IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

REIMAGINING CANOLY CANAL

A Sustainable Urban Development in Kozhikode, Kerala, India

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Abstract: In many parts of the world, canals have played an essential part in the growth and development of cities. Canals have been used for transportation, leisure, irrigation, and as a source of power for industry. Amsterdam, Venice, Italy, and Bangkok are known for their extensive canal networks within the city and significant tourist attractions. By leveraging canal systems for transportation, trade, and water management, canal-oriented development (COD) can reduce congestion, improve market access, and promote the growth of sustainable cities. Furthermore, canal-oriented development can facilitate the creation of green spaces and recreational areas and contribute to preserving natural resources and ecosystems. British engineering played a significant role in constructing canals in India during the colonial period. Engineers such as Arthur Cotton, Henry Connor, H.V. Conolly, and Proby Cautley were instrumental in the planning, designing, and implementing of major canal projects across the country. This study explores the metamorphosis of one such canal in Kerala - the Cannoli Canal, Kozhikode. In the current urban setting of Kozhikode, the economic, social, and ecological benefits of COD are overlooked. Combining this knowledge with the city's existing and proposed development helps us get a holistic understanding of the canal & its environs. The research maps the city's transformation with the canal and a zone-wise detailed study based on various parameters. The study concludes with the ranking zones, identification of projects, and strategies for sustainable development.

IndexTerms **- Sustainable waterfront development, Canal Oriented Development, Urban Landscape**

I. INTRODUCTION

A 'canal' is a man-made waterway, and the word's origin is *'chanel',* implying *'channel',* and usually, it is known as navigation (Ellin, 2010). In the past, canals were frequently employed to reduce the distance between two locations. With technological upgradation and innovative design strategies, canals have been built for irrigation, inland water transportation, and international trade transit (Dutta & Sarkar,2020). If we trace back to the history of canals, the oldest canal identified is in Mesopotamia (4000BC). Large-scale canals for transportation were built in ancient China as early as the 8th to the 5th century (Rahana & Nizar, 2020). Even though the construction of canals dates back to ancient times, the modern era of canal building began in the 19th century, when the Industrial Revolution led to a significant increase in trade and transportation needs.

The construction of canals became widespread in Europe and North America, with projects such as the Erie Canal (1817), the Suez Canal (1869), and the Panama Canal (1914) in the United States, Egypt, and Central America. Canal-oriented development profoundly impacted economic growth and development, as it enabled faster and cheaper transportation of goods and people, facilitating the growth of industries and trade. Consider the Erie Canal linking the Great Lakes and the Hudson River, which was critical to the development of New York City and helped make the city a major commercial and industrial center. The relationship between a city and a canal is often harmonious. Both benefit from each other, as evidenced by their physical and functional characteristics. Many cities around the world use canals as a fundamental component. The development of a city directly influences the canal system. Many cities, such as Stockholm, Amsterdam, Bruges, and Bangkok, rely on their extensive canal networks (Dutta & Sarkar, 2020).

British engineering played a significant role in constructing canals in India during the colonial period. Engineers such as Arthur Cotton, Henry Connor, H.V. Conolly, and Proby Cautley were instrumental in the planning, designing, and implementing of significant canal projects across the country. These canal systems were essential to British India's transportation infrastructure, allowing for efficient transport, growth of the textile industry, and increased agricultural productivity. Some of these canals are the Ganges Canal, the Lower Ganges Canal, the Upper Ganges Canal, Sone Canal, and the Eastern Yamuna Canal. The Ganges Canal was the most extensive, stretching 600 miles. The construction of the canals was a massive undertaking and involved extensive engineering work, including building dams, constructing locks, and laying miles of canals. The British also introduced a system of revenue collection based on the measurement of land under cultivation, which further incentivised the construction of irrigation systems and canals. The canals also facilitated the transportation of goods, with boats carrying goods such as wheat, rice, and cotton along the canals. The canals played a key part in the growth of the textile industry, allowing cotton to be transported from the fields to the mills more efficiently (McGinn, 1991). The colonial canal systems in British India were a significant engineering achievement

and played a crucial role in developing the region's economy and society. However, they also had negative consequences, displacing people from their homes and disrupting the natural water flow, leading to environmental problems such as waterlogging and salinity.

II. NEED OF THE STUDY

Cities worldwide are trying to become more sustainable & energy efficient through nature-based design approaches. The World Cities Report 2016 by UN-Habitat shows that in 2015 Kozhikode became the biggest urban agglomeration in Kerala with a population of 2.5 million after edging out Kochi (a population of 2.4 million). The current population has increased to 3,921,000 as of 2022. Rapid urbanisation combined with unplanned development has led to neglecting the canal & its eco-system (Figure 1). Although designed as a navigation channel, it has become dilapidated with sewage and surface water runoff from Kozhikode City into the Kallai River and the Arabian Sea. The canal's width varies from 8m to 20m and receives water from over 30 drains, including minor streams and nalaas. The canal drains 35-40% of the urban area and is a primary drain for the city (Calicut Master Plan 2035). Also, the cabinet has approved a project of Rs 1118 crore for converting the canal into a significant waterway in Kozhikode. The canal can be developed in an eco-friendly manner with particular emphasis on tourism, flood control in the district, and goods transport. The width and depth of the canal will be developed to the national waterway levels (2022 Feb, Mathrubumi news article). Hence, This study aims to identify the potential ways the canal can be reimagined.

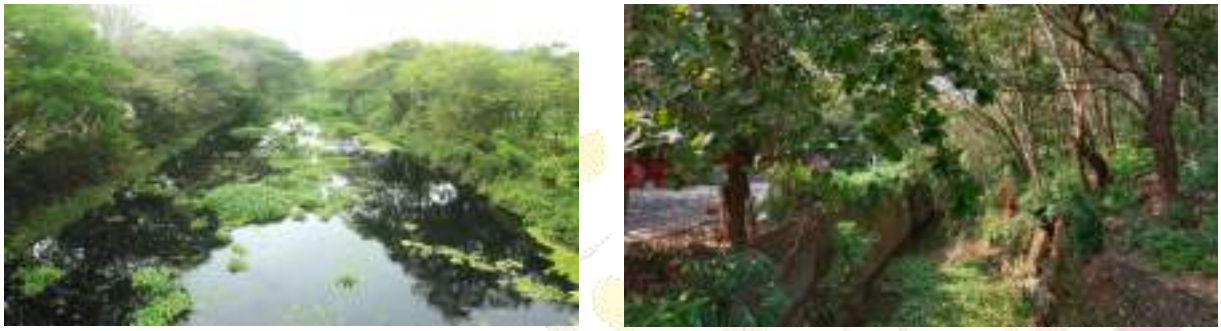


Figure 1: (a)Current canal condition at the urban core and (b)fringe area
Source: Author.

III. METHODOLOGY

To have a comprehensive understanding of the topic & study region, data have been collected, compiled & analysed systematically. The secondary data is collected from Research papers, journal articles, & various govt reports.The review articles are divided into three major sections. 1. Canal-oriented development 2.Indian case examples, and 3. International case examples. The primary data includes onsite observation, regional & zone-wise mapping, Interviews & dialogues with multiple stakeholders within the study region. The evolution is mapped diagrammatically for visual understanding. The study & mapping of the existing condition of the canal is done in a zone-wise manner. SWOC analysis & Comparative analysis have been used to arrive at a ranking matrix. The study will understand the historical significance of the canal, evaluate its current urban settings & identify various challenges & opportunities for sustainable development as a way forward. The following diagram explains the methodology (Figure 2)

