchmark for redressal of customer complaints, with a rate of 84.44%. This suggests a relatively effective system for addressing issues raised by consumers.

Table 2: Service Level Benchmarks – Water Supply Performance in Alibag Municipality

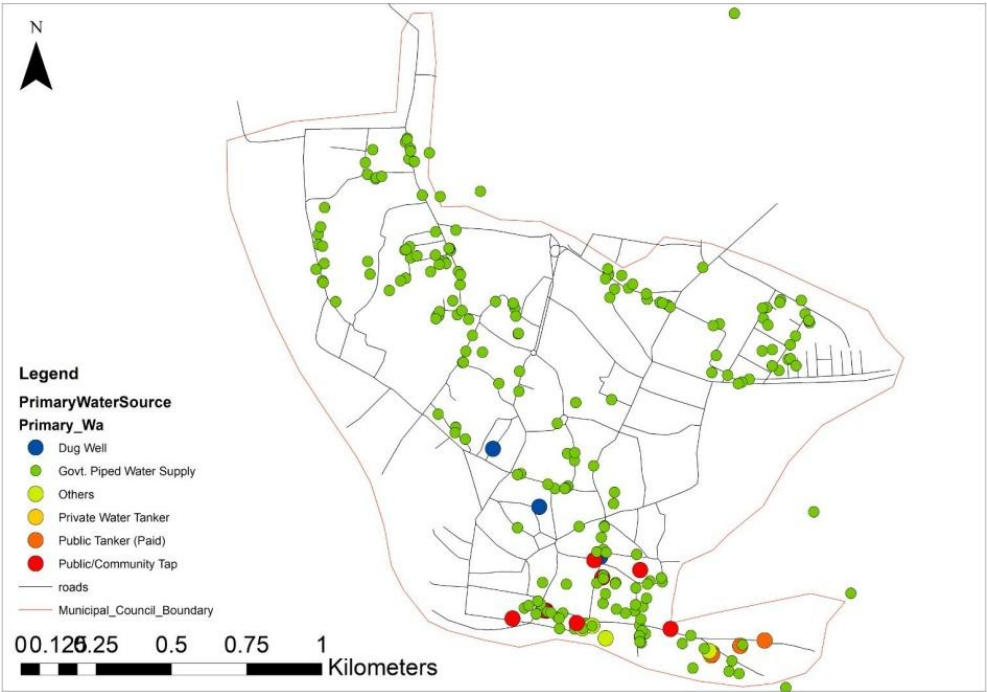
Water Supply Indicators	Benchmark s	India Average*	2023-24**	Gaps at AMC
Coverage Connections (Total no. of HHs with water supply connections)/ (Total no. of HHs in the City)	100%	70.00%	92.50%	-7.50%
Per capita supply (lpcd) (Water supplied)/ (Population served)	135	114	196.0	+61
Metering of connections (No. of metered connections + No. of metered Public Standposts)/ (Total no. of connections + Total no. of Public Standposts)	100%	22.00%	26.22%	-73.78%
Non-revenue water (NRW) (Total water produced) - (Total water sold)/(Total water produced)	15%	31%	13.00%	+2%
Continuity of water supply (hours) Average hours of water supply	24	2.7	2.00	-20
Quality and treatment (Number of samples that meet the specified potable water standards)/ (Total number of complaints received related to water supply)	100%	95%	98.48%	-1.52%
Redressal of customer complaints (Total number of complaints redressed)/ (Total number of complaints received related to water supply)	80%	89%	84.44%	+4.44%
Cost recovery (Total annual operating revenues)/ (Total annual operating expenses)	100%	72%	41.87%	-58.13%
Efficiency in collection charges (Current revenues collected in the given year)/ (Total operating revenues billed during the given year)	90%	60%	36.29%	-53.71%

Source: *CPHEEO Guidelines for 24x7 WSS (Drink from Tap), Dec 2021; **Alibag Municipal Council, 2023-24, Acquired on: 05/08/2024

However, our primary household survey (December 2023) reveals a different picture, with many respondents, particularly from low-income households, reporting issues with both water supply and quality.

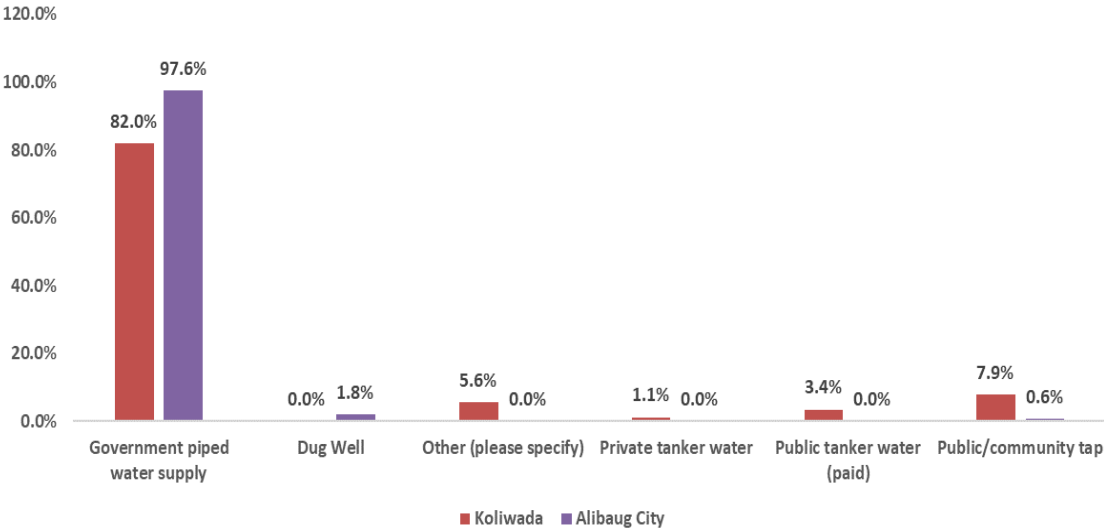
Figure 28 and figure 29 illustrates the distribution of primary drinking water sources in Alibag, predominantly showing a reliance on government piped water, marked in red. Other sources, including public/community taps, paid public tanker water, dug wells, and private tanker water, are represented in much smaller numbers, indicating that these are supplementary or alternative sources used in specific areas where perhaps piped water is less accessible or reliable. As most of the residents in Koliwada have low socio-economic status, nearly 8% households are dependent upon public or community water sources (shown in Figure 29).

Figure 28 : Primary Sources of Drinking Water in Different Parts of Alibag: Socio- spatial Variation



Source: Primary Survey, 2024

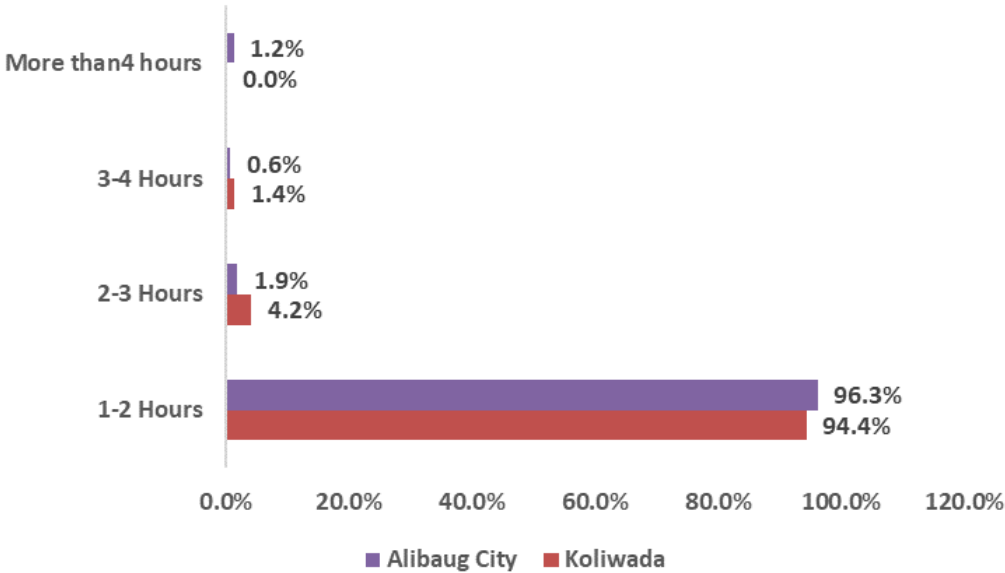
Figure 29: Primary source of water supply in Sample Households



Source: Primary Survey, 2024

In terms of per capita water supply, municipal data indicates an average supply of 200 lpcd, but household survey and interviews with officials reveal that actual supply falls short, with some areas receiving insufficient water. The city is reported to receive a daily water supply of two hours. However, primary survey highlights **disparities in service duration** (Figure 30). Most sampled households receive only 1-2 hours of water supply per day, with this being more common in the core city than in the poor socio-economic neighbourhood like Koliwada.

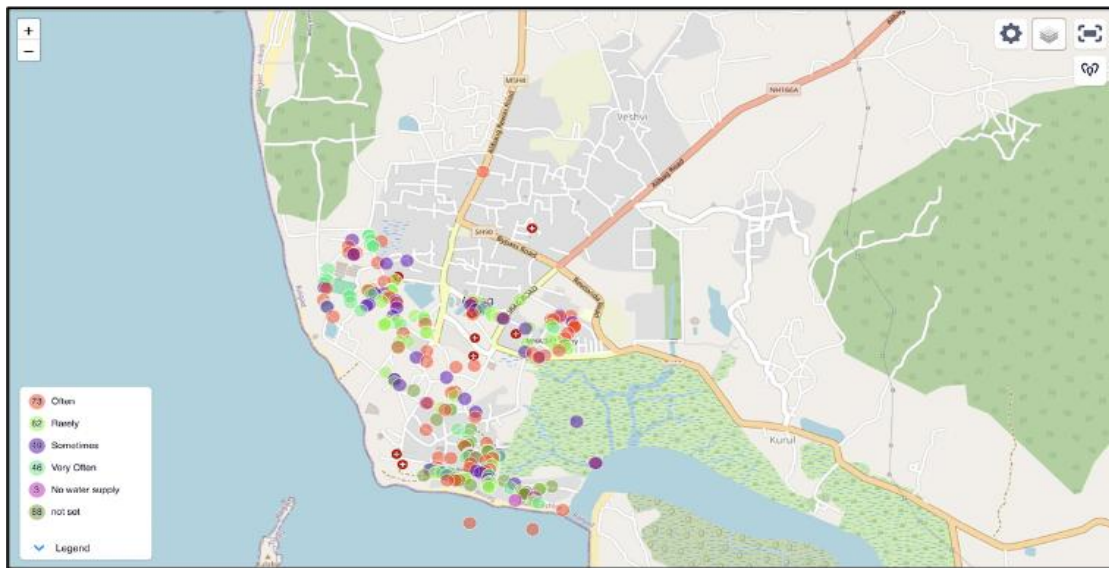
Figure 30: No of hours per day Municipal Water Supply in Sample Households



Source: Primary Survey, 2024

The Figure 31 further provides insights on water supply pressure variability across Alibag, categorized by frequency descriptors such as 'Often', 'Very Often', 'Sometimes', 'Rarely', and areas with 'No water supply'. A significant portion of the area, marked by purple dots indicating 'Often,' suggests stable water pressure, which is crucial for consistent service. In contrast, areas marked 'Rarely' (green) or 'Sometimes' (blue) face lower pressure, possibly due to distribution issues or higher elevations. Red dots indicate areas with 'No water supply,' highlighting severe infrastructural deficiencies.

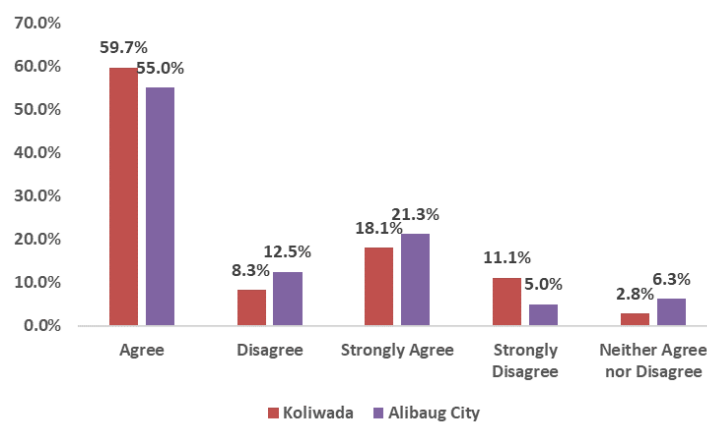
Figure 31 : Variable Water Pressure in Alibag



Source: Primary Survey, 2024

When asked about whether the daily water supply fulfils their needs, nearly 20% people from both the zones were not satisfied (Figure 32).

