Journal of Polity & Society (2024) 16(1), 231 - 248

Sustainable Urban Service Delivery: An Analysis of Water Supply, Waste Management and Pollution in Kerala's Urban Local Bodies

VIMAL V
Kannur University

VIPIN CHANDRAN K P
Krishna Menon Memorial Government Women's College

Achieving sustainability remains a persistent challenge for local governments globally, including in India. To tackle issues like climate change, air pollution, and energy security, Indian local administrations must adopt sustainable policies. Key urban services such as water supply, sewage management, pollution control, and waste management are crucial for citizen well-being. In Kerala, urban local bodies are increasingly embracing sustainable practices. This study assesses the sustainability of Kerala's urban local bodies by examining their water supply systems, waste management strategies, and land use patterns. It also investigates the impacts of water, air, and noise pollution on the urban environment, identifying opportunities for sustainable development. The findings are aimed at improving understanding of urban sustainability and providing recommendations to promote long-term urban viability.

Keywords: Urban local self-government, Service delivery system, Sustainability, Solid waste management, Pollution control, Urban development

---

Urban services such as water supply, transportation, pollution control, and waste management are crucial for city life. In India, rapid urbanisation and population growth heavily strain these systems, causing environmental degradation and challenging sustainable development. Despite numerous initiatives by cities and municipalities, there remains a significant need for enhanced and new sustainable urban strategies. A comprehensive approach that includes government, private sector, civil society, and citizens is crucial. In India, local governments are essential in promoting sustainability and enhancing the delivery of urban services. As the challenges of climate change, air pollution, and energy security deepen, the need for these governments to implement and enforce sustainable policies becomes increasingly critical (Bahadure & Bahadure, 2012; Randhawa & Kumar, 2017).

In recent years, urban local government institutions in Kerala have shifted towards sustainable service delivery approaches, particularly within municipal corporations. These initiatives prioritise efficient land use, water services, pollution control, and solid waste management to cultivate a sustainable future. Among the implemented measures are the promotion of organic farming, rainwater harvesting,

and waste segregation. Nevertheless, Kerala faces persistent challenges such as water, air, and noise pollution. Agricultural practices involving indiscriminate pesticide and fertiliser use contribute to soil and water pollution, while inadequate waste management infrastructure worsens the issue. Urban areas also contend with escalating air and noise pollution, adversely impacting citizen health and well-being (Rad et al., 2022).

Despite these challenges, sustainable urban services offer avenues for economic development, social well-being, and poverty reduction by improving access to basic services, creating job opportunities, and fostering social equity. This study aims to evaluate the sustainability of urban local bodies by analysing their water supply systems, solid waste management practices, pollution control and land use patterns in Kerala. In addition, it seeks to explore the feasibility of sustainable building practices by assessing the impacts of water, air, and noise pollution on the urban environment. This research seeks to provide insights into urban sustainability and present recommendations for enhancing long-term sustainability in urban areas.

Methodology

The present study aimed to evaluate the sustainability of service delivery practices in urban local bodies across Kerala. Employing a comprehensive methodology, both primary and secondary data were utilised. Primary data included structured questionnaires and semi-structured interviews with diverse stakeholders, including government officials, administrators, elected representatives, and citizens. Moreover, secondary data were gathered from reports issued by local, state, and central governments, alongside external sources such as the World Bank and Asian Development Bank, as well as publications from magazines and newspapers. This study meticulously selected four municipal corporations in Kerala - Thiruvananthapuram, Kollam, Thrissur, and Kozhikode - out of the state's six, ensuring representation across various geographical regions and city sizes. The selection process factored in geographic distribution and data accessibility to ensure a balanced and comprehensive sample. Data collection involved a blend of structured questionnaires, semi-structured interviews, and secondary sources to capture a holistic view of service delivery practices. Subsequent analysis employed descriptive statistics and thematic analysis to discern underlying patterns, emerging trends, and interrelationships among variables. The results obtained from the analysis led to the development of meaningful conclusions and recommendations.

Discussion

Land Use in the Urban Local Bodies of Kerala

Sustainable development heavily depends on land use practices, with local governments playing a crucial role in promoting them. Kerala's local administrations have made commendable strides in fulfilling this responsibility by introducing sustainable land use initiatives. These encompass the development of master plans, zoning regulations, and regulations for development control. Moreover, they advocate for eco-friendly waste management methods such as recycling, composting, and waste segregation. These efforts have effectively curbed waste generation and stimulated recycling, thereby fostering the creation of sustainable ecosystems and land utilisation patterns. Moreover, the revision of land use laws is essential for

cultivating sustainable communities (Verburg et al., 2015; Dale, 1997; Patricia E. Salkin, 2009). Local governments are instrumental in advancing resource conservation, mitigating environmental impact, and moderating resource depletion.

Sustainable land use practices should prioritise community-driven approaches that account for the environmental consequences of development. Local administrations must support green infrastructure, protect wetlands, and promote sustainable agricultural techniques (Kerala State Land Use Board, n.d; Salvador & Sancho, 2021). The Kerala State Action Plan on Climate Change (SAPCC) emphasises the dynamic role of local governments in fostering sustainability in land use planning. Their efforts include promoting mixed-use development, improving access to public transportation, and preserving natural ecosystems. Local authorities are committed to safeguarding marginalised communities from disproportionate exposure by facilitating affordable housing and meeting other essential needs (State Action Plan on Climate Change 2023-2030, 2022).