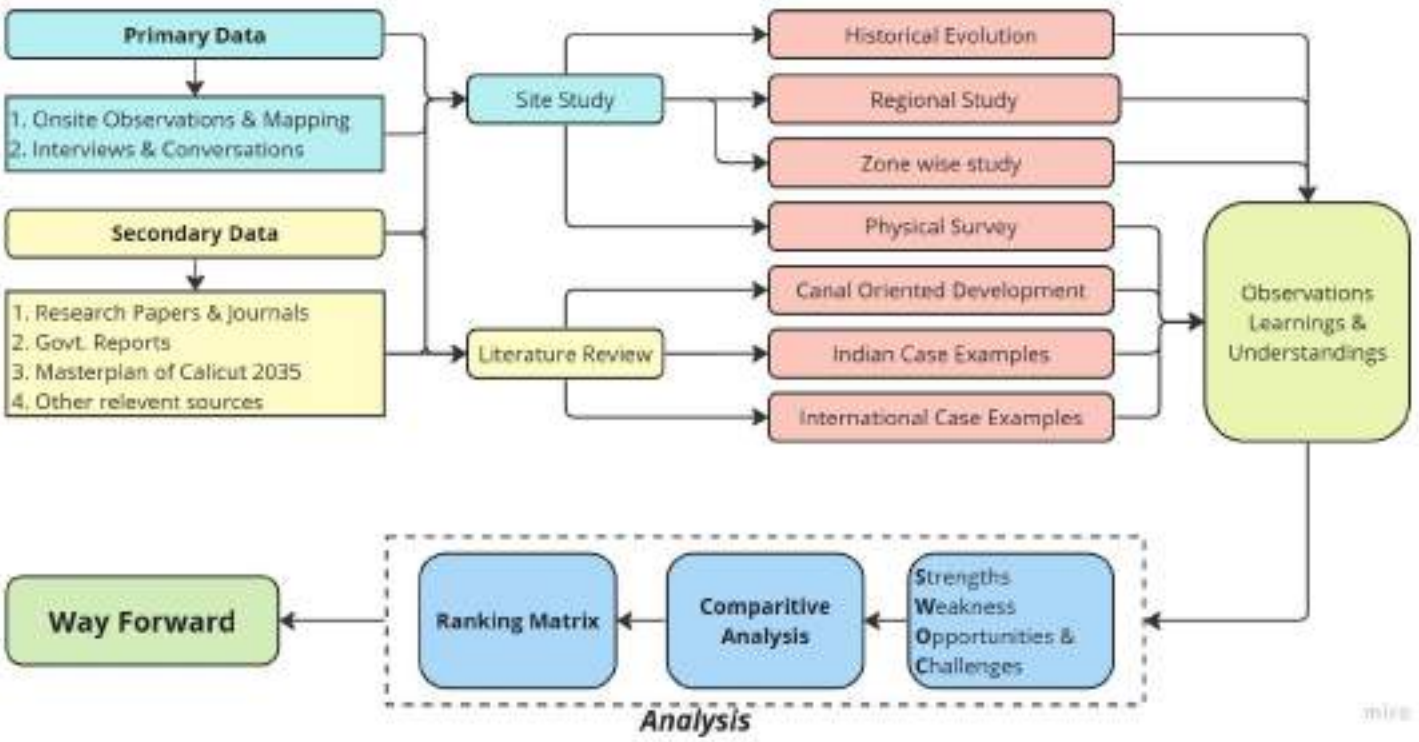


Figure 2: Research Methodology

IV. REVIEW OF LITERATURE

4.1 Waterfront Development

The term "waterfront" has different interpretations depending on the context and the author. It is described as "the part of a town or city adjoining a river, lake, harbor, etc." in the Oxford American Dictionary of Current English. Moretti (2008) considers it "the urban area in direct contact with water", usually employed with port infrastructures and activities. Yassin et al. (2010) define it as the zone where urban development and water intersect, while Hou (2009) describes it as the confluence of water and land.

4.2 Canal-Oriented Development (COD)

Building mixed-use communities along canal banks is the aim of canal-oriented development (COD), a placemaking concept that takes advantage of the waterfront's allure and usefulness as a natural magnet for societal and economic activities (Buckman, 2016). The primary benefit of COD is that it gives developers the freedom to build on many sites along the area it drains. Distinctive zones dependent on size and activity are present across the trail depending on the sense of place steered by the sensitivity of water. The development of inclusive neighborhoods and thriving public spaces can be greatly aided by building functional districts with a sustainable built environment (Dutta, Sarkar, 2020).

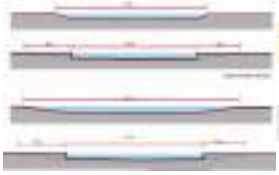
4.3 Case Studies

To conduct a detailed study of the identified project, best practices across India and worldwide have been studied. The common parameter identified for the case study selection is the proximity of the canal/water body to the urban area of the respective city.

The deciding factors include history, function, significance to urban form, the effect of urbanisation on these waterways, and measures to restore these canals. The following case studies have been studied and analysed.

1. Kakinada Canal project, Andhra Pradesh (2021)
2. Sabarmati Riverfront Development, Gujarath (1997)
3. Himatnagar Canal Development, Gujarath (2015)
4. Kapalama Canal Project, Honolulu (2020)

Table 1- Comparative Analysis of Case Studies

	Kakinada Canal Development Project	**Himatnagar Canal Development**	**Sabarmati Riverfront Development Project**	**Kapalama Canal Project**
Attribute for Selection	Developed as National waterway 4	Similar dilapidated conditions of canal	Similar project scale (length)	International best practices
Location	Andhra Pradesh, India	Gujarat, India	Gujarat, India	Honolulu, Hawai
Project Scale	2.5km	500m, 6Ha	11.3km	2km
Master plan				
Sections				
Aim & Vision	The State's planning procedure for waterfront developments would essentially need to connect with the city's overall growth while maintaining a balance between the interests of the City and the local community.	The Hathmati Canal and its surroundings will be transformed into a space for social interaction as part of the development project, which intends to reunite the two disparate areas of the city. Since the project's site is in a dry area, effective water management posed the biggest obstacle.	The project's objectives are to redefine Ahmedabad's identity around the Sabarmati River and to give Ahmedabad a significant waterfront environment. The project aims to improve the neglected areas of the riverside and reestablish a connection between the city and the river.	a seaside promenade, a linear park along the Kapalama Canal, and whole street renovations. The Canal Project will focus on dredging, erosion management, bank stabilisation, and green infrastructure in addition to advancing the community's goals.
Features	The project includes the construction of shopping	People of all ages can utilise the 500-meter-long public	1. Advancement of the Environmental	Community Goals - waterfront trail, tree-lined

	malls, food courts, ethnic restaurants, resorts, spas, sailing clubs, jogging /cycling trails, and other facilities such as Boating Stations. New parks, gardens, and water sports facilities are being constructed in the recovered areas.	garden along the canal front as part of the project, which will give the city much-needed green space. In addition, there are nearby convenient commercial amenities, such as 120 shops, a vegetable market, an informal market, and a zone for food sellers.	2. Establishing a network of public areas 3. Creating access for the public to the river 4. Slums being renovated. 5. Bringing Gujari Bazaar back to life 6. Dhobi rehabilitation 7. Establishing thriving urban neighborhoods 8. Recreational Activities	street & activity areas. Infrastructure Goals- shared street, cycle & pedestrian paths & bridge. Environmental Goals - Erosion Control, trash catchment, Biofilter, sediment forebay Masterplan Goals - integrate with the neighbourhood.
Inference	Multiple projects, such as parks, go-karting, resorts, laser shows & food courts, along with cycling and jogging tracks, are planned efficiently. The parks will make the neighbourhood more livable and strengthen the city's network of green spaces.	The project involves various initiatives, like constructing new canals, repairing and renovating existing canals, installing modern water management technologies, and implementing better water conservation and distribution practices. These efforts aim to provide a reliable and sustainable water supply to the surrounding areas and promote overall economic growth in the region.	Utilising FSI and other policies along the canal stretch. Managing canal-width waterfront planning & development Influence material choice on your design.	Importance of community engagement and participation in developing and implementing water management plans, the need for regular maintenance and cleaning of canals, the integration of green infrastructure solutions such as rain gardens and bioswales,
Source	Kakinada Waterfront DPR - Hypercube	HCP 2021	SRFDCL, nd	Canal Catalyst Project, 2021

V. HISTORY OF KOZHIKODE & CANOLY CANAL

A brief timeline of the city is illustrated below (Figure 3).

