പതിനാലാം കേരള നിയമസഭ

അഞ്ചാം സമ്മേളനം

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ചോദ്യം നമ്പർ : 3025

10/05/2017-ലെ മറുപടി

കൊച്ചിയിലെ കനാലുകളുടെ നവീകരണം സംബന്ധിച്ച പഠന റിപ്പോർട്ട്

ചോദ്യം

ശ്രീ. ജോൺ ഫെർണാണ്ടസ്

മറുപടി

പിണറായി വിജയൻ
(മുഖ്യമന്ത്രി)

എ. കൊച്ചിയിലെ കനാലുകൾ നവീകരിക്കുന്നതിനായി കേരളാ ഷിപ്പിംഗ് ആന്റ് ഇൻലാൻഡ് നാവിഗേഷൻ കോർപ്പറേഷൻ പഠനം നടത്തിയിട്ടുണ്ടോ; എങ്കിൽ പഠന റിപ്പോർട്ടിന്റെ പകർപ്പ് ലഭ്യമാക്കാമോ ;

എ. കൊച്ചിയിലെ കനാലുകളുടെ സമഗ്ര വികസനം സംബന്ധിച്ച് കേരള ഷിപ്പിംഗ് ആന്റ് ഇൻലാന്റ് നാവിഗേഷൻ കോർപ്പറേഷൻ നാറ്റ്പാക്ക് മുഖേന പഠനം നടത്തുന്നുണ്ട്. ഇതിന്റെ സാദ്ധ്യതാ പഠനം പൂർത്തിയാക്കിയിട്ടുണ്ട്. പ്രസ്തുത റിപ്പോർട്ടിന്റെ പകർപ്പ് അനുബന്ധമായി ചേർക്കുന്നു.

ബി. പ്രസ്തുത പഠന റിപ്പോർട്ടിന് സർക്കാർ അംഗീകാരം നൽകിയിട്ടുണ്ടോ ;

ബി. ഉണ്ട്.

സി. ഏതെല്ലാം കനാലുകളാണ് നവീകരിക്കാൻ ഉദ്ദേശിക്കുന്നതെന്ന് വ്യക്തമാക്കാമോ ; ഇതിനായി സ്വീകരിച്ചിട്ടുള്ള നടപടികൾ എന്തെല്ലാമാണെന്ന് വിശദമാക്കാമോ ?

സി. 1) തേവര കനാൽ
2) തേവര-പേരണ്ടൂർ കനാൽ
3) മാർക്കറ്റ് കനാൽ
4) ചിലവന്നൂർ തോട് / കനാൽ
5) ഇടപ്പള്ളി തോട് / കനാൽ

വിശദമായ പദ്ധതി റിപ്പോർട്ട് ലഭ്യമാക്കിയതിന് ശേഷം മാത്രമേ തുടർ നടപടി സ്വീകരിക്കുവാൻ കഴിയുകയുള്ളൂ.

സെക്ഷൻ ഓഫീസർ

FEASIBILITY STUDY ON DEVELOPMENT OF CANALS IN KOCHI

FINALREPORT

KERALA SHIPPING AND INLAND NAVIGATION CORPORATION LIMITED (KSINC)

PROJECT OVERVIEW

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DISCLAIMER

This report has been prepared by NATPAC with inputs based on primary survey conducted by NATPAC and secondary data from various organizations. NATPAC and KSINC disclaim any and all liability for the use that may be made of the information contained in this report.

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FORWARD

Kerala has a good network of waterways formed from rivers, backwaters and man-made cross canals, connecting the various parts of the state. These waterways serve not only as navigational channels but also helps in tourism promotion and economic prosperity. Inland water transport is widely regarded as economic, environment friendly and energy efficient mode of transport. Hence, there is a necessity to revive this system, not only for inland navigation, but also to harness the enormous potentials in other sectors of economy. With the increasing trend of urbanization and motorisation, Kochi City is facing severe traffic problems which hamper the mobility of people and goods transportation. At the instance of Kerala Shipping and Inland Navigation Corporation Limited (KSINC), National Transportation Planning and Research Centre (NATPAC) has undertaken a feasibility study for improvement of Kochi Canals.

Detailed condition survey was conducted for Edapally Canal, Chilavannur Canal, Thevara-Perandoor Canal, Thevara Canal and Market Canal. Details like horizontal and vertical clearance of cross structures, road accessibility, bank protection measures, land acquisition, resettlement and rehabilitation measures, constraints for inland navigation etc. were examined. For restoration of water flow through these canals, the extent of siltation and the quantum of dredging necessary were assessed. Water quality analysis was also carried out.

Based on the studies, development proposals are formulated to operationalise the canals. The proposals include measures like desilting, widening, protection of side banks, provision of navigational aids, improvement of approach roads, reconstruction of cross-structures with adequate clearances, removal of encroachments and rehabilitation measures for project affected people.

Suitable locations were identified for tourism and leisure-time activities. Revenue generation activities like water sports, parks and recreational sites, development of landing places /boat jetties, way side amenities, beautification of canal-front etc. are some of the value-addition to the project.

The development proposals suggested in this Report are expected to have long-term benefits to the society. It is essential that the schemes are prioritized based on the local needs and taken up for early implementation with appropriate funding option.

Thiruvananthapuram **B G SREEDEVI**

January 2017 **DIRECTOR**

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CHAPTER I

INTRODUCTION

1.0 General

India's most idyllic State Kerala, better known as God's own country is now a day's considered as one of the most sought after tourist destinations in Asia. Kerala is located on the southwestern corner of India with the Arabian Sea in the west and the Western Ghats towering 500-2700 m in the east. Kerala having an area of about one percent of the total land area of India, was officially formed in 1956 under the State Reorganization Act. Spread over 38,863 sq.km, it is bordered by Karnataka in the north east, Tamilnadu in the east and south, and the Lakshadweep Sea in the west. With 33,387,677 inhabitants as per the 2011 census, Kerala is twelfth largest State by population and is divided into 14 districts. The State has a coast of 590km length and the width of the State varies between 11 and 121km. The State is divided into three regions the coastal lowlands, the fertile midlands and the eastern highlands. The lowlands of Kerala are networked by endless backwaters and the deltas of forty-four rivers. The midlands are rich with cashew, coconut, arecanut, tapioca, banana, rice, ginger, pepper, sugarcane and vegetable plantations. The forested highlands are rich in tea, coffee, rubber, spice plantations and wildlife reserves.

Kerala is having very good network of various transportation modes like roadways, railways, airways and waterways. Kerala has 145,704km of roads; it translates to about 4.62km of road per thousand population, compared to an average of 2.59km in the country. There are 8 National Highways (NH) that connects all the major cities and towns within the State and outside having length of 1,524km. There are almost 50 State Highways which connect every corner of the State having length of 4341.6km and 18,900km of district roads. Road traffic in Kerala has been growing at a rate of 10 - 11% every year, resulting in high traffic and pressure on the roads. Road density is nearly four times the national average, reflecting the State's high population density.

The rails run through the State connecting most of the major towns and cities except those in the highland districts of Idukki and Wayanad. The total length of the rail route is 1050km which includes 13 major railway routes with 200 railway stations in the State.

Kerala has three international airports; Thiruvananthapuram International Airport, Cochin International Airport and Calicut International Airport. The fourth one is under completion at Kannur. It connects almost all the parts of country and abroad. Cochin International Airport is the largest and busiest in the State, and is the first Indian airport to be incorporated as a public limited company funded by nearly 10,000 non-resident Indians from 30 different countries.

As Kerala is endowed with numerous backwaters, waterways are used for commercial inland navigation. The transportation is mainly done with country craft and passenger vessels. There are 67 navigable routes in the State. The total length of the waterways in the state is 1895km. This includes navigable rivers, backwaters and man-made canals. Most of these are in Travancore -Cochin region. Of the 44 rivers in Kerala, the 41 west flowing rivers together with backwaters and man- made canals form the integral part of inland navigation system. The main constraints to the expansion of inland navigation are lack of adequate depth in the fairway due to siltation, existence of low lying cross structures like bridges, erosion of banks due to non-availability of bank protection, accelerated growth of the water hyacinth, non-availability of navigational aids, non-availability of modern inland terminals with suitable cargo handling system.

The main arterial waterway in the State is the West Coast Canal. The West Coast Canal connects Nileswaram in the North to Kovalam in the South having a total length of about 590km. including the 47kmuncut portion from Azhikkal to Vadakara. The West coast canal runs almost parallel to the sea and National Highway. A portion of the West coast canal, i.e. from Kottappuram to Kollam, is already declared as National waterway-3 in 1993. Recently the northern limit is further extended up to Kozhikode. It is the first national waterway in the country with 24 hours navigational facilities along the entire stretch. Kottappuram- Kollam route is almost in the middle of the WCC, based on that the WCC can be broadly

divided into three sections namely Nileswaram to Kottappuram (348km), Kottappuram – Kollam (168 km) and Kollam-Kovalam (74km) respectively.

1.1 NATIONAL WATERWAYS IN INDIA

India has extensive network of rivers, lakes and canals, which if developed for shipping and navigation can provide an efficient network of inland transportation. An efficient transport infrastructure provides mobility, flexibility and cost-effectiveness. Now-a-days, Government has recognized the need of actively promoting the IWT sector for it to take a reasonable share in the inter-modal mix of inland transport.

In this context, Government of India has declared 111 waterways as National Waterways vide The National Waterways Act, 2016 (No.17 of 2016 dated 25-03-2016). It includes the existing five National Waterways also as given below;

- National Waterway-1: Allahabad–Haldia stretch of the Ganges–Bhagirathi–Hooghly river of total length 1620 km was declared in the year 1986.
- National Waterway-2: Sadiya–Dhubri stretch of the Brahmaputra river of total length 891 km was declared in the year 1988.
- National Waterway-3: Kollam–Kottapuram stretch of West Coast Canal and Champakkara and Udyogmandal canals of total length 205 km was declared in the year 1993.
- National Waterway- 4: Kakinada–Puducherry stretch of canals and Kaluvelly tank, Bhadrachalam–Rajahmundry stretch of River Godavari and Wazirabad–Vijayawada stretch of River Krishna of total length 1078 km was declared in the year 2008.
- National Waterway-5: Talcher–Dhamra stretch of Brahmani- Kharsua river system, Geonkhali–Charbatia stretch of East Coast Canal, Charbatia–Dhamra stretch of Matai river and Mangalgadi- Paradeep stretch of Mahanadi delta rivers of total length 588 km was declared in the year 2008

In Kerala, four new waterways have been declared as National Waterways. Besides, National Waterway-3 is extended up to Kozhikode.

1.1.1 National Waterway- 8

Alappuzha-Changanacherry canal is 28 km which is designated as NW-8. Alappuzha - Changanacherry Canal route passes from Alappuzha to C Block linking Kavalam to Changanacherry. This route has better revenues prospects in the transportation of paddy, hay, manure and other agricultural products, coconuts and allied products, construction materials, lime shell etc. and serving the labour movements. The length of this route is 28 km. Only 1.3 km (Chainage 5.9 to 7.2) of the entire length passes through Vembanad Lake.

1.1.2 National Waterway-9

Alappuzha- Kottayam- Athirapuzha canal is 38 km in length and is designated as NW-9. The canal route starts from Alappuzha via Munro lighthouse between C and S Blocks and continues between Q and R Blocks to Kottayam. The Alappuzha- Kottayam canal also passes a cultivated area reclaimed from the Vembanad Lake where the paddy fields are located in 'Blocks' surrounded by artificial canals and embankments. Agricultural labour is scarce in the locality and requires the transport of labourers to the reclaimed blocks via the Waterway, which is the only route available. Only 3 km (Chainage 3 to 6) of the entire length of the A-K passes through the Vembanad Lake. The Athirampuzha canal starts from Athirampuzha(Chandakkulam). The Canal is 15 km in length and passes through Athirampuzha, Mannanam and Cheeppunkal. The canal from Athirampuzha joins the Kottayam- Vaikom Canal at Maniyamparambu near Pulikkuttissery.

1.1.3 National Waterway-59

The Kottayam -Vaikom canal is 42 km in length is designated as NW-59. It starts from Kottayam, Kodimatha new terminal, continue along the A- K canal until Kanjiram Junction from where it takes a sharp right angle turn towards Vaikom passing Illikal, Prappuzha, Pulikuttycherry, Manyamparambu and enters Vembanad lake at Cheepumkal. It Continues on the inner route between the mainland and the reclaimed coconut plantation (Swamikkalle) joining the National Waterway-3 in Vembanad Lake before Thannermukkom barrage. The total length of Kottayam- Kanjiram stretch is about 3.5 km. The reach from Cheepumkal to Vaikom is 14 km is part of the National Waterway-3. The actual K-V waterway construction work will be confined to 24.5 km only between Kanjiram and Cheepumkal.

1.1.4 National Waterway-13

Ananda Victoria Marthandom canal (AVM canal) is designated as NW-13. The canal has a length of 11 km between Poovar and Erayimmanthurai (Thengapatinam) of which 3 km is in Kerala and the rest 8 km is the Tamil Nadu portion.

1.2 INLAND WATER TRANSPORT

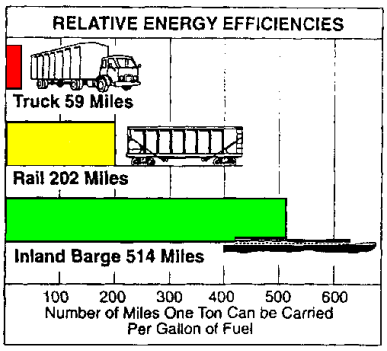
Inland Water Transport (IWT) can play a significant role in the regions where it is having the natural advantage. One of the major advantages of water transport is that waterways being the gift of nature, can be used for navigation with minimum investment. The benefit of water transport lies in its capacity to move bulk cargo at a cheaper cost. The surface transport infrastructure has reached the limit of their capacities and is failing to adequately respond to the ever-increasing traffic demand. Augmenting the capacities of road and rail system require huge investment and long gestation period.

The Inland water transport in Kerala includes rivers and backwaters. This has played a major role in the transportation right from the olden period. This type of transportation is considered as the most efficient, economic and environment friendly means of transportation. Inland waterways have got advantages when compared with the railways and roadways. This is because the former consumes less energy and the cost is also less for cargo transportation when compared to railways and roadways.

Coastal Shipping and Inland Navigation Department (CSIND), State Water Transport Department (SWTD) and Kerala Shipping and Inland Navigation Corporation Ltd (KSINC) are the agencies which are responsible for the development and operation of Inland Water Transport in Kerala.

1.2.1 Fuel Efficiency

Water transport, makes the least demand on energy resources. It is an established fact that it requires less power to move an equivalent tonnage on waterway. One Horse Power is known to move 150 kg of cargo on road, 500 kg on rail and 4000 kg on water. Hence the cost per tone-kilometre is the lowest in the case of inland water transport as shown in **Figure 1.1.**



Total kilometres 1ton can be carried per litre of fuel :

(1 gallon = 3.78litres)

By road: 25km

By rail : 86km

By IWT : 219km

Figure 1.1.Relative Energy Efficiency

Source: :"Environmental Advantages of Inland Barge Transportation", U.S. Department of Transportation, Maritime Administration, August, 1994.

1.2.2 Emissions

Pollutants (in pounds) produced in moving one ton of cargo 1,000 miles(1pound = 453grams). **Table 1.1** shows the impacts of air pollution w.r.t IWT.

Table 1.1: Impact of Air Pollution caused by IWT

IMPACT OF IWT ON AIR POLLUTION			
Air pollution for transport of one ton/km of cargo (in grams)			
Pollutants	**road**	**water**	**National level**
Carbon Monoxide	0.92	0.25	Total inland cargo carried = 1200 Billion ton/km
Sulphurdioxide	0.32	0.06	Every 1% of cargo diverted to IWT will reduce
Nitrogen oxide	2.84	0.27	CO2 emission by 17,800 ton
Carbon dioxide	2.23	0.45	CO emission by 6,700 ton

Inland waterways can relieve the burden on port infrastructure - especially in the maritime ports - and on the surrounding rail and road infrastructure, thereby reducing congestion, energy and fuel costs. In terms of energy consumption per tonne of freight, inland shipping is already regarded as one of the most efficient means of transport.

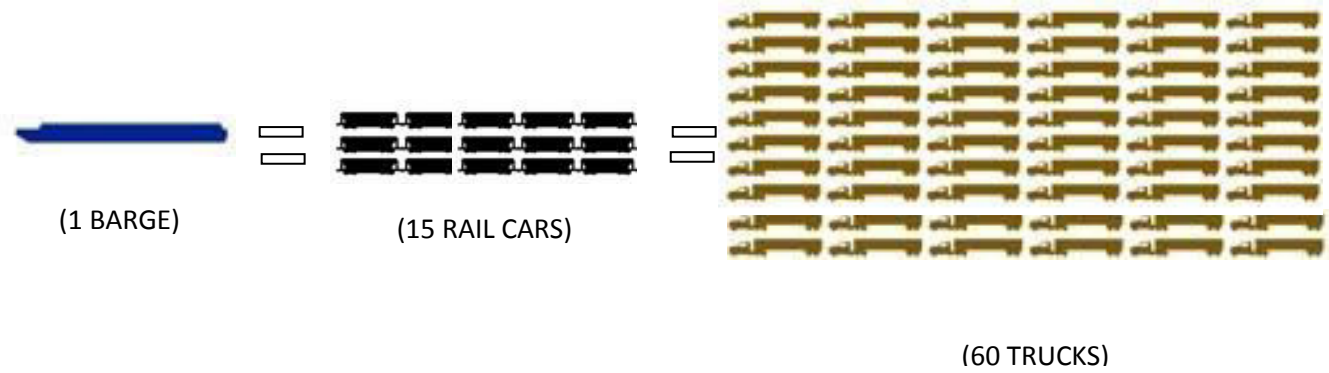


Figure 1.2: Equivalent Capacity of Transport Mode

1.3 STAKE HOLDERS IN IWT IN KOCHI REGION

1.3.1 The Inland Waterways Authority of India

The Inland Waterways Authority of India (IWAI) is the statutory agency in charge of regulation and development of waterways in the country. It was constituted as per the Inland Waterways Authority of India Act of 1985. After the setting-up of this authority important stretches of waterways were accorded the status of national waterways, with an eye on providing much needed impetus to their development and thereby the water transportation sector.

A large portion of the waterways in Kochi Corporation Region (KCR) fall under the National Waterway-3 and therefore come under the purview of the IWAI. IWAI also facilitates cargo movement on the water channels from Alappuzha to Cochin Port at Willington Island. The authority has acquired and maintained dredgers specifically for the purpose of maintenance of the fairway. However, the navigational channel within Cochin port limits are maintained by the Port authorities. The IWAI has provided for twenty-four hour navigation for the entire stretch of NW-3 by providing a combination of navigational aids such as lighted buoys and shore beacons, clearly demarcating the fairway for safe operation of vessels. Besides, IWAI also promulgates navigational information regularly by way of river notices and also published navigational charts and river atlases to help the vessel operators. At present a single lane navigational channel is available for the entire stretch of NW-3. Widening and deepening of certain location is pending due to local resistance. It is expected that the waterway will become fully functional by the end of this year. At present about 10 lakh tonnes of cargo is being moved

through NW-3, primarily limited to in and around Kochi. Once the waterway become fully operational cashew, rare earth and coir products from Kollam can also be transported to the major port of Kochi.

1.3.2 Greater Cochin Development Authority

Greater Cochin Development Authority (GCDA) was formed as per the provisions of the Madras Town Planning Act, 1920 and Travancore Town Planning Act, 1932 to ensure proper planning for the city of Cochin and its surrounding areas. GCDA has its jurisdiction spread from areas under the Municipal Corporation of Cochin, surrounding Municipalities of Tripunithura, Thrikkakkara, Aluva, Kalamassery, Maradu, Eloor, North Paravur, Angamaly and Perumbavoor and twenty-five intervening Panchayats. The total area under GCDA adds up to 632 square kilometres. The GCDA had through its Structural Plan for Cochin, 2001 proposed the integration of the waterways into the comprehensive transportation network of the city. It had also proposed to set up boat jetties at several prominent locations to facilitate passenger movement. Other proposals are mainly related to Road sector viz improvement of junctions, creation of grade separated foot paths and cycle lanes, allocation of parking space, two central bus stations (one for KSRTC and another for all the private buses to be located close to each other), city service stations, transit stations at interchanges road, rail and waterways wherever possible, truck terminals and proposals for improvement of inland waterways and renovation of canal system. However, consequent to the implementation of Panchayatiraj Act, many of the powers of GCDA has been taken out and entrusted with the Local Self Government bodies viz Corporation, Municipality and Panchayath.

1.3.3 Goshree Islands Development Authority

The Goshree Islands Development Authority was carved out of the GCDA in 1994 for the planning of Goshree islands including Vypeen, Vallarpadom, Mulavukadu-Bolghaty, Thannonithuruthu and several other small islands in Kochi region. The major achievement of this authority has been the commissioning of the Goshree bridges that provided much needed road connectivity from the mainland to the Goshree islands. It has also implemented small projects towards the

beautification of the bay areas of Vypeen with the provision of paved walkways. There are plans to develop a coastal ring road in the Vypeen island. The authority also has plans to start a ferry service connecting these islands. However, these plans are still at a nascent stage.

1.3.4 State Water Transport Department

The State Water Transport Department (SWTD) operates passenger boats from jetties in Ernakulam to Vypeen, Fort Kochi, Mulavukadu, Willingdon Island and Mattancherry. Around fifty-nine services are operated daily from the Ernakulam jetty. Most of the boats being operated are steel boats manufactured from private boat building companies. A few services are also operated using old wooden boats. The steel boats have a seating capacity of one hundred only. According to the SWTD staff, more than one and half times that number jostles for space on the boat during peak hours. Each boat requires at least five staff for operations. This team of five is made up of one Serang at the steering wheel, one man at the gearbox called Driver and three more to helpers (called Luscars) the boat land at the jetty and allow the passengers to get on and off the boat. The average monthly collection from the operation of the boat services has been around a steady 8 lakh rupees for the past five years according to the SWTD regional office functioning at the Ernakulam boat jetty. However, the operational costs have gone up due to increase in fuel costs and administrative costs. As a result the department has been incurring losses and continues to operate as a government service for the people with State subsidies to the tune of crores per year.

1.3.5 Kerala Shipping and Inland Navigation Corporation

The Kerala Shipping and Inland Navigation Corporation (KSINC) was formed by merging Kerala Inland Navigation Corporation (KINCO) and Kerala Shipping Corporation (KSC) in 1974. Their objectives are:

- To establish, maintain and operate shipping services and to purchase, charter, hire, build ships, tankers and other vessels.
- To establish, maintain and operate transportation services for the transport of goods and passengers in inland water in the state of Kerala or elsewhere.

- To run, organise, conduct and manage in the state of Kerala or elsewhere workshops, repair shops, service stations for repair and maintenance of marine vessels.
- To establish, provide, maintain and conduct research and training institutions and lab centres.

Accordingly, they are involved in passenger and cargo transportation. The cargo transportation includes bulk raw materials, petroleum products, drinking water, hazardous materials like phosphoric acid, hydrochloric acid, furnace oil etc. They were also involved in the docking and repair of marine vessels besides construction of steel and wooden crafts. Till recently, KSINC also operated passenger ferry services in KCR and was a competitor to SWTD operated boats. However, mounting losses prompted KSINC to withdraw from the sector and the fibre-boats were transferred on government orders to SWTD which failed to use their services citing safety concerns. Currently, KSINC also operates cruise ferries for tourists and is in talks with Kerala Tourism Development Corporation (KTDC) to launch more packages. It is also associated with the Muziris heritage tourism project.

1.3.6 Cochin Port Trust

Since a major portion of the water sheet near the Ernakulam boat jetty falls under the purview of the Cochin Port, a major port under the aegis of the Ministry of Shipping, Government of India, clearances have to be obtained from the Cochin Port Trust (CPT) for operation of passenger or tourist boat services in this area. Apart from the registration of the boats with the Kerala Port department, boats have also to be listed with the CPT before operating in this stretch.

1.3.7 Department of Irrigation, Government of Kerala

The Department has the responsibility of maintenance of all the water channels that do not come under the purview of IWAI. Desilting and dredging of the channels and maintaining a steady minimum depth of 1.7 m to 2 m (as per requirement) is the responsibility of the Irrigation Department. They play a major role in ensuring that all jetties are usable throughout the year. With the low tides, it often becomes difficult for the boats to be brought near the jetty especially in places like Mattancherry, Thevara, Mulavukadu, Nettoor and Kumbalam. This is due to the

steady deposition of silt at such locations. Dredging is required at least once in six months.

1.3.8 Municipal Corporation of Cochin

The Corporation of Cochin (CoC) has interests in operation of ferry services from Fort Kochi and Vypeen to Ernakulam as a significant area of these locations comes under its purview. In stretches such as Vypeen-Fort Kochi the CoC gives licenses to private operators to operate Jungar and boat services. With frequent requests coming from the public, the CoC also had plans to launch its own boat service on several sectors. However, owing to lack of funds and the fact that the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) does not provide for water transportation projects, such ideas were put on a backburner. The opportunity to participate in a future enterprise in this sector still stands for the Corporation.

1.3.9 Kochi Metro Rail Limited

Kochi Metro Rail Limited (KMRL) is also focusing on implementation of integrated water transport system. KMRL plans to link mainland Ernakulam with major jetties on the islands surrounding it. The 'Water Metro' project envisages the development of 16 identified routes, connecting 38 jetties across 10 islands covering a 76km network. Of the 38 jetties, 18 will be developed as boat hubs, while the remaining 20 will be minor jetties for transit services.

1.3.10 Passengers Association

There are several passenger associations in Fort Kochi and Vypeen. These have been active over the years and have contributed greatly in helping the people voice their concerns and bring their difficulties to the notice of the authorities. These associations meet regularly and submit petitions to the relevant authorities regarding problems being faced by the passengers, both related to operation and infrastructure facilities.

1.4 BACKGROUND OF PRESENT STUDY

Kochi a major port city on the south-west coast of India and is part of the district of Ernakulam in the State of Kerala. Kochi is actually a twin city, the main land is called Ernakulam and the island part is called Kochi. The city is located at

9°58'N; 76°13'E, spanning an area of 94.88 square kilometres. The city straddles the backwaters, encompassing the northern end of peninsula, several islands and a portion of the mainland. The current metropolitan limits of Kochi include the mainland Ernakulam, Fort Kochi, the suburbs of Edapally, Kalamassery and Kakkanad to the northeast; Tripunithura to the southeast, and group of islands closely scattered in the Vembanad Lake.

Kochi city is widely known as the commercial or economic capital of the State and is blessed with all types of transport like air, rail, road, sea and inland water transport. The City has a good network of inland waterway system consisting of backwaters, canals, lagoons and estuaries. National Waterway-3 connecting Kollam and Kottappuram passes through the region. The State Water Transport Department (SWTD), Kerala Shipping and Inland Navigation Corporation (KSINC) and private operators are operating passenger services to the adjoining islands and cargo vessel operation to the industrial hubs of Ambalamugal and Eloor/ Edayar.

Kochi has a network of canals, backwaters and river system which have played a predominant role in the maritime history of the region. These waterways were the main highways of trade and commerce in the yesteryears and was the lifeline of the State's economy is dysfunctional due to neglect and ignorance. Hardly 20% of the waterways are in use for navigation and the remaining sections are being used as drainage channel for the city's waste water and effluents from various land uses. Therefore management of important canals and their surroundings in the City are vital for sustainable development of the region.

Realizing the need to improve the waterways with utmost priority, Kerala Shipping and Inland Navigation Corporation (KSINC) has entrusted NATPAC to undertake the feasibility study for the selected canals namely; Edapally canal, Chilavanoor canal, Thevara – Perandoor canal, Thevara canal and Market canal in Kochi area with a view to revive and develop it for inland navigation, tourism and recreational purpose.

This report has been prepared with a view to revive IWT operation through the above canals.

CHAPTER II

TERMS OF REFERENCE

The major objective of the study is to improve the canals such as Edapally Canal, Chilavanoor Canal, Thevara – Perandoor Canal, Thevara Canal and Market Canal to ensure sustainable transport for inland navigation. It also include data collection, study, analysis and making recommendations on various parameters like boat services, landing facilities, safety and management aspects, tourism aspects, technical, economical and financial feasibility. Towards realizing the broad objective, the specific terms of reference (ToR) for the study are given below;

- Its present status with regard to its physical parameters, encroachment, quality of water etc. [*Details of existing cross structures, canal inventory, dredging quantity estimation (approx) and water quality analysis will be done in Phase I**].
- Identify jurisdiction and ownership over these canals and adjoining areas [*Identification of canal ownership either Irrigation dept., Kochi Corporation or any other department will be done in Phase I*].
- Analysis of the scope and potential for development and in what way it can be developed and the beneficiaries of the development. [*The stretches and the beneficiaries will be identified in Phase I and the detailing will be given in Phase II***].
- Analysis of potential for commercial development of the adjoining areas and identifying land under owner ship of the government and that can be acquired. [*Identification of government property within the buffer zone of 100 m from the canal bank will be done in Phase I. The demarcated boundary and its area will be determined in Phase II*].
- Identify encroachments and methods to evict these encroachments. Extend of land that can be freed and that can be used for further development to be assessed. *[(Right of Way (ROW) will be assessed first and thereafter extent of encroachments. (Total number of existing structures) will be identified in Phase I. Detailing of the same will be done in Phase II*].
- Identifying the people that may be affected by the development and how to mitigate the hardship faced by them. These include both encroachers that are need to be evicted and people whose land need to be acquired for the project.

If relocation and rehabilitation is required best methods suitable to them to be studied. [*The number of affected people (approx) in the Project Influenced Area (PIA) will be identified in Phase I and the actual will be estimated in Phase II. LA Act and R&R Rules will be incorporated in Phase II*].

- If rehabilitation is required, you have to identify suitable places as near to the affected people's present place of stay and work. The rehabilitation plan shall be prepared in such a way that there shall be minimum disruption in the life of the affected people and the living standards are not reduced. [*The total number of affected people and number of structures will be given in Phase I. Identification of Rehabilitation site and R&R Plan will be prepared in Phase II*].
- Study/analysis of potential customers/clients/business associates. [*The potential customers/clients on the proposed development of canal will be analysed*].
- Technical, commercial, legal and regulatory feasibility of the project. [*Technical, Financial and Economical Feasibility of the project will be done in Phase I*].
- Potential risks and other issues that may affect the project. [*The Potential risks and other issues that may affect the project will be identified in Phase I*].
- Conduct a SWOT analysis if required. [*SWOT analysis will be conducted in Phase I*].
- Details complementary work to be undertaken by other parties. [*The details of complementary work to be undertaken by other agencies will be furnished in Phase I*].
- Financial/Technical, managerial issues the project may face. [*Financial/Technical, managerial issues the project may likely to face will be done in Phase I*].
- Any other relevant issues/matter that may arise during the conduct of the study. [*Any other relevant issues/matter that may arise during the conduct of the study will be addressed in Phase I*].

Where Phase I* – Feasibility Study and Phase II** – DPR study

CHAPTER III
LITERATURE REVIEW

3.1 DEFINITION AND FUNCTIONS

Inland waterways are the water bodies such as rivers, canals, lakes, lagoons, estuaries, creeks or a combination of these including smooth and partially smooth tidal waters as defined in the Inland Vessel Act, 1917 which are suitable for operation of inland vessels.

Principal functions of waterways are-

- Act as an agent of or catalyst for economic, environmental and social regeneration in urban and rural areas.
- Sustainable mode of transport.
- Water supply, transfer and drainage.
- Tourism, cultural, sport, leisure and recreation resource.
- Heritage landscape, open space and ecological resource.
- Routes for telecommunication.

3.2 GLOBAL SCENARIO

Europe- IWT is estimated to carry about 7% of freight traffic which in fact is in a growing stage in the European Union (EU) states. The modal share in European Union in terms of ton-kilometer percentages are Road 42%, Rail 10% and Waterway is 48%.

North America- In the United States, with its water transport infrastructure over the Missouri-Mississippi and the inter-coastal traffic, together accounts for over 630 million tons of cargo per annum.

China- IWT accounts for almost 10% of the total freight tonnage carried in the country.

Thailand- IWT is estimated to transport about 20 million ton of cargo annually, representing 4.5% of total inland cargo volume better than rail.

3.2.1 CURRENT SITUARION OF INLAND NAVIGATION IN INDIA

Inland waterways carry only about 0.15 percent of the total freight traffic in India even though India has 5 national waterways since 2008.

3.3 INLAND WATER TRANSPORT POLICY IN INDIA

Major objectives of the Inland Water Transport Policy Document of 2001 are

- To actively promote the IWT sector for it to take a reasonable share in the intermodal mix of inland transport.
- Increasing the coverage of National Waterways and provision of necessary infrastructure for shipping and navigation and in augmenting the IWT fleet.
- Large-scale private sector participation both for creation of infrastructure and for fleet operations to supplement the government efforts.
- Government to act as a provider, facilitator and regulator and, at the same time, offer various concessions to the private sector for their effective participation by way of investment for creation of enhanced IWT infrastructure and fleet to operations.