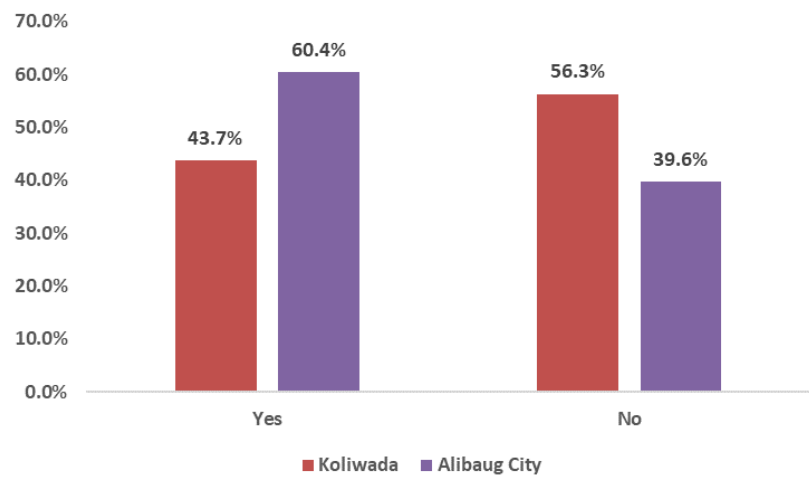
Figure 32: Municipal Water Supply Sufficiency for Daily Water Needs in Sample Households



Source: Primary Survey, 2024

The poor quality of water services and low-pressure forcing residents, to rely on electric pumps, which is leading to increase in energy bills and indirect GHG emissions. Figure 33 indicates percentage of sample households having to rely upon water pumps for meeting their daily water needs.

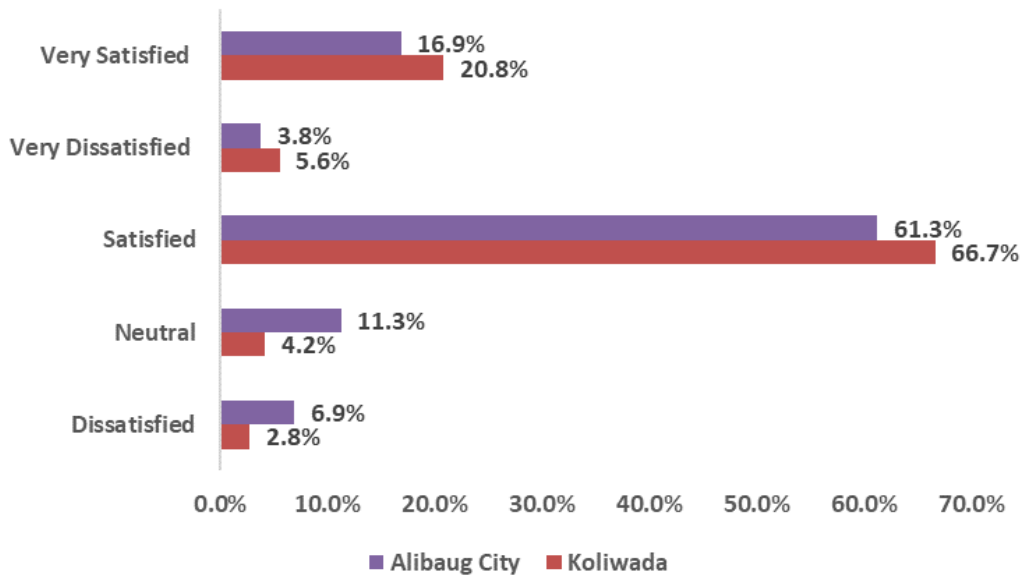
Figure 33: Water pump/motor in Sample Households



Source: Primary Survey, 2024

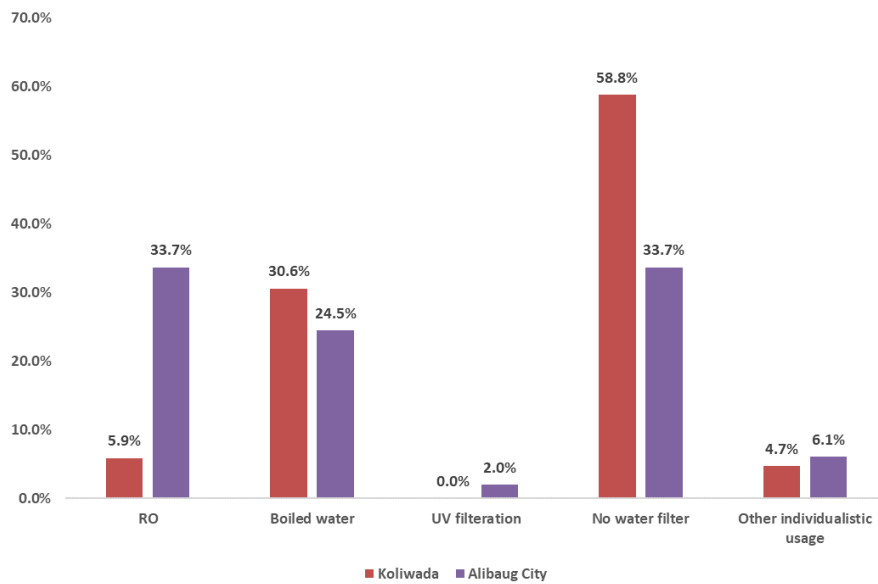
Even though most of the respondents seemed satisfied for the quality of municipal water supplied (Figure 34), majority of them have employed several water purification and disinfection mechanism in their homes, as shown in Figure 35. **It is significant to note that nearly 60% residents from the Koliwada zone do not use any water filtration techniques and the remaining usually boil water before consumption. More than 30% HHs from the Alibag city area are dependent upon the reverse osmosis (RO) type water filter, which again adds to the energy consumption and indirect GHG emissions from water systems at household level.**

Figure 34: Quality of Municipal Water Supply at Sample Households



Source: Primary Survey, 2024

Figure 35: Water purification/disinfection systems in sample households



Source: Primary Survey, 2024

Metering and Billing

AMC reports that household water meter coverage is only 25%, far below the SLB target of 100% (Figure 36). Achieving full metering would allow AMC to implement a volumetric tariff system and better audit water supply. Interviews revealed that most households are billed based on a flat tariff linked to pipe diameter, rather than actual usage. AMC's efficiency in collecting user charges is low compared to the national average. The city has different tariff rates for commercial and residential properties, with higher recovery from commercial users³⁰. However, the low metering rate significantly impacts billing and payment collection, affecting AMC's ability to pay for bulk water from MIDC.

Figure 36 : Extent of Metering in Alibag

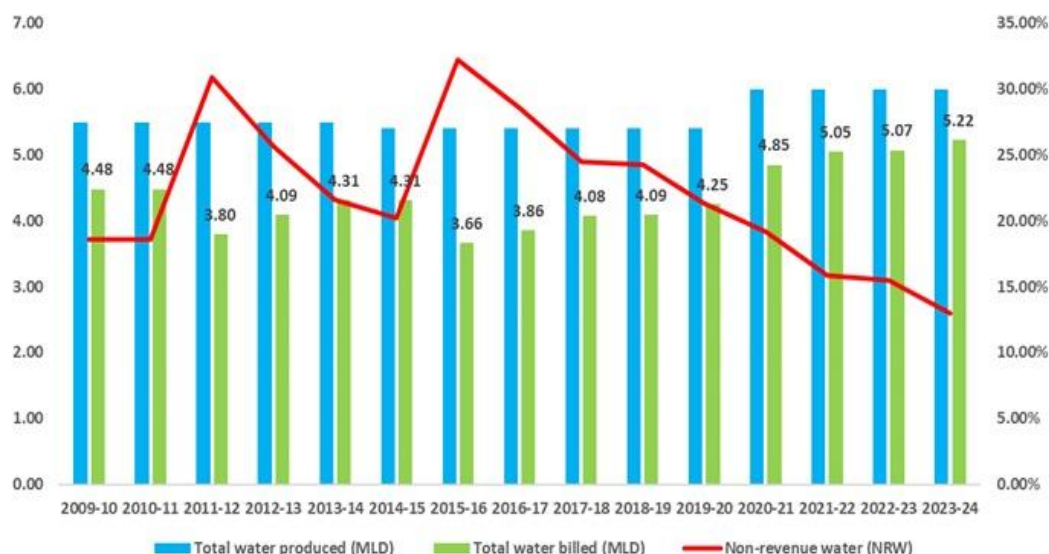


Source: AMC Datasets- Acquired on: 04/08/2024

Non-Revenue Water (NRW)

There has been a significant reduction in the NRW in the city over the years through efficient maintenance of the distribution network (figure 37). However, the reasons for reduction in NRW were not satisfactorily explained by the municipal officials, as they claim that the existing distribution system is old and torn. However, **the NRW is nearly 13% during 2023-24, which is well below the targets advised by the SLBs. High NRW results in both physical and financial losses for municipalities. It also increases water demand, which in turn raises energy consumption and contributes to indirect greenhouse gas (GHG) emissions.**

Figure 37 : NRW at Alibag



Source: AMC Datasets- Acquired on: 04/08/2024

4.5 KEY CHALLENGES

The city's water supply infrastructure is confronted with multiple, interconnected challenges. Water is supplied intermittently, forcing households to depend heavily on individual storage facilities, which creates inequities in access and increases public health risks. The system is also highly dependent on distant bulk water sources, making it vulnerable to disruptions during extreme weather events and disasters. Much of the infrastructure, i.e., pipelines, pumping stations, and distribution networks is aging and in need of repair or replacement, which contributes to frequent leakages, service interruptions, and losses.

Moreover, water distribution across the city is unequal, with low-income neighbourhoods, particularly those located in vulnerable coastal areas, receiving less reliable service compared to wealthier sections of the city. During climate change-induced disasters such as cyclones, storm surges, and flooding, these inequities are magnified. Individual household storage systems in poorer settlements are often damaged or contaminated, leaving communities with limited or unsafe water access at the very moment when demand for clean water is most urgent.

This combination of infrastructural deficiencies, unequal access, and climate vulnerability underscores the urgent need for climate-resilient water supply planning, investment in infrastructure upgrades, and targeted measures to protect the most at-risk communities.

CHAPTER 5: URBAN SANITATION SYSTEMS IN ALIBAG: STATUS, INSTITUTIONS AND CHALLENGES

NEELAM RANA, ABHAY JUNAGHARE & NC NARAYANAN

5.1 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, A. , 2018³¹ ; Yenneti, K., et.al. 2016³²; CPCB,2021³³). *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, M. A., et.al. 2013)³⁴. WaSH services are essential for preventing disease outbreaks, particularly in the aftermath of climate hazards such as heavy rainfall and flooding (Carlton, E.J., et. al. , 2014³⁵ ; Jones, N., et. al., 2020³⁶). 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 scenario* (Cutter, S., et.al., 2012³⁷). 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 (Caretta, M.A., et.al., 2022³⁸).

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'³⁹. 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 **Swachh Bharat Mission (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.

5.2 SANITATION SERVICE CHAIN

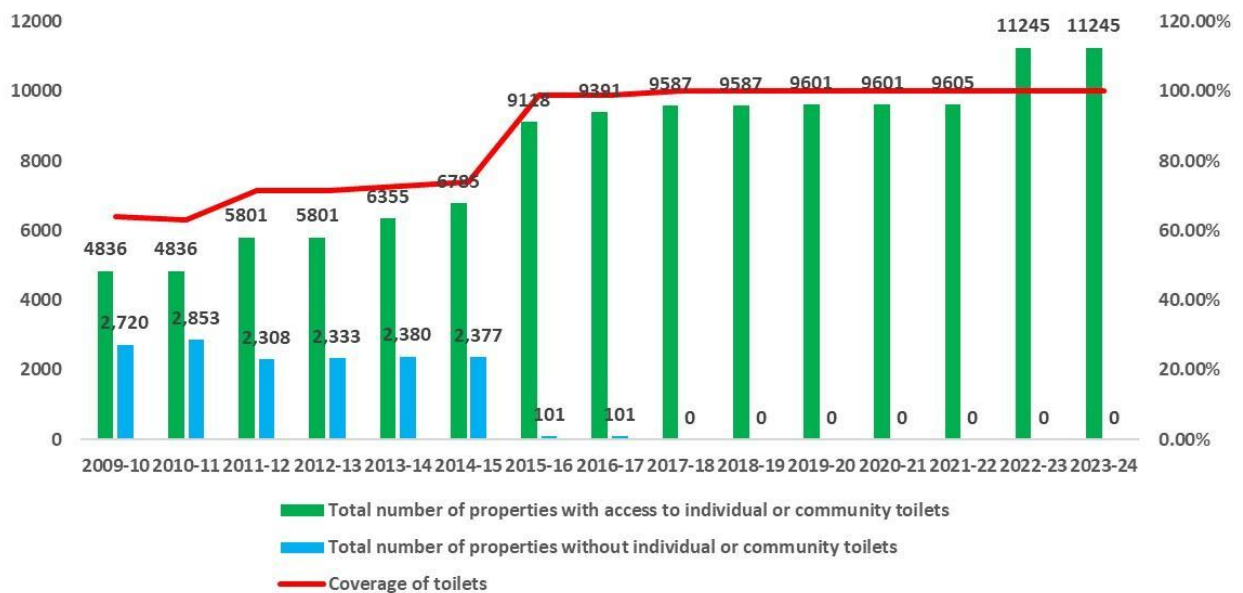
Human waste must be safely managed throughout the entire sanitation service chain, which may have different stages, including capture, containment, emptying, transport, treatment, and disposal or end use (UNICEF, 2020)⁴⁰ Refer **figure 42**.