TABLE 1: **Land use pattern in the Urban Local Bodies of Kerala (in percent)**

Land Uses	Thiruvananthapuram	Thrissur	Kozhikode	Kollam
Residential	56	39.32	68	72.84
Agriculture	22	33.04	2.07	1.24
Paddy not cultivated	1	-	0.45	-
Public and semi-public land	13	10.17	4.7	5.5
Transportation	3	5.97	5.43	5.58
Water body	3	3.34	6.5	5.75
Commercial	1	1.6	2.89	2.13
Industrial	1	1.64	1.5	1.81
Park and open spaces	-	0.54	0.64	3.07
Others	-	4.38	7.82	2.08

Source: Master Plan of respective Municipal Corporations. (Thiruvananthapuram Municipal Corporation: Thiruvananthapuram Master Plan draft, Thrissur Municipal Corporation: Master plan for Thrissur City, Kozhikode Municipal Corporation: Master Plan for Kozhikode Urban Area – 2035, Kollam Municipal Corporation: City Development Plan for Kollam- 2041)

Table 1 illustrates that residential land use predominates in all four municipalities, trailed by public and semi-public land, transportation, water bodies, commercial and industrial land, and parks and open spaces. The substantial proportion of residential land use reflects the escalating population density in urban areas, driving the demand for additional housing. Kollam Municipal Corporation exhibits the highest residential land use percentage at 72.84%, followed by Kozhikode Municipal Corporation at 68%. Conversely, Thiruvananthapuram Municipal Corporation and Thrissur Municipal Corporation register relatively lower residential land use percentages at 56% and 39.32%, respectively. Nonetheless, excessive residential land use can precipitate environmental degradation and biodiversity loss.

Conversely, agricultural land use percentages are relatively modest across all municipalities, largely attributable to the conversion of agricultural land for commercial and residential purposes. Preserving agricultural land is imperative to

ensure food security and safeguard the natural environment (Governance of Land Use - OECD, n.d.). Thrissur Municipal Corporation records the highest agricultural land use percentage at 33.04%, followed by Thiruvananthapuram Municipal Corporation at 22%. Paddy cultivation is not prevalent in Thrissur Municipal Corporation and Kollam Municipal Corporation. Furthermore, Thiruvananthapuram Municipal Corporation exhibits the highest percentage of public and semi-public land use at 13%, followed by Thrissur Municipal Corporation at 10.17%. These insights highlight the necessity for effective land use management within Kerala's municipal corporations to foster a sustainable future (James Sarah, n.d). The allocation of transportation and public and semi-public land use shows a relatively even distribution across all four municipalities. However, advocating for sustainable transportation systems such as cycling and public transit is crucial for reducing carbon emissions and enhancing public health. Among these municipalities, Thrissur Municipal Corporation boasts the highest percentage of transportation land use at 5.97%, followed closely by Kollam Municipal Corporation at 5.58% and Kozhikode Municipal Corporation at 5.43%. Thiruvananthapuram Municipal Corporation exhibits comparatively lower transportation land use percentages at 3%.

The variances in land use patterns among municipalities bear significant implications for the region's sustainable development. Therefore, implementing effective land use management policies tailored to the distinctive characteristics and requirements of each municipality is imperative for fostering sustainable future growth (OECD, 2020). For instance, policies tailored to Thrissur Municipal Corporation, with its notable agricultural land use, may prioritise promoting sustainable agricultural practices and biodiversity conservation. Meanwhile, Kollam Municipal Corporation, with a substantial proportion of public and semi-public land use, could focus on strengthening green infrastructure and enhancing public transportation connectivity (FAO, n.d.).

Water Supply System

In Kerala, the water supply system comprises surface water sources like rivers, streams, and reservoirs, as well as groundwater sources such as wells and bore wells. The Kerala Water Authority (KWA) oversees the state-wide water supply system and distributes treated water to local bodies. By assigning regional offices to specific areas across the state, the KWA ensures efficient water distribution. Moreover, local bodies, including municipal corporations, play a significant role in managing water supply within their respective jurisdictions (Kerala Water Supply and Sewerage Act 14 of 1986 Amendments and Other Regulations, n.d; Performance Report: Kerala Water Authority, 2022). Water management in Kerala holds a vital position due to its dense population and numerous urban areas, which strain the state's limited water resources. Despite efforts to ensure universal access to drinking water, there's still room for enhancing the quality and reliability of water supply in urban regions.

The capacity of water storage reservoirs varies among municipal corporations, with Thiruvananthapuram boasting a capacity of 63.25 million litres, while Kozhikode's stands at 10.8 million litres. Effective management and utilisation of water resources are imperative to ensure a sustainable and equitable water supply to meet the growing demands of Kerala's populace (Manual of Resident Audit Office, Kerala Water Authority, n.d). The capacity of water storage reservoirs significantly influences the continuous and sufficient provision of water. Local bodies are tasked

with managing the water supply system and ensuring fair distribution to all households and businesses, irrespective of their location or economic status. While the structure and management of water supply systems in Thiruvananthapuram, Kollam, Thrissur, and Kozhikode Municipal Corporations are similar, performance varies based on factors like water resource availability, reservoir capacity, and distribution network efficiency (Performance Report: Kerala Water Authority, 2022).

TABLE 2:**Sources of Water in the Municipal Corporations in Kerala (in percent)**

Sources of Water	Thiruvananthapuram	Thrissur	Kozhikode	Kollam
Kerala Water Authority/ or corporation	81	30.57	30	76.62
Own well	10	80.43	64.2	12.37
Public water supply/public				
bore well	5	2.29	4	4.31
Other sources	4	-	1	5.49
River	-	0.01	0.08	1.21

Source: Master Plan of respective municipal corporations

Thiruvananthapuram and Kollam exhibit significant dependence on the Kerala Water Authority, with 81% and 76.62% of their water supply sourced from this centralised entity, respectively. This highlights a centralised and organised approach to water management in these cities, where a large portion of the population depends on a regulated source. Conversely, Thrissur demonstrates a high reliance on its wells, with 80.43% of its water supply sourced from individual wells. This decentralised approach suggests a high level of self-sufficiency among Thrissur residents in meeting their water needs. Public water supply and public bore wells are evenly distributed among the municipalities, with Thrissur showing the highest reliance on public bore wells at 4.31%. These sources play a crucial role in providing accessible water to the population, ensuring equitable access to clean water. Moreover, other sources and rivers are utilised as water sources, although not predominantly in any municipality. Kollam, for instance, relies on other sources for 5.49% of its water supply, indicating a diversified approach. The utilisation of rivers, although in small percentages, in Kozhikode and Kollam suggests the integration of surface water sources into municipal water supply systems. This analysis highlights the complexity of urban water supply dynamics, revealing diverse source utilisation ranging from centralised authorities to individual wells and public supply sources. Such data is invaluable for urban planners, policymakers, and water authorities seeking to enhance the sustainability and reliability of water supply systems in these urban areas.

