WATER-SENSITIVE URBANISM:
FOSTERING COMMUNITY ENGAGEMENT IN THE TRANSFORMATION OF KOZHIKODE'S LANDSCAPE INTO A SPONGE CITY

Politecnico di Torino

DEGREE THESIS REPORT

A.A 2024 -2025

WATER-SENSITIVE URBANISM:
Fostering community engagement in the transformation of Kozhikode's landscape into a sponge city

Msc. in Architecture for Sustainability

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ACKNOWLEDGEMENT

As we reflect on this rewarding yet challenging journey that led to this moment, we are deeply grateful to those who have supported us along the way. This would not have been possible without a great number of people who has showered immense support and guidance through this research process.

We would like to express our heartfelt gratitude to our thesis tutor, Prof. Mario Artuso and co-tutor, Angioletta Voghera for their invaluable guidance and support throughout this research journey. Their expertise in urban studies and constant encouragement have profoundly shaped our understanding and approach, pushing us to explore complex ideas and refine our arguments. The countless hours spent discussing concepts and revising drafts have enriched our work immeasurably. Their insightful feedbacks have been instrumental in shaping our work.

Special appreciation goes to our colleagues and friends for their constructive feedback and unwavering support. Engaging in stimulating discussions with them has broadened our horizons and inspired new ideas that have influenced our work. The collaborative atmosphere within our cohort has been a source of motivation and encouragement.

Furthermore, we extend our warm gratitude to the various organizations and individuals in Kozhikode city who participated in this research. Their willingness to share insights, data, and experiences have enriched our study and provided a real-world context that is essential for understanding urban dynamics.

Last but not the least, we are eternally grateful to our families for their love and encouragement, which has motivated us to pursue our academic goals with passion and dedication. Thankful for their unwavering belief in us, which has inspired us to overcome obstacles and strive for excellence throughout this process.

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ABSTRACT

In rapidly urbanizing areas, water plays a central role in shaping environments that support the well-being of residents. Effective urban planning and design are essential to facilitate these transformations. Water-sensitive urbanism (WSU) fosters healthier urban environments by promoting efficient water use, improving aesthetics, and creating spaces that connect people with their natural surroundings. It is crucial to examine existing local practices, identify barriers to engagement, and propose methods to enhance public involvement in urban initiatives.

In India, urban development often remains informal and unplanned, hindering the implementation of water-sensitive practices. Kozhikode, a city in Kerala, exemplifies this issue; it has experienced significant population growth, becoming the largest urban agglomeration in the state. However, rapid urbanization has neglected vital waterways like the Canoli Canal, which has deteriorated due to pollution from urban runoff. A research question that guides the thesis is ‘‘How can the design of public spaces in Kozhikode be optimized for water retention and biodiversity enhancement?’’. This thesis explores the concept of revitalizing the focus area adjacent to Canoli Canal as a part of a broader initiative to promote water-sensitive development in Kozhikode. The project aims to transform the canal into a multifunctional urban space that enhances water management, biodiversity, and community engagement.

The research emphasizes the significance of ecological infrastructure and community participation in the creation of “sponge cities,” which leverage green and blue interventions to efficiently manage stormwater. This strategy aims to enhance water retention, mitigate flooding, and improve urban settings through features such as rain gardens, terraced swales, wetlands, and permeable surfaces. By engaging local stakeholders, this study seeks to foster a sense of ownership and responsibility towards urban water management.

Utilizing a mixed-methods approach that combines qualitative interviews with quantitative analyses of existing water management systems, this research will draw lessons from successful sponge city implementations in other regions. The findings are expected to also enhance the recreational spaces for residents, promoting physical health and mental well-being with the water-sensitive interventions. By promoting sustainable water management practices rooted in local participation and tailored solutions, this research aims to improve Kozhikode’s livability while preserving its natural resources for future generations. In conclusion, aligning technical innovations with local needs and aspirations, the outcomes are expected to create a resilient urban environment capable of adapting to future challenges while enhancing the quality of life for its residents.

01 CHAPTER INTRODUCTION

CHAPTER 1: INTRODUCTION

1.1. General introduction

“ The future of architecture is not about more or taller buildings, but about more humane, resilient, and sustainable places where people can truly thrive.” _ Norman Foster

As cities across the globe continue to expand at an unprecedented rate, the challenge of balancing urban growth with environmental sustainability has never been more pressing. Nowhere is this tension more visible than in the rapidly urbanizing regions of the Global South, where the convergence of high population growth, rapid industrialization, and inadequate infrastructure strains both the environment and the fabric of communities. In India, a country experiencing one of the most significant urbanization booms in history, this pressure is acutely felt along waterways, particularly canals, which have historically played a crucial role in supporting agricultural, economic, and social life.

India is a country of striking contrasts, marked by its expansive landscapes, rich cultural diversity, and swift urban growth. By 2021, around 35% of its population lived in cities, and this number is expected to exceed 50% by 2031 (Census of India, 2011). This surge in urbanization is largely fueled by the search for economic opportunities, the movement of people seeking a better life, and the allure of improved living standards. However, this rapid shift to urban living brings a host of challenges, especially when it comes to sustainability. One of the most pressing issues is the management of natural resources, particularly water, which is essential for supporting urban life.

The journey of urbanization in India has been shaped by a mix of historical influences and modern-day challenges. Key events like the industrial revolution, the economic policies that followed independence, and the effects of globalization have all played a significant role in transforming the country from agrarian societies to bustling urban centres. The nation is grappling with a pressing dual challenge: water scarcity and pollution, both worsened by the growing urban population and the impacts of climate change. ‘‘According to the World Bank (2018), if current consumption trends continue, India could face a staggering 50% water deficit by 2030’’. This looming crisis calls for a fundamental change in how our cities handle water, highlighting the need for sustainable practices.

“In India’s race to urbanize, canals—the silent witnesses to centuries of growth—are at risk of being erased from the cityscape, putting both communities and ecosystems in peril.”

Once the lifeblood of urban settlements, many of India’s canals are now neglected, clogged, and underutilized. These watercourses, which were carefully designed to manage floods, provide irrigation, and facilitate transport, have been marginalized by unchecked urban sprawl and poorly planned development. The absence of a coordinated approach to canal management in urban planning has led to their degradation, exacerbating the risk of flooding, water scarcity, and loss of biodiversity, while also threatening the well-being of the communities that depend on these waterways.

TWO FACES OF INDIAN WATERBODIES

Reflections of Serenity and Struggle

Figure 1 *Serence canalscape of Kerala*
(Source: https://magikindia.com/en/kozhikode-calicut-kerala/)

Figure 2 *Canal turning into a drain in India*
(Source: Web image)

In light of this, the idea of a “water-sensitive city” comes to the forefront as a viable solution. This approach combines water management with urban planning, aiming to build resilient cities that protect our water resources while improving the quality of life for their inhabitants (Graham & Sutherland, 2017). Implementing such strategies is vital not just for tackling immediate water issues but also for ensuring long-term sustainability in our urban landscapes.

“Framing the state of Kerala through the lens of water”

Kerala, commonly known as “God’s Own Country,” is a south-western state of India known for its lush green terrains and abundant waterbodies, especially the enchanting backwaters. This unique geographical setting not only shapes the state’s natural beauty but also plays a critical role in the cultural identity of its people. Water is deeply woven into the social fabric of Kerala, influencing agricultural practices, traditional festivals, and daily life. One example is the lively Onam festival, where boat races on the backwaters are a key highlight, showcasing how deeply the community values its relationship with water. The reverence for water extends to its use in rituals and local customs, which underscores its importance beyond mere utility.

The state is grappling with serious challenges brought about by rapid urban growth, which has led to notable environmental degradation. The absence of water-sensitive urban design practices has caused the overuse of natural resources, a decline in biodiversity, and heightened flooding during the monsoon season (Nair, 2020). In many urban settings, there is a strong emphasis on infrastructure development, often at the expense of sustainable water management, which overlooks the essential role that natural ecosystems play in preserving ecological balance (Sharma, 2019).

Reviving the lifeline of Kozhikode

The coastal city of Kozhikode, located in the northern part of Kerala, is no exception to the urban challenges of preserving the natural ecosystems. Located on the Malabar Coast, Kozhikode is known for its vibrant cultural heritage and is home to numerous waterways, including wetlands, rivers and canals. However, the rapid pace of urbanization and contemporary development has led to significant damage to these water resources, causing frequent flooding, water shortages, and declination in water quality. The city is currently facing the dual challenges of urban growth and environmental degradation, particularly in terms of water management. This thesis examines the hydro-cultural aspect to encourage a water-sensitive approach to urban renewal in Kozhikode, aiming to blend traditional water management techniques with modern urban planning guidelines that uses the sponge city concept to foster a resilient and sustainable urban landscape.

What are the historical and cultural perspectives on water in urban spaces, and how do they influence modern urban planning?

Water-sensitive urban design (WSUD) is an approach that integrates water management into urban planning and design, aiming to create resilient urban environments that enhance both water resource management and the quality of life for residents. This design philosophy emphasizes the need to incorporate natural water systems into urban

landscapes, promoting the use of green infrastructure such as rain gardens, permeable pavements, and constructed wetlands (Rao, 2021). Water sensitivity involves the implementation of strategies that enhance the natural hydrological processes while also providing social, economic, and environmental benefits. In Kozhikode, the hydro-cultural dimension offers a unique perspective on water sensitivity, drawing on the region's historical relationship with water bodies and traditional water management practices. By adopting WSUD principles, Kozhikode can mitigate the impacts of urbanization on its water resources, ultimately fostering a more sustainable and liveable city. This approach not only addresses immediate water-related challenges but also aligns with broader goals of ecological sustainability and climate resilience.

The need for Urban Guidelines in creating a Water-sensitive city

Given the pressing challenges facing Kozhikode, there is an urgent need for comprehensive urban guidelines that prioritize water-sensitive practices and the preservation of natural ecosystems. The guidelines should advocate for the integration of traditional water management practices with modern urban planning to create a balanced approach that respects local cultural heritage while addressing contemporary needs (Kumar, 2021). By implementing such guidelines, policymakers can ensure that urban development in Kozhikode aligns with ecological sustainability, safeguarding its unique water resources for future generations. The integration of local knowledge and practices into these guidelines will be essential for their effectiveness and acceptance within the community.

This research is important because it has the potential to guide urban planning that respects both environmental sustainability and cultural significance. By exploring the relationship between water management and local culture, the study seeks to provide meaningful insights for community members, decision-makers, and researchers. The results could offer a framework for sustainable urban development not just in Kozhikode, but also in other regions of India facing similar urbanization and water management challenges.

Figure 3 *Kozhikode city along the coast*
(Source: https://www.thrillophilia.com/destinations/calicut/places-to-visit)

1.2. Problem statement

In India, most urban planning and development procedures remain largely unplanned and informal, potentially impeding the attainment of water-sensitive urban transitions (Parker, 2017). ''Waterways have always been an important mode of transport in Kerala, the southernmost state of India''. The *World Cities Report 2016* by UN-Habitat indicates that in 2015, Kozhikode city became the largest urban agglomeration in Kerala, with a population of 2.5 million, surpassing Kochi, which had a population of 2.4 million (UN-Habitat, 2016).

Rapid urbanization combined with unplanned development in Kozhikode has led to neglecting of one of the major canals like **Canoli canal** & its eco-system. Originally built for navigation, the canal is now in poor condition, suffering from sewage and stormwater flowing from the city into the Kallai River and the Arabian Sea. This neglect has impacted both the canal and the surrounding environment.

The transition to a water-sensitive urban framework in Kozhikode faces substantial hurdles due to the consequences of unplanned urban development. The following problems of inefficient stormwater management, water quality degradation, social inequities, loss of biodiversity, and climate change vulnerability collectively illustrate the urgent need for a strategic approach to urban design that prioritizes water management.

Figure 4 *Existing condition of Canoli Canal in Kozhikode*
(Source: Images by Authors)

1. Inefficient Stormwater Management

Unplanned urbanization in Kozhikode has led to inadequate stormwater management systems, which increase flooding risks during monsoon seasons. Urban areas lacking comprehensive drainage systems often face severe flooding, which not only disrupts daily life but also leads to infrastructure damage (Burch et al., 2018). The city's natural drainage patterns have been altered due to the construction of impermeable surfaces, exacerbating runoff and pollution (Kumar et al., 2020).

2. Water Quality Degradation

The lack of planned waste management systems has resulted in the contamination of local water bodies. Pollutants from urban runoff, coupled with inadequate sewage treatment facilities, severely degrade water quality (Ghosh & Rao, 2021). A study highlights that "poor water quality in Kozhikode not only affects aquatic ecosystems but also poses health risks to the local population, emphasizing the need for integrated water quality management in urban planning" (Prasad et al., 2019).

3. Social Inequity in Water Access

Unplanned developments often lead to disparities in water access among different socio-economic groups. According to Ranjan and Gupta (2020), marginalized communities are disproportionately affected by poor water infrastructure and quality, leading to health disparities and social tensions (Ranjan & Gupta, 2020). In Kozhikode, this issue is compounded by informal settlements that lack basic water supply and sanitation services, creating a cycle of poverty and inequity (Sharma, 2021).

4. Loss of Biodiversity and Green Spaces

Urbanization has led to the loss of vital green spaces that serve as natural water management systems. As noted by Gaston et al. (2013), urban green areas play a critical role in stormwater absorption and biodiversity support (Gaston et al., 2013). The disappearance of these spaces in Kozhikode not only affects local flora and fauna but also diminishes the city's resilience to climate change impacts (Srinivasan et al., 2020)

Figure 5 *The less beautiful side of India: State of negligent canals*
(Source: *https://commons.wikimedia.org/wiki/File:India_-_Sights_%26_Culture_-_garbage-filled_canal_(2832914746).jpg)*

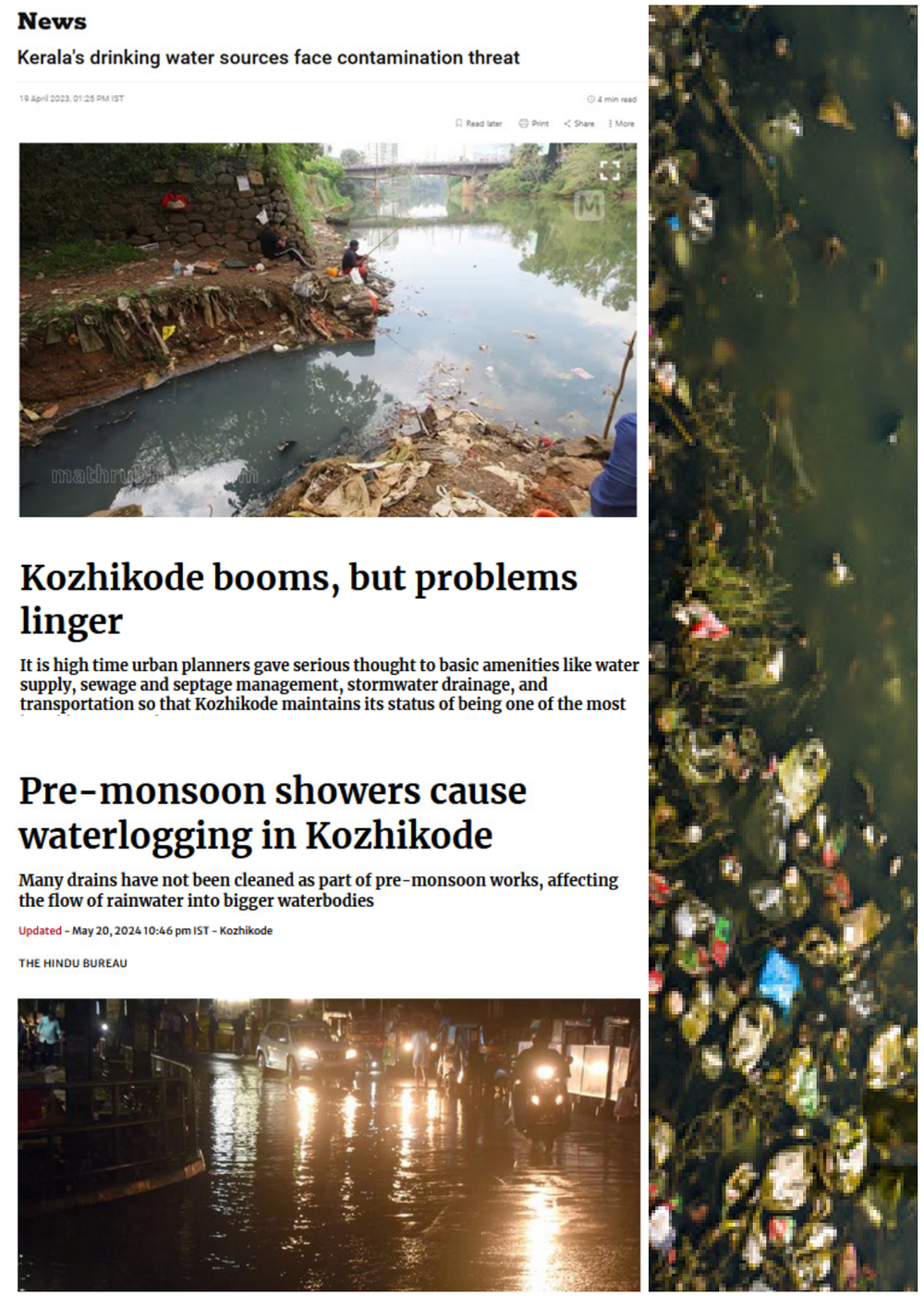


Figure 6 *Newspaper article highlighting the urban water issues in Kerala*
(Source: *https://english.mathrubhumi.com/news/kerala/kerala-s-drinking-water-sources-face-contamination-threat-1.8490974)*

1.3. Relevance of study

The relevance of this thesis study stems from Kozhikode city's pressing water management challenges and the need for sustainable urban development practices. This has led to a **live urban design competition initiated by the Government of Kerala** focused on the rejuvenation of the Canoli Canal in Kozhikode which is already underway. As this initiative is aimed at restoring this vital waterway to enhance urban sustainability and community engagement, this project backed by a substantial state funding, is focused on transforming the canal into a key component of the West Coast Canal network, facilitating tourism, cargo movement, and flood mitigation (KIIFB, 2023).

As urbanization accelerates, Kozhikode faces issues such as flooding, water scarcity, and pollution, necessitating innovative approaches to integrate water management into urban design (van der Meulen, 2024). The study is highly relevant to ultimately align with broader goals such as the Sustainable Development Goals (SDGs) related to clean water and sustainable cities while it initially aims to contribute valuable insights into creating a sustainable and livable urban environment in Kozhikode which is responsive to the needs of its residents.

Moreover, the relevance of this study extends beyond Kozhikode. As urbanization accelerates globally, cities are increasingly looking for sustainable solutions to manage their water resources. The findings from this research could provide valuable insights for other cities facing similar challenges. By examining case studies from successful sponge city implementations in different contexts, the study also aims to identify best practices that can be adapted to Kozhikode's unique circumstances (UCCRN, 2024). The scope of study includes studying water management solutions, community engagement strategies/guidelines, and specific design interventions aimed at enhancing urban resilience.

RETHINKING RAIN:
Relevance of green infrastructure to recharge Kozhikode's thirsty lands and protect from flooding

1.4. Aim and Research objectives

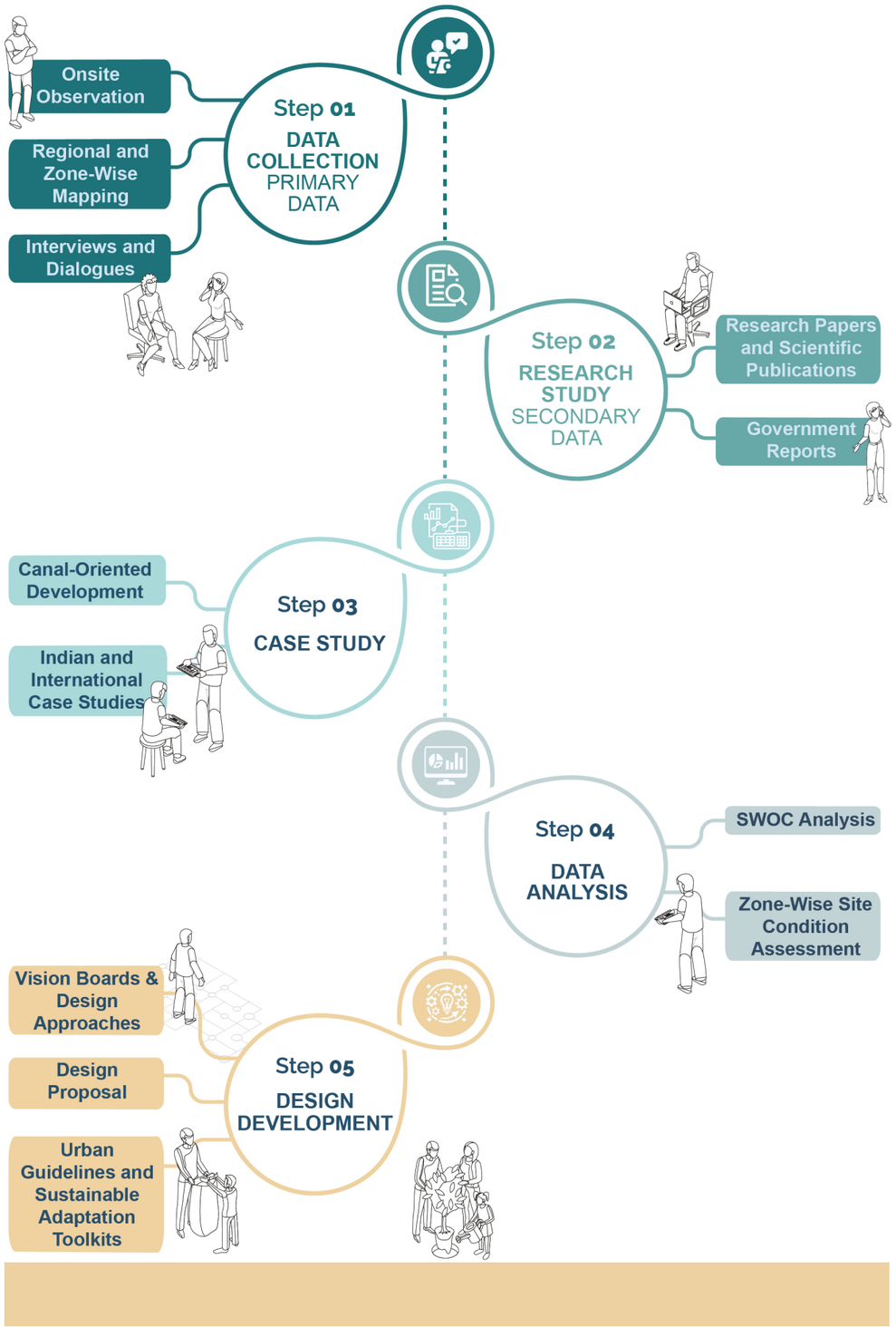
The thesis is dedicated to exploring the potential of a water-sensitive urban rejuvenation using the concept of sponge city for promoting sensitized community development in Kozhikode. By adopting sponge city principles, the research seeks to create a system that mimics natural hydrological processes to manage stormwater effectively. This aims to reaffirm Kerala's commitment to utilizing its waterways for both economic and recreational purposes, ultimately fostering cities that are resilient, inclusive, and adept at managing the challenges posed by increasing urbanization and environmental change. The proposal for an urban rejuvenation of the Canoli Canal ang its surrounding areas in Kozhikode targets to ecologically design the urban spaces that can tackle the flooding issues in a sustainable manner. The main aim is to explore innovative urban planning strategies that integrate water-sensitive design principles into the urban fabric of Kozhikode.

The findings are expected to contribute valuable insights into developing tailored guidelines for Kozhikode that reflect local needs and cultural practices, ultimately supporting the creation of a more sustainable and livable urban environment.

The primary research objectives of this project are as follows:

- To investigate the hydro-cultural dimensions and their spatial expressions within urban settings, ensuring conservation, the provision of ecosystem services, and the potential expansion of existing water networks to revitalize the urban environment.
- To promote sustainable water management practices by integrating green infrastructure solutions that facilitate rainwater harvesting, groundwater recharge, and reduced runoff. The goal is to create a self-sustaining urban water cycle that minimizes reliance on conventional drainage systems.
- To concentrate on transforming city canals into resilient, multifunctional areas that enhance water management, biodiversity, and community well-being through water-sensitive urban design (WSUD) strategies.
- To examine sustainable green and blue infrastructure interventions that utilize natural processes to reduce flood risk, enhance water quality, and create recreational spaces.
- To develop an urban design methodology that is adaptable on a global scale for canal-oriented developments, ensuring collaborative stakeholder engagement to align the project with local needs and priorities, thereby enhancing its feasibility and acceptance.

1.5. Methodology



The methodology adopted for the thesis research is to provide a comprehensive understanding of the topic and study region, focusing on urban design challenges related to the Canoli Canal in Kozhikode. The methodology comprises systematic data collection, analysis, and interpretation, divided into distinct phases.

1. DATA COLLECTION

Primary Data:
Primary data collection involves direct engagement with the study area and its stakeholders, ensuring that the research is grounded in real-world conditions and perspectives:

- **On-site Observation**: Conducting field visits to the Canoli Canal and surrounding urban areas allows for firsthand analysis of the physical and social environment. Observations focus on the canal's condition, usage patterns, and interaction with adjacent urban spaces.

- **Regional and Zone-Wise Mapping**: Geographic Information System (GIS) tools will be employed to create detailed maps that illustrate the spatial characteristics of the canal and surrounding neighborhoods. Zone-wise mapping facilitates a nuanced understanding of different areas' conditions and needs.

- **Interviews and Dialogues**: Engaging with a diverse group of stakeholders—including local residents, urban planners, government officials, and environmentalists—provides qualitative insights into the challenges and opportunities associated with the canal. Semi-structured interviews enable participants to share their perspectives while allowing the researcher to probe deeper into specific issues.

Secondary Data:

Secondary data serves as the foundation for understanding existing knowledge and practices related to canal-oriented development. This data is sourced from:

- **Research Papers and Journal Articles**: Peer-reviewed articles provide insights into theoretical frameworks, previous studies, and contemporary issues surrounding canal development and urban design. A thorough literature review helps identify gaps in existing research and informs the study's direction.

- **Government Reports**: Various governmental publications offer statistical data, policy frameworks, and historical contexts relevant to urban planning and water management in Kozhikode. This information is crucial for understanding regulatory environments and the historical evolution of the canal.

The review of secondary data is organized into three major sections:

1. **Canal-Oriented Development**: This section explores theoretical perspectives and practical examples of how canals can be integrated into urban settings to enhance ecological sustainability and urban livability.

2. **Indian Case Examples**: By examining successful and unsuccessful projects within India,

this section aims to derive lessons that can be applicable to the context of Kozhikode.

3. **International Case Examples**: This section analyzes global best practices in canal development, providing comparative insights that could inform local strategies.

2. DATA ANALYSIS

The analysis phase synthesizes the collected data to derive meaningful conclusions:

- **SWOC Analysis**: A Strengths, Weaknesses, Opportunities, and Challenges (SWOC) analysis will be conducted to evaluate the canal's potential as a sustainable urban asset. This framework will help in identifying internal and external factors affecting canal management and development.

- **Zone-Wise Site Condition Assessment**: The existing conditions of the canal will be assessed in a zone-wise manner, focusing on aspects such as water quality, accessibility, urban failures, environmental systems and surrounding land use. This detailed analysis will help identify specific challenges faced by different areas.

3. DESIGN DEVELOPMENT

Based on the site observations, interviews, site factors and inferences, a conceptual framework with a vision of Sponge city implementation is explored with minimal design interventions to uplift the focus area with a sensitized urban landscape for the community:

- **Vision boards & Design approaches** : The concept of urban rejuvenation is visualized through activity mapping schemes and conceptual perspective views blended into the local context.

- **Design proposal** : Sponge city planning process is explored using certain design strategies which is proposed in the focus area using an overall Master plan. Certain core zones are detailed with views and sections for better visualization.

- **Urban guidelines and sustainable adaptation toolkits**: Community-centric guidelines as a conclusion recommendation along with certain toolkit ideas which could be used as modular solutions on a global perspective.

Note: All the writing was carried out using study references from interviews, books, journal papers and officially published researches on the live topic and related fields. Certain websites such as Grammarly and AI tools were used only to enhance the grammar and style of writing, but ensuring that the scholarly standards and research integrity are maintained.

02 CHAPTER
CONTEXT INTRODUCTION

CHAPTER 2: CONTEXT INTRODUCTION

2.1. Geographical context

WHY KOZHIKODE?

Kozhikode with its unique geographical context nestled between the Arabian sea and the Western Ghats, is an interesting coastal city in Kerala, India to study and promote a water-sensitive urban proposal. Kozhikode is known for its diverse population and rich heritage, making it a microcosm of Indian society. The city has been a melting pot of various cultures due to its historical role as a trading port, which continues to influence its social fabric today (Rijke, J. et al.,2016). This coastal city is crisscrossed by numerous rivers and canals, which historically supported its thriving trade and agriculture. However, rapid urbanization has led to significant environmental challenges, including water scarcity, pollution of water bodies, and increased flooding during monsoon seasons. Kozhikode is increasingly affected by climate change, leading to severe drinking water crises and altered rainfall patterns, necessitating innovative water management strategies to enhance resilience against such challenges In addition to enhancing environmental sustainability, rejuvenating Kozhikode through WSUD aligns with India's broader goals of achieving sustainable development as outlined in the 2030 Sustainable Development Goals (SDGs). There is a strong emphasis on citizen participation in water governance in Kozhikode, making it an ideal location for research that seeks to incorporate local knowledge and practices into water management strategies (IWA Publishing, 2021).

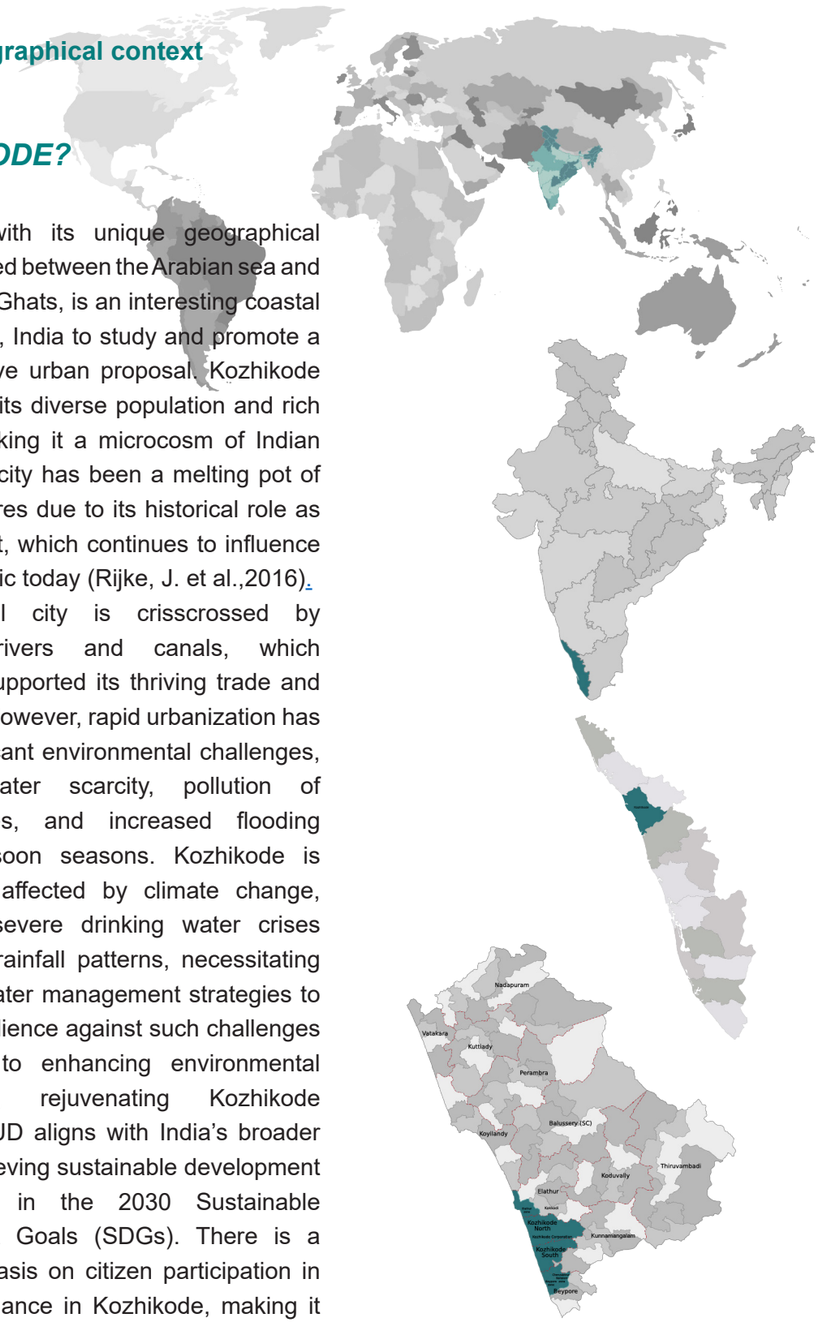


Figure 7 *Location of Kozhikode city in a global context*
(Source: *Illustration by the authors)*

2.1.1. Indian inland waterways

Indian inland waterways are an essential component of the country's transportation infrastructure, offering a sustainable alternative for moving goods and people. The extensive network of rivers, canals, and lakes spans over 14,500 kilometers, providing significant potential for economic development and environmental sustainability. The National Waterways Act of 2016 has designated 111 national waterways, which are crucial for enhancing the efficiency of the logistics sector and reducing congestion on road and rail networks (Government of India, 2016).

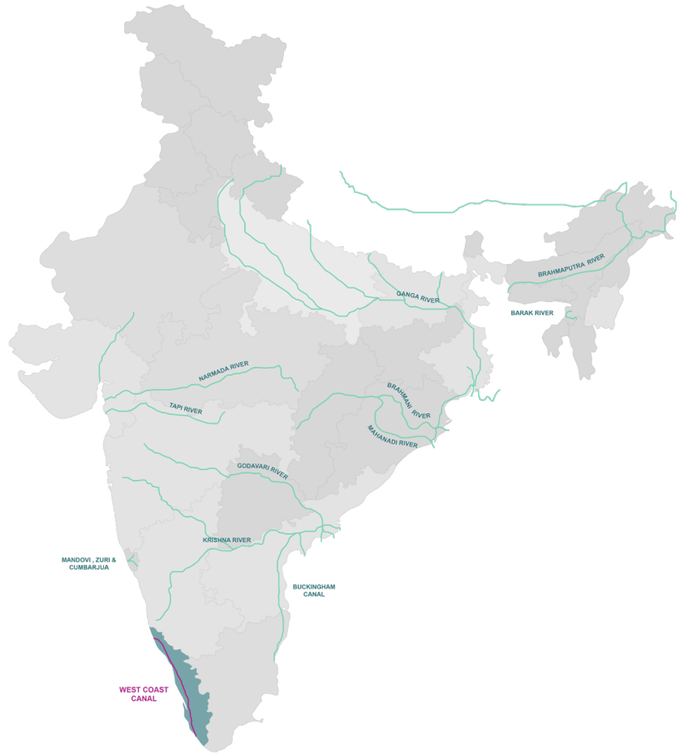


Figure 8 *Map of Indian Inland Waterways*
(Source: *Illustration by Authors based on https://en.wikipedia.org/wiki/List_of_national_waterways_in_India)*

The advantages of utilizing inland waterways include lower transportation costs, reduced carbon emissions, and the ability to transport bulk cargo efficiently. Additionally, the development of these waterways can promote tourism, as scenic routes can attract visitors and enhance local economies. However, the potential of Indian inland waterways remains underutilized due to challenges such as inadequate infrastructure, seasonal variations in water levels, and environmental concerns. Addressing these issues requires investment in modernizing ports, improving navigational aids, and implementing sustainable practices to protect aquatic ecosystems (Kumar, 2020).

"**The Canoli Canal has been designated as a segment of National Waterway 3** (NW-3) following the enactment of the National Waterways Act in 2016" (Inland Waterways Authority of India, 2021). This designation is part of a broader initiative aimed at revitalizing and enhancing inland water transport throughout India. The inclusion of the canal within NW-3 underscores its critical role in the national strategy to improve waterway connectivity, which is essential for fostering economic growth and promoting sustainable transportation solutions (Inland Waterways Authority of India, 2021; Kerala State Planning Board, 2016).

Figure 9 *Lush green terrains of the state of Kerala in South-west India*
(Source: https://www.europosters.it/hills-and-tee-plantations-in-kerala-f323286486)

2.1.2. South-west India and Canalscapes of Kerala

Figure 10 *Illustration of Kerala context with cultural elements*
(Source: https://stock.adobe.com/it/images/tourism-and-traditional-culture-with-kerala-map-vector/313139526)

Kerala's canalscapes are primarily composed of the backwaters, rivers, and man-made canals that crisscross the state. The most renowned among these is Vembanad Lake, the longest lake in India and a key element of the Kerala backwaters. This expansive system of waterways has been shaped by both natural forces and human activities, highlighting the region's historical dependence on water for trade, agriculture, and everyday life. These canals fulfil various functions, particularly irrigation for the verdant paddy fields that define the landscape. The complex irrigation networks have established Kerala as one of India's most agriculturally productive states, especially in rice farming. Additionally, the backwaters sustain a thriving fishing industry, which is vital for the local economy and supports the livelihoods of numerous communities.

The climate in this region is tropical, characterized by heavy monsoon rains which significantly influence water management practices. The canalscapes of Kerala are intricately tied to the region's cultural identity. They are more than just physical features; they are central to the social and cultural life of the local communities. Many festivals, rituals, and daily practices are closely linked to these waterways.

There are many significant projects aimed at restoring canals in Kerala like the Kollam Canal which highlight the potential for improving social connectedness and economic vitality through integrated urban planning (Praseeda, 2022). These initiatives focus on enhancing public access to waterways, thereby fostering community engagement and ownership.

In Kochi, a major urban regeneration project aims to rejuvenate five key canals over a stretch of 34 kilometers. This initiative seeks to improve inland navigation while promoting tourism and recreation (Antea Group, 2025). The project includes developing jetties, parks, and eco-friendly spaces that enhance the urban environment while addressing issues such as waste management and slum rehabilitation (Antea Group, 2025).

By balancing ecological sustainability with economic development, Kerala can leverage its unique canal systems as vital assets for urban transformation.

Figure 11 City view of Kozhikode in Kerala
(Source: https://unsplash.com/photos/an-aerial-view-of-a-beach-and-a-city--c-kWBPqEH0)

2.1.3. About Kozhikode city

Kozhikode, historically known as Calicut, has a rich and complex history that dates back to its establishment in the early 12th century. Originally part of the Chera Empire, Kozhikode emerged as a significant trading hub due to its strategic location along the Malabar Coast. Kozhikode emerged as the capital of the Kingdom of Kozhikode, governed by the Zamorins, who significantly expanded their realm across central Kerala during the 14th century. They achieved this by conquering key territories, including Tirunavaya, which enabled them to consolidate power and influence in the region (Cibin et al., 2020). The Zamorins, known for their cultural sophistication and military prowess, played a crucial role in establishing Kozhikode as a major trading hub on the Malabar Coast. Their reign marked a period of prosperity and expansion, as they engaged in trade with various foreign powers, including Arab and Chinese merchants, further enhancing the city's prominence (Wikipedia, 2024). Through strategic conquests and alliances, the Zamorins not only secured their dominance but also fostered a vibrant economic landscape that attracted traders from across the globe. This historical context laid the foundation for Kozhikode's identity as a significant center of commerce and culture in medieval India.