- **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:** AMC reported 100% toilet coverage as of 2023–24 (figure 38) .However, the household survey revealed that 18% of households do not have individual household latrines (IHHL).Among these, 15% of households rely on

community or public toilets, while 4% continue to practice open defecation (figure 39). Limited water supply to IHHL further contributes to the persistence of open defecation.

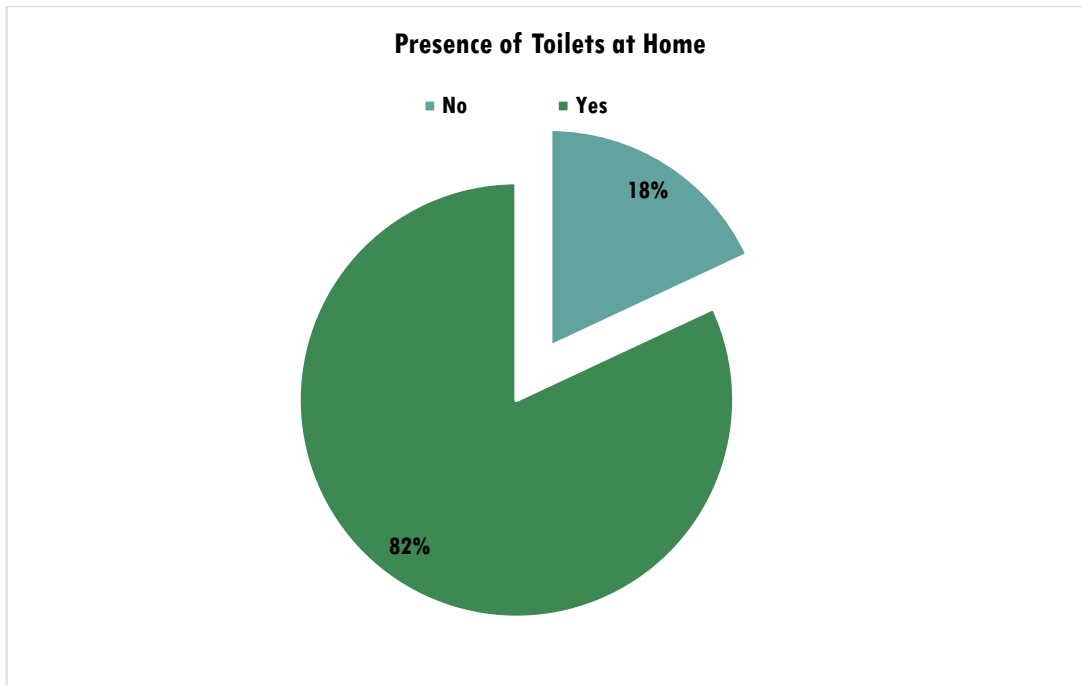
- **Community and Public Toilets:** The city has 23 community and public toilets that primarily serve the floating population and low-income settlements such as Koliwada.

Figure 38 : Toilet Coverage in Alibag



Source: AMC data

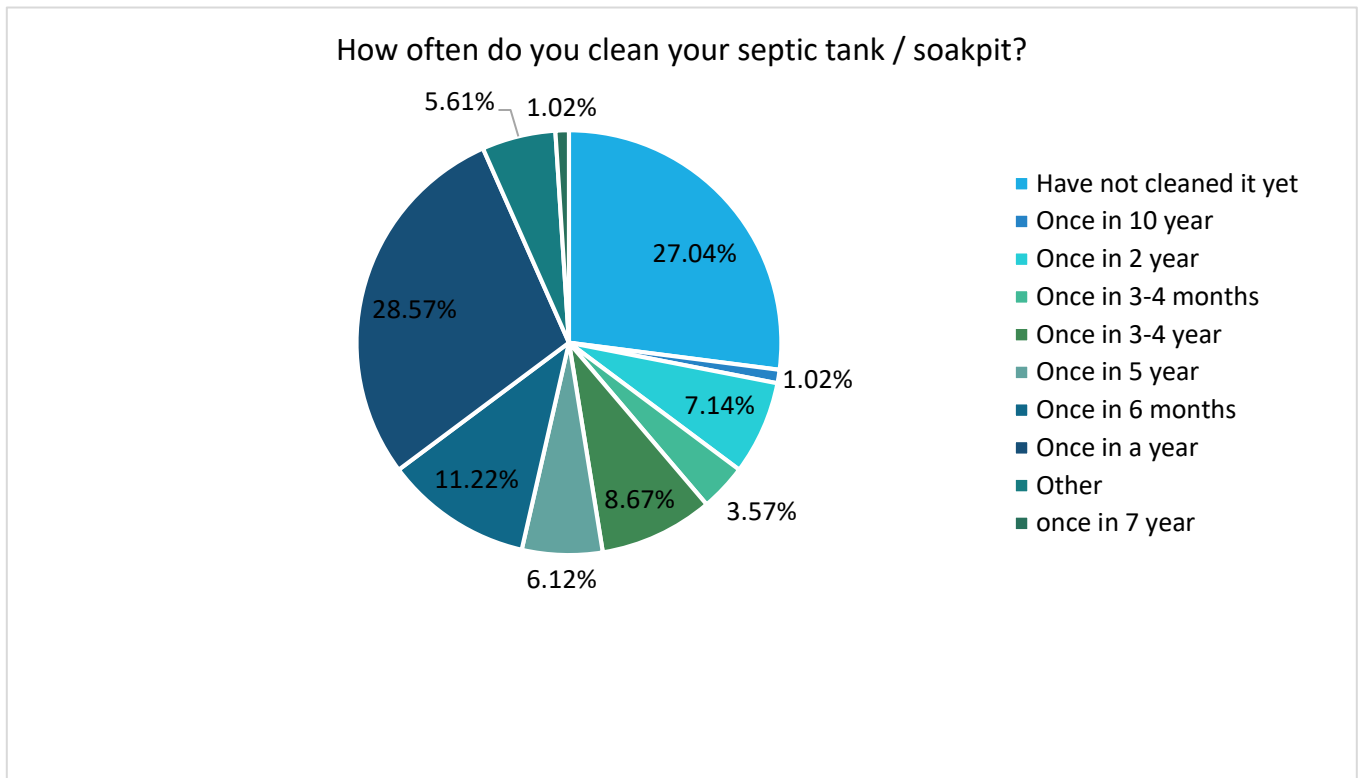
Figure 39 : Toilet Coverage in Sample Households in Sample Households



Source: Data from Primary Sample Household Survey

- **Containment:** Approximately 95.6% of sampled households use septic tanks as their primary on-site sanitation system. The remaining households depend on soak pits, open or closed drains, or direct disposal of excreta into the ground or water bodies.
- **Emptying and Transport:** The town doesn't have sewerage network system. Approximately 95.6% of sampled households use septic tanks as their primary on-site sanitation system. The emptying and transport of fecal sludge are carried out mainly by private sludge vacuum trucks⁴¹. The household survey revealed that a significant proportion of households do not follow regular desludging practices, with 30% reporting that their septic tanks have either never been emptied or are cleaned only once every 7–10 years (figure 40). This irregular maintenance of septic tanks increases the risk of groundwater contamination, poses serious public health threats, and contributes to higher GHG emissions.

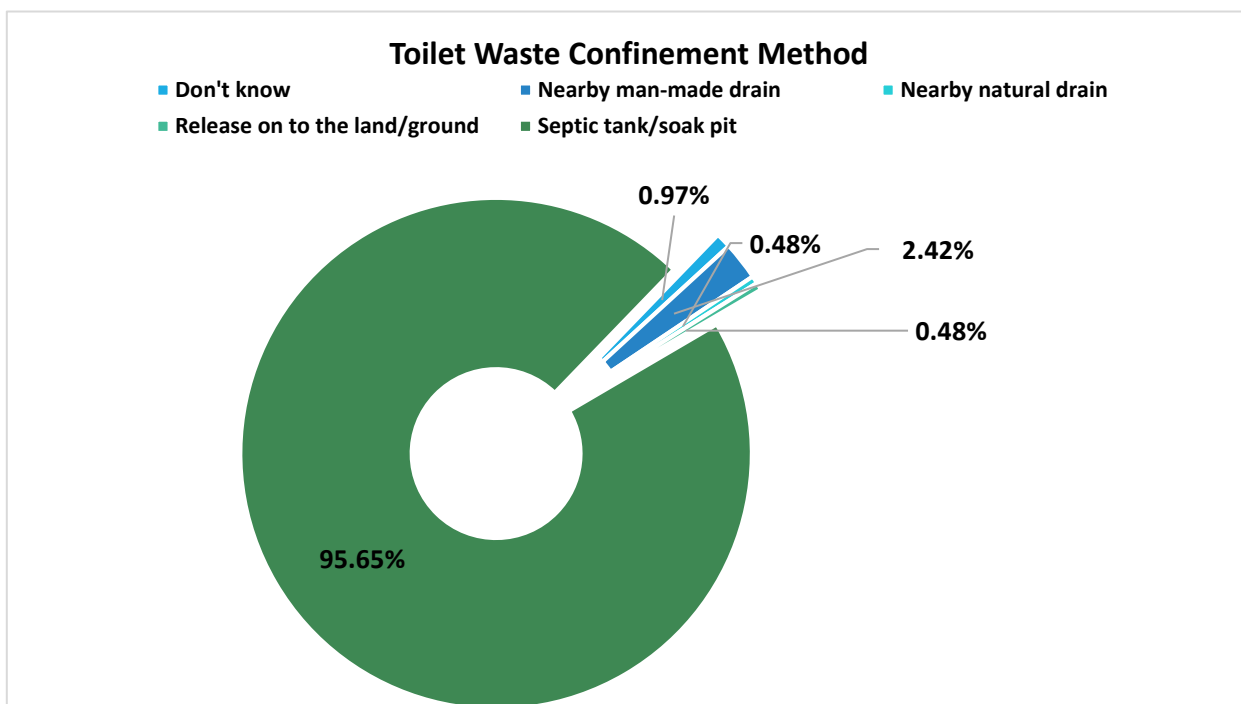
Figure 40 : Cleaning Frequency of On-site Sanitation Systems in Sample Households



Source: Data from Primary Sample Household Survey

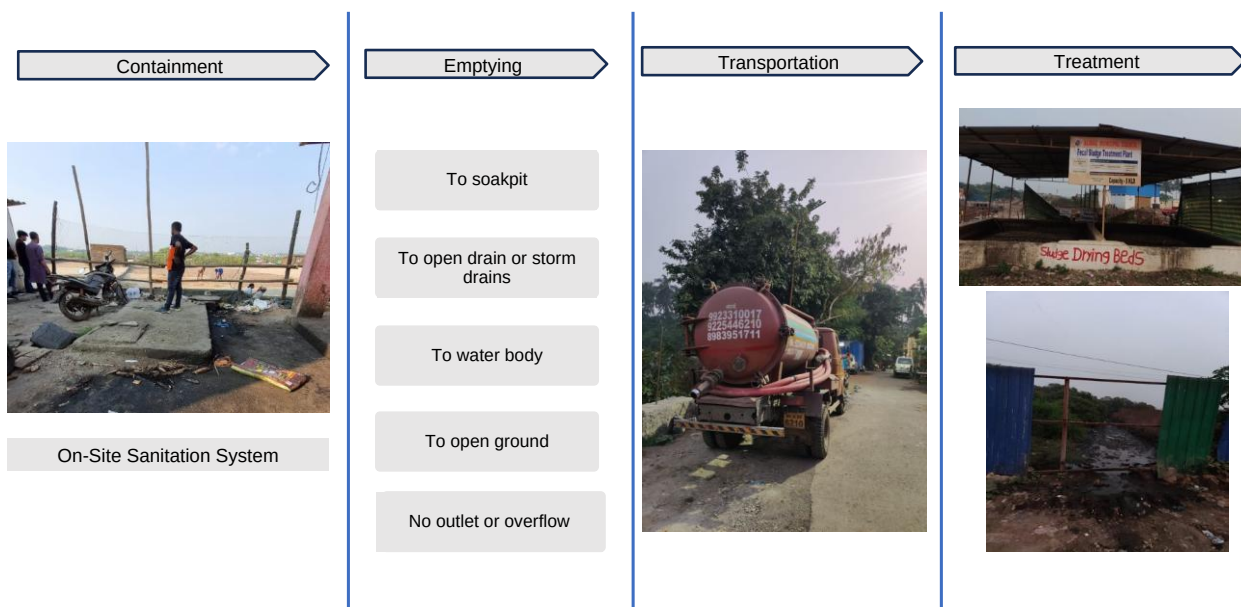
- **Treatment:** The city does not have a sewerage network or a sewage treatment plant (STP), although there are plans to develop one under the State Urban Development Department. Faecal sludge collected from households is treated at a FSTP with an installed capacity of 5 KLD, which has been operational since 2016.
- **End use/Disposal :** In the absence of a sewerage network, around 4.5% of households discharge blackwater directly into drains, water bodies, or open land. Greywater is also frequently disposed of untreated into the surrounding environment, further compounding pollution and public health risks (figure 41).