3.4 COMPARATIVE ANALYSIS BETWEEN INLAND WATER TRANSPORTS WITH OTHER INLAND TRANSPORT MODES

3.4.1 ADVANTAGES OF IWT

Cost- effective transport system:

It is a cost - effective transport system with less cost for development and maintenance as compared to road and rail modes. According to a recent study by National Council for Applied Economic Research (NCER), it is found that the cost of transportation by inland navigation works out to mere 55 paisa per tonne-km as against one rupee per tone-km by rail and Rs1.50 per tonne-km by road.

Energy efficient and environmental friendly

Water transport requires less energy for its functioning. The minimum energy requirement enables the bulk transport with less environmental impact. With One horsepower, 4000kg of cargo can be moved on waterways as against 500kgon rail and 150 kg on road.

Table 3.1 Energy consumption of various modes of transport

Mode	CO_2 emission (g/ton-km)*	Energy consumption (MJ/ton-km)	Fuel Economy (Diesel equivalent) (Liter/ton-km)
Truck	97 – 110	1.13 – 1.28	0.0031-0.0036
Rail Diesel	21 – 86	0.24 – 1.00	0.007 – 0.028
Rail Electric	18 – 80	0.14 – 0.62	0.004 – 0.017
IWT	2.5 – 70	0.44 – 0.84	0.008 – 0.0023

Source: Energy Efficient inland water transport in Bangladesh – International Bank for Reconstruction and Development / The World Bank

Table 3.2 Shares in worldwide co_2 emissions from transport

CO_2 Emissions (Mt CO_2)	1990	Share 2005	2005	Share 2005
Road	1033	82%	1451	87%
Rail	124	10%	104	6%
Domestic navigation	96	8%	111	7%
Total land transport	1252	100%	1667	100%

Source: Energy Efficient inland water transport in Bangladesh – International Bank for Reconstruction and Development / The World Bank

Socio- Economic Growth

Water transport provides direct employment, such as boat building and fishing livelihoods and indirectly helps poor people to access employment in the cities by the improvement of mobility. Increased mobility also plays a significant role in supporting livelihoods of rural producers such as farmers and fisherman by providing a means to access their end-markets. Large number of indirect employment is also generated by water transport in many of its auxiliary and service sectors.

For e.g. in Bangladesh around four million people are getting benefited with the country's waterways, providing an estimated 60% of all employment in the transport sector.

Reduce congestion on road

It acts as a cost effective alternative transport system and reduces congestion in roads. For e.g. in Thailand, to relieve the extreme road traffic congestion in the city, the government of Thailand has adopted the expansion of commuter services on waterways around Bangkok.

Development of backwater Tourism

Inland water transport can acts a key role in development of tourism activities. The integrated development of inland water transport with tourism infrastructure would increase the flow of tourists and the navigation system would become a tourist attraction. Tourist circuits can be developed in different sections of waterways for promotion of tourism.

3.4.2 DISADVANTAGES OF IWT

Environmental Concerns

Inland water transport is affected by many environmental issues. The major environmental problems & risks associated with IWT are;

1. Canalization & dredging (reactivation of polluted sediments into surface waters).
2. Shipping operations (pollution through oil spills; noise pollution; risks of accidents with dangerous cargoes, disposal of waste materials).
3. Import and introduction of invasive species like bacteria and other microbes, small invertebrates and the eggs, cysts and larvae of various species through the ship's ballast water, attached to ships hulls and via other vectors.

Inland water transportation is also influenced by current hydro meteorological conditions. Navigable waterways in many regions dramatically reduce during the dry season due to lack of depth and width of waterway. The other setbacks in inland water transport are due to

- Local community issues in fairway development.
- Slow movement.

- Limited spatial accessibility-the inland water transport will be more effective only where both origin and destinations are located on river fronts.
- Accessibility-requirement of transhipment facilities along the waterway for further movement to other modes which increase total transport costs (multiple handling)

Use of water for irrigation, accumulation of silt in river due to erosion by deforestation activities and neglect in maintenance of fairway reduce the effective use of waterways. Lack of research and development in vessel design to suit local conditions and inadequate attention to modernization of fleet.

3.5 INLAND PORTS PLANNING

Inland ports are the intermediate points between IWT vessels, trains and trucks for the movement of cargoes. Accessibility to IWT is limited to certain locations, which are near to waterways. Therefore, in most cases other complimentary land modes are required for the entire origin-to-destination transport. The main function of IWT system is to move the cargo and to avoid accumulating and damaging it. In order to fulfill efficient cargo transfer, ports or terminals have to be well connected with the other modes of transport such as rail and road.

3.5.1 PORT TERMINOLOGY

A Port consists of several terminals, or the terminals are components of a port. Sometimes, in the large inland ports, under the same port name there could be several locations, each with several terminals.

Intra and Inter-Modal Transfer

The main function of ports is the transfer of cargoes. The transfer operation carried out in ports can be classified as follows.

- Intra-modal transfer- connecting two (or more) hauling services within the same mode of transport.
- Inter-modal transfer- connecting two (or more) services from different transport modes.

Water-to-water transfer

This intra model transfer is related to the change in the dimension of the fairway or the change in routing and this transfer takes place in ports located on the boundary of the deep navigation channel. This type of ports helps deep-draft vessels to be discharged into shallow-draft vessels and shallow-draft vessels to be discharged into deep-draft vessels. Normally, this transfer is operated at anchorage if the dock is very busy, but sometimes, this transfer can be operated at berth when the electrical power supply is needed or the dock is vacant. Apart from a typical routing-related intra-modal transfer takes place in ports located on a confluence of rivers or intersection of canals, these ports act naturally, as interchange points between the services on the various rivers (or canals).

Land-to-water or water-to-land transfer

Land-water transfer is the main important function in inland ports, which transfer most cargoes by land-water or water-land. On the water side, there may be vessel, barge or sometimes oceangoing ship if the channel permits and on the land side, there may be storage yard, warehouse, dock etc.

Multi-modal transfer

The IWT system is limited to locations that are situated on the waterfront. Consequently, in most cases complementary land transport is needed. In many modern inland ports a multi-mode selection is available for serving vessel-to-vessel, vessel-to train, and vessel-to-truck transfer services.

3.5.2 PORT STRUCTURES

Dock - an area for building or repairing vessels

Wharf or quay - a fixed platform, commonly on pilings, where ships are loaded and unloaded.

Harbour- a place where ships may shelter from the weather or stored

Jetty- a structure, such as a pier, that projects into a body of water to protect a harbor or shoreline from storms or erosion.

Berth -an area along a dock or a wharf or a quay or a jetty where a ship may be moored.

Figure 3.1 Dock

Figure 3.2 Wharf or Quay

Figure 3.3 Jetty

3.5.3 CLASSIFICATION OF INLAND PORTS

The port system is organized according to the dimensions of their channel and structures (locks), the size of vessel they serve.

Channel dimensions

The classification of the channel dimension is related to vessel classification and what size vessel the port can be dock is related to port classification. For example, In China, the Changjiang is 6300 km long River, over which are distributed 25 ports, and these ports can be divided into four "levels".

Table 3.3 Classification of port according to the channel dimension of Changjiang River in China

Deep-draft ports	Water depth (m)	Vessels	Weight up to (dead weight tonnage)
Lower Changjiang deep-draft ports	10.5	Mainly ocean going vessels	25000
Shallow-draft ports			
Lower Changjiang shallow-draft ports	4-4.5	Mainly ocean going vessels	5000 – 7000
Middle Changjiang shallow-draft ports	2.9	Barge fleet or river vessel	3000
Upper Changjiang shallow-draft ports	2.9	Barge fleet or river vessel	1500

Source: Inland ports planning and cargos handling operation – Wu Deming, Senior Engineer, Nanjing Port Authority, Nanjing, China

Volumes of throughput

The gross income of the inland port is decided by throughput. For all the enterprises, the finance is composed of two parts, one is fixed cost, and another is

variable cost; if the throughput is increased, the gross income will be increased, the variable cost will be decreased, and the economic benefit of the port will be good. Therefore, in China, the volumes of throughput are appraised as the capacity of the port.

3.5.4 TYPES OF CARGOES

The ports are classified according to the types of cargo they handle. Cargoes can be classified according to their economic uses, or according to the way they are handled. Sometimes, the two classifications may overlap. For example, corn can be shipped in bulk as well as in bags; bagged cargo, however, consists of corn as well as many other bagged commodities. So corn can be bulk cargo, but if bagged it is general cargo.

General cargoes

Usually, all commodities in bags or in boxes (paper box or timber box) or unitized or single unit (usually big or heavy), are general cargoes, so commodities of this kind are many e.g. corn, grain, wheat, rice in bags, cotton, wool, jute, flax package, structural steel, wood and timber, all cargoes in container, Cement, fertilizer in bags, Liquid in drums.

Bulk cargoes

In inland ports of developing countries, most of the break-bulk cargoes are handled "loose"; usually bulk cargo means the break bulk cargoes. The bulk cargoes are classified as follows: Coal (powder, granular, lump), Ore (Powder, granular, lump), Corn, grain, wheat, rice (granular) Fertilizer, Animal foods (granular), Sand, cobble stone (granular), cement (powder).

Liquid cargoes

Major liquid cargoes are crude oil, fuel oil, petrochemical liquid, cooking oil and water. But most liquid cargo is crude oil and petrochemical products. All of these liquid cargoes are handled or transported in inland ports by pipeline.

3.5.5 TYPES OF TERMINALS

The terminals are classified into passenger terminal, general cargo terminals and bulk cargo terminals. The general cargo terminals can be divided into neo bulk

terminals and container terminals, and the bulk terminal group will be divided into dry bulk cargo terminals and liquid cargo terminals.

Passenger terminals

Two types

- The pontoon and access bridge (gangway)
- The pontoon and cable trolley on the ramp.

General Cargo Terminals

Two types

- Pontoon, Access Bridge, storage yard, the lift cranes fixed on the pontoon. Cargoes are put on the platform wagons which move between the pontoon and yard- simple and its investment low.
- The reinforced concrete structure wharves. When the vessel berth at the wharves, the crane can move and operate along the track - efficiency of cargo handling is high.

Bulk cargo terminals

Two types

- Loading terminal.
- Unloading terminal -in both terminals the transportation on land is done by means of belt conveyer on the wharf.

Liquid cargo terminals

Transportation of the liquid cargo is through pipeline.

3.5.6 WATER TERMINAL SITE SELECTION

Water-related considerations

(a) Deeper reach of the water body where less severe channel shifting.

(b) Concave, high bank of the water body where the channel is close to the shore, because this practice needs smaller docking structures.

Land-related considerations

(a) Availability of waterfront land.

(b) Soil conditions and elevation-hard soil

(c) Utilities connection.

(d) Environmental impacts-Elimination of wetland, Compatibility of land use.

(e) Price of waterfront land.

A "basic" general cargo terminal requires some 150-200 meters of water frontage and about 10hectares of backland. Multi-purpose port which consists of several cargo terminals and an industrial complex requires 500-1000 meters of water frontage and 50plus hectares of backland.

Transportation Considerations

Road and rail access is very important.

Other cost considerations

(a) Availability of trained and cost-effective labour.

(b) Availability of reliable and low cost utilities.

(c) Availability of financial incentives.

3.6 BOATS AND VESSELS

Generally boats can be categorized into three types:

- unpowered or human-powered boats
- sailing boats
- motorboats

Unpowered boats mainly consist of rafts and floats meant for one-way downstream travel. Human-powered boats are canoes, kayaks, gondolas and boats propelled by poles like a punt. Sailing boats are propelled solely by means of sails and the motorboats are propelled by mechanical means, such as engines.

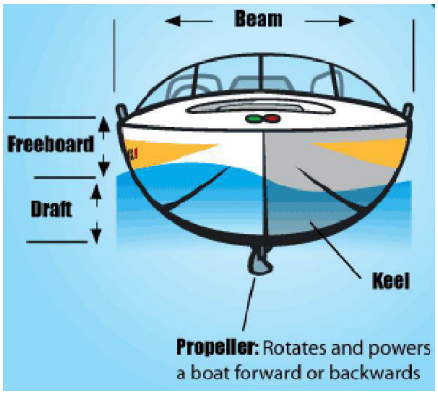


Figure 3.4 Boat

Significant factors for navigation

- length,
- beam,
- maximum draught of vessels

And

- Depth,

- width,
- Cross sectional area and shape of the waterway.

On natural waterways, only a part of the waterway cross section is actually used for the navigation which is called "fairway". The essential elements of a good of vessel are

- speed
- economy
- reliability
- safety
- comfort

According to the hull configuration vessels can be classified as

3.6.1 CONVENTIONAL MONOHULLS

Figure 3.5 Monohull

This is displacement craft and is one of the oldest types of boats. Usually, all the country craft are of mono hull type. The major drawback of this craft is its poor stability. Speed is less than about 25 knots (46km/hr). Nevertheless, stability can be improved but at the cost of power and maneuverability. At higher speeds this craft generates a lot of waves which creates high bank erosion in narrow canals and may cause damage to flora and fauna.

3.6.2 CATAMARAN

Figure 3.6 Catamaran

A catamaran is a multi hulled vessel consisting of two parallel hulls of equal size. Catamaran is geometry-stabilized. Speed is 35-40 knots (65-75km/hr). Catamaran can have a very shallow draught because of being ballast-free and lighter than a monohull. Because of these advantages, catamarans are now used for numerous applications e.g. Passenger ferry, research vessel, landing craft, fishing vessel, small dredgers, carferries...Etc.

3.6.3 TRIMARAN

Figure 3.7 Trimaran

Trimaran is also multihull displacement craft like catamaran and has all the advantage of catamaran. Speed is 35-40 knots (65-75km/hr). It has an additional centre bull, which helps in reducing the "wash" and makes the journey more comfortable also. Only on engine is required to power the vessel in case of small vessel, which can be fitted in the central hull. Most commonly sail-driven yachts designed for recreation, there are very few trimaran ferries and warships.

3.6.4 SMALL WATER PLANE TWIN HULL (SWATH)

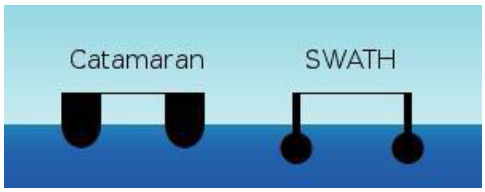


Figure 3.8 SWATH

SWATH is a twin-hull craft that minimizes hull cross section area at the water surface. Speed is greater than 25 knots (46km/hr). The SWATH hull form helps achieve speeds greater than 25 knots but require much more power than other hull forms at those speeds.

3.6.5 SLICE

It's a recently developed one and a SWATH variation with four short hulls, or pods, instead of the SWATH's two long hulls. Speed is About 30 knots (55km/hr). SLICE achieves power efficiencies 20-35% greater than those with conventional SWATH designs at speeds in excess of 18 knots. The SLICE concept is under evaluation and its various merits have not yet been proven.

Figure 3.9 SLICE

3.6.6 HYDROFOILS

Hydrofoils are monohulls with structural attachments that behave like aircraft Wings to lift the main hull clear of the water. As a hydrofoil-equipped watercraft increases in speed, the hydrofoil elements below the hull(s) develop enough lift to raise the hull up and out of the water. This makes a great reduction in hull drag, and a further corresponding increase in speed and efficiency in operation in terms of fuel consumption. Speed is More than 40knots (75km/hr).

Figure 3.10 Hydrofoil

It is observed from experience of inland navigation in Europe and America that catamarans are most suitable form of vessels in terms of economy, capacity, safety, comfort and speed. If a monohull and a catamaran of equal displacement were compared, the catamarans will have a lower draft. Many designs are in service with displacement ranging from a few hundred tonnes to about 3,850 tonnes with speeds of 35-40 knots.

Example to Catamaran- **Argus E35**

Table 3.4 Key Specifications of Argus E35

Nominal Length	10.6	m
Length waterline	10.2	m
Beam	4.7	m
Draft	0.6	m
Water Tanks	2 x 200	l
Fuel Tanks	2 x 300	l
Engines	2 x 90	hp
Light Ship Displacement	4500	kg
Loaded Ship Displacement	5500	kg

It has a speed range of 6 to 16 knots gives incredible flexibility in range and time to destination.

According to the dedicated purpose vessels can be classifies as-

- Commercial vessels including:
- Cargo ships
- Passenger ships for daily excursions or for cruising (equipped with cabins)
- Technical floating objects (push boats, tugs, dredgers, floating cranes, floating docks, workboats etc.)
- Pleasure crafts (motor or sailing yachts and boats, water bikes, wind surfing boards etc.)
- Special ships (police, customs, survey, fire-fighting ships, icebreakers, military vessels, supply ships etc.).

3.6.7 WATER CRAFTS IN DIFFERENT WATERWAYS

Details of water crafts in the National water ways are shown in the below figure.

Table 3.5 Water crafts in National Waterways

Waterway	Type of Vessels	Vessel dimensions (m)			Draft of the vessel (m)	Speed (kmph)	Carrying capacity in Tons
		Length	Breadth	Depth			
The Ganga-Bhagirathi-Hooghly (NW-1)	SPV	70	9.20	3.2	2.6 2.0 1.8	12	1050 730 620
The Brahmaputra (NW-2)	SPV	55	9.50	2.8	1.8	12	600
	Push / Tow	65	10.00	2.9	1.75	10	750
WCC (NW-3)	SPV	50	8.50	2.1	1.5	12	350
KPC (NW-4)	SPV	29	4.25	2.0	1.2	10	100
ECC (NW-5)	SPV	30	6.50	2.0	1.25	10	200

PIANC, the World Association for Waterborne Transport Infrastructure, accepted an international classification system which divided waterways into different classes, depending on their horizontal dimensions.

Table 3.6 Water vessel classification

Type of inland waterway	Class of navigable waterway	Motor vessels and barges					Pushed convoys					Minimum height under bridges
		Type of vessel: générales characteristics					Type of convoy- Générales characteristics					
		Designation	Length	Beam	Draught	Tonnage		Length	Beam	Draught	Tonnage	
			m	m	m	t		m	m	m	t	m
OF REGIONAL IMPORTANCE	I	Péniche Barge	38.50	5.05	1.80-2.20	250-400						4.00
	II	Kast-Caminois Campine-Barge	50-55	6.60	2.50	4.00-650						4.00-5.00
	III	Gustav Koenings	67-80	8.20	2.50	650-1000						4.00-5.00
OF INTERNATIONAL IMPORTANCE	IV	Johan Welker	80-85	9.50	2.50	1000-1500		85	9.50	2.50-2.80	1250-1450	5.25/or 7.00
	Va	Grand bateaux Rhenands/Large Rhine Vessels	95-110	11.40	2.50-2.80	1500-3000		95-110	11.40	2.50-4.50	1600-3000	5.25/or 7.00/or 9.10
	Vb							172-185	11.40	2.50-4.50	3200-6000	
	VIa							95-110	22.80	2.50-4.50	3200-6000	7.10/or 9.10
	VIb		140	15.00	3.90			185-195	22.80	2.50-4.50	6400-12000	7.10/or 9.10
	VIc							270-280 193-200	22.80 33.00-34.20	2.50-4.50 2.50-4.50	9600-18000	9.10
	VII							285 195	33.00 34.20	2.50-4.50	14500-27000	9.10

Peniche-class I

Operational areas: French, Belgian, Dutch, east and West German channels, Meuse river, Schelde, Rhine

Length	m	37.5 -38.5	
Beam	m	4.8 -5.0	
Draught	m	1.8 -2.5	
Dead weight	t	250 -365	
Water depth	m	5	10
Speed	km/h	12	14
Usable power	kW	200	200

Figure 3.11 Peniche-class I

Yacht-class I

Operational areas: French, Belgian, Dutch, east and West German channels, schelde, Rhine, Danube, weser and elbe.

Figure 3.12 Yacht-class I

Length	m	Up to 15	
Beam	m	5	
Draught	m	1.1 -1.5	
Water depth	m	5	10
Speed	km/h	40	40
Usable power	kW	450	450

3.6.8 SOLAR BOATS

Solar boats are electrical boats, with independent, quiet and clean engines, whose batteries store free energy from the sun. Extremely diverse solar boats are available, ranging from small lightweight craft designed to take just one or two crew up to passenger boats capable of carrying 50 or more people. A private 68ft canal barge is presently the largest electric boat on the UK's inland waterways. Use of onboard solar photovoltaic (PV) modules to charge propulsion batteries in solar boats produces a very environmentally benign method of transport.

Figure 3.13 Solar Boat

2.6.9 HOUSEBOAT

Houseboats are very common on the backwaters of Kerala. The houseboats in Kerala are huge, slow moving boats used for leisure trips. Generally, a houseboat is about 60 to 70 feet (18 to 21 m) long and about 15 feet (4.6 m) wide at the middle. The

hull is made up of wooden planks and that are held together by ropes of coconut fiber. The roof is made of bamboo poles and palm leaves. The exterior of the boat is painted with protective coats of cashew nut oil. House boats are one of the main attractive features of Kerala tourism and attract large number of foreign tourists.

Figure 3.14 House Boat

3.7 DESIGN TECHNIQUE FOR INLAND NAVIGATION FAIRWAYS

Design techniques for inland navigation include economic studies, initial design and final design.

3.7.1 ECONOMIC STUDIES

- Cost of fairways and ports
- Cost of vessels
- National economy (e.g., Jobs, import, export, and production)
- Environment.
- Safety, irrigation, flood control, and ground water tables.

3.7.2 INITIAL DESIGN

- Design Requirements- The places of departure and destinations of the cargoes and passengers, use for irrigation purposes, water transport, etc.
- Shipping- selection of vessels
- Alignment- site survey, selecting the harbour site, the areas for quays, stores, and additional facilities

- Dimensioning- dimensions of the design vessels and the alignments, hydraulic structures, fairway cross sections, bank protections, and additional facilities
- Screening- broad evaluation on a cost-benefit or ranking
- basis and includes a selection of the potentially feasible alternatives

3.7.3 FINAL DESIGN

- Impact Assessment -Manoeuvring, Speed prediction and design of bank protections, Hydraulic structures and current patterns, Erosion and sedimentation.
- Final Selection

3.8 WATERFRONT DEVELOPMENT AND ALLIED ACTIVITIES

Waterfront is any property that is located adjacent to the water body such as river, stream, ocean and lake. A good waterfront development includes diversity, community engagement, safety and security, environment and sustainability.

3.8.1 TYPES OF WATERFRONT

Waterfronts are different in nature with respect to their physical features, topography, width, shape, volume, function and location. Based on their location waterfront can be classified as;

- **Riverfront**
- **Lake front**
- **Sea front**
- **Canal front**

Based on their dominant function, waterfront can be classified as;

- **Commercial waterfront**- Manhattan, New York
- **Educational waterfront** -Charles Riverfront, Cambridge
- **Historical waterfront** - Thames Riverfront, London.
- **Religious waterfront**- Ganga Riverfront, Varanasi
- **Recreational waterfront**- Hong Kong waterfront
- **Residential & mixed waterfront**- Cape Town, South Africa
- **Transportation waterfront**- Singapore waterfront

3.8.2 FUNCTIONS OF WATERFRONT AREAS

- **Productive function-**They encourage development of adjacent areas by providing a positive impact on the surrounding land use.
- **Protective function-**They can act as open and breathing spaces for the entire city fabric.
- **Ornamental function-** Image ability of a city can be enhanced by the aesthetic and complimentary qualities of waterfront. Therefore, Waterfronts act as landmarks of the city.
- **Recreational function-**Apart from functional aspects of Waterfronts; they also fulfil the recreational needs of people. The type of recreation can be either active or passive.
- **Socio-cultural and religious function**-Many Rivers are regarded as sacred and are venues for several socio-religious functions. They remain an integral part of the city and the socio-cultural and religious life of its people.
- **Environmental function-**Waterfronts help to maintain a balanced integration of natural and human environment.

3.8.3 PROBLEMS AND ISSUES RELATED WITH WATERFRONT DEVELOPMENT

- Degradation of public open spaces and amenities.
- Incompatible and underutilized land use.
- Hydrological issues, Flooding, Scouring and Erosion along the banks, Shifting Course of the river.
- Environmental issues (water, air, soil and visual pollution).
- Underutilization of the water body for transportation, Problems of accessibility to waterfront areas.
- Aged and obsolete structures.
- Land ownership along the riverbank.
- Haphazard and poor skyline along the riverfront.

3.8.4 DEVELOPMENT PRINCIPLES

- Maximize continuous public access to the water's edge
- Create public spaces that are of high quality, rich in amenities and flexible in their use
- Preserve and interpret historical uses, activities and forms of the waterfront, and conserve lands with marine industrial use potential
- Provide active and dynamic year-round destinations
- Integrate well with, and support, the surrounding urban fabric
- Improve architectural quality, have animated streetscapes, and support activity at the water's edge.
- Create it economically and environmentally sustainable.

3.8.5 PRINCIPLES OF SUSTAINABLE WATERFRONT

One of the widely accepted definitions of sustainability is "sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"-(Brundtl and commission, 1987)

The major principles of sustainable waterfront development are-

1. Secure the quality of water and environment.
2. Waterfronts are part of existing urban fabric.
3. The historic identity gives character.
4. Mixed use is a priority.
5. Public access is prerequisite
6. Planning in public-private partnership speeds the process
7. Public participation is an element of sustainability
8. Waterfronts are long-term process
9. Revitalization is a ongoing process
10. Waterfronts profit from international market.

3.8.6 GREEN INFRASTRUCTURE

Integrating green infrastructure features into walkways, streets and open space can create physical, visible and conceptual connections between upland and

the public space in waterfront area. This provides a lot of benefits such as mitigate storm water runoff, improve water and air quality...Etc.

The main objective of green infrastructure is to create a healthy green edge to water front or riverside area by increasing waterfront access and diversifying transport options combined with developing a sustainable storm water management initiative. The integration of trees and soft infrastructure such as shrubbery along the greenway creates a pedestrian-friendly path, an attractive public space and it helps for reducing the risk of storm overflow, regulating city temperatures and cleaning the air.

Green Infrastructure Benefits

- Increases Groundwater Recharge
- Reduces Energy Use
- Improves Air Quality and Reduces Urban Heat Island Effect
- Improves Community Liveability
- Cultivates Public Education Opportunities

3.8.7 ELEMENTS OF RIVERFRONT DEVELOPMENT PLAN

- Land use
- Open space network
- Cultural destinations and districts
- Pedestrian and bicycle connections
- Ecological zones
- Transportation networks

3.9 ENVIRONMENTAL MANAGEMENT OF WATERWAY

3.9.1 WATERWAY ECOSYSTEM

It includes complex interactions among watershed and waterway process, boundary sediments, bank and flood-plain conditions and ecological resources. The waterway development and management involves many activities such as flood protection, land reclamation, water discharge, public and industrial waste water discharge, irrigation and mining of sediments apart from its use for inland navigational activity.

Canals

Canals are often accompanied by locks and weirs that regulate the flow of water and water levels and helps in navigation or irrigation and drainage, when the currents and water level are absent. Navigation makes the natural banks of canal susceptible to wave action and other dynamic hydraulic effects. Therefore, canals are often stabilized to prevent erosion. Local disturbance on canal cause larger consequences as waterways are large scale systems and corridors for fauna, flora and human use.

3.9.2 BASIC FUNCTIONS

The basic functions that waterways support can be divided into five categories:

- Evolution through morphologic processes
- Maintenance of hydrologic balance
- Continuity of sediment processes
- Provision of habitat
- Maintenance of chemical and biological processes

Table 3.7 Summary of primary functions

Morphological evolution	Hydrological balance	Sediment continuity	Habitat provision	Chemical and biological process
Stream evolution process	Surface water storage process (short & long-term)	Full sedimentation process	Biological communities and process	Water and soil quality processes
Energy process	Surface/subsurface water exchange process	Substrate and structural processes	Necessary habitats for all life cycles	Chemical processes and nutrient cycles
Riparian succession	Hydrodynamic character	Quality and quantity of sediments	Trophic structure and pathways	Landscape pathways and processes

Source: EnviCom Report of WG 6 2003

3.9.3 WATERWAY USES

Waterways provide for a wide variety of uses. The below table depicts the different uses and its relation with waterway functions.

Table 3.8 Waterway uses

Uses	Function				
	Morphologic evolution	**Hydrologic balance**	**Sediment continuity**	**Habitat provision**	**Chemical and biological processes**
Sink					
Cooling water	O	O	O	I	I/O
Drainage	O	I	I	I	I/O
Flood storage and attenuation	I/O	I/O	I/O	I/O	I/O
Wastewater	O	O	-	I	I
Consumptive					
Aggregate withdrawal	I/O	I/O	I/O	I/O	I/O
Drinking water	O	I/O	O	I/O	I/O
Fishing and hunting	-	-	O	-	I/O
hydropower	I/O	I/O	I/O	I	I
Industrial water supply	I/O	I/O	I/O	I	I/O
Irrigation	I/O	I/O	I/O	I	I/O
Groundwater withdrawal	-	I/O	-	I	I/O
Riparian timber harvest	I/O	I/O	I/O	I/O	I
Non- consumptive					
Aesthetic	-	-	O	-	-
Ecosystem protection	I/O	I/O	I/O	I/O	I/O
Housing	I/O	I/O	I/O	I	I
Landscape feature	-	-	O	I	I
Recreational boating	I/O	O	O	I/O	I/O
Commercial transport(passengers, freight)	I/O	I/O	I/O	I/O	I/O
Navigation service	I/O	I/O	I/O	I/O	I/O
Non- boating recreation	O	O	O	I/O	I/O
Spatial corridor (e.g. Utilities, transport)	I/O	I/O	I/O	I/O	I/O
Key					
- No Discernable Impact I Use May Impact Indicated Function O Use May Be Impacted By Indicated Function					

Source: EnviCom Report of WG 6 2003

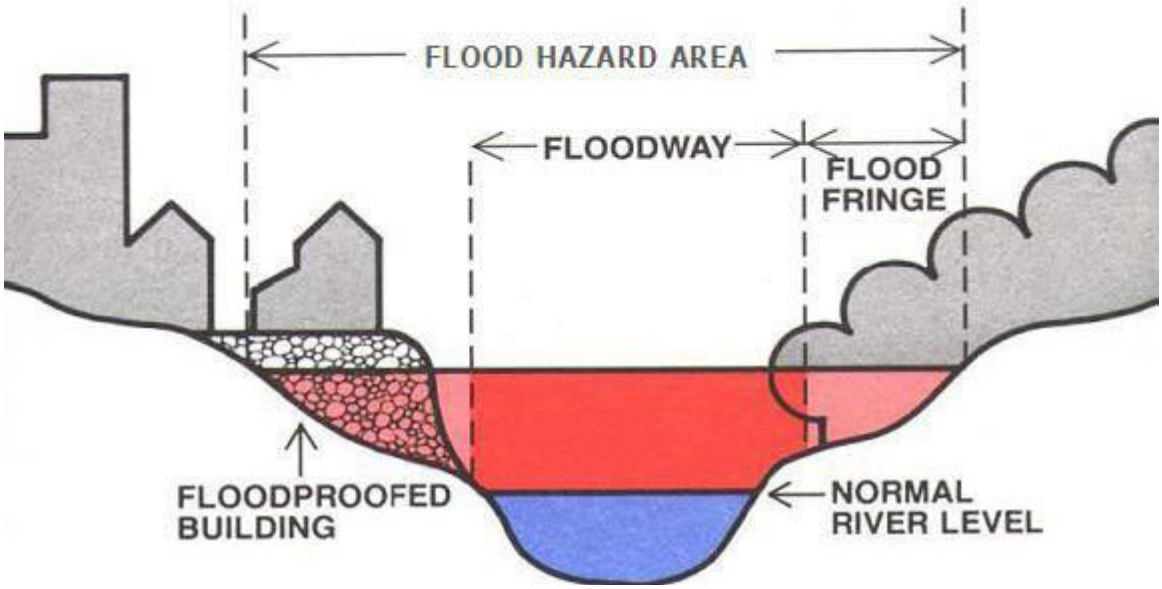
3.9.4 CHANGES TO THE CATCHMENT DUE TO URBANIZATION

- Increases in flow result in changes to the plan form, size and shape of the channel.
- Erosion of the channel to accommodate increased flows results in vegetation loss, smothering of habitat, loss of river pools and increased turbidity.
- Changes to water quality- The contaminants from poorly managed storm water, such as metals that are toxic to aquatic fauna and nutrients and they can increase excessive algal growth that depletes the water column of dissolved oxygen.

3.9.5 DESIGN GUIDELINE

It's a two-phased system,

- During low intensity rainfall events-Infiltration, detention and treatment of the storm water through contact with vegetation are maximized at base flow.
- During high rainfall events- flood protection is maintained by conveyance in the floodway, Reduction of flow velocity and increase of flood storage by providing abroad vegetated floodway.