Figure 12 Vasco da Gama docks on the banks of Kozhikode
(Source: National library of Portugal)

Figure 13 Old city of Kozhikode
(Source: https://historicalleys.blogspot.com/2014/07/electrifying-calicut-city.html)

Brief historical Timeline of Kozhikode:

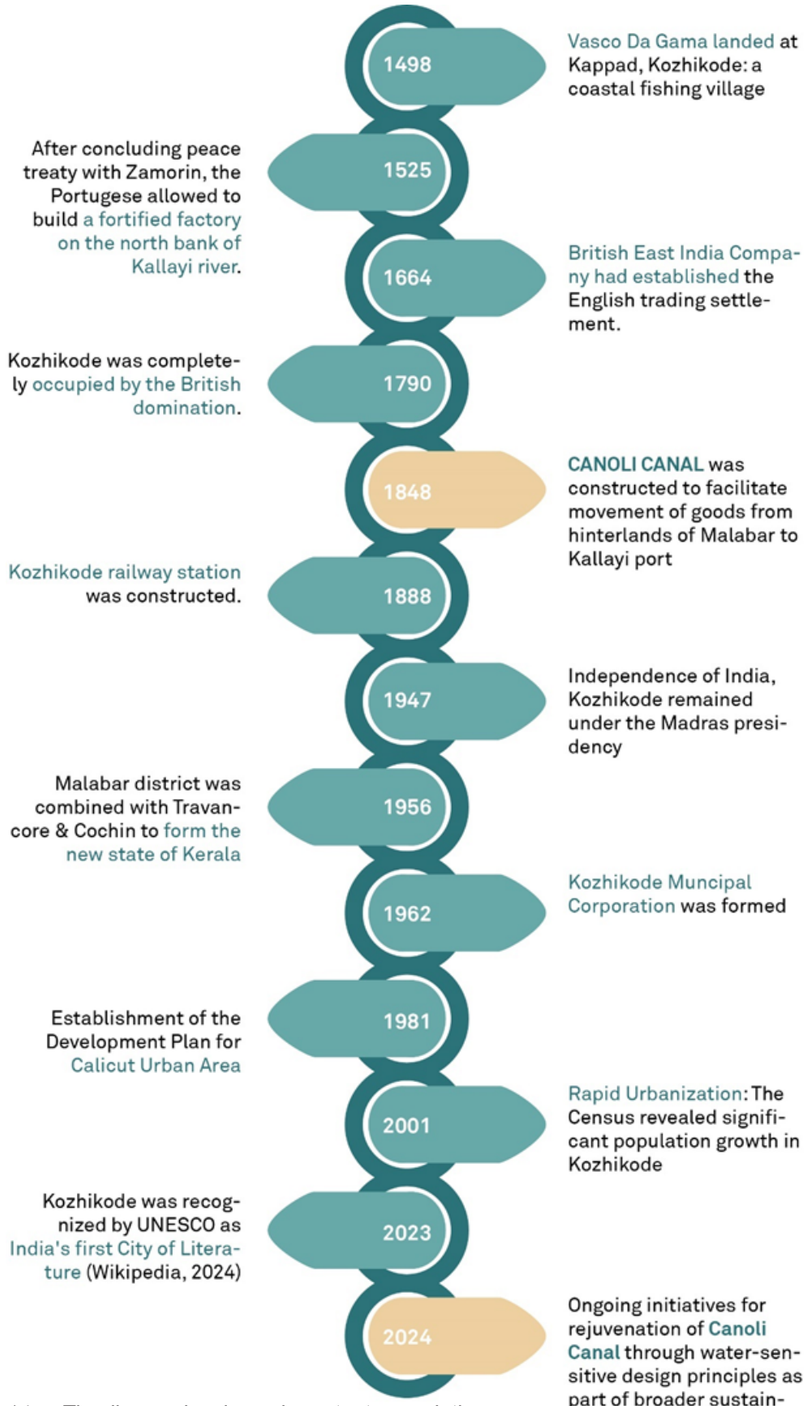


Figure 14 Timeline showing important evolution developments of Kozhikode
(Source: Illustration by Authors based on IJNRD Report)

The district boasts a coastline of about 71 kilometers and covers an area of 91 square kilometers. Serving as a central hub for four districts in northern Kerala, Kozhikode has historically emerged as a significant center for forest and agro-based industries. Historically, Kozhikode has been a pivotal trading hub, attracting merchants from across the globe due to its strategic location along the Arabian Sea. The city plays a crucial role in trade, particularly in food grains, marine products, and spices, demonstrating a strong economic development potential for the entire northern part of the state. ‘‘In view of this, Kozhikode is considered as one of the priority cities in the state’’ (District Urbanization Report, Kozhikode, 2011).

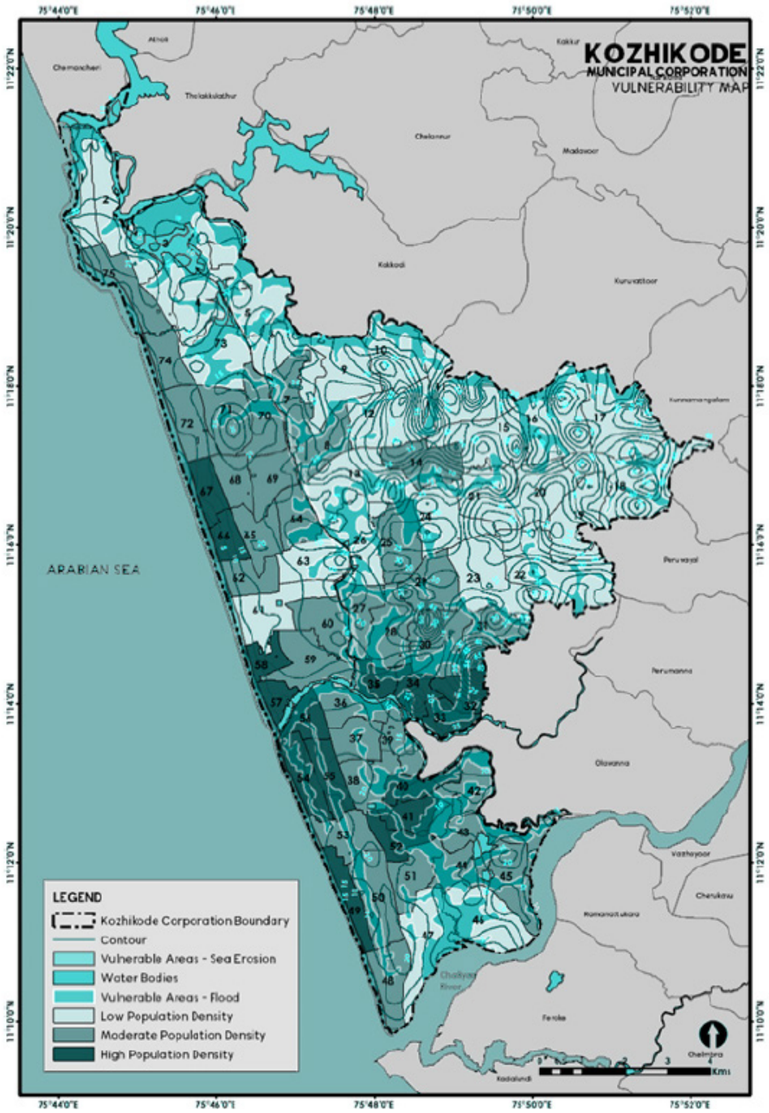


Figure 15 Vulnerability Map of Kozhikode

(Source : Resilience master plan as the pathway to actualize sustainable development goals - A case of Kozhikode, Kerala, India)

CLIMATE:

The district experiences a tropical monsoon climate characterized by high humidity and significant rainfall, particularly during the monsoon season from June to September. The dramatic shift in elevation from the West Coast to the hilly areas of the Western Ghats in the east, combined with its closeness to the Arabian sea, plays a crucial role in shaping different aspects of the climate. which moderates temperatures and contributes to the region’s lush vegetation (Town and Country Planning Department, 2017). In this region, temperatures generally peak between 27.8°C and 32.2°C, while the lows range from 21.9°C to 26.8°C. April stands out as the hottest month, with average highs reaching 32.2°C and lows around 26.8°C.

- Rainfall: Average annual rainfall in Kozhikode ranges from 2,500 to 3,000 mm, with July typically being the wettest month (Kumar, 2022).

- Urban Heat island effect: As vegetation cover decreases due to urban sprawl, temperatures in built-up areas have risen significantly. Research indicates that land surface temperatures (LST) in Kozhikode have increased by approximately 7 degrees Celsius

#	District	Summer Season 2020			S.W. Monsoon Season 2020			N.E. Monsoon Season 2020			Winter season 2021		
		April + May	Normal	% Dep	June to September	Normal	% Dep	October to December	Normal	% Dep	January to March	Normal	% Dep
1	Alappuzha	468	404.93	15.6	1856	1722.3	7.8	416.1	587.9	-29.22	150.0	91.47	63.99
2	Kannur	210.6	267.99	-21.4	3365.9	2638.1	27.6	344.6	375.6	-8.25	84.1	17.91	369.46
3	Ernakulam	377.9	368.17	2.6	2256.3	2038	10.7	433.3	519.9	-16.66	202.2	59.63	239.12
4	Idukki	387.3	381.51	1.5	2470.4	2615	-5.5	507.5	567.7	-10.60	190.7	73.89	158.12
5	Kasaragod	125.1	258.91	-51.7	3605.7	2971.4	21.3	394	344.4	14.40	115.6	17.09	576.59
6	Kollam	436.9	392.83	11.2	1352.4	1280.9	5.6	434.3	630.8	-31.15	173.4	107.37	61.54
7	Kottayam	567.5	387.66	46.4	2329.6	1871.9	24.5	453.7	535.1	-15.21	237.5	80.74	194.13
8	Kozhikode	337.8	328.89	2.7	3440.4	2577.4	33.5	378.6	450.1	-15.89	172.4	27.11	535.83
9	Malappuram	231.5	291.70	-20.6	1987.3	2005.5	-0.9	201	478.9	-58.03	106.4	29.00	266.85
10	Palakkad	153	219.46	-30.3	1705.6	1531.6	11.4	220	403.3	-45.45	62.9	33.84	85.86
11	Pathanamthitta	683.2	428.91	59.3	1836.4	1618.7	13.4	533.2	603.2	-11.60	439.2	123.89	254.50
12	Thiruvananthapuram	561.4	323.86	73.3	1153.7	865.1	33.4	346.6	550.8	-37.07	126.4	77.14	63.80
13	Thrissur	230.4	351.34	-34.4	1999.7	2280.8	-12.3	295.4	514.3	-42.56	103.2	34.26	201.13
14	Wayanad	269.7	254.34	6.0	2082.4	2525.5	-17.5	240	335.9	-28.55	105.5	34.16	208.91

Figure 16 Seasonal and Normal Rainfall in 2020-21 in Kerala State

(Source : Ground water Year book of Kerala (2020-2021))

District	2020									2021			Total
	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	
Alappuzha	84.2	383.8	495.3	346.8	378.3	635.6	243.2	112.8	60.1	98.4	1.5	50.1	2890.1
Kannur	56.4	154.2	987.8	856.2	803.7	718.2	259.1	39	46.5	64.7	15.1	4.3	4005.2
Ernakulam	140.7	237.2	501.5	549.9	628.6	576.3	233.9	155.8	43.6	149.2	0.3	52.714	3269.7
Idukki	131.7	255.6	400.3	524.4	854.3	691.4	298	158.4	51.1	116.9	12.3	61.514	3555.9
Kasaragod	2.6	122.5	878.6	1056	729.4	941.7	309.6	46.5	37.9	108.3	5.7	1.6	4240.4
Kollam	90.2	346.7	355.2	263.3	331.1	402.8	248	130.3	56	89.1	7.9	76.443	2397
Kottayam	201.5	366	617.9	588.1	546.6	577	251.8	132.5	69.4	155.1	0.8	81.586	3588.3
Kozhikode	96	241.8	1166.7	735.9	676.1	861.7	236.4	91.8	50.4	164.9	5.6	1.9	4329.2
Malappuram	111	120.5	463.4	463.9	485.7	574.3	131	49.8	20.2	82.7	12.5	11.186	2526.2
Palakkad	85.3	67.7	309.4	417	524.2	455	162.3	38.7	19	37.3	2.4	23.2	**2141.5**
Pathanamthitta	191.7	491.5	487.5	432.9	305.2	610.8	231.4	198.4	103.4	242	28.8	168.37	3492
Thiruvananthapuram	129.3	432.1	366.4	149.5	217	420.8	203.2	107.1	36.3	93.3	2.4	30.657	2188.1
Thrissur	80.8	149.6	477.4	447.3	498.8	576.2	218.3	65.8	11.3	64.7	2.6	35.857	2628.7
Wayanad	145.4	124.3	293.1	426.7	867.7	494.9	125	84.6	30.4	66.2	18.9	20.414	2697.6

Figure 17 Monthly Rainfall Distribution during 2020-2021 (Figures in mm)

(Source : Ground water Year book of Kerala (2020-2021))

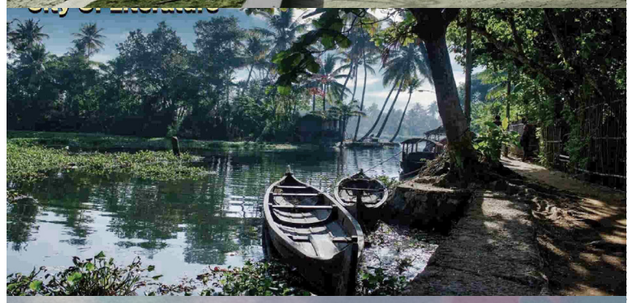
from 1993 to 2022 due to the loss of green spaces (Nair et al., 2024). This temperature rise not only affects local climate conditions but also impacts public health and energy consumption. This climate influences architectural design in the region, where buildings are often constructed with features that promote ventilation and shade to mitigate heat.

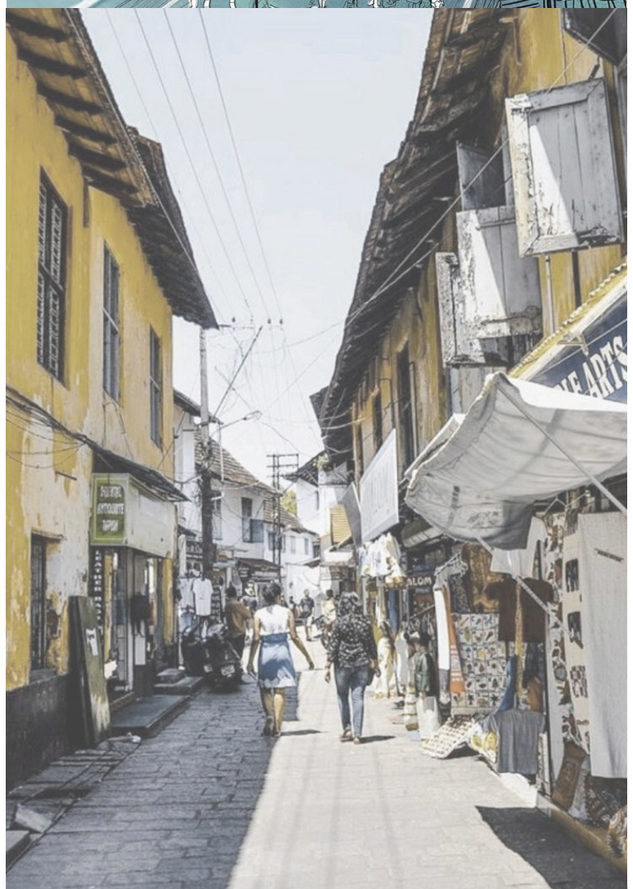
ARCHITECTURE:

Kozhikode's architectural landscape is a testament to its historical significance as a prominent trading port, showcasing a fusion of indigenous Kerala styles and colonial influences. The city is home to several notable structures, such as the Tali Temple, which exemplifies traditional Kerala architecture with its intricate wooden carvings and distinctive sloping roofs (Kozhikode District Website, 2024). Additionally, colonial-era buildings highlight European architectural styles, particularly the Indo-Saracenic design evident in the local railway station, which reflects the city's colonial past and its role in facilitating trade (Anjith, 2016).

CULTURE:

Culturally, Kozhikode is a tapestry woven from various communities, including Keralites and Arabs. The city is renowned for its culinary heritage, particularly its Malabar biriyani and seafood dishes. Festivals like Onam and Eid are celebrated with great enthusiasm, showcasing the harmonious coexistence of different religions and traditions. The local art scene is vibrant, featuring traditional performance arts such as Theyyam and Kathakali that are integral to the region's cultural identity (Anjith, 2016).





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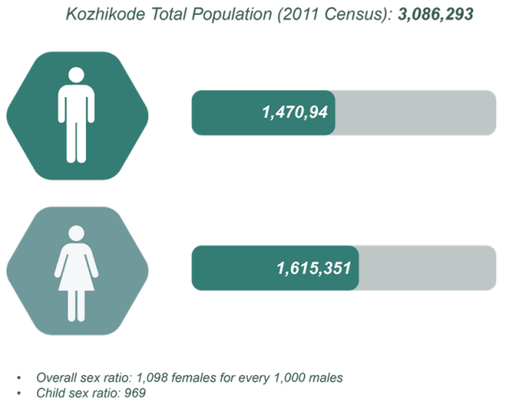


Figure 18 Male-female ratio of Kozhikode population

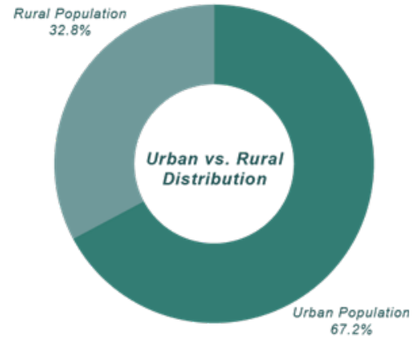


Figure 19 Chart of Urban vs Rural distribution

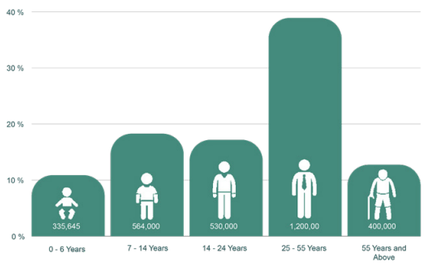


Figure 20 Graph of Population based on age categories

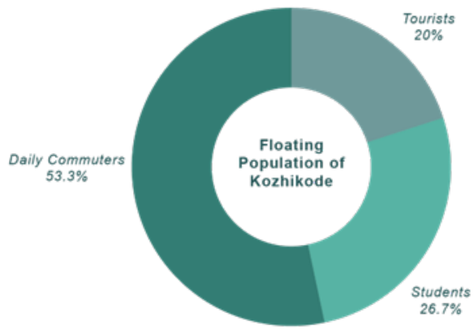


Figure 21 Chart of Floating population of Kozhikode

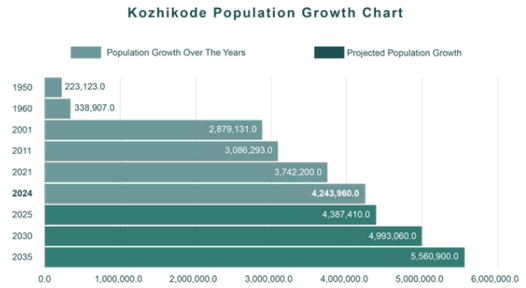


Figure 22 Population Growth Chart of Kozhikode

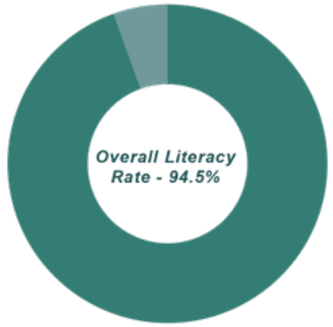


Figure 23 Literacy rate chart

(Source: Illustrations by Authors)

LANDUSE:

Kozhikode's land use is characterized by a diverse mix of residential, commercial, industrial, and agricultural areas, reflecting its historical significance and rapid urbanization. The Master Plan for Kozhikode Urban Area outlines comprehensive strategies for urban development until 2035. It emphasizes sustainable land use, the importance of preserving water bodies, and enhancing public spaces. The plan includes provisions for improving drainage systems and managing stormwater effectively, which are critical for the rejuvenation of the Canoli Canal (Town and Country Planning Department, 2017).

According to the ‘‘Master Plan for Kozhikode Urban Area’’ (2015-2035), approximately 82% of the planning area is designated for urban uses, which include residential neighborhoods, commercial zones, and institutional spaces (Town and Country Planning Department, 2019). Additionally, the presence of interstitial spaces—neglected or underutilized areas—presents opportunities for urban regeneration and community engagement (Athens Journals, 2023). The agricultural land use is primarily located on the peripheries of the urban area, contributing to local food security while facing pressures from urban expansion (Kozhikode Corporation, 2019). This dynamic land use pattern necessitates effective planning strategies that balance development with environmental sustainability and community needs.

Kozhikode's inclusion in India's Smart Cities Mission necessitates adherence to guidelines that promote urban renewal through technology and sustainability. The rejuvenation proposal should align with these guidelines to leverage smart technologies for effective water management and enhance urban livability (Ministry of Housing and Urban Affairs, Government of India, 2015).

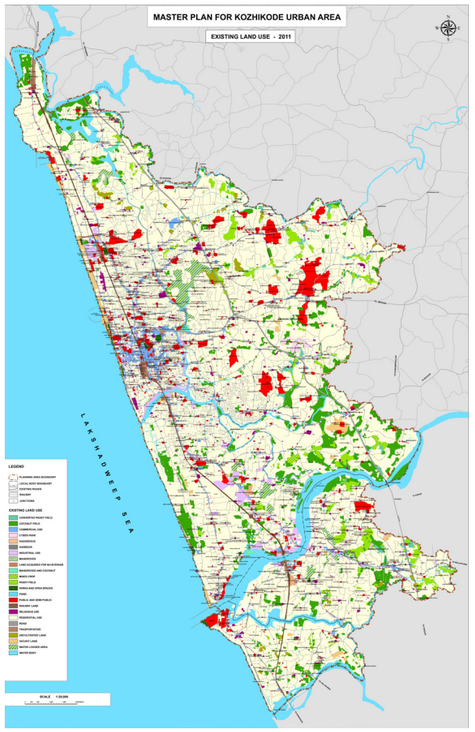


Figure 24 Existing Land Use Map of Kozhikode
(Source : Master Plan for Kozhikode Urban Area - 2035)

Land Use	Area (Sq.km)	% of Planning Area	% of Developable Area
Commercial	3.36	1.88	2.11
Residential	120.53	67.63	75.73
Industrial	3.26	1.83	2.05
Public ,Semipublic	7.17	4.03	4.51
Religious	1.85	1.04	1.16
Roads & Transportation	9.53	5.35	5.99
Environmentally Sensitive	7.47	4.19	
Water Body	11.57	6.50	
Parks and Open spaces	0.32	0.18	0.20
Dry Agriculture	11.41	6.40	7.17
Vacant Land	1.73	0.97	1.09
Total	178.21	100.00	100.00

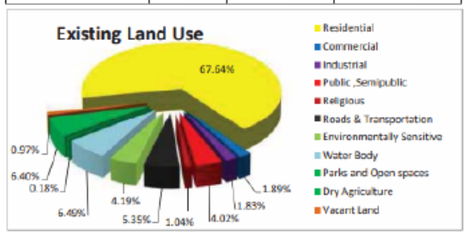


Figure 25 Existing Land Use Break Up
(Source : Master Plan for Kozhikode Urban Area - 2035)

URBANIZATION IN KOZHIKODE

Kozhikode is experiencing rapid urbanization, with a population growth rate of 34.5% between 2015 and 2020, making it one of the fastest-growing urban areas globally (Times of India, 2020). This surge is driven by economic factors, particularly the growth of the IT sector and real estate development, attracting significant intra-state migration (Zinfog, 2022). “The Urban Extent of Kozhikode in 2014 was 23,642 hectares, increasing at an average annual rate of 15.2% since 2001. The urban extent in 2001 was 3,316 hectares, increasing at an average annual rate of 18.1% since 1991, when its urban extent was 535 hectares.” (Atlas of Urban Expansion, n.d.)

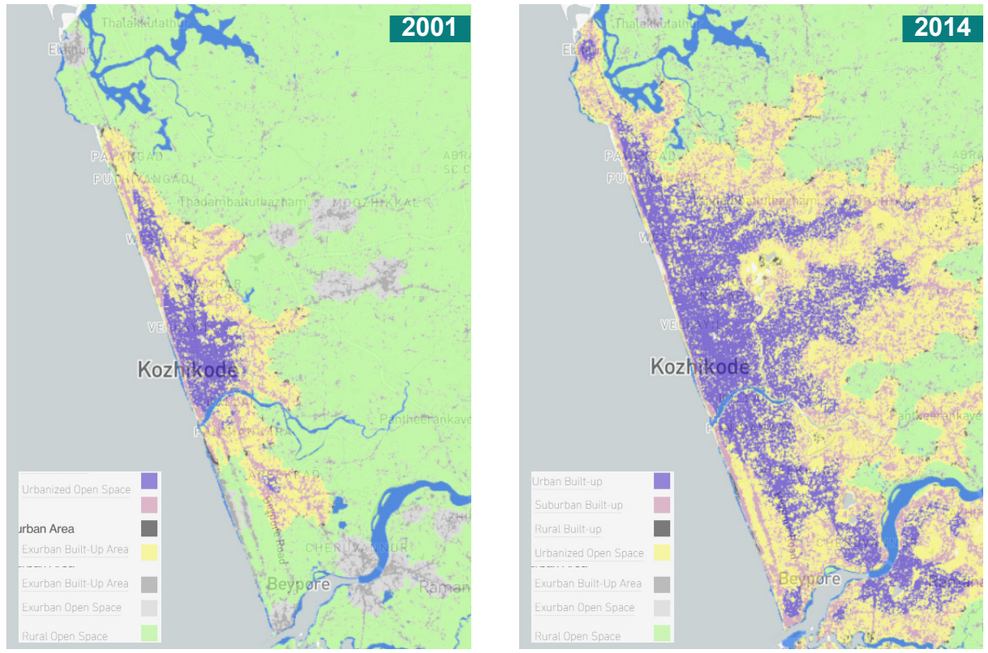


Figure 26 Urban extent comparison showing the urbanisation in Kozhikode
(Source : http://atlasofurbanexpansion.org/cities/view/Kozhikode)

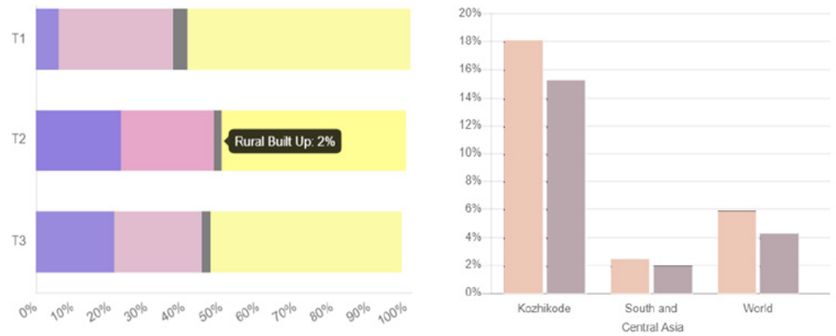
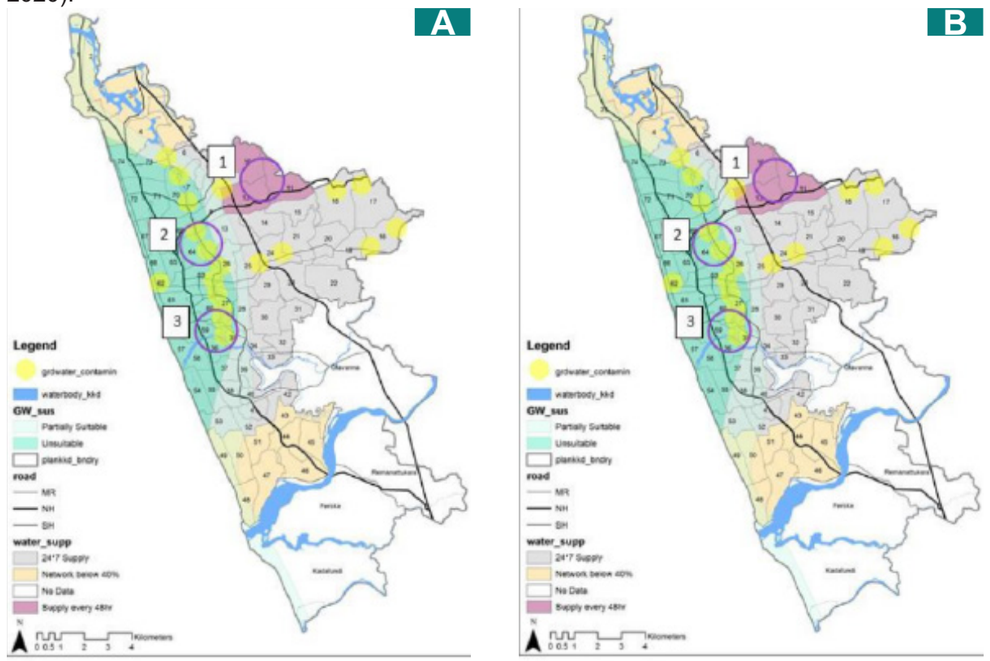


Figure 27 Urban Composition and Urban extent average annual % change
(Source : http://atlasofurbanexpansion.org/cities/view/Kozhikode)

URBAN WATER & FLOODING:

The water resources in Kozhikode are primarily derived from monsoon rains, which are both abundant and seasonal. However, this reliance on monsoon rains poses risks; periods of drought or erratic rainfall can lead to severe water shortages (CWRDM, 2021). Groundwater resources are also under pressure in Kozhikode. Over-extraction for agricultural and domestic use has resulted in declining water tables and increased salinity in some areas (CWRDM, 2021). The competition between urban needs and agricultural demands reflects a broader trend observed across South India, where rural-urban migration is often driven by the search for better living conditions but simultaneously exacerbates inequities in water access (Rajagopal & Janakarajan, 2020).

The expansion of urban infrastructure often occurs at the expense of natural systems, resulting in increased flooding, pollution, and water scarcity (CWRDM, 2021). The Center for Water Resources Development and Management (CWRDM) has highlighted that effective water management is critical for sustaining urban life in Kerala, especially in cities like Kozhikode where historical water bodies are increasingly neglected (CWRDM, 2021). The challenges posed by climate change further complicate this scenario; rising sea levels and erratic rainfall patterns threaten both the quality and availability of freshwater resources (Nagendra et al., 2018).



A: Identified hotspots where urban water systems failed in Calicut. B: Identified hotspots in the development plan 2015-2035 where similar hotspots may occur

Figure 28 Identified hotspots of Kozhikode

(Source : An Assessment of Spatial-Ecological and Water Sensitive Planning for Calicut)

2.1.4. Regional context of Kozhikode and Canoli canal

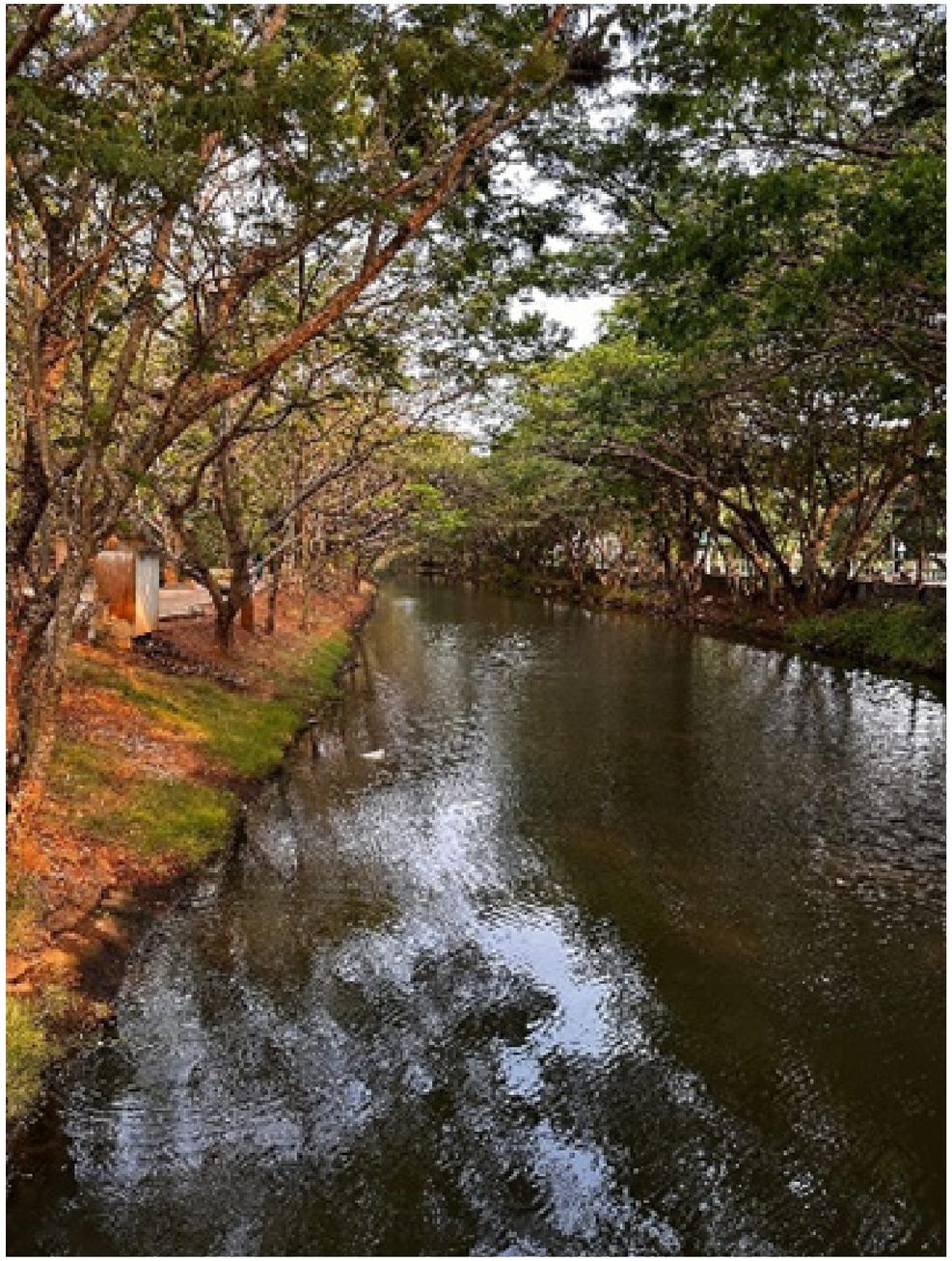


Figure 29 Canoli canal image adjacent Sarovaram Bio park

(Source: Authors)

Kozhikode is situated along the Malabar Coast, bordered by the Arabian Sea to the west and the Western Ghats mountain range to the east. The district covers an area of approximately 2,344 square kilometers, with a coastal length of about 80 kilometers (Kozhikode District Website).

The topography of Kozhikode is characterized by three distinct regions: the sandy coastal belt, the lateritic midlands, and the rocky highlands formed by the Western Ghats.

The city serves as an administrative and commercial hub within the district, housing several institutions of national importance such as the National Institute of Technology Calicut (NITC) and Indian Institute of Management Kozhikode (IIMK). The urban landscape is composed of a combination of traditional markets, modern infrastructure, and residential neighborhoods.

The city center itself is characterized by a mix of commercial and residential spaces. Mananchira Square serves as the heart of Kozhikode, surrounded by historical buildings and vibrant markets like S.M. Street and Valiyangadi, which are essential for local commerce (European Transport, 2020). This area attracts not only residents but also visitors seeking to experience the rich tapestry of local culture through food, shopping, and social interactions. However, the rapid urbanization over the years has led to significant traffic congestion and pressure on infrastructure.

Figure 30 Keyplan of Kozhikode showing the Canoli canaland focus area of study

(Source: Illustration by Authors)

Streets are often bustling with people and vehicles, creating a lively yet chaotic atmosphere that reflects the city's growth.
The Canoli canal forms a crucial part of the West Coast Canal network, interlinking various rivers such as the Korapuzha in the north and the Kallai River in the south, thus creating a vital waterway that supported cargo movement for over a century (IJNRD, 2023). It traverses through urban areas that are densely populated and economically active.

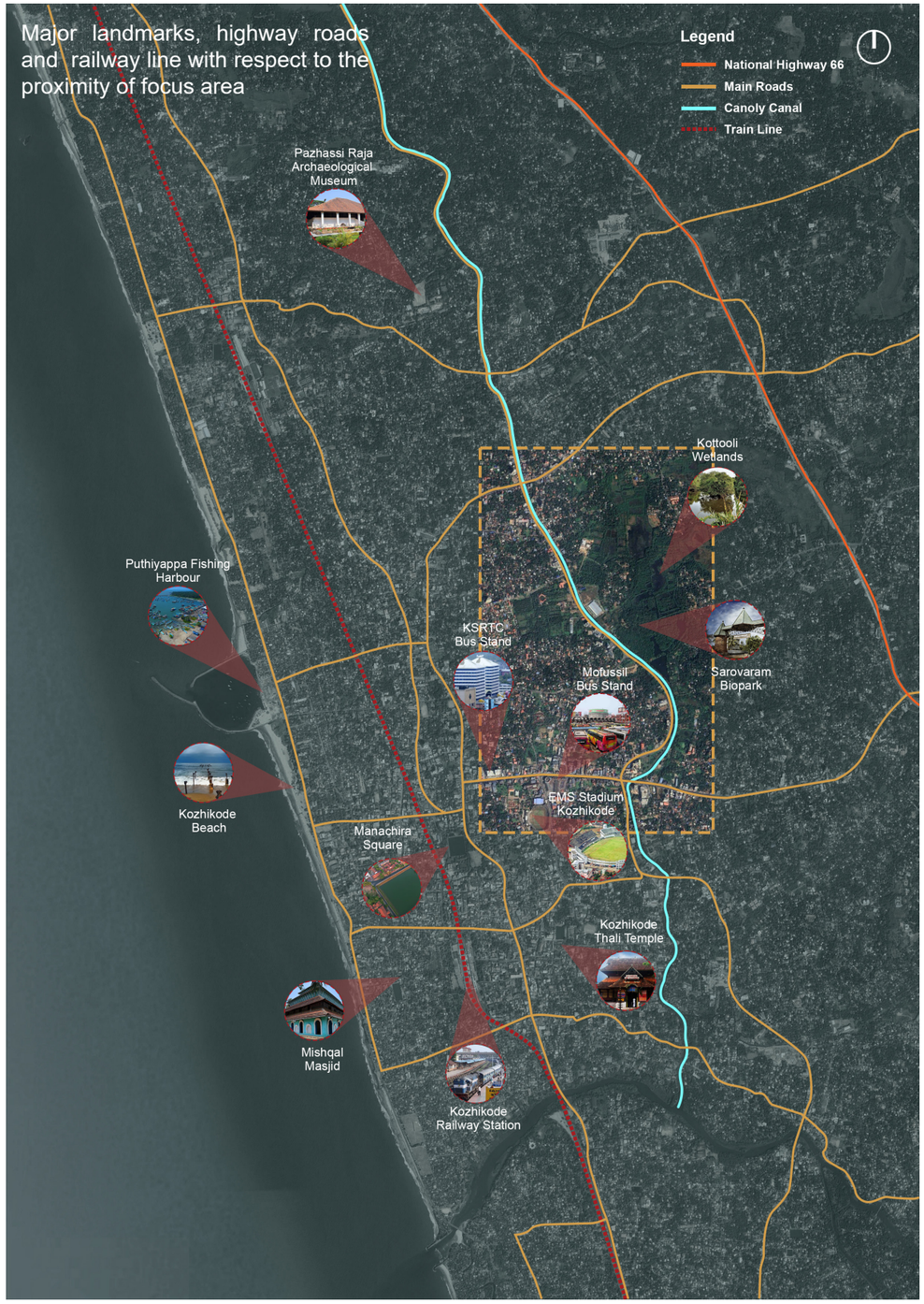


Figure 31 Map showing regional context of Kozhikode

(Source: Illustration by Authors)

Figure 32 Key map of Canoli canal netwrok showing crucial points
(Source: Illustration by Authors)

1 The canal begins at its intersection with the Korappuzha River, where it has a width of approximately 15 meters and a sufficient depth for water flow. The starting section of the canal is lined with trees and greenery, creating a natural, shaded environment. Along the canal banks, residential spaces are present, integrating the canal into the local living areas.

Figure 33 Korapuzha river - Elathur site
(Source: Illustration by Authors)

2 This location, with the Canoli Canal on one side and Eranhikal Lake on the other, offers great potential for water sports tourism and activities. Its scenic views and proximity to residential areas create opportunities for integrating tourism with the local community, enhancing both recreation and economic growth.

Figure 34 Canal road along Eranjikkal view point
(Source: Authors)

3 Along the Kunduparamb area, level difference to the road rises by 10 meters above the canal. The edges in this section are in need of reconstruction, as several areas have been damaged. The canal transitions into more urbanized zones, leading to increased traffic and a higher concentration of buildings.

Figure 35 Canal view along Kunduparambu
(Source: Authors)

4 This section is the primary focus of our study, where the canal width ranges between 12 to 20 meters, with a depth of approximately 60 cm to 1.5 meters. The area is shaded by a canopy of trees and is regularly maintained. However, despite its upkeep, the lack of seating and recreational activities has led to it being underutilized by the local community. To unlock its full potential, we propose introducing more activities, such as small gondola-style boat rides, which could engage the local population and attract more visitors.

Figure 36 Canal along Sarovaram Biopark road - Proposed focus area
(Source: Authors)

5 At this point, after flowing for 11 kilometers, the Canoli Canal reaches the Kallai River. The junction where the canal meets the river is in a state of disrepair and has been left largely unattended. Currently, the area is predominantly used by local timber mills, where logs are submerged in the water for wood treatment. This lack of proper maintenance and the industrial use of the junction have significantly impacted the area's overall condition and potential for other uses.