Figure 41 : Toilet Waste Confinement Method in Sample Households



Source: Data from Primary Sample Household Survey

Figure 42: Sanitation Service Chain in Alibag

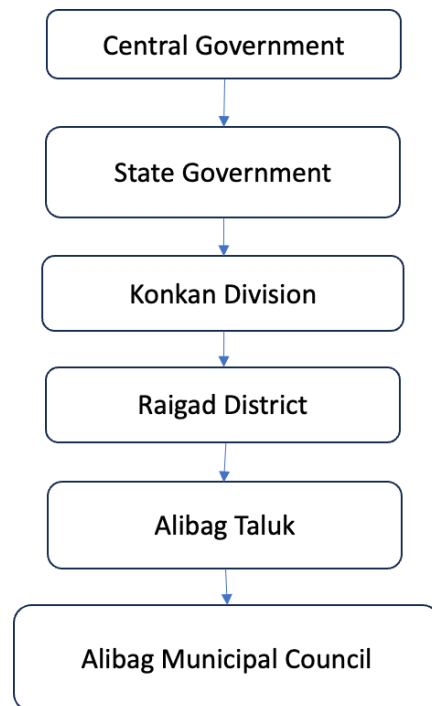


Source: Author's illustration

5.3 INSTITUTIONAL FRAMEWORK IN WASH

Alibag is structured across multiple levels of governance, with responsibilities shared between central, state, and local authorities (figure 43). According to the 7th Schedule of the Constitution of India, water is a state subject, and the state has the prerogative to take decisions about the available water resources within the state jurisdiction.

Figure 43 : Multi-tier Governance Structure: Alibag Municipal Council



In WaSH, at the national level, the Ministry of Housing and Urban Affairs (MoHUA) is responsible for formulating policies and guidelines related to urban water and sanitation and the states have the authority to ratify the policies in their respective states. The MoHUA also came out with the national level service level benchmarks (SLBs) for urban water supply and sewerage infrastructure and services in 2010. The Central Public Health Environment and Engineering Organisation (CPHEEO), the technical arm of MoHUA, formulates guidelines and manuals on water supply and sewage management and defines the SLBs for water supply and sewerage. The Central Pollution Control Board (CPCB), under the Ministry of Environment, Forests, and Climate Change, is responsible for setting environmental pollution standards, which the State Pollution Control Boards (SPCB) are tasked with enforcing. ULBs and state water and sewerage boards are required to comply with these standards.

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

Funds from central schemes like AMRUT and SBM are first received by the state and then disbursed to ULBs through a State High Power Steering Committee (SHPSC), with technical approval from the State-Level Technical Committee (SLTC). The Maharashtra Water Resources Regulatory Authority (MWRRA) regulates water and sanitation services, including tariff setting and quality standards, while Maharashtra Jeevan Pradhikaran (MJP)- state-owned corporation - handles retail tariffs at the ULB level and provide technical support to ULBs. AMC's Water Department oversees water supply provision, infrastructure, and operations, with project planning led by the mayor and Chief Officer, and final approval by the state urban development department (UDD) and Directorate of Municipal Administration (DMA)¹. The department is currently led by a Deputy Engineer. The Swachh Bharat Mission-Urban (SBM-U), launched in 2014, aims for universal urban sanitation coverage, with MJP responsible for executing water and sewerage schemes in Maharashtra. AMC, under state guidelines, is responsible for local sanitation services, including implementing projects, maintaining sewerage systems, and managing waste. Key institutions in climate change are district disaster management office, which do not have any say in the WaSH policies.

5.4 KEY CHALLENGES

- **Inadequate Sanitation Infrastructure** – The town lacks both a sewage treatment plant and a sewerage network. Previous proposals have faced challenges due to the high costs of constructing sewerage systems in coastal regions with high water tables. To address this, the town could consider more cost-effective, decentralized solutions that require only shallow digging for sewerage networks.
- **Need for a Proper Faecal Sludge Management Strategy** – Although the town has a FSSTP, field visits revealed that it is non-functional. Additionally, the frequency of desludging septic tanks is very high, indicating gaps in planning, operations, and long-term sustainability.
- **Inadequate Services in Low-Income Areas** – The Koliwada community struggles with inadequate access to both toilets and septic tanks. Field visits revealed reliance on

¹The general body is composed of the elected ward members and the mayor is chosen amongst them. Although, at AMC the general body is dissolved and non-functional.

community septic tanks, often constructed with residents' own money. This highlights serious service gaps that the ULB needs to urgently address.

- **Fragmented institutional roles:** Multiple agencies (MoHUA, CPHEEO, CPCB, SPCB, MWRRA, MJP, ULBs) with overlapping but weakly coordinated mandates in WaSH governance.
- **Exclusion of climate institutions:** Climate change governance (e.g., district disaster management office) is disconnected from WaSH policy and planning.
- **Weak local autonomy:** ULBs have limited power; project planning and approvals are heavily dependent on state-level departments and committees.
- **Top-down policy flow:** National and state schemes (AMRUT, SBM, Nagaroththan) dominate funding and decision-making, with little flexibility for local priorities.
- **Limited technical capacity:** ULBs depend on MJP and other state agencies for technical support and tariff-setting.
- **Service delivery constraints:** AMC's water department is understaffed (led only by a Deputy Engineer) despite wide responsibilities in infrastructure and service provision.

CHAPTER 6: GREENHOUSE GAS EMISSIONS FROM WATER AND SANITATION SYSTEMS : A CASE STUDY OF ALIBAG

ASHISH DANGI AND NC NARAYANAN

6.1 BACKGROUND

As we move towards climate-resilient development, it's crucial to recognize the significant GHG emissions associated with vital water and sanitation services. These emissions can be surprisingly high, even in small towns like Alibag, Maharashtra, underscoring the importance of understanding and addressing them as a key step toward building more sustainable and climate-resilient communities. Higher emissions in these areas also present an opportunity to reduce the overall carbon footprint of the city through simple interventions. Such measures can achieve significant carbon savings at a lower cost compared to sectors where efficiency efforts have already reached saturation. By focusing on these under-addressed areas, we can make meaningful strides in reducing emissions and enhancing the sustainability of our communities. Our analysis of AMC's water supply and sanitation systems revealed some significant findings. The study focuses solely on operational emissions from water supply and OSS systems and FSTP, including energy consumption and direct GHG emissions from biological processes. It excludes emissions embedded in infrastructure (e.g., construction of pipelines, treatment plants) and indirect emissions from chemicals and materials used in these processes, which could also contribute significantly to the overall carbon footprint.

This section discusses the key findings on types and sources of emissions, details emissions from Alibag's water system and OSS, and concludes with recommendations to reduce emissions, highlighting the need for targeted interventions to enhance sustainability.

6.2 GREENHOUSE GAS EMISSIONS FROM WATER SERVICES

The operational emissions from Alibag's water supply and sanitation systems are primarily categorized into three types: **Carbon Dioxide (CO₂)** primarily results from energy consumption associated with pumping, treatment, distribution, and transport; **Methane (CH₄)** is generated through the anaerobic decomposition of organic matter in non-sewered sanitation systems such as septic tanks; and **Nitrous Oxide (N₂O)** emerges from nitrification and

denitrification processes in wastewater systems, especially those dealing with nitrogen-rich waste GHG Emissions from Water System.

City' water supply system, which includes abstraction, treatment, distribution, and end-use stages, results in significant CO₂ emissions due to energy use as discussed below (figure 44):

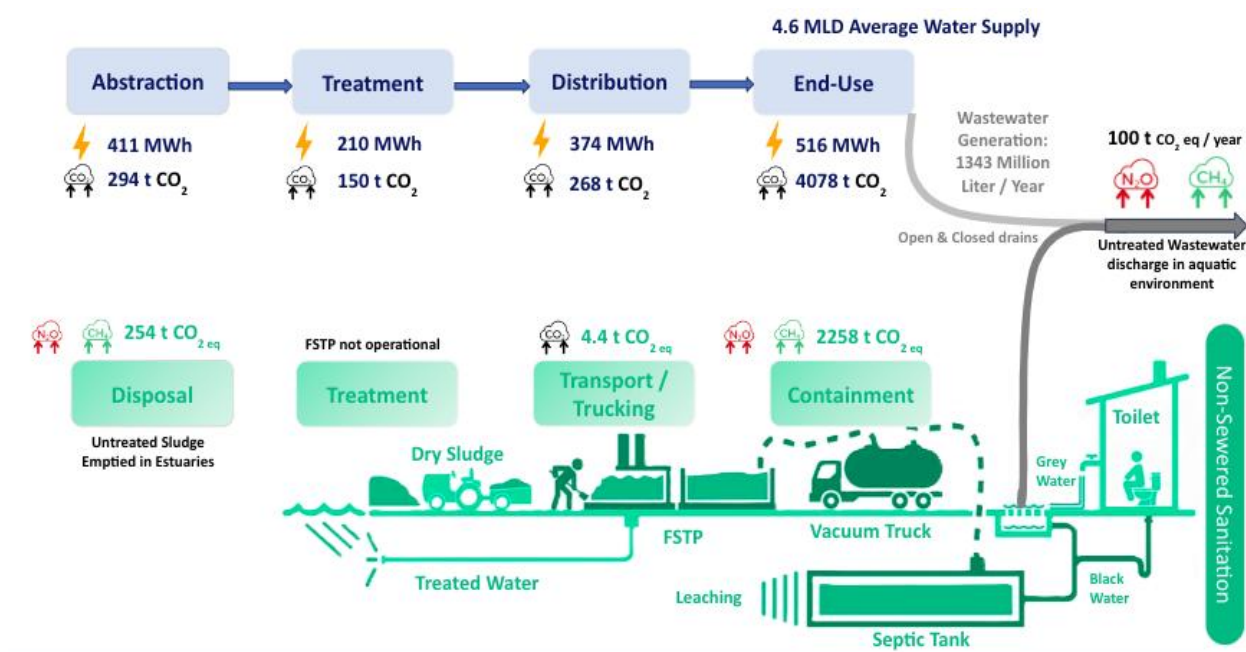
- **Abstraction:** This process, involving the extraction of water from natural sources, consumes 411 MWh of energy, resulting in 294 tons of CO₂ emissions.
- **Treatment:** The treatment stage consumes 210 MWh of energy, leading to 150 tons of CO₂ emissions. This includes processes like coagulation, filtration, and disinfection. The energy consumption for treatment also includes the energy needed to pump pure water to an uphill sump; from there, the water is conveyed by gravity.
- **Distribution:** With 374 MWh of energy consumption, this stage generates 268 tons of CO₂ emissions. The energy is mainly used to pump bulk water from a Ground Storage Tank (GSR) to Elevated Storage Tanks (ESRs), which then distributes the water to nearly 5,000 households in the AMC area.
- **End-Use:** The end-use stage, with the highest energy consumption of 516 MWh, results in 864 tons of CO₂ emissions. This stage involves significant energy use for water heating and household-level water pumping.

6.3 GREENHOUSE GAS EMISSIONS FROM SANITATION SYSTEMS

Our analysis found that the non-sewered sanitation systems in Alibag, such as septic tanks, are significant sources of CH₄ and N₂O emissions. The analysis mapped emissions throughout the sanitation service chain - containment, transport, treatment and disposal.

- **Containment (Septic Tanks):** These systems store and partially treat wastewater, emitting methane due to anaerobic decomposition of organic matter. The containment stage alone is responsible for 2258 tons of CO₂ equivalent emissions.
- **Transport/Trucking (Vacuum Trucks):** The periodic removal and transport of fecal sludge contribute 4.4 tons of CO₂ equivalent emissions.
- **Treatment:** Although the FSTP is designed to treat fecal sludge, its non-operational status currently leads to the disposal of untreated sludge, significantly impacting the environment.
- **Disposal:** Untreated sludge disposal, often in estuaries, results in 254 tons of CO₂ equivalent emissions and contributes to further methane emissions and environmental pollution.

Figure 44 : Process Flow and Stage-wise Energy Consumption with Carbon Emissions from Water and Sanitation Cycle in Alibag Municipal Council



Source: (Dangi & Narayanan, forthcoming)⁴²

6.4 KEY CHALLENGES

In summary, non-sewered systems contribute to GHG emissions primarily through the production of methane and nitrous oxide. The IPCC methodology provides a framework for estimating these emissions based on specific factors such as system type, environmental conditions, and waste characteristics. Understanding these emissions is critical for designing interventions that minimize the climate impact of sanitation systems, such as improving anaerobic treatment processes, capturing methane, or optimizing nitrogen management to reduce N₂O emissions.

The study revealed that the system's operational emissions—those generated by the day-to-day running of water and sanitation services—are substantial and come from various sources. The emission profile of the water and non-networked sanitation systems in AMC highlights significant sources of CO₂, CH₄, and N₂O emissions. **The most considerable emissions arise from the end-use of water and the containment of wastewater in septic tanks.**

The emissions from the containment stage, particularly in septic tanks, are primarily due to the anaerobic decomposition of organic matter. In septic tanks, the lack of oxygen creates

conditions that favor the production of methane (CH₄), a potent greenhouse gas. Methane emissions are significant because they have a much higher global warming potential compared to carbon dioxide (CO₂), making even small quantities highly impactful.