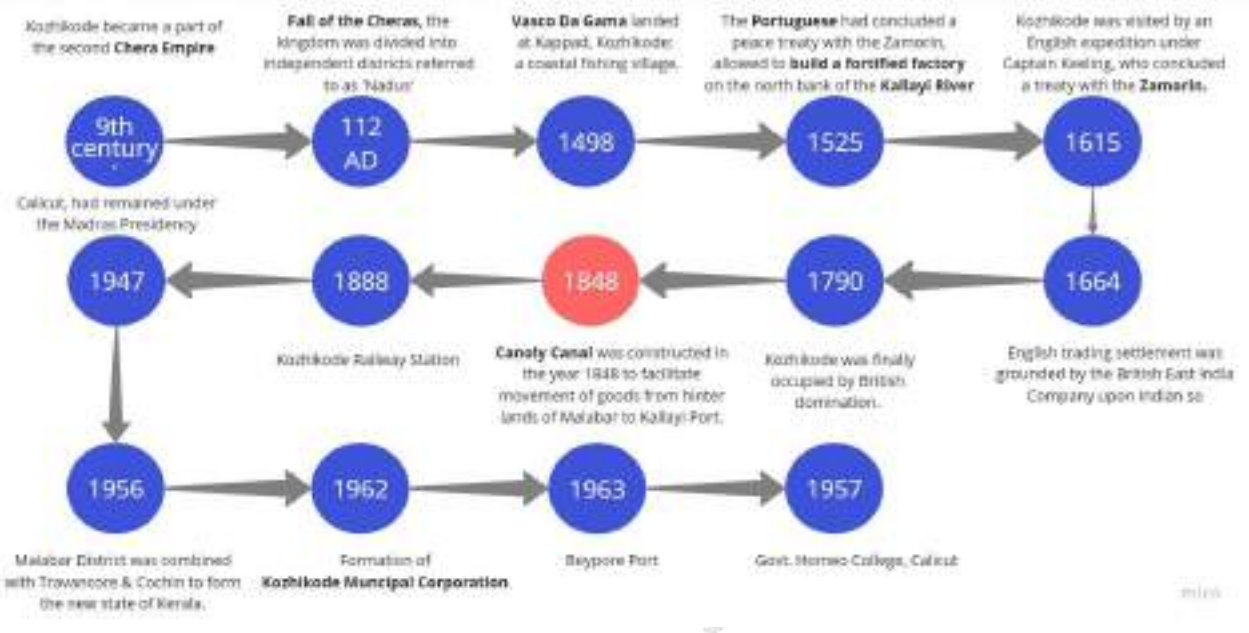


Figure 3: Timeline of Kozhikode (Source: Author compiled)

The construction of the canal was ordered by the then Malabar collector, H.V. Conolly, in 1848 to facilitate the movement of goods from the hinterlands of Malabar through the Kuttiyadi and Korapuzha river systems to Kallayi Port (Reviving the historic Canoly Canal, 2005). By the second half of the 19th century, Calicut is attractive for its Canoly canal with the movements of hundreds of canoes. He constructed a canal that connected the Elathur River to Kallai and Kallai with the Beypore River (Figure 4). This canal is identified as Elathur- Kallai Canal in the earliest records. The canal played a significant role in Kozhikode's nineteenth-century water transport, irrigation, and commerce. In 1924, an audit of the ferry boats found that 538 small boats and 2035 *changadams* were registered at Olavanna. At Kallai, 234 small boats and 506 *changadams* were registered. The British had 2000 ferry boats (Valsa, 2017)

Figure 4(a) Canoly canal from map of Calicut Railway Station 1893

Figure 4(b)Cannoli canal from map of Malabar District 1900

Source - BM Archives. (n.d.). *"Arbeitsgebiet der Basler Missions Station Calicut"*.

Source - BM Archives. (n.d.). *"Map of the Malabar District"*. Basel Mission Archives.

The 19th century also witnessed a turning point in the development of East India Company's timber trade, and the canal helped conduct trading activities. The canal connected the principal trade centres like Kozhikkode, Ponnani, Chavakkad, Kodungallur, and Kochi. The river Kallai has its role in developing the Kallai region as a centre of timber trade and industry. The history of timber trade in Kallai starts with the reign of Tipu Sultan. A. Sreedhara Menon mentions that the most important industrial centres of the state, like Punalur, Elur, Kallai, and Baliyapattanam have risen on the banks of its rivers. Kallai was one of Malabar's oldest timber trading centres (Figure 5).

Figure 5: River Of Logs In Kallai River (left) (Source - British era Calicut old photo, 1898)

Present-day - Seasoning of timber in Kallai River (Source - Author)

The following diagram (Figure 6) helps us understand the development of Kozhikode city and the Canoly Canal. During the city's initial development, the canal acted as an edge. But rapid urbanisation & development has resulted in city expansion, and the canal is now a part of the urban centre. However, neglected maintenance and silt accumulation caused the Canoly Canal to fall into disrepair over time. In recent years, communities & government bodies have tried to revive and restore the canal.

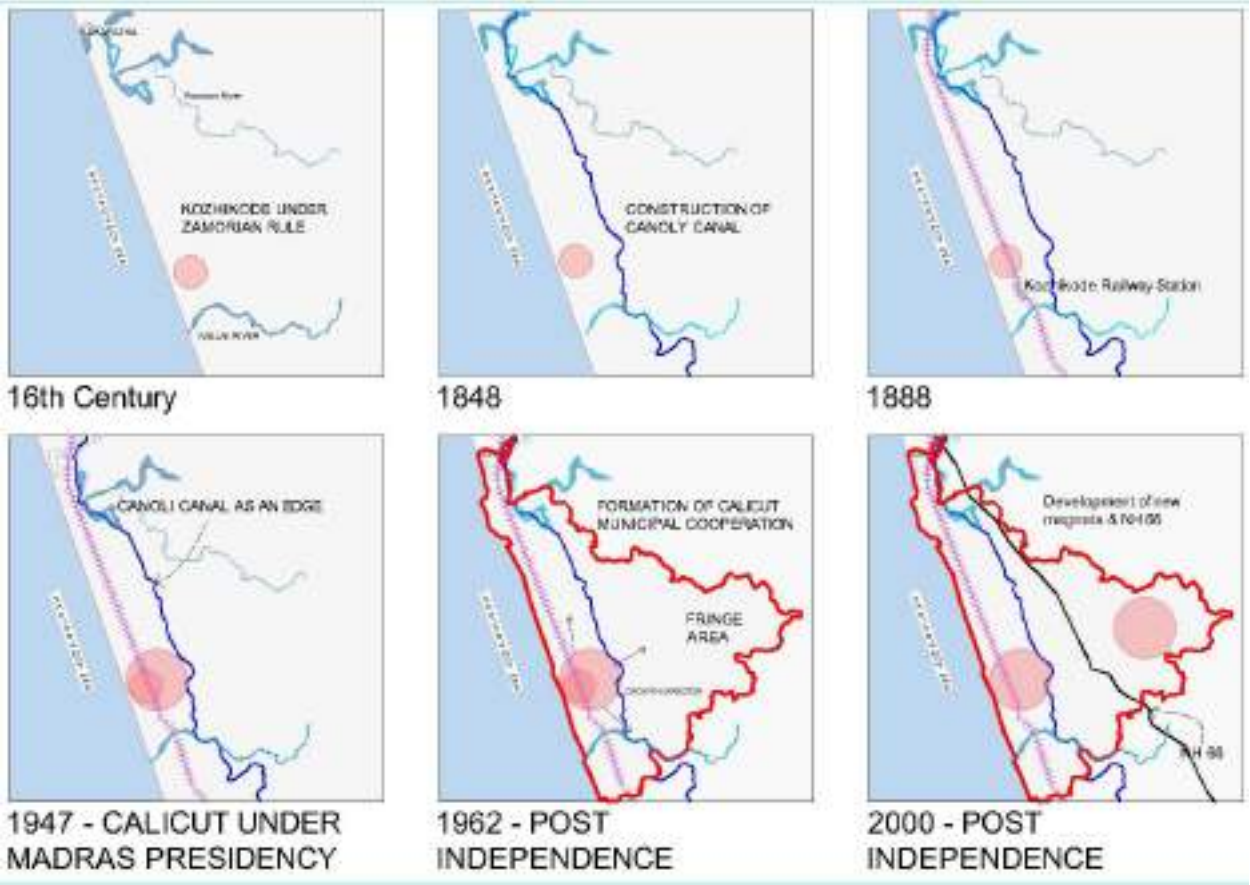


Figure 6: Illustration depicting the evolution of the city, with respect to Canoly Canal Source: Author.

5.1 City Profile: Kozhikode.

Kozhikode, also known as Calicut, is a coastal district in the southern state of Kerala, India. (Figure 7) The city has a rich history and was once a major trading centre for spices like pepper, cardamom, timber, and silk, attracting traders worldwide. Kozhikode was also the capital of the powerful Zamorin dynasty, who ruled the region for centuries. Today, Kozhikode is a bustling city known for its beautiful beaches, serene backwaters, and historical landmarks. The city is also famous for its culinary delights and seafood dishes. Kozhikode is the gateway to nearby popular tourist destinations such as Wayanad and Malappuram in Kerala.