Groundwater Management

Groundwater stands as a crucial resource in achieving universal access to drinking water, sanitation, and hygiene, aligning with the Sustainable Development Goals. In Kerala, its significance has escalated due to diminishing river systems, loss of wetlands

and paddy fields, escalating demand, over-exploitation, and pollution (Varma, n.d.). Managed by both government and private entities, groundwater serves millions of farmers in Kerala and is pivotal for irrigation, constituting 43% of global water usage for this purpose. It sustains stream flow during dry periods and plays a vital role in maintaining numerous lakes and wetlands. The imperative lies in monitoring and managing groundwater resources to prevent pollution and over-extraction, thereby ensuring sustainable utilisation for future generations (Varma, n.d.).

According to the Groundwater Estimation Committee appointed by the Government of India, groundwater in phreatic aquifers in Kerala is generally fresh and suitable for domestic, irrigation, and industrial purposes. The occurrence and movement of groundwater across various litho-units in the state are influenced by diverse terrain units. Depths to water levels in aquifers range from 2 to 16 metres below ground level, with well yields varying between 2 to 10 cubic metres per day. Experimental drilling conducted by the Central Ground Water Board in crystalline overburden and wells situated in elevated areas contributes to understanding groundwater dynamics. Rainfall serves as a primary recharge mechanism for groundwater, with pre-monsoon and post-monsoon seasons significantly impacting recharge levels.

TABLE 3: **Ground water recharge and monsoon contribution in Municipal Corporation and Districts**

Assessment Unit/ District	Thiruvana-nthapuram MC	Thiruvana-nthapuram District	Kollam MC	Thrissur MC	Thrissur district	Kozhikode MC	Kozhikode district
Total Geographical Area of Block (Ha)	33727	218797	14703	22892	302385	16351	234230
Rainfall (mm)	1818.94	1818.94	2417.69	3176.64	3176.6	3382.46	3382.46
Average Pre monsoon Water level (mbgl)	8.68	9.17	7.31	10.36	6.53	4.67	5.21
Average Post monsoon Water Level (mbgl)	6.9	7.44	5.97	9.02	4.9	3.29	3.66
Recharge from rainfall during monsoon season	4299.22	21075.45	2651.36	3629.66	45874.26	2472.27	31186.83
Recharge from other sources during monsoon season	32	570.29	135.54	129.9	840.67	34.86	398.96

Recharge from rainfall during non-monsoon season	986.47	5623.81	349.33	116.98	1999.45	365.65	1565.21
Recharge from other sources during non-monsoon season	137.52	2734.43	345.38	1922.63	14282.56	143.74	1437.35
Total Annual Ground Water Recharge	5455.21	30003.98	3481.61	5799.17	62996.94	3016.52	34588.35

Source: ground water resource of Kerala

In Kerala, groundwater recharge from rainfall during the monsoon season varies significantly across districts and municipal corporations and constitutes the primary contributor to total annual groundwater recharge. Notably, despite Thiruvananthapuram Municipal Corporation and District receiving lower rainfall amounts compared to other districts by 1818.94 mm, they exhibit a substantial total annual groundwater recharge of 30003 ha.m. This is attributed to high recharge from other sources during non-monsoon seasons, totaling 5455.21 ha.m, significantly contributing to the district-level performance. Conversely, Kollam Municipal Corporation experiences higher rainfall during the monsoon season (2417.69 mm) than Thiruvananthapuram but registers a lower total annual groundwater recharge due to lesser recharge (348161 ha.m) from other sources during non-monsoon seasons. However, the high recharge from rainfall during the monsoon season significantly impacts groundwater recharge.

Similarly, Kozhikode Municipal Corporation records higher monsoon season rainfall (3382.46 mm) than Thiruvananthapuram and Kollam Municipal Corporations. However, it demonstrates a lower total annual groundwater recharge due to reduced recharge from other sources during non-monsoon seasons. Thrissur Municipal Corporation receives higher rainfall during the monsoon season (3176.64 mm) compared to Thiruvananthapuram, Kollam, and Kozhikode Municipal Corporations. It contributes nearly 20% of the total annual groundwater recharge in the district, totaling 5799.17 ha.m, attributed to significant recharge from rainfall during both monsoon and non-monsoon seasons, as well as recharge from other sources during non-monsoon seasons. The significance of monsoon rainfall in recharging groundwater determines the total annual groundwater replenishment in Kerala, with variations in performance observed across municipal corporations and districts. For sustainable groundwater management and ensuring long-term water availability, it is crucial to comprehend the dynamics of both monsoon and non-monsoon recharge.

Solid Waste Management

Efficient management of solid waste is a critical issue in Kerala, prompting various initiatives by local governments and international organisations. The Asian Development Bank funds the Kerala Sustainable Urban Development project, aiming to improve access to reliable solid waste management services in urban areas. Moreover, the World Bank has approved a $105 million project to bolster the state's

solid waste management systems, prioritising operational, financial, and environmental sustainability while enhancing flood resilience. The Government of Kerala's 'Haritha Kerala Mission' prioritises solid waste management. A collaborative framework involving businesses, governments, and academic institutions has been established to advance waste management solutions. This approach emphasises integrated solutions engaging all stakeholders for effective solid waste management (Anuardo et al., 2022).

Waste management poses a significant challenge in Kerala, but innovative solutions have emerged in two cities. Thiruvananthapuram launched a unique campaign post a public health emergency, encouraging residents to manage their waste better. The local government distributed compost bins to each neighbourhood for solid waste management, encompassing plastic bottles and food scraps. Conversely, Alappuzha initiated a pilot project across 12 wards, utilising slurry from bins as fertiliser for homes with gardens. Awareness campaigns were integral, teaching waste segregation and processing techniques, culminating in the state-wide program "Haritha Keralam" (Green Kerala). This initiative aims to achieve a garbage-free Kerala by 2020 through decentralised composting and recycling units at the panchayat level (Gopalan Sajan, 2020; Weisbrod Katelyn, 2019).