Figure 37 Kallai river site
(Source: Authors)

Figure 38 Eranjikkal View point - Road crossing through Canal and Lake
(Source: Authors)

Kottuli Wetlands

Figure 39 Kottuli Wetlands
(Source : Azeez et al., 2008, Conservation of Kottuli Wetland, Kozhikode)

The Sarovaram Project spans an area of 273 acres, consisting of 260 acres of wetlands and 13 acres of dry land covered with vegetation and trees. The water bodies in this region are linked to the Connolly Canal, which makes the water quite brackish. This unique environment allows for the growth of a few species of mangroves. Overall, the project area is largely uninhabited, with only a handful of abandoned houses scattered throughout. The nearby communities are primarily middle-class, and interestingly, none of the residents rely on the wetland for their main source of income or as a critical supplement to their livelihoods. Instead, they engage in various other economic activities that do not depend on this ecosystem (Sarovaram Bio Park, 2024).

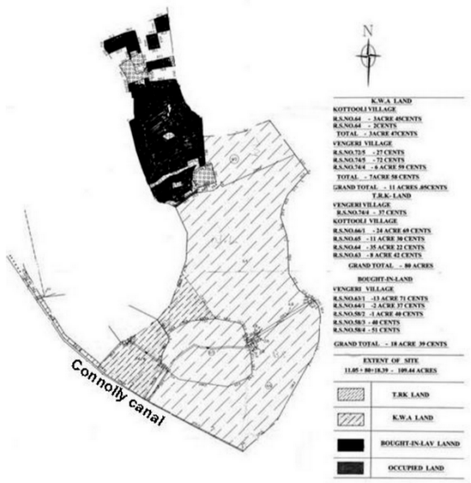


Figure 40 The site plan of the project located in Kottuli Panchayath
(Source : Azeez et al., 2008, Conservation of Kottuli Wetland, Kozhikode)

This wetland is part of a broader ecosystem that includes mangroves and estuarine environments, which are crucial for supporting a diverse range of flora and fauna (Kottuli Wetland Report, 2024). The geographical coordinates of the wetland range from 11°15’56” to 11°17’1” N latitude and from 75°47’22” to 75°48’31” E longitude, placing it within a region that experiences significant tidal influences from the nearby sea.

The Kottuli wetland is primarily fed by rainfall, catchment runoff, and tidal inflow from the sea, resulting in brackish water conditions that support various mangrove species. Notable plant species include Acanthus ilicifolius, Avicennia sp., and Excoecaria agallocha, among others (Kottuli Wetland Report, 2024). The area also hosts a rich diversity of animal life, including numerous bird species such as the Oriental Darter and Woolly-necked Stork, as well as various reptiles and mammals like the Indian Rock Python and Smooth-coated Otter. This biodiversity highlights the ecological significance of Kottuli as a habitat for both resident and migratory species. However, the wetland faces several threats that jeopardize its ecological health. Pollution is a significant concern, with untreated wastewater from nearby urban areas contributing to organic pollution loads. Additionally, the encroachment of land for agricultural and urban development poses a serious risk to the wetland’s integrity (Kottuli Wetland Report, 2024). The spread of invasive species like Salvinia molesta further exacerbates these challenges by disrupting native ecosystems. Despite these threats, Kottuli wetland provides essential ecosystem services. It plays a role in groundwater recharge and offers recreational opportunities through eco-friendly initiatives such as the Sarovaram Bio Park. This park not only serves as a tourist attraction but also fosters awareness about the importance of wetland conservation (Kottuli Wetland Report, 2024). Furthermore, local communities engage in fishing activities within the wetland; however, these practices often occur without proper regulation or oversight.

Local residents participate in fishing and gathering plants for personal use, which can impact the ecological balance if not managed sustainably (Kottuli Wetland Report, 2024). The presence of several temples in the vicinity adds cultural significance to the area; rituals associated with these sites may influence local interactions with the wetland.

Figure 41 Pneumatophores growth in a mangrove patch
(Source : Azeez et al., 2008, Conservation of Kottuli Wetland, Kozhikode)

Figure 42 Pneumatophores growth in a mangrove patch
(Source : Azeez et al., 2008, Conservation of Kottuli Wetland, Kozhikode)

2.1.5. Focus area

The focus area selected for the design proposal is a very crucial zone in terms of environmental aspect, length of the zone & proximity to the city. Wetlands & lakes on the east side drain into the canal, an essential part of the system. Multiple hospitals, schools, govt institutions etc., are also present.

The selected stretch is around **2.8 km long** in between Arayadathupaalam junction and Eranjipalam junction which are two of the major nodes of the city. Nestled strategically along major thoroughfares, Eranhipalam experiences significant vehicular movement, making it a focal point for both local commuters and those traveling to and from the city. The roads here are often congested during peak hours, reflecting the challenges of urban mobility in a rapidly growing city. However, this traffic flow also underscores the area's importance as a commercial hub, with various shops, eateries, and services catering to the needs of residents and visitors alike. Sarovaram Biopark acts as the highlighted landmark of the stretch offering natural wetlands and serene ambience.

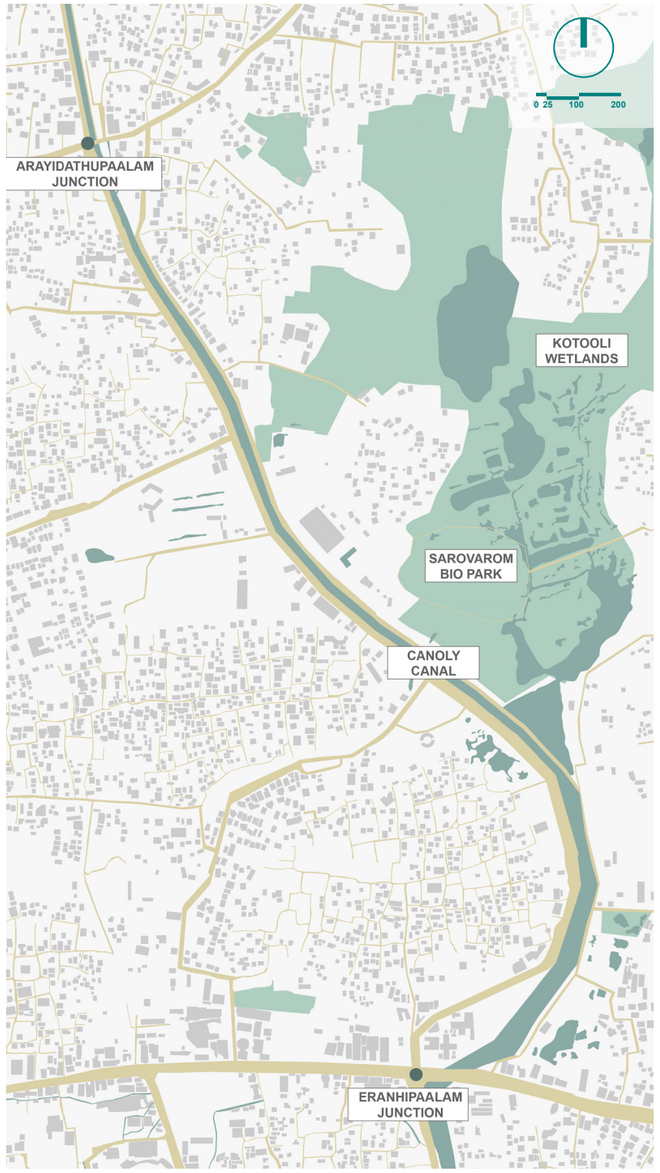


Figure 43 Map of focus area between Eranjipaalam and Arayidathupaalam in Kozhikode

(Source: Illustration by Authors)

2.2. Local authorities and main institutions

Some of the local authorities and main institutions involved in the urban development of the city of Kozhikode would be the following:

1. **Kozhikode Municipal Corporation** is the primary authority responsible for urban planning and development within the city. It oversees land use, zoning regulations, and infrastructure development.

2. **The Kerala State Town Planning Department** provides guidance and support for urban planning initiatives, including master plans and development regulations.

3. **The Kozhikode Development Authority (KDA)** focuses on land development and urban planning, facilitating housing projects and infrastructure improvements in the region.

4. **Local Self-Government Institutions (LSGIs),** which include various ward committees and panchayats, play a significant role in local urban governance and planning initiatives.

5. **Environmental Impact Assessment (EIA)** authorities involve various environmental agencies that assess the impact of urban development projects to ensure sustainable growth.

6. **The Public Works Department (PWD)** is responsible for infrastructure projects, including roads and public buildings, which significantly influence urban design.

2.3. Urban policies and planning measures

Based on the urban policies published by the Town Planning Department of Kozhikode, Kerala in Master Plan for Kozhikode Urban Area - 2035:

"Kottuli Wetlands Management Plan - Urban policy measures to preserve the wetland are as follows:

- *The wet land is to be kept as pollution free and no waste outlets are allowed to be discharged*
- *Sediment trap or silt trap has to be installed at the point of treated effluent water entering the canal*
- *Ensuring full functions of sewage treatment plants located on the banks.*
- *Ensuring stringent action to those who discharge untreated water to wet land*
- *No constructions are permitted*
- *Exploring the possibility of converting Kottuli wet land as a Bio park without losing character and without compromising on ecological importance." (Source: Government of Kerala, Master Plan for Kozhikode Urban Area (2015-2035), 2015, pp.341)*

"Conservation of Heritage Structures and Open Space"

"6.5.2 The extent of parks and open spaces in the urban areas of Kerala is far below the standard norms. Development of the same including those of specialized nature such as amusement parks, recreational walkways etc., will also be given appropriate weightage and encouragement. Prospects for involvement of N.G.O.s in the upkeep of parks and play grounds will be explored. Conversion of existing recreational open spaces for other uses will be prevented." (Source: Government of Kerala, Master Plan for Kozhikode Urban Area (2015-2035), 2015)

"6.5.3 Government shall require all developers including government agencies to attach Environmental Impact Assessment (E.I.A.) statements to all applications for obtaining approval for major development projects. The Government shall issue necessary guidelines in this regard. Guidelines for preparation of Environmental Impact Statements will also be issued by Government." (Source: Government of Kerala, Master Plan for Kozhikode Urban Area (2015-2035), 2015)

"Development of a Walkable Community - Traffic control measures:

- *Design and planning interventions to reclaim flood prone sidewalks which are not accessible/ safe during monsoons.*
- *Creation of Safe Routes to Schools/ educational institutes – create a pedestrian sidewalk network towards educational institutes from important transit points, residential localities etc..*
- *Prepare a 'street user hierarchy framework' for the planning area*
- *Delineate 'Traffic Zones'- Traffic zones specify and standardize expected travel behavior by clearly identified zones, such as 40 kmph, 30 kmph, and 20 kmph zones, pedestrian-priority zones with continuous and clear route for pedestrians with reduced mobility and dedicated pedestrian-only areas.*
- *Build a Comprehensive Sidewalk Network with Safe Routes to transit stations, hospitals, public places etc.., and targeting special sections of population like the elderly, challenged, women etc..*
- *Redesign important roads to include Motorized Vehicles', Walking, and Bicycle lanes by adapting roadway geometry (including reducing or narrowing travel lanes), traffic-signal plans, and adjacent land uses.*
- *Locate parking lots/plazas in such a way to encourage walking*
- *Identification and temporary conversion of unused public/private land to organized parking lots." (Source: Government of Kerala, Master Plan for Kozhikode Urban Area (2015-2035), 2015)*

(Source: Government of Kerala, Master Plan for Kozhikode Urban Area (2015-2035), 2015)

03 CHAPTER LITERATURE REVIEW

CHAPTER 3: LITERATURE REVIEW

3.1. Hydro-cultural dimensions in an urban city development

Water carries profound symbolic significance across various cultures, often representing themes of life, purity, and renewal. In urban design, planners must recognize these cultural dimensions when developing public spaces. Features such as traditional fountains, canals, and water gardens not only reflect cultural heritage but also enhance aesthetic appeal and recreational opportunities within urban settings (van der Meulen, 2024). By integrating culturally meaningful water elements, urban designers can strengthen community identity and foster a sense of belonging among residents. The hydro-cultural dimension underscores the intricate relationship between water and culture, encompassing how societies perceive, utilize, and manage their water resources (Budds & Hinojosa, 2012). This perspective is increasingly vital for creating sustainable urban environments.

For instance, India's historical relationship with water conservation reveals a rich tradition of harvesting practices shaped by reliance on the monsoon season. Unique systems like the stepwells of Gujarat and the johads of Rajasthan exemplify communities' adaptive management of water resources (Kumar & Bindu, 2022). However, the degradation of water bodies can lead to cultural loss and social inequalities, emphasizing the need for culturally inclusive urban design to restore both physical environments and community connections (European Transport, 2020).

Figure 44 *Interaction with water in the cultural aspects*

(Source: Web images)

In India, water bodies hold immense cultural and historical significance where they serve as sites for rituals, festivals, and traditional practices. The degradation of these water bodies leads to the erosion of cultural heritage. For instance, in many Indian cities, rivers and lakes are integral to local customs and ceremonies. The loss of these water bodies results in the disappearance of these cultural practices (Baviskar, 2007). Another major issue is the pollution and degradation of water bodies which can cause significant public health problems. Contaminated water sources lead to waterborne diseases, affecting the health and well-being of urban populations, burdening healthcare systems, and reducing overall quality of life (World Health Organization, 2008).

Additionally, urban water management should integrate both practical needs and cultural values. In cities like Singapore, the incorporation of water features in public areas not only tackles water management issues but also underscores the city's dedication to sustainability, thereby deepening residents' connection to water (Chong, 2022). Similarly, in historic cities such as Venice, water plays a crucial role in shaping urban life and cultural identity, significantly influencing city planning and architecture (Nixon, 2021). In Kerala, the significance of water is woven into the very fabric of the local culture and traditions. It's not just a resource; it's a crucial part of the state's identity, shaping everything from agriculture to the vibrant festivals celebrated throughout the year (Mohan, 2018).

In Kozhikode, water holds cultural significance through historical trade routes and spiritual practices. The Canoli Canal and local rivers are integral to rituals like Onam, where community members engage in ceremonial baths. These water bodies foster social cohesion and identity, reflecting their vital role in the city's heritage and daily life.

In Kozhikode, you'll find a rich tapestry of hydro-cultural practices, such as traditional fishing techniques, lively monsoon festivals, and community-driven water management systems. These practices underscore the importance of adopting a water-sensitive approach to urban rejuvenation—one that honors and integrates local traditions and knowledge.

Figure 45 *Famous boat race of Kerala, India*

(Source: Web image)

Figure 46 *Fishing as a major occupation of people*

(Source: Web image)

Figure 47 *Religious rituals on the water embankments*

(Source: Web image)

By delving into this hydro-cultural aspect, we can create strategies that not only tackle the technical challenges of water management but also resonate deeply with the community's cultural identity.

How does the concept of “urban acupuncture” apply to revitalizing neglected waterways in Kozhikode?

3.2. Canal-Oriented Development (COD)

A canal is a man-made waterway derived from the term chanel, meaning channel, and is primarily utilized for navigation (Ellin, 2010). Historically, canals were constructed to shorten travel distances between locations. However, advancements in technology and design have led to their use in irrigation, inland transportation, and facilitating international trade (Dutta & Sarkar, 2020). The oldest known canal dates back to Mesopotamia around 4000 BC. Ancient China also constructed extensive canals for transport as early as the 8th to 5th centuries BC (Rahana & Nizar, 2020). Although canal construction has ancient roots, the modern era began in the 19th century, spurred by the Industrial Revolution, which heightened the demand for trade and transportation.

Canal-oriented development (COD) is an innovative urban planning strategy that revitalizes urban areas by integrating canals into city landscapes. This approach capitalizes on the aesthetic and functional appeal of waterways to encourage mixed-use developments that foster social interaction and economic activity (Buckman, 2013). For instance, the Erie Canal was pivotal in New York’s economic growth during the 19th century, illustrating how waterways can stimulate urbanization (Buckman, 2013).

In contemporary settings, cities without traditional waterfronts can adopt COD to create attractive urban environments that appeal to residents and tourists. By developing mixed-use spaces along canal banks, cities can enhance urban density and economic vitality while promoting sustainable transport options like walking and cycling

Figure 48 Canal-front Development with public recreational promenades (Source: Web image)

(Kotval & Mullin, 2001). Additionally, COD aligns with sustainable urbanism principles by incorporating green infrastructure that manages stormwater and improves water quality (Millspaugh, 2001).

Moreover, COD promotes community engagement through attractive public spaces that serve as social hubs. These areas often feature parks and recreational facilities that enhance residents’ quality of life (Hecksher, 1977). The concept of **urban acupuncture**, involving small-scale interventions to improve urban spaces, complements COD by addressing localized issues along canal precincts (Academia.edu, 2022). Thus, COD represents a viable strategy for transforming underutilized waterways into valuable assets that enhance economic development and foster community engagement.

Figure 49 Canals of Kerala

(Source: https://www.indiautentica.com/travel/kerala-travel-guide/)

3.2.1. Canals & Urban Life in Venice & Kerala: A comparison

The urban setting of the canals in different parts of the world vary immensely with respect to context, user category, integration with urban layouts, day-to-day activities and so on. Venice's canals are an integral part of the city's urban life, directly affecting daily activities, commerce, and transportation within a compact area. "The Venetian canals are not just a means of transportation; they are a cultural and historical identity that shapes the very fabric of the city" (Muir, 2019). The canals of Venice are a UNESCO World Heritage Site, celebrated for their architectural significance and the city's unique urban layout. The interplay of water and architecture in Venice creates a distinct aesthetic that attracts millions of tourists annually. In contrast, Kerala's canals are more rural and spread out, connecting different parts of the state rather than focusing on a single urban center. "Kerala's Backwaters are a network of interconnected canals, rivers, lakes, and inlets" (Karan, 2017).

In terms of transportation, as canals are the main accessways for commuting in Venice where even entry to buildings are through boats, Kerala often use canals as a secondary mode of transportation way in addition to roadways where canals are predominantly used for tourism. Unlike Venice, where the canals are within a single city, Kerala's canals are spread over a larger area, connecting various villages and towns. Kerala's backwaters illustrate a strong link to local communities and their environmental practices, whereas the canals of Venice symbolize historical urban growth and tourism. Both areas highlight the fragile relationship between human endeavors and natural ecosystems, underscoring the importance of sustainable management strategies to protect these essential waterways for future generations.

"Venice's unique urban structure has been shaped by its canals, influencing its architecture and lifestyle" (Norwich, 1989).

Figure 50 Canals of Venice – European context

(Source: https://www.gondola-rides-venice.com/it/)

Figure 51 Canals of Kerala – Indian context

(Source: Web image)

CASCADING CHANGE

How can we harness hydrological Insights for the Future of Kozhikode's Urban Development ?

3.3. Sponge city concept

The Sponge City Concept represents a transformative approach to urban design that integrates natural water management systems into the fabric of cities. The Sponge City Concept was pioneered by Professor Kongjian Yu of Peking University in 2013. It emphasizes the need for urban areas to function like sponges, absorbing, storing, and reusing rainwater rather than allowing it to run off into drainage systems. This approach is increasingly critical as cities face intensified flooding due to climate change, rapid urbanization, and inadequate infrastructure (Martínez Euklidiadas, 2022).

Key Principles:

1. **Natural Absorption**: Sponge cities are designed to maximize the absorption of rainwater through permeable surfaces and green infrastructure. This includes parks, green roofs, rain gardens, and bioswales that allow water to infiltrate into the ground rather than accumulating on hard surfaces (ENVI-met, 2024).
2. **Water Storage and Recycling**: These urban environments incorporate systems for capturing and storing rainwater for later use. This reduces dependency on external water sources and enhances local water security (Verti-Grow, 2024).
3. **Biodiversity Enhancement**: By integrating green spaces into urban planning, sponge cities promote biodiversity and improve air quality. These areas provide habitats for various species while offering recreational spaces for residents (UCEM, 2024).
4. **Community Engagement**: Involving local communities in the planning process is essential. This ensures that designs reflect the needs and values of residents, fostering a sense of ownership and stewardship over public spaces (Martínez Euklidiadas, 2022).

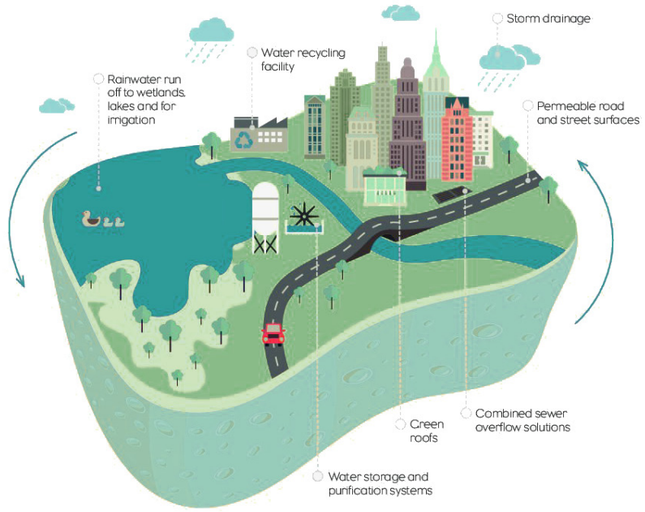


Figure 52 Sponge city concept illustration

(Source: https://focus.cbbc.org/sponge-citiies/)

URBAN ELEMENTS

1 - Green Areas for Infiltration and Recharge
Stormwater is captured in green spaces featuring permeable basins, which facilitate the recharge of shallow groundwater and help mitigate peak runoff. This approach can be seamlessly integrated with a recreational park that showcases various types of vegetation.

- Manage uncontrolled runoff
- Reduce storm water peaks causing flooding
- Strengthen water resources (recharge)

2 - Bio Swale
Swales are shallow excavations, while bunds are earthen or stone barriers designed to capture runoff and enhance water infiltration into the soil. These features are particularly well-suited for use on private land.

- Reduce uncontrolled runoff
- Strengthen water resources (recharge)
- Increase infiltration capacity of the soil
- When coupled with tree planting they reduce the risk of seedlings drying out.

3 - Permeable Paving
Permeable paving made with cobblestones reduces peak runoff and enhances water infiltration. Additionally, it serves as an excellent source of temporary employment for young people.

- Reduce uncontrolled runoff
- Strengthen water resources (recharge)
- It is an excellent form of temporary employment for youth.

4 - Community Garden
Harness rainwater to irrigate small vegetable plots near your home. A community garden helps you make the most of limited space in urban environments or residential areas while promoting water recycling. This initiative not only enhances local food production but also fosters a sense of community and encourages sustainable gardening practices.

- Recycled water are used for irrigation for the community garden
- Optimize the use of a small green areas in town
- Add greening and provide for the town

5 - Greywater Reuse Systems
Greywater reuse is a beneficial solution for hotels, schools, and homes. It is an affordable option that can lead to significant savings on your water bills. By recycling water from sources such as sinks, showers, and laundry, these systems promote sustainable water use while reducing overall consumption.

- Low cost technology
- Good to combine with kitchen gardens
- Water usage can be reduced

6 - Roadside Tree Planting
Stormwater can be directed to trees strategically planted along roadways. Shallow trenches capture the water, providing moisture to the trees, which will ultimately help control erosion caused by road runoff.

- Reduces soil erosion, holds the soil in place
- Flood control by slowing down and absorbing road runoff
- Removes dust and other pollutants from the air
- Trees provide many benefits, also think of providing shade, shelter and beauty
- Trees can be nursed and sold by women/ youth groups/ local businesses
- Trees can trap dust and contribute to clean air, hence decreasing dust related health hazards






Figure 53 Sponge city examples with nature based solutions
(Source: Web images)

Sponge cities:

An absorbing idea in

the face of climate change

3.4. Canal City Project Competition of West coast canal

A live urban proposal is underway by the Kerala government, prioritizing the rejuvenation of the West Coast Canal, spanning from Kovalam to Bekal, with development efforts already in progress and expected to conclude by 2025. A significant focus is on the Canoli Canal, an 11.20 km stretch that connects the Kallai River and Korapuzha River through Kozhikode. The competition emphasizes eco-friendly development strategies that include dredging, bank stabilization, and the construction of recreational facilities along the canal banks (IJNRD, 2023). The primary aim of the project is to transform the Canoli Canal into a vibrant Urban Waterfront. This initiative will focus on canal-oriented development, emphasizing tourism, transportation, and flood mitigation within Kozhikode City. Kerala Waterways and Infrastructures Ltd. (KWIL) plans to implement innovative and globally recognized eco-friendly practices to facilitate comprehensive development along the canal.

*"The vision is to stimulate economic activities, reposition the canal from a geographical barrier to a central hub for tourism and recreation, and promote Kozhikode as India's '**Canal City**' "(KIIFB, 2023).*


Newsletter

CANAL CITY PROJECT

Shri. S Suhas IAS
Managing Director, KWI

THE TIMES OF INDIA

Canoli Canal may see better days

TNN | Jun 17, 2012, 05.38 AM IST

KOZHIKODE: The irrigation department here has submitted a project proposal to the government to develop t 9.5-km stretch of the Canoli Canal from Beypore to Kallayikkal.

The department has also submitted a proposal to the National Bank for Agriculture and Rural Development (NABARD) to develop the area for inland navigation: Rs 37 crore would be required to implement the two projects. The inland navigation proposal aims at connecting Chaliyar and Kallai rivers.

"We will be able to take up the developmental works only if funds are made available. The project will facilitate the revival of the Kallai timber industry," said Abdul Rasak Koottill, assistant executive engineer, Irrigation South sub-division.

"The stretch can be developed easily as problem of land acquisition does not arise for widening the canal," he said.

The officials, however, said the chance of developing the 11.2-km Elathur-Kallai (EK canal) stretch of the canal passing through the heart of the city for inland navigation was bleak.

The irrigation department has divided the canal from Beypore to Kallayikkal area and Elathur to Kallai River for development purposes.

Figure 54 Official news of Canal development by Irrigation department

(Source: https://timesofindia.indiatimes.com/city/kozhikode/canoli-canal-may-see-better-days/articleshowprint/14196678.cms)

Key Objectives of the Project

The project outlines several salient objectives:

- ***Eco-Friendly Development:*** *Prioritizing sustainable canal-oriented development that enhances tourism, facilitates cargo movement, and addresses flood mitigation.*
- ***Infrastructure Improvement:*** *Reconstruction of cross structures to meet relevant waterway standards.*
- ***Canal Modification:*** *Widening and deepening the canal according to established waterway standards, including proper disposal of dredged materials following detailed topographic and bathymetric surveys.*
- ***Embankment Reconstruction:*** *Rebuilding embankments and constructing boat jetties at strategic locations to enhance accessibility.*
- ***Traffic Management:*** *Implementing necessary junction and road improvements to accommodate anticipated future traffic flow following the canal's development.*
- ***Land Acquisition and Rehabilitation:*** *Addressing land acquisition needs and ensuring rehabilitation as required.*
- ***Pollution Prevention:*** *Installing interceptor sewers linked to treatment systems to prevent polluted inflows into the canal.*
- ***Public Amenities:*** *Proposing canal bank roads, leisure facilities, and other essential amenities for community use.*
- ***Beautification Initiatives:*** *Enhancing the aesthetic appeal of canal banks through landscaping and recreational spaces such as walkways and cycle tracks.*
- ***Utilization of Adjacent Properties:*** *Effectively utilizing vacant government and private properties adjacent to the canal for development purposes.*
- ***Waterbody Rejuvenation:*** *Revitalizing adjacent water bodies to improve overall ecological health.*

(Source: Based on KIIFB (2023). Detailed project report for the development of Canoli Canal)


Conolly canal to be a major waterway

Canadian agency to conduct feasibility study and prepare detailed project report

Updated - January 22, 2022 02:42 am IST - KOZHIKODE

AABHA RAVEENDRAN

READ LATER PRINT

The protective walls of the Conolly canal being reconstructed at Karaparamba in Kozhikode.

Figure 55 Newspaper article on Canoli canal developments

(Source: https://www.thehindu.com/news/cities/kozhikode/conolly-canal-to-be-a-major-waterway/article38305783.ece)


Canoly canal revival project gets Rs.2.41 crore grant

11.4-km stretch from Elathur to Kallayi to be de-silted

Updated - November 16, 2021 09:22 pm IST - Kozhikode

KRISHNADAS RAJAGOPAL

READ LATER PRINT

FOR A NEW LEASE OF LIFE: Strengthening of sidewalls toprotect against encroachment forms part of the project to revitalise the Canoly canal. Photo: S. Ramesh Kurup

Figure 56 Fund granted for Canoli canal development

(Source: https://www.thehindu.com/news/cities/kozhikode/canoly-canal-revival-project-gets-rs241-crore-grant/article5071025.ece)

3.5. Scientific publications with detailed background study of Canoli Canal

“The main arterial waterway in the state of Kerala in India is the West Coast Canal and it connects the places between Neeleswaram in the north to Kovalam in the south and the stretch extends about 590 km long” (KIIFB, 2023). The northern part of the West Coast Canal, from Chettuva Lake in Thrissur District to Kuttiyadi River near Payyoli in Kozhikode District, was built in the mid-nineteenth century. This construction was led by H.V. Connolly, the District Collector of Malabar at the time, who proposed the Mangalore-Cochin canal to improve transportation in the area. The canal was created by connecting various backwaters and rivers like Kadalundi, Chaliyar, Kallai, Korappuzha, Akalapuzha, and Kuttyadi River with several man-made canals, which are now known as the Canoli Canal, named after H.V. Connolly.

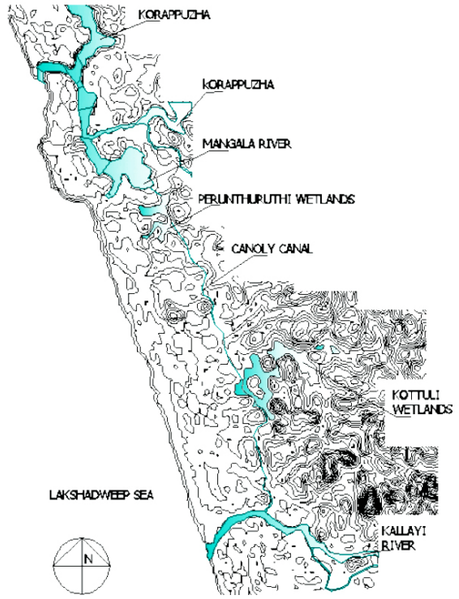


Figure 57 Topography of Canal environment
(Source: Anjana Bhagyanathan and Kasthurba A.K (2013). Hydrological Study of Canoly Canal, Calicut, Kerala, India)

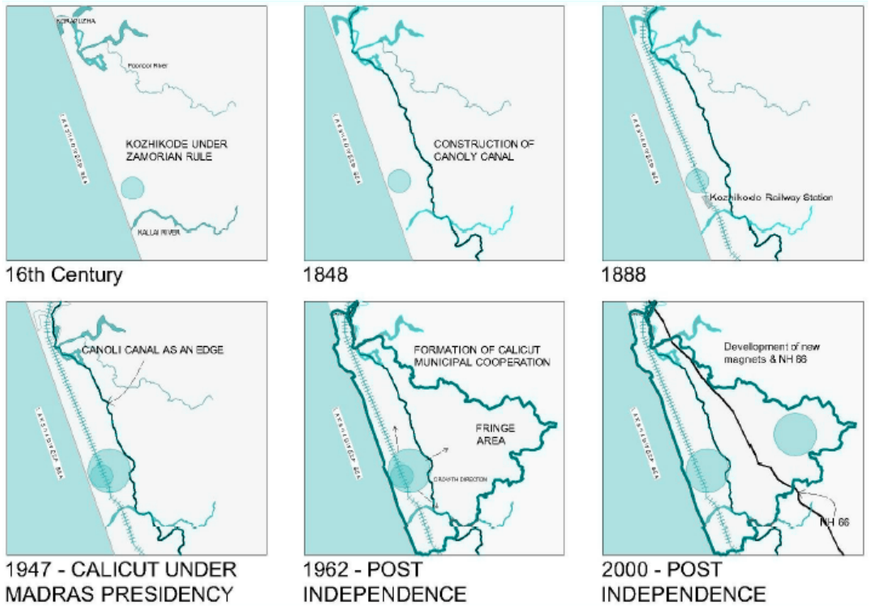


Figure 58 Evolution of the city of Kozhikode with respect to Canoli canal

(Source : https://www.ijnrd.org/papers/IJNRD2304379.pdf)

Figure 59 River Of Logs In Kallai River
(Source - British era Calicut old photo, 1898)

Figure 60 Present-day - Seasoning of timber in Kallai River

(Source: IJNRD (2023)

Figure 61 Canoli canal from map of Calicut Railway Station 1893
(Source - BM Archives. (n.d.). Arbeitsgebiet der Basler Missions Station Calicut)

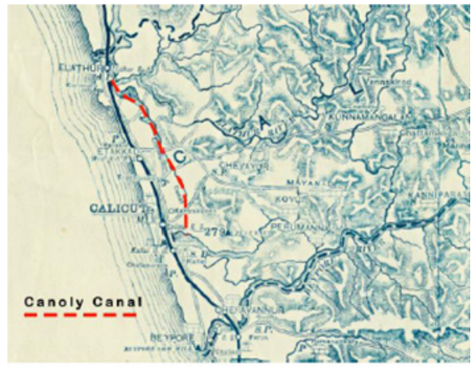
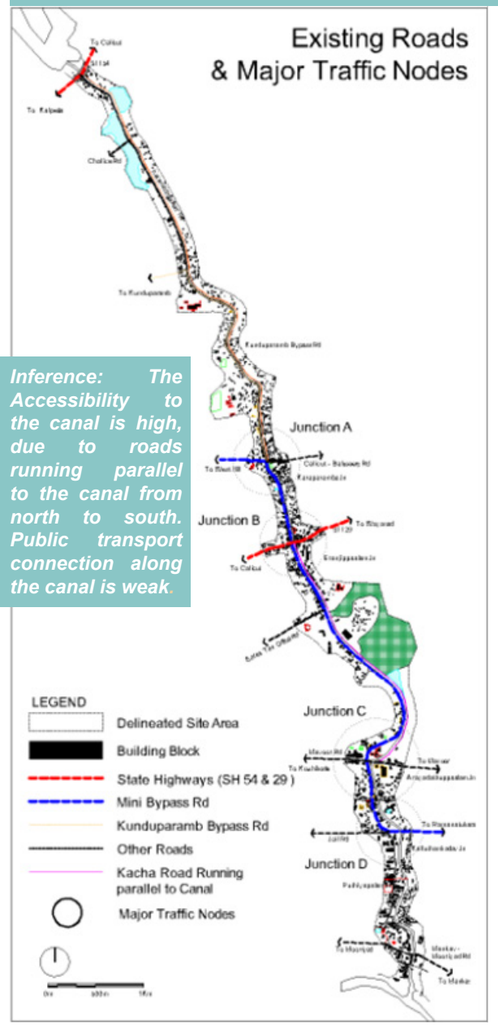


Figure 62 Canoli canal from map of Malabar District 1900
(Source - BM Archives. (n.d.). “Map of the Malabar District”. Basel Mission Archives.)

Historically, the canal was a bustling artery of commerce, supporting the livelihoods of many local fishermen and traders. The waterway allowed for the efficient movement of products, which was essential for Kozhikode’s economy, particularly during the spice trade era. Kallai was one of Malabar’s oldest timber trading centres(IJNRD, 2023). However, as urbanization accelerated in the latter half of the 20th century, the canal began to suffer from neglect and pollution. ‘‘Rapid industrialization and residential expansion led to encroachments on the canal banks, while untreated sewage and waste from nearby settlements significantly deteriorated water quality.’’ (Sharma, 2019).

These changes not only impacted the canal’s ecological health but also undermined its potential as a recreational and economic asset. The canal spans approximately 11.2 kilometers and varies in width from 6 to 20 meters (IJSER, 2022). It was initially celebrated for its role in boosting local commerce by providing an efficient means for transporting goods to and from the bustling port city of Kozhikode. However, following Conolly’s assassination in 1855, further extensions to the canal were halted, leading to its gradual decline (Historical Alleys Blog, 2017).

Canoli canal is one of the main veins of the city of Kozhikode since this canal absolves the flooding of the city. Over the years, the importance of the inland waterways has declined and the focus shifted on the development of better road and rail transportation systems with urbanization. Lack of maintenance of the waterways and the negligence of the canals led to the accumulation of waste and sediment deposits in the waterways. Encroachments of the canal banks due to the large increase in population resulted in turning the canals into a dumping area of waste. These have affected the flood carrying capacity of the Canoli Canal to a great extent as it was initially intended to serve as an outlet for the Kerala monsoon flood water as well.



Inference: The Accessibility to the canal is high, due to roads running parallel to the canal from north to south. Public transport connection along the canal is weak.

Figure 63 *Map of major road networks & traffic nodes*

(Source: IJNRD (2023). Reimagining Canoli Canal: A comprehensive approach towards sustainable development.)

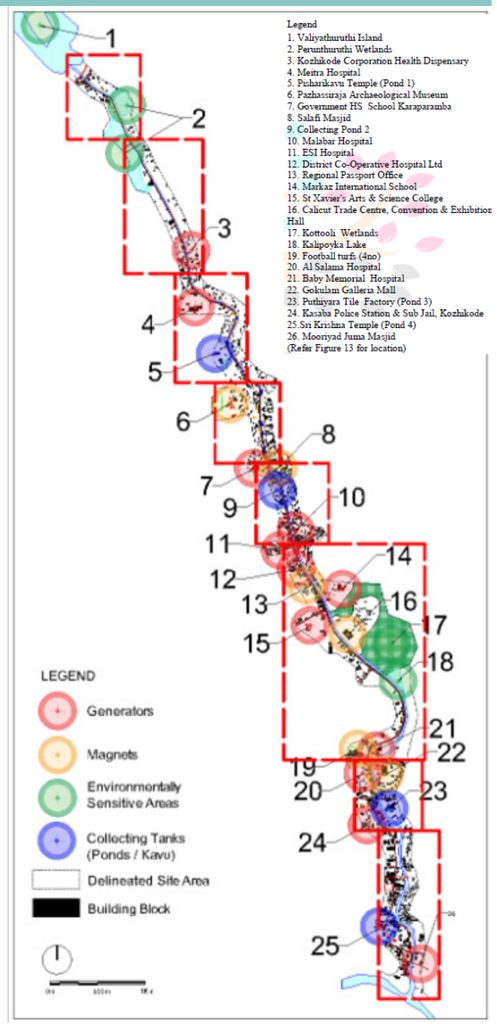


Figure 64 *Generators, Magnets & Ecological hotspots within the study area.*

(Source: IJNRD (2023). Reimagining Canoli Canal: A comprehensive approach towards sustainable development.)

3.5.1. Hydrological study

The hydrology of Canoli Canal is characterized by its variable width—ranging from 6 to 20 meters—and depth, which fluctuates between 0.5 to 2.0 meters during peak monsoon seasons (Ghosh et al., 2019). The canal receives inflow from over 30 drains and minor streams, draining approximately 35-40% of Kozhikode's urban area (Calicut Master Plan 2035). This extensive catchment area contributes to the canal's role as a primary drainage system for the city, particularly during heavy rainfall events. However, this hydrological function is compromised by pollution from untreated sewage and solid waste.

Groundwater hydrology: Kozhikode district features a shallow, unconfined sandy aquifer that varies in thickness between 4 to 12 meters. Throughout the year, the groundwater depth fluctuates significantly, ranging from 0.21 meters to 4.5 meters. Notably, the Kottuli and Perunthuruthi wetlands are believed to experience the highest water table levels, particularly during the monsoon months when it can reach as shallow as 0.21 meters. "The flow pattern shows a generalized flow towards the west, the Arabian Sea. Once the canal was built in 1848, the surface water and ground water was directed to the canal to maintain the water level for navigational purposes " (Anjana Bhagyanathan and Kasthurba A.K, 2013).

The inflow of domestic and industrial effluents has resulted in high levels of biochemical oxygen demand (BOD) and total suspended solids (TSS), often exceeding permissible limits set by environmental regulations (IJSER, 2022). Such pollution not only degrades water quality but also impacts the canal's ecosystem, leading to reduced biodiversity and habitat quality. The pollution dynamics within Canoli Canal are influenced by several anthropogenic factors. Urban runoff containing fertilizers, pesticides, and other contaminants significantly contributes to nutrient loading in the canal (Ghosh et al., 2019). During the monsoon season, increased runoff exacerbates these issues as pollutants are washed into the canal from surrounding urban areas. Furthermore, the canal has become a dumping ground for solid waste due to inadequate waste management practices in Kozhikode. This accumulation of debris not only obstructs water flow but also leads to sedimentation, further reducing the canal's depth and increasing flood risks (KIIFB, 2023). The presence of invasive species and algal blooms has also been reported, indicating a shift in the ecological balance due to nutrient enrichment from pollution (IJSER, 2022).