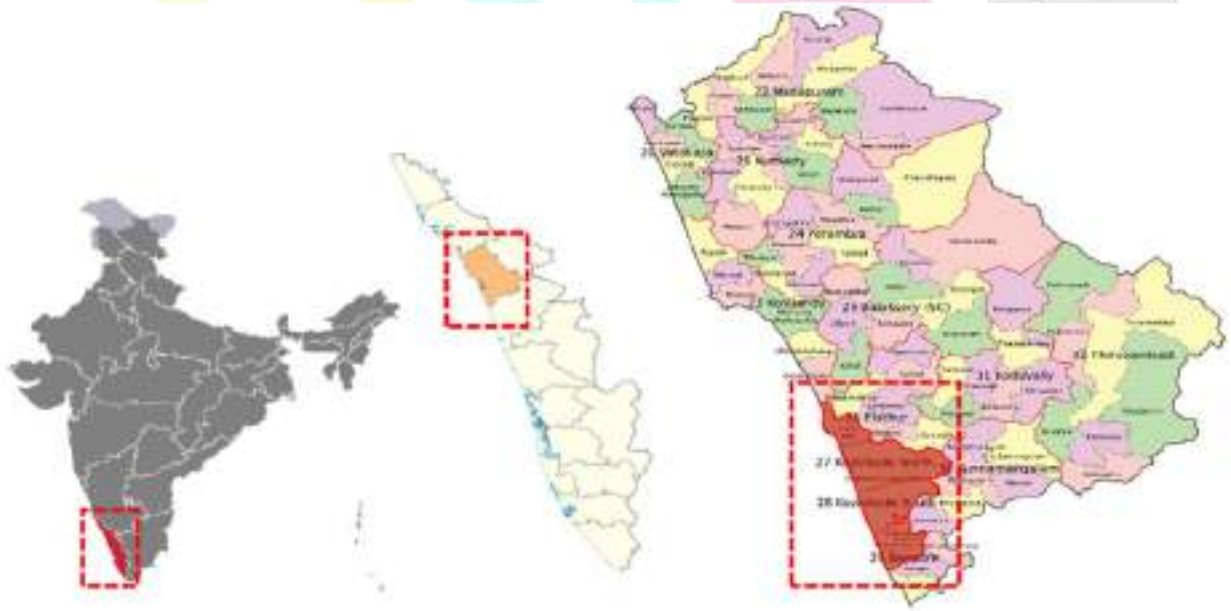


Figure 7. Location of Kozhikode Municipal Corporation (KMC)

The Kozhikode Urban Agglomeration contains 75 local bodies, eight statutory towns, a metropolitan area of 1803 km2, and a total population of 2.3 million (2,344,996), according to the 2011 Census. It also encompasses a sizable chunk of the Kozhikode district.

According to the 2011 Census, the urban area's sex ratio ranges from 981 to 1208 among local bodies, with an average of 1106 higher than the state average of 1084. Since 1991, employment in the primary sector has decreased significantly, with the majority of jobs being in the tertiary sector.(Fig 8) The region's overall employment rate is 28%, and 50.76% represents male employment, while only 7.82% represents female employment (Kumar et al., 2020).

Table 2: Distribution of workers in three sectors of economic activity Kozhikode Municipal corporation. (Census of India,2011)

		Total Population	Total worker (Main + marginal)	Primary Sector (3%)	Secondary Sector (2%)	Tertiary Sector (95%)
Kozhikode Municipal Corporation (2011)	Total	550440	174152	2641	2075	169436
	Male	262939	139030	2100	1601	169436
	Female	287501	35122	541	474	135329

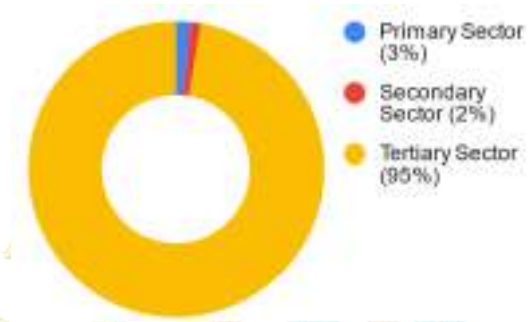


Figure 8: Distribution of workers in three sectors of economic activity Kozhikode Municipal corporation.

One of the region's and Kerala state's major sources of income comes mostly from remittances sent abroad from the Middle East and the service sector (Firoz, 2015, Firoz et al., 2014). However, tourism, fishing, agriculture, horticulture, and small hydro resources are important to the local economy and jobs.

5.2 Agriculture & Horticulture

Despite the fact that agriculture-related economic activity is not very active in the study region, household-level protected farming is nevertheless present and frequently gaining popularity. This aids homes and farmers in growing vegetables by utilising high-tech greenhouses and complex environmental control systems. Research by Vinod and co-authors demonstrates the effectiveness of this agricultural practice, with farmers receiving a 25–30% greater yield compared to open-field farming and a significantly higher average household income (Kumar et al., 2020)

5.3 Inland Fisheries

According to Kerala Inland Fisheries, Kozhikode has nine small inland fishing centres. The study region has 1931 active fishermen, 669 families, and a predominately male population. Pen culture is one of the area's most well-liked forms of aquaculture (Cage Culture). The centrally sponsored programmes Rashtriya Krishi Vikas Yojana (RKVY), Matsya Samridhi Project under Fish Farmers Development Agency (FFDA), Matsya Keralam Project of the Government of Kerala, etc., where community-level local economic development took place, gave the fisheries projects their impetus. The Coastal Aquaculture Authority Act of 2005 provides the necessary legal support for this economic activity. It encourages the regulated farming of prawns, prawns, fish, or other aquatic life in ponds, pens, enclosures, or other brackish water bodies (Kerala Inland Fisheries statics, 2013).

5.4 Tourism Development

Kozhikode is fortunate to have a variety of tourist attractions, including ecotourism, beach tourism, history tourism, and cultural tourism. Despite the district's abundance of fascinating tourist attractions, many of the locations are still under development and offer untapped potential. The district has a rich culture, untapped wildlife, tranquil backwaters, cool hill stations, and charms of pristine beaches, many of which are still undiscovered (Firoz M, 2015). Table 3 explains the different types of tourism and places in the study region. Regarding daily and weekly footfall, the Calicut beach continues to rank among the most alluring.

Table 3 - Tourist resources in Kozhikode

Source - Cardwell et al. (2009)

Sl No	Type of Tourism	List of Locations
1	Leisure tourism	Kozhikode City beach, Kolavipalam turtle beach, Beypore, Thikkodi Beach, Sand Banks in Badagara, Kappad Beach, Mananchira Square, Sarovaram Biopark
2	Ecotourism	Kakkayam, Kadalundi, Thusharagiri, Janakikad, Vanaparvam
3	Heritage tourism	Temple festivals, Thira, Kalaripayattu, SM Street, Malabar Cuisines, Ponmeri Shiva Temple, Thali temple, Misqual Mosque, Lokanarkavu temple, Sargaalaya Craft village, Pazhassi Raja Museum

4	Cultural tourism	Varakkal Devi temple, Pisharikavu temple, MisqualMosque, Thali temple
5	Fairs	Malabar River Festival, KorapuzhaJalotsavam