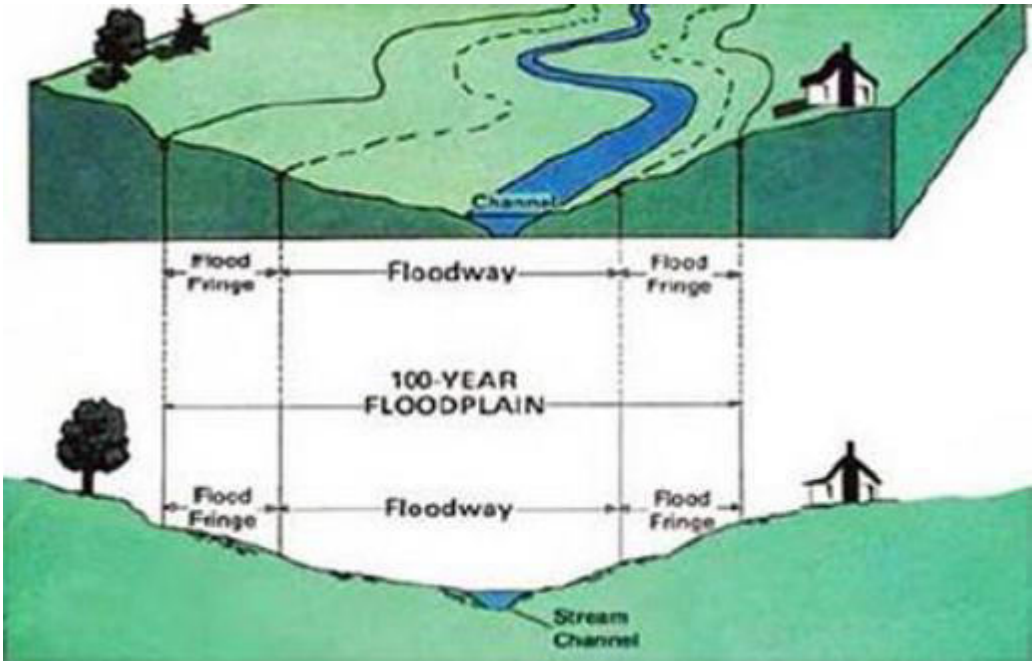


Figure 3.15 Waterway section

Channel design

The stability of a channel can be established by selecting a suitable channel width to accommodate the dominant flow, known as the bankfull discharge. Typically, the bank full discharge is the average peak flow for a 1.5 year average recurrence interval(ARI) event. The bank full width is the width of the channel at water level during a bank full discharge. Confining flood flows to a deep, narrow channel will increase the potential for erosion and deliver flows faster; increasing the risk of flooding downstream. The floodplain cross section should be evenly sloped on a slight grade towards the low flow channel to avoid water logging and water ponding. Bunds or levees should not be constructed along the banks of the channel as they confine flows to the channel and prevent floodwaters from re-entering the channel from the floodplain as floods recede. Manning's equation can be used to estimate the channel capacity and velocity.

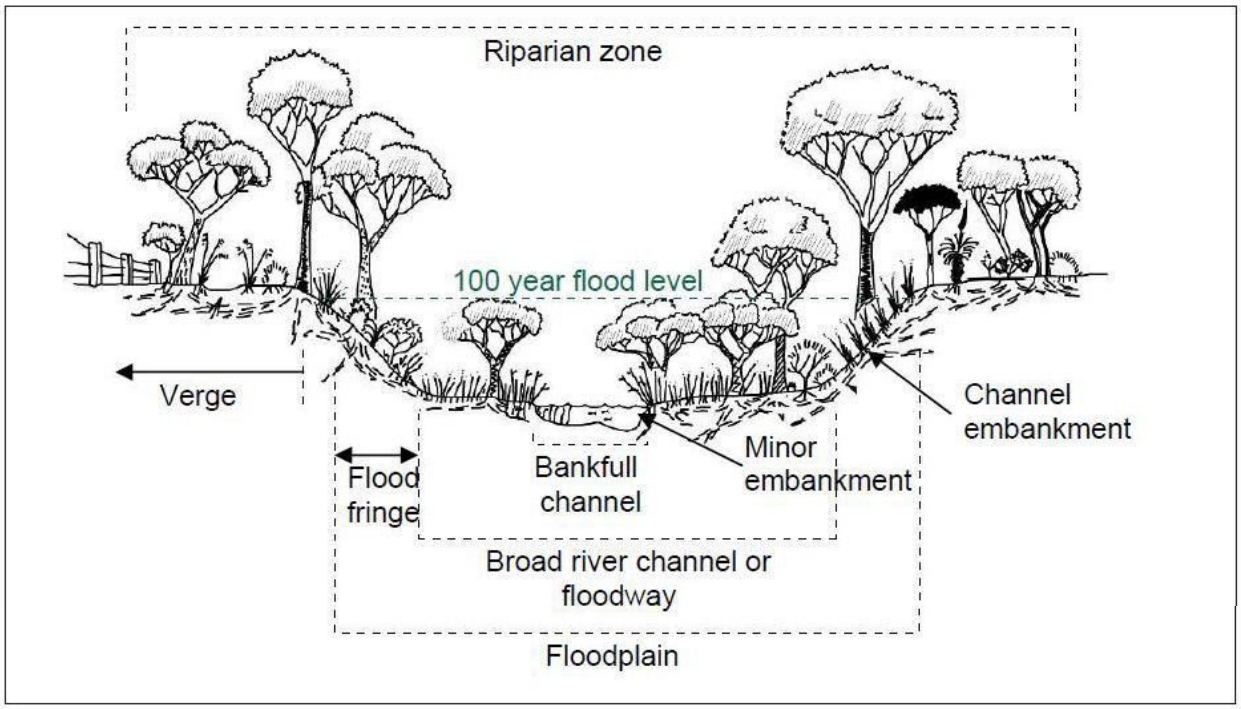


Figure 3.16 Stages of a natural river channel cross section.

Channels should be constructed to give a natural, broad U-shape, rather than a fixed artificial shape such as a trapezoidal or rectangular cross section. Newbury and Gaboury(1993) found the ratio of depth to width for natural channels to fall within the range of1:10 to 1:15. Nevertheless, broad, shallow channels are not the most efficient shape for conveying flow and may result in large areas of land being required to meet flood control objectives. If land availability is a constraint, then the conveyance efficiency of the waterway can be increased by designing a narrower, deeper channel, however this will increase the tractive force of flows and may result in additional bed protection being required to prevent erosion.

Slope construction must be designed with a consideration of structural stability, freed raining conditions, maintenance activities and public safety. For vegetated waterways, slopes should be limited to a maximum grade of 1:4 to facilitate vegetation establishment and ensure structural stability. A gentle slope of not steeper than 1:6 is required to facilitate for ease of maintenance and to provide a safe transition between the bank and the drain invert. The longitudinal slope of the constructed waterway should be the same as the natural grade of the waterway or

reference waterways in the region. Slopes steeper than 1:100 are feasible by using engineered bed armoring or a series of grade controls such as a riffle sequence.

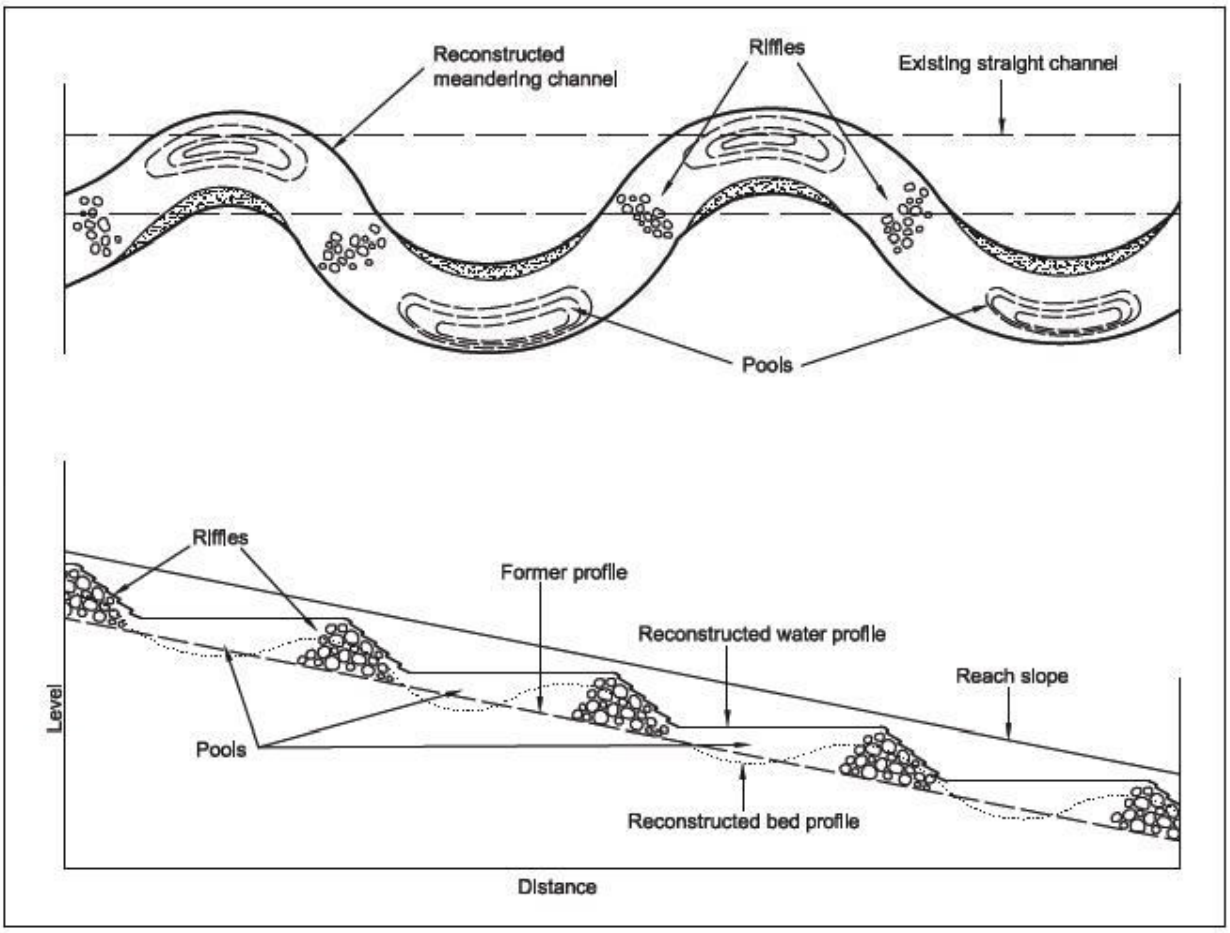


Figure 3.17 Riffle pool system

Gentler slopes may be required in open earth channels or where vegetation alone armors the bed. Very flat longitudinal slopes may result in water logging or stagnant ponds; however this may not be an issue in well-draining soils (e.g. coastal plain sands).

Erosion prevention

Erosion often occurs in the vicinity of crossings on waterways. Bridges or culvert crossings should be designed so that they do not obstruct flow or inhibit the migration of aquatic fauna. The design should ensure that the local hydrology and stream characteristics (e.g. meanders) remain essentially unchanged. Open span bridge/arch structures or low level floodway crossings are preferred where feasible to minimize interference with the natural flows and aquatic habitat of a river channel. If culverts are being used, then multi-celled box culverts that replicate the

cross section shape and size of the channel are recommended so that flows are not concentrated or flooding increased and to provide faunal passage.

At least one of the box culverts (located nearest to the bank) should be recessed below bed level to allow fish passage. Crossings should not be located at or near bends due to the potential to cause bank erosion. Erosion protection of the bed and banks in the vicinity of the crossing should be provided.

Direct discharge of piped storm water to a receiving waterway should be avoided where possible. Ideally, piped flow should cease at the boundary of the riparian area of the receiving living stream and flow made to spread out and filter through buffer vegetation before entering the waterway channel, where piped flow enters waterways, the invert level, size, slope and alignment should be designed to minimize potential impacts on the waterway.

Figure 3.18 Multi-celled box culverts

Table 3.9 Recommended flow velocities for various bed materials

Type of waterway bed material	Recommended maximum flow velocity
Rock lined channels (100-150 nun)	2.5-3.0 m/s
Grassed covered surfaces	1.8m/s
Stiff, sandy clay	1.3 – 1.5 m/s
Coarse gravel	1.3 -1.8 m/s
Coarse sand	0.5 – 0.7 m/s
Fine sand	0.2 - 0.5 m/s

Vegetation management

Managing vegetation in living streams is mainly addressing four key issues:

- Stabilizing natural surfaces against erosion by providing the necessary armouring.
- Attenuating and treating storm water flows.
- Improving aesthetic value of multiple use corridors.
- Improving the ecological value of the catchment.

Native plants that provide shade and have hard leaves that decompose slowly are essential elements of healthy stream ecosystems. In choosing appropriate species, the soil limits of the species should be taken care of. The hydro period and flow velocity is also important to plant species selection.

A vegetation plan is a useful tool for determining the area to be revegetated and/or the area of vegetation to be retained and enhanced, the range of soil types and riparian zones present, the number of plants/seeds required and timing schedule. A basic plan may include the following requirements:

- Define floodplain, embankment and channel bed area (m^2) requiring re-vegetation
- Characterize water quality salinity, nutrients and turbidity.
- Identify existing soil, vegetation community species and existing weed characteristics and extent in the waterway.
- Map the morphology (plan and cross section) and indicate annual flood line and points of erosion and deposition.
- Ongoing review of the success of the plantings and weed management.

The minimum recommended buffer of native vegetation adjacent to constructed waterways in urban areas is 10 to 20 m from the top of the bank full channel.

Maintenance

The successful rehabilitation of a healthy, ecologically functioning waterway is a long term process. Waterway engineering works should be inspected at least annually and, if possible, after each heavy rain. If problems develop, maintenance should be performed promptly to prevent additional, costly damage.

Common maintenance problems include weeds, eroded or bare areas, sediment deposits litter accumulation and inadequate plant establishment. Pre-treatment methods, such as filter strips or litter and sediment traps, upstream of the living stream will assist in managing maintenance by providing a designated area to remove these pollutants.

3.9.6 BIO-REMEDIATION

Bioremediation can be defined as any process that uses microorganisms or their enzymes to return the environment altered by contaminants to its original condition. Technologies can be generally classified as in situ or ex situ. In situ bioremediation involves treating the contaminated material at the site, while ex situ involves the removal of the contaminated material to be treated elsewhere.

Bioremediation includes a fungal-based remediation (mycoremediation) and plant-based remediation (phytoremediation). Mycoremediation is a process where hazardous organics are degraded or detoxified by fungi that are introduced to the contaminated soil. Phytoremediation is the use of plants to remove, degrade, or render harmless environmental contaminants, usually in combination with other technologies. Some plants, like the poplar tree in this case, have the ability to accumulate high levels of some contaminants into their tissues, removing the contaminants from the soil.

3.9.7 MAURI MODEL

The Mauri Model was created by Morgan (2006) to assess the impact of a certain event on the mauri, or life force, of a specific site. It can be used as a decision-making tool that helps to improve water management processes by making them inclusive of all knowledge sources available (indigenous and science based).

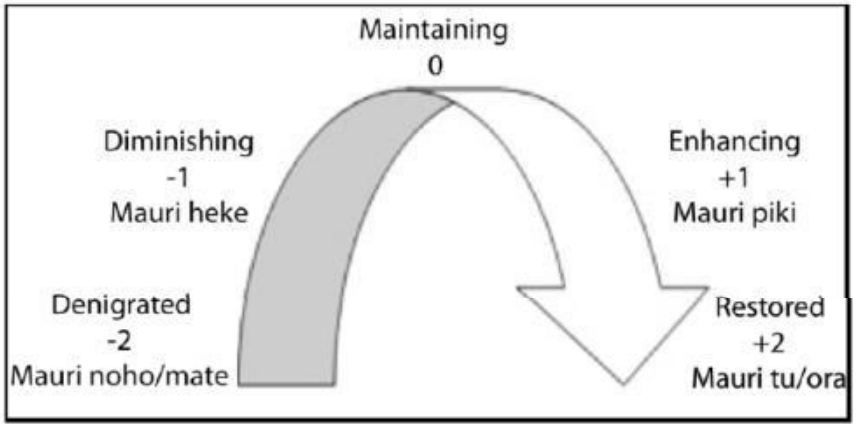


Figure 3.19 Graphical representation of the mauri assessment

Table 3.10 Mauri to Kopeopeo Canal: Integrating indigenous knowledge with bioremediation and the Mauri Model

	INDICATOR	Pre-dumping	Present	Post Bioremediation	
				Immediately following	After 20 years
ENVIRONMENTAL	Waste dumped on banks	2	-1	1	2
	Waste dumped into canal	2	-1	1	2
	Toxins in waste	2	-2	1	2
	Native biodiversity in canal	2	-1	1	2
	Native biodiversity on canal banks	2	-1	1	2
CULTURAL	Collecting food	2	-2	1	2
	Sacred place	2	-1	1	2
	Medicinal purpose	2	-1	1	2
	Red ocher for pigmentation	2	-2	1	2
	Flora collection	2	-1	1	2
SOCIAL	Swimming	2	-2	1	2
	Health	2	-2	1	1
	Fishing camps	2	-1	1	2
	Gathering place	2	-2	1	2
	Loss of respect	2	-1	1	2
ECONOMIC	Cost of bioremediation	2	-1	-1	1
	Food costs	2	-1	-1	1
	De-valued adjacent land	2	-1	1	2
	Research costs	2	-1	1	2
	Loss of potential earnings	2	-1	1	2
	Mauri Assessment	2	-1.3	0.80	1.85

Source: Annie Tran Geography: 333 Research Report Rough Draft

CHAPTER IV
STUDY AREA

4.1 GENERAL

The city of Kochi is located by the Lakshadweep Sea in Ernakulam district and is the commercial and industrial hub of Kerala. Geographically Kochi city is situated between Northern Latitude 9°58' and Eastern longitude 76°16'. The city is characterized by sandbars running in the North-South direction with tidal canals in between. The importance of Kochi in the region is evident from its population size and growth. Kochi Urban Agglomeration ranks seventeenth with a population of about 21.17 lakh. It is the largest urban agglomeration in the state and is widely referred to as the commercial capital of Kerala.

4.2 PHYSICAL FEATURES

4.2.1 Topography

Being a coastal district majority of the Kochi region is within the low land regions of the state. The average altitude towards the eastern fringes is about 7.5 m above MSL, and towards the west the altitude is less than one metre on an average. The whole of the land slopes gradually from east to west. The flat terrain of the central city with the low altitude interspersed with a network of canal system provide link to the backwaters. The main canals are navigable for small and medium crafts. The secondary canals used to serve as natural drainage canals in the city for flood waters, but today they are in an advanced stage of deterioration through silting and waste dumping and fail to serve their purpose. The effects of inadequate drainage become visible and real with flooding and water logging of low lying areas during rainy season.

The terrain features have adverse influence on the sewerage and drainage system of the area. Percolation of effluent from septic tank and dispersion trenches pollute the ground water. Commercial wastes are mostly directed to open surface drains. To ensure ruling gradient the drains have to be deepened often below the sea level and the sewage has to be regularly pumped to its outfall regions for disposal. The outfall regions are again the back waters. The back waters further take the load

of effluents from the industry, most of which are located in the water fronts and river side. The continued effects of all these factors result in the abuse of water courses, environmental deterioration and public health hazards.

4.2.2 Soil Type

The soil of the planning region can be broadly classified into two categories viz. alluvial and lateritic. The lateritic soil covers the eastern portion of the area. The soil is porous and well drained and hence suited for all garden works. On removal of the top soil, laterite is present as a homogeneous mass which can be cut as building blocks. The alluvial soil is the characteristic type seen over the remaining part of the city. It has been formed from the deposition and consolidation of river discharge laden with fine silt and clay. Soil exploration has revealed that this deposit is present even to a depth of about 50 metre from the sea level. This fact presents the unique foundation engineering problems of this area.

4.2.3 Climate, Rainfall and Waterbodies

The annual variation of temperature in the Kochi region is between 220 C and 320 C and a more or less uniform temperature exists throughout the year. Because of the nearness to the sea and due to the large area of backwaters in the region, the humidity is high all round the year. Kochi has a tropical climate with intense solar radiation and abundant precipitation.

Kochi region experiences only two major seasons, namely the dry season and the wet season, as in all other places in Kerala. The wet season is usually associated with the months in which the south-west and north-east monsoon occur. The north-east monsoon commences in October and continues till November. The rain fall varies from 1500 mm to 2000 mm during south west monsoon and 400 to 700 mm during the north-east monsoon. The maximum annual rainfall in the region is around 3000 mm. Heavy showers during the monsoons over the whole of the state, sustains a system of rivers and estuaries originating from the Western Ghats. These rivers transport the sediments from high lands and mid lands to the plains and discharge them into Arabian Sea. The interaction between the river discharge and

the tidal forces has helped the sediment deposition, there by directly influencing the creation of lagoon system and land forms of Kochi.

The characteristic physical feature of Kochi is the expanse of backwaters and low lying wet lands. The backwaters of Kochi form part of the Vembanad water basin of the Central Kerala. This, together with a number of canals provides the cheapest means of transportation, especially for bulk goods to and from the city. However due to misuse these canals are not adequately used as waterways for transport. These water bodies are often made to contribute to environmental degradation due to waste dumping and other misuses.

The backwaters are rich in their marine foods and hence form the means of livelihood for a large portion of the population. Further, it presents great potential for recreation. The wet lands are formed by the gradual leaching of dry land into the flood basins of the watercourse, canals and estuaries. They remain covered by water during rainy seasons, but in summer they partially dry up and become suitable for paddy cultivation. With spiraling labour cost and decreasing size of holdings, presently they are mostly left uncultivated. More often, they are used for pisciculture by bunding and in filling by water from the back water. Potential of converting the paddy fields and marshy lands into urban land has also led to indiscriminate filling of such area in recent times; often creating possibilities of flooding and water logging in adjoining areas.

4.3 LAND USE

The land use pattern of a City is essentially a reflection of its economic and social form and structure. In view of the diversity in the economic and social structures of cities and towns, there are nearly as many patterns of land use. However, in general there seem to be several similarities in the pattern of land use in most cities and towns.

The existing land use pattern in Kochi Corporation area in 2009 is given in Table 4.1. The graphical representation of the same is shown in Figure 4.1.

Table 4.1. Existing Land Use in Kochi Corporation

S.No	Land use category	Existing area (Ha)	% share (gross)	% share (net)
1	Residential	5040.9	53.1	73.1
2	Commercial	211.6	2.2	3.1
3	Public &Semi Public	444.8	4.7	6.4
4	Industrial	173.5	1.8	2.5
5	Transportation	553.6	5.8	8.0
6	Parks and open areas	66.7	0.7	1.0
7	Paddy land/Wet land	441.0	4.6	-
8	Agriculture/Dry cultivation	10.2	0.1	0.1
9	Water bodies	2148.3	22.6	-
10	Other (SEZ and unclassified area)	397.3	4.2	5.8
	Total area (gross)	9488.0	100	-
	Total area (net)	6898.7		100

Source: Development Plan of Kochi City Region – 2031 (Draft)

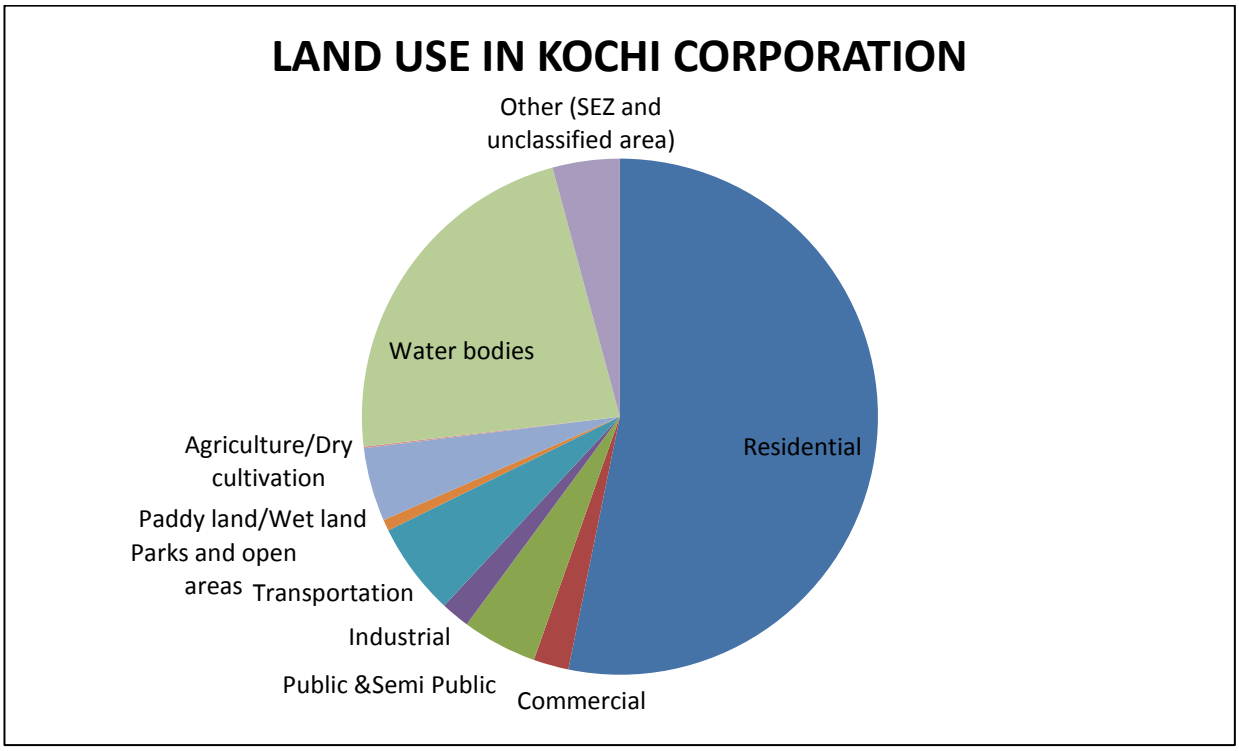


Figure 4.1. Existing Land Use Pattern in Kochi Corporation

It was observed that out of the net area (6,898.7 Ha) of corporation of Cochin, almost three-fourth of the area is under residential use (73.1%). The area under Transportation and Public & semi public uses is 8% and 6.4% respectively. The share of commercial and industrial areas within the corporation area is less than 3.5%.

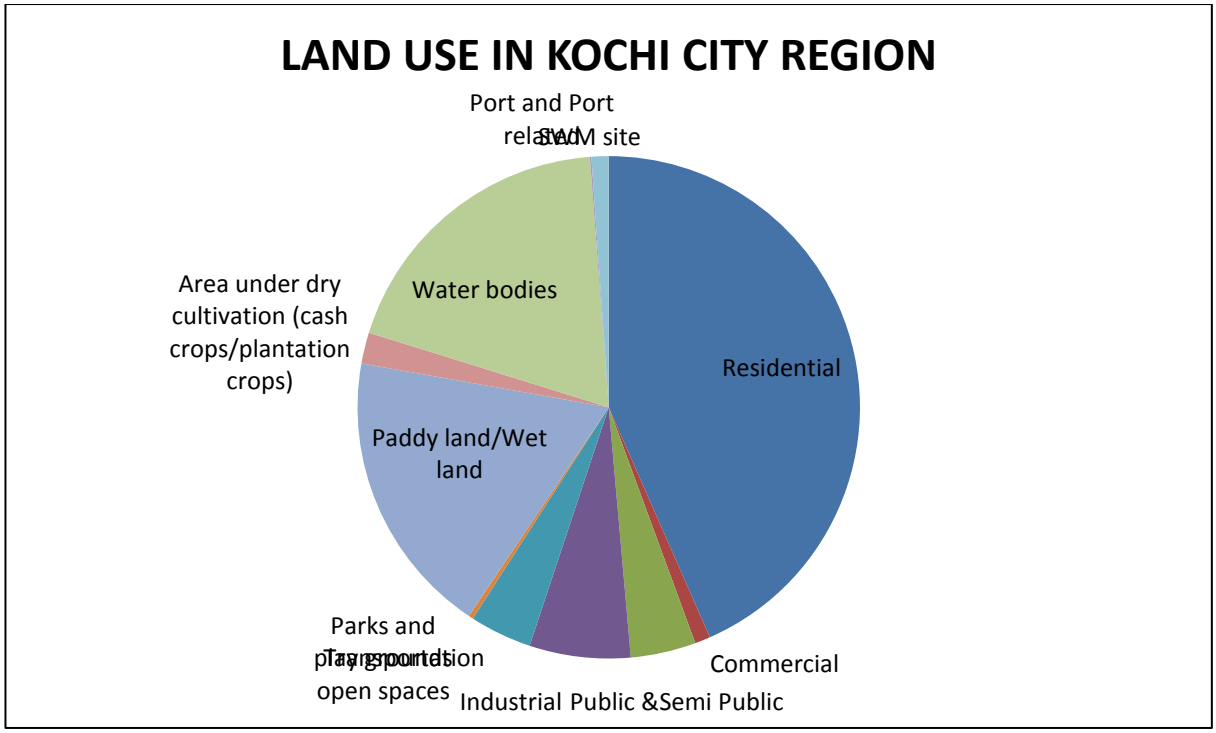


Figure 4.2. Existing Land Use in Kochi City Region

Table 4.2. Existing land use in Kochi City Region

S.No	Land use category	Existing area (Ha)	% share (gross)	% share (net)
1	Residential	16057.9	43.4	69.4
2	Commercial	367.1	1.0	1.6
3	Public &Semi Public	1538.37	4.2	6.6
4	Industrial	2404.61	6.5	10.4
5	Transportation	1486.35	4.0	6.4
6	Parks and play grounds open spaces	113.79	0.3	0.5
7	Paddy land/Wet land	6817.55	18.4	
8	Area under dry cultivation (cash crops/plantation crops)	754.06	2.0	3.3
9	Water bodies	7011.43	19.0	
10	SWM site	23.66	0.1	0.1
11	Port and Port related	397.3	1.1	1.7
	Total area (gross)	36972.12	100.0	
	Total area (net)	23143.14	-	100.0

Source: Development Plan of Kochi City Region – 2031 (Draft)

The existing land use distribution of Kochi City Region is given in Table 4.2. In this case as well the residential land uses have a predominant share (69.4%). The industrial land uses occupy the second major (10.4%) share out of the total net area of Kochi city region. The share of public& semi public uses and transportation is

almost the same at 6.5%. The graphical representation of existing land use in KCR is shown in Figure 4.2.

4.4 DEMOGRAPHY AND SOCIO-ECONOMIC PROFILE

4.4.1 Population growth trend in Kochi

The population growth rate of the Corporation of Cochin has been declining in the past few decades. The population had increased from 5.64 lakh in 1991 to 5.96 lakh in 2001 and eventually reached 6.02 lakh in 2011 as shown in Table 4.3. The growth rate has declined from 10% in 1981-91 to 1% in 2001-11.

Table 4.3.Population in Kochi Region

S.No	Name of Local body	Population 2001	Population 2011	Growth Rate 1991-01	Growth Rate 2001-11
1	Corporation of Cochin	595575	602046	5.5	1.1
2	Thripunithura municipality	59884	69390	17.2	15.9
3	Kalamassery municipality	63116	71038	16.1	12.6
4	Other panchayts	445650	437123	19.8	-1.9
	Total Kochi region	11,64,225	11,79,597	11.7	1.3

Source: Census of India-2011, Development Plan of Kochi City Region -2031 (draft)

Population Density in Kochi

The corporation of Cochin has a very high density as compared to the surrounding area and it is also the most densely populated city in the state. It has a geographical area of 94.88 sq.km, which is 1/4th of the total area of KCR, but more than 50% of the total population of the region resides here. The population density in Kochi area is shown in Table 4.4.

Table 4.4. Population Densities in Kochi Area

Administrative Division	Area (Ha)	Population (in Lakh)		Density (PPHa)	
		2001	2011	2001	2011
Kochi corporation	9488	5.95	6.02	62.8	63.5
Kochi city region	36972	11.6	11.8	31.5	31.9
GCDA	63200	18.1	21.2	28.6	33.5

Source: Development Plan of Cochin Region – 1976, Development Plan of Kochi City Region – 2031 (draft), Census of India-2011

4.5 INDUSTRY

Industrialization process of the region was started with the establishment of Fertilizers and Chemicals Travancore Limited in 1947. A number of major industries including Hindustan Machine Tools Limited, Cochin Refineries, Fertilizers and Chemicals Travancore Ltd (FACT), Binani Zinc Ltd, Appollo Tyres, Indian Aluminum, port based Cement bagging industries etc. have come up in the district. Due to the existence of Cochin Shipyard along the side of Ernakulam Channel, the Cochin region has become the hub of industrial activities in the State. Other prominent industrial areas include Eloor-Edayar, Kakkanadu, Ambalamugal, Aroor, Angamaly, Aluva, Thrippunithura, Perumbavoor and Vyppin islands. The existing industrial area is distributed over an area of 7,000 acres and employing more than 2 lakh people. With the prospect of establishing prestigious projects like Infopark and Smart City Cochin is expected to become the leading IT destination in Kerala State. In addition, the development of Vallarpadam Container Terminal, LNG Terminal, Petrochemical Complex, proposed outer harbour project of Cochin port, Biotechnological Park, etc in Cochin would further enhance the industrialization process of this region.