Figure 65 *Flow pattern discounting the canal*

(Source: Anjana Bhagyanathan and Kasthurba A.K (2013). Hydrological Study of Canoly Canal, Calicut, Kerala, India)

Figure 66 *Waste water inlet between the canal into the wetlands*

(Source: Image by Authors)

3.5.2. Comparison of water quality: Pre-COVID & Post-COVID lockdown

A study titled “Assessment of Water Quality and Ecosystem Health of a Canal System during the Lockdown Period” was conducted by researchers at the Centre for Water Resources Development and Management (CWRDM) in Kozhikode where the water quality of the Canoli Canal before and during the COVID-19 lockdown was evaluated. The investigation quantitatively analyzed various water quality parameters, including pH, electrical conductivity (EC), dissolved oxygen (DO), and biological oxygen demand (BOD), across five segments of the canal (Sruthi et al., 2023).

For determining the level of pollution, higher the DO value indicates that there is a lower level of pollution with a reduced input of sewage.

The research revealed that E. coli, an important marker for fecal contamination, was entirely absent during the lockdown, which was in stark contrast to the levels observed before the lockdown. Principal component analysis indicated that both weathering processes and human waste were significant factors influencing ecosystem health the findings advocate for ongoing pollution control measures and suggest that temporary reductions in pollution sources can lead to notable improvements in aquatic ecosystems, providing valuable insights for policymakers aiming to enhance environmental health (Sruthi et al., 2023).

BOD indicates the amount of oxygen needed by aerobic bacteria to break down organic waste in water.

Focus area

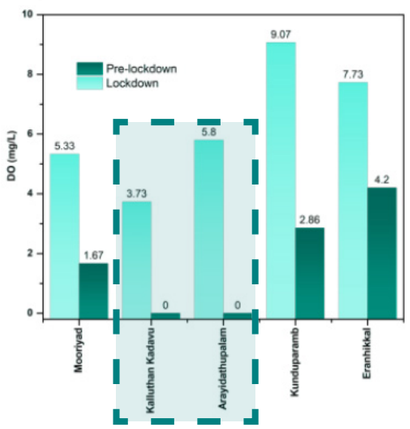


Figure 67 *DO values at different sampling site*
(Source: Sruthi, K., et al., ‘Assessment of Water Quality and Ecosystem Health of a Canal System during the Lockdown Period’, 2023)

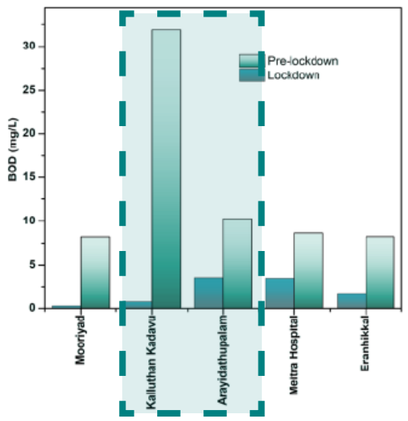


Figure 68 *BOD values at different sampling site*
(Source: Sruthi, K., et al., ‘Assessment of Water Quality and Ecosystem Health of a Canal System during the Lockdown Period’, 2023)

Inference: The DO level in our focus area has increased drastically during lockdown period indicating reduction in the pollution level during lockdown period.

Inference: Lower BOD. Together suggests that the Arayidathupalam region has organic pollution, which can be attributed to waste inputs from domestic activities, hospitals, hotels, garages, and slaughterhouses (Bhagyanathan & Kasthurba, 2013)

Focus area

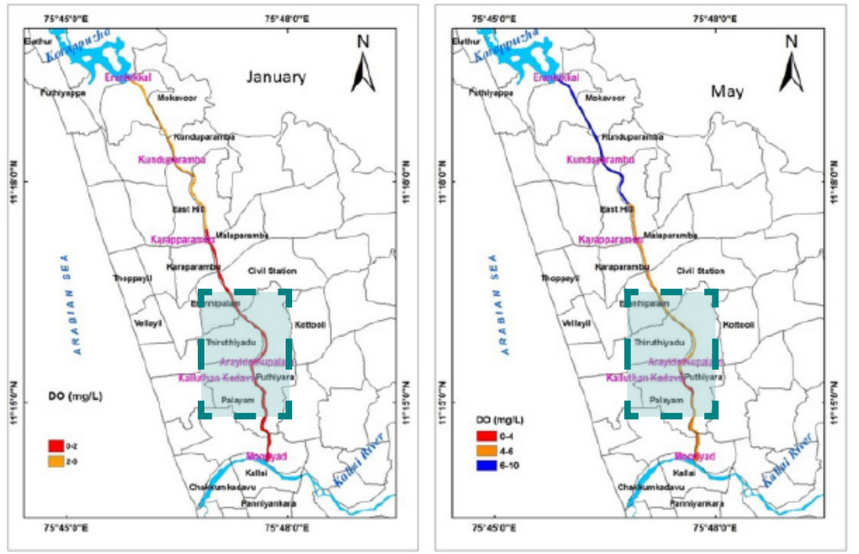


Figure 69 *Spatial distribution of DO along the Canal stretch during two periods*
(Source : https://doi.org/10.1007/s40899-022-00784-0 , Assessment of water quality and ecosystem health of a canal system during the lockdown period)

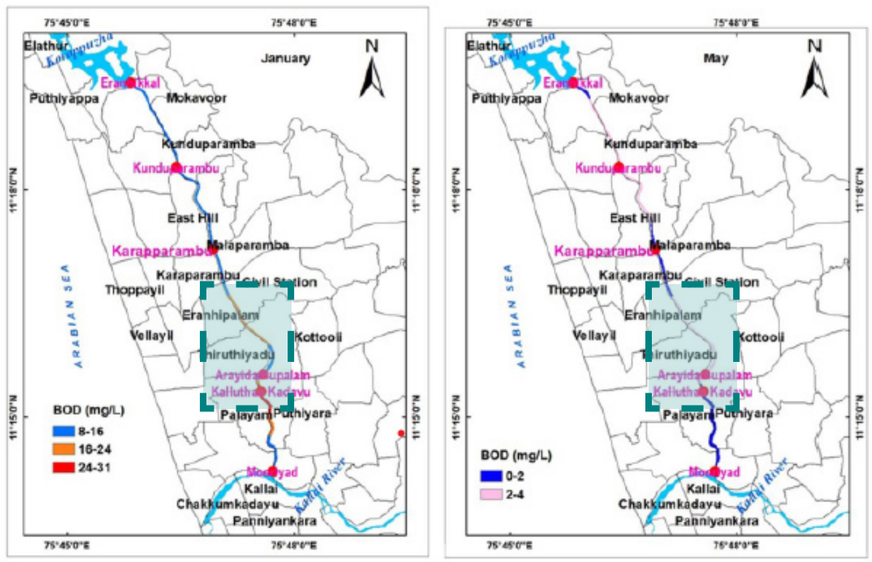


Figure 70 *Spatial distribution of BOD along the Canal stretch during two periods*
(Source : https://doi.org/10.1007/s40899-022-00784-0 , Assessment of water quality and ecosystem health of a canal system during the lockdown period)

3.5.3. Tidal influence on the Canoli canal

Focus area

Sampling Stations	Sampling Code	Latitude	Longitude
Mooriyad foot bridge	CC 1	$75^0$47.718'	11^0 14.268'
Puthiyapalam	CC 2	$75^0$47.720'	11^0 14.268'
Arayidathpalam	CC 3	$75^0$47.563'	11^0 15.332'
Sarovaram	CC 4	$75^0$47.448'	11^0 16.132'
Karimbanapalam	CC 5	$75^0$47.226'	11^0 16.438'
Eranjipalam	CC 6	$75^0$47.061'	11^0 16.783'
Karaparamba	CC 7	$75^0$46.924'	11^0 17.217'
Madappattupalam	CC 8	$75^0$46.816'	11^0 17.428'
Kakkuzhipalaam	CC 9	$75^0$46.720'	11^0 17.555'
Kunduparamba	CC 10	$75^0$46.598'	11^0 18.474'
Eranjikkal	CC 11	$75^0$45.834'	11^0 19.424'

Figure 71 Spatial distribution of DO along the Canal stretch during two periods
(Source : TIDAL_INFLUENCE_OF_POLLUTANTS_ON_CANOLI_CANAL_BESIDE_KOTTULI_WETLAND_IN_KOZHIKODE_CITY)

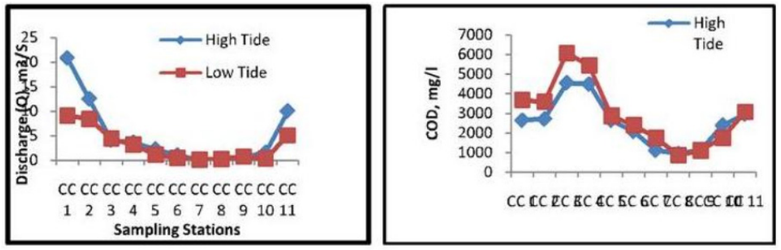


Figure 72 Variation of Discharge and COD concentration
(Source : TIDAL_INFLUENCE_OF_POLLUTANTS_ON_CANOLI_CANAL_BESIDE_KOTTULI_WETLAND_IN_KOZHIKODE_CITY)

A research study was conducted by Centre for Water resources Development and Management, Kozhikode, Kerala titled "Tidal influence of Pollutants on Canoli Canal beside Kottuli Wetlands in Kozhikode city". The study shows that Canoli canal has impacts of tidal actions where it allows the entry of saltwater from Arabia Sea during the high tides through the connecting rivers. "During high tide, the discharge from the Canoli Canal can fluctuate significantly, ranging from 0.1 to 20.83 m^3/s, while during low tide, it decreases to between 0.1 and 9.07 m^3/s" (Revathi & Mohanan Namboodiri, 2022).

Interestingly, pollutant levels tend to peak during low tide, which indicates that contaminants are washed out into the wetlands when high tide occurs. The tidal movements significantly influence the dynamics of the Canoli Canal, causing water levels to rise during high tides and allowing water to flow into adjacent wetland areas through various inlets. As the tide recedes, pollutants from the canal are drawn into these wetlands. This repetitive cycle of polluted water entering and exiting adversely affects the wetlands' health, degrading their ecological integrity and diminishing water quality. Consequently, this threatens the biodiversity that relies on these sensitive ecosystems. Over time, such processes contribute to the gradual decline of wetland functionality, impairing their ability to act as natural filters and habitats for various species (Bhagyanathan, 2023).

3.5.4. Canal initiatives : Operation Canoli Canal

Figure 73 Operation Cannoli Canal and similar initiatives carried in Kozhikode city
(Source: Deccan Chronicle dated on 28th August 2018 and Web images)

Projects such as 'Operation Canoli canal' and other clean-up drives were carried out by a local waste management group called 'Niravu' and local communities where the moss and garbages were cleared in a period of 30 days. This highlights the potential of involving local stakeholders and communities in the sustainable strategies of maintaining the urban spaces. However, lack of follow-up initiatives led to the accumulation and deterioration of the canal and its adjacent wetlands.

3.5.5. Comparative study of Turin's Hydrological scenario & solutions

Turin, located in the northwestern region of Italy, presents a complex hydrological scenario shaped by its historical reliance on rivers and canals, particularly the Po River and its tributaries. The city is characterized by significant spatial and temporal variability in precipitation, influenced by its geographic positioning near the Alps and exposure to moisture-laden air from the Mediterranean Sea (Brussolo et al., 2022). Over recent decades, Turin has faced challenges related to urbanization, climate change, and water management, necessitating innovative strategies for sustainable urban development.

Turin's approach to hydrological management has evolved to incorporate nature-based solutions (NBS) and sustainable urban drainage systems (SuDS), which aim to mitigate flooding risks while enhancing urban green spaces (Cavallaro et al., 2022). These strategies not only address immediate water management challenges but also promote community engagement and resilience against climate impacts. As Kozhikode seeks to implement similar water-sensitive rejuvenation initiatives for its Canoli Canal, examining Turin's hydrological practices provides valuable insights into integrating ecological sustainability with urban development. In terms of water management practices, Turin has implemented rigorous water quality monitoring systems that involve regular assessments of pollutants and proactive measures to mitigate contamination. The city employs green infrastructure solutions such as constructed wetlands and bioswales to filter runoff before it enters the waterways (Cibin et al., 2020).

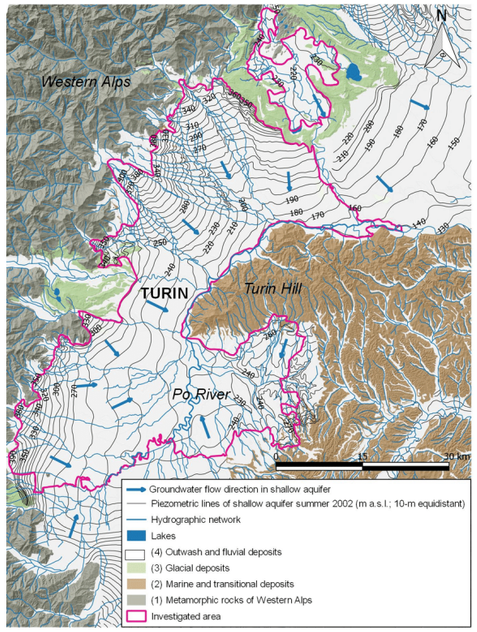


Figure 74 Geo-hydrological map of the area investigated
(Source: https://www.researchgate.net/figure/Geo-hydrological-map-of-the-area-investigated_fig2_314715076)

Key Hydrological Solutions Implemented in Turin:

1. **Integrated Urban Water Management (IUWM)** Turin has adopted an Integrated Urban Water Management (IUWM) framework that emphasizes the interconnectedness of water supply, wastewater treatment, stormwater management, and ecological health. This approach facilitates coordinated planning across different sectors and stakeholders, ensuring that water management strategies are holistic and sustainable (Cavallaro et al., 2022). The inclusion of various stakeholders—from government agencies to local communities—enhances the effectiveness of water management initiatives.
2. **Nature-Based Solutions (NBS)** A significant aspect of Turin's strategy is the implementation of nature-based solutions (NBS) aimed at enhancing urban green spaces while improving water quality and managing stormwater. Initiatives such as green roofs, permeable pavements, and urban forests have been introduced to mitigate flooding risks and enhance biodiversity (Cibin et al., 2020). For example, the city has developed several parks that incorporate wetlands designed to absorb excess rainwater and filter pollutants before they enter the river systems.
3. **Sustainable Urban Drainage Systems (SuDS)** Sustainable Urban Drainage Systems (SuDS) have been integrated into Turin's urban planning to manage stormwater effectively. These systems mimic natural drainage processes by using features such as swales, bioretention areas, and detention basins to slow down runoff and promote infiltration (Cavallaro et al., 2022). The implementation of SuDS has proven effective in reducing peak flow rates during heavy rainfall events, thereby minimizing flooding risks in urban areas.
4. **Community Engagement and Education** Engaging local communities in water management practices has been a cornerstone of Turin's approach. Educational programs aimed at raising awareness about water conservation and pollution prevention have been implemented throughout the city (Cibin et al., 2020).
5. **Monitoring and Adaptive Management** Continuous monitoring of hydrological conditions is crucial for effective water management. Turin employs advanced monitoring systems that track rainfall patterns, river levels, and water quality across its waterways (Brussolo et al., 2022).

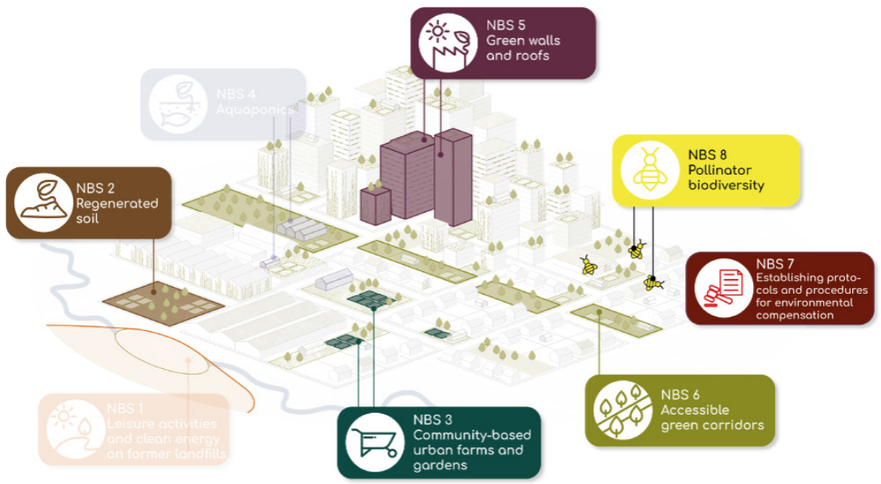


Figure 75 Implemented progireg NBS in the Turin Living Lab
(Source: https://progireg.eu/fileadmin/user_upload/Turin/ProGIreg-Living_Lab-Turin.pdf)

04 CHAPTER CONTEXT ANALYSIS

CHAPTER 4: CONTEXT ANALYSIS

4.1. SWOT ANALYSIS

STRENGTH:

1. **Natural resources:**
   The focus area selected has a huge potential of implementing sensitive development practices due to its close proximity to the natural bio-park and the vast area of wetlands setting the backdrop of a beautiful ecosystem. The Canoli Canal and surrounding wetlands provide essential ecosystem services, including biodiversity support, flood mitigation, and water purification. These resources can be leveraged to enhance the area's ecological health and aesthetic appeal (CWRDM, 2023).

2. **Strategic Location:**
   Connecting two major traffic nodes/ junctions of Eranjipalam and Ariyadathupaalam, the location of the selected stretch offers the ideal conditions to study the mobility patterns of vehicles and pedestrians. Proximity to Sarovaram Biopark offers potential for recreational and educational opportunities, promoting environmental awareness among residents and visitors (Kozhikode Corporation, 2019).

3. **Community participation:**
   The neighborhood of local residents and users use this spine of Canoli canal as an active urban corridor catering to the daily activities of the community. The surrounding residents play a crucial role in the urban proposal for a sensitive maintenance and awareness of the urban guidelines. The local community's involvement in environmental initiatives can foster a sense of ownership and commitment to the rejuvenation project. Community-led efforts can enhance the sustainability of water management practices (MDPI, 2023).

WEAKNESS:

1. **Pollution issues:**
   One of the most critical weaknesses is the pollution of water in the canal from waste disposals and urban runoff, especially from the sewers affecting the overall life of the ecosystem. One of the primary contributors is the direct discharge of untreated sewage from residential areas, hospitals, and commercial establishments. Approximately 70 drains empty into the canal, carrying untreated wastewater that severely impacts water quality (Siddik et al., 2022). The canal also receives effluents from nearby industries, including timber processing and slaughterhouses. The increased impervious surfaces in Kozhikode due to urban development also led to higher volumes of urban runoff entering the canal without adequate treatment.

2. **Infrastructure deficiencies:**
   The structural integrity of the canal's embankments is compromised in several locations due to inadequate foundations and erosion. Many stone masonry embankments have collapsed or are in a state of

disrepair, which poses risks of further degradation and flooding (KIIFB, 2023). Additionally, thick vegetation growth in some stretches obstructs water flow, exacerbating flooding issues during heavy rains. Over the years, inadequate maintenance has led to the accumulation of sediments and waste within the canal. This sedimentation reduces the canal's depth and flow capacity, making it less effective as a drainage system for stormwater and monsoon floods (KIIFB, 2023). The existing infrastructure of the drainages are also inadequate for managing the high volume of wastewater flowing from the heavily populated areas surrounding the canal.

3. **Lack of Water Quality Management Systems:**
   There is a notable absence of effective water quality management systems along the canal. Without monitoring and treatment facilities to address pollution from residential and industrial sources, efforts to rejuvenate the canal will be ineffective (IJSER, 2023).

OPPORTUNITIES:

1. **Innovative Water Management Practices:**
   Implementing WSUD principles such as rainwater harvesting, green roofs, and permeable pavements can improve water quality and reduce flooding while enhancing urban aesthetics (Tandfonline, 2022). Along the stretches of the canal, there are multiple potential public areas that could be proposed with integrated rain gardens and green infrastructure solutions that could be utilized by the residents as recreational spaces while catering to the ecological needs and an effective water management.

2. **Sustainable Development Goals (SDGs):**
   Aligning the rejuvenation project with the UN's SDGs can attract funding and support from governmental and non-governmental organizations focused on sustainable urban development (CSE India, 2018). Since the Canoli canal redevelopment project is an existing proposal from the official authorities, a sensible development plan that focuses on preserving the natural ecosystems and sustainably address the key issues.

3. **Ecotourism Potential:**
   The Canoli Canal is home to diverse aquatic and terrestrial ecosystems, including various fish species, migratory birds, and unique vegetation along its banks. This biodiversity can attract nature enthusiasts and researchers interested in studying the local flora and fauna (Ghosh et al., 2019). Promoting eco-friendly activities such as bird watching and guided nature walks can enhance visitor engagement with these natural resources.

THREATS:

1. **Climate Change Impacts:**
   As a coastal region, Kozhikode is vulnerable to rising sea levels due to climate change. The Canoli Canal discharges into the Arabian Sea through the Kallai River, making it susceptible to saltwater intrusion, particularly during high tide events (KIIFB, 2023).

This intrusion can alter the freshwater balance of the canal, negatively impacting aquatic ecosystems and reducing the viability of freshwater species. Higher temperatures can lead to increased evaporation rates and reduced water levels in the canal. Increasing rainfall variability and rising sea levels pose significant risks to urban water management systems. These climate-related challenges could undermine rejuvenation efforts if not adequately addressed (CWRDM, 2023).

2. **Urbanization Pressures:**
   Rapid population growth, lack of infrastructure development, sudden urban sprawl in Kozhikode may lead to further encroachment on natural water bodies and green spaces, complicating efforts to implement sustainable practices (MDPI, 2023). Encroachments along the canal banks have been a persistent issue, with significant portions of land being illegally occupied for housing or commercial purposes. Reports indicate that approximately 25 acres have been encroached upon near the Kallayi River and Canoli Canal (The Hindu, 2017).

3. **Environmental Degradation:**
   The ongoing pollution from residential areas has led to a decline in biodiversity within the canal ecosystem. Sensitive aquatic species are unable to survive in polluted conditions, leading to a loss of ecological balance (CWRDM, 2018). The presence of waste islands formed by accumulated solid waste further impedes water flow and contributes to habitat degradation (The Hindu, 2016). The pollution from the Canoli Canal has downstream effects on connected water bodies, including the Kallayi River. Contaminants flowing from the canal contribute to broader water quality issues in these rivers, affecting local fisheries and drinking water supplies for nearby communities (The Hindu, 2016).

4. **Political Instability**
   Changes in local governance or policy priorities could affect funding and support for long-term projects like water-sensitive urban rejuvenation (CSE India, 2018). Fragmented decision making and lack of coordination between multiple government authorities and local bodies could hamper a comprehensive planning or overshadow a critical environmental assessment due to short-term focused political agendas. Delay in the implementation of urban policies can stall necessary infrastructure improvements.

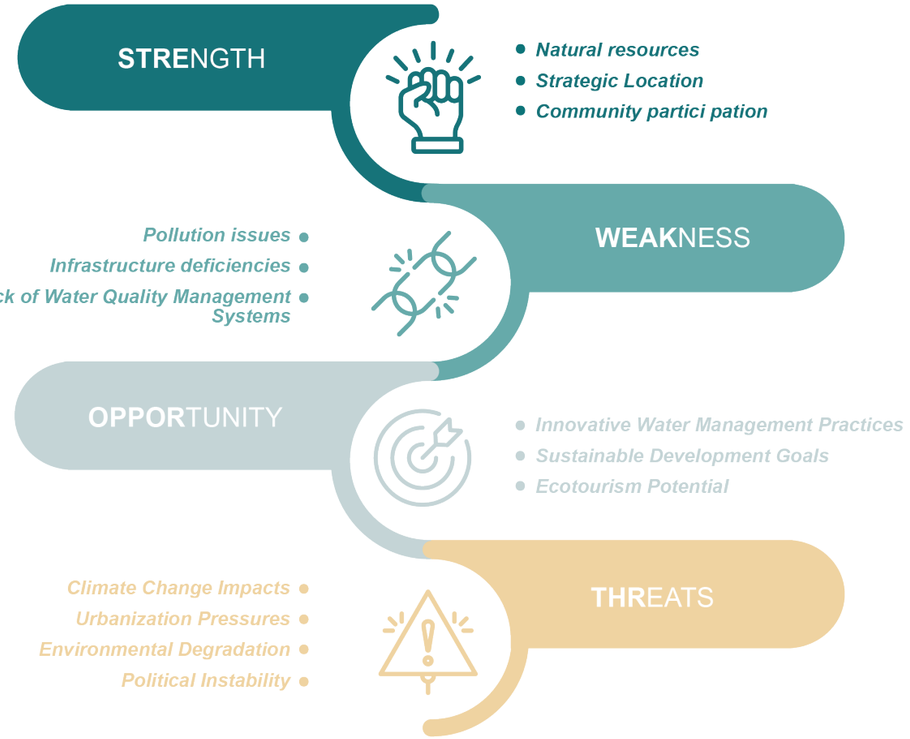


Figure 76 *Illustration highlighting summary key points of SWOT analysis*
(Source: Illustration by Author)

4.2. Kozhikode mobility and nodes analysis

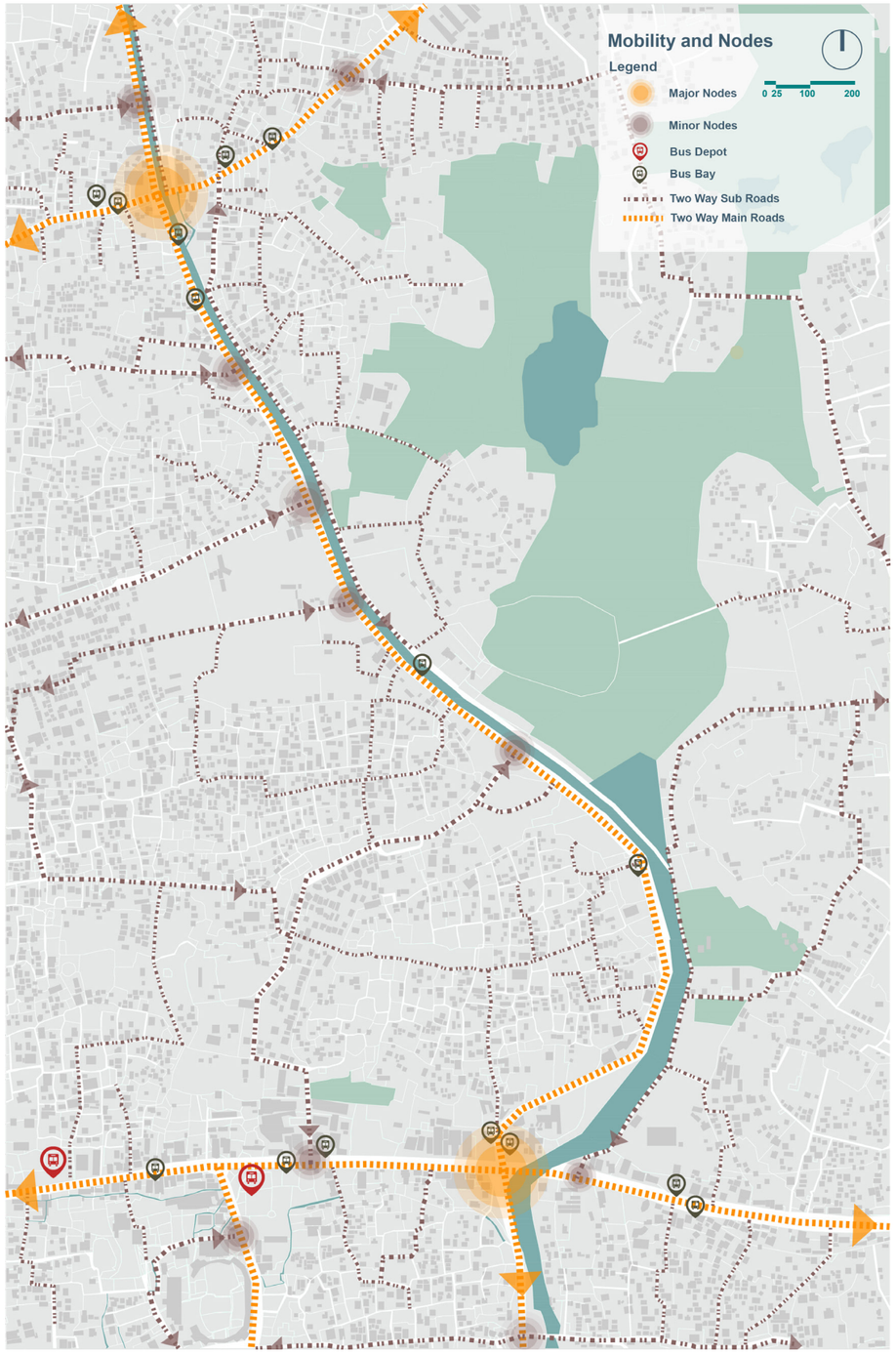


Figure 77 *Vehicular mobility and nodes analysis of focus area*
(Source: Illustration map by Authors)

4.3. Kozhikode pedestrian paths and open spaces

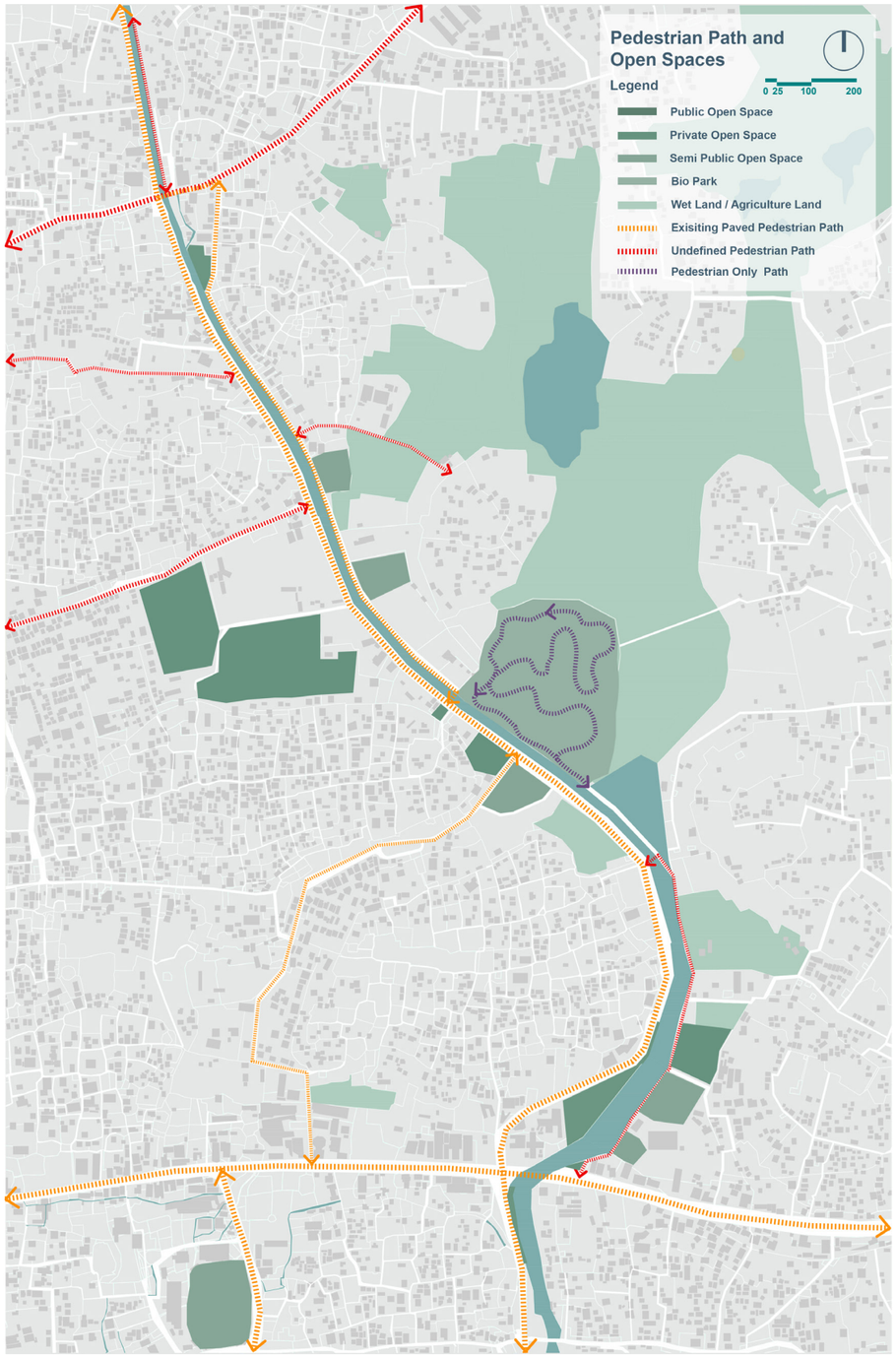


Figure 78 *Pedestrian movement and open spaces analysis of focus area*
(Source: *Illustration map by Authors)*

4.4. Green areas and waterbodies

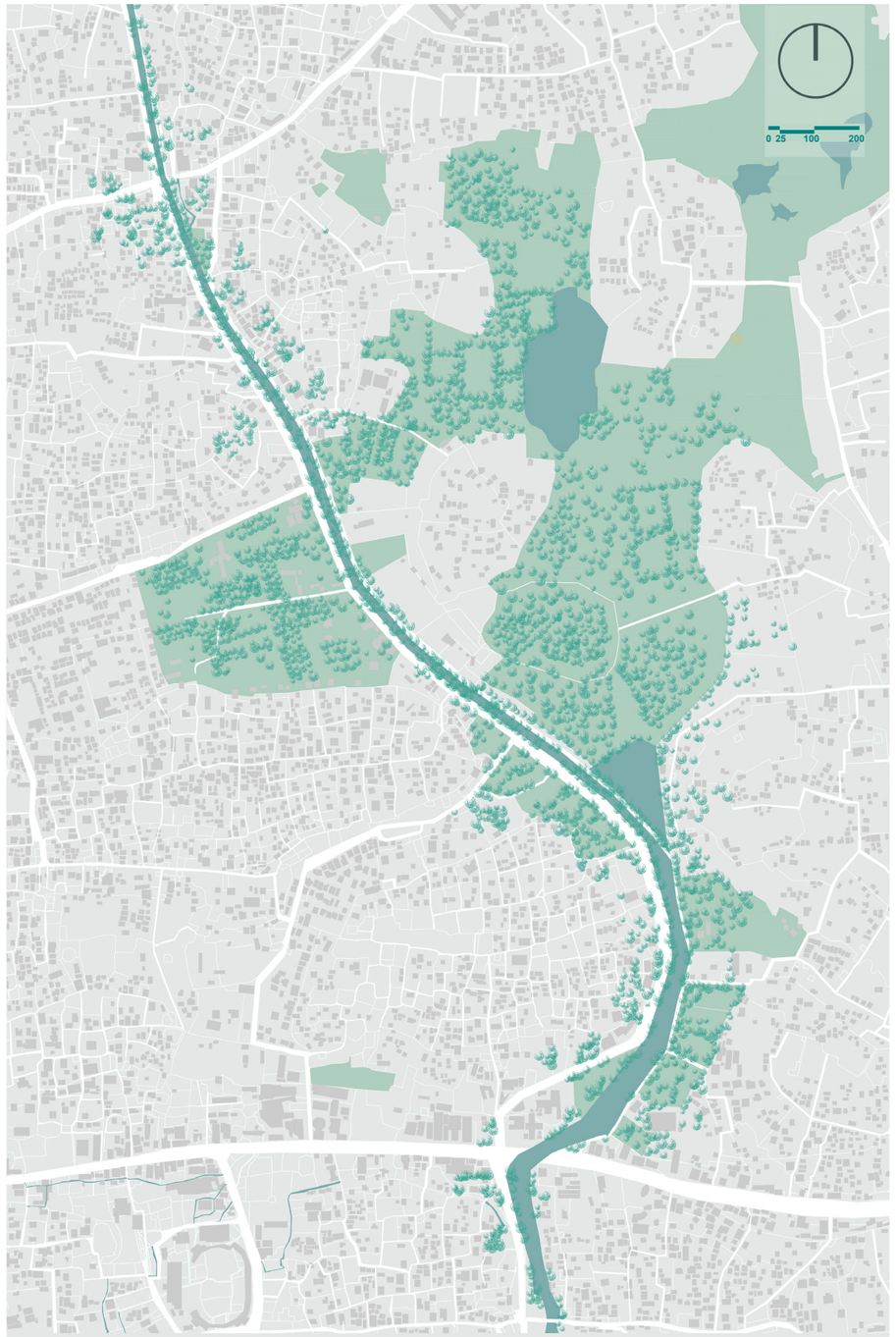


Figure 79 *Vegetation and environmental systems analysis of focus area*
(Source: *Illustration map by Authors)*

4.5. Slope & Drainage patterns

Inference: *Low-lying areas are especially at risk of flooding because they tend to collect water more easily, and their drainage is slower. This can lead to water pooling or extended periods of flooding during heavy rain or when canals overflow. Studies show that regions with gentle slopes are particularly prone to flooding, as these slopes allow water to gather while also being less likely to experience soil erosion due to lower runoff energy. As a result, these areas become increasingly vulnerable during heavy rainfall events, significantly raising the likelihood of inundation.*

Figure 80 *Vegetation and environmental systems analysis of focus area*
(Source: *Illustration map by Authors)*

Existing Drainage:

Kozhikode city features an undulating topography, with ground level variations of approximately 14 meters.

The natural slope of the area runs from east to west, characterized by small hilly terrains in the eastern and central regions. The city experiences an average annual rainfall of about 3,000 mm, distributed over approximately 115 rainy days each year. Numerous natural drainage channels exist within the city, primarily functioning as secondary drainage outlets that transport both stormwater and wastewater to the Conolly Canal or directly to the Arabian Sea. The Canoli Canal connects the Elathur River to the north and the Kallai River to the south of the city, serving as the main recipient of surface water runoff. Its catchment area encompasses about 35% to 40% of the total Municipal Corporation area.

However, the existing secondary drains are frequently inadequate to handle the full volume of stormwater runoff, particularly during the monsoon season. While approximately 40% of the roads within the municipal corporation have side drains, only around 30% of these drains are covered (Kozhikode Municipal Corporation, 2021; Rainwater Harvesting, 2020).

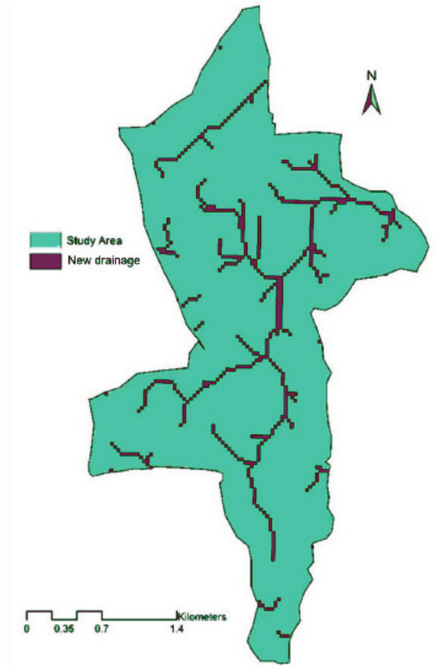


Figure 81 *New Drainage map analysis carried out using 2014 SRTM DEM*
(Source: *Report on Assessing the Potential of Sponge City Concept for Urban Flood Management in Kozhikode City Using GIS)*

4.6. Urban failures

- **Severe Water Pollution:**

The Canoli Canal is heavily polluted, receiving untreated sewage from numerous sources, including hospitals, hotels, and households which discharge waste directly into the canal. This has resulted in foul odors and contamination of local water sources, affecting the health of natural ecosystem.

- **Poor Waste Management:**

One of the key issues of this site is the improper management of waste by littering as well as dumping of waste into the canal and empty public grounds adjacent to the canal. This leads to environmental degradation of the water/surrounding soil and health hazards for residents/visitors.

- **Damaged footpaths & canal sidewalls**

Many footpaths in this location are cracked and uneven, making them difficult to navigate for pedestrians posing safety hazards and lack of accessibility for differently abled users. The canal walls have suffered from erosion and collapse due to inadequate maintenance and pollution making it an unsafe edge for users as well. Barrier-free accessways and well-planned edge treatments with sensitive elements are necessary for improving the urban landscape of this site.

- **Encroachment by street vendors along canal stretch:**

Kiosks and vendor carts are placed on some pathways along the banks of the Canoli Canal and in the corner of junctions which limit free access for users due to limited width.