5.5 Kozhikode Masterplan 2035

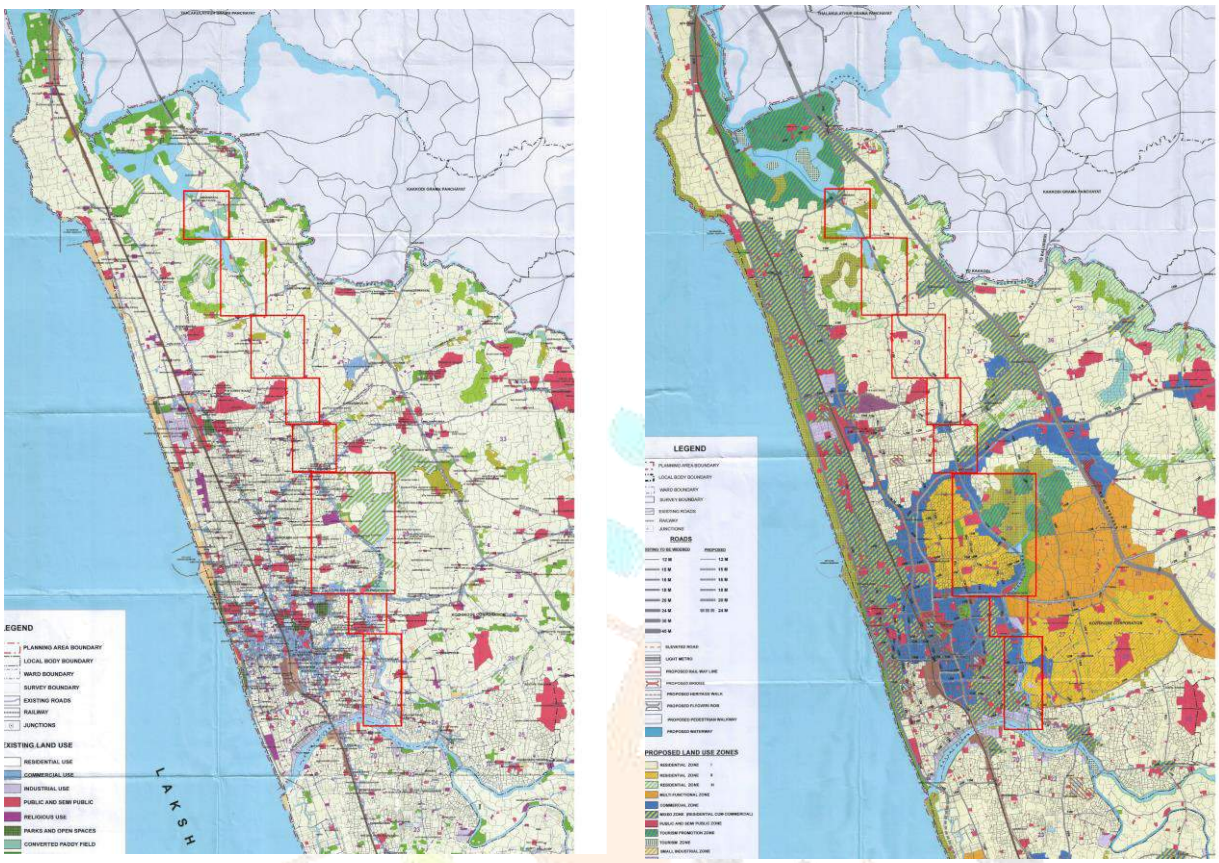


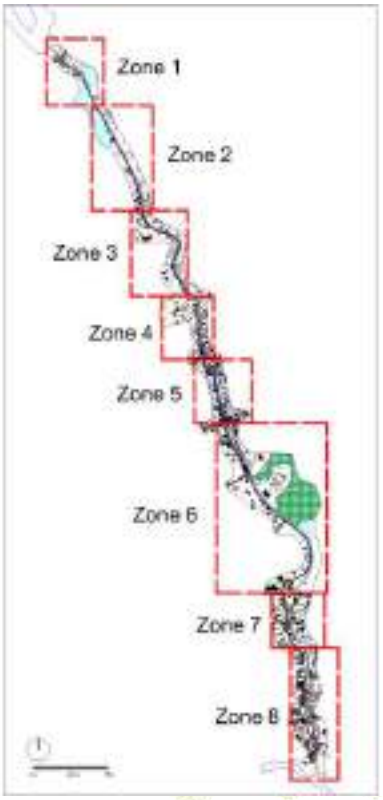
Figure 9: (a)Existing Landuse Plan (b)Proposed Landuse Plan
(Calicut Masterplan 2035)

The latest masterplan of Kozhikode 2035 and previous versions have understood the relevance of Canoly Canal, even though they have failed to address canal oriented development or any other strategies. The most active zone was identified in the 2003 perspective plan as being between the beach and the canal. (Masterplan, Kozhikode, 2035). Poor SWM & pollution of the canal are raised as an issue in the masterplan 2035. The canal's potential to be developed for boating, watersports & other eco-tourism-related activities is also considered. The canal is also identified as one of the primary drains of the city. About 35-40% of the city's catchment area drains through this canal. The master plan has plans to keep the minimum width of the canal as 15m.

VI. STUDY AREA

The 11.4km stretch of Canoly Canal within the Kozhikode Municipal Corporation (KMC) limits is identified as the study region. A buffer of 150m (minimum) on either side of the canal is considered for the delineated study area. The total site area is 1024 acres. The site is further divided into eight zones for a comprehensive understanding. The division of zones is based on significant landmarks & traffic intersections. The location of the study area & Keymaps for the zones are given below. (Figure 10 & 11)

Figure 10(a) Kozhikode District 10(b)Canoly Canal within KMC



Zone 1 - Elanthur - Chalice Road Jn
Zone 2 - Chalice Rd Jn - Kunduparamba Jn
Zone 3 - Kunduparamba Jn - Karaparamba Jn
Zone 4 - Karaparamba Jn - Karaparamba Jn
Zone 5 - Karaparamba Jn - Eranhipalam Jn
Zone 6 - Eranhipalam Jn - Arayidathupalam Jn
Zone 7 - Eranhipalam Jn - Mavoor Road
Zone 8 - Mavoor Road - Kallayi

Figure 11: Keymap for Zone-wise study. (Source: Author)

6.1 Study Area mapping - Road network

Table 4: VC Ratio of major traffic nodes in the study area

Jn Code	Volume Capacity Ratios			
	Name of Road Section	Peak Hour Volume	Capacity	V-C Ratio
A	West Hill - Karapparamba	2343.33	1800	1.3
B	Karapparamba - Eranhippalam	2541.55	1800	1.41
C	Eranhippalam - Arayidathupalam	2122.12	3600	0.59
D	Arayidathupalam - Kalluthan Kadavu	3742.09	1800	2.08

.

•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.
•The northern portion of the canal has roads on either side till karaparamaba junction (Jn A). The west side has pucca road and the east side has a narrow kucha road.
•SH 29 & SH 54 intersects the canal at the northern and mid part of the canal, respectively
•After Kalluthankadav Jn (Jn D), road width reduces, and the canal edge is primarily used for timber seasoning
•There are a number of pedestrian & vehicular bridges across the canal.
•Arayadathupalam Jn (Jn C) is the busiest, followed by Eranjipalam (Jn.B) & Karaparaparambu.(Figure 12)