4.6 TOURISM

Kochi is referred to as the 'Queen of the Arabian Sea' and has in store for visitors some heritage sites as well as historic ones with a landscape crisscrossed by backwaters, which meet the Arabian Sea at various points. Ernakulam district hosts the highest number of international and domestic tourists in Kerala. Major tourist attraction in Ernakulam district include backwaters of Kochi, Marine Drive, Fort Kochi, Hill Palace, Mattanchery Palace, Jewish Synagogue, Santa Cruz Basilica, Bolghatty Palace, Kochi International Marina, Willingdon Island, Cherai Beach, Museum of Kerala History, St.Francis Church, Koonankurishu Church, Fort Emmanuel, Pallipuram Fort, Kodungallur Bhagavathy Temple, Kanjiramattom Mosque, Mangalavanam Bird Sanctuary, Kalady, Bhoothathankettu, Chottanikkara Temple etc.

4.7 TRANSPORT CONNECTIVITY

Three major national highways connect Kochi with other parts of the country. NH 544 from Panavel to Kochi, connects Kochi with Mumbai via most of the major towns in the Malabar area, the west Karnataka port town of Mangalore and the State of Goa. The NH 66from Kanyakumari to Salem via Ernakulam connects Coimbatore and Salem in Tamil Nadu via Palakkad and Thrissur. NH 85connects Kochi with Thondi point in Tamil Nadu and passes through Madurai via the hill resort of Munnar. Kochi is well connected to other parts of state through various state highways.

Cochin International Airport at Nedumbassery (near Angamali town), 28 km from the city, is the largest airport in Kerala in terms of passengers and number of flights. The airport is well connected by many international & national carriers that operate regular flights to the Middle East and elsewhere in Asia. Many direct chartered services from Europe and the US reach Kochi during tourist seasons. Domestically the airport is well connected to the other main cities in India.

Kochi is well connected to major urban centres in the state as well as to other places through major railway lines namely Thiruvananthapuram – Palakkad railway line via Kottayam and Alappuzha and Thiruvananthapuram – Shoranur- Mangalore line.

4.7.1 Kochi Metro Rail

Kochi Metro is a mass rapid transit system under construction for Kochi city in the district of Ernakulam. The 25.65 km metro line runs from Aluva to Petta includes 22 stations. The proposed metro rail will be completed in phases. The first phase of construction began in June 2013 and is expected to be completed by 2017. The Kochi metro will feature a single line route. It will start from Aluva and pass through stations such as Kalamassery, Cochin University of Science and Technology (CUSAT), Pathadippalam, Edappally Junction, Changampuzha Park, Palarivattom, Nehru Stadium, Kaloor, Town Hall, Madhava Pharmacy, Maharajas College and Ernakulam Junction.Phase II includes an extension from Aluva to Angamaly via Cochin International Airport, an extension from Petta to Tripunithura, and a branch line from Palarivattom to Infopark via Kakkanad.

4.7.2 Inland Water Transport

Kochi has a good network of inland waterway system consisting of backwaters, canals and lagoons. National waterway- 3 connecting Kollam and Kottappuram pass through the region. Major canals in Cochin region are Edapally canal, Thevara-Perandoor Canal, Chilavanoor canal, Thevara canal, Market canal, Mullassery canal, Manthara canal, Rameswaram canal, Pandarachira canal, Pashni thodu and Pallichal thodu.

Currently, there are very limited passenger boat services operating from Ernakulam jetty and High court jetty. The main routes served by the inland water transport are Ernakulam-Fort Cochin, Ernakulam– Mulavukadu, Ernakulam-Bolghatty, Ernakulam-Varapuzha, Ernakulam-Mattancherry and Ernakulam–Vyppin. Goods transport through waterways is also on the decline due to development of road transport facilities. Goods traffic movements are mainly handled from Murukkupadom jetty and Thevara jetty. There are three oil barges and four water barges operating from Thevara jetty and two water barges operating from Murukkupadam jetty. Other goods movements include 16 barges operating from Cochin port to FACT by KSINC.

4.8 Study Stretches

The canals selected for this study are as follows;

1. Edapally Canal
2. Chilavanoor Canal
3. Thevara – Perandoor Canal
4. Thevara Canal and
5. Market Canal

Edappally Canal, Thevara - Perandoor Canal and Chilavannur Canal are three major canals in Kochi City aligned in the North - South direction, cutting across the heartland of Ernakulam main land. Edappally Canal provides an easy link between the two industrial hubs of Kochi namely - Udyogamandal and Ambalamugal. It is connecting the Muttar River a branch of Periyar River on northern end and Chitrapuzha River on Southern end. Improving this canal will

facilitate economizing the transportation cost of cargo movement between these two industrial hubs. Chilavanoor canal and Thevara-Perandoor is also connected with Periyar River and both the canals having connection through Thevara canal on southern side. The development of Thevara Canal will reduce the navigable distance between Kundanur and Venduruthy Backwaters. The Market Canal is passing through Broadway and the Market road - the commercial hub of the City - where the bulk of wholesale and retail activities of the city take place. The canal, once developed will provide a good potential for diversion of goods traffic through waterways, thereby decongesting the main roads leading to the Market area. The Marine drive at the starting of the canal is a main tourist attraction. Thus, the development of these canals will facilitate passenger and cargo movement through waterways in addition to augmentation of tourism potential of the Kochi City. Figure 4.3 shows the study area map.

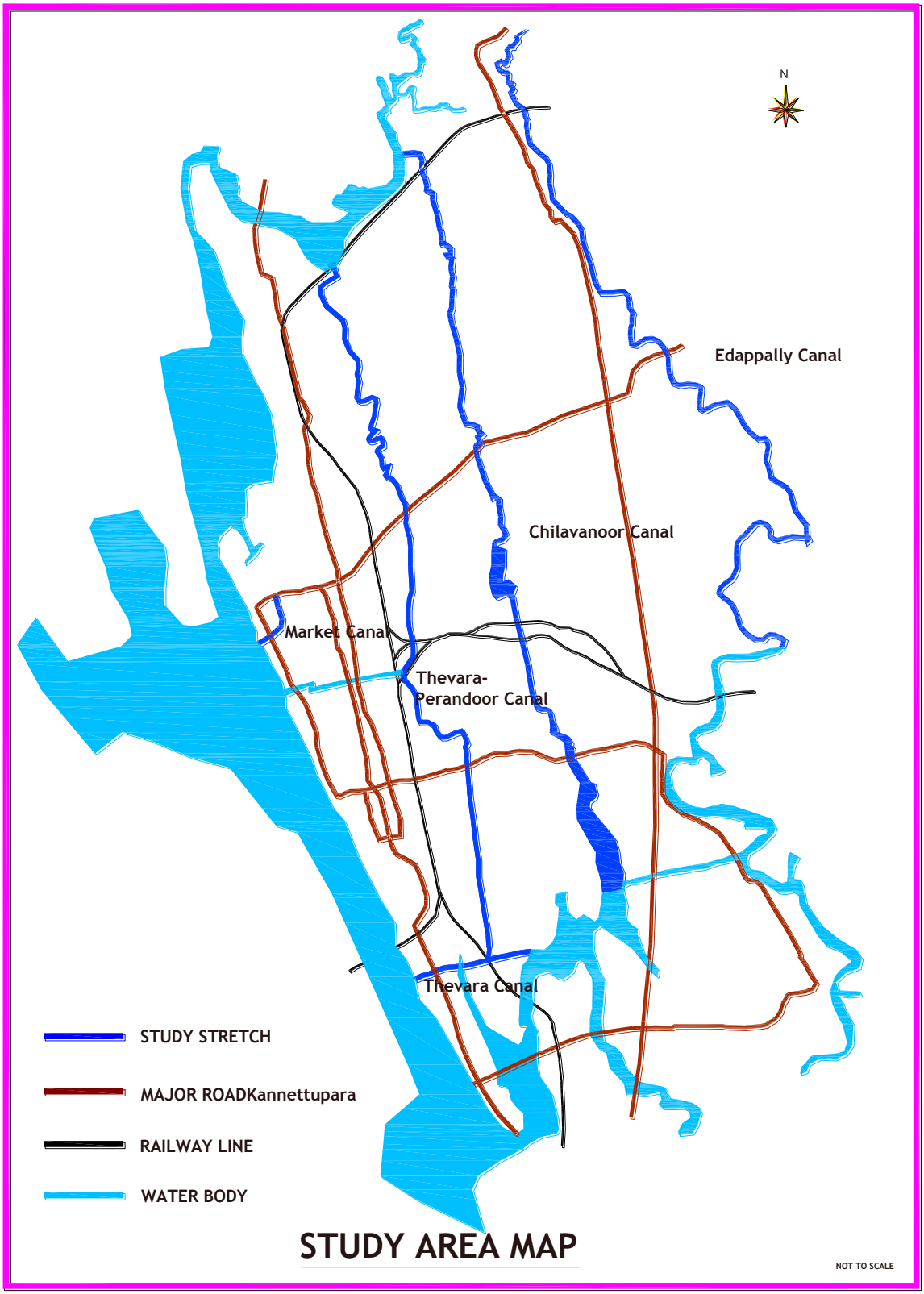


Figure4.3. Study Area Map

CHAPTER V

METHODOLOGY

The methodology started with a reconnaissance in which existing activities and environmental condition of the canal has been identified. Canal inventory, data related to present condition of the canal, details of households/encroachments and its location were collected to find out the existing problems and to assess the development strategy and future potential of the canal. The detailed methodology adopted for this study is described below:

5.1 Literature Review

In order to develop a proper and exact procedure to achieve the objectives of this study, a comprehensive review of the previous available reports were undertaken. Special attention was given to specific aspects like estimation of dredging quantity, bank protection measures, cross structures, operational characteristics, land acquisition, resettlement and rehabilitation, water quality analysis, sewage and solid waste disposal, improvement proposals, tourism prospects, cost estimation, investment details, technical, financial and economical feasibility. Best practices being followed both in India and abroad have been studied.

5.2 Collection of Secondary Data

Secondary data was collected to know about the previous condition of the canal stretch, utility etc. Discussions were held with officials of Coastal Shipping and Inland Navigation Directorate, Irrigation Department, Revenue Dept., Inland Waterways Authority of India, Survey of India Dept., District Tourism Promotion Council and other various stake holders including local residents. The data collection was done from various sources including previous reports and from various agencies.

5.3 Reconnaissance, Inventory and Status Survey

A detailed reconnaissance stretch-wise study was conducted to assess the present condition of the canal. The missing links in Chilavanoor canal and Thevera-Perandoor canal are identified. Other bottlenecks such as insufficient width, shallow depth, points of discharge of sewage, dumping of solid waste etc were located.

Detailed inventory and data on present condition of the waterway were collected including vertical& horizontal clearances, type, connectivity and condition of cross structures. The number of households within the designed buffer zone of 12m canal and 20m wide canal were identified. It includes the type of houses like thatched roof, tiled roof, katcha/pakka house, RCC, etc and number of floors. The existing bank protection and its condition were also recorded. The environmental constraints such as weed growth, sources of water pollution, locations of discharge/ disposal of sewage and solid waste into canals etc were also included in the inventory. The detailed topographic and hydrographic surveys will be conducted to obtain the actual morphological condition of the canal at the DPR stage.

5.4 Environmental Status Survey

Water samples at 15 locations were collected where there is change in the characteristics of water and tested in the laboratory for parameters like pH, temperature, turbidity, conductivity, total dissolved solids, total hardness, chloride, sulphate, nitrate, iron, calcium, magnesium, Chemical Oxygen Demand, total suspended solids, and E-coli.

5.5 Estimation of Dredging Quantity

The existing bed profile of the canal and water level were collected at every 100m cross sectional interval using manual method. The width of canal was collected using Distometer having accuracy of ± 2cm. Due to the absence of tidal action; it is assumed that the existing water level is the lowest low water and hence considered as datum level and the dredging quantity was estimated accordingly. The dredging estimation has been done for two scenario viz. 12 m wide and 20 m wide canal.

5.6 Navigational Aids

The navigational aids include shore marks, channel marks, information, warning and direction signboards etc are proposed for the study stretch. Information boards shall indicate the adjacent important places with distance. At road bridges and rail bridges these boards can give the details of the nearby places and route network. Warning signs should show the clearance restriction under bridges, narrow canal, bends & curves, depth constraints, feeder canal crossings etc. Channel

markings are proposed for demarcating the fairway. In wider reaches buoys with reflectors/light are also proposed to be installed to show the right of way.

5.7 Land Acquisition and Resettlement & Rehabilitation

The land required to make canal navigable was estimated considering the proposed design width. This has been done under two scenario viz. 12 m and 20 m wide (bottom width) fairway. The details of existing structures like type of building, number of floors, built up area etc were also collected. The survey numbers of the buffer zones i.e 100 m approx from the centreline of the existing water body was collected from concerned village offices. As per The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 the detailed study in this regard will be carried out at DPR stage.

5.8 SWOT Analysis

SWOT analysis is a structured planning method that evaluates four elements strength, weakness, opportunity and threats of the project. It involves specifying the objective of the project and identifying the internal and external factors that are favourable and unfavourable to achieve that objective. The internal factor means that the strengths and weaknesses internal to the project and the externals factors- the opportunities and threats presented by the environment external to the project. The internal factors such as financial resources, physical resources, human resources, natural resources and its accessibility were identified. The external factors like political, environmental and economic regulations of the project were also identified. With the consideration of all these factors, the SWOT matrix for all the canals was prepared.

5.9 Improvement Proposal

Development proposals were identified to make the canal navigable which includes dredging/ desilting, widening, protection of banks, improvement of the canal, provision of navigational aids, construction of jetties/ landing places, improvement of approach roads, reconstruction of cross-structures with inadequate clearance and removal of other impediments, sewage and sewerage treatment facilities, land acquisition, resettlement & rehabilitation and safety measures etc.

In order to sustain the utility of the canal, locations were identified to develop spots for tourism activities. Canal beautification schemes are also outlined.

5.10 Cost Estimation

The activities required for development of the canal for navigation was identified and the quantities were computed. The rates are arrived at in consultation with the State/ Central departments to estimate the project implementation cost.

CHAPTER VI

ANALYSIS OF EXISTING SITUATION

6.1 EDAPALLY CANAL

Edapally canal starts from Muttar bridge (10° 02' 36.78"N and 76° 18' 12.40"E) and connects with Champakkara Canal (part of NW-3) near Eroor bridge (09° 58′ 46.47"N and 76° 19′ 56.29"E) as its end point. It passes through Edapally, Vennala, Chakkaraparambu and Chalikkavattom. This canal provides the shortest link between the two industrial hubs of Kochi namely - Udyogamandal and Ambalamugal. Improvement of this canal will facilitate reduction in transportation cost of cargo movement between these two industrial hubs.

Total length of the canal is 11.15km. Canal width varies from 28.72m (average) and depth ranges between 0.8m to 1.30m (average). It is perennial water body and presently, there is no visible water flow in most of the portions of the canal.

6.1.1 Details of Cross Structures

Different types of cross structures are observed along the canal. The location, type, length, width, No. of span, horizontal clearance, vertical clearance and connectivity details were collected. It is observed that, 18 cross structures are existing along the canal which includes 15 road bridges, 2 rail bridges and one foot over bridge. The details of cross structures are given in **Table 6.1.**

In the case of 12m and 20m wide designed canal, the horizontal and vertical clearance of 20m and 4.0m is assumed for an effective movement of vessel operation. The horizontal clearance of Muttarkadavu bridge, oriental timber bridge and temporary wooden bridge is not sufficient for vessel movement at present. Three cross structures namely, Puravankara New bridge, Arakkakadavu bridge and Kuzhuveli bridge are having desired vertical clearance. At Edapally NH bridge, debris of construction waste from Kochi metro is blocking the water flow as well as resulted less vertical clearance and all other cross structures have less horizontal and vertical clearances.

Table 6.1. Details of Cross Structures – Edapally Canal

CHAINAGE(km)	NAME OF BRIDGE	TYPE OF BRIDGE	COORDINATES		NO. OF SPAN	LENGTH (m)	WIDTH (m)	CLERANCE(m)		REMARKS
			LAT	LONG				H	V	
1	Muttarkadavu Bridge	RCC Road Bridge	10°2'35.9"	76°18'11.8"	1	7	2.5	6.1	1	From NH47 to Muttarkadavu Jn.
2	Indraji Bridge	RCC Road Bridge	10°2'10.1"	76°18'13.2"	1	19.2	7.8	13	3.4	To Kalamassery toll; 2 pipelines (30cm dia)
3	Railway bridge 1	Steel Rail Bridge	10°2'10.1"	76°18'13.2"	1	20.4	2.2	17.7	3.3	2 pipelines (35cm dia, 15cm dia)
4	Railway bridge 2	Steel Rail Bridge	10°2'9.9"	76°18'13.4"	1	20.4	2.2	17.7	3.3	2pipeline (8cm dia); 2 pipeline (10cm dia); 4 pipeline (5cm dia)
5	Chembakadavu bridge	RCC Road Bridge	10°1'58.8"	76°18'16.8"	1	13.5	7.7	12	3.5	new bridge under construction
6	Inside Lulu mall	RCC Road Bridge	10°1'35.3"	76°18'26.9"	1	16.4	16.6	12.3	3.5	Inside Lulu mall car parking
7	Edapally bridge (NH)	RCC Road Bridge	10°1'32.2"	76°18'30.1"	1	30.4	30	14.8	2	Edappally to Thrissur road
8	Marattichodu bridge	RCC Road Bridge	10°1'23.3"	76°18'37.8"	3	34.1	6.7	19.2	3.8	Edappally to Thrikkakara road
9	Oriental timber bridge	RCC Road Bridge	10°1'12.1"	76°18'40.5"	1	12.9	3.7	9	3.5	bridge to timber godown
10	Temporary Wooden bridge	Wood Foot over bridge	10°1'3.7"	76°18'42.8"	4	18.5	1	2.5	1.5	connecting Pvtproperty
11	Puravankara Iron bridge	Steel road bridge	10°1'1.4"	76°18'43.7"	1	24.1	5.4	13.4	2.5	Puravankara Projects
12	Puravankarapvt bridge	RCC Road Bridge	10°1'1.5"	76°18'44.3"	1	27.6	16.3	15.7	4.9	new bridge under construction
13	Pipeline bridge	RCC Road Bridge	10°0'52.9"	76°18'57.4"	1	25.6	4.2	16.9	2.5	To Cherumuttapuzhakara
14	Ayyanad bridge1	RCC Road Bridge	10°0'38.2"	76°19'11.2"	1	24.4	7.1	16.2	2.6	To Thrikkakara
15	Ayyanad bridge2	RCC Road Bridge	10°0'37.6"	76°19'11.4"	1	17.1	8.5	13.4	3	To Thrikkakara
16	Palachuvadu bridge	RCC Road Bridge	9°59'58.7"	76°19'50.1"	1	26.4	8	13.8	2	Vennala to Palachuvadu
17	Arakkakadavu bridge	RCC Road Bridge	9°59'27.4"	76°19'42.0"	1	24	8.5	21.1	4.5	3 pipelines 3" dia
18	Kuzhuvelippalam	RCC Road Bridge	9°59'56.1"	76°19'37.6"	1	21	3.3	19.1	4	To Kuzhuveli Temple

6.1.2 Present Condition of the Canal

Canal is highly silted and polluted by domestic waste, commercial waste, construction waste, weeds growth and other sources. The canal is divided in to eight stretches according to width, depth, population density and accessibility. The **Figure6.1** shows the study area and its divisions.

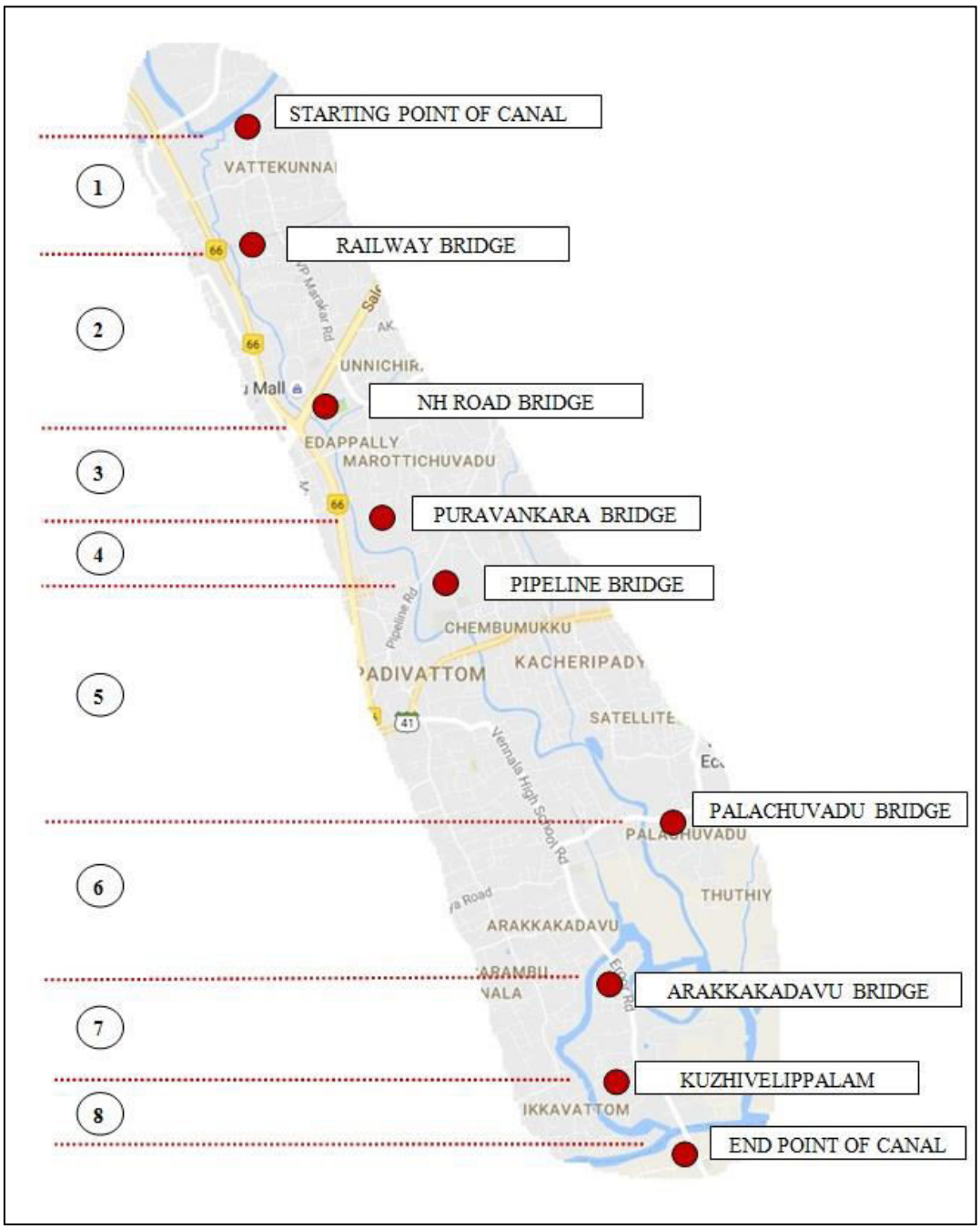


Figure 6.1. Study area Map of Edapally Canal

The present condition of the canal described section wise in detail is follows;

Section I: Canal Starting Point – Railway Bridge (0.00km – 1.11km)

The canal originates from Muttar River and is connected through a branch of Periyar River. Also the starting point of canal is having road connectivity with National Highways at Muttar junction (400m away). The length of the section is 1.11km.The average width of canal varies from 10.93m and the depth ranges from0.4m to 0.7m was observed. Due to the absence of tidal action, very minimal velocity of flow was observed.

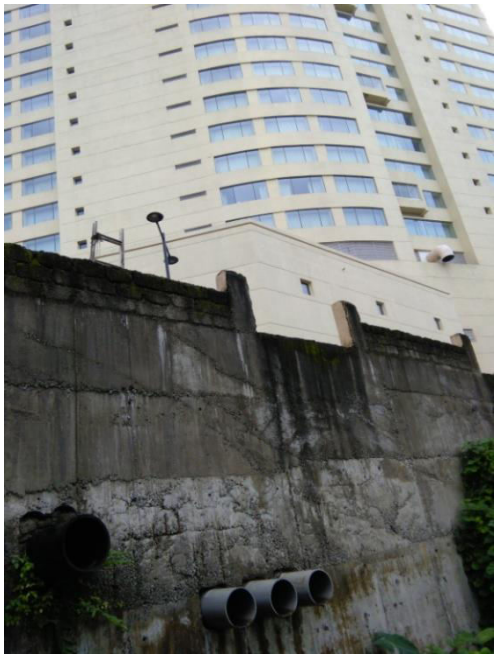
The settlement on left bank was thick up to 0.2km chainage. Damro furniture go-down construction was under progress at 0.5km. Indiraji bridge connecting National Highways and Kalamassery toll Jn. and minimal amount of commercial activities held around this part of the canal. Two Confident Pride Flat with G+11 and G+12 floors construction was under progress and the compound wall of the flats constructed on the top of left bank between 0.75km and 0.85km. In general, the land use pattern up to 150m observed as marshy land and parcels of coconut cultivation was also present. The canal bank was not protected up to Indiraji bridge and RR type bank protection with slope 1:1.5 was observed from Indiraji bridge to Railway bridge.

On right bank, marshy land was observed from the starting point to 0.3km. Settlers along the bank were also less and mixed vegetation was the predominant land use pattern on right side. Open and vacant land was existing up to 200m along the canal. The banks were protected between 0.25km and 0.43km and the stretch between Indraji bridge to Railway bridge by RR masonry with 1:1.5 slope.

Section II: Railway Bridge – NH Road Bridge (1.11km – 2.46km)

This section of the canal is running parallel to National Highways 47 and ends with NH 17. Kochi Metro Construction is under progress at the end of this section. The length of this section is 1.35km. Average width of canal was12.33m and the depth of the canal was observed as 0.3m to 0.5m.

There were seven drainage pipes varying different diameters connected to the canal on left side. Residential activity was relatively less at left bank and at end of this section is occupied with LuLu mall a large commercial centre. In between,



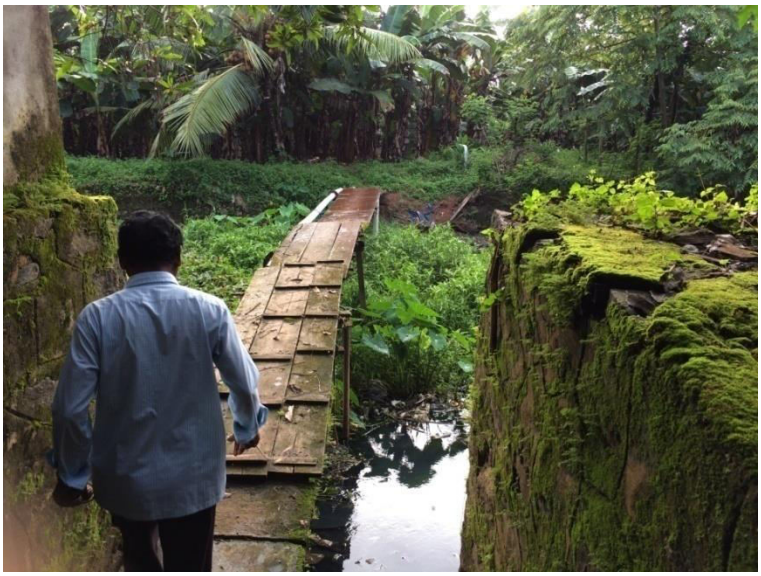
Chembakkadavu bridge at 1.49km was observed. Vacant land at few places was also observed between 1.3km to 1.8km. The retaining wall on left bank was constructed from 1.95km to 2.46km i.e. Lulu mall area and the parking area of the mall is connected through the bridge at 2.33km. At the end, the construction waste from Kochi Metro is temporarily blocked the flow of canal. The bank is well protected throughout the section and the weeds growth is the major concern in the view of water flow.

Open marshy land was observed up to 1.35km on right side. Thereafter, residential and commercial activities equally balanced the land use pattern. Lulu mall parking and metro construction occupied towards the end of this section. Two Skyline apartments having G+11 floors existing along the canal at 2.05 km. RR masonry bank protection having slope of 1:1.5 along the canal is protecting the banks.

Section III: NH Road Bridge – Puravankara Bridge (2.46km – 3.54km)

The total length of canal section is 1.08 km. It is having an average width of 14.92 m. The depth of the canal varies from 0.2m – 0.4m. Due to the metro construction the canal flow is restricted and it has resulted in higher amount of siltation. This section is having 4 cross structures.

The commercial activities are predominant at the starting point of the section. Upto Marottichodu bridge the canal is narrow and the wider canal is existing towards the end of the section. The apartments mainly Trinity and Palladium are existing between 2.6 km and 2.8 km. The residential buildings on the left bank are very minimal. At 2.69 km a small channel having 9 m width is connected to the left bank of the canal. Oriental Timber godown is existing at 3.18 km on the left bank of the canal. The chainage between 2.83 km – 3.05 km, the land use pattern is observed as marshy land. Two drainage channels having width of 1.5 m are connected to the canal on left bank at 2.55 km and 3.51 km respectively. Random rubble masonry type bank protection is existing between 2.6km-3.2 km on left bank.



The metro construction activities at the starting point of the canal is spreaded over 30 sq.m (approx) the right bank. The commercial activities are extended upto 3.2 km on the right side up to Puravankara Bridge. An 8 m wide channel is existing on right bank at 3.45 km. The bank protection starts at 2.84 km and ends at timber godown bridge (3.2km).

Section IV: Puravankara Bridge – Pipeline Bridge (3.54km – 4.15km)

The length of this section of canal is 0.61 km. The average width of the canal is 16.03 m. The wider portion of the canal starts from this section. The average depth of the canal varies from 0.4m – 0.6m.

Vacant land and marshy land are the major land use on left bank upto 3.9 km. Maruthi Service Centre having 4 buildings is existing on left bank between 4.0 km and 4.1 km. The bank is protected between 3.9 km-4.15 km stretch of the canal.

After Puravankara bridge a cluster of houses are existing until 3.8 km on the right bank. The vacant land starts from 3.9 km and extends upto the end of this section. Two pipelines of diameter 1m and 1.5m are passing across the canal near the pipeline bridge. The bank protection starts from 3.9 km and ends at 4.15 km.

Section V: Pipeline Bridge – Palachuvadu Bridge(4.15km – 7.24km)

The total length of canal section is 3.09 km having an average width of 22.8 m. The depth of the canal varies from 0.8m to 1.6m. It is having potential navigation possibilities without further land acquisition.

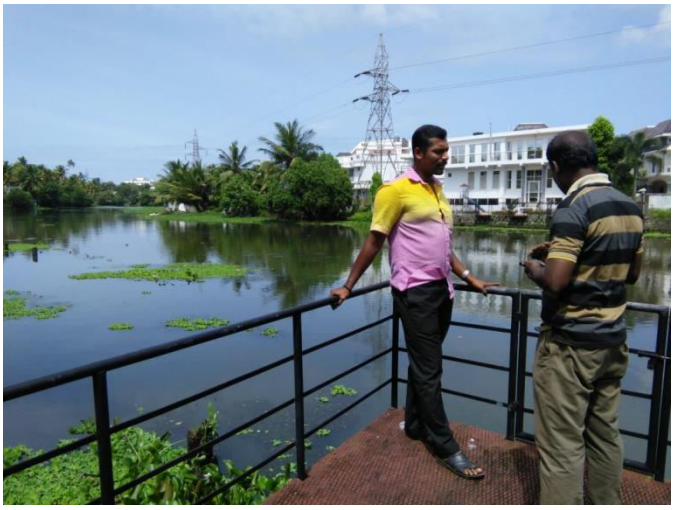
Assisi Vidhyaniketan Public School and SnehaNilayam Special School are the notable landmarks in this section. At Ayyanad the canal is having 2 bridges at 5.7 km which connects Thrikkakara town. A water body having area of 9500 sq.m is speaded over adjacent to the left bank between 6.5 km-6.65 km. There are 6 channels on left bank connected with the canal having width varying from 1.5m-3.5 m. 80% of the land on left bank is marshy, vacant and mixed vegetation. The canal is protected between pipeline bridge and Ayyanad bridge by random rubble masonry having slope of 1:1.5. The natural bank protection measures are existing on rest of the banks of the canal.

On right side four Penta Queen Apartments having G+7 floors are at 4.6 km-4.72 km which are closer to the bank. The chainage between 4.72 km- 4.95 km the land use consist of higher number of residential buildings. At 5.00 km Geojit building G+11 floors exist closer to the bank. Mather Apartments with G+11 floors is also existing at 5.2 km. Scattered residential buildings are noted down between 5.3 km and 5.5 km. Marshy land is existing between 5.5 km-5.7 km. Again the residential buildings extend up to 5.9 km. There after the land use pattern is marshy and vacant up to the end of this section. At 4.58 km, a channel having 3.5m width is connected to the canal. The bank is well protected from starting point to 5.2 km.

Section VI: Palachuvadu Bridge – Arkkakadavu Bridge (7.24km – 9.26km)

The total length of this canal section is 2.02 km having an average width of 42.6 km. The average depth varies from 1.3m to 2.2m. The canal is having connection with Chithrapuzhariver, i.e., Vytilla- Kakkanad boat service route. It starts at 8.3 km. Again the branch rejoins at 8.8 km of this section. A water body namely Kallikuzhy having an area of 13500 sqm(approx) is held between 7.9 km-8.15 km stretch of the canal on left bank. There is no accessibility throughout this section. Marshy land is the predominant land use pattern on both banks. One channel having 1.5 m width is connected at 8.85 km on the left bank. Similarly on the right bank 2 channels of 3m and 1m width are connected at 7.32km and 7.51 km respectively. Both the banks are not protected throughout the section.