- **Neglected Interstitial Spaces:**

This urban stretch has numerous neglected interstitial spaces that are underutilized and often become sites for illegal activities or dumping grounds. Lack of maintenance or urban vitality in these areas make it a grey zone for the neighbourhoods instead of a potential pulse points for the city.

Figure 82 *Site photo showing poor waste dumping*
(Source: Authors)

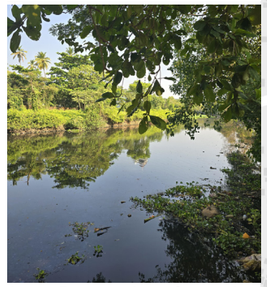
- **Lack of cycle tracks and proper soft mobility integration:**

The selected location and Kozhikode city as a whole does not have any designated bicycle lanes along with soft mobility pathways. Without dedicated cycle tracks, cyclists are forced to share road space with motor vehicles, leading to increased traffic congestion and dangerous alternative for cyclists. Poor integration of soft mobility affects local businesses, as areas that are not pedestrian-friendly or accessible by bicycle may see reduced foot traffic.

- **Limited Recreational Use:**

Once a potential site for leisure activities, the poor condition of the canal has deterred recreational use by residents and tourists alike, limiting opportunities for community engagement with nature.

1. Polluted wetlands and foul-smelling water in canal



2. Damaged footpaths, missing pedestrian walkways

3. Neglected interstitial spaces

4. Informal vendor carts covering canal stretch

Figure 83 *Site photos observing urban failures*
(Source: Authors)

Figure 84 *Map showing urban failures along Canoli canal*
(Source: Illustration by authors)

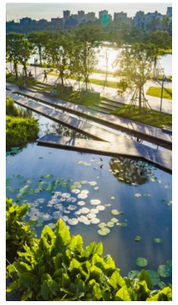
05 CHAPTER CASE STUDIES

CHAPTER 5 : CASE STUDIES

5.1. Reasons for choosing case studies

Case studies are essential to provide practical examples of successful strategies and methodologies that can be adapted to local contexts. By analyzing diverse projects, we can identify effective approaches to water management that enhance ecological health and community engagement. These case studies also highlight the importance of integrating cultural insights and local needs into water-sensitive design, ensuring that solutions are context-specific and sustainable (Zhang et al., 2019; De Vries et al., 2018).

1



Meishe River Greenway and Fengxiang Park, Haikou, China

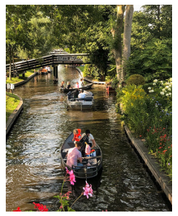
Reason for Choice: The project is an example of implementing Sponge city concept, ideal to study how effectively green infrastructure can be incorporated into urban areas. It shows that restoring natural ecosystems not only enhances water quality but also creates recreational spaces for the community. The park serves as a model for integrating natural water management solutions into urban parks, which can be replicated in Kozhikode to enhance green spaces while addressing flooding and water quality issues (Zhang et al., 2019).

The Floating Island Project, Bruges Canal, Belgium

Reason for Choice: This is an example of how minimal interventions can be implemented to bridge the gap between the street and the canals. This project is chosen to understand the innovative approach on how urban waterways can be transformed into vibrant ecological spaces and enhance the public engagement with water bodies.

2

3



Giethoorn Canals, Netherlands

Reason for Choice: This case illustrates the potential for integrating waterways into urban transport systems while preserving the environment. Giethoorn canals can inspire similar participatory approaches in Kozhikode to enhance local engagement of residents along with promoting tourism and local culture.

Alappuzha Canal Development. Kerala, India

Reason for Choice: As a local context example, this project demonstrates effective strategies for revitalizing waterways that are directly applicable to Kozhikode's canals, addressing both environmental sustainability and economic development. It highlights the importance of community involvement and sustainable practices in managing water resources effectively (Nair & Raghavan, 2020).

4

Figure 85 Meisha River Corridor, Haikou City, 2016

(Source: https://www.ajlajournal.org/articles/the-sponge-city-planning-design-and-political-design)

5.2. Meishe River Greenway and Fengxiang Park, Haikou, China

For decades, **Haikou City** in China has grappled with severe flooding due to its monsoon climate and water pollution stemming from untreated sewage and urban runoff. The rivers in the region were primarily channeled using concrete structures aimed solely at flood control, which resulted in lifeless waterways devoid of ecological resilience (Chen et al., 2021). In response to these challenges, landscape architects have spearheaded initiatives to implement nature-based solutions that transform these gray concrete rivers into vibrant green infrastructures.

Figure 86 Old state of Meisha river

(Source: https://www.chinese-architects.com/en/turenscape-haidian-district-beijing/project/turning-gray-into-green-meishe-river-greenway-and-fengxiang-park-haikou-china)

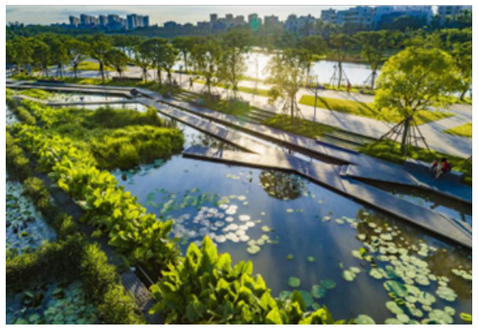


Figure 87 Wetlands with boardwalks

(Source: https://www.chinese-architects.com/en/turenscape-haidian-district-beijing/project/turning-gray-into-green-meishe-river-greenway-and-fengxiang-park-haikou-china)

Figure 88 Boardwalks on the transformed wetlands

(Source: https://www.chinese-architects.com/en/turenscape-haidian-district-beijing/project/turning-gray-into-green-meishe-river-greenway-and-fengxiang-park-haikou-china)

Figure 89 Melshe River corridor, Haikou City, 2016 - Master Plan

(Source : https://www.ajlajournal.org/articles/the-sponge-city-planning-design-and-political-design)

This transformation involves removing concrete flood walls and replacing them with eco-friendly, flood-resilient waterways. Mangrove habitats have been rehabilitated, and constructed wetlands have been established along the riverbanks to capture and cleanse contaminated runoff (Xu, 2023). Additionally, recreational facilities have been integrated into this ecological infrastructure, promoting social vitality and community engagement. The nature-based solutions showcased in this project not only revitalize the river with clean water and lush landscapes but also serve as a replicable model for other regions facing similar environmental issues. These initiatives highlight the potential for inexpensive and scalable solutions to urban flooding and pollution problems, ultimately fostering a more resilient urban ecosystem (Chapman Taylor, 2023).

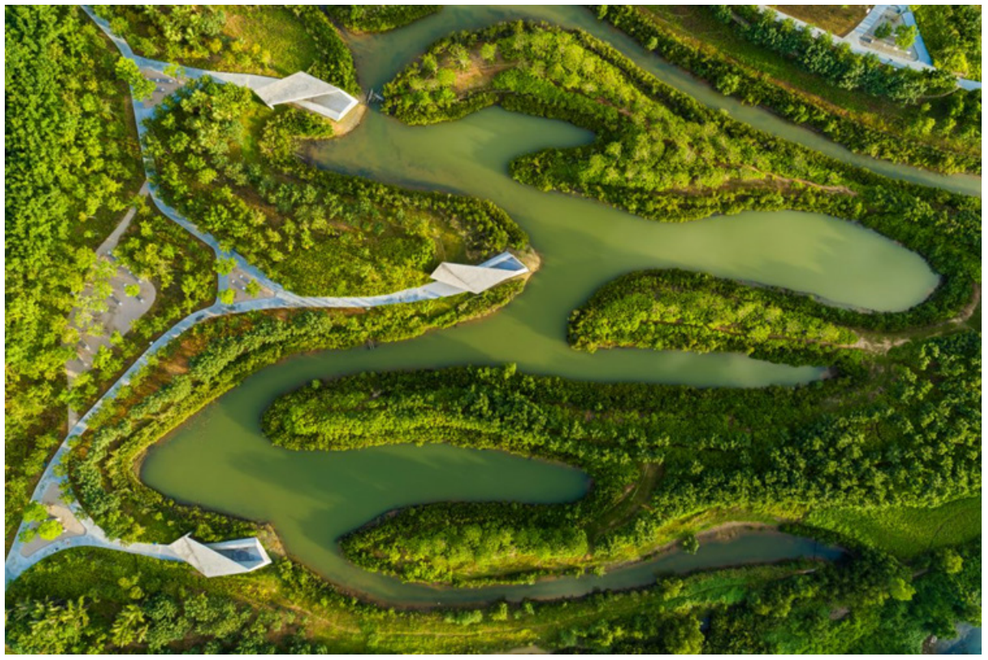


Figure 90 Sanya Mangrove Park, Sanya 2016.
(Source: https://www.ajlajournal.org/articles/the-sponge-city-planning-design-and-political-design)

Figure 91 Site plan : Sanya Mangrove Park, Sanya 2016.
(Source:https://www.ajlajournal.org/articles/the-sponge-city-planning-design-and-political-design)

Sustainable approach:
The Meishe River Greenway project utilizes a **nature-based solutions** approach to tackle severe water pollution and flooding issues that have plagued the region for decades. The strategy focuses on creating a "**sponge city"** model that integrates green infrastructure with traditional civil engineering (Turenscape, 2019). This includes the establishment of **constructed wetlands and interconnected terraces** designed to filter stormwater runoff and treat sewage from local communities that lack access to centralized treatment facilities (Ebrary.net, 2018). By transforming concrete flood walls into eco-friendly riverbanks and reintroducing mangroves along the riverbanks, the project enhances biodiversity while improving water quality (Centre for Liveable Cities, 2018).

Design concept:
The design concept behind the Meishe River Greenway is centered on creating an integrated ecological corridor that serves both functional and recreational purposes. The project encompasses an **80-hectare park and a 13-kilometer linear river corridor,** designed to restore the river's natural flow and enhance public access (Turenscape, 2019). The landscape architects have prioritized aesthetic appeal alongside ecological functionality by incorporating walking paths, viewing platforms, and educational signage throughout the park. The design also emphasizes cultural significance by integrating local art and historical narratives into the landscape, creating a vibrant space that reflects Haikou's identity.

Community involvement:
Community engagement has been a pivotal aspect of the Meishe River project. Local residents were actively involved in workshops and discussions that shaped the design process, ensuring that the park meets their needs for recreation and relaxation (Turenscape, 2019). The project also includes educational components that inform visitors about the ecological restoration efforts and encourage stewardship of the environment. By creating spaces for social interaction and leisure, such as walking paths and resting areas along the riverbanks, the project fosters a sense of ownership among community members (Centre for Liveable Cities, 2018).

Urban Impact:
The revitalization of the Meishe River has had significant urban impacts on Haikou. Once plagued by pollution and neglect, the river is now a thriving ecosystem that attracts both residents and tourists. The successful implementation of nature-based solutions has improved water quality, allowing fish populations to rebound and enhancing local biodiversity (Turenscape, 2019). Furthermore, Haikou was recognized as one of the **18 International Wetland Cities** by the Ramsar Convention in 2018, highlighting its commitment to sustainable urban development (Ebrary.net, 2018). The transformation of this area not only enhances environmental health but also contributes to the city's economic vitality by attracting visitors to its newly accessible green spaces.

Figure 92 *Floating Island Project , Bruges*
(Source: https://www.slideshare.net/slideshow/case-study-236129847/236129847#3)

5.3. The Floating Island Project, Bruges Canal, Belgium

Design: **OBBA & Dertien12 Architects**

Bruges,often referred to as the “Venice of the North,” is a captivating city in Belgium that has earned recognition as a UNESCO World Heritage site. The picturesque canals that weave through Bruges, combined with its Gothic brick buildings, create a stunning visual landscape that transports visitors back in time (National Geographic, 2018). Most canals are between 5 and 20 meters wide, with the broader sections historically designed to accommodate larger trading vessels. In contrast, the narrower sections were intended for local transport and drainage. In terms of depth, Bruges’ canals generally range from 2 to 3 meters, although this can vary.

Figure 93 *Burges Canal , Belgium*
(Source: https://www.kayak.it/Hotel-a-Bruges-Exclusive-Guesthouse-Bonifacius.345402.ksp)

Figure 94 *Burges Canal , Belgium*
(Source: https:https://expatstraveltogether.com/destination/belgium/bruges-la-venise-du-nord/ksp)

During the TRIENNALE BRUGGE 2018, the architectural firm OBBA aimed to subtly transform the stunning landscapes of Bruges by introducing “The Floating Island.” This pavilion, designed in a sleek, elongated shape, floats gracefully on the canal’s surface, effectively dissolving the strict boundaries between land and water. OBBA’s vision encourages visitors to engage more intimately with the waterside, re-imagining the canal as a vibrant space for walking, resting, reflecting, and enjoying the scenery rather than merely a picturesque backdrop (ArchDaily, 2018). The structure is constructed from pontoons, metal frames, and deck plates, featuring upper rails and rope curtains that create dynamic spaces.

Sustainable approach:
The Floating Island represents a sustainable design strategy that integrates **ecological considerations with urban functionality**. This floating platform covers over **100 square meters** and is constructed using environmentally friendly materials such as pontoons and metal frames (ArchDaily, 2018). The pavilion’s design allows it to adapt to fluctuating water levels, ensuring resilience against climate change impacts. Additionally, the use of **elastic nets** as hammocks and seating not only provides recreational space but also encourages visitors to engage with the canal environment in a sustainable manner (Metalocus, 2018).

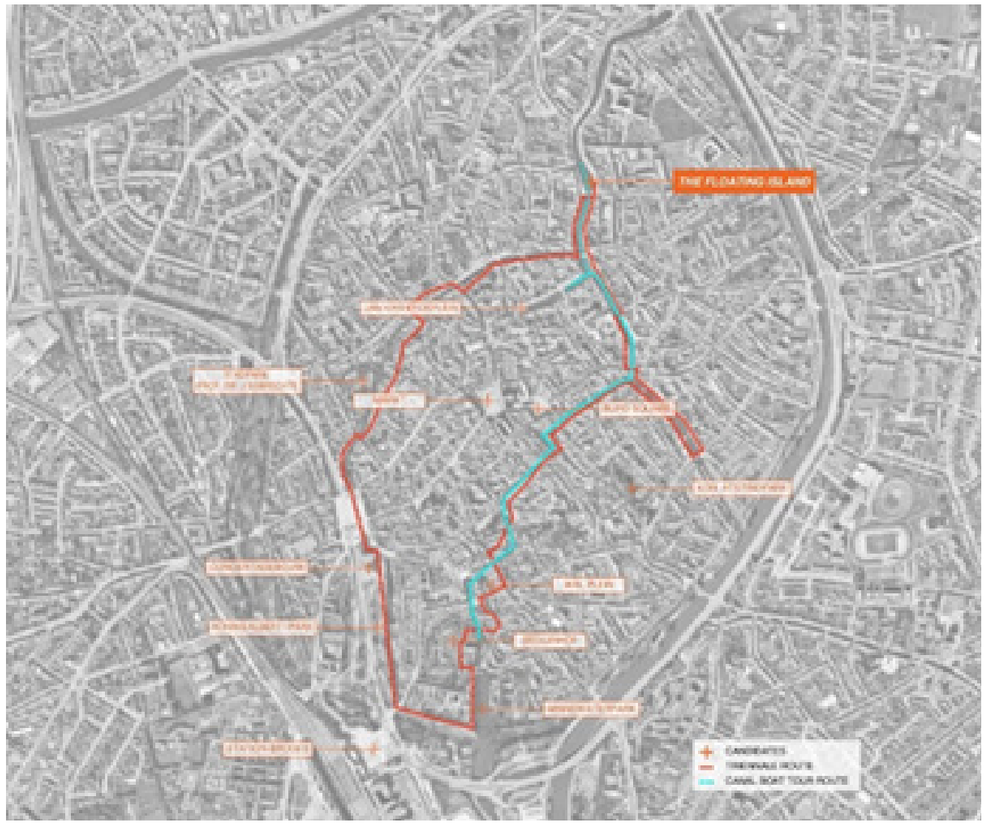


Figure 95 *Bruges - Canal tour boat route*
(Source: https://www.archdaily.com/899820/the-floating-island-obba-and-dertien12)

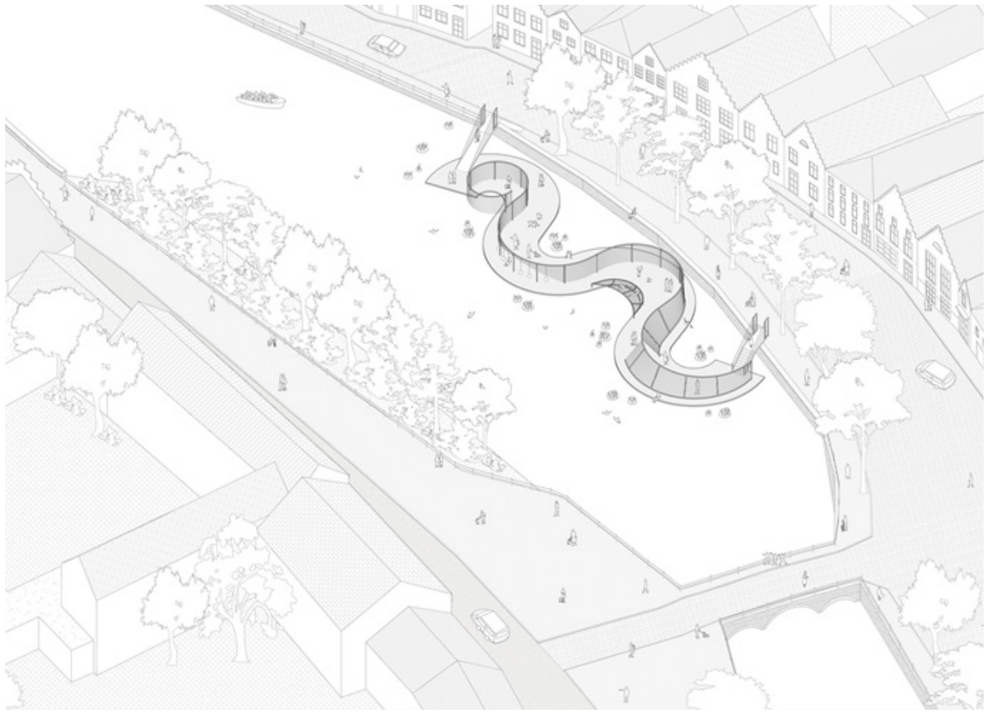


Figure 96 Floating island , Bruges Design illustration.
(Source: https://www.archdaily.com/899820/the-floating-island-obba-and-dertien12)

Figure 97 Floating island , Bruges - View
(Source: https://www.archdaily.com/899820/the-floating-island-obba-and-dertien12)

Figure 98 Floating deck design along canal
(Source: https://www.archdaily.com/899820/the-floating-island-obba-and-dertien12)

Design Concept

The design concept of the Floating Island aims to create an interactive public space that enhances the experience of Bruges' canals. The pavilion features a **streamlined shape** that flows seamlessly into the waterway, inviting visitors to explore its surroundings (Domus, 2018). Rope curtains surround the structure, creating dynamic spaces that shift with light and wind, thus altering perceptions of the familiar landscape (OBBA & Dertien12, 2018). This innovative use of materials allows for both openness and privacy, encouraging various activities such as lounging, reading, or simply enjoying the view.

Community involvement:

Community involvement is a cornerstone of the Floating Island Project. Local residents are encouraged to participate in the design and maintenance of these islands, fostering a sense of ownership and stewardship (De Vos, 2023). Workshops and educational programs are organized to raise awareness about environmental issues and promote sustainable practices among the community.

Urban Impact:

The integration of floating islands into the urban fabric of Bruges not only enhances the aesthetic appeal of the canal but also contributes to improved air quality and biodiversity. By providing a space for social interaction and environmental education, this project exemplifies how urban design can address ecological challenges while enriching community life (Janssens, 2023).

Figure 99 *Giethoorn canals , Netherlands*
(Source: https://www.getyourguide.com/giethoorn-l5074/tour-di-giethoorn-t658377/?visitor-id=MTRG8ZE-7JYJE5F3NWL8EGDH0WLGOXYZJ&locale_autoredirect_optout=true)

5.4. Giethoorn canals, Netherlands

Giethoorn, often referred to as the “Venice of the North,” is a charming village in Overijssel, Netherlands, celebrated for its extensive network of canals that serve as the primary mode of transportation in this car-free environment. Unlike Venice, which is characterized by urban density and grandeur, Giethoorn offers a serene, rural charm that attracts visitors seeking tranquility (Giethoorn Village, 2024).

The canals in Giethoorn are narrower than those in other famous canal cities, primarily accommodating eco-friendly boats such as punts and whisper boats. The entire canal network stretches approximately 7.5 kilometers (4.6 miles), with most canals ranging from 3 to 5 meters (10 to 16 feet) wide and an average depth of about 1 meter (3.3 feet). This design fosters a tranquil atmosphere focused on water-based movement and pedestrian access (Girl Gone Wandering, 2022). The village features around 180 wooden bridges that facilitate pedestrian movement while allowing boats to pass underneath.

In Giethoorn, traditional wooden boats called “punters” serve as the main mode of transport. Many of these boats are powered by poles or quiet electric motors known as whisper boats, which help maintain the village’s peaceful ambiance. The absence of cars encourages exploration through narrow walking and cycling paths, making cycling a popular option for navigating both within the village and to nearby areas. Sustainability is central to life in Giethoorn, with electric boats and well-maintained wooden bridges enhancing its charm (Holland Windmills, 2024).

Figure 100 *Boating routes of Giethoorn*
(Sources: https://www.gpsmycity.com/blog/a-weekend-getaway-in-giethoorn--netherlands-5021.html)

Figure 101 *Canal edges of Giethoorn*
(Sources: https://giethoornvillage.com/)

Environmental Considerations and Canal Maintenance

Water management is crucial in Giethoorn, as the canals are part of a larger system that helps protect the village from flooding, a common risk in the low-lying areas of the Netherlands. To manage this, the village relies on a well-maintained network of sluices, pumps, and dikes. The water quality in the canals is also closely monitored to prevent stagnation and ensure a healthy environment.

As time passes, sediment naturally builds up in the canals, which reduces their depth. To keep the canals navigable, especially since they’re already shallow, regular dredging is necessary. This process is carefully done to minimize any disruption to the local ecosystem.

With climate change leading to rising water levels, Giethoorn, like much of the Netherlands, faces potential future challenges. Urban planners and environmental experts are actively developing strategies to protect the village and ensure that its canals continue to serve their purpose without causing flooding. Giethoorn’s canal system is a remarkable example of human adaptation to a watery environment, evolving from peat-cutting ditches to a unique and tranquil transportation network. The canals shape not only the village’s urban layout but also its environmental practices, social interactions, and economy.

Sustainable approach:
The Giethoorn canals exemplify a sustainable design strategy that integrates **ecological preservation with local culture.** The village relies on a network of canals for transportation and irrigation, which has historically minimized the need for road infrastructure. The use of **electric-powered boats and traditional punters** (flat-bottomed boats) reduces emissions and noise pollution, preserving the tranquil environment that attracts tourists (Grain Sustainability, 2023). Additionally, the community has implemented measures to maintain water quality by promoting responsible tourism practices and limiting motorized traffic on the canals (Korthals Altes et al., 2018). This approach not only protects the delicate aquatic ecosystem but also enhances the overall experience for visitors.

Figure 102 *Scenic route fromThe Hague to Giethoorn*
(Source: https://www.mylittleadventure.it/best-things/the-hague/tours/sightseeing-tour-to-giethoorn-from-the-hague-dKB842pKSa)

Figure 103 *Aerial view of Giethoorn Canals*
(Source: https://www.freepik.com/premium-photo/giethoorn-drone-view-netherlands-village-aerial-footage-most-beautiful-dutch-village-venice_258464965.htm)

Figure 104 Giethoorn canals
(Source:https://pixorange.com/no-roads-and-no-traffic-problem-in-a-village-in-netherlands/)

The design concept of the Giethoorn canals is rooted in their historical function as a peat extraction site, where waterways were essential for transporting goods. The canals are lined with charming thatched-roof houses and lush greenery, creating an idyllic landscape that reflects the region's cultural heritage (Borgs, 2022). Recent enhancements have focused on improving accessibility while preserving the village's character. The introduction of **pedestrian pathways and bicycle lanes** encourages sustainable transportation methods among both residents and tourists (Grain Sustainability, 2023). Furthermore, strategic landscaping along the banks enhances biodiversity by providing habitats for local wildlife, including storks and other bird species that have become emblematic of the area (Korthals Altes et al., 2018).

Community Involvement:
Local residents actively participatte in decision-making processes regarding tourism management and environmental conservation (Borgs, 2022). Initiatives such as the **"Quality Tourism"** campaign aim to promote sustainable practices among visitors while encouraging locals to share their knowledge about the canals' ecological significance (Gemeente Steenwijkerland, 2020). The establishment of local associations has empowered residents to advocate for their interests and collaborate on projects that enhance both community well-being and environmental health.

Urban Impact:
As a major tourist destination, Giethoorn attracts over **972,000 visitors annually**, leading to economic benefits for local businesses while also posing challenges related to overcrowding (Steenwijkerland, 2020). The high ratio of tourists to residents—over **351 tourists per resident**—has raised concerns about maintaining quality of life for locals (Borgs, 2022). In response, local authorities are implementing measures to manage visitor flows better and promote off-peak tourism. By fostering sustainable tourism practices and enhancing public spaces, Giethoorn serves as a model for how communities can balance economic growth with environmental stewardship.

Figure 105 Alappuzha Canal
(Source : https://www.istockphoto.com/it/search/2/image-film?phrase=alappuzha)

5.5. Alappuzha canal development, Kerala, India

Alappuzha, also known as Alleppey, is often referred to as the “Venice of the East” due to its extensive network of canals and backwaters that define its landscape. Historically, this charming town in Kerala has been a vital hub for trade and commerce, with its waterways facilitating movement and exchange for centuries (Wikipedia, 2024). The canal system, which dates back to the 13th century when peat farmers settled in the area, remains integral to Alappuzha’s economy and cultural identity (Nehru Trophy Boat Race, 2024).

The town features two types of canals: narrow canals primarily found in industrial areas and wider canals located in the backwaters region. These waterways not only serve transportation needs but also enhance the town’s aesthetic appeal. The canals are lined with greenery, although some areas have seen vegetation decline (Urban Anecdotes, 2024). Alappuzha’s urban design follows a linear pattern, with public buildings strategically placed along the canals to create visual interest.
The intersection of these canals with the beach has become a popular recreational area, historically significant as it aligns with the old port of Alleppey. This unique canal system has shaped Alappuzha into a sought-after tourist destination while preserving its rich heritage (Alappuzha District, 2018).

Figure 106 “Thodu Odayalla” - Transformation of the streets
(Source: https://www.inspirationcollective.org/projects/rejuvenation-of-alappuzhas-canal-network)

Figure 107 “Thodu Odayalla” - Transformation of the polluted canals
(Source: https://www.inspirationcollective.org/projects/rejuvenation-of-alappuzhas-canal-network)

Sustainable approach:
The Alappuzha Canal Development employs a **decentralized and nature-based approach** to address the pressing issues of pollution and degradation in the canal system. The project focuses on **integrated interventions** that combine technical solutions with community participation. A key strategy involves the establishment of **liquid and solid waste treatment systems** for over 40,000 households, promoting at-source waste management to reduce pollution entering the canals (Inspiration Collective, 2024). Additionally, the project incorporates **constructed wetlands and phytoremediation** techniques to naturally filter and clean water, enhancing ecological health while minimizing reliance on conventional infrastructure (Benny Kuriakose, 2020).

Design concept:
The design concept for the Alappuzha Canal Development emphasizes creating vibrant public spaces along the canal banks. The initiative includes cleaning and desilting 14 canals, removing obstructions, and constructing over **10 kilometers of green pedestrian walkways** (Inspiration Collective, 2024). These walkways are designed to be accessible and aesthetically pleasing, featuring improved lighting, paving, waste bins, and motivational graffiti to encourage community engagement. The revitalized canal banks not only enhance the visual appeal of the area but also provide spaces for recreation and social interaction (KILA, 2018). By transforming these waterways into functional public spaces, the project aims to restore the cultural significance of the canals in daily life.

Figure 108 "Thodu Odayalla" Alappuzha canal side renovation project transformations
(Source: https://www.inspirationcollective.org/projects/rejuvenation-of-alappuzhas-canal-network)

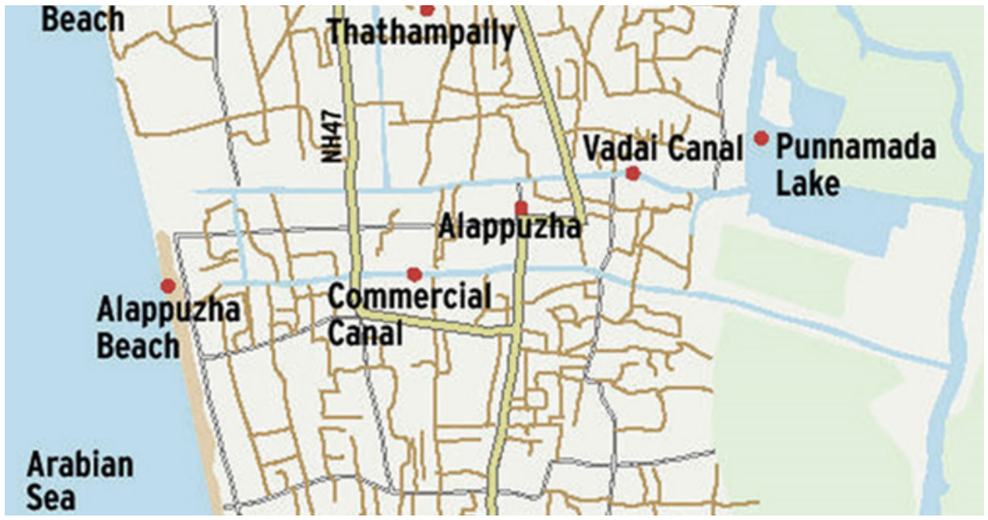


Figure 109 Alappuzha canal planning
(Source: https://th-i.thgim.com/public/migration_catalog/article11573772.ece/alternates/FREE_1200/ki18alappuzha.eps)

Figure 110 Alappuzha Canals
(Source: https://benjanews.com/exploring-the-venice-of-the-east-a-memorable-visit-to-alappuzha-india/)

Community Involvement:
Community engagement has been central to the success of the Alappuzha Canal Development project. Local residents were involved in workshops and discussions that shaped the project's direction, ensuring that their concerns and aspirations were addressed (Benny Kuriakose, 2020). The youth-led campaign "**Thodu Odayalla**" (Canals are Not Drains) has played a significant role in raising awareness about environmental issues and encouraging community stewardship of the canals (Inspiration Collective, 2024). Local volunteers were trained to monitor waste management practices and participate in maintaining the newly installed infrastructure. This grassroot involvement foster a sense of ownership among residents, empowering them to take an active role in preserving their natural resources.

Urban Impact:
The Alappuzha Canal Development project has had a profound impact on the urban landscape of Alappuzha. By revitalizing 14 canals and creating over 10 kilometers of green walkways, the project has significantly improved accessibility and aesthetics in the area (KILA, 2018). Enhanced water quality has led to a resurgence of biodiversity within the canals, benefiting both local ecosystems and community health. The initiative also aims to boost economic opportunities by improving water transport systems that connect various parts of the town (Inspiration Collective, 2024). As a result of these efforts, Alappuzha has gained recognition for its innovative approach to urban transformation and sustainable development.

5.6. Outcomes of case studies

	MEISHE RIVER GREENWAY & FENGXIANG PARK, HAIKOU	THE FLOATING ISLAND PROJECT, BRUGES CANAL	GIETHOORN CANALS, NETHERLANDS	ALAPPUZHA CANAL DEVELOPMENT, KERALA,
				
Attribute for Selection	Successful implementation of **Sponge city concept**	**Minimal intervention** connecting streets and canals	**Integrating waterways** while preserving the environment.	**Similar context - Local** example of revitalized waterways
Location	China	Belgium	Netherlands	India
Project Scale	Approx . 13km	Approx . 24.6km	Approx . 7.5km	Approx . 7 km
Sustainable approach	• Nature based solutions • Sponge city model • Green infrastructures integrated such as creation of constructed wetlands and interconnected terraces	• Ecological considerations with urban functionality. • Adapt to fluctuating water levels • Environmentally friendly materials such as pontoons and metal frames.	• Ecological preservation with the local culture. • Use of electric-powered boats and traditional punters reduces emissions and noise pollution	• Decentralized and nature-based approach • The establishment of liquid & solid waste treatment systems • Incorporate constructed wetlands and phytoremediation techniques
Design concept	• Integrated ecological corridor • 80-hectare park and a 13-kilometer linear river corridor • Restoring the river's natural flow and improving public access.	• Interactive public space • A streamlined shape • Rope curtains surround the structure, creating dynamic spaces	• The implementation of water transportation, pedestrian pathways, and bicycle lanes • Strategic landscaping along the banks enhances biodiversity	• 10 kilometers of green pedestrian walkways • Create vibrant public spaces along the canal banks • Cleaning and desilting 14 canals
Community involvement	• Local residents actively participated in workshops and discussions • Ensured the park addresses their needs for recreation and relaxation.	• Local residents are invited to take part in the design and maintenance of these islands. • Workshops and educational programs are organized	• Local residents actively participate in decision-making processes • Establishment of local associations has empowered residents	• Youth-led campaign "Thodu Odayalla" (Canals are Not Drains) - encouraging community stewardship of the canals
Urban Impact	• Once plagued by pollution and neglect, the river is now a thriving ecosystem • Fish populations have rebound • Haikou was recognized as one of the 18 International Wetland Cities by the Ramsar Convention in 2018	• Enhances the aesthetic appeal of the canal • Contributes to improved air quality and biodiversity. • Provide a space for social interaction and environmental education	• A model for how communities can balance economic growth with environmental stewardship. • As a major tourist destination leading to economic benefits for local businesses	• Improved accessibility and aesthetics • Enhanced water quality, and revived biodiversity in the canals • Benefiting local ecosystems and community health

06 CHAPTER SITE CHARACTERISTICS

SAROVARAM BIO-PARK
SITE CONTEXT

Figure 111 Sarovaram Bio park

(Source: https://www.kozhikodeonline.in/guide/sarovaram-biopark-in-kozhikode)

CHAPTER 6 : SITE CHARACTERISTICS

6.1. About Sarovaram Biopark

Sarovaram being among the 27 wetlands identified by the Indian government, is the only of its kind found in Kerala. The Sarovaram Bio park project, spanning over 200 acres, covers Kottuli in Kozhikode city along with the villages of Vengeri and Kasaba. Sarovaram Biopark is a vibrant haven that features an impressive range of ecosystems, including lush wetlands and mangrove forests. The park is especially famous for its rich birdlife, drawing birdwatchers and nature lovers from far and wide who come to observe both resident and migratory birds in their natural habitat. Beyond its ecological role, Sarovaram emphasizes environmental education through a range of programs and workshops designed to enhance public awareness about conservation efforts (Travelsetu, 2024). The park features well-maintained walking paths, an artificial lake for boating activities, and recreational areas for children's play, making it a favored spot for families and nature enthusiasts.

Figure 112 Entryway of Sarovaram along the canal edge walkway

(Source: Authors on site visit)

Figure 113 Boating area of Sarovaram Bio park

(Source: Authors on site visit)

6.2. Factors to be considered

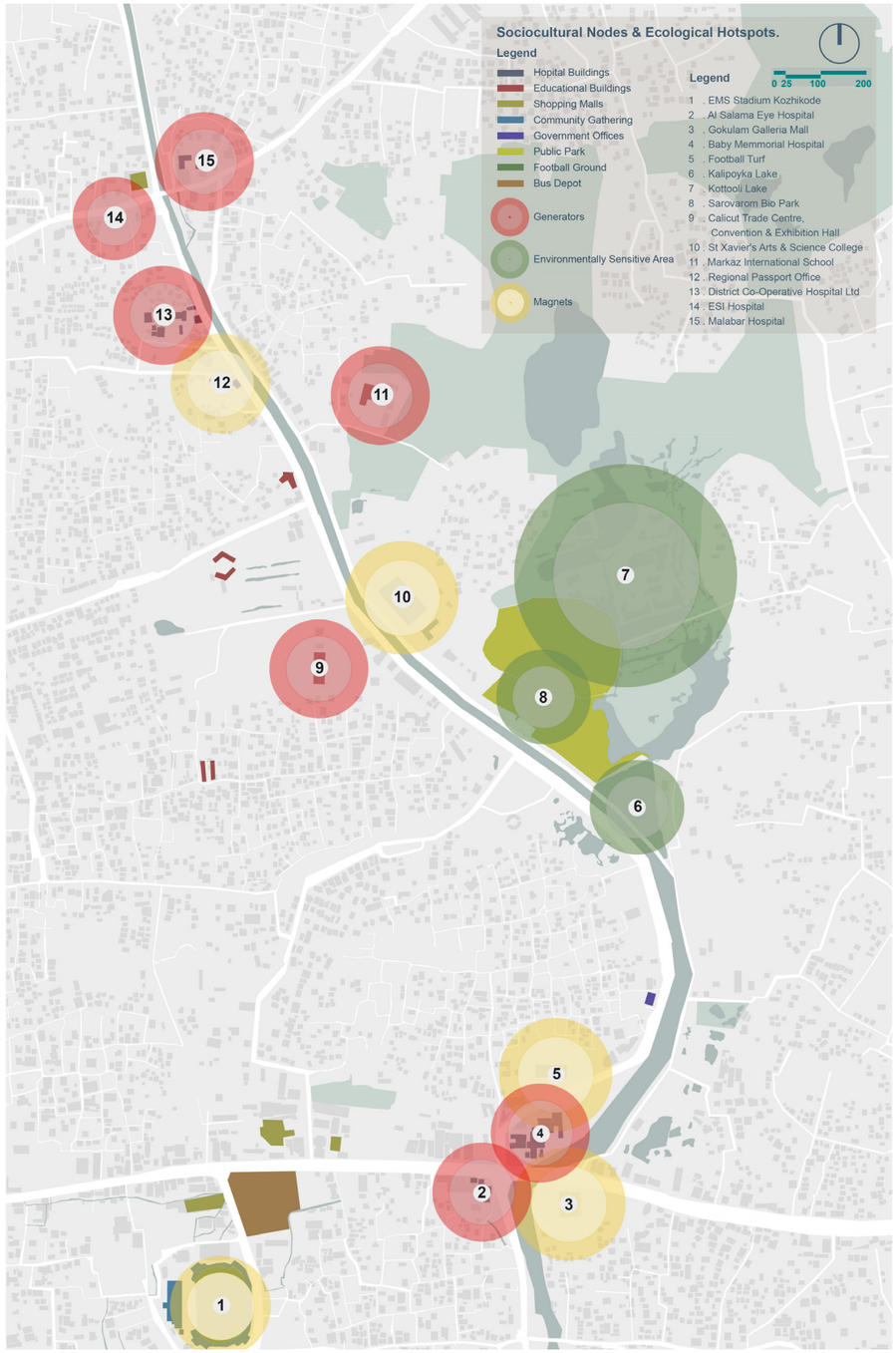


Figure 114 Existing landmarks: Generators, Magnets and Enviornmentally sensitive
(Source: Illustration map by Authors)

Figure 115 Images of existing landmarks - Functional context
(Source: Web images)

6.2.1. Public place making

Through thoughtful urban planning, various underutilized spaces along the canal can be transformed into accessible public areas. This transformation would facilitate a seamless integration of these spaces with the surrounding urban fabric, creating a cohesive spatial experience that encourages social interaction and community activities (Kozhikode Corporation, 2019). For instance, adding public art installations and cultural spaces that truly reflect the local heritage and community identity could improve the quality of experience of the urban spaces. Imagine vibrant sculptures, colorful murals, and lively performance areas that celebrate the rich history and culture of our city.

Accessibility Features:
The site currently lacks barrier-free access along the canal functions which results in minimal usage by residents. Ensuring that all public spaces along the canal are accessible to people of all ages and abilities is critical to revitalize the space. This includes installing ramps, tactile paving, and seating areas that accommodate diverse needs, fostering inclusivity within the community.

Community markets & Events:
The existing event spaces in the site are Calicut trade center and adjacent grounds along with the open-air amphitheatre located inside Sarovaram Bio-park which hosts certain events & flea market by the local groups. Regular community markets can create a platform for artisans and food producers to connect directly with consumers, thereby promoting local goods and services. Spaces for cultural festivals and social events can serve as essential gathering points for residents, encouraging social interaction.