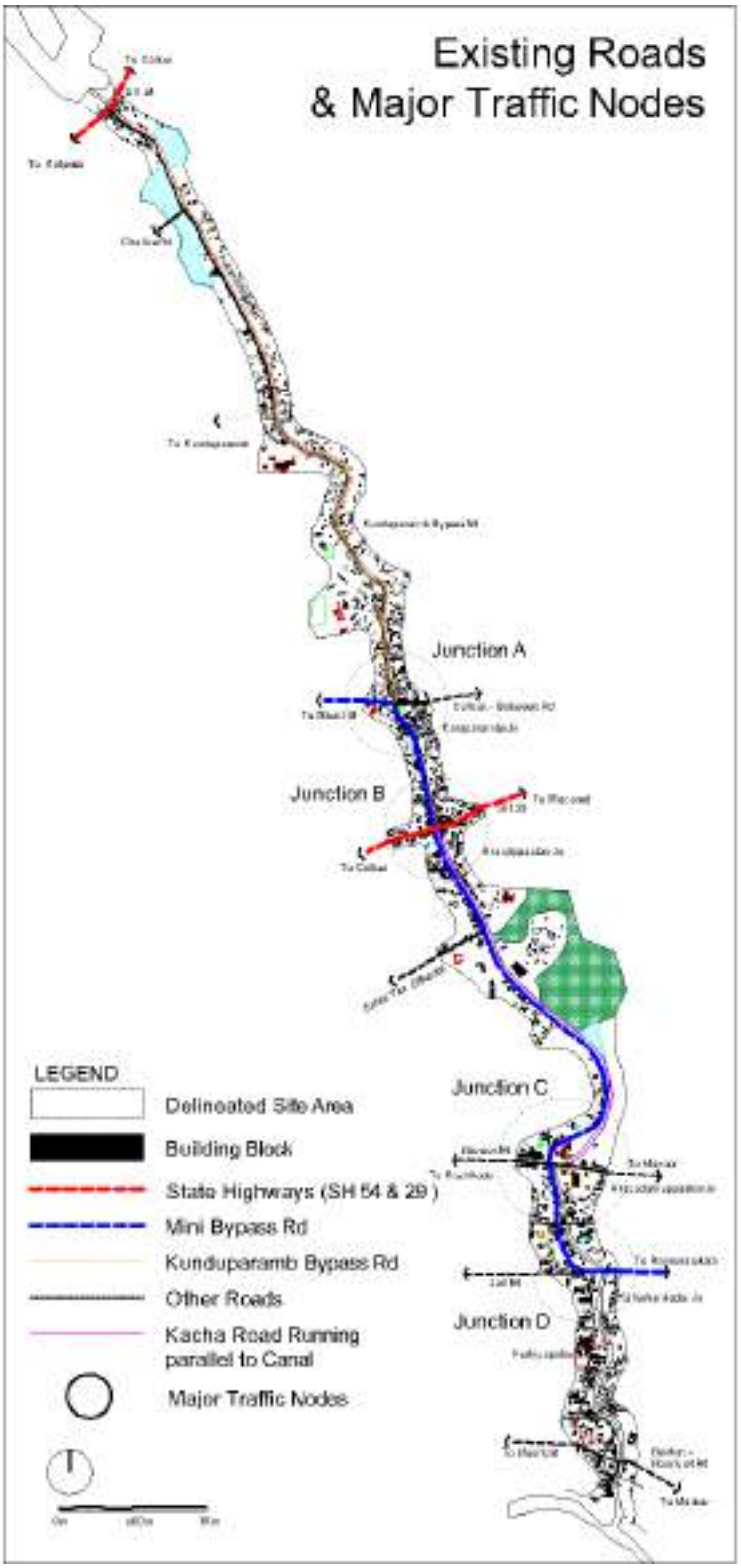
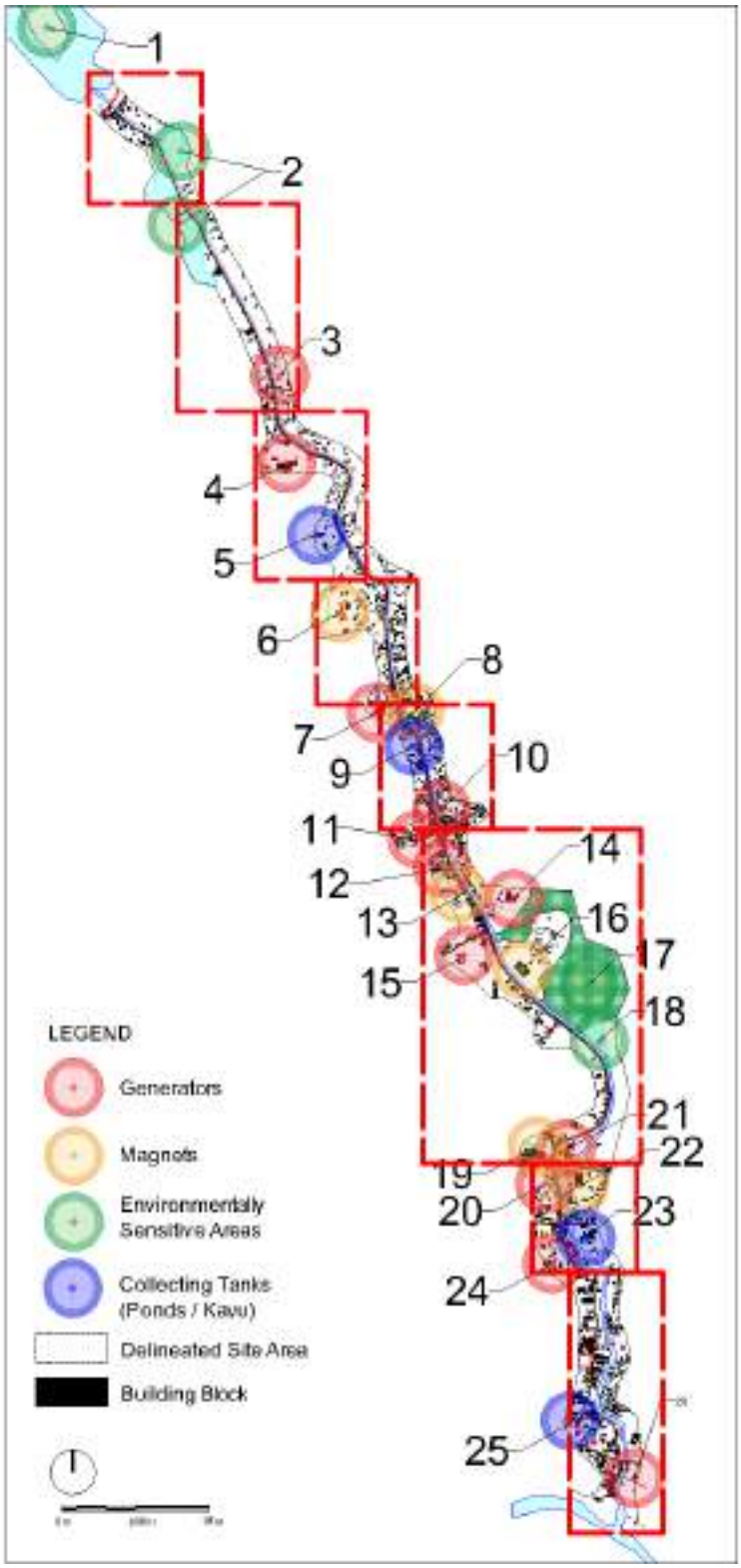


Figure 12: Map of major road networks & traffic nodes.

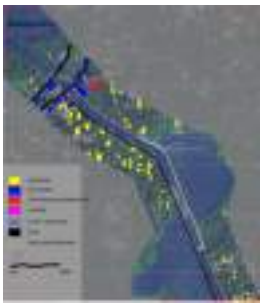
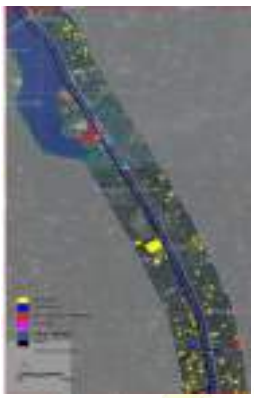
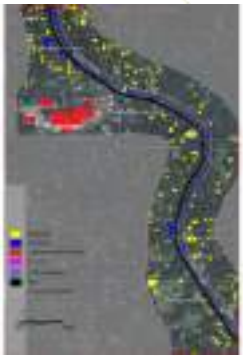
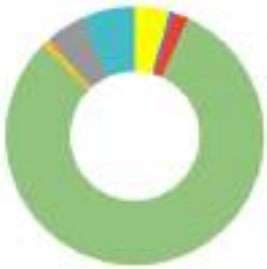
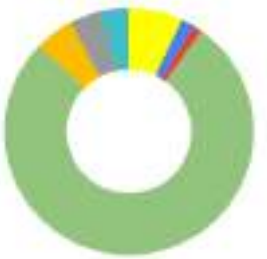
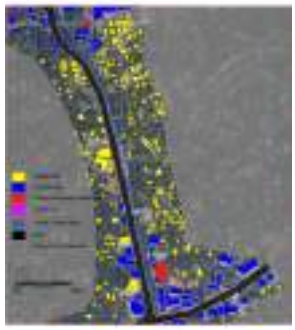
6.2 Study Area Mapping - Sociocultural Nodes & Ecological Hotspots.