High methane emissions from septic tanks significantly contribute to the town's overall GHG emissions, highlighting the need for improved management practices and technology to capture and utilize methane. For small towns like Alibag, incorporating non-sewered sanitation systems into climate action plans is crucial to effective GHG reduction. The surprising energy demands for water heating and reliance on household water pumping also indicate areas where targeted mitigation efforts can lead to substantial reductions in emissions.

These findings underscore the necessity for energy efficiency improvements, operational enhancements, and sustainable practices to mitigate the environmental impact of essential services. Decision-makers should integrate emissions analysis into climate-resilient development planning to help towns adapt to climate change while contributing to broader mitigation goals. Addressing these operational emissions will enable towns like Alibag to advance towards a more sustainable and climate-resilient future.

CHAPTER 7: FINANCIAL ANALYSIS OF WATER SUPPLY AND SANITATION AT ALIBAG MUNICIPAL COUNCIL

ABHAY JUNAGHARE⁴³ AND NC NARAYANAN

7.1 INTRODUCTION

This section analyses the types of funds available to AMC, including (i) central and state Government grants, and (ii) its own revenue sources. The section also assesses the financial health of the AMC by examining capital receipts, capital expenditure, operating income, and operating expenditure⁴⁴. This helps assess AMC's preparedness to meet current and future demands for WaSH 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 2 subsections viz., 1) funds received from central and state government schemes and AMC's own revenue resources for water supply, and financial health of the water supply sector, funds received from central and state government schemes and AMC's own revenue resources in sanitation.

7.2 REVENUE STREAM

Central Government Grants

The two key central schemes under which AMC has received central grants are AMRUT and Swachh Bharat Mission (Urban)⁴⁵. In 2021, AMRUT 2.0 was launched, and the AMC was included in the scheme to enhance its existing water supply infrastructure. The AMC assessed the city's water demand through the City Water Balance Plan (CWBP) and requested the Mission Directorate for INR 35 crores under the City Water Action Plan (CWAP) in 2023. During one of our interviews, **the AMC officials confirmed that the central government sanctioned only INR 25 crores out of the requested INR 35 crores. While this amount is yet to be disbursed, current budget analyses emphasize actual spending, indicating that the AMRUT scheme has not yet been reflected in the central government's fund receipts analysis.**

According to the budget documents of AMC, it has not yet received any funds under the SBM (U) scheme. However, each beneficiary (applicant) is directly provided with INR

12,000 in two stages for construction of individual household latrines (IHHL). The following table (3) delineates the status of IHHL at Alibag.

Table 3: Status of individual household latrines (IHHL) at Alibag

#	Particulars	Number
1.	No. of Wards	17
2.	Total Application Count for IHHL	185
3.	Applications in Applied stage	3
4.	Applications Re-Applied	1
5.	Applications Verified	107
6.	Applications Approved	107
7.	Applications Rejected	44
8.	Applications Closed	30
9.	Constructed Toilet	111
10.	Commenced Toilets	62

Source: Summary Report of IHHL Application (Retrieved from http://swachhbharaturban.gov.in/RPT_IHHLSTATUS.aspx in September, 2024)

Other centrally sponsored grants (considered capital receipts) under which AMC has received funds are Urban Infrastructure Development Scheme for Small & Medium Towns (UIDSSMT), Member of Parliament Local Area Development Program (MPLADS)⁴⁶, 12th, 13th, 14th, and 15th Finance Commission, aimed at enhancing its water and sanitation facilities. As shown in Table 4, prior to 2014, AMC primarily relied on the UIDSSMT, with total allocations of INR 5.58 crore between 2009 and 2011. After 2014, new funding sources were introduced, including MPLADS and the 13th, 14th, and 15th Finance Commission. The Finance Commission has been a relatively consistent source of funding for AMC post 2014-15, though with some fluctuations, likely reflecting the performance of the ULB, as certain grants from the Commission are tied to the ULB's performance.

However, funding under MP/MLA LADS remained sporadic, and limited funding post 2019⁴⁷. **Even though funds are available under the MPLADS, the schemes has faced criticism for corruption (Blair, 2017)⁴⁸, and more importantly for violating 73rd and 74th Constitutional Amendments (Aiyar, 2010)⁴⁹.** For example, MPs spend funds on activities on the State lists, many of which, under the 73rd and 74th Constitutional Amendments, are the responsibility of ULBs, and funds are disbursed through district administration without consulting local governments (Aiyar, 2010). Moreover, a quick review of the MPLADS dashboard for Raigad district indicates that most of the projects undertaken through the scheme are not related to water and sanitation services.

Table 4: Funds (in INR) received by AMC for Water Supply and Sanitation under Central Schemes

Budget Year	Funds Received Urban Infrastructure	Funds Received under Member of Parliament/	Funds Received under 12 th Finance Commission	Funds Received under 13 th Finance Commission	Funds Received under 14 th Finance Commission	Funds Received under 15 th Finance Commission
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	Development Scheme for Small and Medium Towns (UIDSSMT)	Member of Legislative Assembly Local Area Development Scheme (MP/ MLA LADS)				
2009-10	49600000	560000	3076169	NA	NA	NA
2010-11	6200000	0	4573087	NA	NA	NA
2011-12	0	1000000	NA	NA	NA	NA
2012-13	0	0	NA	3902523	NA	NA
2013-14	0	2380000	NA	13417607	NA	NA
2014-15	0	0	NA	6244649	NA	NA
2015-16	0	0	NA	6297048	11394223	NA
2016-17	0	1026698	NA	NA	15867129	NA
2017-18	0	0	NA	2700000	8819199	NA
2018-19	0	489000	NA	NA	28798374	NA
2019-20	0	0	NA	NA	52061984	NA
2020-21	0	0	NA	NA	NA	6071784
2021-22	0	0	NA	NA	NA	5300222
2022-23	0	53496	NA	NA	781396	8379990
Grants Received	₹ 5,58,00,000	₹ 55,09,194	₹ 76,49,256	₹ 3,25,61,827	₹ 11,77,22,305	₹ 1,97,51,996
Total Grants Received from Central Government Schemes by AMC = ₹ 23,89,94,578						
NA = Not Applicable						

Source: Budget Documents (2009-10 to 2022-23), AMC

State Government Funds

The key state schemes implemented at Alibag are Reforms for Dalit Settlements, Maharashtra Suvarna Jayanti Nagarotthan Maha Abhiyan (MSJNMA), Swachh Maharashtra Abhiyaan, City Development Scheme, Grants under Specific Tasks, District Planning and Development Grant (Innovative Scheme), Grants Received from MMRDA under Nirmal MMR Abhiyaan, and Grants under Sujal Nirmal Abhiyaan (Table 5). Except for the Swarna Jayanti Nagarotthan Mahabhiyan scheme, fund releases under other schemes have been inconsistent. The Swarna Jayanti Nagarotthan Mahabhiyan scheme has emerged as the most significant contributor to AMC's funding. In 2019-20, the Mumbai Metropolitan Region Development Authority (MMRDA) made a substantial contribution of ₹95,80,445, marking a key infusion of funds that year. This grant is critical, as MMRDA plays a pivotal role in urban planning and development in the region, but it was sanctioned only once during this period, highlighting the sporadic nature of funding from this source. Another key point is that the last CDP funds were released only in 2013-2014.

Table 5: Funds (INR) received by AMC for Water Supply and Sanitation under state schemes

Funds and Grants Received under Scheme	Dalit Settlement Reforms	Swarna Jayanti Nagarothan Mahabhiyan	Swachh Maharashtra Abhiyaan	City Development Scheme	Grants under Specific Tasks	District Planning and Development Grant (Innovative Scheme)	Grants Received from MMRDA under Nirmal MMR Abhiyaan	Grants under Sujal Nirmal Abhiyaan
2009-10	0	0	0	0	0	0	0	0
2010-11	500000	2626184	0	0	0	0	0	0
2011-12	400000	4205704	0	0	0	0	0	0
2012-13	400000	5111280	0	0	0	0	0	4764000
2013-14	0	13716000	0	364912	0	0	0	0
2014-15	0	2721703	0	0	0	2208000	0	0
2015-16	600000	27594046	0	0	0	0	0	0
2016-17	400000	6742979	0	0	0	0	0	0
2017-18	0	11369556	6777318	0	0	0	0	0
2018-19	0	8761826	3450001	0	0	0	0	0
2019-20	0	4735000	0	0	0	0	9580445	0
2020-21	0	9881151	139000	0	0	0	0	0
2021-22	0	6570000	0	0	0	0	0	0
2022-23	1187824	5839506	0	0	25236885	0	0	0
Total Grants Received	₹ 34,87,824	₹ 10,98,74,935	₹ 1,03,66,319	₹ 3,64,912	₹ 2,52,36,885	₹ 22,08,000	₹ 95,80,445	₹ 47,64,000
Total Grants Received from State Government Schemes by AMC = ₹ 16,58,83,320								

Source: Budget Documents (2009-10 to 2022-23), AMC

The analysis shows inconsistencies in receiving funds under various central and state government schemes and programmes. This underscores, the need for AMC to explore additional avenues for funding to address ongoing challenges effectively.

Own Revenue Resources

The recent CAG report highlights a steady downward trend in the percentage contribution from the ULBs own resources to their total financial resources between 2015 and 2020, which underscores an increasing reliance of ULBs on central and state grants (Government of Maharashtra, 2022)⁵⁰. Same is observed for AMC.

To understand **own revenue from Water Supply** for AMC, we investigated trends from 2009 to 2023 for revenue income in water supply sector **which includes revenue from water supply Income by tanker, water connection fee, water supply meter fine, and general water tax**. Following the significant increase in 2013-14 from the general water tax, the revenue income remained relatively stable indicating a period of sustained financial health

for the AMC (Table 6). From 2018-19 onwards revenue income shows a downward slope. This sharp decline raises concerns about the council's financial stability and its ability to maintain services, especially as the revenue dropped significantly during 2022-23.

One of the reasons for poor revenue generation is poor cost recovery and collection from water supply. As per SLB reporting, AMC falls short in cost recovery, with only 41.87% of operating expenses being covered by revenues (Figure 44). The trend of average cost recovery (%) in water sector reveals fluctuating and downward trend starting 2020.

Table 6 : Revenue Income from Water Supply at AMC

Year	Water Supply Income by Tanker	Water Connection Fee, etc.	Water Supply Meter Fine	General Water Tax
2009-10	74000	254392	0	6360911
2010-11	73750	259476	0	7436705
2011-12	56510	103320	0	7122279
2012-13	168150	116170	0	6170709
2013-14	67962	43300	0	11138870
2014-15	102750	27450	271042	8966791
2015-16	196690	36500	281693	11063368
2016-17	89000	112100	251966	10656876
2017-18	132500	50250	265627	10512576
2018-19	152600	20025	132247	7604603
2019-20	244000	5825	272828	9546541
2020-21	122000	0	340352	7339010
2021-22	97650	0	339277	7537810
2022-23	71000	5800	158243	3654489
Total Revenue Income	₹ 16,48,562	₹ 10,34,608	₹ 23,13,275	₹ 11,51,11,538
Total Revenue Income for Water Supply at AMC = ₹ 12,01,07,983				

Source: Budget Documents (2009-10 to 2022-23), AMC

Analysing the **revenue generated from various sanitation-related fees and services** from 2009-10 to 2022-23 (Table 7) reveals trends in public toilet rentals, environmental control fees, septic tanker rentals, fines under solid waste management rules, and sanitation taxes. In the initial years, particularly from 2009-10 to 2012-13, there was a noticeable fluctuation in public toilet rental fees, with the highest collection in 2011-12 at ₹87,993. However, this revenue sharply decreased in subsequent years, with the lowest collection recorded in 2017-18 at ₹7,000. Environmental control and sanitation fees have shown some variation, peaking in 2010-11 and 2014-15, but generally reflecting a downward trend by 2021-22. The septic tanker rental fee demonstrated inconsistency as well, peaking in 2012-13 at ₹5,88,900 but dropping to zero in the last few years. This decline indicates a reduced reliance on septic tank

services. The Kondwada (Stray Animal Enclosure) fee was only recorded in two years, with minimal impact on overall revenue. The sanitation tax saw a significant rise in 2020-21, with collections reaching ₹32,62,403, the highest in the period. It suggests an increased focus on sanitation financing. The trends indicate a need for improved awareness and enforcement of sanitation regulations to boost revenue and maintain effective sanitation services in the city.