TABLE 4 **:Solid waste compositions in the Urban Local Bodies of Kerala (in percent)**

Solid Waste Compositions	Thiruvananthapuram	Thrissur	Kozhikode	Kollam
Domestic	57	63.76	47	55.88
Street sweeping	16	-	10	8.24
Commercial	8	22.73	24	10
Restaurants Hotels	6	-	7	11.18
Market	5	5.78	6	3.53
Slaughter houses	2	3.12	4	1.18
Schools & institutions	1	-	-	4.12
Hospital	-	2.18	2	1.18
others	6	2.43	-	4.71

Source: Same as Table 1.

Table 4 reveals that domestic waste is the primary source of waste in all four cities, with Thrissur recording the highest percentage at 64% and Kozhikode the lowest at 47%. Commercial waste follows, with Kozhikode leading at 24% and Thrissur at the lowest with 23%. Notably, restaurants and hotels contribute significantly to waste generation in Kollam (11.18%) and Kozhikode (7%). Likewise, the market is a notable waste source in Kozhikode (6%), Thrissur (5.78%), and Kollam (3.53%). Slaughterhouses also contribute, with Kozhikode reporting the highest percentage at 4% and Kollam the lowest at 1.18%. Overall, domestic waste remains a significant challenge across all Municipal Corporations, while differing waste management policies and sources influence waste composition. For instance, Kollam focuses on

waste from restaurants, hotels, and the market, whereas Thrissur prioritises commercial waste.

Water Pollution

Water pollution poses a severe environmental threat in several major cities of Kerala, due to rapid urbanisation, industrialisation, and inadequate waste management systems, despite the state's abundant water resources. In Thiruvananthapuram, domestic sewage, industrial effluents, and agricultural runoff are the primary pollutants, with the city generating about 207 million litres of sewage daily, of which only around 80% undergoes treatment before discharge (Kerala State Pollution Control Board, 2017). Industrial activities, including 5000 small-scale and 100 large-scale industries, significantly contribute to pollution, notably contaminating the Karamana River. Drinking water sources, primarily groundwater, face contamination due to poor sanitation and landfill waste disposal. The Thiruvananthapuram Municipal Corporation has initiated projects such as sewage treatment plants, biogas plants, and rainwater harvesting, alongside strict regulations to control industrial waste discharge (Kerala State Pollution Control Board, 2017). In Kollam, the Ashtamudi Lake faces severe water pollution threats due to untreated sewage and industrial waste discharge, with the city producing approximately 44 million litres of sewage daily, of which only 40% undergoes treatment (City Development Plan for Kollam - 2041, 2014). Small-scale industries, like cashew processing units, discharge untreated effluents into water bodies, and a 2017 study by the Kerala State Pollution Control Board revealed compromised water quality, rendering it unsuitable for any purpose.

Thrissur Municipal Corporation contends with water pollution from industrial effluents, domestic sewage, and agricultural runoff, with the city's canals, serving as transportation and drainage routes, heavily contaminated with sewage and solid waste, posing health risks (Kerala State Pollution Control Board, 2017; Environment Master Plan for Thrissur City, n.d.). The Chalakudy River, traversing the city, suffers from pollution due to industrial and domestic waste dumping, and despite producing 65 million litres of sewage daily; only 40% undergoes treatment before release. Agricultural practices using chemical fertilisers and pesticides further pollute groundwater and surface water, exacerbated by unrestrained bore well use, worsening water scarcity. In Kozhikode, untreated sewage and industrial effluents heavily pollute water bodies like the Kallai River and Canoli Canal, with the city generating 150 million litres of sewage daily, of which only 60% undergoes treatment (Chitharanjan, 2016). Small-scale industries worsen the issue by releasing untreated effluents, and inadequate sanitation and landfill waste further contaminate groundwater, posing health risks like cholera and hepatitis. While the Kozhikode Corporation installed sewage treatment plants to mitigate pollution, sustainable waste management remains crucial, and community involvement and education are vital to curb water pollution effectively.

TABLE 5:**Water quality parameters for all river stations in April 2021**

River Station	Temperature(°C)	pH	Conductivity (µS/cm)	Turbidity (NTU)	Total Alkalinity	Chlorides (mg/L)	COD (mg/L)	Hardness (mg/L)	DO (mg/L)	TC (MPN/100ml)	FC (MPN/100ml)
Thumpamon	24	6.8	181	1.7	39	36	8	54	6.9	540	180
Chennithala	23	6.7	171	2.3	44	38	8	50	6.6	380	110
Kallarakkadavu	23	6.8	191	1.6	36	38	9	50	6.5	380	110
Pandalam	25	6.3	190	1.2	34	39	8	52	6.2	460	130
Chengannur	30	7.5	56	2.8	0	10	0	24	6.2	310	100
Thakazhi	32	7.2	87	2.7	0	14	6.4	28	5.1	100	84
Pamba Down	32	6.4	71	3	0	12	6.4	26	7	390	140
Kidangoor	26	6.9	65	3.3	25	8	6.4	18	6.9	1200	700
Kalloorppara	30	7.2	186	0	40	40	8	50	5.2	2100	840
Thondara	30	7.4	147	0	30	30	0	30	5.1	100	0
Eloor	30	6.8	11100	0	55	3100	8	1350	8	2000	260
Kalady	31	6.4	35	2.2	0	0	0	12	7	1200	430
Ashtamudi	24	6.4	16290	1.2	130	5010	46	1900	6.1	400	110
Paravur	23	6.9	13560	2	64	4810	24	810	6.3	490	140
Aluva	30	6	50	1.9	0	0	0	0	6	400006300	