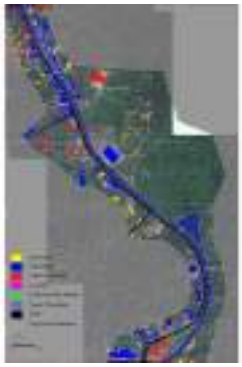
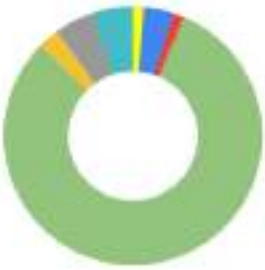
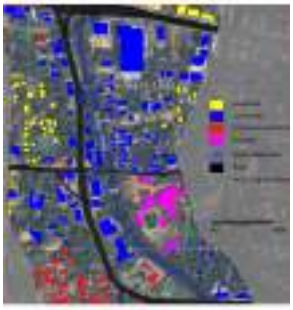
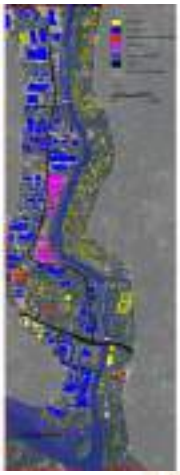


Legend
1. Valiyathuruthi Island
2. Perunthuruthi Wetlands
3. Kozhikode Corporation Health Dispensary
4. Meitra Hospital
5. Pisharikavu Temple (Pond 1)
6. Pazhassiraja Archaeological Museum
7. Government HS School Karaparamba
8. Salafi Masjid
9. Collecting Pond 2
10. Malabar Hospital
11. ESI Hospital
12. District Co-Operative Hospital Ltd
13. Regional Passport Office
14. Markaz International School
15. St Xavier's Arts & Science College
16. Calicut Trade Centre, Convention & Exhibition Hall
17. Kottooli Wetlands
18. Kalipoyka Lake
19. Football turfs (4no)
20. Al Salama Hospital
21. Baby Memorial Hospital
22. Gokulam Galleria Mall
23. Puthiyara Tile Factory (Pond 3)
24. Kasaba Police Station & Sub Jail, Kozhikode
25.Sri Krishna Temple (Pond 4)
26. Mooriyad Juma Masjid
(Refer Figure 13 for location)

Figure 13. Generators, Magnets & Ecological hotspots within the study area.
Source: Author

6.3 Zone Wise Analysis

	Built - vs Unbuilt (150m study area)	% Distribution chart	Observations & Inferences
ZONE 1			**Length of canal stretch** - 1.1 km **Average Width** - 20.0 m **Zone Character** - Starting point of the canal. SH 54 intersects the canal. Water salinity is a concern for residents. A low-density low-rise residential pattern is observed, with few commercial shops along the road. The canal is well maintained with rubble masonry side walls. Perunthuruthi wetlands & waterbody are present. Agriculture & fishing activities dominate.
ZONE 2			**Length of canal stretch** - 1.3 km **Average Width** - 15.0 m **Zone Character** - Wetlands & waterbody continuous into this zone. A waste management plant is located along the water body. Built density slightly increases, Kozhikode corporation dispensary, a milma boot and village art club are present. Zone 1 & 2 has more village character with people engaged in agriculture & fishing. The road along the canal is also 6m wide, with minimum traffic. Multiple pedestrian crossings are observed.
ZONE 3			**Length of canal stretch** - 1.2 km **Average Width** - 15.0 m **Zone Character** - Built density increases, and a super speciality hospital (Meitra hospital) becomes a strong magnet in the zone. Canal encroachment by 10-15 vendors. The quality of water & the edge condition also reduces. Drains of surrounding neighbourhoods connect directly to the canal.
ZONE 4			**Length of canal stretch** - 1.1 km **Average Width** - 12.0 m **Zone Character** - Observed medium-built density with four high-rise residences. One major traffic node of the city is in this zone. Pazhasiraja archaeological museum, the East hill school, Kendriya Vidyalaya & a number of temples are present in this zone. The width of the canal reduces significantly due to the increased elevation of adjacent land.
ZONE 5			**Length of canal stretch** - 1.1 km **Average Width** - 12.0 m **Zone Character** - Located between 2 major traffic nodes of the city, have high density built pattern of residential & commercial buildings. A number of highrise buildings are under construction. Malabar Hospital is located on the banks of the canal. Road width has increased significantly due to the mini bypass road. The canal does not have clearance in the southern junction.

ZONE 6			**Length of canal stretch** - 2.8 km **Average Width** - 18.0 m **Zone Character** - Most 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. Arayadathupaalam junction is one of the major nodes of the city.
ZONE 7			**Length of canal stretch** - 1.0 km **Average Width** - 18.0 m **Zone Character** - Being the smallest zone, observed high-density built pattern with commercial, public & industrial land use dominating. Water quality dropped significantly, as expected in the city, and poor edge conditions led to parking for vehicles & taxis.
ZONE 8			Length of canal stretch - 1.8 km Average Width - 20.0 m Zone Character - The canal exits to Kallai River in this zone. The canal's west bank is dominated by timber industries & seasoning of timber. Kalluthankadavu slum is located on the east bank. Industrial & commercial land use dominates in this zone. Road accessibility is weak compared to other zones & types of activity. Wetland-type of vegetation is also observed on the canal banks.
	Residential Commercial Institutional Industrial Green cover / Agriculture Road Network Canal / Waterbody		

6.4 SWOC (Strength, Weakness, Opportunities, Challenges) Analysis

6.4.1 Strengths

- The perennial rivers on the north & south end of the canal ensure continuous water flow year around (Akalapuzha on the east & Kallayi on the west).
- Multiple ecosystems, such as wetlands(Perunthuruthi & Kottooli wetlands), estuaries(Akalapuzha estuary & Kallai Estuary), rivers(Agalapuzha, Kallai & Chaliyar) and lagoons are connected via the canal.
- The canal passes through the city centre with the railway line on the west & NH 66 (widening & development in progress) on the east side running parallel to each other. Hence, the geographical position of the canal offers an advantage in developing NMT infrastructure & networks for the city.
- The eco-system of canals, ponds, and wetlands can offer a city-level green space for Kozhikode. This can play a crucial role in reducing urban flooding in Kozhikode if developed in a sustainable manner.
- The canal lays down a basic framework for stormwater runoff & drainage from surrounding land parcels. The existing system can be enhanced to a Blue Green Grey Infrastructure.
- Basic road infrastructure runs parallel to the canal, offering accessibility & view.
- Zones 1 & 2 have the potential for inland tourism, aquaculture & agricultural development.
- Zones 3,4 & 5 offers residential opportunities close to the city.
- Zones 6 & 7 offer commercial space where as Zone 8 offers commercial & industrial development. Parking infrastructure is also viable in zones closer to city core.
-

6.4.2 Weakness

- The current development of Kozhikode has failed to utilise the full potential of Canal Oriented Development (COD).
- The salinity of the canal has to be considered during development, as it can contaminate groundwater sources such as open wells.
- The canal has a width varying from 8m to 20m along the 11.4km stretch. The developmental trends & density patterns adjacent to the canal, offer very less opportunity for widening as per National Waterway 3 requirements.
- The location of multiple hospitals in close proximity to the canal has led to poor quality. Dumping of waste & direct discharge of sewer drains into the canal is one of the major issues.
- The location of the SWM plant (Zone 2)adjacent to the canal & waterbody has increased the risk of contamination.
- There are multiple pedestrian & vehicular crossings for the canal. Traffic nodes 1,2, & 4 do not offer clearance under the canal for water transportation. These are major nodes for Kozhikode city.
- One of the most ecologically sensitive areas is located in zone 6 (Kottooli Wetlands), which is close to the urban core.
- Timber seasoning in zone 8 significantly reduces the quality of water getting discharged into the Kallayi River.
- Setback restrictions (CRZ II) for canals & buffers for wetlands reduce the FSI utilisation in adjacent plots.
- Public transport network & accessibility along the canal is limited to zones 6 & 7.
- Multiple pedestrian & vehicular bridges obstruct water mobility through the canal.
- Non-availability of govt land is also a major concern.

6.4.3 Opportunities

- Integrated development of Sarovar bio park, Kottooli wetlands, Kalipoyka Lake, and the canal can offer long-term sustainable development.
- Zone 6 is a strategic location connecting the TOD corridor on the east side & Canal on the west side. The land identified for the mobility hub (masterplan proposal) is adjacent to the bio park. Hence zone 6 can be used for connecting the latter.
- Presence of various schools, colleges, govt. Institutions & hospitals in close proximity to the canal increase the development potential of the canal as a water network for transportation.
- Developing canal sections that increase accessibility to green parks & public spaces can help in creating healthy cities.
- Developing a tourism corridor connecting the canal & Pazhassiraja Archaeological Museum (Zone 4)
- The canal offers a strategic location for setting up of Sewage treatment plant for the city.
- Integrating existing wells, ponds & temple tanks into the canal ecosystem.
- Developing jogging & cycling tracks along the canal.