Table 7: Revenue Income from Sanitation at AMC

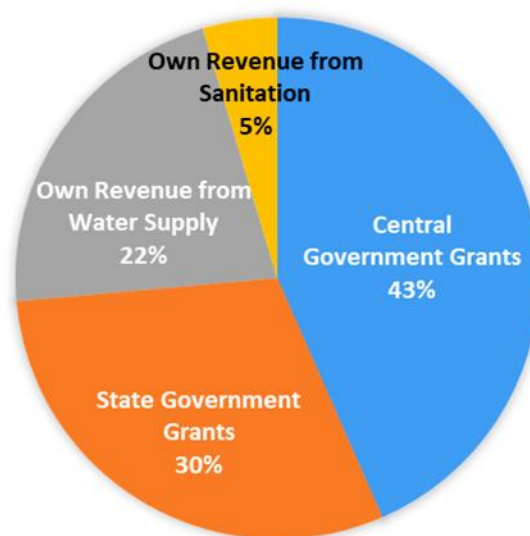
Year	Public toilet rental	Environmental control and sanitation fee	Septic tanker rental fee	Fine under Solid waste management rules	Kondwada (Stray Animal Enclosure)	Sanitation Tax
2009-10	18900	1295794	320178	0	0	0
2010-11	67800	1127000	287371	0	1330	0
2011-12	87993	1127282	413028	0	20630	0
2012-13	66385	983392	588900	0	500	0
2013-14	36000	699421	438066	0	6000	0
2014-15	18250	1296745	330956	4000	0	0
2015-16	44000	560721	230650	0	0	0
2016-17	69000	1172610	152150	0	0	0
2017-18	7000	933970	125905	0	21500	0
2018-19	84000	860860	0	0	800	0
2019-20	56000	901660	0	0	19950	1994657
2020-21	28000	520000	0	0	0	3262403
2021-22	105000	0	0	0	0	2378321
2022-23	56000	610000	0	0	0	1781919
Total Revenue Income	₹ 7,44,328	₹ 1,20,89,455	₹ 28,87,204	₹ 4,000	₹ 70,710	₹ 94,17,300
Total Revenue Income for Sanitation at AMC = ₹ 2,52,12,997						

Source: Budget Documents (2009-10 to 2022-23), AMC

Own Revenue to Grants Ratio

The Figure 45 presents a breakdown of financial contributions from various sources towards water supply and sanitation efforts. Analysing these figures provide insights into the funding landscape for these essential services.

Figure 45: Share of grants vs own revenue for water supply and sanitation at AMC



Source: Budget Documents (2009-10 to 2022-23), AMC The central government grants amount to ₹23,89,94,578 from 2009 to 2023 representing 43% of the total funding. This substantial contribution underscores the central government's commitment to improving water supply and sanitation at the ULB level. These grants support a range of initiatives, from infrastructure development to community awareness programs. The state government grants totalling ₹16,58,83,320 or 30% reflects the state's role in complementing central funding and highlights a collaborative approach to address water supply and sanitation challenges. The state government's investment is crucial for ensuring that local projects align with broader regional goals. However, the figure suggests that 73% of the funds for water and sanitation comes from the central and state government grants, which can create dependency and are largely insufficient to create capital assets for WaSH. While the revenue income for water supply and sanitation is only 22% and 5% respectively.

7.3 FINANCIAL ASSESSMENT

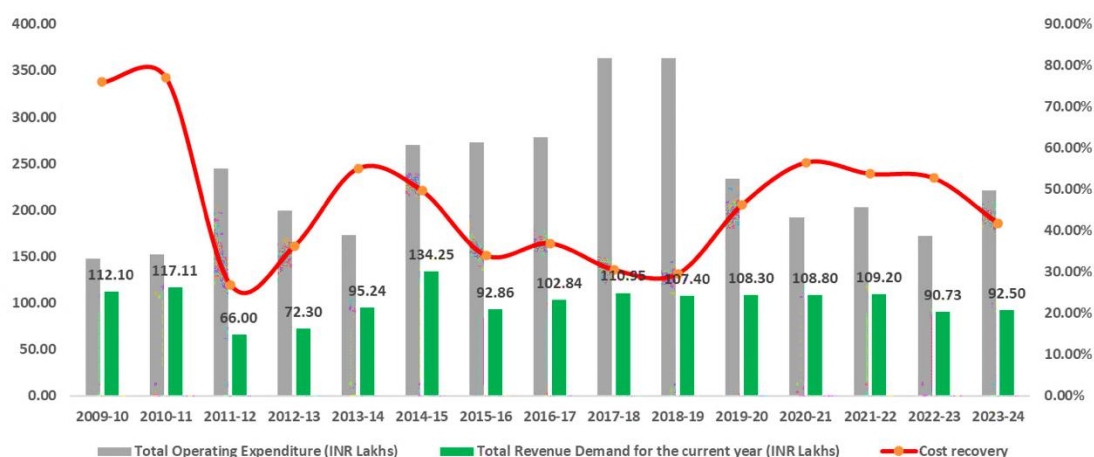
7.3.1 WATER SUPPLY

Cost Recovery

The trends suggest that the total operating expenditure and revenue demand at AMC has fluctuated significantly over the years (figure 46). The cost recovery ratio, which indicates the percentage of operating expenditure covered by revenue demand, has varied significantly over the years. The decline indicates challenges in covering operational costs through revenue generation, with long-term implications for water utilities and inefficiencies affecting

consumers. However, the intermittent upward trends reflect AMC's efforts to stabilize revenue and manage operating expenditures. The fluctuations in both expenditure and revenue demand highlight the need for a more strategic approach to budgeting and financial planning. The decline in cost recovery ratios suggests that AMC may need to explore alternative revenue-generating mechanisms or enhance operational efficiency to ensure that it can meet its financial obligations while continuing to provide essential water supply services to its residents.

Figure 46: Trend analysis of average cost recovery for water supply at AMC



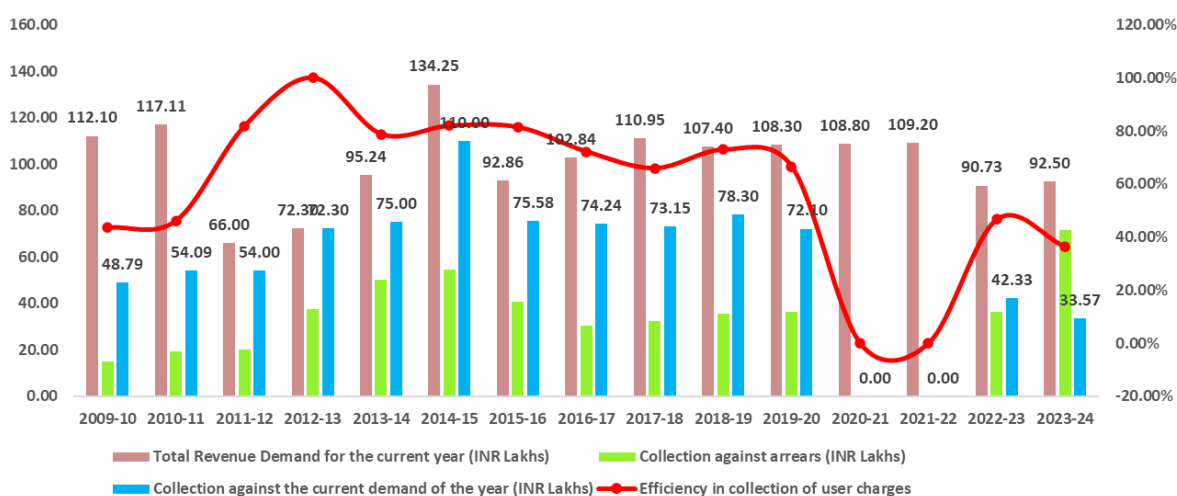
Source: Budget Documents (2009-10 to 2022-23), AMC

Collection Efficiency

The current collection efficiency in collecting charges is also low, with only 36.29% of billed revenues being collected. The ULB is not able to improve its collection efficiency with respect to the total revenue demand estimated by the ULB (figure 47). Arrears have consistently outpaced collections, especially post-COVID. AMC's total revenue demand fluctuated, starting at ₹112.10 lakhs in 2009-10, peaking at ₹134.25 lakhs in 2014-15, and dropping to ₹66.00 lakhs in 2011-12, likely due to demand estimation issues or service reductions. Demand stabilized between ₹90-110 lakhs until 2023-24. Arrear collections varied, beginning at ₹14.81 lakhs in 2009-10, peaking at ₹54.50 lakhs in 2014-15, and halting completely in 2020-21 and 2021-22. Recovery efforts resumed in 2022-23, with collections reaching ₹36.51 lakhs and projected to rise to ₹71.50 lakhs in 2023-24. Revenue collection against current demand has fluctuated significantly, starting at ₹48.79 lakhs in 2009-10, peaking at ₹110 lakhs in 2014-15, and falling to zero in 2020-21 and 2021-22. This sharp decline raises concerns about AMC's collection capabilities during these years. There has been gradual recovery since, with ₹42.33 lakhs in 2022-23 and ₹33.57 lakhs projected for 2023-24. Efficiency in collecting user charges has also varied, peaking at 100% in 2012-

13 but dropping to 0% in 2020-21 and 2021-22 due to COVID challenges, before rebounding to 46.65% in 2023-24. These fluctuations highlight vulnerabilities in AMC's financial management, calling for improved revenue collection mechanisms and better financial stability.

Figure 47: Trend analysis of revenue income in water supply at AMC

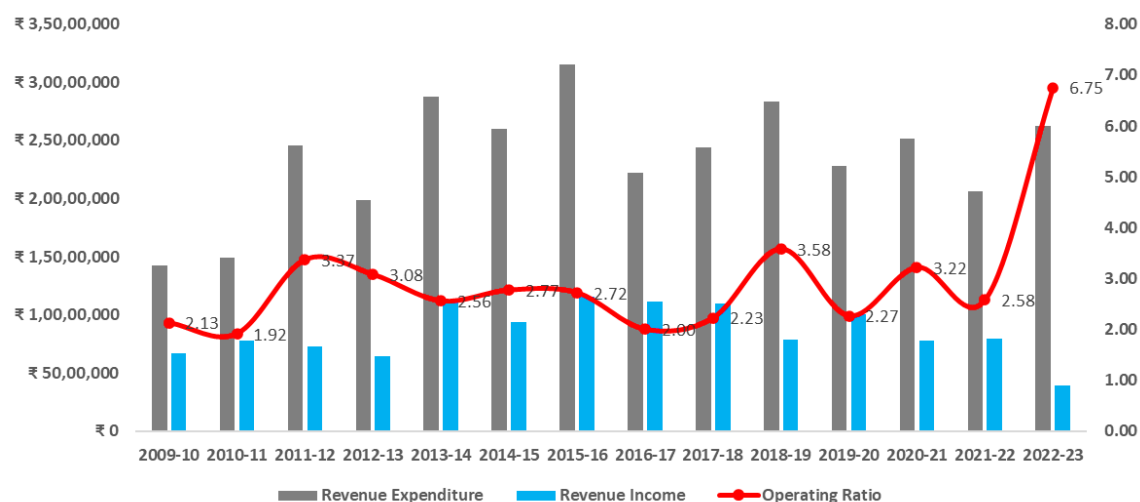


Source: Budget Documents (2009-10 to 2022-23), AMC

Operating Ratio

The operating ratio, reflecting the efficiency of the water utility in managing its operating expenses relative to its revenue, indicates how many times the operating expenses exceed the revenue. A higher ratio suggests increased operating costs relative to income, which can indicate inefficiency. The operating ratio for the water utility demonstrates significant fluctuations over the years, highlighting instability in both operational efficiency and financial management. Notably high ratios in specific years, such as 2011-12, 2018-19, and 2022-23, indicate periods where the utility struggled to effectively control costs (Figure 48). These challenges may stem from external factors, including rising costs of materials or labor, as well as internal inefficiencies. **The alarming spike to 6.8 in 2022-23 underscores a critical situation for the utility, potentially resulting from inadequate revenue generation, drastic increases in operational costs, or a combination of both. Immediate attention and strategic intervention are essential to address these issues and restore financial stability.**

Figure 48: Operating Ratio for the water utility at AMC



Source: Budget Documents (2009-10 to 2022-23), AMC

Cost of Bulk Water Purchase

The fact that AMC does not have its own water resources adds to the cost to the AMC. **The annual expenditure for bulk water purchase suggests that the cost of purchasing bulk water from MIDC is way higher than the revenue income (Figure 49).** The average bulk water purchase cost is INR 1.69 Crores, whereas, the revenue income stands at INR 0.85 Crores that is half the purchase cost. This disparity, seen as early as 2009-10 with a deficit of INR 47.20 lakhs, has persisted, reflecting inefficiencies in pricing or cost management. By 2022-23, the deficit had worsened to nearly INR 97 lakhs, highlighting the urgent need for strategic financial reforms. The utility's inability to align water procurement costs with revenue generation underscores systemic issues, requiring better financial strategies, cost control, and operational improvements for long-term sustainability.