Figure 116 Flea markets hosted in the event grounds in Kozhikode

(Source: https://timesofindia.indiatimes.com/city/kozhikode/third-edition-of-calicut-flea-market-begins/articleshow/72916897.cms)

Figure 117 A bimonthly gathering for readers at Sarovaram Bio Park, Kozhikode

(Source: https://www.instagram.com/soc_reads/)

Figure 118 Aftermath of flooding seen in Canoli canal

(Source: https://www.deccanchronicle.com/nation/current-affairs/280818/ksidc-to-adopt-weavers-village.html)

Figure 119 Desilting and dredging works carried out in Canoli canal

(Source: https://timesofindia.indiatimes.com/city/kozhikode/dredging-desilting-works-begin-on-ek-canal-stretch/articleshow/69208574.cms)

Figure 120 Bridges across Canoli canal with low vertical clearance

(Source: KIFB Newsletter report, 2023)

6.2.2. Flood Mitigation

Rampant construction activities and unscientific urban planning have exacerbated flooding issues by disrupting natural water flow and reducing the area's absorptive capacity (IJNRD, 2023). The existing drainage infrastructure has proven insufficient, with 70 drains flowing into the canal as evidenced by recurrent flooding events that overwhelm culverts and drainage systems (Mathrubhumi, 2024). To keep the water flowing smoothly and prevent blockages from plants and debris, it's important to regularly de-silt and dredge the canal.

Many existing bridges across the canal lack adequate vertical and horizontal clearances, impeding water flow during heavy rainfall. To mitigate flooding effectively, it is crucial to reconstruct these bridges with adequate clearances to ensure they meet relevant waterway standards and facilitate unobstructed water flow during heavy rains (IJNRD, 2023).

Integrating green infrastructure solutions along the canal is vital to enhance the resilience to flooding in the site. Heavily impermeable surfaces and lack of proper drainage for surface run-off water has resulted in contributing to flooding during monsoons. Terraced bio-swales, rain gardens, permeable soil treatments etc are some of the solutions that need to be considered.

Effective flood mitigation requires community involvement in planning processes. Additionally, enforcing zoning regulations that restrict development in flood-prone areas will minimize impervious surfaces that contribute to runoff.

6.2.3. Improving soft mobility

In terms of pathway design and mobility, the existing infrastructure around the canal including numerous roads and bridges, hinder pedestrian and cyclist access. The pathways have only sporadic access points and poorly maintained surfaces. The canal banks have been encroached upon for road development, further restricting safe mobility options for non-motorized users. To create an effective and sustainable transportation network, it is crucial to design dedicated pathways that connect key destinations, such as parks, commercial areas, and public transport hubs, to encourage walking and cycling (KIIFB, 2023).

The soft mobility routes should be wide enough to accommodate foot and bike traffic while ensuring safety from vehicular interference. Incorporating features such as dedicated bike lanes and pedestrian crossings at strategic points will enhance accessibility (KIIFB, 2023). Traffic calming measures such as speed bumps and expanded sidewalks can further enhance pedestrian safety. Additionally, adequate lighting along pathways will increase visibility at night, encouraging more people to walk or cycle after dark.

Establishing green districts can significantly enhance the appeal of soft mobility. As the focus area has good local vegetation areas with heavily shaded trees, enhancing the spaces with better design gardens and recreational areas can contribute to encouraging walking/cycling. Green corridors can be developed alongside pathways to promote biodiversity and ecological health while offering shaded routes for pedestrians and cyclists.

Figure 121 Pedestrian walkways without designated cycle lanes in Sarovaram

(Source: https://ktil.in/development-of-sarovaram-bio-park-kozhikode/)

Figure 122 Cycle rental facilities in Sarovaram Bio-park

(Source: https://www.pinklungi.com/sarovaram-biopark-in-kozhikode-is-an-eco-and-couple-friendly-park-you-should-visit/)

Figure 123 Potential corridors along canal for soft mobility expansion with cycle track

(Source: Image by Authors)

Figure 124 Potential corridors along canal for soft mobility expansion with cycle track

(Source: https://www.keralatourism.org/destination/sarovaram-biopark/585/)

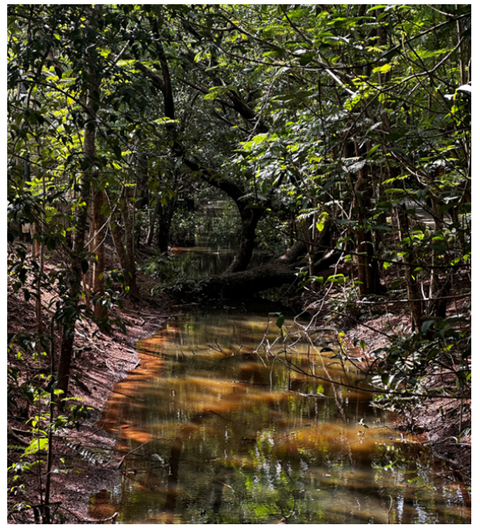


Figure 125 Potential bio-swale stretches adjacent to Sarovaram and wetlands

(Source: Image by Authors)

Figure 126 Mangroves in the wetlands provide abode for birds and other species

(Source: Report on Conservation of Kottuli Wetlands, Calicut, Kerala, 2008)

6.2.4. Water - sensitive and ecological approaches

The Sarovaram wetlands adjacent to the Canoli Canal are crucial for maintaining local biodiversity. These wetlands act as natural buffers against flooding. The canal currently serves as a habitat for various aquatic species, but pollution and habitat degradation have diminished its ecological value (IJNRD, 2023). Introducing native vegetation along the banks can improve habitat quality, provide natural filtration for stormwater runoff, stabilize soil and prevent sedimentation in the canal.

The wetlands of Calicut are reported to be rich in aquatic organisms (Seedikkoya, 2003), that includes several insects, gastropods, amphibians and reptiles. Urban development should focus on creating habitats for local wildlife along the canal. This can involve building bird habitats, designing fish passages, and planting native plants that provide food and shelter for local animals. By incorporating these elements, we can enhance the biodiversity of the area and create a healthier ecosystem that benefits both wildlife and the community.

There is an existing huge urban biological network of marshy lands, miyawaki forests and wetlands in the focus area that adds to the life of the city. These potential landscape functions can be efficiently utilized by pollution monitoring measures, buffer zones, constructed wetlands, etc for ensuring a sensitive approach in the focus area. Community-driven initiatives such as clean-up drives and educational programs can raise awareness about the importance of maintaining clean waterways (KIIFB, 2023).

07 CHAPTER
SITE OBSERVATIONS

CHAPTER 7 : SITE OBSERVATIONS

7.1. Introduction

The Canoli canal integrated with the city circuit adapts to varying organic contexts including the variations in the physical parameters such as width, depth, edge treatments, etc in respect to the unplanned developments of the city over the years. On visiting the site, the feel of space along the canal route also changes in terms of scenic aesthetics, surrounding natural ambience, urban access, quality of water, etc. Soft mobility pathways are not well developed even in the critical stretches connecting major urban nodes.

The on-site observations are carried out in terms of quantitative and qualitative analysis of the urban areas with respect to the key objectives of the thesis research. Gehl's observational tools were followed in a systematic method for gathering data on people and their interactions with the environment. The quantitative data from people counting with qualitative insights from interviews/ surveys , we were able to gain a comprehensive understanding of how urban spaces are utilized and perceived. Qualitative analysis is mapped using site photographs to highlight the key urban elements of the area. The monitoring of community engagement and usage patterns were also able to provide insights into social interactions with the canal.

Figure 127 Site photographs taken as part of the on-site observations in Kozhikode (Source: Images by Authors)

7.2. Quantitative Analysis

7.2.1. Gehl's Observation Tools

Gehls Observation tools is developed by urbanist Jan Gehl which provide a systematic approach for quantitatively analyzing urban spaces. These tools focus on understanding human behaviour in public environments, which is essential for creating vibrant and functional urban areas. The methodology emphasizes counting and mapping activities to gather data on how people interact with their surroundings.

Some of the main tools used are counting, mapping, tracking, tracing and photographing. One of the key components include various observation techniques such as behavioural mapping, where observers record the types and locations of activities. This allows to quantify aspects like pedestrian movement patterns and duration of stay in specific areas. Additionally, the tools facilitate the documentation of public life through photographic evidence and diaries that capture nuances of urban interactions (Gehl, 2010). The application of these tools can yield valuable insights into the effectiveness of urban design interventions. By employing Gehls methodologies, we aimed to generate data that informs policy recommendations and design strategies aimed at enhancing public spaces (Gehl & Svarre, 2013). Ultimately, these observations contribute to a deeper understanding of urban dynamics, enabling to prioritize human-centric design in their projects.

7.2.2. Interviews and Participant survey feedbacks

For the **participant survey**, a mix of guided questions and open-ended questions were prepared and shared with a varying group of users for an exploration of users' thoughts and feelings about the urban environment.

Also, a **structured interview** was carried out with a set of pre-determined questions which were asked to gather specific information about users' habits, preferences, and satisfaction with the space. In order to gather diverse perspectives on the site, various categories of users were selected to gather data which would also provide insights on the community involvement extends that could be incorporated in the urban rejuvenation proposal.

User study conducted:

Categories of people interviewed for site feedback and purpose of survey data:

1. **Families** – Neighboring residents of the canal areas for a yearly observation in living conditions.
2. **Existing shop & business owners** – Crucial stakeholders for development proposal & sustainable opportunities.
3. **Working groups** - Staff of Sarovaram Biopark & Transport drivers for daily level feedback.
4. **Children & Young adults** – Inclusions to be considered for recreational facilities
5. **Tourists** – First time visitors for the attractive quality of Canoli canal

Figure 128 *On-site interview/ survey conducted with users at our focus area*

(Source: Authors)

GEHL'S OBSERVATION - CHRONOTOPIC MAP

Following the main tools of Gehl"s observation, the **people counting** involved systematically counting the number of people engaging in various activities in a given space.

Figure 129 Illustration based on people counting at different points during week days
(Source: Illustration by Authors)

PEOPLE COUNTING | MOVEMENT TRACKING

People density in the main junctions during the different times of day provides an understanding of the volume of footfall of users and the potential of new proposals based on the density

Figure 130 Illustration based on people counting at different points during weekends
(Source: Illustration by Authors)

PARTICIPANT SURVEYS

Public Opinion Survey About Canoli Canal and Surrounding areas

Objective : To gather insights from the community regarding their lifestyle, perceptions, and suggestions for the revitalization of the Canoli Canal.

☑ Male ☐ Female Age : 51 Occupation : Vendor Date : 21-08-2024

1 How would you describe your relationship with this area?
☑ Resident ☐ Tourist
☑ Work Here / Nearby ☐ Student (Nearby Institution)
☐ Others describe

2 How did you get here today?
☑ Walking ☐ Taxi / Cab
☐ Bike ☐ Bicycle
☐ Public Transportation ☐ Car

3 How Often do you visit this place?
First time here | ☐ Daily | ☐ Weekly | ☐ Monthly | ☐ Rarely

4 What brings you here today?
☐ Just passing through ☐ Walking my pet
☐ Meeting up with friends ☐ Visiting with family
☐ To explore this area ☐ Cultural event / Performance

5 How much time do you plan to spend here today?
☐ 0 - 15 Minutes ☐ 1 - 2 Hours
☐ 15 - 30 Minutes ☑ More than 2 Hours
☐ 30 - 60 Minutes ☐ I'm not sure

6 How would you describe the current condition of the Canoli Canal?
☑ Very Poor | ☐ Poor | ☐ Average | ☐ Good | ☐ Very Good

7 What do you believe are the main issues facing the canal? (Select all that apply)
☑ Pollution ☐ Lack of Recreation Space
☑ Waste Dumping ☐ Encroachment
☐ Others describe

8 How do you feel about this Public Space?
Strongly Negative | ☐ Negative | ☑ Neutral | ☐ Positive | ☐ Strongly Positive

9 How do you feel about visiting and spending time by the canal or park edges in this area?
☐ I enjoy it ☑ I dont have a strong opinion
☐ It's Okay ☐ I do not enjoy it

10 How does the condition of the Canoli Canal affect your lifestyle?
☑ Negatively | ☐ No Impact | ☐ Positively

11 What improvements would you like to see along the Canoli Canal? (Select all that apply)
☑ Clean-up and maintenance efforts ☑ Development of parks and recreational areas
☐ Improved waste management systems ☐ Enhance soft mobility

12 What activities would you like to see implemented adjacent to the rejuvenated canal stretch? (Select all that apply)
☐ Walking / Jogging Paths ☐ Fitness / Outdoor gym
☐ Cycling Tracks ☑ Paddle Boating
☑ Cafes and Food Stalls ☐ Fishing
☑ Childrens Play Area ☑ Others (please specify)
Seating benches

13 How safe do you feel while visiting / walking here?
☐ Not at all Safe | ☐ Slighty Uneasy | ☐ Neutral | ☑ Safe | ☐ Very Safe

14 Would you be interested in participating in community initiatives aimed at revitalizing the Canoli Canal? (Yes / No)

15 If yes, what type of activities would you be interested in?

Thank You

Public Opinion Survey About Canoli Canal and Surrounding areas

Objective : To gather insights from the community regarding their lifestyle, perceptions, and suggestions for the revitalization of the Canoli Canal.

☐ Male ☑ Female Age : 26 Occupation : ARCHITECT Date : 21-08-2024

1 How would you describe your relationship with this area?
☐ Resident ☐ Tourist
☑ Work Here / Nearby ☐ Student (Nearby Institution)
☐ Others describe

2 How did you get here today?
☐ Walking ☐ Taxi / Cab
☐ Bike ☐ Bicycle
☐ Public Transportation ☑ Car

3 How Often do you visit this place?
First time here | ☐ Daily | ☐ Weekly | ☑ Monthly | ☐ Rarely

4 What brings you here today?
☐ Just passing through ☐ Walking my pet
☑ Meeting up with friends ☐ Visiting with family
☐ To explore this area ☐ Cultural event / Performance

5 How much time do you plan to spend here today?
☐ 0 - 15 Minutes ☐ 1 - 2 Hours
☑ 15 - 30 Minutes ☐ More than 2 Hours
☐ 30 - 60 Minutes ☐ I'm not sure

6 How would you describe the current condition of the Canoli Canal?
☑ Very Poor | ☐ Poor | ☐ Average | ☐ Good | ☐ Very Good

7 What do you believe are the main issues facing the canal? (Select all that apply)
☑ Pollution ☑ Lack of Recreation Space
☑ Waste Dumping ☐ Encroachment
☐ Others describe
No good amenities along edges

8 How do you feel about this Public Space?
Strongly Negative | ☐ Negative | ☐ Neutral | ☑ Positive | ☐ Strongly Positive

9 How do you feel about visiting and spending time by the canal or park edges in this area?
☐ I enjoy it ☑ I dont have a strong opinion
☐ It's Okay ☐ I do not enjoy it

10 How does the condition of the Canoli Canal affect your lifestyle?
☐ Negatively | ☑ No Impact | ☐ Positively

11 What improvements would you like to see along the Canoli Canal? (Select all that apply)
☑ Clean-up and maintenance efforts ☑ Development of parks and recreational areas
☐ Improved waste management systems ☑ Enhance soft mobility

12 What activities would you like to see implemented adjacent to the rejuvenated canal stretch? (Select all that apply)
☑ Walking / Jogging Paths ☐ Fitness / Outdoor gym
☑ Cycling Tracks ☑ Paddle Boating
☑ Cafes and Food Stalls ☑ Fishing
☐ Childrens Play Area ☐ Others (please specify)
Event spaces, Canal-front promenade

13 How safe do you feel while visiting / walking here?
☐ Not at all Safe | ☑ Slighty Uneasy | ☐ Neutral | ☐ Safe | ☐ Very Safe

14 Would you be interested in participating in community initiatives aimed at revitalizing the Canoli Canal? (Yes / No)

15 If yes, what type of activities would you be interested in?
Planting & volunteering

Thank You

Public Opinion Survey About Canoli Canal and Surrounding areas

Objective : To gather insights from the community regarding their lifestyle, perceptions, and suggestions for the revitalization of the Canoli Canal.

☐ Male ☑ Female Age : 15 Occupation : STUDENT Date : 21-08-2024

1 How would you describe your relationship with this area?
☑ Resident ☐ Tourist
☐ Work Here / Nearby ☐ Student (Nearby Institution)
☐ Others describe

2 How did you get here today?
☐ Walking ☐ Taxi / Cab
☑ Bike ☐ Bicycle
☐ Public Transportation ☐ Car

3 How Often do you visit this place?
First time here | ☑ Daily | ☐ Weekly | ☐ Monthly | ☐ Rarely

4 What brings you here today?
☐ Just passing through ☐ Walking my pet
☑ Meeting up with friends ☐ Visiting with family
☐ To explore this area ☐ Cultural event / Performance

5 How much time do you plan to spend here today?
☐ 0 - 15 Minutes ☑ 1 - 2 Hours
☐ 15 - 30 Minutes ☐ More than 2 Hours
☐ 30 - 60 Minutes ☐ I'm not sure

6 How would you describe the current condition of the Canoli Canal?
☐ Very Poor | ☐ Poor | ☑ Average | ☐ Good | ☐ Very Good

7 What do you believe are the main issues facing the canal? (Select all that apply)
☐ Pollution ☑ Lack of Recreation Space
☑ Waste Dumping ☐ Encroachment
☐ Others describe
BAD SMELL FROM WASTEWATER

8 How do you feel about this Public Space?
☐ Strongly Negative | ☐ Negative | ☑ Neutral | ☐ Positive | ☐ Strongly Positive

9 How do you feel about visiting and spending time by the canal or park edges in this area?
☐ I enjoy it ☐ I dont have a strong opinion
☑ It's Okay ☐ I do not enjoy it

10 How does the condition of the Canoli Canal affect your lifestyle?
☐ Negatively | ☑ No Impact | ☐ Positively

11 What improvements would you like to see along the Canoli Canal? (Select all that apply)
☐ Clean-up and maintenance efforts ☑ Development of parks and recreational areas
☐ Improved waste management systems ☑ Enhance soft mobility

12 What activities would you like to see implemented adjacent to the rejuvenated canal stretch? (Select all that apply)
☑ Walking / Jogging Paths ☐ Fitness / Outdoor gym
☐ Cycling Tracks ☐ Paddle Boating
☐ Cafes and Food Stalls ☑ Fishing
☑ Childrens Play Area ☐ Others (please specify)
Parks

13 How safe do you feel while visiting / walking here?
☐ Not at all Safe | ☐ Slighty Uneasy | ☐ Neutral | ☑ Safe | ☐ Very Safe

14 Would you be interested in participating in community initiatives aimed at revitalizing the Canoli Canal? (Yes / No)

15 If yes, what type of activities would you be interested in?

Thank You

Public Opinion Survey About Canoli Canal and Surrounding areas

Objective : To gather insights from the community regarding their lifestyle, perceptions, and suggestions for the revitalization of the Canoli Canal.

☐ Male ☑ Female Age : 20 Occupation : Student Date : 21-08-2024

1 How would you describe your relationship with this area?
☐ Resident ☑ Tourist
☐ Work Here / Nearby ☑ Student (Nearby Institution)
☐ Others describe

2 How did you get here today?
☐ Walking ☐ Taxi / Cab
☐ Bike ☐ Bicycle
☑ Public Transportation ☐ Car

3 How Often do you visit this place?
First time here | ☐ Daily | ☐ Weekly | ☑ Monthly | ☐ Rarely

4 What brings you here today?
☐ Just passing through ☐ Walking my pet
☑ Meeting up with friends ☐ Visiting with family
☐ To explore this area ☐ Cultural event / Performance

5 How much time do you plan to spend here today?
☐ 0 - 15 Minutes ☐ 1 - 2 Hours
☐ 15 - 30 Minutes ☐ More than 2 Hours
☑ 30 - 60 Minutes ☐ I'm not sure

6 How would you describe the current condition of the Canoli Canal?
☐ Very Poor | ☐ Poor | ☑ Average | ☐ Good | ☐ Very Good

7 What do you believe are the main issues facing the canal? (Select all that apply)
☑ Pollution ☐ Lack of Recreation Space
☑ Waste Dumping ☐ Encroachment
☐ Others describe

8 How do you feel about this Public Space?
☐ Strongly Negative | ☐ Negative | ☐ Neutral | ☑ Positive | ☐ Strongly Positive

9 How do you feel about visiting and spending time by the canal or park edges in this area?
☐ I enjoy it ☐ I dont have a strong opinion
☑ It's Okay ☐ I do not enjoy it

10 How does the condition of the Canoli Canal affect your lifestyle?
☐ Negatively | ☑ No Impact | ☐ Positively

11 What improvements would you like to see along the Canoli Canal? (Select all that apply)
☐ Clean-up and maintenance efforts ☑ Development of parks and recreational areas
☑ Improved waste management systems ☐ Enhance soft mobility

12 What activities would you like to see implemented adjacent to the rejuvenated canal stretch? (Select all that apply)
☐ Walking / Jogging Paths ☐ Fitness / Outdoor gym
☑ Cycling Tracks ☐ Paddle Boating
☑ Cafes and Food Stalls ☐ Fishing
☐ Childrens Play Area ☐ Others (please specify)

13 How safe do you feel while visiting / walking here?
☐ Not at all Safe | ☐ Slighty Uneasy | ☐ Neutral | ☑ Safe | ☐ Very Safe

14 Would you be interested in participating in community initiatives aimed at revitalizing the Canoli Canal? (Yes / No)

15 If yes, what type of activities would you be interested in?

Thank You

Public Opinion Survey About Canoli Canal and Surrounding areas

Objective : To gather insights from the community regarding their lifestyle, perceptions, and suggestions for the revitalization of the Canoli Canal.

☐ Male ☑ Female Age : 31 Occupation : ASHA WORKER Date : 21-AUG-202

1 How would you describe your relationship with this area?
☑ Resident ☐ Tourist
☐ Work Here / Nearby ☐ Student (Nearby Institution)
☐ Others describe

2 How did you get here today?
☑ Walking ☐ Taxi / Cab
☐ Bike ☐ Bicycle
☐ Public Transportation ☐ Car

3 How Often do you visit this place?
First time here | ☐ Daily | ☑ Weekly | ☐ Monthly | ☐ Rarely

4 What brings you here today?
☑ Just passing through ☐ Walking my pet
☐ Meeting up with friends ☐ Visiting with family
☐ To explore this area ☐ Cultural event / Performance

5 How much time do you plan to spend here today?
☐ 0 - 15 Minutes ☐ 1 - 2 Hours
☑ 15 - 30 Minutes ☐ More than 2 Hours
☐ 30 - 60 Minutes ☐ I'm not sure

6 How would you describe the current condition of the Canoli Canal?
☐ Very Poor | ☑ Poor | ☐ Average | ☐ Good | ☐ Very Good

7 What do you believe are the main issues facing the canal? (Select all that apply)
☑ Pollution ☐ Lack of Recreation Space
☑ Waste Dumping ☐ Encroachment
☐ Others describe

8 How do you feel about this Public Space?
☐ Strongly Negative | ☐ Negative | ☐ Neutral | ☐ Positive | ☑ Strongly Positive

9 How do you feel about visiting and spending time by the canal or park edges in this area?
☐ I enjoy it ☐ I dont have a strong opinion
☐ It's Okay ☑ I do not enjoy it

10 How does the condition of the Canoli Canal affect your lifestyle?
☐ Negatively | ☐ No Impact | ☑ Positively

11 What improvements would you like to see along the Canoli Canal? (Select all that apply)
☑ Clean-up and maintenance efforts ☐ Development of parks and recreational areas
☐ Improved waste management systems ☐ Enhance soft mobility

12 What activities would you like to see implemented adjacent to the rejuvenated canal stretch? (Select all that apply)
☑ Walking / Jogging Paths ☐ Fitness / Outdoor gym
☑ Cycling Tracks ☐ Paddle Boating
☑ Cafes and Food Stalls ☐ Fishing
☑ Childrens Play Area ☐ Others (please specify)

13 How safe do you feel while visiting / walking here?
☐ Not at all Safe | ☑ Slighty Uneasy | ☐ Neutral | ☐ Safe | ☐ Very Safe

14 Would you be interested in participating in community initiatives aimed at revitalizing the Canoli Canal? (Yes / No)

15 If yes, what type of activities would you be interested in?
CLEANING THE CANAL EDGES, AWARENESS CAMP

Thank You

Public Opinion Survey About Canoli Canal and Surrounding areas

Objective : To gather insights from the community regarding their lifestyle, perceptions, and suggestions for the revitalization of the Canoli Canal.

☑ Male ☐ Female Age : 45 Occupation : OFFICE STAFF Date : 21-08-2024

1 How would you describe your relationship with this area?
☑ Resident ☐ Tourist
☐ Work Here / Nearby ☐ Student (Nearby Institution)
☐ Others describe

2 How did you get here today?
☑ Walking ☐ Taxi / Cab
☐ Bike ☐ Bicycle
☐ Public Transportation ☐ Car

3 How Often do you visit this place?
First time here | ☐ Daily | ☑ Weekly | ☐ Monthly | ☐ Rarely

4 What brings you here today?
☐ Just passing through ☐ Walking my pet
☐ Meeting up with friends ☑ Visiting with family
☐ To explore this area ☐ Cultural event / Performance

5 How much time do you plan to spend here today?
☐ 0 - 15 Minutes ☐ 1 - 2 Hours
☐ 15 - 30 Minutes ☐ More than 2 Hours
☑ 30 - 60 Minutes ☐ I'm not sure

6 How would you describe the current condition of the Canoli Canal?
☐ Very Poor | ☑ Poor | ☐ Average | ☐ Good | ☐ Very Good

7 What do you believe are the main issues facing the canal? (Select all that apply)
☐ Pollution ☐ Lack of Recreation Space
☑ Waste Dumping ☑ Encroachment
☐ Others describe
SEWAGE DISPOSAL

8 How do you feel about this Public Space?
☐ Strongly Negative | ☐ Negative | ☐ Neutral | ☑ Positive | ☐ Strongly Positive

9 How do you feel about visiting and spending time by the canal or park edges in this area?
☑ I enjoy it ☐ I dont have a strong opinion
☐ It's Okay ☐ I do not enjoy it

10 How does the condition of the Canoli Canal affect your lifestyle?
☐ Negatively | ☐ No Impact | ☑ Positively

11 What improvements would you like to see along the Canoli Canal? (Select all that apply)
☑ Clean-up and maintenance efforts ☐ Development of parks and recreational areas
☑ Improved waste management systems ☐ Enhance soft mobility

12 What activities would you like to see implemented adjacent to the rejuvenated canal stretch? (Select all that apply)
☑ Walking / Jogging Paths ☐ Fitness / Outdoor gym
☐ Cycling Tracks ☐ Paddle Boating
☐ Cafes and Food Stalls ☑ Fishing
☑ Childrens Play Area ☐ Others (please specify)

13 How safe do you feel while visiting / walking here?
☐ Not at all Safe | ☐ Slighty Uneasy | ☐ Neutral | ☑ Safe | ☐ Very Safe

14 Would you be interested in participating in community initiatives aimed at revitalizing the Canoli Canal? (Yes / No)

15 If yes, what type of activities would you be interested in?

Thank You

Public Opinion Survey About Canoli Canal and Surrounding areas

Objective : To gather insights from the community regarding their lifestyle, perceptions, and suggestions for the revitalization of the Canoli Canal.

☑ Male ☐ Female Age : 24 Occupation : Student Date : 21-08-24

1 How would you describe your relationship with this area?
☐ Resident ☐ Tourist
☐ Work Here / Nearby ☑ Student (Nearby Institution)
☐ Others describe

2 How did you get here today?
☐ Walking ☐ Taxi / Cab
☑ Bike ☐ Bicycle
☐ Public Transportation ☐ Car

3 How Often do you visit this place?
First time here | ☐ Daily | ☐ Weekly | ☐ Monthly | ☑ Rarely

4 What brings you here today?
☐ Just passing through ☐ Walking my pet
☑ Meeting up with friends ☐ Visiting with family
☐ To explore this area ☐ Cultural event / Performance

5 How much time do you plan to spend here today?
☐ 0 - 15 Minutes ☑ 1 - 2 Hours
☐ 15 - 30 Minutes ☐ More than 2 Hours
☐ 30 - 60 Minutes ☐ I'm not sure

6 How would you describe the current condition of the Canoli Canal?
☐ Very Poor | ☑ Poor | ☐ Average | ☐ Good | ☐ Very Good

7 What do you believe are the main issues facing the canal? (Select all that apply)
☑ Pollution ☐ Lack of Recreation Space
☑ Waste Dumping ☐ Encroachment
☐ Others describe

8 How do you feel about this Public Space?
☐ Strongly Negative | ☐ Negative | ☑ Neutral | ☐ Positive | ☐ Strongly Positive

9 How do you feel about visiting and spending time by the canal or park edges in this area?
☐ I enjoy it ☑ I dont have a strong opinion
☐ It's Okay ☐ I do not enjoy it

10 How does the condition of the Canoli Canal affect your lifestyle?
☐ Negatively | ☑ No Impact | ☐ Positively

11 What improvements would you like to see along the Canoli Canal? (Select all that apply)
☑ Clean-up and maintenance efforts ☑ Development of parks and recreational areas
☐ Improved waste management systems ☐ Enhance soft mobility

12 What activities would you like to see implemented adjacent to the rejuvenated canal stretch? (Select all that apply)
☐ Walking / Jogging Paths ☐ Fitness / Outdoor gym
☑ Cycling Tracks ☑ Paddle Boating
☐ Cafes and Food Stalls ☑ Fishing
☐ Childrens Play Area ☐ Others (please specify)

13 How safe do you feel while visiting / walking here?
☐ Not at all Safe | ☐ Slighty Uneasy | ☑ Neutral | ☐ Safe | ☐ Very Safe

14 Would you be interested in participating in community initiatives aimed at revitalizing the Canoli Canal? (Yes / No)

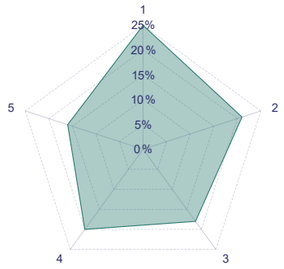
15 If yes, what type of activities would you be interested in?

Thank You

SUMMARY OF FEEDBACKS BASED ON INTERVIEW RESULTS:

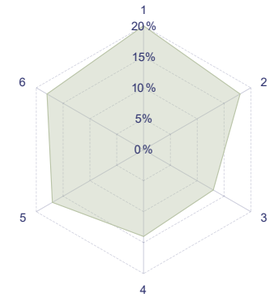
I. What type of neighborhood do you live in?

1. **Urban Center**
2. Suburban Area
3. Rural Community
4. Mixed-Use Development
5. Gated Community



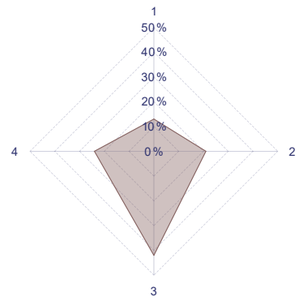
II. What kind of public space do you think should be prioritized in the future development of Kozhikode?

1. **Parks and Green Spaces**
2. **Waterfront Development**
3. Cultural and Community Spaces
4. Marketplaces and Commercial Areas
5. Recreational Facilities



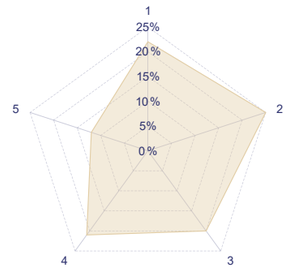
III. Should future development efforts in Kozhikode focus on attracting more tourists?

1. Yes, definitely.
2. Yes, but with a focus on sustainable tourism.
3. **No, we should prioritize local community needs first.**



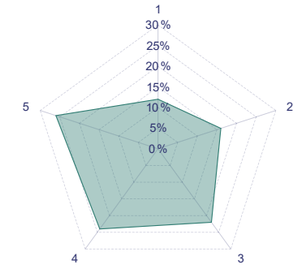
IV. With respect to climate change, what are the major issues people face in Kozhikode?

1. **Flooding**
2. **Rise of temperature**
3. Longer dry season
4. Heavy and unsteady rainfall
5. Not Aware at All



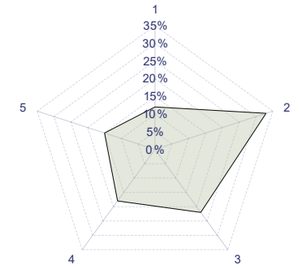
V. Were there any fears associated with the canal problems faced within your families/communities?

1. Very Good
2. 2
3. 3
4. 4
5. **5(No waste collection)**



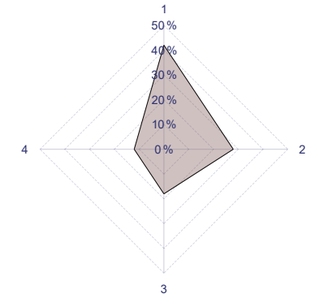
VI. Do you feel that there is a lack of public spaces to meet people in Kozhikode?

1. I often find it difficult to find places to meet others.
2. **There are some spaces, but they are not sufficient.**
3. I believe there are enough public spaces available.
4. I think there are plenty of good places to meet
5. I haven't really thought about it.



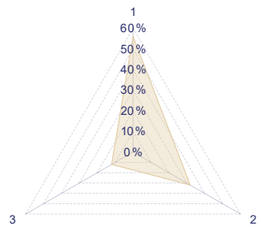
VII. How important is it to maintain the ecological health of the Canoli Canal

1. **Very Important**
2. Important
3. Somewhat Important
4. Not Important

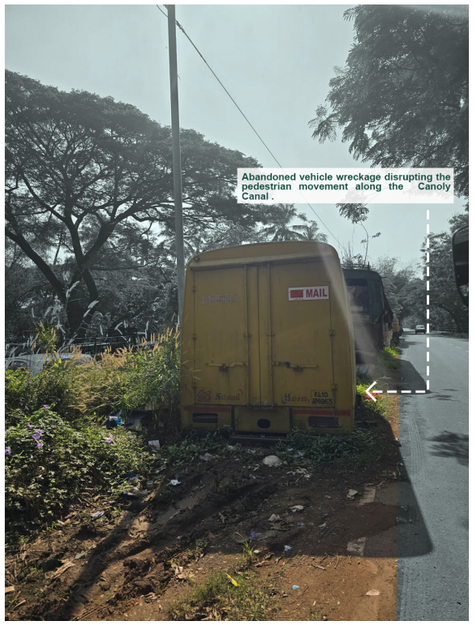


VIII. Do you think that improving the canal can boost local businesses in Kozhikode

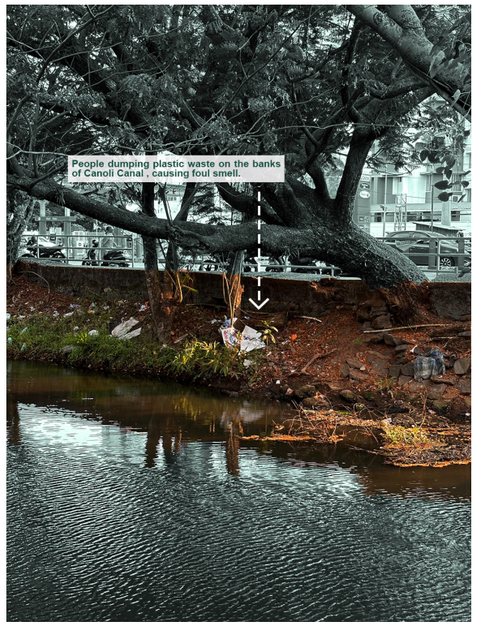
1. **Yes, definitely**
2. Maybe
3. No



7.3. Qualitative Analysis



Top left : Interstitial buffers adjacent pedestrian pathways along Mini Bypass road
Top right: Broken edges and muddy terrain as sidewalks along the secondary roads
Bottom left: Lack of Pedestrian mobility tracks along stretches of Canoli Canal
Bottom right: Constructed sidewalks along the Sarovaram Biopark road



Top left : Widest portion of canal in the focus area with most polluted zone; adjacent to Baby Memorial Hospital
Top right: Inside the Sarovaram Biopark - Potential areas
Bottom left: Embankments of Canoli canal edges
Bottom right: Sarovaram Biopark with zones for bioswales and raingardens

7.4. Site visit summary

- Condition of the water and the canal edges to be maintained with better management especially in regards to better water quality and prevention of waste accumulation.
- Often the canal water has a pungent smell and a grey water appearance with the dumping of waste water from adjacent buildings which makes it difficult to access the pavements along the canal.
- Sarovaram Bio park is actively used by adults and families especially kids for activities such as cycling, recreational parks and boating. It is the only area adjacent to the canal that offers some public amenities like seating, shaded green stretches and defined activities.
- Lack of bus route or public transport along the main stretch of the Sarovaram - Ariyadathupalam road leads to a decline of users along the stretches of prime areas of Canoli canal.
- Local residents prefer an urban development that caters to the community needs with better recreational facilities and well-planned mobility that allows an active participation.

08 CHAPTER

CONCLUSION & DESIGN PROPOSAL

Figure 131 Envisioned transformation of the Canoli canal water-front spaces
(Source: Illustration by Authors)

CHAPTER 8: CONCLUSION & DESIGN PROPOSALS

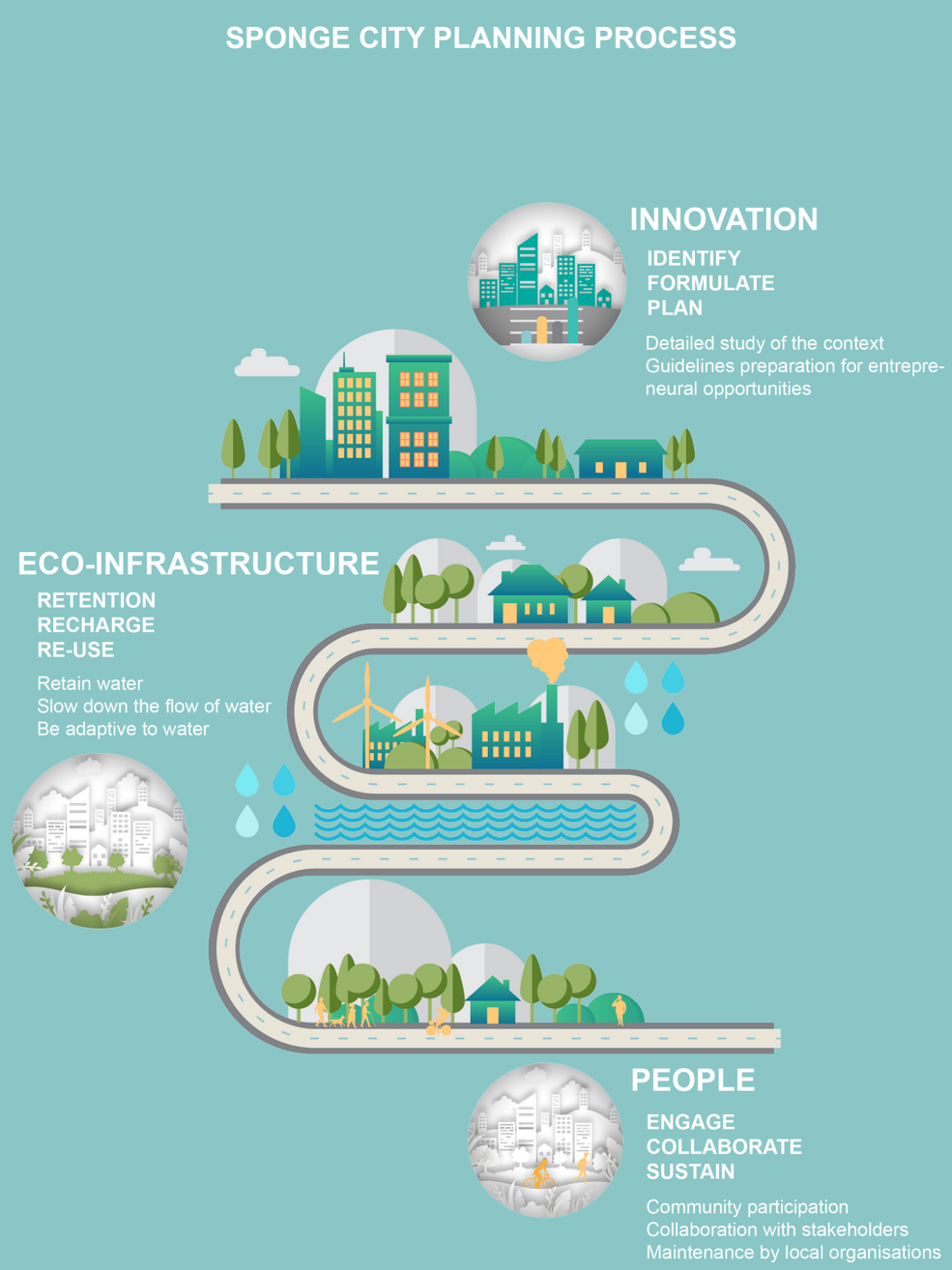
8.1. Vision

The vision of the design is to emphasize on a transformative approach to urban water management, integrating ecological principles with community engagement. Key features of this vision include the implementation of permeable pavements, terraced gardens, green roofs, and constructed wetlands. These elements not only enhance the city's capacity to manage stormwater but also contribute to improved air quality and urban biodiversity (Urban Design Lab, 2024). The focus of the thesis is to propose minimal interventions in terms of urban design along with preserving the natural ecosystem catering to the flora and fauna. The extent of design would be to creatively transform the traditional urban landscapes into multifunctional spaces that prioritize water retention and filtration. This would ensure that Kozhikode can mitigate flooding risks while creating vibrant public areas for community interaction (Arkance, 2024).