Section VII: Arkkakadavu Bridge – Kuzhuvelippalam (9.26km – 10.44km)



This section is having 1.18 km length of the canal. Average width of the canal in this section is 48.15 m. The depth of canal varies from 1.4m to 2.1m.The wider portion of the canal is extended in this section too. River Dale Recreation centre and Good Earth apartments are the notable landmarks on the left side of the canal. The residential buildings on the left side are relatively less. Marshy land is the major land use pattern and it extends towards the end of the canal. The bank protection is existing between 9.27 km-9.62 km, 9.9 km-10.0 km, 10.1km-10.44 km respectively on the left side. 110 KV line is passing over the canal at 9.6 km.

On the right bank, the residential buildings are existing between 9.7 km-10.15 km. Marshy and Vacant land are the other land use pattern on right bank. Except 9.65km-9.8km, 10.0km-10.1km, 10.2km-10.44 km, the canal banks are well protected.

Section VIII: Kuzhuvelippalam – Canal Ending Point (10.44km – 11.15km)

The length of this section is 0.71km and is connected with Chithrapuzha river. It leads the connection between Chambakkara canal of National Waterway 3, a commercial centre. The average width of the canal is 62m and depth varies from 1.4m to 2.4m. There is no commercial activities in this section and very few houses on left side towards the end of the canal is observed. On the right side, scattered houses exist between 10.5km-10.8km. The banks are well protected on both sides throughout the section.

6.2 CHILAVANOOR CANAL

Chilavanoor canal originates from Champakkara Canal (09° 57' 11.27"N and 76° 18' 49.22"E) of National Waterway- 3 and ends at PerandoorPuzha (10° 01' 53.39"N and 76° 17' 23.49"E) back side of the Amritha Institute of Medical Science (AIMS), Edapally. The canal passes through Chilavanoor, Elamkulam, Kathrikkadavu, Kaloor, International Stadium and Elamakkara.

The wider portion of the canal is existing for the stretches starting point of the canal to SCB road bridge and Edapally Ragavan bridge to end point of the canal. The major bottle neck is missed link between 6.79km -6.86km i.e. the canal portion passing Kaloor - Palarivattom road. Due to metro construction the canal is diverted through a pipeline and it passes through KSEB Sub-Station, Kaloor premise covered by concrete slabs. The same situation is extended up to the chainage 7.19km i.e., end of KSEB, Kaloor sub-station end. Again the canal is covered by RCC slab between the sections 7.25km – 7.30km and 7.585km – 7.65km. Similarly, average width of 1.5m RCC slabs of 5 Nos. exists between Keerthinagar bridge to BTS road bridge.

The canal is divided in to eleven stretches according to width, depth, population density and accessibility. The **Figure 6.2** shows the study area and its divisions.

Total length of the canal is 11.023 km. Canal width varies from 3.5m to 200m and the average width is 34m and depth ranges between 0.6m to 1.1m.

6.2.1 Details of Cross Structures

Different types of cross structures are observed along the canal. The location, type, length, width, No. of span, horizontal clearance, vertical clearance and connectivity details were collected. It is observed that, 38 cross structures are existing along the canal which includes 30 road bridges, 3 rail bridges and 5 foot over bridges. The details of cross structures are given in **Table 6.2.**

Table 6.2. Existing Cross Structures in Chilavanoor Canal

S.NO	CHAINAGE (km)	NAME OF BRIDGE	TYPE OF BRIDGE	COORDINATES		NO. OF SPAN	LENGTH (m)	WIDTH (m)	CLERANCE (m)		REMARKS
				LAT	LONG				H	V	
1	0	Chilavanoor Bridge	RCC Road	9°57'15.9"	76°18'49.3"	3	36	10	11.9	1.5	Connects Chilavanoor to NH 47
2	1.53	Elamkulam Bridge-1	RCC Road	9°58'2.3"	76°18'33.6"	3	36.4	10.5	10	2	pipeline (30 cm dia)
3	1.53	Elamkulam Bridge-2	RCC Road	9°58'3.0"	76°18'33.2"	3	36.4	13.3	10	2	4 pipelines (10 cm dia)
4	2.24	Foot Over Bridge	RCC FOB	9°58'20.9"	76°18'21.5"	1	5.2	9.5	5	0.5	Bridge to house
5	2.27	Concrete Slab Bridge	FOB	9°58'20.8"	76°18'20.6"	1	8.3	1.8	7.5	0.5	Bridge to house
6	2.33	SCB Road Bridge	RCC Road	9°58'21.2"	76°18'18.7"	1	6.2	9.5	4.6	1.2	4 Pipelines (15cm dia),2 pipelines(3 cm dia), 1 pipeline (15cm dia)
7	2.57	Private Road Bridge	Steel FOB	9°58'28.5"	76°18'16.7"	1	7.5	1.4	5.5	0.8	----
8	2.83	St. Sebastian Road Bridge	RCC Road	9°58'36.6"	76°18'15.2"	1	8.5	3.6	8	1.5	1 pipeline(15cm dia), 1 pipeline (10cm dia), 4 pipelines(5cm dia)
9	2.91	Palathuruthu Bridge	RCC Road	9°58'39.5"	76°18'14.4"	1	9	3.8	3.9	0.7	1 pipeline(5 cm dia). Connects Palathuruthu to Kumaranasan road
10	2.97	Rail Nagar Bridge-1	RCC Road	9°58'41.3"	76°18'14.0"	1	11	4.8	10.1	2	----
11	3.1	Rail Nagar Bridge-2	RCC Road	9°58'42.7"	76°18'10.1"	1	13.1	4.5	11.8	1.4	----
12	3.44	Panorama Residency Road Bridge	RCC Road	9°58'44.5"	76°17'59.0"	1	13	4.5	9.3	1.8	1 Pipeline 10cm dia. Bridge to Panorama Residency
13	3.79	Steel Bridge	FOB	9°58'49.6"	76°17'49.5"	1	11.2	1	9.6	2	Steel walk way. 2 pipeline 90cm dia, 2 pipelines 75 cm dia, 3 pipelines 50 cm dia passing near by
14	3.81	Rail Bridge	Steel	9°58'50.2"	76°17'49.6"	1	22	18	8.1	2.5	4 rail bridges. 13 pipelines 7.5cm dia, 10 pipelines 5cm dia, 3 pipelines 2.5 cm dia, 1 pipeline 30 cm dia
15	3.93	Railway Quarters Bridge	RCC Road	9°58'52.8"	76°17'51.8"	1	15.3	4.8	10.8	2	----
16	4.66	Nazir Flat Temporary Bridge	Steel FOB	9°58'58.5"	76°18'10.3"	1	7.5	0.5	7	1	-----
17	4.77	Karanakoodam Bridge-1	RCC Road	9°59'1.7"	76°18'8.9"	1	14.7	4.5	8.1	2.3	3 pipelines 4" dia,1 pipeline 3" dia, 2 pipelines 2" dia, 1 pipeline 2m dia
18	4.77	Karanakoodam Bridge-2	RCC Road	9°59'2.0"	76°18'9.1"	1	14.7	8	8.1	2.3	1 pipeline 4" dia, 1 pipeline 3" dia
19	5.28	Skyline Bridge	RCC Road	9°59'15.2"	76°18'4.0"	1	9.5	6	6.4	1.5	Stadium Link Road to Skyline Imperial

											Gardens
20	5.36	IMA house Bridge	RCC Road	9°59'18.3"	76°18'5.7"	1	9	6.6	5.6	0.5	Stadium Link Road to IMA House Cochin
21	5.51	Vyloppilli Lane Bridge	RCC Road	9°59'22.8"	76°18'5.8"	1	6.3	4.7	6	1.1	Stadium Link Road to Vyloppilli Lane. 1 pipeline 3" dia
22	5.54	Private Bridge	RCC Road	9°59'24.5"	76°18'6.0"	1	9	12	5	2	Connection to private property
23	5.62	Kent Constructions Bridge	RCC Road	9°59'26.3"	76°18'6.1"	1	6.8	6.6	5.6	1.5	To Kent Hail Gardens Property
24	5.83	Foot Bridge	RCC Road	9°59'32.8"	76°18'4.9"	1	7.5	2.2	6.5	1	1 pipeline 1" dia
25	5.98	Noel Builders Bridge	RCC Road	9°59'38.1"	76°18'5.0"	1	9.7	10.5	9.5	2	Bridge under construction
26	6.27	Stadium Complex Gate Bridge	RCC Road	9°59'44.0"	76°18'0.6"	1	6.5	4	3.8	1.5	Near Entrance to Stadium Complex
27	6.54	Stadium Gate Bridge	RCC Road	9°59'51.5"	76°17'57.5"	1	6.5	4.5	5.1	1.3	Connects VIP road to Stadium
28	6.79	Concrete Bridge	RCC Road	9°59'59.0"	76°17'54.6"	1	5.2	2	4.7	1.7	Near Banerji road.
29	7.07	KSEB Bridge	RCC Road	10°0'8.1"	76°17'56.1"	1	9.4	3.8	2.5	1	Inside KSEB compound. Connected to 110 KV Kaloor Substation
30	7.34	Greenz Villa Bridge	RCC Road	10°0'13.5"	76°17'52.0"	1	4	4.5	3	1	Connection to Greenz Villa Residency
31	7.84	Comrade Nagar Bridge	RCC Road	10°0'23.9"	76°17'49.4"	1	3.8	3.8	2.3	1	2 pipelines 3" dia
32	7.96	SIUPS Road Bridge	RCC Road	10°0'27.7"	76°17'48.1"	1	3.6	5.1	3	0.8	At National Public School Road
33	8.30	Keerthi Nagar Bridge	RCC Road	10°0'38.2"	76°17'46.4"	1	6.7	3.7	4.5	1.5	At PottakuzhiMamangalam Road
34	8.59	Keerthi Nagar Extension Bridge	RCC Road	10°0'47.2"	76°17'44.3"	1	4	4.5	3.1	0.9	To Keerthi Nagar Junction
35	8.75	BTS Road Bridge	RCC Road	10°0'52.2"	76°17'43.1"	1	6.6	4	3.5	1.2	1 pipeline 6" dia,4 pipelines 4" dia, 1 pipeline 3" dia, 2 pipelines 2" dia
36	9.32	EdappallyRaghavan Pillai Road Bridge	RCC Road	10°1'10.5"	76°17'43.0"	1	11.7	6.4	7.6	2.3	1 pipeline 6" dia, 1 pipeline 4" dia, 1 pipeline 3" dia, 1 pipeline 80 cm dia
37	10.60	Railway double Bridge	Steel	10°1'46.4"	76°17'30.7"	1	20.2	4	20.2	0.5	1 pipeline 30 cm dia, 3 pipelines 3" dia, 3 pipelines 2" dia, 2 pipelines 1.5" dia
38	10.61	RCC Rail Bridge	RCC	10°1'46.8"	76°17'30.0"	1	20.2	10	20.2	2	---

The desired limit of horizontal and vertical clearances of the cross structures are 20m and 4m respectively. No one of the cross structures are obeying the standard value and it is recommended to reconstruct/modify the same.

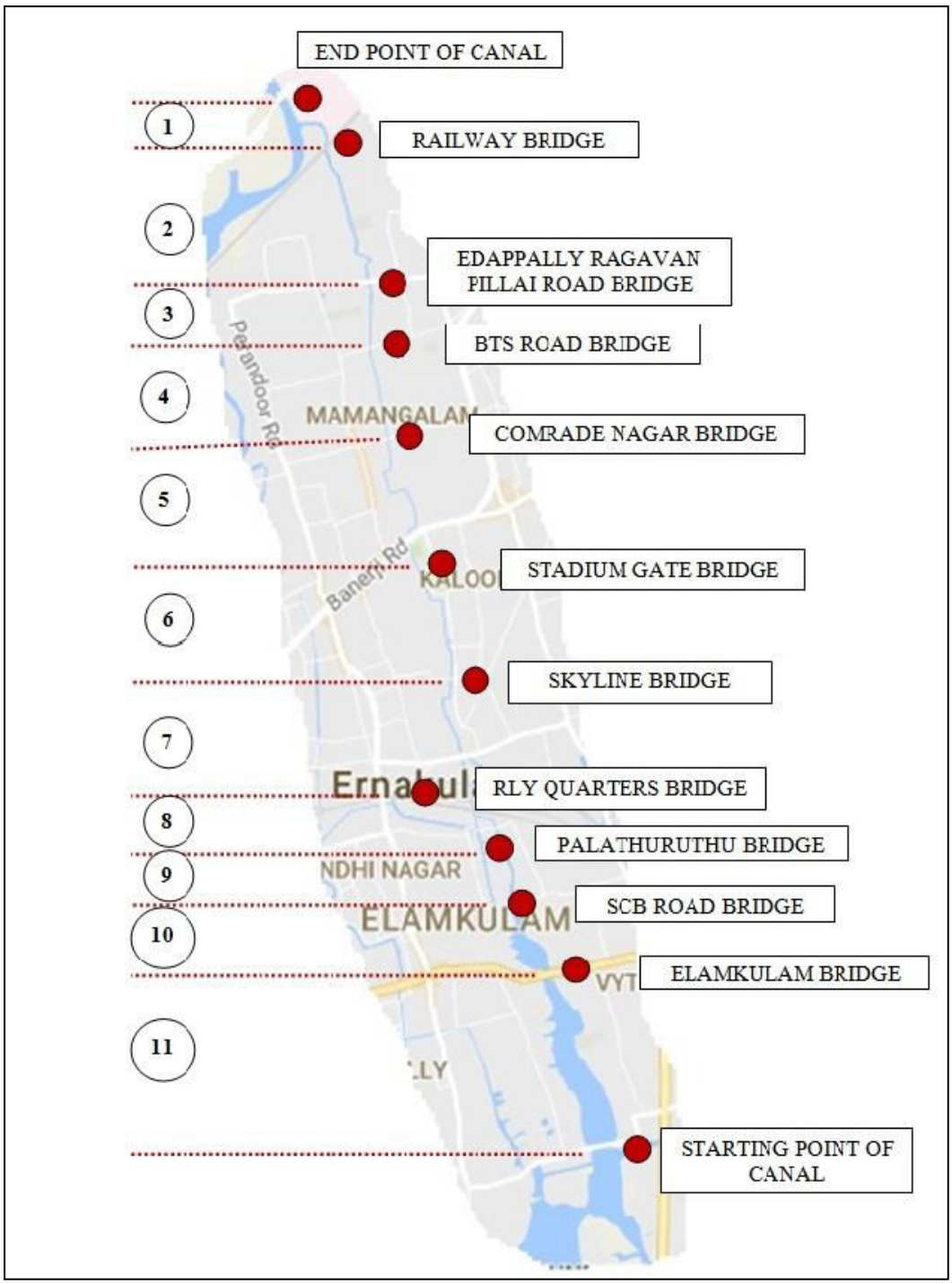


Figure 6.2. Study Area Map of Chilavanoor Canal

6.2.2 Present Condition of the canal

The present condition of the canal described in detail is given as following sections;

Section I: Canal starting point – Elamkulambridge(0.00km – 1.53km)

Chilavanoor canal starts from the waterbody of Thevara canal and is proximate to National Waterway 3. The length of the beginning section of the canal is 1.53km. The average width of the canal in the starting section of the canal is 200m and is uniformly spread out in the initial stage of the canal. The canal becomes narrower while it is nearing the Elamkulam bridge. The average water depth varies from 1.2m to 2.5m.

Galaxy Hamilton apartment is the major high rise structure on the left bank of the canal. Vacant land some scattered houses are seen in the initial 0.3km stretch of the canal. This is followed by residential area and apartments. 110KV electric line is crossing the canal at 0.124km. Open land extends from 0.8km to 1.3km on left bank. Residential and commercial buildings are found near the Elamkulam bridge. The bank is protected up to 1.2km on right bank.

The right bank is having good accessibility and is more developed. Jewel Bay view apartment, DLF riverside apartments, Choice garden flat, Kannarkkat Condominium Flat, Cochin Gymkhana club, TocH public school are the major attraction on the right bank of the canal. The land use pattern is mainly builtup area with some vacant areas left in between. Four channels are connected to the canal

having width varying from 1.5m to 4.5m.The bank is protected from 0.25km to 0.6 km, 0.8 km to 1.2 km and 1.4 km to 1.5 km. The commercial activities are concentrated at the end of this section due to proximity with SA road which connects Vyttila and Elamkulam leading to MG road.

Section II: Elamkulam bridge – SCB bridge (1.53km – 2.326km)

The length of the canal section is 0.796 km. This stretch is consisting of 4 bridges which includes 2 foot bridges. The average width of the canal is 75m. The wider portion of the canal is found near the middle portion 1.65km-2.04km. Subhash Chandra Bose road runs parallel to the canal and cross over the canal nearing the end of the section. The average water depth varies from 0.8m to 1m.

Left bank of the canal is mostly unoccupied. Marshy and vacant land can be mostly seen in the portion up to 2.2 km. The following portion of this section is settlement area and commercial shops. An 8m wide channel is connected to the canal along the left bank at 2km. Kerala Water Authority Sewage Treatment plant is located near to this branch. Canal is fully covered with slab from 2.3km to SCB Bridge and is occupied with shops. The bank is protected from 1.95 km to 2.32 km. The canal is narrowed down from 2.22km onwards.

Patches of marshy land with some buildings can be seen near the Elamkulam bridge with some buildings in between. Residential area is found between 1.76km and 2.09 km. The land use pattern is found to be marshy up to 2.2km. A patch of government property extends in this region. SCB road providing good road access to the right bank of the canal. Canal is having 2 channels, 1.5m and 7 m wide connected at 1.78 km and 2.18 km respectively. The canal branches in to two at 2.21 km. The

bank is well protected from 1.6 km to 2.05 km. The bank protection again starts from 2.25 km onwards.

SectionIII: SCB bridge – Palathuruthu bridge (2.326km – 2.910km)

This section is having a length of 0.584 km. This stretch is mostly occupied with houses. There are four bridges across the canal providing good connectivity between the banks. The average width of canal is 9.5 m and the average water depth various from 0.9m to 1.2m. The canal width is almost uniform along this stretch.

The land use pattern is observed as settlement area. It starts from SCB Road Bridge to 2.69km Open land extent up to 2.8km followed by residential area up to Palathuruthu Bridge on the left bank. The bank is having parallel road up to 2.46km providing access to residential area. The bank protection is not found between 2.5km to 2.57km, 2.8km to 2.85km. The remaining area is fully protected.

Residential apartments of Star Gardens, Unidac Enclave are found on the right bank. The settlement area extents up to 2.6km from the beginning. Open roads and marshy land is found in the following area. Residential area again starts from 2.76km to the end of the section. Two channels 0.5m wide are connected to the canals at 2.42km and 2.62km respectively. A wider channel of 3.3m is found at 2.88km. The right bank is fully protected along this stretch of the canal.

Section IV: Palathuruthubridge – Railway quarters bridge (2.910km – 3.932km)

The total length of the canal section is 1.022km having an average width of 12.56m. The depth varies between 0.7m to 0.9m. The canal is having great deviation from it's straight portion and is having a great curvature in its path followed. This section is having seven bridges which includes the railway bridge and a Steel walk way. The canal is connected with many channels which increases the flow in the canal.

Scattered houses and open land are seen in the left bank up to 3.1km. Single storied and double storied houses extent from 3.1 km to 3.7km followed by vacant land up to the Railway Quarters Bridge. Road parallel to the left bank is found between 2.98km to 3.1 km of width 5m. A 4.6m wide channel is connected to the

canal at 3.69km another channel joints the water body at 3.88km A drainage channel is connected near the steel bridge at 3.8km. A series of water pipelines are crossing the canal near to the railway bridge at 3.8km. The left bank is well protected from Palathuruthu bridge to 3.46km.

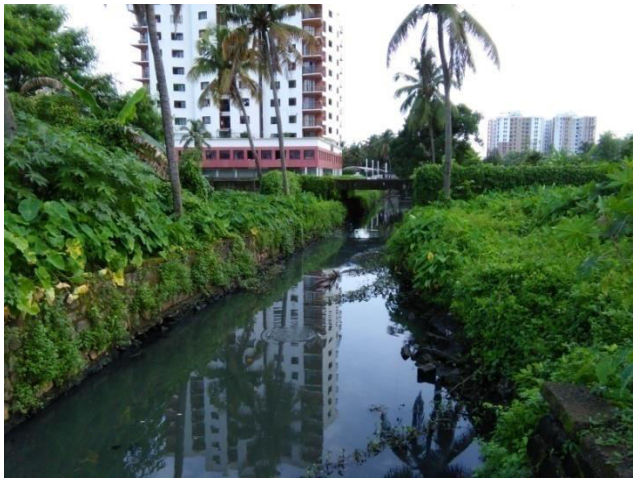
Three storied residential apartments are seen on the right bank. It is mostly a residential area with some open plots. The land use pattern is found to the vacant and marshy land from 3.6km to 3.9km. The right bank is having good road connectivity from 3km to 3.6km along the bank. The width of the road varies from 3m to 5m providing easy access to the canal. The right bank is protected up to 3.55 km from the beginning of the section. The bank protection again starts from 3.8km till the end of the section. The canal is having 11m wide branch 2.99km and a 1.2m wide channel at 3.7km.

Section V: Railway quarters bridge – Skyline bridge (3.932km – 5.280km)

This section of the canal is having a length of 1.348km. The initial portion of the section runs parallel to the railway marshalling yard. Thammanam Pullepady road cross the canal through Karanakkodam Bridge at 4.76km. Two pipelines of diameter 1.5m and 2m are found across the canal at 4.9km. The average width of the canal is 12.2m with the water depth varying from 0.3m to 0.6m.

The land is patterned on the left bank is marshy land up to 4.26km followed by residential area until 4.6km. Vacant land and scattered houses can be seen later.

DD Platinum planet apartment and skyline imperial gardens are the major high rise buildings in this section. All flats are constructed without providing provision to the flow of water. The left bank is connected with the channel 2m wide at 3.95 km. The bank protection starts at 4.52 km and continues the skyline bridge. The initial portion is having parallel road access up to 4.12 km.



The right bank of the canal is near to the railway marshalling yard. The buildings occupied up to 4.4 km belongs to the railway. Two RCC Overhead water tanks are found nearer to the right bank. Vast extent of marshy land is spread over the right bank from 4.4 km to 4.65 km, 4.76 km to 4.98 km. The Panjos flat and Skyline G+12 structure under construction are the major landmarks on right bank. Six channels are connected to the canal having width varying from 0.5m to 2m. A wider branch of 8m is seen at 4.53m. The bank protection is found between 4.55km to Skyline bridge.

Section VI: Skyline bridge – Stadium Gate bridge (5.280km – 6.541km)

The total length of the section is1.26 km, having a width of 7.04m. The canal is flowing parallel to the stadium link road and is passing near the Jawaharlal Nehru international stadium, Kaloor. The canal is having almost uniform width in this section. Commercial buildings and Flats have occupied their space along the banks of the canal. The average water depth of the canal varies from 0.4m to 0.6m. There are seven bridges across the canal.

IMA House Cochin and Kent Hail Garden are the major land mark on the left bank. Up to 6.1 km settlement area has been spread out with few open lands in between. This is followed by open and marshy land up to stadium complex gate bridge. Few more houses can be seen in the final stretch of the section. The nearness to the road facilities makes this area Suitable for commercial activities. A drainage is

connected to the canal at 5.89 km. The left bank is strongly protected with random rubble masonry.

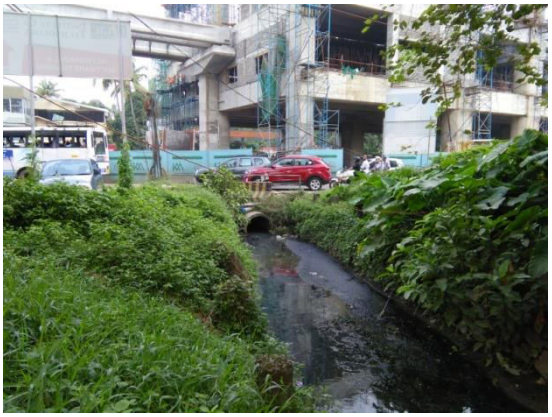
Open plots and vacant land are seen on the right bank up to 5.7 km. Commercial buildings are occupying the adjacent areas. Open grassy land can be found near to the Kaloor stadium on the right bank. Trinity Eye Hospital, Noel Builders building are the major constructions on this bank. Most of the area is devoid of construction a 0.5m wide channel is connected to the canal at 6.45 km on the right bank. The right bank is also fully protected in this section.

Section VII: Stadium Gate bridge – Camradenagar bridge (6.541km – 7.844km)

The canal now passes through the Banerji Road collecting Kaloor and Palarivattom. The free movement of the flow of water is prevented at the Banerji road. The metro Construction is being undergoing on top of this roadway. The total length of the canal is 1.30 km. Canal is carrying through a pipeline and passing the Banerji road. The water flow is almost stagnant. Average width of the canal is 3.54m and the water depth varies from 0.3m to 0.4m. The canal is fully covered with slab from 6.95km to 7.16km which is inside the KSEB compound. A 110KV electric line is crossing the canal at 7.2km. Slab covering again found at 7.24km to 7.3km, 7.58km to 7.65km.

The left bank of the canal is having good road connection along the bank providing an entrance to the stadium. Both residential and commercial buildings are seen up to 6.78km on the left bank. Electric power station and some office buildings are seen on the left bank inside KSEB plot. Thickly populated residential area can be seen from 7.31km to the end of the section on the left bank. The banks of the canal are fully protected. Four drainage channels are connected to the canal on the left bank.

Open area is found in the initial portions of the section up to 7.2km. A 2.5m wide channel is connected to the canal at the right bank. Residential buildings and some open plots are found in the remaining stretch of the section. Residential villas are also concentrated along the bank. A 2m wide channel is connected at 7.6km.



Section VIII: Camradenagar bridge – BTS road bridge(7.844km – 8.748km)

This section is having a total length of 0.90 km with an average width of 4.66m there are four over bridges and six concrete slab foot bridges across the canal. Both the banks of the canal are fully occupied average water depth varies from 0.6m to 0.8m. The canal width is uniform along this section.

Adab Oriental Gardens is the major high rise building in the left bank. Open and marshy land is found between 8.3km and 8.49km. Rest of the areas is occupied by houses one meter wide channel is connected to the canal at 8.25km. Two drainage channels are also connected to the left bank. There is good road connectivity between both the banks and the adjacent areas. There is parallel road passing along the left bank from 8.5km to the end of the section. Both the banks of the canal are protected by random rubble masonry.

70% of the area on the right bank are occupied by residential buildings. Open plots are also seen in this stretch of the canal. 110KV electric line passing over the canal at 8.42km. A channel of width 2m is connected to the canal at 8.71km and a drainage at 8.15km. Four concrete slab foot bridges are found between 8.6km and 8.7km. The end portion of the canal is thickly populated due to the connectivity with the BTS Road.

Section IX: BTS road bridge – Ragavan Pillai road bridge (8.748km – 9.322km)

The canal escape from the city limit and regain its flow in the outskirts of the town. The total length of the section is 0.57km at an average width of 8.4m. Green patches of open land and marshy land starts to re appear along the banks. The average water depth varies from 0.5m to 0.8m. There are two foot bridges crossing the canal.

The left bank is characterized its residential buildings up to 9 km. Open and marshy land patches are seen up to 9.25m. Galaxy Marvel flat is seen at the end nearer to EdappallyRaghavan Pillai road. Canal starts widening after 9 km onwards. Both the banks of the canal are fully protected in this section. Starting from BTS road bridge there is a parallel road connectivity along the left bank providing easy access.

The right bank of the canal is featured by Chirampuram Temple located very close to the bank. The residential buildings are mainly concentrated in the beginning section until 9 km. A vast stretch of vacant and marshy land can be seen in the remaining portion of the canal section. Right bank is connected with 3 channels of with varying from 1m to 1.5m which increases the flow in the canal.

Section X: Ragavan Pillai road bridge – Railway bridge (9.322km – 10.603km)

The canal is getting widened towards the end and the average width is 16.3m. The length of this stretch of the canal is 1.28 km. EdappallyRaghavan Pillai road provides good accessibility resulting in the greater developments in the initial portions of this canal section. The average water depth varies from 0.7m to 1m providing good flow in the canal.

Maruthi Suzuki godown in located near to Raghavan Pillai Bridge followed by Popular vehicles & services. Marshy land and mixed vegetation can be found in this section that extends up to 10.4 km on the left bank and settlement area can be seen in the end portion of the canal section. The left bank is protected up to 9.8 km from the beginning of this section.

The right bank is characterized by Kalpaka Castle, Champian School and other apartments. It is more populated than the left bank. Vacant land stretch can be seen 9.45km to 9.88 km. The right bank is occupied with residential buildings in the

rest of the areas with some vacant land patches. 10 channels are connected to the canal with varying width of 0.3m to 2m. The bank is not protected between 10.05km to 10.2 km stretch of the canal.

Section XI: Railway bridge – End Point of Canal (10.603km – 11.023km)

The final section of the canal is of 0.42km in length starting from the railway bridge. The canal gets widened providing good navigational possibilities. The canal then merges in to the Perandoor Canal. The width of the canal gets increased to 29.5m in this section. The average depth of flow gets increased and it varies between 1m to 2m.

The land use pattern observed on the left bank is settlement area. There are no prominent features on this bank due to lack of good road connectivity. Two drainage channels are connected to the canal at 10.95 km and 11.1 km of width 0.75m and 1.3 m respectively. The right bank of the canal is landmarked by Amrita Institute of Medical Sciences. The left bank is not protected from 10.75 km to 10.925 km while the right bank is fully protected.

6.3 THEVERA-PERANDOOR CANAL

The canal starts from PerandoorPuzha at Railway bridge (10° 01' 12.00"N and 76° 16' 56.00"E) and connects Thevara canal at Railway bridge (9° 56' 44.37"N and76° 18' 02.45"E). The canal passes through the major places like Perandoor, Vaduthala, Pachalam, Kaloor, Ernakulam South, Giri Nagar, Kadavanthara andPanampilly Nagar.

The total length of the canal is 9.84km. The width of canal is varying from 8.0m to 48m and the average width is 17.9m. The depth of canal varies between 0.6m and 1.0m.

The canal flow is maintained by Perandoorpuzha a branch of Periyar river at northern end and Thevera Canal a branch of Chembakkara canal on southern end. The wider portion of canal exists between staring point (0.00km) and Sastha temple road bridge (3.45km). Due to metro construction along Kaloor road corridor the canal is blocked at 3.78km. The canal is stagnant between this point and Judges avenue road bridge due to absence of flow of water. Another bottleneck at chainage 5.33km – 5.356km is observed i.e., the canal is partially blocked and a small channel from 5.40km is started again. The weeds growth is intensive at the section 5.40km – 5.70km due to blockage of canal flow. The wider portion of the canal again starts from SalimRajan road bridge(5.75km) and extended up to ending point of the canal.