Source: Water Air Quality Directory 2021 Kerala State Pollution Control Board

The water quality data for river stations in Kerala in April 2021 reveals concerning levels of pollution in many rivers. High turbidity levels above 5 NTU, indicating significant suspended sediment loads, were observed at stations like Pamba Down, Kidangoor, Chengannur, and Thakazhi, rendering the water unsuitable for drinking without treatment according to the CPCB guidelines (Water Air Quality Directory 2021, 2021). Alarmingly high faecal coliform (FC) counts exceeding 500 MPN/100ml were recorded at stations like Kidangoor, Kalloorppara, and Aluva, indicating potential contamination from human/animal waste and rendering the water unsuitable for outdoor bathing as per CPCB standards (Kerala State Pollution Control Board, 2019). Extremely high total dissolved solids (TDS) over 500 mg/L at stations like Eloor, Ashtamudi, and Paravur point to inorganic pollution, possibly from industrial effluents (Meera & Bijoy Nandan, 2010). At industrial hotspots like Eloor and Ashtamudi, very high conductivity levels exceeding 1000 ìS/cm, indicative of unchecked discharges, corresponded to elevated chloride levels surpassing 1000 mg/L. These findings, previously linked to industrial sources, were reported in the Water Air Quality Directory 2021.

Nutrient contamination, as indicated by elevated levels of COD, nitrates, and phosphates at specific stations, has been identified as a factor promoting eutrophication hazards (Chattopadhyay, 2020). This data emphasises significant concerns regarding municipal and industrial pollution loads that degrade river water quality across Kerala. Implementing stringent discharge norms and proper waste

treatment mechanisms is essential to address this alarming trend and preserve the ecological integrity of riverine systems, under mandates from the CPCB and NGT.

Air and Noise Pollution

Air and noise pollution are critical environmental concerns that have been increasingly affecting the urban districts of Kerala. The state's rapid development has led to a surge in pollution levels, primarily due to vehicular emissions, industrial activities, and construction work. These pollutants not only degrade the environment but also pose serious health risks to the population. In Thiruvananthapuram, the busy state capital, air quality is a major issue, particularly due to the dense traffic and industrial activities in areas like Techno Park. Construction sites contribute to the problem with the use of diesel generators, which release significant pollutants into the air. Noise pollution is another significant concern, especially in crowded places such as the Palayam market. The local government has taken several measures to combat these issues, including the implementation of an Air Quality Index monitoring system, promotion of public transport, and strict regulations on construction activities to control pollution levels (Thiruvananthapuram Corporation Master Plan, 2021.). Kollam faces similar environmental challenges. The district is home to numerous small-scale industries, including cashew processing units that burn coal and wood, releasing large amounts of particulate matter into the atmosphere. The heavy traffic contributes to both air and noise pollution, particularly in the commercial zones. The Kollam Municipal Corporation has installed air quality monitoring stations and has been promoting public transport to reduce the reliance on private vehicles. They have also enforced strict emission standards to improve air quality (City Development Plan for Kollam, 2014).

Thrissur, known for its vibrant textile industry, is another district grappling with air pollution. The industrial emissions from textile mills, combined with the dust from construction sites, significantly contribute to the particulate matter in the air. The noise from traffic, construction, and industrial operations is a constant source of disturbance. In response, the Thrissur Municipal Corporation has introduced initiatives like promoting cycling and restricting loudspeaker usage after certain hours. They have also installed noise barriers near construction sites to minimise the impact on the surrounding areas (Master Plan for Thrissur city Environment, n.d.). Kozhikode's air quality issues are highlighted by the fact that in 2020, the average PM2.5 levels were recorded at 52.2 μg/m³, which is higher than the National Ambient Air Quality Standards (NAAQS) limit of 40 μg/m³. The NO2 levels, mainly from vehicle exhaust and industrial emissions, averaged 25.9 μg/m³, also exceeding the NAAQS levels. These pollutants are known to cause respiratory illnesses such as bronchitis and asthma.

The Kozhikode Corporation has been actively monitoring air quality, promoting the use of public transport, and enforcing stringent emission standards for industries and vehicles to address these concerns (Peris Eulalia, 2020). Despite the efforts made by municipal corporations, the progress in reducing pollution has been slow. This is largely due to the lack of enforcement and compliance with the existing regulations. The municipalities must strengthen their monitoring and enforcement mechanisms, engage with stakeholders to foster behavioural change and utilise technology to pinpoint pollution hotspots. To effectively tackle the root causes of pollution, a shift towards cleaner energy sources is necessary. Promoting sustainable

transportation options and adopting circular economy practices are essential steps to reduce waste and emissions. Municipal corporations have the opportunity to spearhead systemic changes and promote a long-term perspective on environmental management, paving the way for a sustainable future.

Sustainability Initiatives of Urban Local Bodies

Urban Local Bodies (ULBs) and Panchayati Raj Institutions (PRIs) in India, particularly in Kerala, are at the forefront of implementing sustainable development initiatives that are closely aligned with the Sustainable Development Goals (SDGs). These local governance bodies, strengthened by the financial support from the 14th Finance Commission, undertake a variety of projects aimed at enhancing the quality of life for their communities while promoting environmental sustainability (Gandham et al., 2019; Karim & Rupa, 2017). In Kerala, the Kerala Sustainable Urban Development Project (KSUDP) is a notable initiative funded by the Government of India and the Asian Development Bank. It focuses on sustainably improving urban infrastructure services, serving as a 'Special Purpose Vehicle' (SPV) to implement multi-disciplinary projects under the Local Self-Government Department (Kerala Sustainable Urban Development Project | LSGD, n.d.).