A crucial aspect of this vision is the active involvement of local communities in the planning and implementation processes. This community-centric approach not only enhances the effectiveness of sponge city initiatives but also promotes social cohesion and resilience. Amenities are envisioned to be operated with the participation of the local communities including organizations or clubs for maintaining certain activity spaces.

*"Crafting cities that **absorb, store**, and **release**, intertwining nature with urban life to forge vibrant **green corridors for both people and wildlife."***

Figure 132 This photo depicts the state of side roads along Canoli canal
(Source: Illustration by Authors)



INNOVATION:

A sponge city is designed to maximize the use of existing resources, such as buildings and natural landscapes, to create effective and low-cost water management solutions. By leveraging local materials and skilled labor, the city can reduce overall expenses significantly. This reduction is achieved through inexpensive sponge interventions that not only protect existing infrastructure from water-related hazards but also extend their lifespan (Climateways, 2025). Revenue generated from water harvesting initiatives encourages further investment in innovative sponge town projects. Detailed study of the potential sites are carried out, post which the planning guidelines are formulated for the city of Kozhikode including business opportunities. Ultimately, the development of sponge towns aligns with urban policies aimed at improving water quality and diversifying supply while safeguarding against floods (ENVI-met, 2025).

ECOLOGICAL INFRASTRUCTURES:

Nature-based ecological infrastructure plays a vital role in providing essential ecosystem services, and it works hand-in-hand with traditional grey infrastructure. By integrating natural elements—like parks, wetlands, and green roofs—with conventional structures such as roads and buildings, we create a more resilient and sustainable environment. This combination not only enhances the functionality of urban areas but also improves air and water quality, supports biodiversity, and offers recreational spaces for communities. Water is fundamental to creating effective ecological infrastructure. The guiding principle here is to retain water, slow its movement, and design urban spaces that are more adaptable to water's presence.

Ecological redesign of the critical zones to adapt to monsoon floods is prioritized along with stormwater regulation by absorbing excess water with more permeable surfaces. Strategies such as Terracing, Ponding, Islanding are tried to be incorporated, not only to protect communities from water-related challenges but also promotes a harmonious relationship between the built environment and natural water systems.

PEOPLE:

The community is a treasure trove of ideas and resources. When residents see how these initiatives can benefit their locality , they become deeply committed to the cause. Many citizens and local organizations are eager to take action themselves—whether it's collecting rainwater, planting greenery, creating mini-parks, or organizing town-cleaning campaigns. Their local knowledge and connections are invaluable in designing a sponge city that truly meets the needs of the community. Ideas of community farming, organic vegetable markets, reading clubs etc are also intended as part of the design program which has an already active involvement by the communities in Kozhikode context.

VISION BOARD : ACTIVITY MAPPING

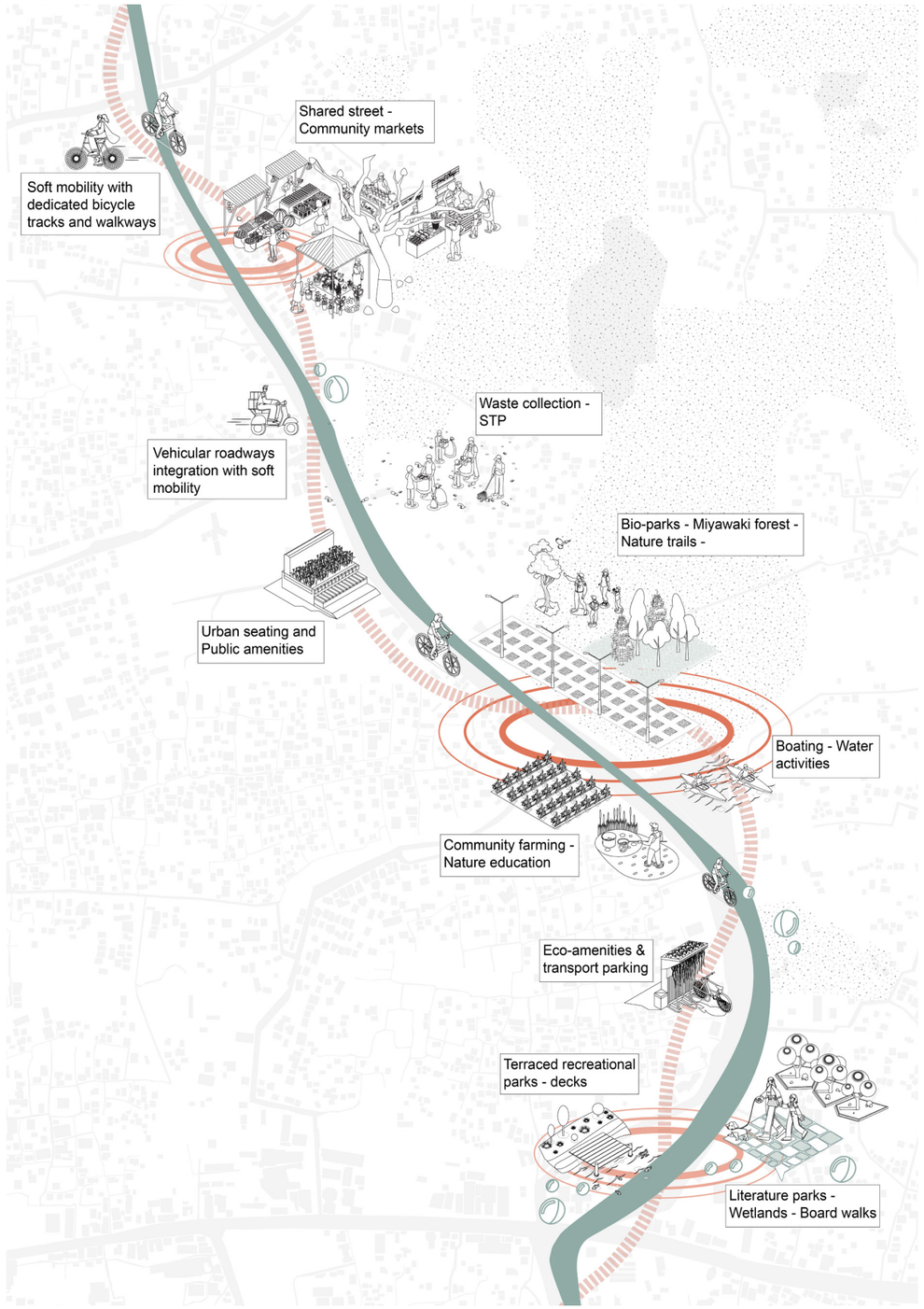
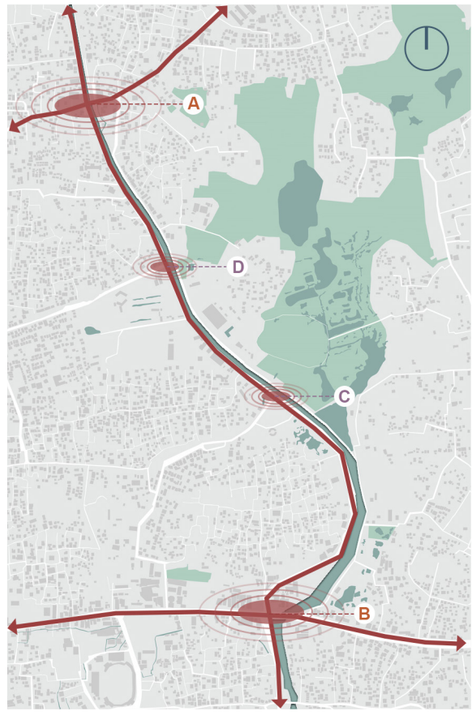


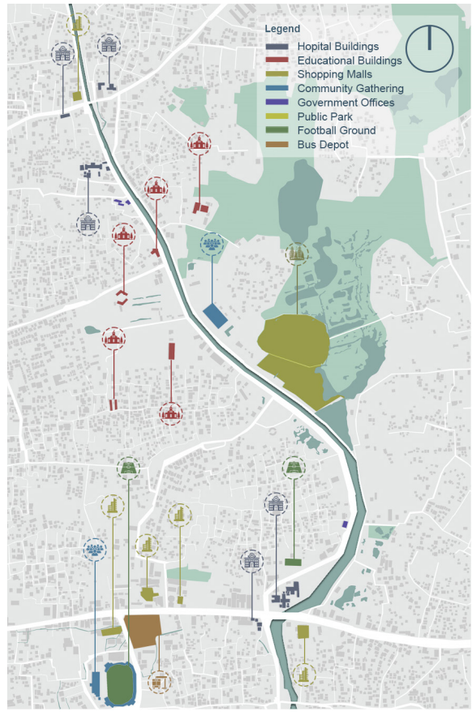
Figure 133 Activity mapping concept for a rejuvenated urban context of the site
(Source: Illustration by Authors)

8.2. Design approach and positioning



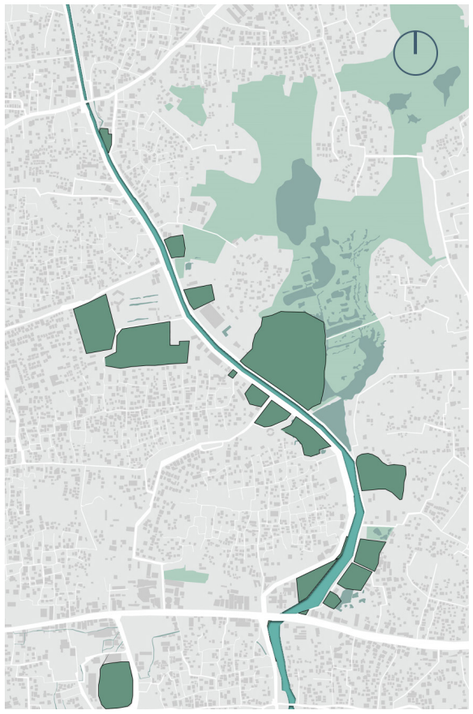
Identification of Major Nodes and major road networks of Site Area :

The analysis identifies two major nodes, A and B, and two minor nodes, C and D, within the site area and these nodes in relation to primary roads and traffic patterns,This overview enhances our understanding of how these nodes serve as central hubs of activity and connectivity in the urban environment.



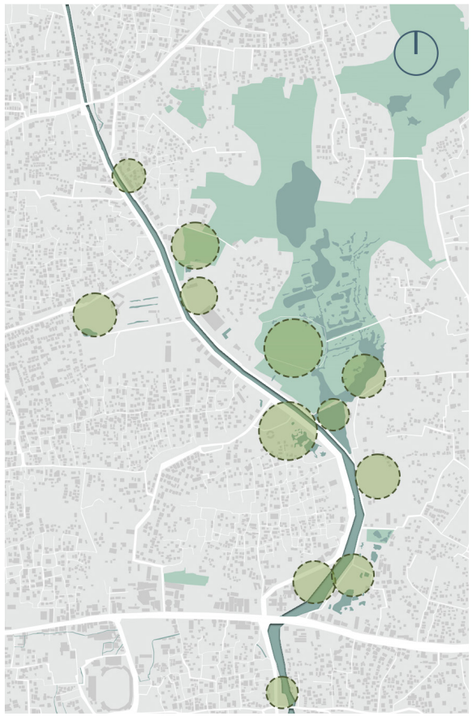
Identifying Important Landmarks in the Site:

This analysis highlights the significant landmarks within the site , the map illustrates these landmarks and their relationship to the revitalization efforts, emphasizing how they influence the surrounding environment and settlement patterns. By considering these factors, we can gain a better understanding of the area's dynamics and inform future development strategies that enhance community living and environmental sustainability.



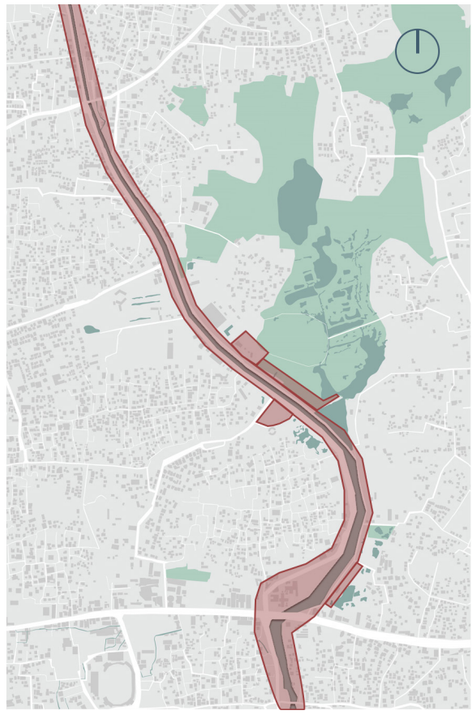
Identifying Existing Green Spaces

The map identifies existing green spaces , highlighting their roles and effectiveness in relation to the surrounding environment. While some spaces are active, they may not fully realize their potential in enhancing the area. This analysis considers surrounding settlement patterns and public space functions, providing insights into how these green spaces can be optimized for better community integration and future development, fostering a more vibrant and sustainable urban environment.



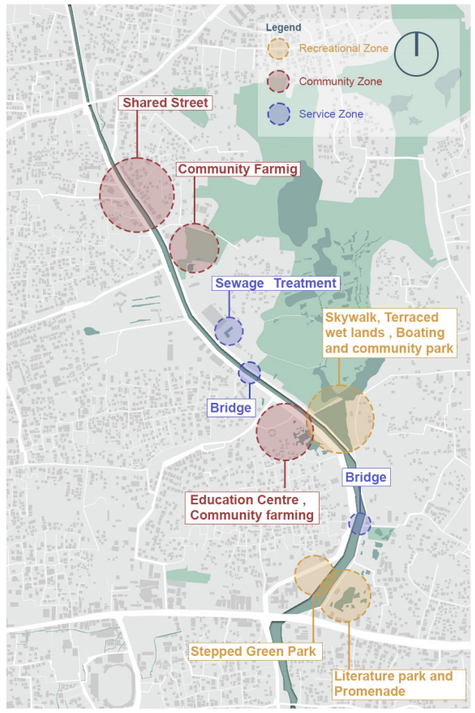
Identifying Potential Public Open Spaces:

The map shows existing public open spaces that are currently underutilized or not actively engaged by the community, which limits their potential impact on the surrounding environment. By analyzing it we can define appropriate public space functions for these areas, such as community gathering spots, green parks, and educational centers. This approach aims to enhance community interaction and promote a more vibrant urban atmosphere, ultimately transforming these neglected spaces into valuable assets for the community.



Depaving and Introducing Permeable Pavements

The proposal involves removing impermeable surfaces from the side roads adjacent to canals and replacing them with permeable pedestrian paths and cycle tracks. This change enhances water absorption in the surrounding area, significantly reducing stormwater runoff. By facilitating natural water infiltration, these permeable pavements not only help mitigate soil erosion but also contribute to the transformation into a sponge city, fostering a more resilient urban ecosystem.



Design zoning based on amenities

The map indicates the potential zones of recreational spaces, community facilities and services that relates to the local context. The integration of the ecological infrastructures with the existing resources and interstitial spaces could revive the vitality of the urban character. The pockets of green and blue infrastructures blends seamlessly with the landscape and is centered around the participation of the local community. The terraced gardens, educational parks and community farming areas are some of the key amenities of the zoning

8.3. Design strategies

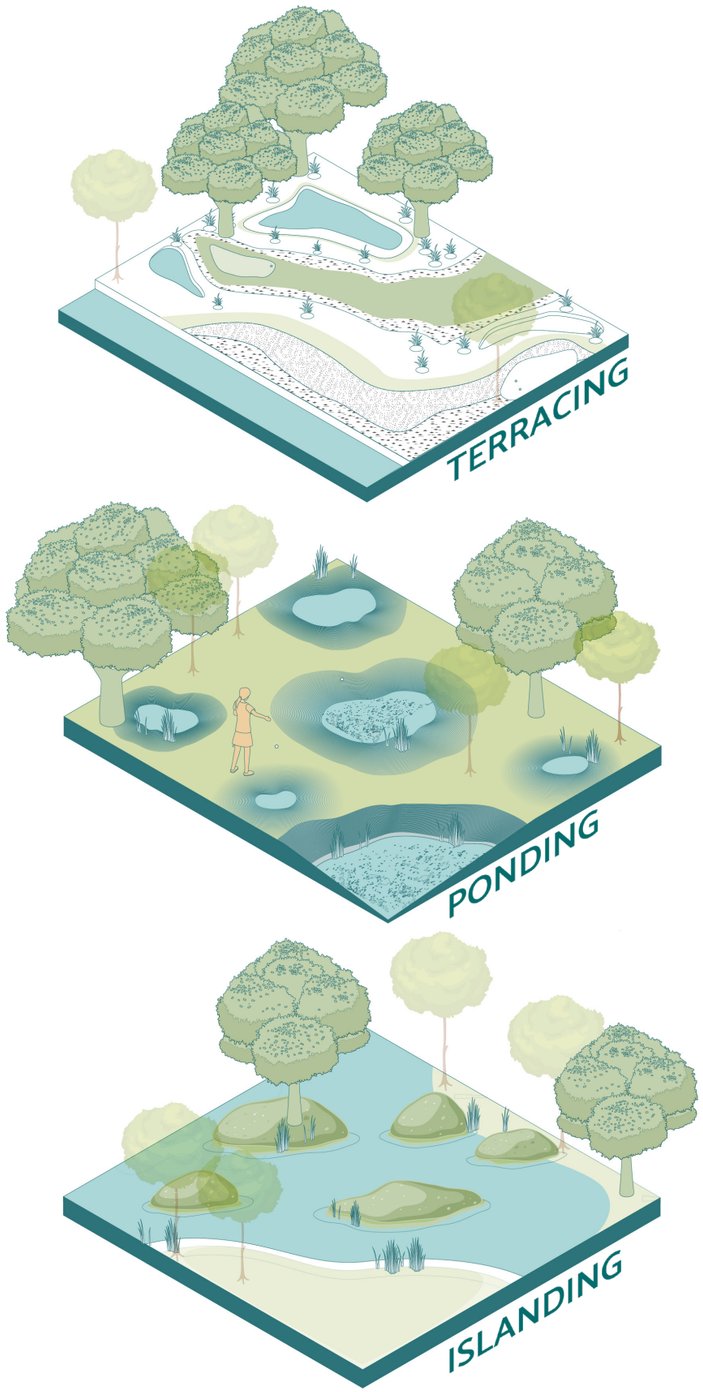


Figure 134 Major design strategies used in the planning process
(Source: Illustration by Authors)

Some of the main design strategies to be implemented for the city of Kozhikode with inspiration of a sponge city concept are listed as the following:

1. Water Management Systems

- **Ponding:**

Ponding involves creating shallow depressions or basins that can temporarily hold water during heavy rainfall events. This strategy allows for the natural absorption and filtration of stormwater, reducing runoff and mitigating flooding in urban areas.

- **Shallow Wetlands**: By designing shallow wetlands or retention ponds, excess rainwater can be collected and allowed to percolate into the ground, replenishing groundwater supplies. This also creates habitats for various species, enhancing local biodiversity.

- **Vegetated Swales**: Incorporating vegetated swales in urban landscapes can direct stormwater runoff into these ponding areas. The vegetation helps filter pollutants from the water while providing aesthetic and recreational spaces for residents.

- **Terracing:**

Designing terraces to create flat planting areas on slopes, which can effectively slow down water runoff and promote infiltration. This method involves constructing terraced swales along the natural contour lines of the landscape. Integrating terracing with other water-sensitive urban design strategies, such as rainwater harvesting systems and permeable surfaces, can enhance overall water management efficiency.

- **Retention Basins:** Incorporating retention basins within the terraced design allows for temporary storage of excess rainwater. These basins can be strategically placed to collect runoff from impervious surfaces, facilitating groundwater recharge and reducing flooding risk.

- **Vegetated Terraces:** Planting vegetation on terraces not only stabilizes the soil but also enhances water retention through root systems that improve soil structure. Native plants can be selected to minimize maintenance while providing habitat for local wildlife.

- **Islanding:**

Islanding by creating elevated landforms or islands within wetland areas that provide refuge for wildlife during flooding events. This strategy can enhance habitat diversity and resilience in urban wetlands.

- **Constructed Islands**: Designing small islands within ponds or wetlands allows for the establishment of diverse plant communities that can withstand fluctuating water levels. These islands can serve as nesting sites for birds and other wildlife.

- **Community Spaces**: Islands can also be designed as community spaces with walking paths and educational signage about local ecology, promoting public awareness and appreciation of wetland environments.

- **Rainwater Harvesting**: Implement systems for collecting rainwater from rooftops for irrigation or non-potable uses.

2. **Green Infrastructure Development:**
   - **Permeable Pavements**: Replace traditional concrete with permeable materials that allow rainwater to infiltrate. This can include permeable asphalt or interlocking pavers designed to facilitate drainage.

   - **Green Roofs**: Encourage the installation of green roofs on buildings to absorb rainwater and reduce heat island effects.

   - **Rain Gardens**: Design landscaped areas that capture stormwater runoff and promote infiltration while enhancing aesthetic value.

3. **Urban guidelines proposal**
   - **Zoning Regulations**: Suggestions on the modification of zoning laws and urban guidelines to encourage or require green infrastructure in new developments.

   - **Incentives for Sustainability**: Proposal for providing tax breaks or grants for property owners who implement sponge city features on their properties.

4. **Community Involvement**
   - **Workshops and Education**: Conducting workshops to educate residents about the benefits of sponge city features and how they can participate in maintaining these spaces.

   - **Collaborative Design Processes**: Engaging community members in the design phase to ensure their needs are met and foster a sense of belonging.

TRANSITIONING VISION INTO REALITY

A Design Synthesis : From Principles to Plans

Figure 135 Existing map of the focus area - Present context
(Source: Google maps)

8.4. Master plan

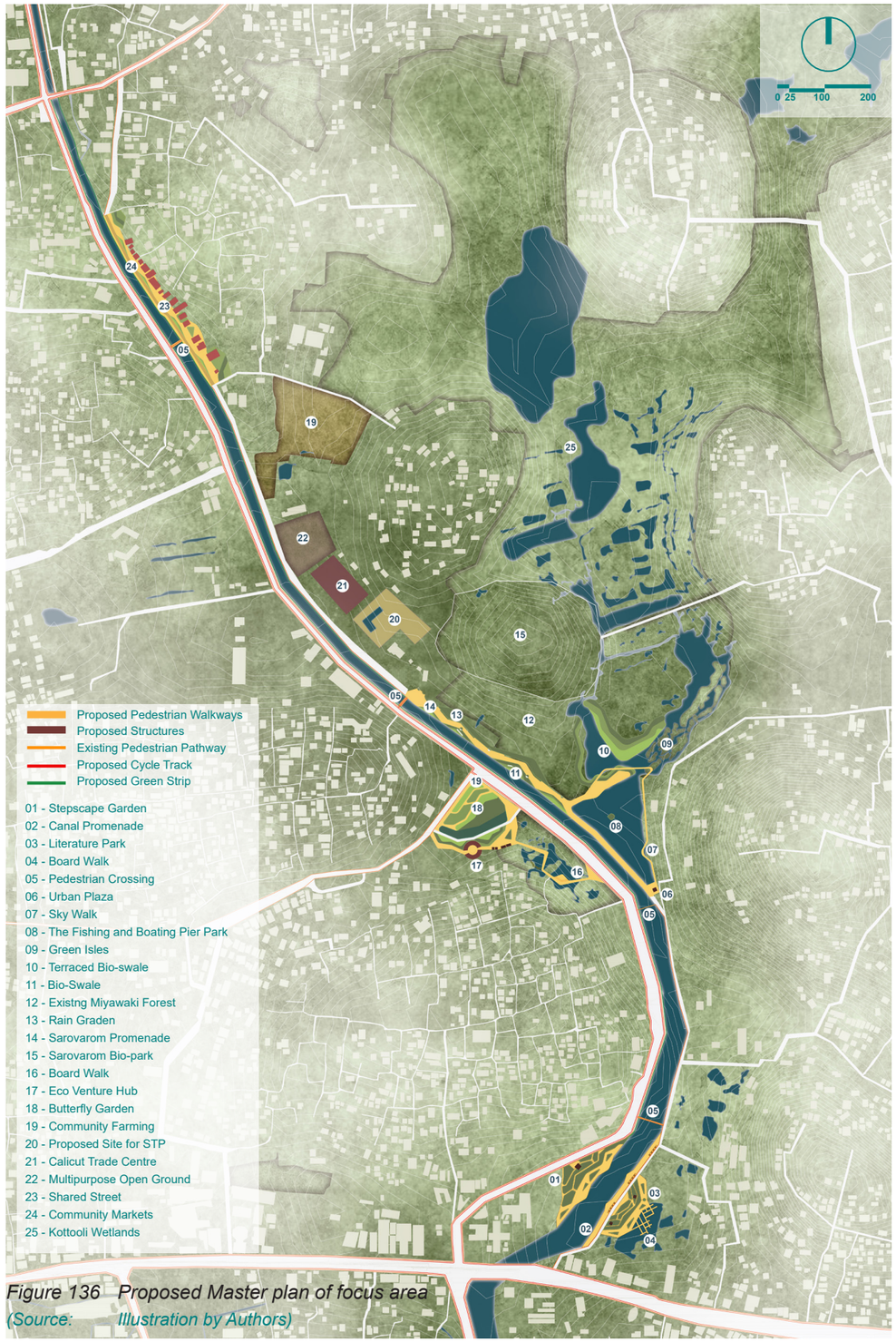


Figure 136 Proposed Master plan of focus area
(Source: Illustration by Authors)

8.5. Proposed solutions

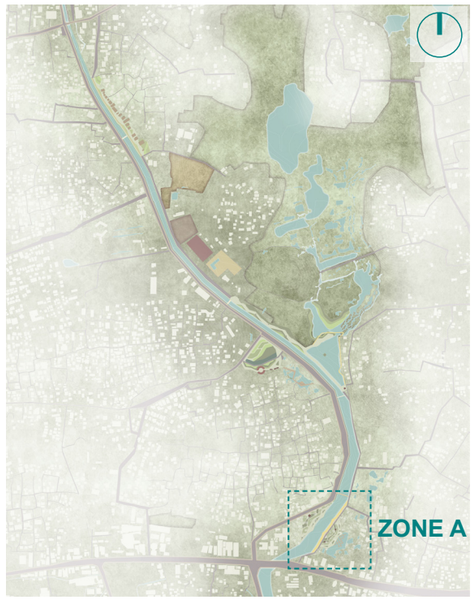


Figure 137 Key Plan highlighting Zone A
(Source: Illustration by Authors)

Zone A : Terraced Recreational Magnets

Creating spaces for reflection, healing and community engagement with significance to the culture and history of the space. Stepscape garden and literature park with a canal-front lowered platform offers the users to connect with water. By adding elements such as board walks on seasonal wetlands and decorative mural walls along the pedestrian routes as an ambient backdrop allow these areas to be used by the residents as an active urban space for gatherings and relaxation. These gardens are designed as bio-purification terraces that absorbs the stormwater run-off and filters the pollutants before draining into the canal.

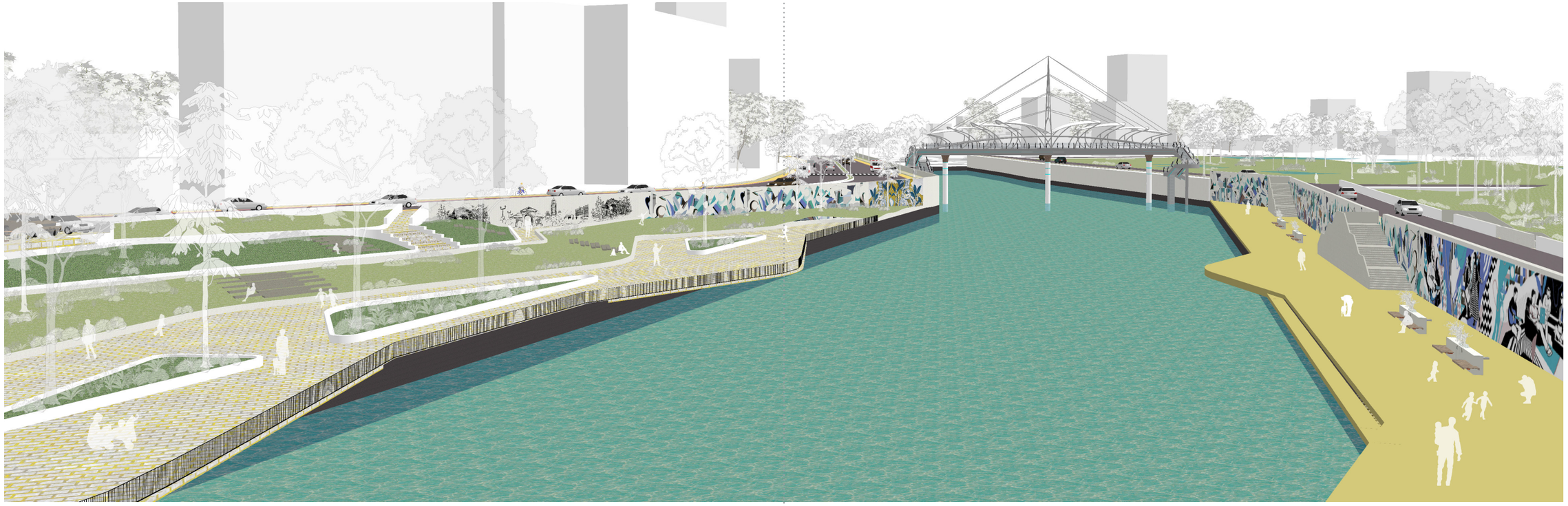


Figure 138 View of the stepscape garden and canal promenade
(Source: Illustration by Authors)

Figure 139 Schematic plan showing activity layouts of the recreation zone
(Source: Illustration by Authors)

Terraced park acting as a green lung with seasonal flower gardens, sloped lawns, and landscape seating along with walkways and cafe activities along the canal-front with viewing decks into the canals.

Literature park is treated as an ecological habitat rejuvenated with seasonal wetlands and board walks, providing a co-habitat with nesting areas for fauna through plantation. Shaded pavilions and resting areas are blended into the green landscape which could host literary club activities.

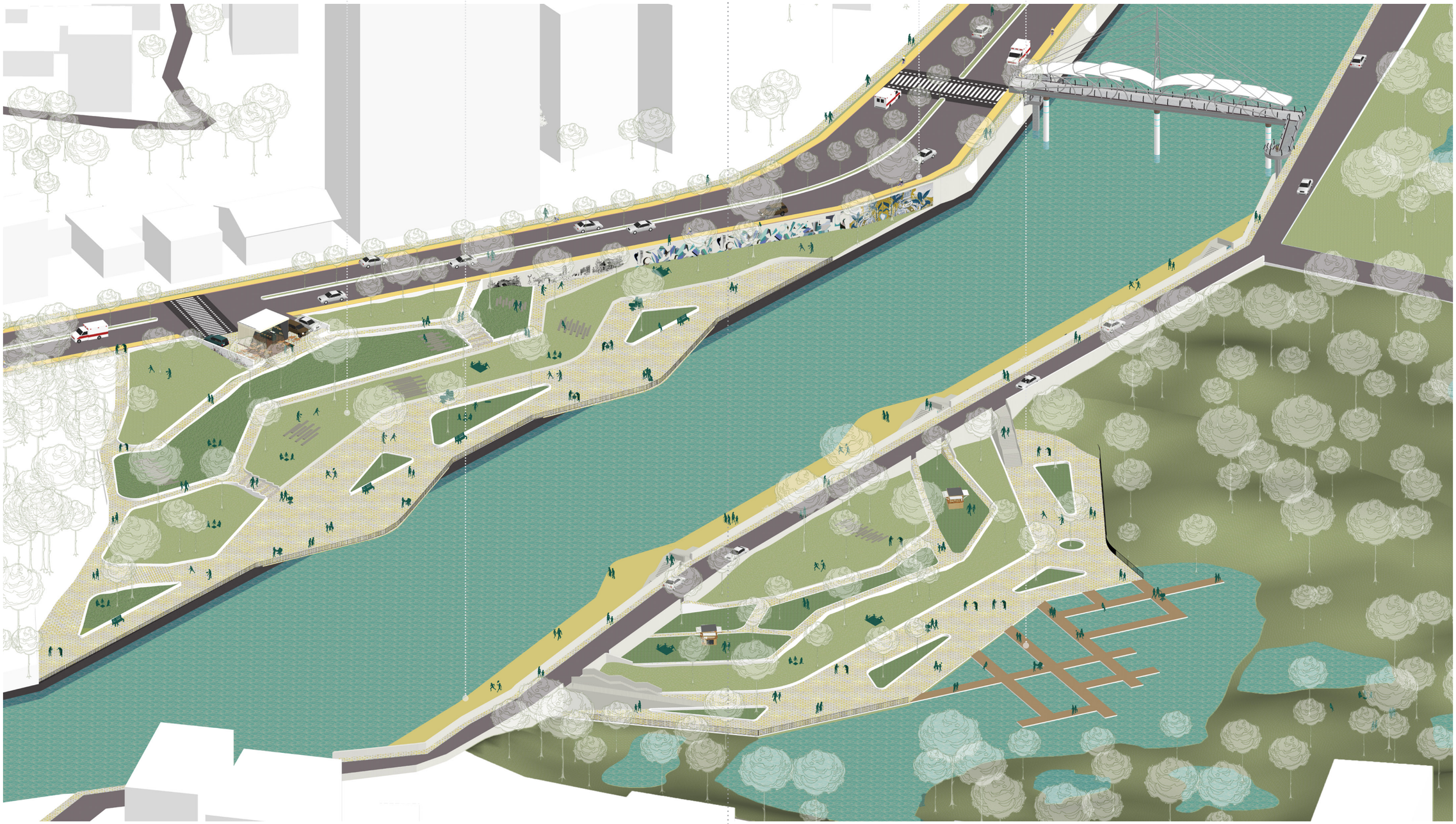


Figure 140 3D view of the focus area
(Source: Illustration by Authors)

Figure 141 Stepscape garden
(Source: Illustration by Authors)

Bio-purification terraces in the stepscape garden use phytoremediation techniques by adding different layers of planting for the sub-surface filtration of the stormwater run-off from the roads and pathways.

Figure 143 Canal promenade
(Source: Illustration by Authors)

Waterfront promenade seamlessly integrate with water edge creating dynamic visual and physical connection between the urban landscape and canal.

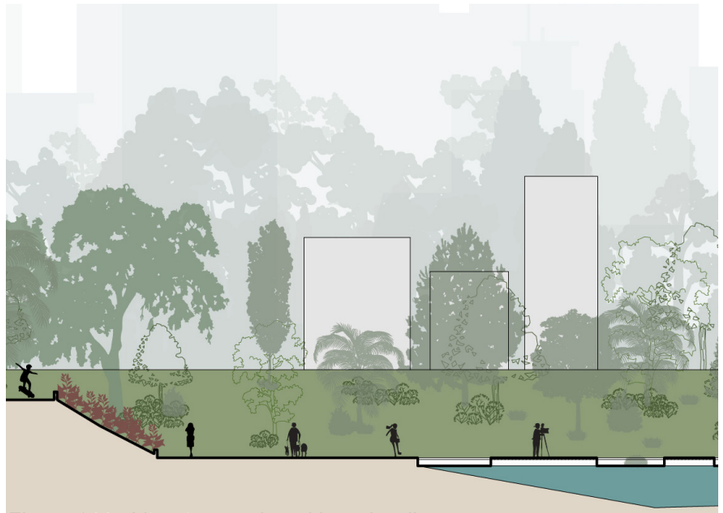


Figure 144 Literature park and board walks
(Source: Illustration by Authors)

Ecological habitat rejuvenated with seasonal wetlands and board walks as floating decks providing a co-habitat with nesting areas for fauna through plantation.

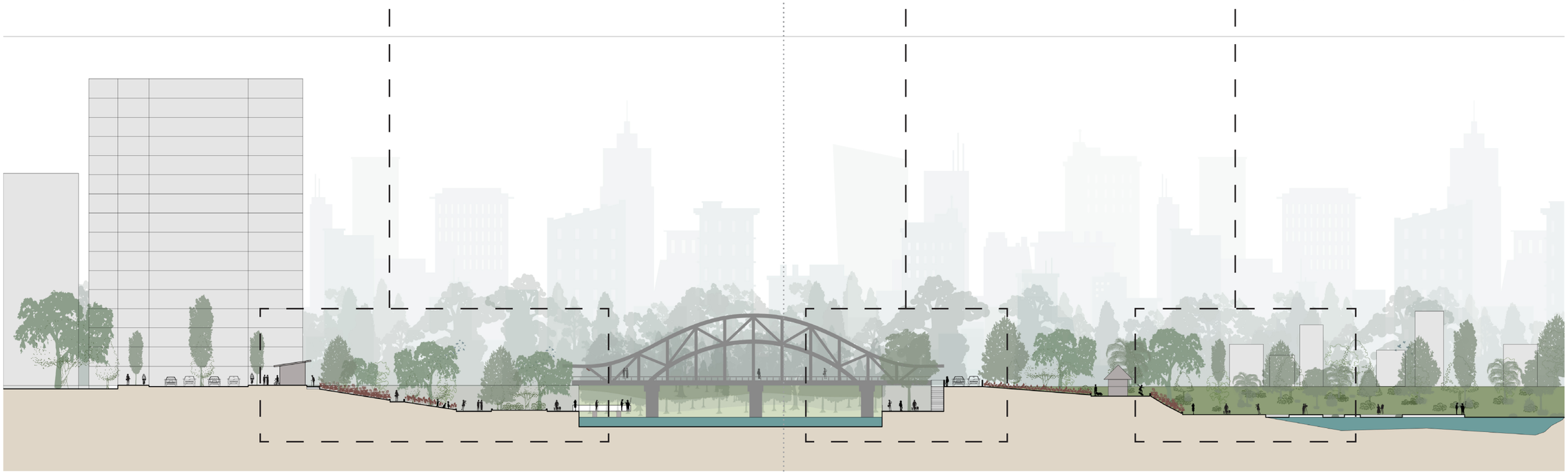


Figure 142 Site section AA - along the recreational area near Baby Memorial Hospital
(Source: Illustration by Authors)

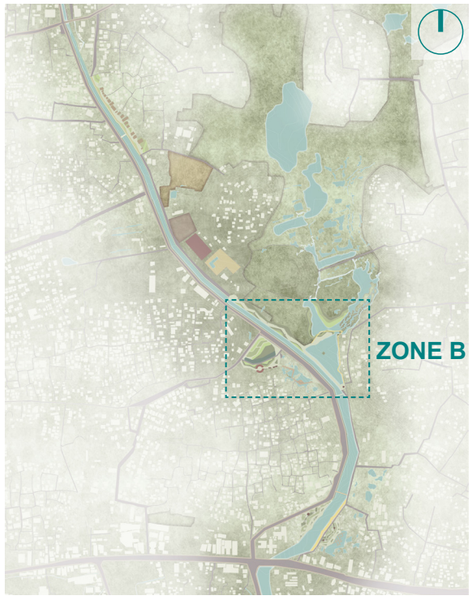


Figure 145 Key plan highlighting Zone B
(Source: Illustration by Authors)

Zone B : Environmentally sensitive zone

Proposing spaces for community farming, environmental exploration, outdoor learning with hands-on approaches, wetland parks with eco-tours and nature trails. Bioswales along the canal edges are designed to slow down the rainwater and rain gardens on the other edges of pedestrian walkways are designed to capture maximum water for flood resilience. Skywalk through the serene wetlands, butterfly parks, urban farms, boating and fishing activities are also planned in this environmentally rich zone to engage communities in environmental stewardship, where recreational oppurtunities support both ecological health and public well-being.