6.3.1 Details of Cross Structures

Different types of cross structures are observed along the canal. The location, type, length, width, No. of span, horizontal clearance, vertical clearance and connectivity details were collected. It is observed that, 38 cross structures are existing along the canal which includes 30 road bridges, 3 rail bridges and 5 foot over bridges. The details of cross structures are given in **Table 6.3.**

Table 6.3. Existing Cross Structures in Thevara-Perandoor Canal

S.NO	CHAINAGE(km)	NAME OF BRIDGE	TYPE OF BRIDGE	COORDINATES		NO OF SPAN	LENGTH(m)	WIDTH(m)	CLERANCE(m)		REMARKS
				LAT	LONG				H	V	
1	0.02	Rail RCC Bridge	RCC Rail	10°1'12.6"	76°16'55.9"	1	40	4.5	30	2	----
2	0.02	Rail Bridge-1	Steel	10°1'12.3"	76°16'56.2"	1	30.48	2.5	30	1.5	2 pipelines 1.5" dia, 1 pipeline 2" dia
3	0.02	Rail Bridge-2	Steel	10°1'11.8"	76°16'56.1"	1	30.48	2.5	30	1.5	1 pipeline 10" dia, 1 pipeline 3" dia, 1 pipeline 1.5" dia
4	2.21	Pottakuzhy Road Bridge	RCC Road	10°0'16.6"	76°17'14.3"	2	19.5	8.5	8.5	2.5	Pottakuzhy road to Perandoor road
5	3.46	Sastha Temple Road Bridge	RCC Road	9°59'46.9"	76°17'23.2"	1	13	5	8	3	SRM Junction to Perandoor road. 1 pipeline 30cm dia
6	3.56	KaloorManappattiparambu Bridge	RCC + Steel Road	9°59'43.6"	76°17'24.1"	1	13.7	8.2	8	1.3	1 pipeline 4" dia, 1 pipeline 1.5" dia
7	3.76	Kaloor Bridge	RCC Road	9°59'37.3"	76°17'26.5"	1	18.3	6.3	5.6	0.5	1 pipeline 1m dia, 1 pipeline 2" dia, 3 pipelines 3" dia
8	3.99	Reserve Bank Staff Quarters Bridge	RCC Road	9°59'30.1"	76°17'27.9"	1	5.4	5.7	6	1.6	1 pipeline 3" dia, 1 pipeline 1.5" dia
9	4.08	Judges Avenue Road Bridge	RCC Road	9°59'27.4"	76°17'28.1"	1	6	4.6	4.9	1.3	1 pipeline 2" dia
10	4.10	Foot Bridge	RCC	9°59'26.5"	76°17'28.2"	1	9.5	6	8	1.4	----
11	4.21	Skyline Road Bridge	RCC Road	9°59'23.1"	76°17'28.5"	1	7.7	6	7	1.5	1 pipeline 3" dia, 1 pipeline 2" dia, 1 pipeline 1" dia
12	4.35	Foot Bridge	RCC	9°59'18.7"	76°17'28.8"	1	5.6	3.8	5	0.7	6 pipelines 1.5" dia
13	4.42	Steel Foot Bridge	Steel	9°59'16.4"	76°17'28.7"	1	10	0.7	4	1.1	
14	4.48	Chemmani Road Bridge	RCC Road	9°59'14.5"	76°17'28.6"	1	9.5	5	8.6	1.2	1 pipeline 5" dia, 1 pipeline 3" dia, 1 pipeline 2" dia
15	4.60	Concrete Slab Foot Bridge	RCC	9°59'10.6"	76°17'28.7"	1	8.1	1.3	3.7	0.6	1 pipeline 2" dia
16	4.73	Church Road Bridge	RCC Road	9°59'6.2"	76°17'29.2"	1	8.7	3.5	7.1	2.8	1 pipeline 5" dia, 1 pipeline 4" dia, 1 pipeline 3" dia
17	4.82	Steel Foot Bridge-1	Steel	9°59'3.6"	76°17'29.1"	1	7.3	1.2	6.2	2.4	Bridge to Ibrahim Traders
18	4.85	Steel Foot Bridge-2	Steel	9°59'3.1"	76°17'29.0"	1	6.7	0.5	6	2.1	walk way
19	4.92	Steel Foot Bridge-3	Steel	9°59'0.0"	76°17'28.4"	1	7.5	1.2	6	2	----
20	4.97	Pulleppady Road Bridge	RCC Road	9°58'58.7"	76°17'28.2"	1	9.5	7.3	8	3.4	Thammanam- Pullepady Road. 1 pipeline 6" dia, 1 pipeline 3" dia, 2 pipeline 2 " dia, 1 pipeline 0.75 m

21	5.19	Concrete Slab Foot Bridge	RCC	9°58'51.7"	76°17'29.0"	1	9.2	1.2	9	0.8	----
22	5.23	Concrete Foot Bridge	RCC	9°58'50.1"	76°17'29.3"	1	6.5	1.4	5.8	1	----
23	5.49	Foot Bridge	RCC	9°58'43.3"	76°17'29.4"	1	6.6	1.2	5.5	1.7	1 pipeline 1.5m passing nearby
24		Foot Bridge-2	RCC Road	9°58'43.2"	76°17'29.4"	1	8.1	2	4.2	1.1	1 pipeline 2" dia
25	5.74	SalimRajan Road Bridge	RCC Road	9°58'35.4"	76°17'26.4"	1	4.5	7.3	4.2	0.8	Flyover above. 1 pipeline 2" dia
26	5.81	Bridge near Kochi refinary pipeline	RCC Road	9°58'33.9"	76°17'26.5"	1	7.4	3	2.2	0.5	1 pipeline 1m dia, 2 pipeline 80cm dia, 3 pipeline 50cm dia
27	6.01	Steel Foot Bridge	Steel	9°58'28.1"	76°17'30.1"	1	14	1.2	7	1.2	To railway shed
28	6.23	Iron Foot Bridge	Steel	9°58'23.5"	76°17'33.6"	1	13.5	1.1	7	1.4	To colony
29	6.56	Karshaka Road Bridge	RCC Road	9°58'15.8"	76°17'35.0"	1	13	9.8	9	1.3	1 pipeline 2" dia
30	6.82	Kadavanthra Market Bridge	RCC Road	9°58'11.3"	76°17'41.1"	1	15.5	6.7	11	1.4	1 pipeline 3" dia
31	7.53	SahodaranAyyappa n Road Bridge	RCC Road	9°57'59.1"	76°17'51.1"	1	14.8	17	9.6	1.7	1 pipeline 6" dia, 2 pipelines 4" dia, 3 pipelines 3' dia, 2 pipeline 1" dia
32	7.66	Elders Forum Road Bridge	RCC Road	9°57'55.1"	76°17'51.8"	1	11	4.8	7.5	1.2	2 pipelines 6" dia
33	7.99	Iron Foot Bridge	Steel	9°57'44.6"	76°17'53.0"	1	17.7	1.6	5.7	2.1	1 pipeline 6" dia, 2 pipelines 4" dia, 1 pipeline 1.5" dia
34	8.34	Panampilly Nagar-Girinagar Road Bridge	RCC Road	9°57'33.3"	76°17'54.8"	1	14	5.8	7	1.5	1 pipeline 8" dia, 1 pipeline 2' dia
35	8.68	Panampilly Nagar Link Road Bridge	RCC Road	9°57'22.5"	76°17'56.4"	1	14.3	4	12.9	1.5	1 pipeline 6" dia, 1 pipeline 4" dia, 1 pipeline 3" dia, 1 pipeline 2" dia
36	8.81	Panampilly Nagar-Vidhyanagar Road Bridge	RCC Road	9°57'18.1"	76°17'56.8"	1	13.2	5.6	10	1.5	1 pipeline 8" dia, 1pipeline 4' dia, 1 pipeline 2" dia.
37	9.16	KochuKadavanthra Road Bridge	RCC Road	9°57'6.6"	76°17'58.6"	3	12	6.5	5.8	1.5	2 pipelines 5" dia, 1 pipeline 3" dia
38	9.42	Iron Foot Bridge	Steel	9°56'58.4"	76°17'59.6"	1	15	1.1	9.8	1.6	----
39	9.51	New Bridge	RCC Road	9°56'55.5"	76°18'0.2"	3	14.1	10.7	8.2	1.5	----
40	9.80	Anamthuruthu Road Bridge	RCC Road	9°56'45.8"	76°18'1.4"	1	17.8	7.7	15.5	1.8	----

6.3.2 Present Condition of the Canal

The canal is divided in to seven stretches according to width, depth, population density and accessibility. The **Figure 6.3** shows the study area and its divisions.

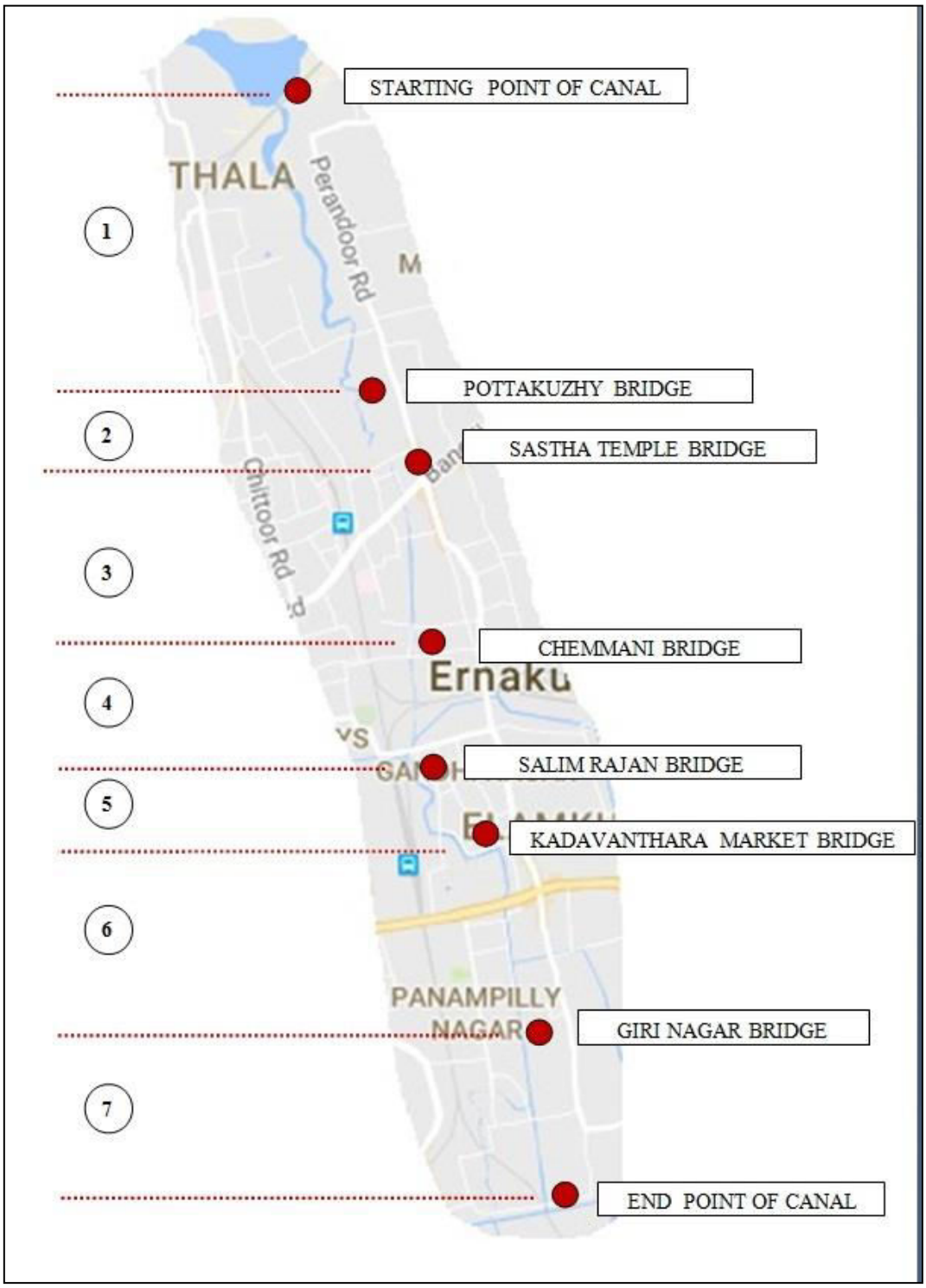


Figure 6.3. Study Area Map of Thevara-Perandoor Canal

The present condition of the canal described section wise in detail is follows;

Section I: Canal starting point – Pottakuzhybridge(Chainage 0.000-2.207)

Thevara-perandoor canal starts off from the Perandoor canal. The railway bridge is found near the starting point. The total length of the starting section of the canal is 2.21 km. This section is having an average width of 48.75 m and the water depth varies between 1.3 m to 2.1 m. The canal is found to be much wider providing good flow of water. Not much cross structures are seen in this section of the canal and green patches can be seen spread out in the banks.

The left bank of the canal is not much occupied. The SaraswathyVidhyaNikethan Public School, Skyline apartments are the landmarks on the left bank. A cluster of houses are seen at 0.2 km while most of the area is open and marshy land. Some more settlement patches can be found near the School compound. The left bank is provided with a good walk way of 1.45m along the bank side extending from 0.3m to 0.95m. Parallel road connectivity is found up to 1.5 km from the beginning. A number of drainage channels are connected to the canal having width of 1m to 2m. A 4.5m wide channel is connected to the left bank at 1.35 km. The left bank is lacking bank protection between 1.4 km to 1.5 km and 1.75 km to 1.9 km.

The settlement area on the right bank starts from 1 km and extents up to the end of the canal. Lords Cottage Heavenly homes villas and galaxy homes are also the part of the right bank. The land is patterned the initial stretch of the canal is marshy land. The canal is having road connectivity along the bank from 0.18 km to 6.5 km. The right bank is connected with a number of drainage and water channels. The right bank is protected up to 1.2 km from the beginning and between 1.3 km to 1.6 km. The canal width gets reduced in the end portion of the section.

Section II:Pottakuzhy bridge – Sasta temple bridge(Chainage2.207-3.460)

This section of the canal having a length of 1.253km is more occupied combined to the beginning. The average width of the canal section is 14m having water depth varying from 0.9m to 1.3m. The canal flows through S shaped curves along the section and gets narrower towards the end.

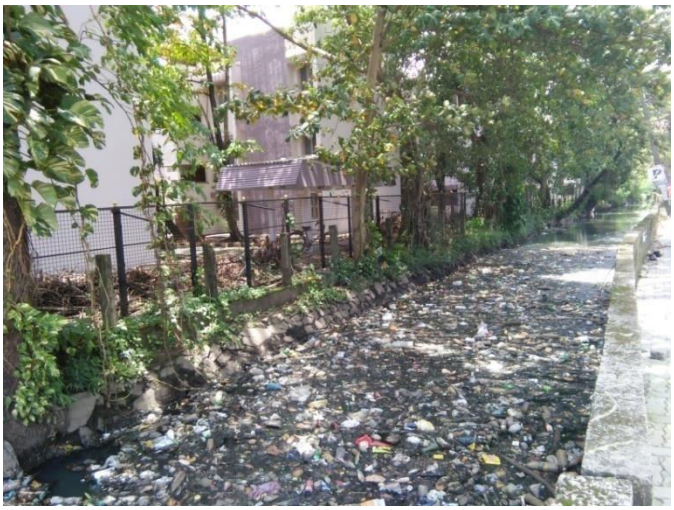
The land use pattern of the left bank is mostly residential area. Open and marshy land are found between 2.2km to 2.3km, 2.7km to 2.85km, 3.1km to 3.2km. JM Manor flats, ACE Nimbus and galaxy apartments are the land marks on this bank. A 3.5m wide channel is connected to the left bank at 2.52km. Four drainage channels are also connected to this bank. The left bank is protected between 2.4km to 2.5km, 2.95km to 3km, 3.17km to the end of the section.

The Galaxy Arcade, Thottathupadi Masjid, VB Residency are the major features on the right bank. A stretch of marshy land extents from 2.35km to 2.8km followed by residential area up to the end of the section. A group of six houses forming a colony is found very close to the bank near the Sastha temple road bridge. The right bank is having protection between 2.25km to 2.55km, 2.85km to 3.35km. Two channels having width 2m and 0.3m are connected to the right bank at 2.2km and 2.88km respectively.

Section III: Sasta temple bridge – Chemmanibridge(Chainage 3.460-4.475)

The canal flows under the Banerji road near Kaloor. Commercial buildings and towers have become part of the banks of canal. The proximity with Kaloor make the stretch having a length of 1.015 km, really good for commercial activities. The average width of the canal is 8m with the water depth varying from 0.2m to 0.4m. The canal flow is obstructed at 3.7km and a sheet roofed structure is found above the slab covered canal. The water flow is hindered at Kaloorbridge due to the deposition of construction waste due to metro construction. The canal takes a straight path after this portion.

The left bank is having Kaloor market, PVS Memorial Hospital, Reserve Bank of India and Sky line flats as the major attractions. Some other RCC structures are found in this highly occupied commercial area leaving no vacant land. The left bank is having a road parallel to it between 3.56 km to 3.78 km which connects to Banerji road. A retaining wall is protecting the left bank between 3.6km to 3.2km. The total length of the section is fully bank protected except between 4.3km to 4.4km.



Right bank is also having important buildings like SreeGokulam Convention Centre, Hotel Gokulam Park Inn, Mini Muthoot Tech Towers, The New Indian Express, Kavanal Square etc. Residential apartments and houses can be found between 3.93km to the end of the section. Some of the buildings are seen as a block of 4 to 6 houses. 9 bridges are found across the canal providing connectivity between the banks. Drainage line starts from 3.8km parallel to the road and is connected to the canal at suitable intervals. Commercial shops are found at the end of the section. A 1.5m wide channel is connected to the canal at 3.7km. A road parallel to the right bank of the canal starts from 3.8km and continues to the end of the section. The right bank is having protection with RR masonry.

Section IV:Chemmani bridge – Salimrajanbridge(Chainage 4.475-5.741)

This stretch of canal mostly occupied with residential buildings is having a length of 1.266km. The railway line connecting to the Marshalling Yard and to Kottayam is found along this stretch. The canal is not found in this portion as there is no cross structures across the canal which extents between

5.33km to 5.7km. Average width of the section of canal is 8m with the water depth varying from 0.3m to 0.5m. Nine bridges are found across the canal which includes 5 foot bridges.

Employees Provident Fund Office, Commercial buildings like Ibrahim traders iron and steel, Police Quarters, Central Excise Bhavan have occupied the left bank of the canal. Residential buildings and some open land are seen in the rest of the portion. Road parallel to the left bank is found from the starting of the section to the 5.3km. Drainage channels of width 0.5m to 2m are found connected to the left bank. The bank is fully protected except near the railway line.

Residential buildings are the major land use pattern of the right bank. Vacant plots are also seen in between providing scope for future development. 5m wide parallel road is found along the right bank of the canal for the major length of the section. Drainage line running parallel to the road is also connected to the right bank. Two channels of width 0.4m and 1m are connected near 5.2km. The right bank boundary is protected all along the length.

Section V:Salimrajan bridge – Kadavanthara market bridge(Chainage 5.741-6.815)

This section of the canal is having a length of 1.074km. The canal takes a series of curve shaped path along the stretch. The average width of the canal 13.8m. The depth of water varies between 0.4m to 0.5m. Seven pipelines are crossing the canal at 5.81km having diameter varying from 0.5m to 1m. The canal flows uniformly in this section.

The KSINC Head Office and Lakshadweep Guest house are the major structures of the left bank. The colony settlement area consisting of a group of houses is found to extent from 6.0km to 6.55km along the left bank. Some commercial buildings are found near the Kadavanthra Market Bridge. A 5m channel is connected to the canal along the left bank at 5.83km. Udayanagar road is providing good accessibility to the right bank of the canal. The left bank which is fully protected is also having some drainage connections of 1m width.

Marshy land and some buildings belonging to the railway property are seen in the initial portions on the right bank. Colony settlements are also found on the right bank at 6.25km. Indian Oil Corporation Limited has occupied a vast stretch of land from 6.3km to 6.5km. GCDA Flat and vacant property are found near Karshakaroadbridge. Residential buildings are seen in the end of the section. A 10m wide channel is connected 5.78km. Drainage channels are connected 6.32km and 6.58 km the right bank which is also protected as the left bank.

Section VI:Kadavanthara market bridge – Girinagarbridge(Chainage 6.815-8.336)

The canal which flows through the commercial area and crosses SahodaranAyyappan Road which having a length of 1.521km. It is a thickly occupied section of the canal due to its nearest to Kadavanthra Junction. The average width of the canal section is 15.9m and water depth varies from 0.5m to 1m. Five bridges are found across the canal in this section.

Rajeev Gandhi Indoor Stadium, ABM Towers and GCDA office are the major landmarks on the left bank of the section. Kadavanthra Market is found close to the

left bank in the beginning of the section followed by commercial shops and Janamaithri Police Station. Residential settlement area can be found to spread out from 7.6 km to the end of the section on the left bank of the section which is having parallel road near the bank. The left bank of the canal which is fully protected is having some drainage connections from the adjoining streets.

Hindustan Petroleum Corporation Limited holds the property on the right bank from the start of the section to 7.4 km. Many commercial buildings including 3 star Regency have occupied near SA road on the right bank. Road parallel to the canal bank starts from 7.65 km and continues till the end of the section. Commercial activities are found to get concentrated along this road which is having drainage channels opening at the canal along the right bank. Residential settlement are found to be thickly occupied on the other side of the road. The right bank of the canal is fully protected along this section of the canal.

Section VII: Girinagar bridge – End point of canal(Chainage8.336-9.840)

The length of the final stretch of the canal is 1.504km. The thevara-perandoor canal merges in to the Thevara canal. The canal flows through a straight stretch without much obstruction to the flow with an average width of 16.5m. The depth of flow varies from 0.8m to 1.4m. There are six bridges across the canal providing accessibility between the banks. Panampillynagar and Girinagar housing colonies are situated on either banks of the canal.

Namasita Apartments, Vanshika Apartments, Abad Cloud Nine, Galaxy Apartments are some of the high rise buildings on the left bank. The land use pattern is mainly settlement area. The Cochin shipyard Compound exists between 8.46km to 8.6km on the left bank. The 110KV substation is found at 9.75km near the

end of the section. Many drainage channels of width varying from 0.5m to 3m is connected to the left bank. The bank protection continues up to 9.8km.

Telecom Staff Quarters, NJK Nath Apartments, Lakshadweep Development Corporation Ltd, Skyline Belair Apartments, Koithara Childrens Park, Central Govt Officers Association & commercial building are all found on the right bank. Residential buildings and apartments occupied to 9.05km from the beginning of the section. It is followed by a Interlocked walk way and cycle track developed along the right bank of the canal as a part of beautification of Shihabthangal Road at Panampilly Nagar under KMRL. It extends from 9.05km to 9.5km. 110KV Kadavanthara Substation is in between 9.6km to 9.8km on the right bank. Two channels of width 3m are connected to the right bank at 8.37km and 9.6km and a 7m channel at 9.05km. The right bank is fully protected up to the end.

6.4 THEVERA CANAL

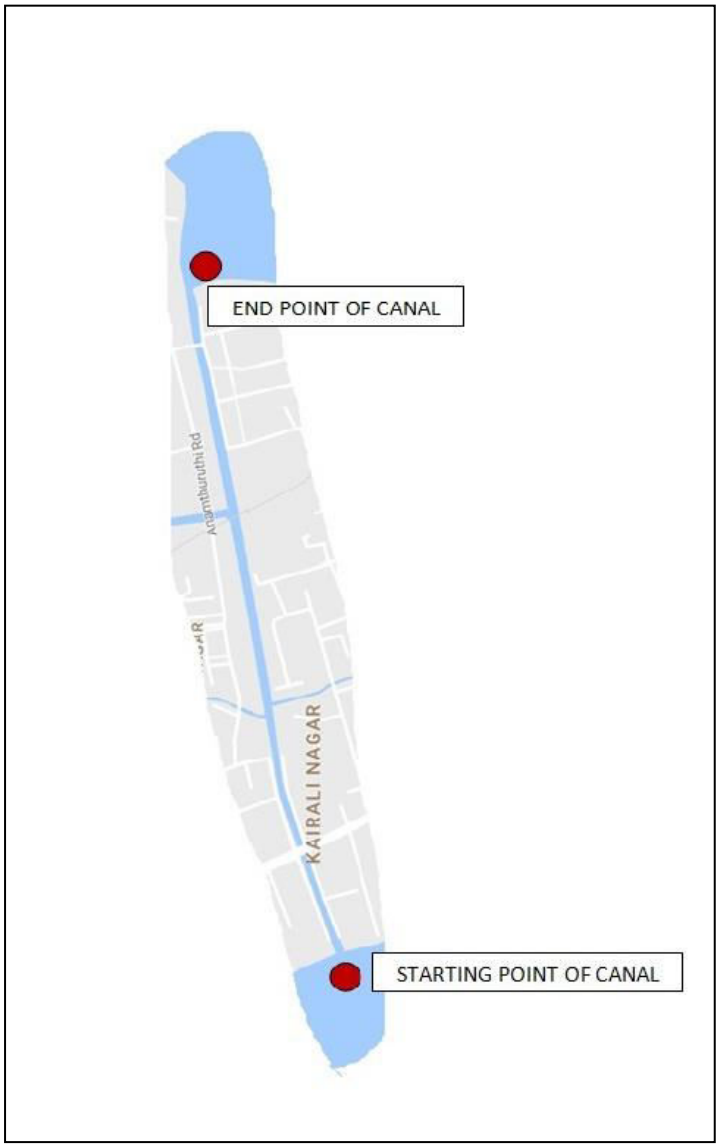
The canal originates from VenduruthyPuzha (9° 56' 37.20"N and 76° 17' 32.50"E) and connects with KundanoorPuzha (9° 56' 47.18"N and 76° 18' 17.57"E). This canal is linked with National Waterways No.3 and Thevera-Perandoor canal. The major places it passes through are Thevara market, Koithara and Kallumpalam. The developed canal is having potential of connecting Chembakkara canal with Inland Water Authority of India (IWAI) terminal at Maradu.

The total length of the canal is 1.41km. The average width and depth of the canal is 18.5m and 1m-1.5m respectively. The flow is towards western side and it is affected by the settlers through dumping of solid waste into the canal. The waste generated from the fish market situated on right bank at 0.2km chainage is another major source of pollution. **Figure 6.4** shows the study area map of Thevara canal.

6.4.1 Details of Cross Structures

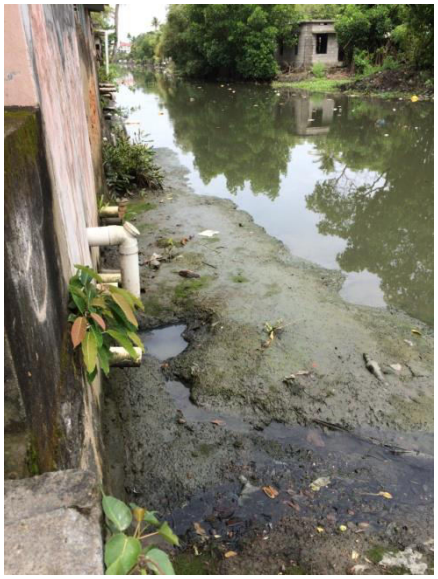
It is observed that, 3 cross structures are passing through the canal. The type of structure, its location, horizontal clearance, vertical clearance, length and width details are collected. The details of the cross structures are given in **Table 6.4.** Of 3 cross structures, 2 are road bridges and one is rail bridge. The vertical clearance and

horizontal clearance of the structures are not obeying the desired standard and it is recommended that the above structures have to be reconstructed/modified.



6.4.2 Present Condition of the Canal

The canal starts from Venthuruthypuzha is having linkage with NW 3. The siltation at entrance point is more and it is resulted lower depth. The canal is having very good road connectivity on both sides. The residential activity is the major land use on both banks especially between 0.55km to 0.9km on left bank a colony is situated. The generated sewerage and solid waste are directly discharged into the canal poses serious threat to canal ecosystem. A drainage having width of 1.5m at 0.41km is connected with canal on left bank. 9.5m and 2m channels are connected with left bank at chainage 0.5km and 0.68km respectively. At 0.93km, Thevara-Perandoor canal is connected with this canal on left side.



On right side, three small drains existing between 0.00km and 0.40km. At 0.52km a channel having 2m width is connected with canal on right bank and 4.5m wide channel is also connected with right bank at 1.05km. A major source of water pollution is caused by the discharge of waste from fish market at 0.2km on right side. The slaughter house waste is also directly dumped into this canal is the serious issue of environmental concern.

The RR masonry bank protection is observed along the banks except 0.18km to 0.21km and 0.60km to 1.15km on left bank. Similarly, the section of 0.7km to 1.05km, right bank is not protected. End point of the canal flow is restricted by higher growth of water hyacinths. Periodical cleaning is required to address the above issue.

6.5 MARKET CANAL

The canal starts from Ernakulam channel at Rainbow bridge (09° 58′ 47.65″ N and 76° 16′ 30.15″ E) and it ends at Banerji Road (09° 59′ 05.09″ N and 76° 16′ 34.31″ E). The Market Canal is passing through Broadway and the Market road - the commercial hub of the City - where the bulk of wholesale and retail activities of the city take place. Even though the length of the canal is small, is having tourism potential at starting point i.e., The Marine drive and possibility of cargo movement through Rainbow bridge to market area.

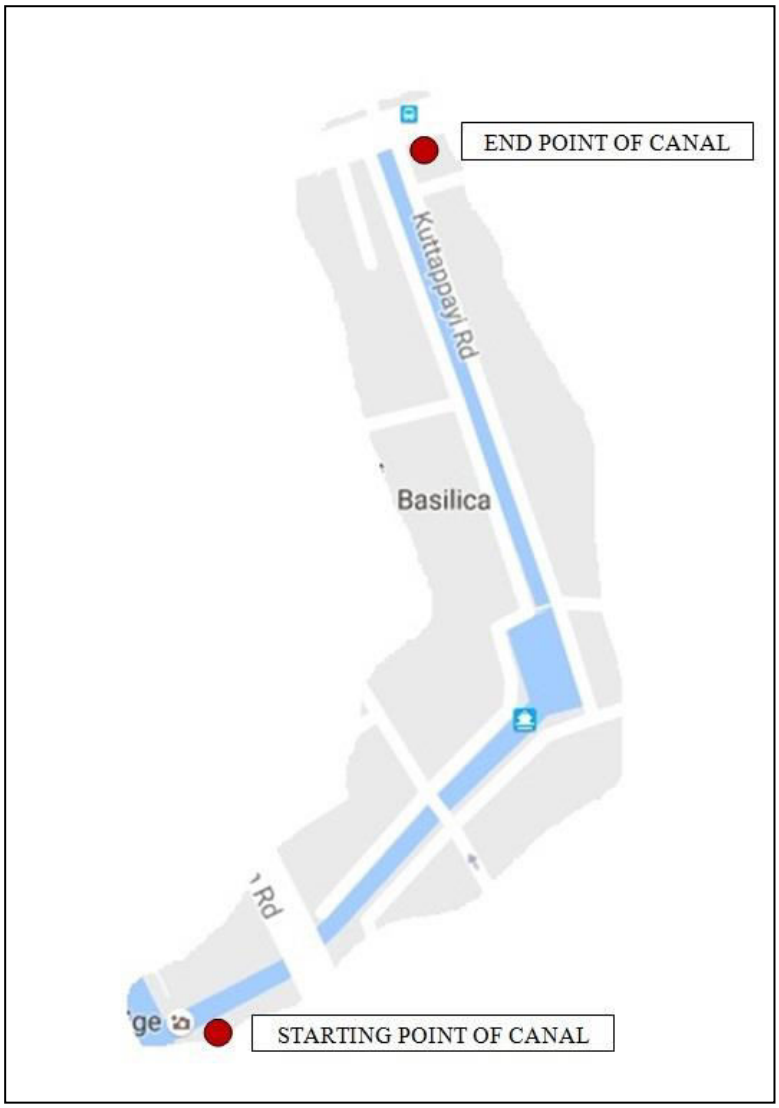


Figure 6.5. Study Area Map of Market Canal

The total length of the canal is 0.66km. The average width and depth of the canal is 9.94m and 0.6m-1.0m respectively. **Figure 6.5** shows the study area map of Market canal.

6.5.1 Details of Cross Structures

There are four cross structures passing across the canal. Of 4 structures, three are road bridges and one is foot over bridge. The vertical and horizontal clearance of the desired limit is met by rainbow bridge. Rests of structures are not obeying the standard and it is recommended to reconstruct. The details of cross structures are given in **Table 6.5.**

6.5.2 Present Condition of the Canal

It originates from Vembanad lake and is also linked with National Waterways No.3 on western end and it ends at Banerji road. The starting point of the canal itself having tourism potential i.e., Marine drive one of the popular tourism location in Kochi city and it connects with Ernakulam market. The small portion is connects with the nearby cities like Alappuzha, Kottayam and Thrissur through waterways and provides the opportunity of cargo movement through this canal.

The width of the canal is uniform and the banks are protected with RR masonry. A height of 3m of cast iron fencing on both banks is constructed to protect throughout of waste materials into the canal. A foot path having 0.5m width is constructed on both banks from 0.41km to end of the canal. The canal is having road connectivity on both sides and the permanent shops are constructed 2 to 2.5m away from the canals. Temporary shops are existing on right bank at chainage 0.21km to 0.37km. The discharge of waste from shops are causing higher amount of pollutant concentration into the canal. The average width of canal at centre portion i.e., market area is about 35m and it provides the turning radius for minimum 20m length of the vessel.