Figure 49: Bulk Water Purchase at AMC

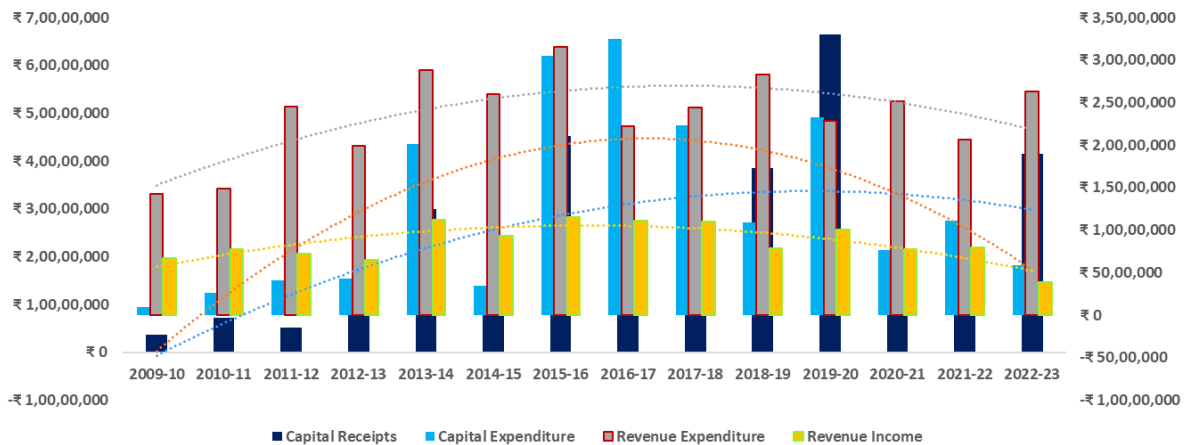


Source: Budget Documents (2009-10 to 2022-23), AMC

Budget Trends

Figure 50 examines revenue generation and expenditure with capital receipts and capital expenditure from 2009-10 to 2022-23. It suggests that the AMC experienced significant fluctuations in capital receipts, peaking in 2019-20. **There is a positive trend in capital receipts, particularly from 2015-16 onward, which could indicate improved funding access or project implementation success.** AMC's capital expenditure shows substantial variability, peaking in 2015-16. This rise coincides with increased capital receipts, suggesting effective utilization of funds for infrastructure improvements. However, capital expenditure declined significantly in 2022-23, raising concerns about the municipality's ongoing investment in water supply development. The patterns indicate that AMC's capital expenditure is closely tied to available capital receipts, reflecting its dependency on external funding for infrastructure projects.

Figure 50: Budget trends for the water supply at AMC

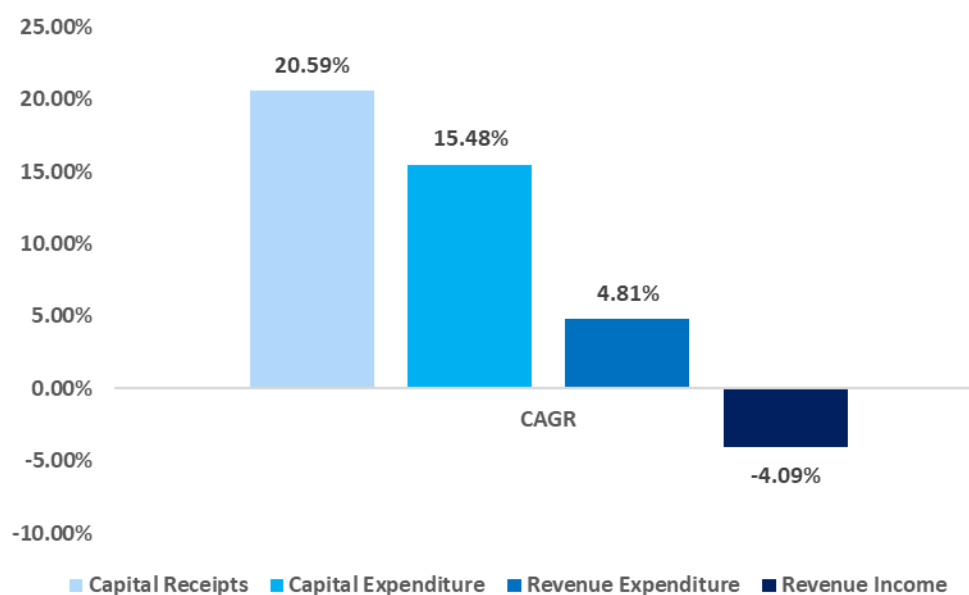


Source: Budget Documents (2009-10 to 2022-23), AMC

The revenue expenditure at AMC has generally been on the higher side, peaking in 2015-16. The trends indicate that as capital investments increase, so do operational costs, highlighting the need for effective management of both capital and operational expenditures. **The most notable observation is that revenue expenditure has generally been stable, with only minor fluctuations, indicating consistent operational demands regardless of capital availability. The revenue income, has been relatively low compared to both capital receipts and expenditures.** This decline points to challenges in revenue collection and possibly a lack of effective mechanisms to enhance local income from water supply services.

Moreover, the CAGR analysis of Alibag's water supply finances indicates a mixed trend. Capital Receipts recorded the highest growth at 20.59%, reflecting a substantial increase in funds mobilized for capital investments, while Capital Expenditure also grew significantly at 15.48%, indicating continued investment in water supply infrastructure. In contrast, Revenue Expenditure increased modestly at 4.81%, suggesting relatively controlled operational and maintenance costs. However, Revenue Income registered a negative CAGR of -4.09%, implying a decline in revenue generation from water supply services. **This divergence between rising expenditure and declining revenue income may point to challenges in cost recovery and highlights the need to strengthen revenue collection and improve the financial sustainability of the water supply system (Figure 51).**

Figure 51: Compound annual growth rate (CAGR) for water supply at AMC



Source: Budget Documents (2009-10 to 2022-23), AMC

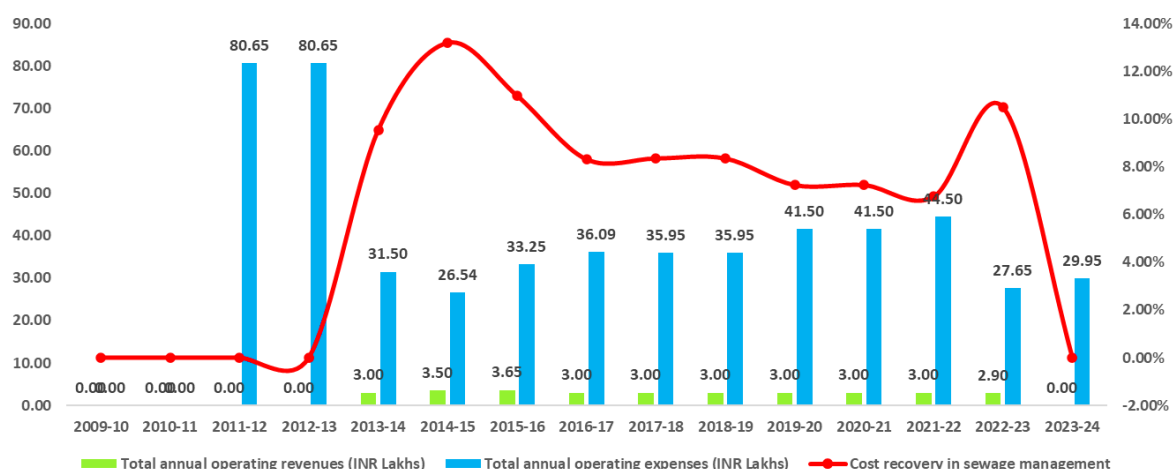
7.3.2 FINANCIAL HEALTH FOR SANITATION

Revenue from sanitation (wastewater management) services primarily comes through a sanitation tax levied alongside property tax. In Alibag, a property tax collection efficiency of 39% was reported for the period from 2015-16 to 2019-20 (Government of Maharashtra, 2022), highlighting a significant shortfall in the contribution of revenue to the ULB's own financial resources.

Cost Recovery

The financial performance of the sewage sector is notably weak, with only a 10.49% cost recovery achieved by 2023 (Figure 52). The primary reason is the increasing operating expenses (salaries, O&M etc.) compared to stable operating revenues (taxes, user fee, charges) in sewage management, indicating poor financial performance of the sector. This persistent underperformance raises serious concerns about the long-term sustainability and effectiveness of the city's sanitation management.

Figure 52 : Cost Recovery in Sewage Management



Source: CPHEEO Service level Benchmark, Alibag Municipal Council 23-24, Data Collection Date: 5th Aug 2024, Alibag

Similarly, Figure 53 shows the overall trend of revenue receipts and expenditures for the AMC from the financial year 2009-10 to 2022-23, revealing a clear gap where expenditures are much higher than revenue. This points to a financial deficit, which could signal issues with fiscal sustainability.

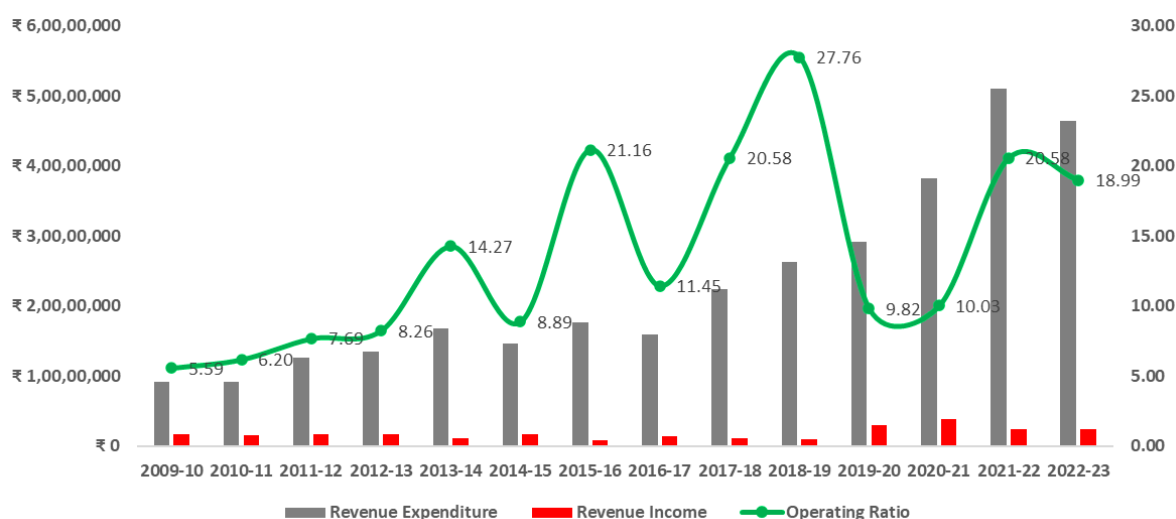
This uneven spending brings up a few important concerns. It seems the AMC may be giving priority to some areas while potentially neglecting crucial sectors like WaSH services. For example, irregular spending in certain categories might suggest that funds are being allocated based on immediate needs or emergencies, rather than through a long-term, well-thought-out financial plan. This inconsistency can lead to gaps in services, especially in areas that need constant investment, like infrastructure maintenance. For example, declining revenue receipts under 'environment control and sanitation fee' and 'septic tanker fee' indicate poor revenue.

Operating Ratio

The operating ratio for sanitation in Alibag shows a consistently high and generally increasing trend over the period from 2009-10 to 2022-23, indicating that revenue expenditure substantially exceeded revenue income throughout the study period. The operating ratio increased from 5.59 in 2009-10 to 27.76 in 2018-19, the highest recorded value, reflecting a sharp rise in expenditure without a corresponding increase in revenue. Although the ratio improved to 9.82 and 10.03 during 2019-20 and 2020-21 due to higher revenue income, it again remained high at 20.58 in 2021-22 and 18.99 in 2022-23. The total operating ratio

of 12.82 indicates that on average, sanitation expenditure was nearly thirteen times the revenue generated, highlighting the ULB's heavy dependence on grants and limited recovery of sanitation service costs through its own revenue sources.

Figure 53: Operating Ratio for sanitation at AMC



Source: Budget Documents (2009-10 to 2022-23), AMC

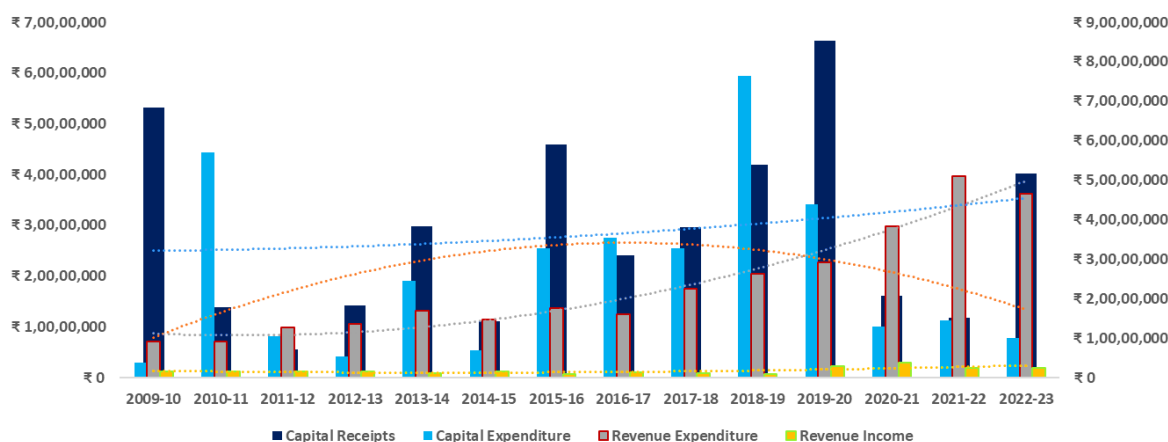
Budget Trends

The analysis of Figure 54 reveals a consistent imbalance between revenue receipts and expenditure at AMC. It is evident that the revenue expenditure has consistently exceeded revenue receipts, which raises concerns about the sustainability of AMC's financial health. A continuous shortfall between these two indicators suggests that the institution might be relying heavily on external financing or reserves to cover operational costs, potentially leading to fiscal strain. This persistent gap in revenue receipts and expenditures could indicate inefficiencies in revenue generation or collection mechanisms at AMC. Capital receipts and expenditures, the data reveals significant volatility. The fluctuating capital receipts indicate potential issues in long-term financial planning and investment attraction. In 2018-19, capital expenditure dramatically outpaced capital receipts, which suggests that AMC may have undertaken large-scale capital projects without corresponding funding. Similarly, in 2019-20, expenditures again exceeded receipts, highlighting ongoing misalignments in financial planning.