The Kerala Institute of Local Administration (KILA) has developed a fact sheet that provides a comprehensive overview of the state's progress in achieving the SDGs. This document serves as a valuable resource for local bodies to understand the importance of localising SDGs and creating a roadmap for future development (Fact Sheet of Sustainable Development Goals Kerala Status, 2023). Moreover, Kerala's ULBs are set to enhance their solid waste management capabilities with the introduction of solid waste management engineers under the Kerala Solid Waste Management Project (KSWMP), supported by the World Bank and Asian Infrastructure Investment Bank. This initiative aims to improve decentralised solid waste management systems, which is crucial for reducing environmental pollution and promoting resource efficiency (The Hindu, 2022). These efforts are complemented by a range of programs that promote sustainable agricultural practices, such as organic farming, zero-budget natural farming, watershed development, and biodiversity conservation. These practices not only reduce the reliance on chemical fertilisers and pesticides but also contribute to healthier food systems and environmental conservation (Joseph et al., 2020; Neeraja, 2019). Renewable energy is another area where significant strides have been made. Projects involving biogas plants, solar power installations, and micro-hydel projects are increasingly common, helping communities to reduce their dependence on fossil fuels and lower greenhouse gas emissions. Disaster management planning is also a critical focus, with local bodies developing comprehensive strategies to enhance community resilience against natural calamities. The Kerala Rural Water Supply Augmentation Programme (KRWSAP) is a prime example of the state's commitment to ensuring access to safe drinking water, especially in rural areas, while also addressing issues such as water pollution and illegal sand mining (Kerala Rural Water Supply and Sanitation Agency, n.d.).

To combat air and noise pollution, local bodies have implemented vehicle emission testing programs, established noise pollution control units, and promoted green transportation methods, such as the development of pedestrian and cycle-friendly infrastructure (Ullas, 2020). These initiatives demonstrate the proactive

role played by Kerala's ULBs and PRIs in promoting sustainable development. In Kerala, sustainable construction entails implementing practices that minimise environmental impact, conserve resources, and enhance social well-being throughout the lifespan of buildings, integrating energy efficiency, water conservation, waste reduction, and eco-friendly materials. Local self-governments in Kerala hold a crucial role in advancing sustainable construction by establishing and enforcing regulations on building codes, land use planning, and environmental protection. Through the incorporation of sustainability criteria into building regulations and zoning ordinances, local governments incentivise developers and builders to embrace eco-friendly construction practices. Their involvement in promoting sustainable construction is multifaceted, spanning regulatory, promotional, and educational efforts, aimed at aligning policies and practices with sustainability principles to foster healthier, more resilient, and environmentally responsible built environments.

Policy Interventions at the Urban Local level

Kerala claims significant resources conducive to sustainable development, including a well-educated populace, fertile land, and abundant water bodies. However, despite governmental efforts, the integration of sustainable development practices has been challenging (Towards Kerala's Sustainable Development, 2022). To address this, the Government of Kerala has launched various initiatives, including the Kerala Sustainable Urban Development Project (KSUDP). Operating as a Special Purpose Vehicle (SPV) under the Local Self-Government Department (LSGD), KSUDP is tasked with implementing multi-disciplinary projects to enhance urban infrastructure services sustainably. With financial backing from both the Government of India and the Asian Development Bank, KSUDP aims to foster sustainable urban development. Furthermore, it serves as the State Level Nodal Agency for components of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) (Kerala Sustainable Urban Development Project, LSG Kerala). Kerala's Responsible Tourism Mission, initiated by the Government, stands as a crucial effort to promote sustainable tourism practices. Tasked with executing the Rural Tourism Development Project of the Ministry of Tourism, Government of India, it also serves as the State Nodal Agency for the same. Embracing a triple-bottom-line approach, the mission emphasises the economic, social, and environmental facets of sustainable tourism. The initiative's fundamental goal is to harness tourism as a driving force for local community development, poverty reduction, and the empowerment of women. To brace for potential future disasters, the Government of Kerala has implemented a range of measures, including risk-informed urban master planning, multi-year investment budgeting, and the adoption of emergency management protocols. Further strengthening the state's resilience, the World Bank has sanctioned a $125 million program to enhance climate adaptation, resource management, and the resilience of agriculture and road sectors to disasters. The First Resilient Kerala Development Policy Operation (DPO), endorsed in June 2019, introduced various measures, including the formulation of a River Basin Conservation and Management Act to safeguard and manage river basins across the state.

Achieving sustainable urban development in Kerala necessitates tackling various critical issues, including land use, water supply, solid waste management, and air and water pollution. An integral aspect involves enhancing land use practices through

mixed-use development, which entails integrating residential, commercial, and industrial spaces within a single area while preserving green spaces and promoting urban agriculture. These efforts can enhance food security, mitigate the urban heat island effect, improve public health, and reduce carbon emissions. Ensuring efficient water supply is paramount, leveraging Kerala's abundant rainfall through rainwater harvesting systems and optimising water distribution networks to minimise loss and ensure equitable access to clean water. These initiatives not only reduce freshwater demand but also strengthen resilience against droughts.

Effective solid waste management remains a persistent challenge necessitating collaborative efforts from both state and local governments. Initiatives like waste segregation at the source and efficient waste collection systems are essential in addressing this issue. Encouraging recycling and composting practices can substantially diminish landfill waste volume, strengthening sustainability efforts. Furthermore, leveraging waste-to-energy facilities offers an innovative approach to managing non-recyclable waste while generating electricity, aligning with renewable energy objectives. Alongside, combating air and water pollution is essential for sustainable urban development. Enforcing stringent emission standards for industries and vehicles is imperative to mitigate air pollution and enhance air quality. Promoting alternative transportation modes like public transit, cycling, and electric vehicles can mitigate carbon emissions and alleviate traffic congestion. Implementing efficient wastewater treatment systems is essential to prevent water pollution and protect water bodies, thereby fostering a healthier environment for the residents of Kerala.

The Government of Kerala has made substantial strides in fostering a sustainable future by allocating funds through its 2023-24 budget. Notably, the budget underlines a commitment to sustainable and modern development, exemplified by 'Nava Kerala' (New Kerala) initiative. With an ambitious target of achieving net-zero carbon emissions by 2050, the state is incentivising consumers to adopt solar energy by offering interest subsidies on loans for solar panel installations. Provisions for new energy parks and the formulation of a fresh energy policy underscore the government's dedication to renewable energy sources. The budget also reflects a prioritisation of education, sports, arts, and culture, evident in the increased allocation of funds. However, despite these commendable efforts, challenges persist, notably in balancing committed expenditures, such as employee salaries and pension liabilities, against available funds for development projects. With committed expenses expected to rise by 5% and accounting for 70% of total expenditure, sustaining long-term asset creation and future development initiatives remains a significant challenge. Achieving a sustainable future requires collaboration among various stakeholders, extending beyond the state government.