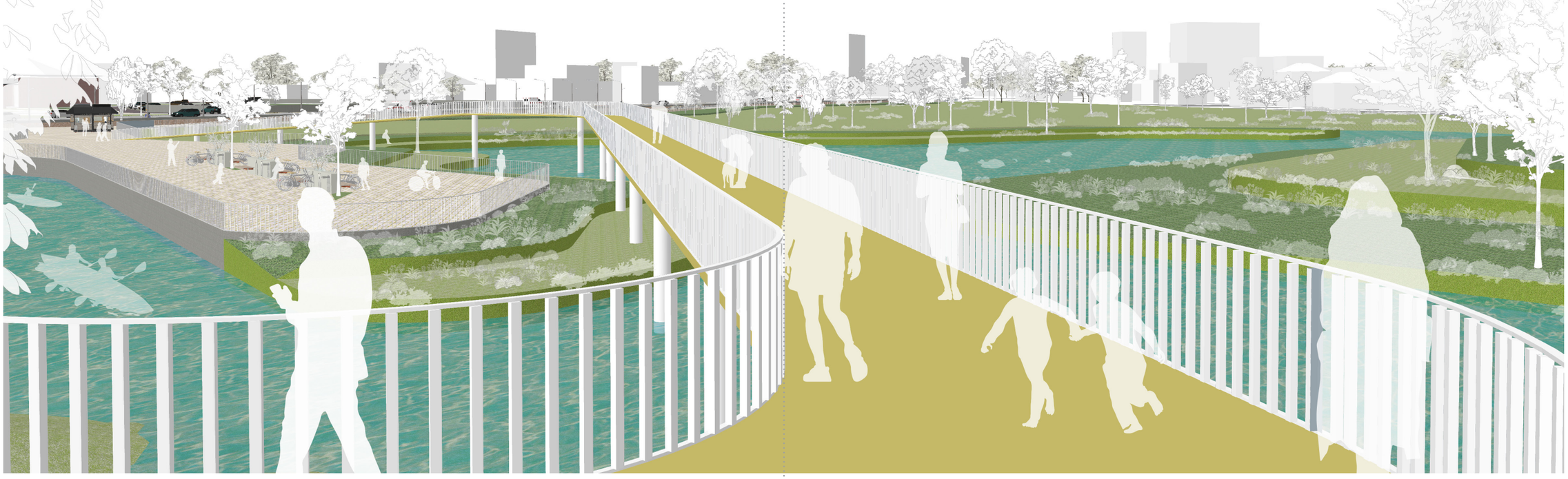


Figure 146 View of the bio-park plaza and wetland terraced bio-swales
(Source: Illustration by Authors)

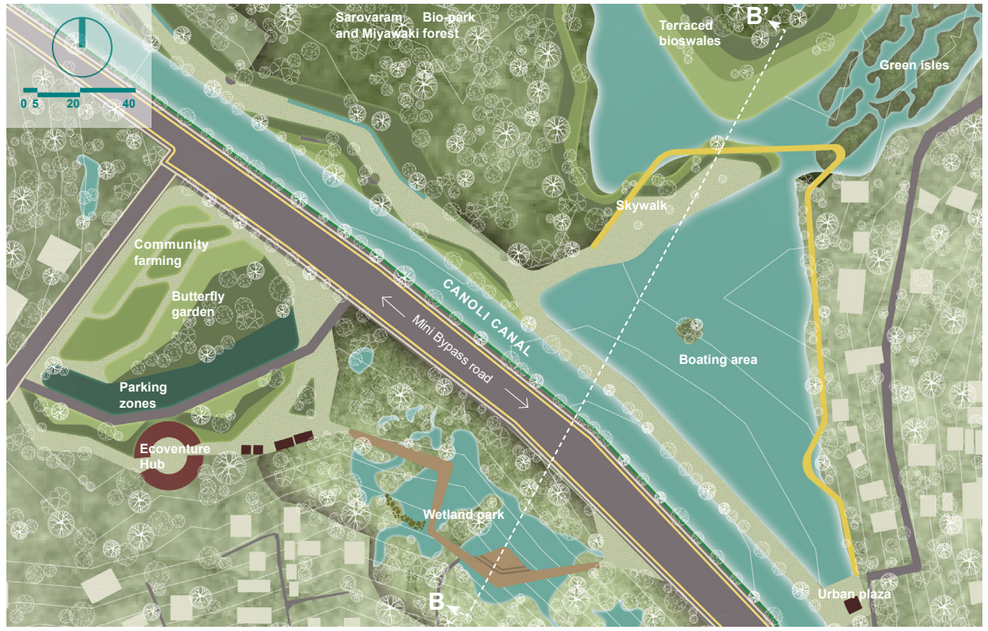


Figure 147 Schematic plan of Zone B
(Source: Illustration by Authors)

Community urban farm and Eco venture hub include green roofs for structures, herb gardens, outdoor classrooms, farming plots, organic product stalls, wooden boardwalks and viewing platforms along the wetland edges with eco-art installations

Elevated pedestrian walkways reduce foot traffic on sensitive wetland areas preserving natural habitats and offer panoramic views of different areas of bio-park where the public engagement with parks ecology is enhanced without disturbing wildlife. Light canoes, kayaks or paddleboats along with bird watching and fishing practices on a designated waterbody increases the interactional quality within bio-park for different typology of users.

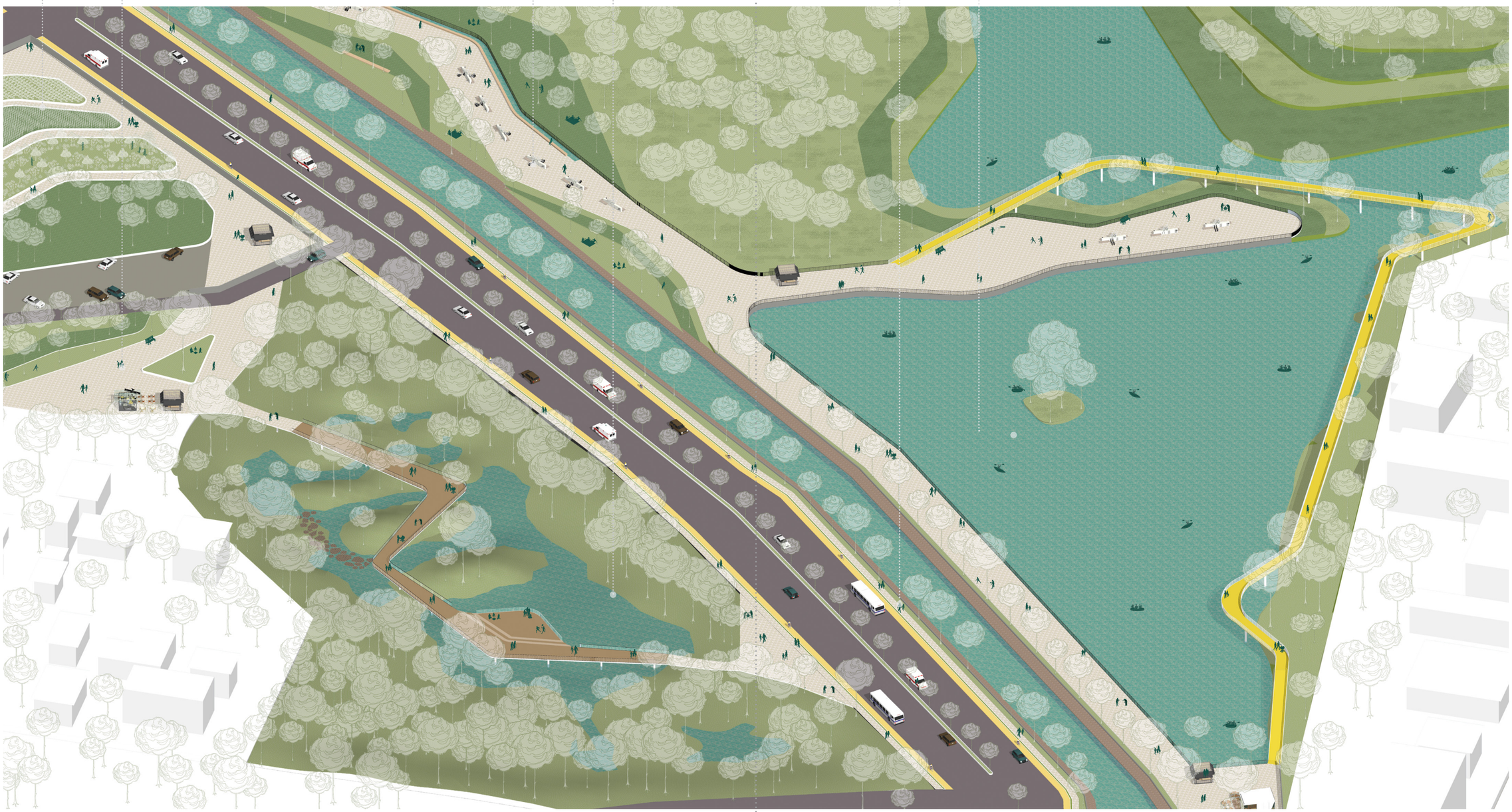


Figure 148 Axonometry view of Zone B: Restored areas and design interventions
(Source: Illustration by Authors)

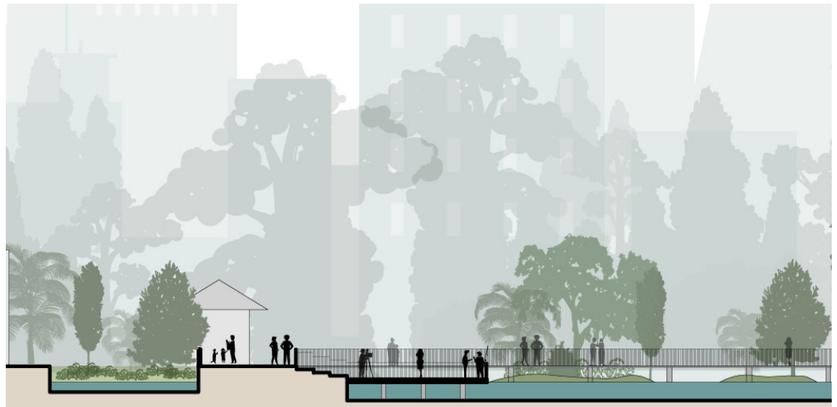


Figure 149 Educational wetland site
(Source: Illustration by Authors)

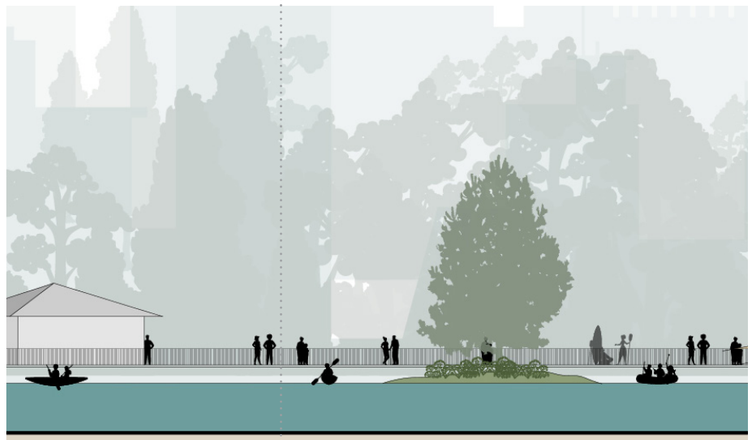


Figure 151 Boating area and pocket islands
(Source: Illustration by Authors)

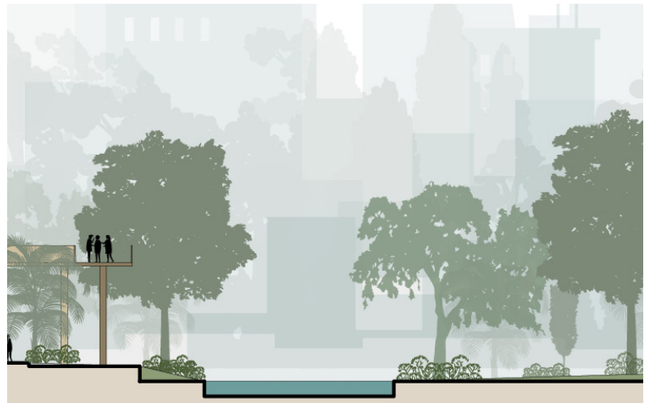


Figure 152 Skywalk and green isles along the canal
(Source: Illustration by Authors)

Eco venture hub within the restored wetlands is proposed with smart water management systems, ecological monitoring and digital platforms to promote active involvement of the community and residents in wetland restoration and eco-ventures. Green isles in wetlands are introduced for biodiversity boost, increase carbon sequestration and mitigate pollution.

Small islands as buffer zones in the water have different native planting that withstand fluctuating water levels and provide nesting areas for fauna. Passive forms of recreation such as birdwatching, fishing and light boating are proposed to co-exist with natural preservation

Along with soft mobility, skywalks and observation decks are incorporated with educational signages and interactive features to raise awareness.

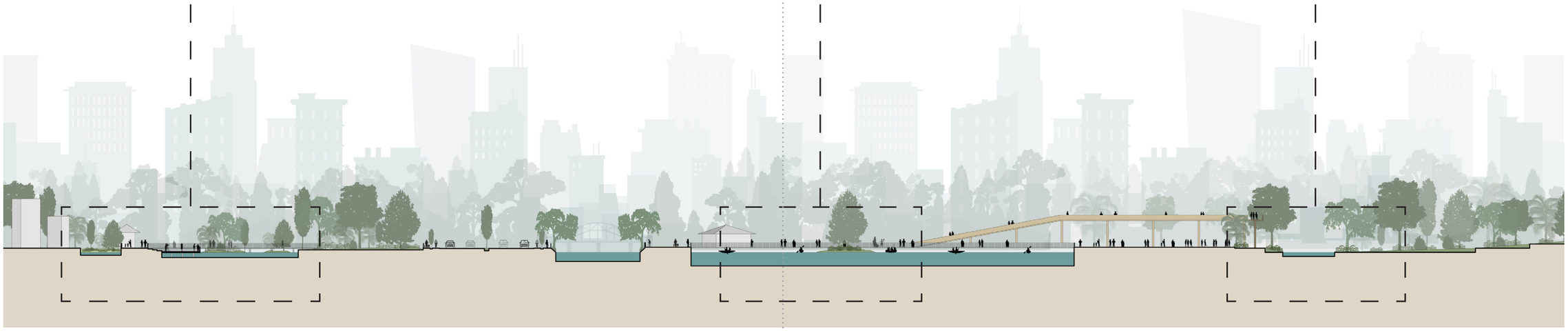


Figure 150 Site section BB - along Sarovaram boating area and Nature education sites
(Source: Illustration by Authors)

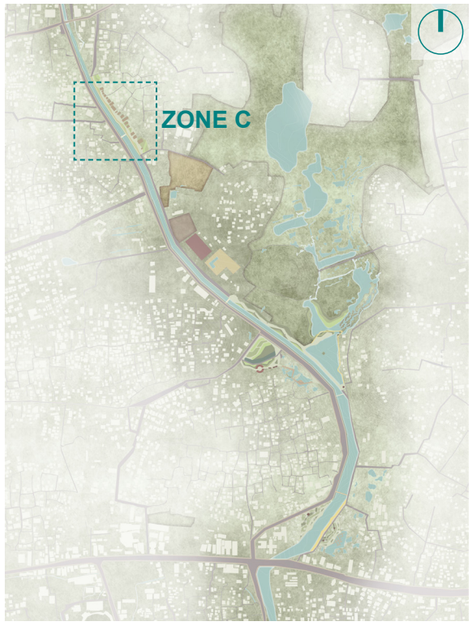


Figure 153 Key plan highlighting Zone C
(Source: Illustration by Authors)

Zone C : Shared streets and community markets

Reimagining the street along the canal into a vibrant active urban corridor where canal becomes a central feature of the community life. The design prioritizes soft mobility including cycle tracks, pedestrian walkways along with limited vehicular movement with speed restrictions in the shared street. By integrating permeable pavements and raingardens, this ecological corridor also caters as a market space with local vendors and community fairs for local economy. Socially inclusive and environmentally resilient streets could be treated as a module that could be replicated along various stretches of the canal.

Slowing down car traffic encourages a pedestrian and cycle friendly environment

Green roofs, permeable paving and shading elements can help in the micro-climate regulation

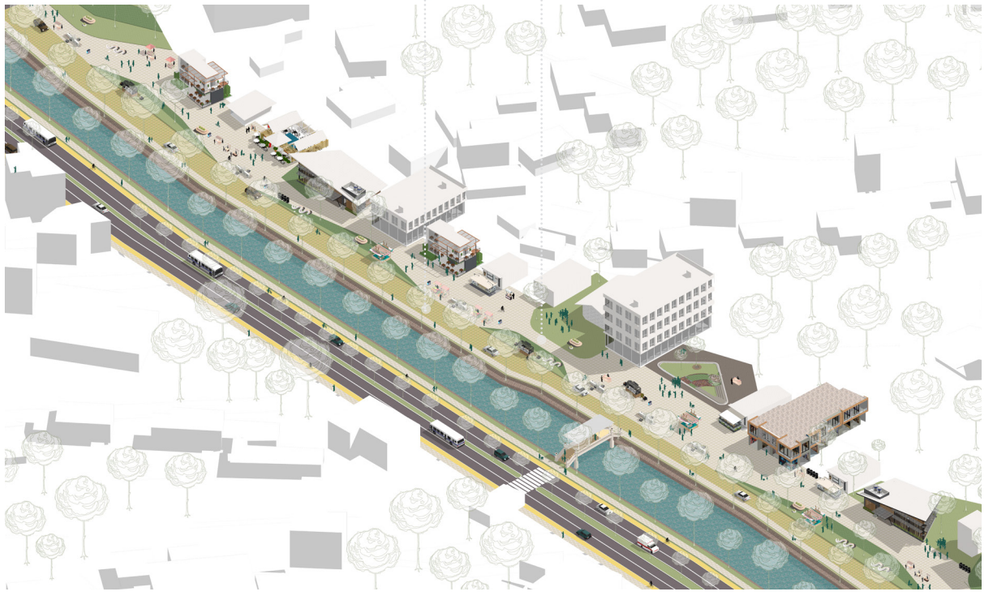


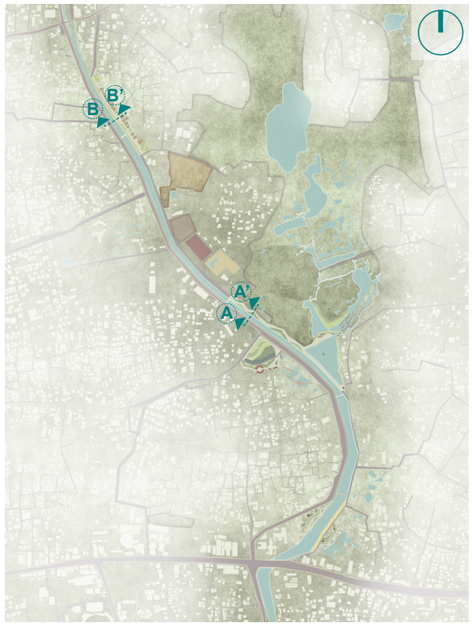
Figure 154 Axonometry view of the shared streets and community market zones
(Source: Illustration by Authors)

Figure 155 Schematic plan of Zone C
(Source: Illustration by Authors)

Using a participatory design process where market space reflects local needs is ideal for social cohesion and co-designing green spaces such as urban farms, pocket parks or raingardens by the community members could also foster a sense of ownership in maintaining these areas.

Figure 156 View of the de-paved water-front urban corridor
(Source: Illustration by Authors)

ROAD PROFILE AND SECTIONS ALONG DIFFERENT STRETCHES OF THE SITE:



Prioritizing cycling lanes and pedestrian pathways, the existing road profiles of the main road and secondary roads are reimagined to include soft mobility planning and green zones. Internal roads with low traffic are visualised as shared streets creating a pedestrian friendly environment along with recreational plazas for local community''s cultural life. Soft landscaping features along these road profiles include roadside planting of shading trees, green berms and water features along with eco-friendly infrastructures. The diverse sections outlined with sponge-like elements are blended into the context for transforming the canal into a lively resource for the local population and the environment.

Figure 157 Key plan showing road profile and sections
(Source: Illustration by Authors)

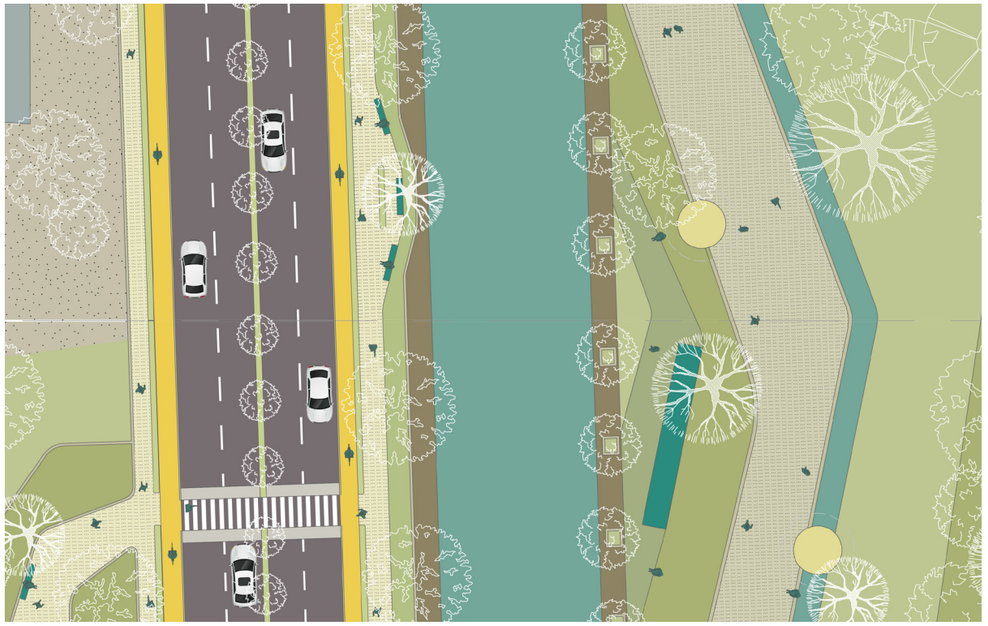


Figure 158 Road profile of Mini bypass- Sarovaram road
(Source: Illustration by Authors)

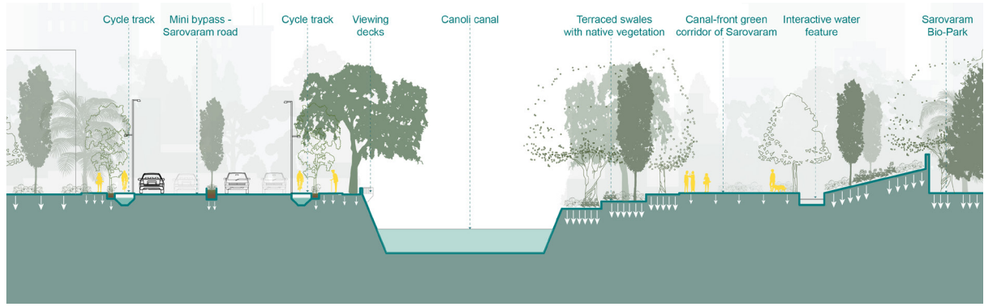


Figure 159 Section AA' : Mobility along recreational corridor of Sarovaram bio park
(Source: Illustration by Authors)

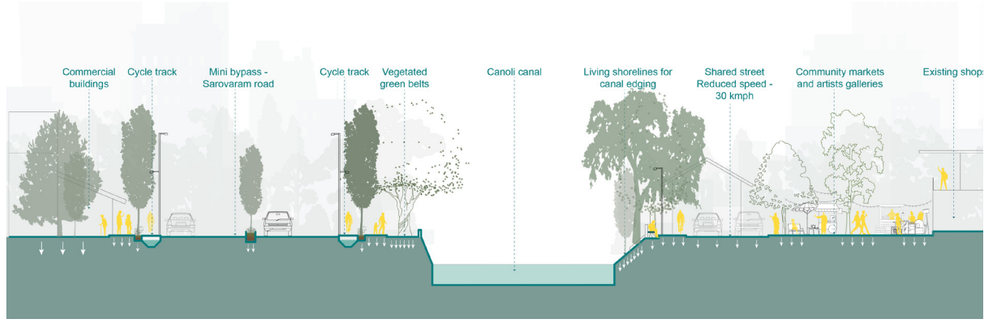


Figure 160 Section BB' : Mobility section along the shared street
(Source: Illustration by Authors)

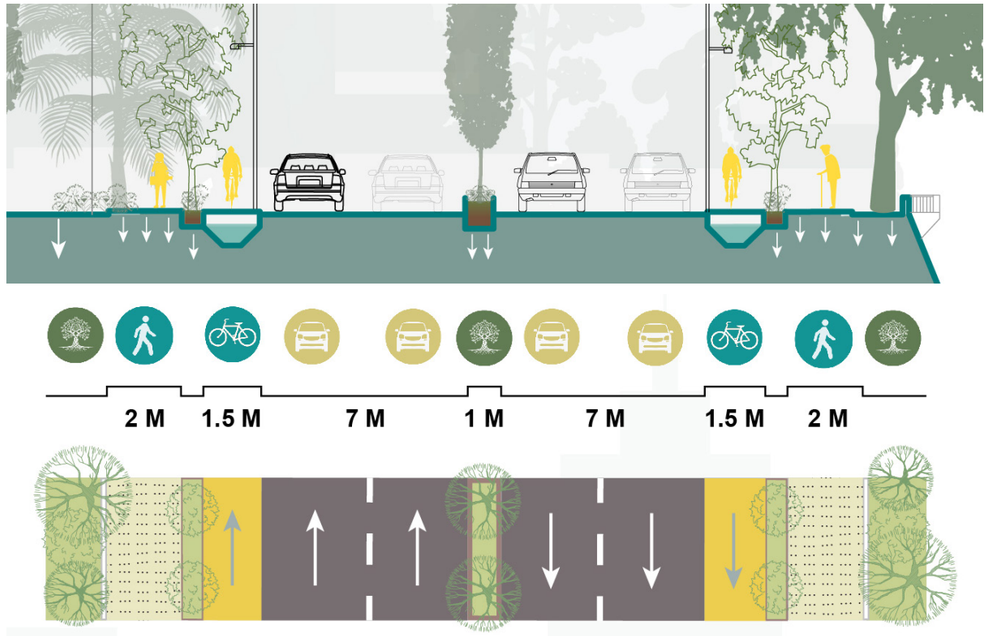


Figure 161 Main road detailed profile for integrating soft mobility and green belts
(Source: Illustration by Authors)

DETAILS OF NATURE BASED SOLUTIONS VISUALIZED ON-SITE

Integrated approach of using nature based-solutions in the focus area of Kozhikode contribute to the holistic goal of a water-sensitive urban design with ecological restoration, urban beautification and environmental sustainability. With the concept of a sponge city transformation, permeability of surfaces has been a key focus in the design. Roadside planting, rain gardens and bioswales along the canal edges contribute to stormwater infiltration, runoff filtration, vegetation for pollution control, flood mitigation and urban heat island reduction. The interstitial public spaces which has been neglected can be repurposed for these interventions to maximise their functionality within the urban fabric.

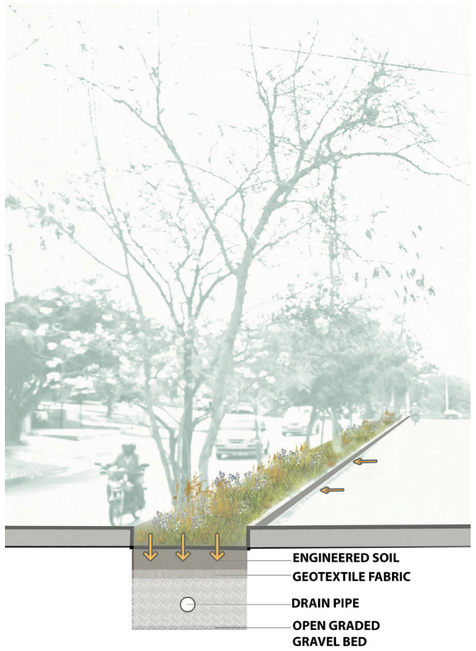


Figure 162 Roadside planting detail section
(Source: Illustration by Authors)

Figure 163 Detailed section of a rain garden adjacent to the secondary roads
(Source: Illustration by Authors)

The proposed gains in water absorption and reduction of impervious surface areas across the canal areas indicate the potential of nature-based solutions to improve water management and ecological restoration of the urban landscape of Kozhikode. Semi permeable pavements in parking areas , pedestrian walkways and plaza spaces along with green and blue infrastructures contribute to creating a more natural and water-absorbing habitat. Urban spaces that are traditionally dominated by concrete surfaces when designed with green pathways and sensitized design interventions that reconnect the fragmented ecosystems improves the air/water quality and cools down the urban areas. The visualization of these concepts shows the tangible benefits to transform Kozhikode into a sponge city that could also be adaptable for other cities in a global context. .

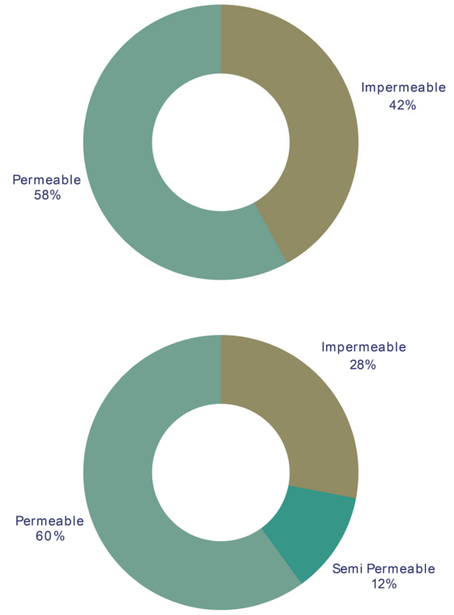


Figure 164 Schematic evaluation of increase in permeability of surfaces in focus area
(Source: Illustration by Authors)

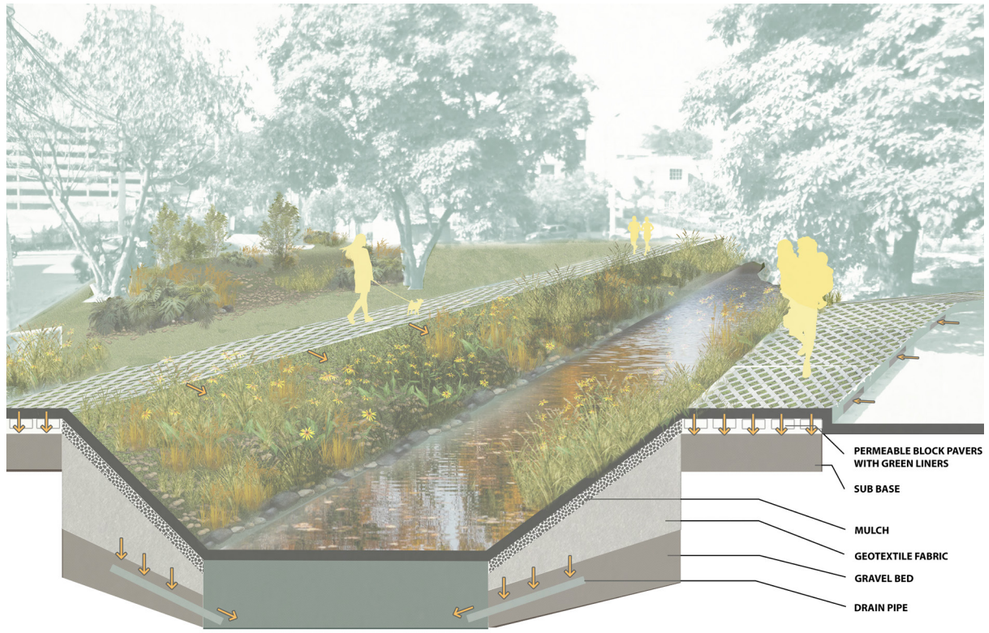


Figure 165 Detailed section of the canal edges and permeable walkways
(Source: Illustration by Authors)

8.6. Sustainable adaptations and design toolkit

Some of the sustainable solutions and toolkit modules which could be followed globally for a sensitized urban design are identified so that could be adapted in multiple sites with similar contexts.

Traffic tamed but not forbidden:

Emphasis in the need for streets in mixed-use areas to serve as vibrant meeting places, where social interactions and community engagement take precedence over vehicle movement. These streets are envisioned not merely as conduits for cars, but as lively spaces that foster conviviality among residents and visitors alike.

While vehicles should not dominate the streets of mixed-use areas, their presence can play a crucial role in creating lively urban environments. By prioritizing pedestrian experiences while accommodating necessary vehicular access, cities can cultivate spaces that are both functional and inviting. This approach not only enhances community interaction but also contributes to safer and more vibrant urban landscapes.

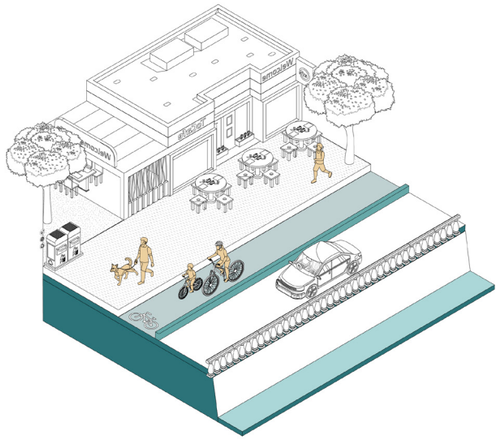


Figure 166 Shared streets with reduced traffic
(Source: Illustration by Authors)

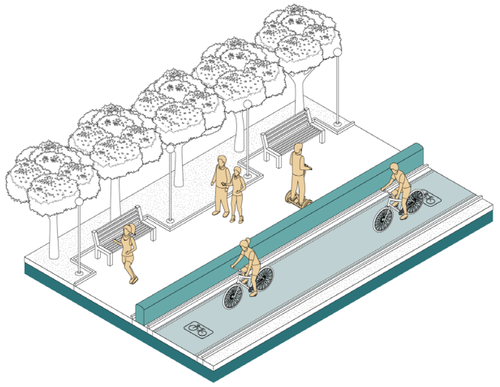
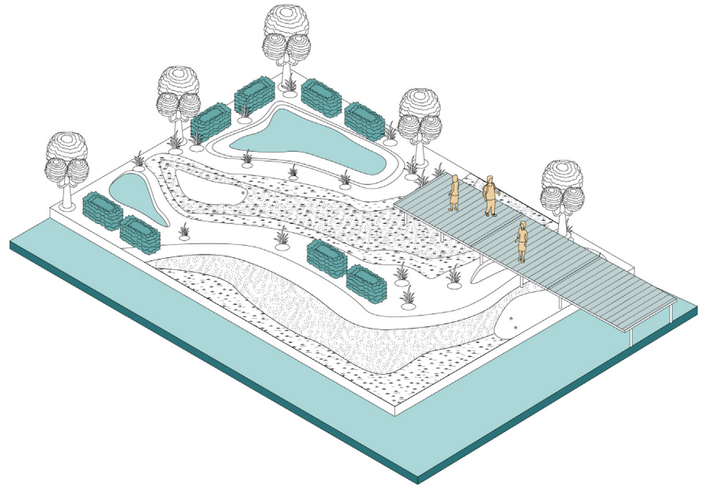


Figure 167 Soft mobility with public seating
(Source: Illustration by Authors)

Local identity:

While the built environment alone cannot create communities, it plays a pivotal role in establishing conditions conducive to neighbourliness and belonging. By involving local residents in design processes, reusing existing structures, and creating spaces that meet human needs, urban planners can cultivate vibrant communities rich in identity and connection. According to research, when communities have a say in how their environments are shaped, they are more likely to develop a sense of ownership and pride in their surroundings (ESPON, 2020). It also ensures that traditional knowledge and practices are respected and integrated into modern solutions (Dodman et al., 2017). Additionally, educational initiatives and nature programs including eco-venture training can raise awareness about environmental issues and sustainable water use practices among residents. Existing community-led groups could play a vital role in urban maintenance.



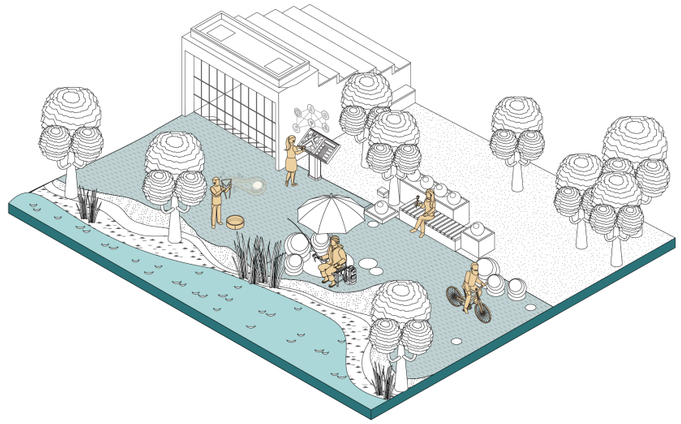


Figure 168 Adaptable design models for wetland parks and canal-front urban corridors
(Source: Illustration by Authors)

Preserve, restore and co-exist:

Protecting the natural resources, restoring the natural functions of degraded wetlands and ecological integrity of canals and its surrounding environmental systems is crucial while the urban amenities co-exist with the nature without disturbing the flora and fauna. Terraced bio-swales with native vegetation and phytoremediation techniques could be proposed along the water edges for filtration of pollutants and stormwater management along with integrated pedestrian walkways.

Weaving lightly for a delicate balance:

To enhance the wetland experience, minimal interventions for the public could revive the urban character and quality of public spaces. Elevated walkways and boardwalk decks could allow visitors to appreciate the natural environment while minimizing disturbance on the delicate ecosystem. These elevated structures allow water to flow freely and prevent damming effects. An adaptive design that accommodates natural fluctuations of water would be ideal for flood-prone areas.

8.7. Conclusion

Kozhikode stands at a crossroad where its rich historical legacy intersects with contemporary challenges posed by rapid urbanization and climate change. The thesis has evolved from the idea of promoting a water-sensitive rejuvenation proposal of Kozhikode through a series of research questions addressing the multiple urban issues, its water quality, environmental context and studying the critical factors contributing to urban failures within the city in detail to a tailored yet adaptive design approach that is in tune with preserving the ecosystem and the people.

An integral methodology that contributed to the findings of the thesis stemmed from the on-site visits and the structured surveys carried out with the local residents and visitors of the focus area which allowed a first-hand interaction with the potential stakeholders of this community-centric proposal. This research underscores the vital role of local communities in shaping the urban life and its core elements. Our participant surveys and interviews revealed that residents are keen on an improvised public space that caters to the local needs of the residents with lesser focus on tourism. Recognizing the area's abundant natural resources and thriving ecosystem, this thesis demonstrates the importance of integrating native flora and fauna habitats into the design of urban spaces.

The selected 2.8m long Canoli canal stretch of the focus area and its adjacent potential pockets were proposed with minimal design interventions like an urban acupuncture with focus on the revitalization of existing green areas and sensitizing the community spaces.

The results of the research thesis with our design proposal can be concluded into:

- Adopting sponge city principles can increase the permeability of rain to mitigate flooding issues and stormwater management.
- Revealed the transformative power of minor enhancements and sensitive design, revitalizing an overlooked public area and enhancing its appeal.
- Possibility of revival of interstitial neglected areas into vibrant socio-ecological pockets with varied activities can also increase local economy.
- Introduction of soft mobility and pedestrian-friendly green corridors can increase interactive public spaces along the canal for the community.
- Actively protecting wildlife and aquatic species in their natural ecosystems must be a central focus.
- Training residents and fostering local participation can enhance the upkeep of urban infrastructure and amenities.
- Proves the potential for harmonious co-existence between carefully considered construction and the existing ecosystem.

The research highlights not only the technical feasibility of such interventions but also their socio-cultural relevance. By adopting water-sensitive strategies that respect both the environment and community needs, the findings from this thesis research helps to align with global sustainability goals while also enhancing the city's resilience against future uncertainties related to water scarcity and environmental degradation with approaches that could be adapted globally.

8.7.1. Recommendations and urban guidelines

Some of the recommendations based on the research and subsequent **urban guidelines** as part of the design development to observe even better results would be as follows:

- The incorporation of green roofs, green walls, rain gardens, and permeable pavements to be prioritized and promoted within the urban areas and potential buildings to enhance stormwater absorption and micro-climate enhancement.

- Encourage the installation of rainwater harvesting systems in residential and commercial buildings to reduce runoff and promote water reuse.

- Effective implementation of the Sponge City concept requires supportive policy frameworks at local and state levels. Policymakers must prioritize sustainable urban development strategies that align with global sustainability goals. This includes incentivizing green infrastructure projects and establishing regulations that promote water-sensitive urban design.

- Continuous monitoring of implemented strategies is essential to adapt to changing climatic conditions and urban dynamics.

- Establishing a feedback mechanism will allow for iterative improvements in design and management practices based on real-time data (Xu et al., 2019).

- Implement Zoning Regulations for Green Spaces: Create zoning laws that mandate the inclusion of green spaces in new developments to promote sponge city principles.

- Conducting Regular Water Quality Assessments: Establish a framework for ongoing monitoring of water quality in urban waterways to ensure compliance with health standards.

- Facilitate Public Education Campaigns: Develop educational programs, workshops and awareness campaigns regularly to inform residents about the benefits of sponge cities and sustainable water practices.

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