Table 6.4. Existing Cross Structures in Thevara Canal

S.NO	CHAINAGE (km)	NAME OF BRIDGE	TYPE OF BRIDGE	COORDINATES		NO.OF SPAN	LENGTH (m)	WIDTH (m)	CLERANCE (m)		REMARKS
				LAT	LONG				H	V	
1	0.22	Thevara Bridge	RCC Road	9°56'39.6"	76°17'38.6"	3	31.8	11.5	8	5.2	1 pipeline 6" dia, 2 pipelines 4" dia, 2 pipeline 3" dia, 2 pipelines 3" dia
2	0.92	Railway Bridge	RCC Rail	9°56'44.4"	76°18'1.2"	3	32	4	8.9	4.6	---
3	1.28	Kallupalam Bridge	RCC Road	9°56'46.7"	76°18'13.0"	1	11	5.3	5.2	2.6	---

Table 6.5. Existing Cross Structures in Market Canal

S.NO	CHAINAGE (km)	NAME OF BRIDGE	TYPE OF BRIDGE	COORDINATES		NO. OF SPAN	LENGTH (m)	WIDTH (m)	CLERANCE (m)		REMARKS
				LAT	LONG				H	V	
1	0.003	Rainbow Bridge	RCC FOB	9°58'47.7"	76°16'30.4"	1	18.5	8.2	13.6	5	At Marine Drive Walkway
2	0.008	Shanmugham Road Bridge	RCC Road	9°58'49.3"	76°16'33.1"	1	20	30	14.6	3	1 pipeline 8" dia, 2 pipelines 4" dia, 2 pipelines 3" dia, 1 pipeline 2" dia,1 pipeline 50cm dia
3	0.02	Broadway Road Bridge	RCC Road	9°58'51.9"	76°16'35.4"	1	8.5	10.4	7.5	2	2 pipelines 4" dia, 1 pipeline 2" dia, 1 pipeline 1.5" dia
4	0.04	Ernakulam Market Canal Bridge	RCC Road	9°58'55.9"	76°16'37.5"	1	12.9	3	10.5	1.1	---

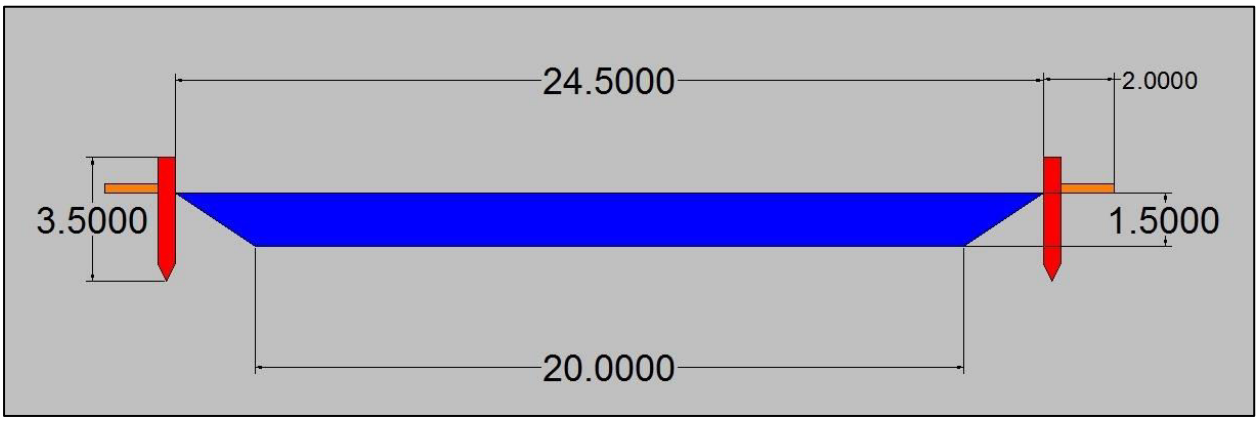
6.6 DREDGING

From the literatures on vessel operation in inland water canals, it is learnt that the maximum width for passenger and tourist vessel is 3.40m and for cargo vessel, the 100T barge has a minimum width of 4.25m. Considering the above aspects, it is proposed two types of fairways are as given below;

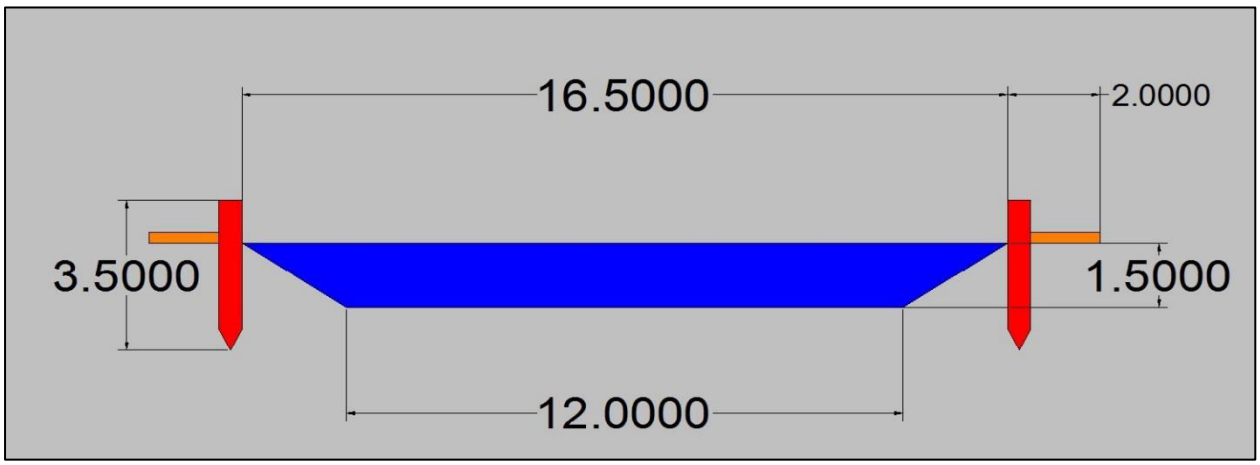
Bottom width of 12m; Top width of 16.5m and water depth of 1.5m with 2m wide walkway on both side in the artificial canal portion, and

Bottom width of 20m;Top width of 24.5mand water depth of 1.5m with 2m wide walkway on both side in the artificial canal portion.

The fairway design is considered as two options and the cross section with side slope of 1:1.5 is shown below;



OPTION I (20M FAIRWAY)



OPTION II (12M FAIRWAY)

6.6.1 Edapally Canal

The cross sectional details of the canal were taken at 100m interval, unless there is any appreciable change in cross-section or alignment is noted. The estimated dredging quantity of Edapally canal is given in **Table 6.6.**

Table 6.6 Dredging Quantity – Edapally Canal

S. NO	SECTION	20m wide canal Quantity (Cum)	12m wide canal Quantity (Cum)
1	Starting Point of canal – Railway bridge	22615.82	9828.91
2	Railway bridge –NH Road bridge	29074.17	13625.43
3	NH Road bridge – Puravankara bridge	23471.36	11562.19
4	Puravankara bridge – Pipeline bridge	11085.11	5118.49
5	Pipeline bridge – Palachuvadu bridge	16907.96	6077.64
6	Palachuvadu bridge – Arakkakadavu bridge	0.00	0.00
7	Arakkakadavu bridge – KuzhuveliPalam	0.00	0.00
8	KuzhuveliPalam – End Point of canal	0.00	0.00
	TOTAL	103,154.42	46,212.66

The maximum siltation occurred in section 2 i.e., Railway bridge – NH road bridge and Section 6 to 8 the dredging quantity is nil. The total quantity estimated for 20m fairway is 103,154 cum and 46,213 cum for 12m fairway. The percentage distribution of dredging quantity for Edapally canal is shown in **Figure 6.6.**

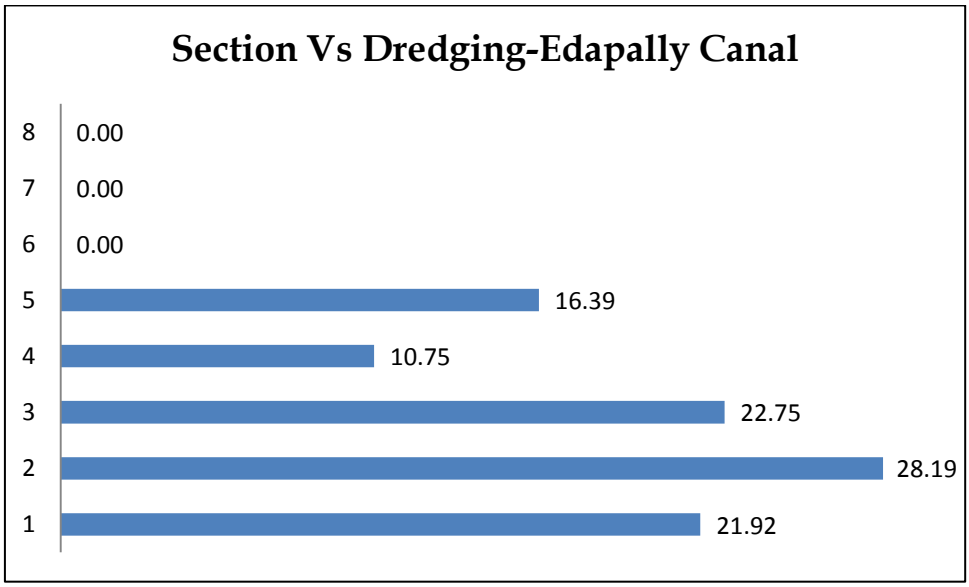


Figure 6.6. Section wise dredging quantity – Edapally canal

6.6.2 Chilavanoor Canal

The section wise estimation of dredging quantity for Chilavanoor canal is given in **Table 6.7.** The total quantity for 20m wide canal is 173,799 cum and 78,098 cum of dredging quantity is estimated for 12m wide canal. The canal passing through Kochi city limit is having maximum amount of siltation i.e., the sections between 4 and 8. The percentage distribution of dredging quantity for Chilavanoor canal is shown in **Figure 6.7.**

Table 6.7 Dredging Quantity – Chilavanoor Canal

S. NO	SECTION	20m wide canal Quantity (Cum)	12m wide canal Quantity (Cum)
1	Canal starting point – Elamkulam bridge	2.47	0.00
2	Elamkulam bridge – SCB bridge	6356.31	3018.44
3	SCB bridge – Palathuruthu bridge	10180.63	2871.31
4	Palathuruthu bridge – Rly quarters bridge	16273.28	5369.95
5	Rly quarters bridge – Skyline bridge	28434.78	13210.24
6	Skyline bridge – Stadium Gate bridge	29030.29	13877.10
7	Stadium Gate bridge – Camradenagar	30984.18	16199.85
8	Camradenagar bridge – BTS road bridge	21054.37	10175.35
9	BTS road bridge – Ragavan Pillai road bridge	13089.27	6205.93
10	Ragavan Pillai road bridge – Railway bridge	18189.60	7168.85
11	Railway bridge – Canal end point	204.20	1.00
	TOTAL	173,799.38	78,098.03

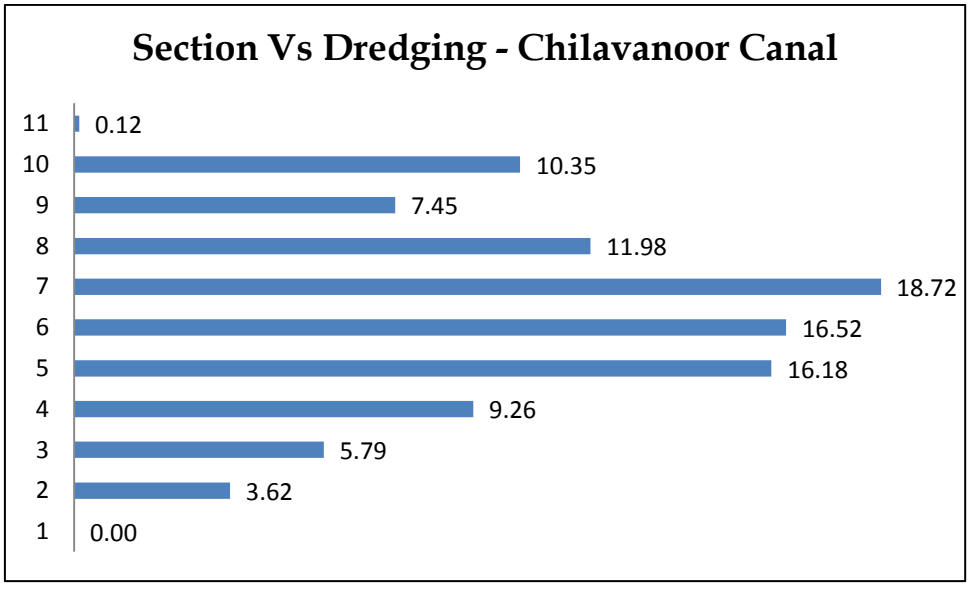


Figure 6.7. Section wise dredging quantity – Chilavanoor canal

6.6.3 Thevara – Perandoor Canal

The estimated dredging quantity for 20m and 12m fairway are 126,055 cum and 52,319 cum respectively for Thevara – Perandoor canal. The minimum siltation presented in canal starting section which is having wider portion and the maximum amount of siltation is occurred in section 5 i.e., Salimrajan road bridge – Kadavantharabridge. The canal sections 2 to 6 falls in the city limit and it resulted higher amount of siltation. **Table 6.8** shows the dredging quantity of Thevara – Perandoor canal and the percentage wise distribution is shown in **Figure 6.8.**

Table 6.8 Dredging Quantity – Thevara - Perandoor Canal

S. NO	SECTION	20m wide canal Quantity (Cum)	12m wide canal Quantity (Cum)
1	Canal starting point – Pottakuzhy bridge	191.00	1.10
2	Pottakuzhy bridge – Sasta temple bridge	15629.18	5196.18
3	Sasta temple bridge – Chemmani bridge	24302.07	12184.03
4	Chemmani bridge – Salimrajan bridge	29974.54	14708.03
5	Salimrajan bridge – Kadavanthara market	18389.29	8172.75
6	Kadavanthara market bridge – Girinagar	22724.65	8717.41
7	Girinagar bridge – End point of canal	14844.45	3339.19
	TOTAL	126,055.17	52,318.68

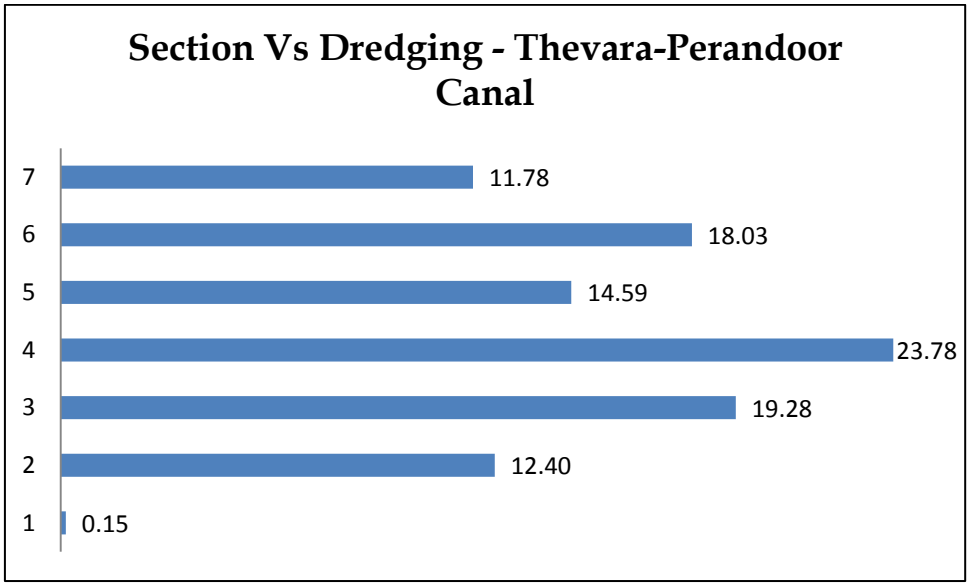


Figure 6.8. Section wise dredging quantity – Thevara-Perandoor canal

6.6.4 Thevera Canal

Due to absence of tidal action, the canal siltation is more at starting and ending point. The estimated dredging quantity for 20m and 12m waterway is 8522 cum and 2183 cum respectively. **Table 6.9** shows the required dredging quantity for Thevara canal.

Table 6.9 Dredging Quantity – Thevara Canal

S. NO	SECTION	20m wide canal Quantity (Cum)	12m wide canal Quantity (Cum)
1	Canal starting point – End point of canal	8521.71	2182.505
	TOTAL	8521.71	2182.505

6.6.5 Market Canal

The siltation at starting point is less and it is in increasing trend towards the end of canal due to less flow rate and commercial activities. The end point at Banerji road is connected with drains and the flow of canal is restricted resulted higher amount of siltation between market bridge and Banerji road bridge. The estimated dredging quantity for 20m and 12m waterway is 12,155 cum and 4872 cum respectively. The result of dredging quantity for market canal is given in **Table 6.10.**

Table 6.10 Dredging Quantity – Market Canal

S. NO	SECTION	20m wide canal Quantity (Cum)	12m wide canal Quantity (Cum)
1	Canal starting point – End point of canal	12154.71	4872.349
	TOTAL	12154.71	4872.349

6.7 WATER QUALITY

The water samples at 15 locations were collected where the canal is stagnant, change in canal characteristics, identified sources of pollution etc. The location of sampling stations is given in **Table 6.11.**

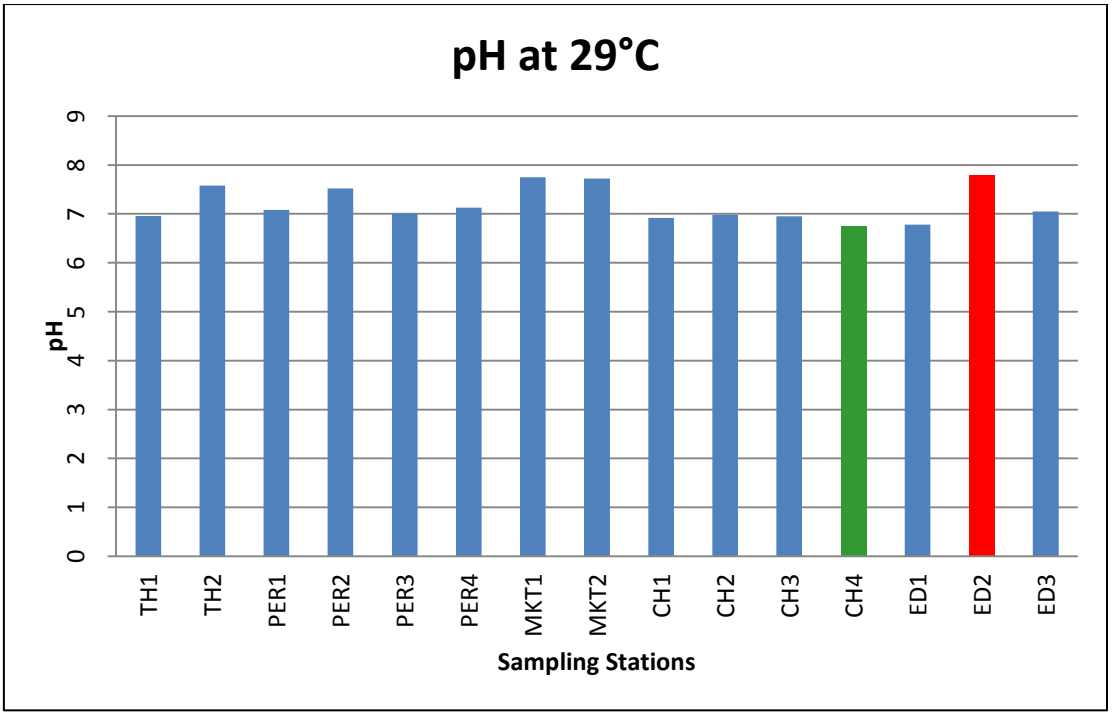
Table 6.11. Location of Water Samples

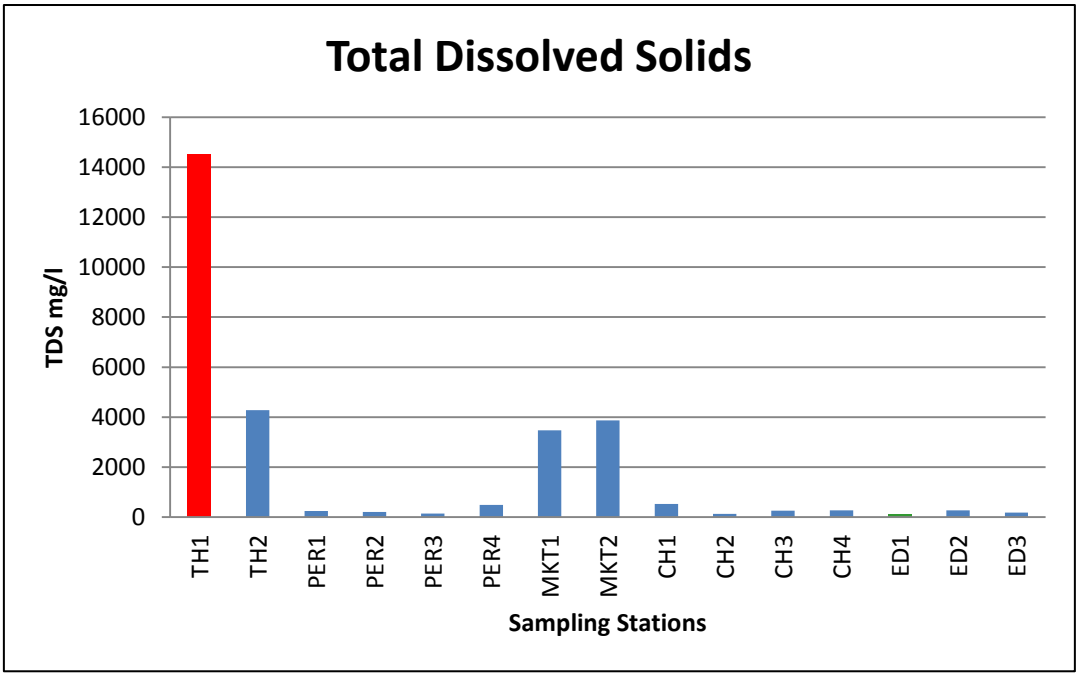
SAMPLE NO	CANAL	SAMPLE ID	SAMPLING LOCATION	LATITUDE	LONGITUDE
1	THEVARA CANAL	TH-1	Near Thevara bridge	9°56'39.41"	76°17'37.68"
2		TH-2	Near Kallumpalam bridge	9°56'45.43"	76°18'9.11"
3	THEVARA-PERANDOOR CANAL	PER-1	Near Sastha temple road bridge	9°59'50.27"	76°17'18.22"
4		PER-2	Near RBI quarters bridge	9°59'29.94"	76°17'27.74"
5		PER-3	Near KSINC office	9°58'26.92"	76°17'32.5"
6		PER-4	Near Panampilly-Giri Nagar bridge	9°57'34.5"	76°17'54.6"
7	MARKET CANAL	MKT-1	Near Broadway bridge	9°58'51.56"	76°16'35.22"
8		MKT-2	Near Market canal bridge	9°58'55.18"	76°16'36.98"
9	CHILAVANOOR CANAL	CH-1	Near SCB road bridge	9°58'20.92"	76°18'20.70"
10		CH-2	Near Stadium gate bridge	9°59'52.13"	76°17'57.1"
11		CH-3	Near Comrade Nagar bridge	10°0'23.76"	76°17'48.97"
12		CH-4	Near EdapallyRagavan Pillai road bridge	10°1'10.63"	76°17'42.94"
13	EDAPALLY CANAL	ED-1	Near Muttarkadavu bridge	10°2'35.79"	76°18'11.97"
14		ED-2	Near NH road bridge	10°1'31.05"	76°16'32.31"
15		ED-3	Near Pipeline bridge	10°0'52.98"	76°18'57.18"

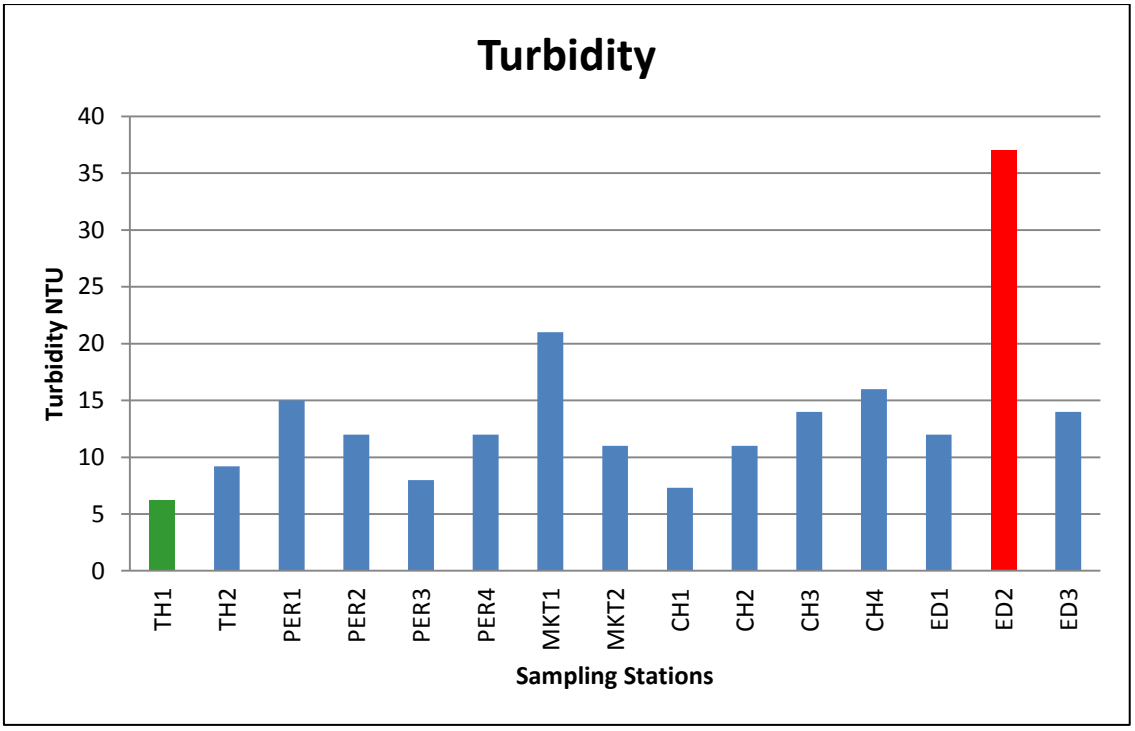
The physical, chemical and biological parameters were analyzed and the summarized result of water sample analysis is given in **Table 6.12.** The graphical representation of each parameter is shown in **Figure 6.9.**

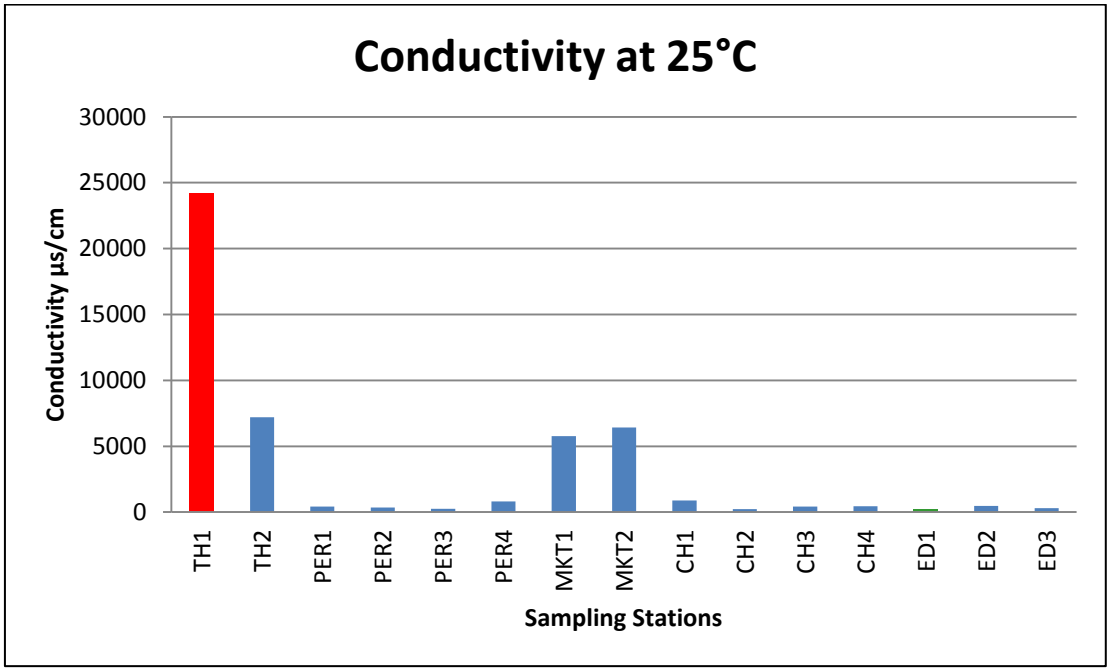
Table 6.12.Summarised Result of Water Sample Analysis

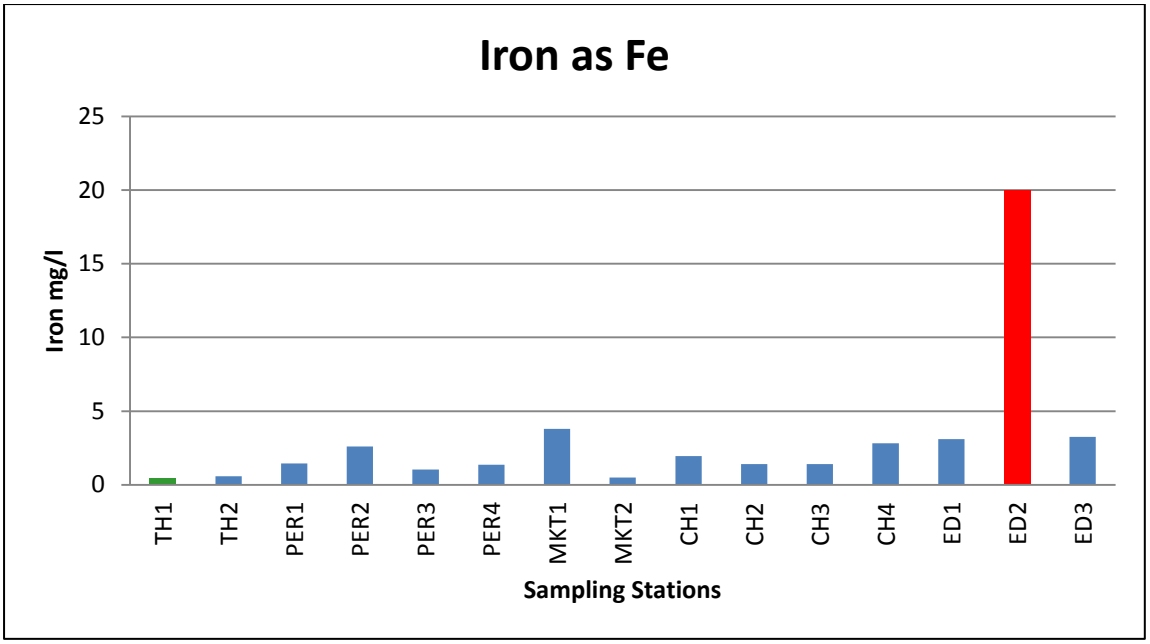
S.NO	PARAMETERS	UNIT	THEVARA CANAL		THEVARA-PERANDOOR				MARKET CANAL		CHILAVANOOR CANAL				EDAPALLY CANAL		
			TH1	TH2	PER1	PER2	PER3	PER4	MKT1	MKT2	CH1	CH2	CH3	CH4	ED1	ED2	ED3
1	pH at 29^{0}C		6.96	7.58	7.08	7.52	7.01	7.13	7.75	7.72	6.92	6.98	6.95	6.75	6.78	7.79	7.05
2	Total Dissolved Solids	mg/l max	14500	4280	238	210	148	484	3472	3864	524	130	258	269	104	275	177
3	Turbidity	NTU	6.2	9.2	15	12	8	12	21	11	7.3	11	14	16	12	37	14
4	Temperature (°C)	°C	29	29	29	29	29	29	29	29	29	29	29	29	29	29	29
5	Conductivity at 25°C	µS/cm max	24200	7200	420	360	254	810	5775	6420	892	225	435	460	185	470	312
6	Total Hardness as $CaCO_3$	mg/l	2231	776	89.24	81.48	62.08	135.8	630.5	630.5	164.9	69.84	116.4	120.28	38.8	126.1	89.24
7	Chloride as Cl	mg/l max	7231.8	1807.95	57.85	44.36	30.86	163.92	1687.42	1807.95	221.78	21.21	44.36	52.07	30.86	25.07	40.5
8	Sulphate as SO_4	mg/l max	818.47	292.72	9.73	17.33	6.74	13.48	169.47	146.36	17.33	3.37	5.01	18.58	12.81	31.01	13
9	Nitrate as NO_3	mg/l	0.81	0.6	0.45	0.51	0.6	0.57	0.55	0.49	0.53	0.53	0.49	0.57	0.49	0.49	0.51
10	Iron as Fe	mg/l	0.42	0.59	1.45	2.6	1.04	1.36	3.8	0.5	1.95	1.4	1.4	2.82	3.1	20	3.25
11	Calcium as Ca	mg/l	155.51	58.32	26.44	26.44	17.11	31.1	58.32	58.32	34.99	21.77	40.43	38.88	10.89	23.33	27.99
12	Magnesium as Mg	mg/l	447.85	153.21	5.66	3.77	4.71	14.14	117.86	117.86	18.86	3.77	3.77	5.66	2.83	16.5	4.71
13	Chemical Oxygen Demand	mg/l	55	38	43	9	21	38	179	55	21	13	51	51	51	136	21
14	Total Suspended Solids	mg/l	212	238	91	62	42	98	198	54	80	85	105	42	90	368	196
15	E.Coli	index/ 100ml	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600	>1600