Local governments, the private sector, and civil society play central roles in shaping and implementing sustainable urban development policies. Policymakers must incentivise innovation and the adoption of technology to tackle pressing urban challenges like traffic congestion, air pollution, and water scarcity. Smart city solutions offer promising avenues for optimising traffic flow and improving energy efficiency in buildings. To advance sustainable development in Kerala, the state government should increase budgetary allocations for development projects, with a focus on education, healthcare, gender equality, and poverty alleviation. Thiruvananthapuram and Kochi's high rankings in the NITI Aayog's Urban Sustainable

Development Goal Index underscore the importance of replicating their successes state-wide. Collaboration among stakeholders in Kerala, including local governments, the private sector, and civil society, is crucial for achieving sustainable development. This involves collective action, innovative policy prioritisation, technology adoption, and efficient resource utilisation to ensure a more sustainable future for citizens.

Conclusion

The municipal corporations in Kerala have made significant steps towards building a sustainable future through effective land use management, water service delivery, and solid waste management practices. Policies promoting organic farming, rainwater harvesting, and waste segregation have yielded positive outcomes. Despite progress, challenges persist, particularly concerning water, air, and noise pollution. Pesticide and fertiliser misuse in agriculture exacerbate soil and water pollution, while urban areas grapple with air and noise pollution, impacting public health. To address these issues, a comprehensive, integrated approach is essential. Enhanced coordination among government agencies, the private sector, and civil society organisations is crucial. Encouraging the adoption of innovative technologies and practices can mitigate the adverse environmental effects of human activities.

Achieving a sustainable future centres on enhancing land use management, refining water service delivery, and implementing robust solid waste management practices. For instance, advocating mixed-use development can minimise commuting distances and foster walkable communities, thus optimising land use. Leveraging Kerala's ample rainfall through rainwater harvesting systems and bolstering water distribution networks can ensure equitable access to clean water while curbing water loss. Implementation of innovative solutions like smart city technologies can streamline traffic flow and slash energy consumption in buildings, contributing to sustainability efforts. Moreover, promoting eco-friendly transportation modes like public transit, cycling, and electric vehicles can mitigate carbon emissions and alleviate traffic congestion. Though the journey toward sustainability may pose challenges, concerted efforts from all stakeholders can pave the way for a cleaner, greener, and more sustainable future. Kerala can steer towards enduring sustainability by nurturing collaboration and embracing innovative strategies.

References

Agarwal, R., & Chaudhary, M. (2015). Waste management initiatives in India for human wellbeing. International Journal of Environment, Ecology, Family and Urban Studies, 5(2), 1-8.

Anuardo, R. G., Espuny, M., Costa, A. C. F., & Oliveira, O. J. (2022). Toward a cleaner and more sustainable world: A framework to develop and improve waste management through organisations, governments and academia. Heliyon, *8*(4), e09225. https://doi.org/10.1016/j.heliyon.2022.e09225

Calicut Air Quality Index (AQI): Real-Time Air Pollution | Kerala. (2023). Air Quality Index (AQI) - Pure Logic Labs India Pvt Ltd. Retrieved 2nd March 2023, from https://www.aqi.in/in/dashboard/india/kerala/calicut

Chattopadhyay, S. (2020). Water quality degradation in Kerala: The challenge ahead. Kerala Economy. Gulati Institute of Finance and Taxation.

Chitharanjan, S. (2016, 10th May). Kozhikode corporation to act tough against those polluting drains. The Times of India. https://timesofindia.indiatimes.com/city/

kozhikode/kozhikode-corporation-to-act-tough-against-those-polluting-drains/articleshow/52198155.cms

City Development Plan for Kollam, 2041. (2014). Kollam Municipal Corporation. http://kollamcorporation.gov.in/sites/default/files/202403/Final%20MASTER%20PLAN1.pdf

Directorate of Environment and Climate Change, Government of Kerala. (2022). State action plan on climate change 2023-2030. https://envt.kerala.gov.in/wp-content/uploads/2022/12/Kerala-State-Action-Plan-on-Climate-Change-2.0.pdf

Food and Agriculture Organization of the United Nations. (n.d.). Sustainable land management. Land & Water. Retrieved 1st March 2023, from https://www.fao.org/land-water/land/sustainable-land-management/en/

Gopalan, S. (2020, 22nd December). The tale of two cities: Two Kerala models for waste management. Policy Circle. Retrieved 2nd March 2023, from https://www.policycircle.org/environment/the-tale-of-two-cities-two-kerala-models-for-waste-management/

IQAir. (2023). Thiruvananthapuram air quality index (AQI) and India air pollution. Retrieved 2nd March 2023, from https://www.iqair.com/in-en/india/kerala/thiruvananthapuram

IQAir. (2023). Thrissur air quality index (AQI) and India air pollution. Retrieved 2nd March 2023, from https://www.iqair.com/in-en/india/kerala/trichur

James, S. (n.d.). Local governments and sustainability: The power of public goods. Public Administration Review. American Society for Public Administration. Retrieved 1st March 2023, from https://patimes.org/local-governments-sustainability-power-public-goods/

Kerala Solid Waste Management Project - Projects - AIIB. (n.d.). Retrieved 2nd March 2023, from https://www.aiib.org/en/projects/details/2021/approved/India-Kerala-Solid-Waste-Management-Project.html

Kerala State Land Use Board. (n.d.). Projects and programmes strengthening state land use. Department of Planning and Economic Affairs, Government of Kerala. Retrieved 1st March 2023, from https://www.kslub.kerala.gov.in/index.php/about-us/important-officials/2-uncategorised/38-proejcts

Kerala State Pollution Control Board. (2017). Report by the Kerala State Pollution Control Board on pollution. Government of Kerala.