6.4.4 Challenges

- Land availability & procurement for the development of the canal is a challenge.
- A scientific map for Kottooli wetlands is not developed. The wetlands have a wide variety of flora & fauna that must be preserved.
- Community involvement & active participation must be ensured for long-term solutions.
- Edge condition of the canal is deprived in zone 8 due to the seasoning of the timber.
- A low-density slum area (Kalluthankadavu Slum) characterises the East side of zones 7 and 8.

6.5 Comparative Analysis

Figure 14:(a) Built use percentage distribution
(b)Non-built percentage distribution

The comparative analysis of each zonehas been compiled in figure 14. Zones (Zone 1 - 4) in the northern part have more residential buildings. Commercially built dominate in Zones 6-8. Industrial built use is seen in zone 7 & 8. Zone 1,2 & 6 are environmentally sensitive.

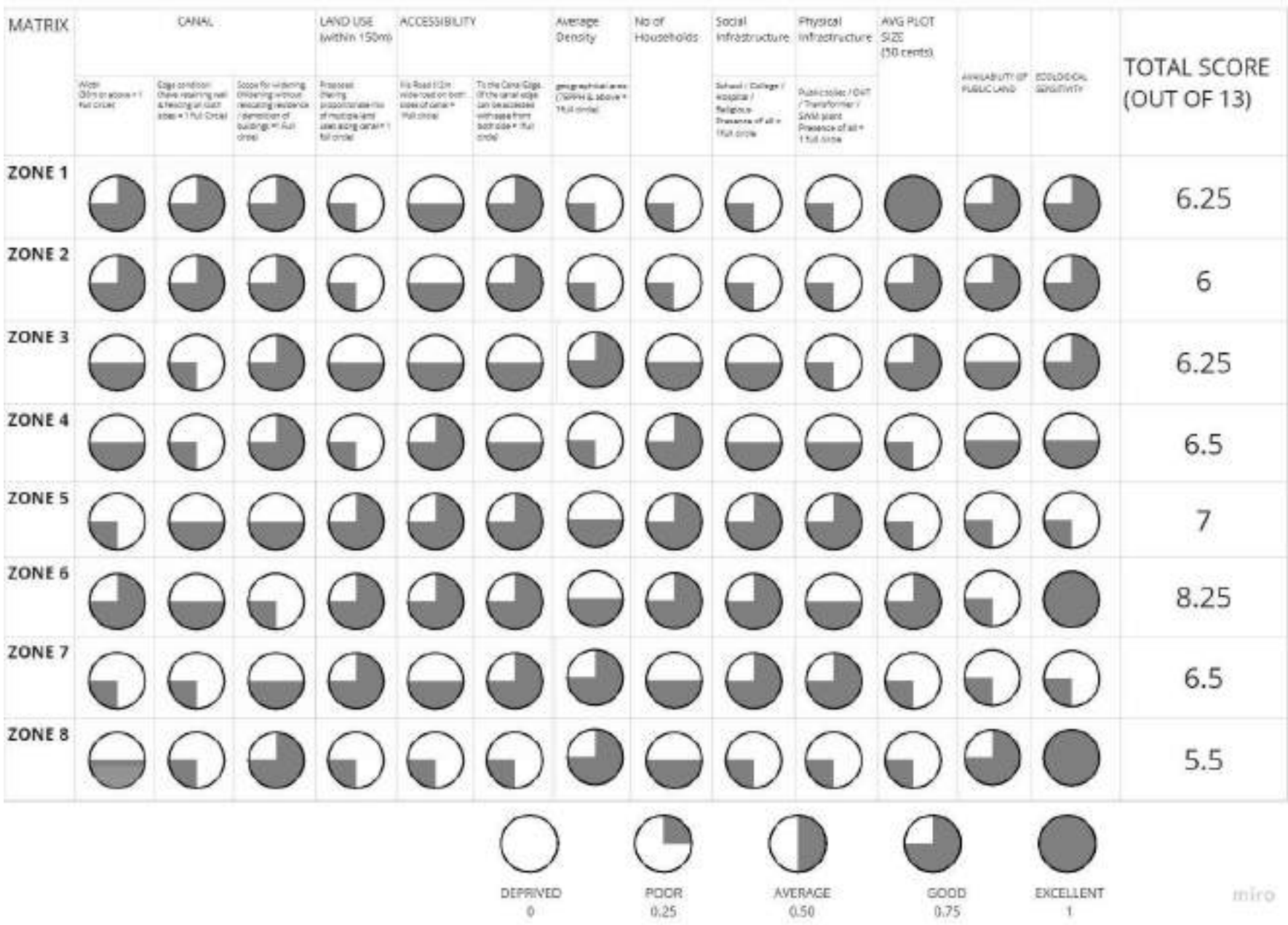


Table5 : Ranking Matrix

6.6 Zone Ranking Matrix

Zone	Inference
Zone 1	• Starting point of the canal - Ecologically sensitive. • Scope for water tourism & allied opportunities. • 30Acre of island present in the estuary can be developed. • Promotion of aquaculture, pearls etc, possible. • The edge condition of the canal opening can be developed for walkways. • The wetlands & waterbodies present should be mapped & protected
Zone 2	• Solid waste collecting facility should be relocated/redesigned to ensure zero contamination of wetlands. • The village arts & sports club can be enhanced into a sociocultural centre for the neighbourhoods. • It is ideal for locating a desalination plant, pumping stations & overhead tanks for KMC
Zone 3	• The canal undergoes twist/turn-modification of edge conditions to reduce erosion. • Canal edge encroachment to be addressed. • Canal width widening mandatory. The topography rises & water level reduces.
Zone 4	• Presence of the museum & school makes it ideal for a cultural node. • Urban design projects which connect the latter with the canal are possible.
Zone 5	• Existing neighbourhood drains connect directly - ideal for decentralised nature based water treatment plan. • Also suitable for canal-front commercial properties. • Existing water bodies can be connected to the canal.
Zone 6	• Detailed survey map of wetlands is required. • Neighbourhood planning for occupants adjacent to the wetlands. • Canal edge becomes crucial - with wetlands. • Govt has proposed STP adjacent to the wetland - Questionable • Mobility hub proposal on the east side of wetlands. Zone 6 offers a walking and cycling path to be developed to the canal. • Masterplan proposal has multiple plots under transportation. • This zone offers COD on one side and TOD on the other - connected via wetlands.
Zone 7	• The canal edge has vacant lands that can be connected via pathways. • Canal side walkways between zone - zone 7 & zone 8 will be ideal. • Demonstration of commercial & mixed use buildings.
Zone 8	• Kalluthankadavu slum rehabilitation project. • Identifying suitable infrastructure for seasoning timber with minimum environmental impact.

VII. CONCLUSION

The canal has huge potential to be developed as a central green spine for Kozhikode City, incorporating multidimensional aspects like transportation, drainage, tourism & commercial aspects. Projects such as cycling/jogging track, green parks etc, along the canal, can help to create regional-level parks & connectivity to the city as a whole. The Kottooli wetlands & Sarovar Bio park in Zone 6 can be further developed in line with eco-tourism & wetland conservations. Enhancing the canal can increase the resilience of the city by providing better drainage & reducing urban flooding. The analysis highlights the necessity for a thorough area development plan incorporating the canal into Calicut's urban fabric. The study revealed that the existing condition of the canal is weak & needs urgent maintenance. The lack of available land on canal banks remains a key challenge in the development of the Canoly Canal. Multiple schools, hospitals, institutions, parks & public amenities are located along the canal. These generators & magnets can help develop waterways & networks through the canal. Since the canal has laid out a basic drainage pattern, it can be further developed as a Blue-Green-Grey infrastructure for the adjacent land. This ensures the city's development in a sustainable way. The northern part of the canal (Zones 1-4) has the potential for tourism-related development aspects, including homestays, fisheries, watersports, and boating. Zones 5-8(Southern part) are closer to the urban core and has potential for commercial, mixed-use & infrastructure projects for the city. Multiple plots adjacent to the canal & the wetlands have building restrictions due to CRZ & landuse. Effective policy implementations to utilise FSI & TDR can be implemented for these plots.

ACKNOWLEDGMENT

Authors acknowledge the contribution of Mr. Girish Kumar T.K,Town Planner,Town and Country Planning office, Kozhikode, Mr. Girish Kumar P, Deputy Town Planner,Town and Country Planning office, Kozhikode, and Mr.Harikumar, Scientist at CWRDM, Kozhikode for providing information regarding the site. We also acknowledge the Government of Kerala and the Government of India for documenting the data and providing the possibility of accessing the data.

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