This trend of imbalance in both revenue and capital budgets could undermine the operational efficiency of AMC and might lead to increased borrowing, which can further exacerbate the fiscal deficit. The uneven balance in both these areas demands serious consideration, with a need for structural reforms in financial management. Improved forecasting, better alignment

of receipts with planned expenditures, and enhanced revenue generation initiatives could be key areas to address this issue.

Figure 54: Budget trends for sanitation at AMC



Source: Budget Documents (2009-10 to 2022-23), AMC

7.4 KEY CHALLENGES

AMC's financial data reflects a complex landscape of capital investment and operational challenges in water supply services. While there is potential for growth through increased capital receipts, the council must address the inefficiencies in revenue generation to create a more balanced financial structure. Strengthening local revenue streams will be essential to support sustainable water supply and sanitation operations and infrastructure development moving forward.

The financial health of AMC for WaSH services highlights a growing dependence on external funding due to a decline in self-generated revenue from 2015 to 2020. While central government grants have improved water infrastructure, inconsistent disbursements raise concerns about long-term sustainability. AMC's reliance on fluctuating state and central funds complicates budget planning, while challenges in tax collection further strain revenue generation. The low-cost recovery ratio (46.88%) and deficits from bulk water purchases emphasize the need for financial reforms. Strengthening local revenue streams and improving operational efficiency are critical for AMC to ensure sustainable water supply services and financial independence.

CHAPTER 8: SECTORAL RECOMMENDATIONS FOR ENHANCING CLIMATE RESILIENCE OF WASH INFRASTRUCTURE AND SERVICES IN ALIBAG

NEELAM RANA, ASHISH DANGI , ABHAY JUNAGHARE, UDIP PRAN DAS & N.C. NARAYANAN

8.1 BACKGROUND

Alibag, is a Class-III coastal town in the Raigad district and Konkan division of Maharashtra, India. It serves as district headquarters. It lies along the Arabian Sea and falls within one of the state's seven agroclimatic zones, known for very high rainfall. The Alibag taluka features diverse landscapes—farms, fishing villages, and ecologically significant wetlands with mudflats, salt marshes, and mangrove forests. These ecosystems provide crucial services such as water purification, storage, nutrient cycling, shoreline stabilization, and habitat support.

Raigad district is moderately vulnerable to drought (Mohanty & Wadhawan, 2021; (National Centre for Disease Control , 2022). Alibag has a history of exposure to extreme weather, notably Cyclone Nisarga in June 2020, which brought winds of 110–120 km/h, causing severe damage to infrastructure, uprooting trees, and disrupting power supply. Proactive evacuation of over 50,000 people minimized casualties, and emergency services swiftly undertook restoration and relief.

Future projections for the Konkan division indicate a moderate temperature rise (1.1–1.28°C) and a 10–30% increase in monsoon rainfall by 2030 (The Energy and Resources Institute, 2014). Extreme rainfall events are expected to increase by 10–14%, while additional dry days may rise by 3–5. Sea levels along Maharashtra's coastline may rise by 0.24–0.66 m by century's end, increasing risks of storm surges, coastal erosion, and saltwater intrusion into aquifers for towns like Alibag. Although Maharashtra's coastline faces a 25.5% erosion rate, Alibag's coast shows signs of accretion (Kankara, Murthy, & Rajeevan, 2018), (National Centre for Coastal Research, 2022).

These challenges disproportionately affect marginalized communities like the Koli fishing community, particularly in flood-prone low-lying areas with poor sanitation and informal water access. Spatial analysis using GIS highlights localized "hot spots" of vulnerability,

emphasizing the need for area-specific disaster planning and infrastructure upgrades. Further, Alibag's bulk water supply comes from MIDC, with no local water sources. An aging distribution system, low pressure, limited metering, and NRW issues hamper water access and efficiency. Sanitation services are similarly weak. Most households rely on septic systems, and 18% lack individual toilets. Poor desludging practices, limited public toilets, and infrequent septic tank maintenance increase health risks, especially during floods. These conditions contribute to GHG emissions from unmanaged waste and inefficient pumping systems. Financially, Alibag struggles with low cost recovery and heavy dependence on state and central grants, raising concerns about the sustainability of its infrastructure and the limited autonomy of the ULB, contrary to the spirit of the 74th Constitutional Amendment. Strengthening water and sanitation infrastructure, improving efficiency, and empowering local governance are critical for building long-term climate resilience in Alibag.

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.

8.2 WATER

1. Reduce Non-Revenue Water (NRW)

- Conduct regular water audits to identify leakages, illegal connections, and billing inefficiencies.
- Invest in upgrading aging pipelines and improving distribution system efficiency.

2. Optimize Bulk Water Procurement: Explore renegotiation of bulk water purchase agreements with MIDC or other suppliers to reduce long-term cost burdens.

3. Diversify and Decentralize Water Sources

- Promote local water harvesting solutions (e.g., rainwater harvesting, recharge wells) to reduce overdependence on distant bulk sources.
- Explore small-scale decentralized treatment and supply systems for underserved or remote areas.

4. Rehabilitate and Modernize Infrastructure

- Prioritize replacement of aging pipelines and leak-prone sections to reduce losses and improve supply reliability.
- Upgrade pumping and storage facilities to meet current and future demand.

5. Ensure Equitable Water Distribution

- Conduct water audits and pressure mapping to identify and address supply disparities across wards and neighbourhoods.
- Redesign distribution zones to ensure regular and fair access, especially in low-income coastal areas.

6. Improve Storage and Resilience at Household Level

- Support community-led construction of resilient water storage tanks in vulnerable areas.
 - Offer targeted subsidies or incentive schemes for water storage infrastructure in low-income households.
- 7. Enhance Service Continuity During Climate Events**
- Develop and implement climate-contingency protocols for emergency water supply during floods or cyclones.
 - Establish decentralized water kiosks or mobile distribution units for use during disruptions.
- 8. Strengthen Institutional Capacity and Data Systems**
- Improve GIS-based asset mapping and monitoring for better planning and maintenance.
 - Build ULB capacity for integrated water resource management and emergency response planning.
- 9. Promote Water Efficiency and Conservation**
- Launch public awareness campaigns on water conservation, especially in water-stressed and high-use zones.
 - Introduce incentives for water-efficient appliances and plumbing fixtures.

8.3 SANITATION

1. ***Climate-Resilient Sanitation Planning:*** Integrate climate risk assessments into sanitation planning to identify vulnerable areas and prioritize interventions.
2. ***Upgrade and Climate-Proof Infrastructure:***
 - Retrofit or relocate sanitation infrastructure in flood-prone and erosion-prone areas to reduce exposure.
 - Use flood-resilient designs for toilets, septic tanks, and treatment plants.
3. ***Strengthen On-Site Sanitation Management***
 - Promote climate-adapted septic systems and soak pits with sealed designs to prevent contamination during floods.
 - Ensure regular desludging and safe disposal, especially in low-lying and high water table zones.
4. ***Invest in Faecal Sludge and Wastewater Treatment***
 - Establish or upgrade FSSTPs with flood-safe siting and contingency protocols.
 - Promote decentralized wastewater systems to reduce reliance on centralized infrastructure during disruptions.
 - Introduce **scheduled desludging services** with proper monitoring instead of on-demand desludging.

- Ensure safe transport and disposal of sludge through stricter regulation and oversight.
- 5. **Enhance Institutional Coordination and Governance:** Foster collaboration across urban development, disaster management, and health departments for integrated sanitation resilience strategies.
- 6. **Secure Dedicated Funding for Resilient Sanitation:** Mobilize financial support from state and national schemes with earmarked funds for climate-adaptive sanitation infrastructure.
- 7. **Strengthen Sanitation Infrastructure**
 - a. Explore **decentralized and modular treatment systems** suited for high water table coastal areas.
 - b. Provide **subsidized household toilets** and septic tanks under SBM-U or state schemes.

8.4 FINANCIAL SUSTAINABILITY

1. **Enhance Local Revenue Generation**
 - Revise water and sanitation tariffs based on affordability and consumption levels.
 - Introduce volumetric pricing and metering to improve billing accuracy and reduce wastage.
 - Expand tax base and improve collection mechanisms for property tax and user charges.
2. **Improve Cost Recovery**
 - Develop a phased strategy to gradually increase cost recovery through rationalised tariffs and reduced operational losses.
 - Regularly monitor and benchmark cost recovery performance against similar towns.
3. **Strengthen Financial Planning and Budgeting**
 - Develop multi-year financial plans that account for future O&M (operation and maintenance) costs and capital investments.
 - Establish a contingency/resilience fund to manage uncertainties in grant disbursements.
4. **Institutional Capacity Building**
 - Build AMC's internal financial and technical capacity for improved budgeting, asset management, and service delivery.
 - Provide training to staff on cost accounting, financial reporting, and performance monitoring.
5. **Ensure Transparent Use of Grants**

- Link grant utilisation to performance indicators and community reporting to build accountability and trust.
- Regularly publish financial statements and audit findings related to WaSH services.

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. **Non-revenue water (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 Sustainable Development Goals (SDGs) and is relevant for climate adaptation frameworks. Additionally, it plays a critical role in estimating greenhouse gas (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)⁵¹ 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 the Ministry of Housing and Urban Affairs (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 the ULB 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.

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. Depinder Kapur 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

AMC Alibag Municipal Council

AMRUT Atal Mission for Rejuvenation and Urban Transformation

CCA Climate Change Adaptations

CDRI Coalition for Disaster Resilient Infrastructure

DDMP District Disaster Management Plan

DM District Magistrate

DMC Dwarka Municipal Council

DRR Disaster Risk Reduction

FSSTP Faecal Sludge and Septage Treatment Plant

GIRI Global Infrastructure Risk Model and Resilience Index

GIS 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

MSL Mean Sea Level

NbIS Nature-Based Infrastructure Solutions

NRW Non-Revenue Water

ODF Open Defecation Free

OSS On Site Sanitation Systems

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

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Supply System, Water Management Works through Sujal Nirmal Abhiyan Grant, expenditure for constructing Water Tank under Dalit Settlement Water Supply Scheme, Water Supply Depreciation Fund, Water Supply Deposit expenditure under Suvarna Jayanti Nagarotthan Mahabhiyan (State and District), expenditure under grants for 14th, and 15th Finance Commission, MPLAD scheme, expenditure through the grants received from MMRDA. Operating income (revenue) includes income from Water Supply Income by Tanker, Water Connection Fee, Water Supply Meter Fine, and General Water Tax. Operating expenditure is comprised of expenditure for Establishment (Including Salaries), Sump House Electricity Bills, Water Purchase Bills, Other Repair Maintenance, Annual Materials Purchase, Water Cess, Fuel for the Sump House Generator, Sump House Generator Repair and Maintenance, Pond Repair, Tuition Stipend for ITI Trainees, Purchase of New Solar Panels, Water and Energy Audit Costs, Security Guard/ Home-guard, Diesel Oil for Water Tankers, Water Tanker Repair, Chemicals for Water Purification (Chlorine, etc.), Purchase of New Generators, Pump Motor Maintenance and Repair, and expenditure for Provident Fund Subscription.

- 45 After the launch in 2014, the primary aim of AMRUT scheme is to ensure basic services such as water supply and sewerage for all. Initially, the scheme focused on a select 500 cities across India in its first phase, known as AMRUT 1.0. These cities were chosen based on various criteria, including population size, urbanization levels, and infrastructure needs. In 2021, AMRUT 2.0 was launched to target all statutory towns in the country, irrespective of their population (AMRUT 1.0, 2014; AMRUT 2.0, 2021). The Swachh Bharat Mission – Urban (SBM-U) 1.0, launched in 2014, marked a key step in India's efforts to enhance urban sanitation and hygiene. It focused on eliminating open defecation and improving solid waste management through the construction of toilets, waste segregation promotion, and public awareness campaigns. With a budget of approximately ₹14,623 crores (around \$2.2 billion), SBM-U aimed to develop sanitation infrastructure and support awareness initiatives. The initiative also introduced Swachh Survekshan, which ranks cities on sanitation practices, fostering competition among local bodies. Currently, SBM 2.0, launched in 2020, emphasizes sustainable practices, waste processing, recycling, and citizen participation, while leveraging technology for monitoring and improvement
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