Kerala State Pollution Control Board. (2021). Water air quality directory 2021. https://kspcb.kerala.gov.in/assets/uploads/widget/directory/Water_Air_Quality_Directory_2021_(2).pdf

Kerala State Pollution Control Board. (n.d.). Kerala State Pollution Control Board. Retrieved 2nd March 2023, from https://kspcb.kerala.gov.in/

Kerala Sustainable Urban Development | Asian Development Bank. (2005). Retrieved 2nd March 2023, from https://www.adb.org/projects/32300-012/main

Kerala Urban Service Delivery Project (KUSDP). (n.d.). Kerala Urban Service Delivery Project (KUSDP) Terms of Reference Strategic Assessment of Solid Waste Management Services and Systems in Kerala.

Kerala Water Authority. (2015-2023). Performance report: Kerala Water Authority. Government of Kerala. https://kwa.kerala.gov.in/en/performance-report/

Kerala Water Authority. (n.d.). Kerala Water Supply and Sewerage Act 14 of 1986 amendments and other regulations.

Kumar, S., Smith, S. R., Fowler, G., Velis, C., Kumar, S. J., Arya, S., Rena, Kumar, R., & Cheeseman, C. (2017). Challenges and opportunities associated with waste management

in India. Royal Society Open Science, *4*(3), 160764. https://doi.org/10.1098/RSOS.160764

Manual of Resident Audit Office, Kerala Water Authority (First Edition). (n.d.). Retrieved 1st March 2023, from www.pdffactory.com

Master Plan for Kozhikode Urban Area – 2035. (n.d.). Kozhikode Municipal Corporation. https://kozhikodecorporation.lsgkerala.gov.in/system/files/2019-06/master-plan-kozhikode-corp-report.pdf

Master Plan for Thrissur City drinking water. (n.d.). Thrissur Municipal Corporation. https://thrissurcorporation.lsgkerala.gov.in/en/master_plan

Mater Plan Thiruvananthapuram. (2021). Thiruvananthapuram Municipal Corporation Department of Town and Country Planning, Government of Kerala. https://drive.google.com/drive/folders/1ixdzxqI5yNT31DrXHotdktDkbeIG-u1T

Maya, S. M., & Sreedevi, C. (2015). Analysis of traffic noise pollution in Thiruvananthapuram City using mapping and modelling. International Journal of Engineering Research & Technology (IJERT), *4*(11), 67-72. https://www.ijert.org/research/analysis-of-traffic-noise-pollution-in-thiruvananthapuram-city-using-mapping-and-modelling.pdf

Meera, S., & Bijoy Nandan, S. (2010). Water quality status and primary productivity of Valanthakad Backwater in Kerala. Indian Journal of Marine Sciences, 39(1), 105-113.

Merlin, S. (2017, 2nd March). What India can learn from Alappuzha about waste management. The Print. Retrieved 2nd March 2023, from https://theprint.in/india/governance/india-learn-alappuzha-waste-management/19258/

OECD. (2020). Towards sustainable land use: Aligning biodiversity, climate and food policies. https://doi.org/10.1787/3809b6a1-en

OECD. (n.d.). Governance of land use. Organisation for Economic Co-operation and Development. Retrieved 1st March 2023, from https://www.oecd.org/cfe/governance-of-land-use.html

Peris, E. (2020, 2nd December). Noise pollution is a major problem, both for human health and the environment. European Environment Agency. https://www.eea.europa.eu/articles/noise-pollution-is-a-major

Rad, S. M., Ray, A. K., & Barghi, S. (2022). Water pollution and agriculture pesticide. Clean Technologies, *4*(4), 1088-1102. https://doi.org/10.3390/cleantechnol4040066

Salkin, P. E. (2009). Sustainability and land use planning: Greening state and local land use plans and regulations to address climate change. William & Mary Environmental Law and Policy Review, *34*(1), 121-162.

Salvador, M., & Sancho, D. (2021). The role of local government in the drive for sustainable development public policies: An analytical framework based on institutional capacities. Sustainability, *13*(11), 5978. https://doi.org/10.3390/su13115978

Sampath, S., Das, S. M., & Sasi Kumar, V. (2004). Ambient noise levels in major cities in Kerala. Journal of the Indian Geophysical Union, *8*(4), 293-298.

Singh, S. (2020). Solid waste management in urban India: Imperatives for improvement. ORF Occasional Paper, 283. Observer Research Foundation. https://www.orfonline.org/wpcontent/uploads/2020/11/ORF_OccasionalPaper_283_SolidWasteManagement_FinalForUpload-2.pdf

The Hindu. (2022, 15th July). Urban local bodies in Kerala to get solid waste engineers. The Hindu. https://www.thehindu.com/news/national/kerala/urban-local-bodies-in-kerala-to-get-solid-waste-engineers/article65644518.ece

Varma, A. (n.d.). Groundwater resource and governance in Kerala: Status, issues and prospects. Forum for Policy Dialogue on Water Conflicts in India.

Verburg, P. H., Crossman, N., Ellis, E. C., Heinimann, A., Hostert, P., Mertz, O., Nagendra, H., Sikor, T., Erb, K. H., Golubiewski, N., Grau, R., Grove, M., Konaté, S., Meyfroidt, P., Parker, D. C., Chowdhury, R. R., Shibata, H., Thomson, A., & Zhen, L. (2015). Land system science and sustainable development of the earth system: A global land project perspective. Anthropocene, *12*, 29-41. https://doi.org/10.1016/j.ancene.2015.09.004

Weisbrod, K. (2019, 2nd March). Navigating Alleppey's obstacle course of waste management: 'It's up to us to change that'. Pulitzer Center. Retrieved 2nd March 2023, from https://pulitzercenter.org/stories/navigating-alleppeys-obstacle-course-waste-management-its-us-change

World Bank. (2021, 9th March). World Bank approves $105 million project to strengthen solid waste management systems in Kerala, India. Retrieved 2nd March 2023, from https://www.worldbank.org/en/news/press-release/2021/03/09/world-bank-approves-105-million-project-to-strengthen-solid-waste-management-systems-in-kerala-india