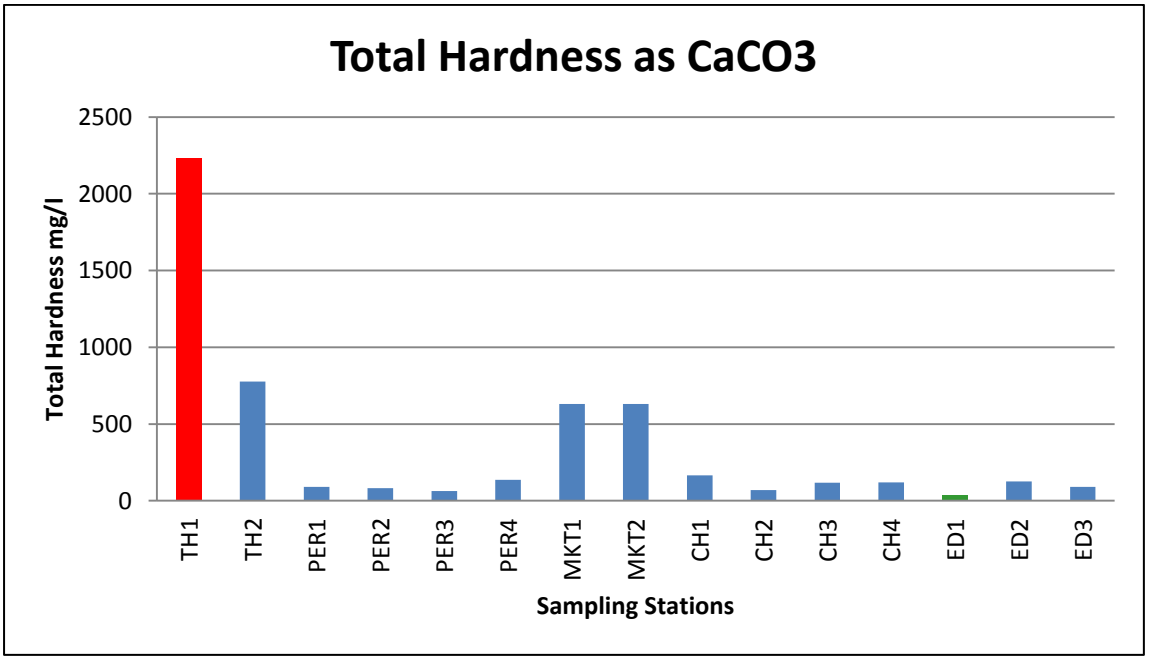

pH at 29°C
pH
0
1
2
3
4
5
6
7
8
9
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations

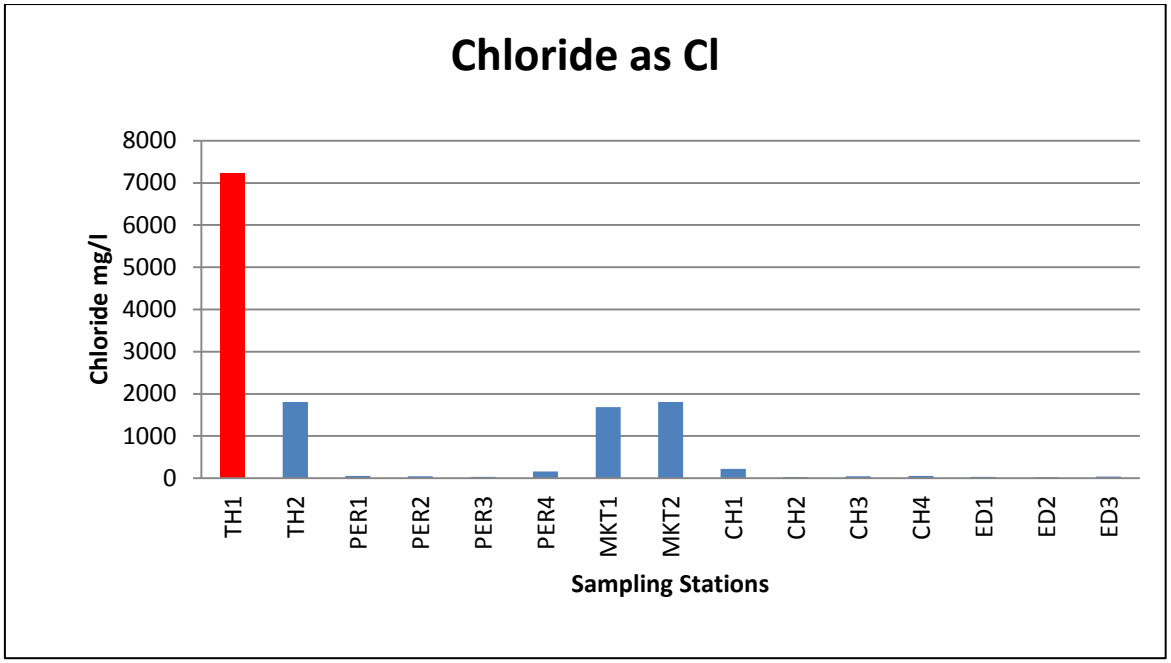

Total Dissolved Solids
TDS mg/l
16000
14000
12000
10000
8000
6000
4000
2000
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations

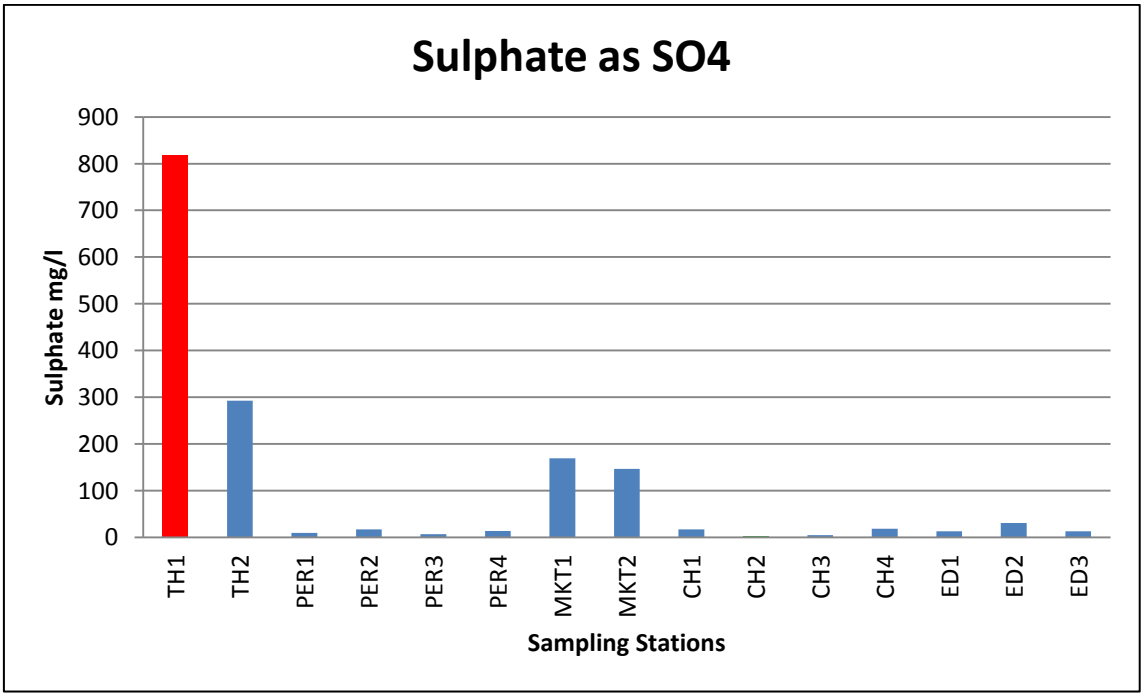

Turbidity
Turbidity NTU
40
35
30
25
20
15
10
5
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations

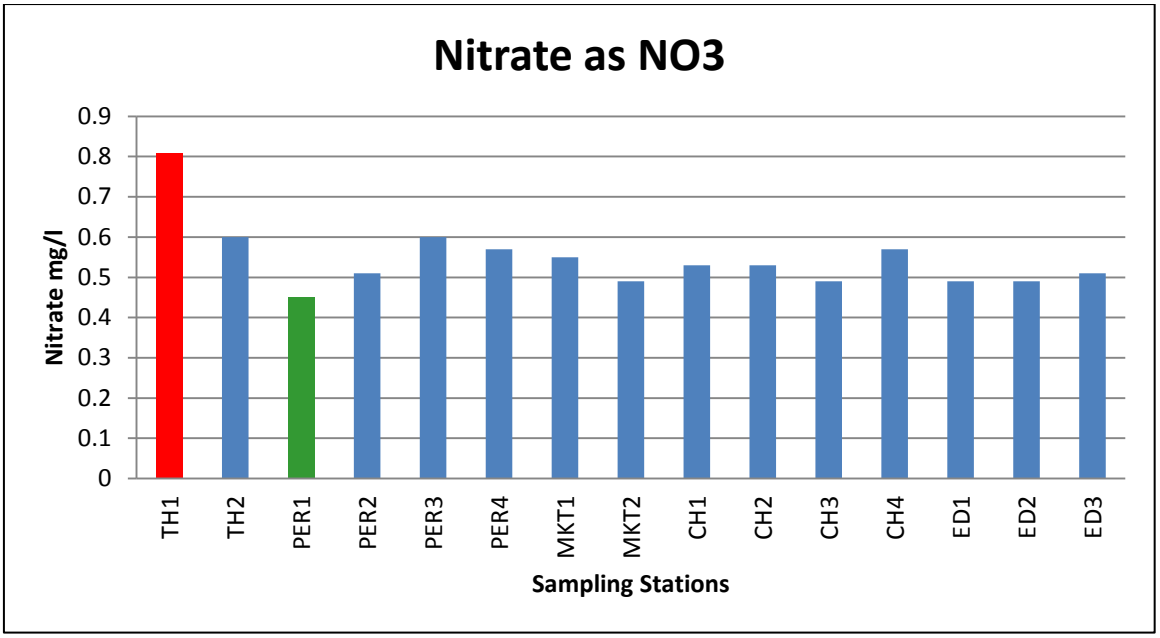

Conductivity at 25°C
Conductivity µs/cm
30000
25000
20000
15000
10000
5000
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations

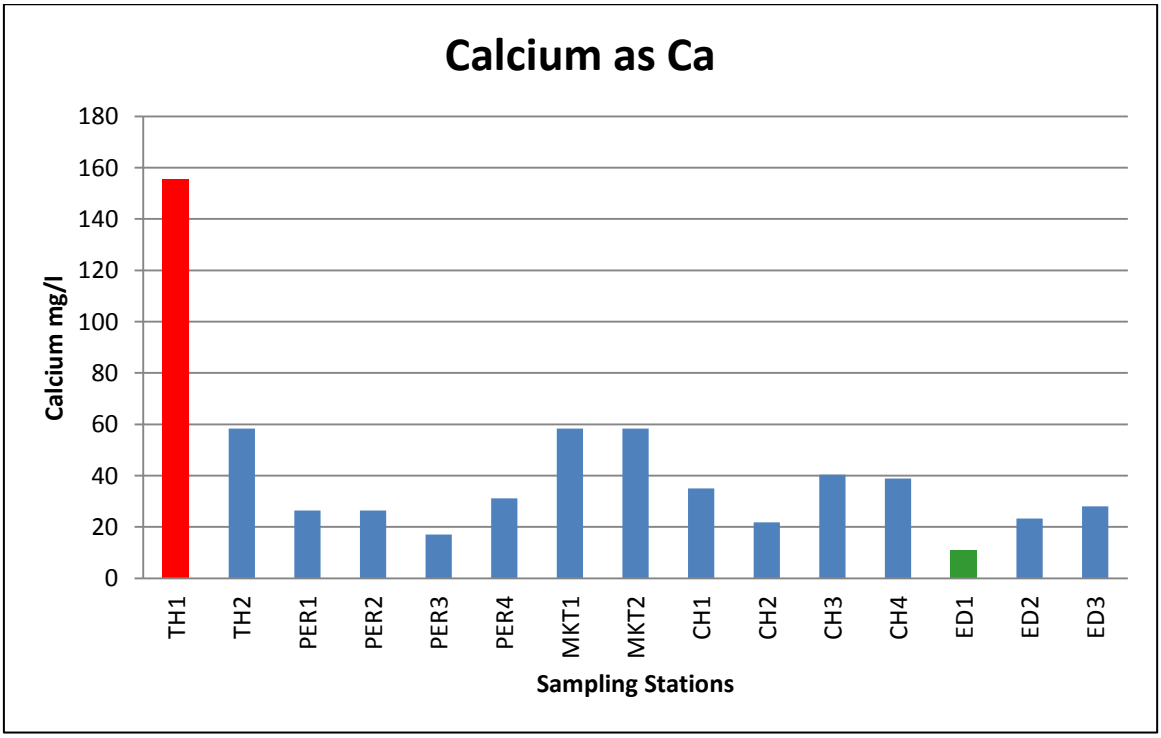

Iron as Fe
Iron mg/l
25
20
15
10
5
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations

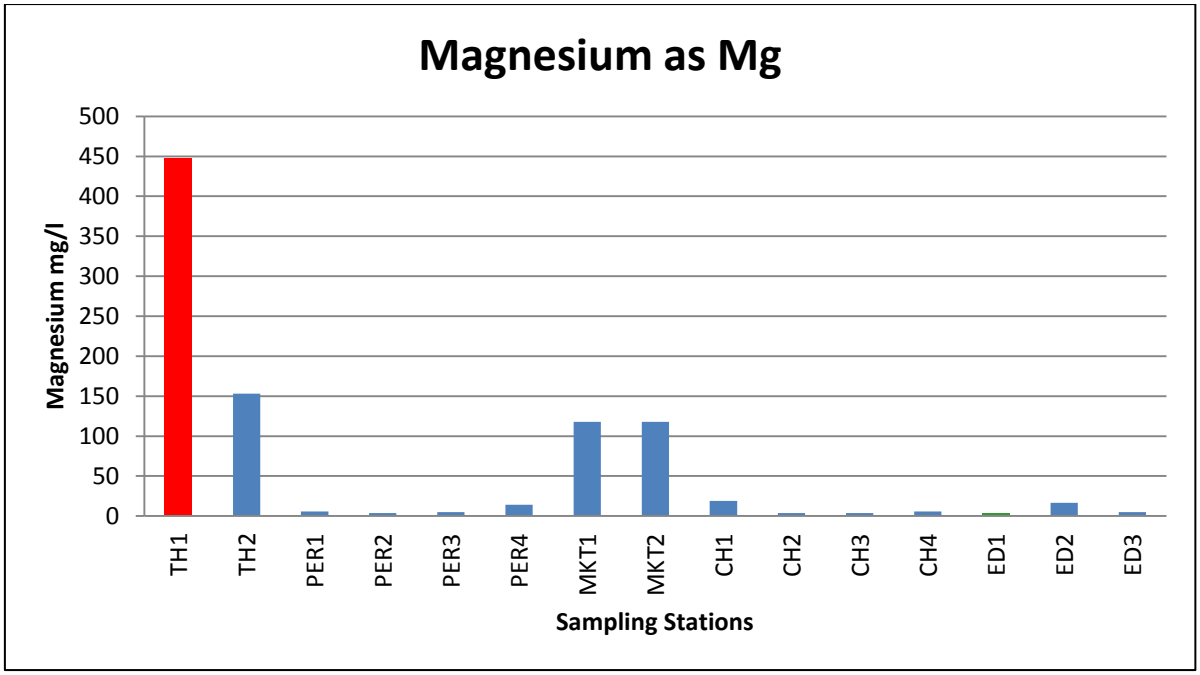

Total Hardness as CaCO3
Total Hardness mg/l
2500
2000
1500
1000
500
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations

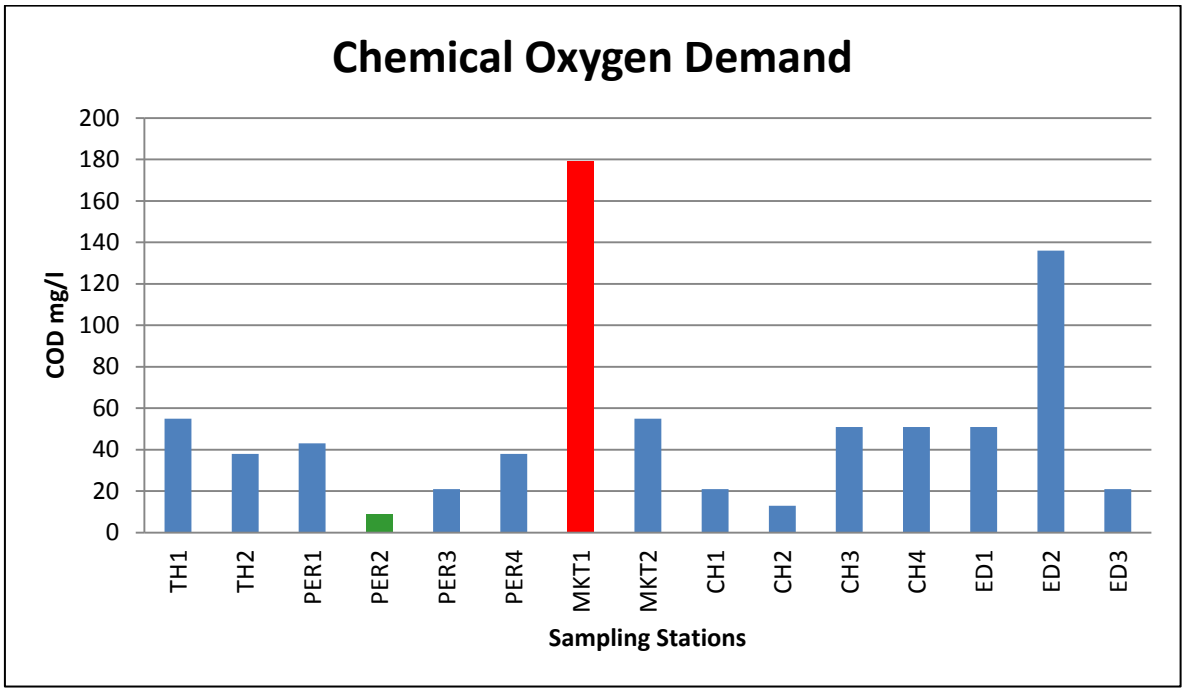

Chloride as Cl
Chloride mg/l
8000
7000
6000
5000
4000
3000
2000
1000
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations


Sulphate as SO4
Sulphate mg/l
900
800
700
600
500
400
300
200
100
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations


Nitrate as NO3
Nitrate mg/l
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations


Calcium as Ca
Calcium mg/l
180
160
140
120
100
80
60
40
20
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations


Magnesium as Mg
Magnesium mg/l
500
450
400
350
300
250
200
150
100
50
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations


Chemical Oxygen Demand
COD mg/l
200
180
160
140
120
100
80
60
40
20
0
TH1
TH2
PER1
PER2
PER3
PER4
MKT1
MKT2
CH1
CH2
CH3
CH4
ED1
ED2
ED3
Sampling Stations

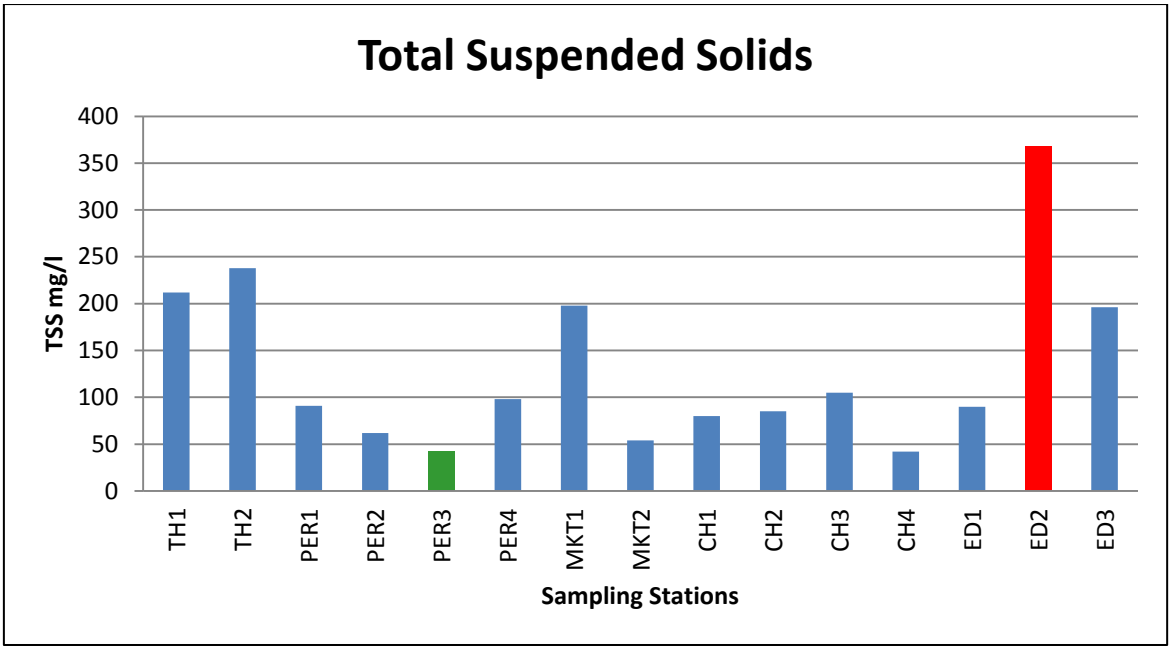


Figure 6.9 Graphical representation of Water Quality Analysis

The major findings of the water sample analysis are discussed as follows;

pH value was observed between 6.75 – 7.79. The minimum value 6.75 was observed at near Raghavan road bridge of Chilavanoor canal due to discharge of two channels nearer to the sampling station and it is resulted acidic. The maximum value 7.79 near NH road bridge of Edapally canal was observed. The flow of water at NH road bridge is restricted due to metro construction and it is resulted higher amount alkalinity. Similarly, high values of pH at Market canal (2 samples) were observed due to stagnant water and discharge of market waste into the canal. Near Kallaumpalam sample of Thevara canal was also recorded pH value 7.58 is due higher amount weeds growth.

The Total dissolved solids was high at Thevara bridge sample of Thevara canal and the minimum was recorded at Muttarkadavu of Edapally canal. The fish market liquid and solid waste are directly discharged into the canal resulted the maximum concentration of TDS at Thevara bridge sample. The higher TDS concentration at Kallumpalam bridge of Thevara canal, and market canal samples are also observed.

The maximum and minimum concentration of turbidity was recorded at NH road bridge of Edapally canal and Thevara bridge of Thevara canal. It is resulted mainly due to the flow rate of water in the canal.

The concentration of conductivity, total hardness, chloride, sulphate, nitrate, calcium and magnesium were maximum at Thevera bridge sample of Thevera canal. Due to the absence of tidal action the canal is heavily silted and discharge from fishing market right bank of the canal results the higher concentration of above pollutants.

The parameters like conductivity, total hardness, calcium and magnesium are observed lesser amount at Muttarkadavu sample of Edapally canal shows flow of the canal can influence the self purification capacity of the canal and results minimum levels of pollutants.

E-Coli index at all sample shows are well beyond the permissible limit and it is fit for drinking purpose at any cause. It also indicates that the canal is best suited place for mosquito breeding. It may cause various diseases to human health also it will affect the canal ecosystem.

6.8 EXISTING BUILDINGS

The details of buildings along left bank and right bank are collected. It includes type of buildings like single floor RCC, double floor RCC, more than two floors RCC, sheet roofed, tiled roof and other types. The collected building details further categorized into two types of right of way i.e., 28.5m buffer zone and 20.5m buffer zone. The classified building details are furnished in **Annexure I and II.** The canal wise buildings details are discussed below;

6.8.1 Edapally Canal

The total buildings existing within 28.5m buffer zone is 86. Of 86, 36 buildings are in left bank and 50 are in right bank. 19 buildings from left bank and 21 buildings from right bank and total of 40 buildings are falls under 20.5m buffer zone. Maximum number of buildings was observed between Muttarkadavu and Palachuvadubridge i.e., Sections 1 to 5.

The section wise building details are given in **Table 6.13.**

Table 6.13. Existing Buildings – Edapally canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Starting Point of canal – Railway bridge	8	6	14	5	5	10
2	Railway bridge –NH Road bridge	13	11	24	6	7	13
3	NH Road bridge – Puravankara bridge	7	6	13	4	3	7
4	Puravankara bridge – Pipeline bridge	3	7	10	1	2	3
5	Pipeline bridge – Palachuvadu bridge	5	20	25	3	4	7
6	Palachuvadu bridge – Arakkakadavu bridge	0	0	0	0	0	0
7	Arakkakadavu bridge – KuzhuveliPalam	0	0	0	0	0	0
8	KuzhuveliPalam – End Point of canal	0	0	0	0	0	0
	TOTAL	**36**	**50**	**86**	**19**	**21**	**40**

6.8.2 Chilavanoor Canal

The settlers and buildings are more around Chilavanoor canal. Except Section 1, the buildings along the banks are spreaded over throughout the canal. Within 28.5m buffer zone, on left side 182 buildings and 116 buildings on right side are existing. The total number of buildings fall in this zone is 298. Similarly, in 20.5m buffer zone total numbers of 184 buildings are observed. Of 184, 112 buildings on left side and 72 buildings on right side was observed. The section wise details are given in **Table 6.14.**

Table 6.14. Existing Buildings – Chilavanoor canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – Elamkulam bridge	0	0	0	0	0	0
2	Elamkulam bridge – SCB bridge	5	2	7	3	2	5
3	SCB bridge – Palathuruthu bridge	28	15	43	18	4	22
4	Palathuruthu bridge – Rly quarters bridge	15	12	27	6	2	8
5	Rly quarters bridge – Skyline bridge	21	8	29	7	3	10
6	Skyline bridge – Stadium Gate bridge	20	9	29	19	6	25
7	Stadium Gate bridge – Camradenagar	41	15	56	30	14	44
8	Camradenagar bridge – BTS road bridge	26	30	56	18	26	44
9	BTS road bridge – Ragavan Pillai road bridge	13	16	29	8	13	21
10	Ragavan Pillai road bridge – Railway bridge	6	9	15	1	2	3
11	Railway bridge – Canal end point	7	0	7	2	0	2
	TOTAL	**182**	**116**	**298**	**112**	**72**	**184**

6.8.3 Thevara – Perandoor Canal

Section 1 of the canal is having sufficient width and the settlers on this section are nil. From Pottakuzhy bridge to end of the canal section, the buildings extended uniformly. The total number of buildings accounted for 28.5m buffer zone is 227 which includes 102 on left side and 125 on right side. The 20.5m buffer zone consists of 115 buildings which includes 49 on left and 66 on right side of the canal. The section wise building details are given in **Table 6.15.**

Table 6.15. Existing Buildings – Thevara - Perandoor Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – Pottakuzhy bridge	0	0	0	0	0	0
2	Pottakuzhy bridge – Sasta temple bridge	15	23	38	14	18	32
3	Sasta temple bridge – Chemmani bridge	19	24	43	8	10	18
4	Chemmani bridge – Salimrajan bridge	21	38	59	8	21	29
5	Salimrajan bridge – Kadavanthara market	7	18	25	5	8	13
6	Kadavanthara market bridge – Girinagar	13	9	22	9	4	13
7	Girinagar bridge – End point of canal	27	13	40	5	5	10
	TOTAL	**102**	**125**	**227**	**49**	**66**	**115**

6.8.4 Thevara Canal

Total number of buildings falls within the buffer zone of 28.5m is 61. Of 61, 45 buildings are existing on left side and 16 are on right side of the canal. In the case of 20.5m zone, 31 buildings are existing on both sides. The details of existing buildings on Thevara canal is given in **Table 6.16.**

Table 6.16. Existing Buildings – Thevara Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – End Point of canal	45	16	61	23	8	31

6.8.5 Market Canal

The commercial activity is predominant in this canal banks and the buildings are situated away from the canal. Only 3 buildings on right side of the canal falling in 28.5m buffer zone and 2 buildings are found within 20.5m buffer zone. **Table 6.17** shows the building details of the canal

Table 6.17. Existing Buildings – Market Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – End Point of canal	0	3	3	0	2	2

6.9 PROJECT AFFCETED PEOPLE (PAP)

To assess the settlers along the canal bank, a household survey was conducted and the Project Affected People (PAP) of implementation of the project is estimated separately for two types of fairways. For 20m fairway, the existing PAP's along left bank is 2018 and 2055 on right bank are assessed. Similarly for 12m fairway, 897 people on left bank and 1043 people on right bank were observed. The total number of PAP's of 20m and 12m fairways are 4073 and 1940 respectively is assessed for the study stretches. The maximum number of PAP's are obtained in city limit region. The detailed canal wise PAP particulars are discussed below;

Edapally Canal

The settlers are predominant between canal starting point and Palachuvadubridge for both fairways. The total PAP's of 20m fairway is 419 and for 12m fairway it is 150. The section wise PAP's are given in **Table 6.18** for Edapally canal.

Table 6.18. Project Affected People – Edapally canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Starting Point of canal – Railway bridge	50	24	74	22	19	41
2	Railway bridge –NH Road bridge	52	46	98	23	28	51
3	NH Road bridge – Puravankara bridge	57	39	96	14	9	23
4	Puravankara bridge – Pipeline bridge	12	27	39	3	8	11
5	Pipeline bridge – Palachuvadu bridge	16	96	112	9	15	24
6	Palachuvadu bridge – Arakkakadavu bridge	0	0	0	0	0	0
7	Arakkakadavu bridge – KuzhuveliPalam	0	0	0	0	0	0
8	KuzhuveliPalam – End Point of canal	0	0	0	0	0	0
	TOTAL	**187**	**232**	**419**	**71**	**79**	**150**

Chilavanoor Canal

The PAP's for 20m and 12m fairways are assessed and the maximum amount of PAP's is obtained on left bank i.e. towards the city region. The PAP's of 20m and 12m fairways are 1661 and 882 respectively is assessed. The section wise PAP details are furnished in **Table 6.19.**

Table 6.19. Project Affected People – Chilavanoor canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – Elamkulam bridge	0	0	0	0	0	0
2	Elamkulam bridge – SCB bridge	19	6	25	10	6	16
3	SCB bridge – Palathuruthu bridge	115	125	240	73	15	88
4	Palathuruthu bridge – Rly quarters bridge	94	97	191	39	24	63
5	Rly quarters bridge – Skyline bridge	83	50	133	28	28	56
6	Skyline bridge – Stadium Gate bridge	100	67	167	80	71	151
7	Stadium Gate bridge – Camradenagar	270	80	350	125	75	200
8	Camradenagar bridge – BTS road bridge	158	143	301	77	125	202
9	BTS road bridge – Ragavan Pillai road bridge	85	67	152	31	55	86
10	Ragavan Pillai road bridge – Railway bridge	22	52	74	4	8	12
11	Railway bridge – Canal end point	28	0	28	8	0	8
	TOTAL	**974**	**687**	**1661**	**475**	**407**	**882**

Thevara-Perandoor Canal

The existing PAP's within 20m and 12m fairways are estimated for Thevara-Perandoor canal. The total number of affected people for 20m fairway is 1704 and 761 people will be affected due to implementation of 12m fairway. The settler's population is relatively thicker on right bank than left bank. The section wise PAP's of 20m and 12m fairway is given in **Table 6.20.**

Table 6.20. Project Affected People – Thevara - Perandoor Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – Pottakuzhy bridge	0	0	0	0	0	0
2	Pottakuzhy bridge – Sasta temple bridge	108	184	292	105	134	239
3	Sasta temple bridge – Chemmani bridge	223	194	417	33	72	105
4	Chemmani bridge – Salimrajan bridge	90	249	339	35	115	150
5	Salimrajan bridge – Kadavanthara market	33	155	188	21	50	71
6	Kadavanthara market bridge – Girinagar	66	83	149	47	48	95
7	Girinagar bridge – End point of canal	140	179	319	17	84	101
	TOTAL	660	1044	1704	258	503	761

Thevara Canal

The PAP's for Thevara canal is estimated and is given in **Table 6.21.** The canal is considered as one section and it is observed that the PAP's are maximum on left bank. The total PAP's for 20m and 12m are 278 and 141 respectively.

Table 6.21. Project Affected People – Thevara Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – End Point of canal	197	81	278	93	48	141

Market Canal

The PAP's on left bank is nil on left bank for both fairways. The total number of PAP's for 20m fairway is 11 and for 12m fairway it is observed as 6. **Table 6.22** provides the detail of PAP's for Market canal.

Table 6.22. Project Affected People – Market Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – End Point of canal	0	11	11	0	6	6

6.10LAND ACQUISTION

The approximate land requirement for development of Kochi canals is estimated. The area may vary from findings of Detailed Project Report (DPR) of the study. The detailed topography survey using advance geo-informatic instruments like Differential Global Positioning System and Electronic Total Station will be carried out in DPR stage. The base plan consists of canal boundary, ownership of the property which comes under project affected area, boundary of the property and other relevant details from revenue department will be prepared. The actual land required for canal development will be assessed.

In this study, the land required for 20m and 12m waterway of the canals are determined. The affected area may be notified by the Government of Kerala under the relevant land acquisition acts for the purposes of land acquisition for the project. The Land Acquisition Act 1894 or under the Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 or any other prevailing Government orders are the legislations has to be followed for land acquisition.

The estimated land requirement for canal development is discussed canal wise as follows;

6.10.1 Edapally Canal

The total land required for 20m fairway is 8.18 Ha. and for 12m waterway it is estimated as 3.51 Ha. The land needed for canal development is lies between the sections 1 and 5 i.e., Starting point of the canal to Palachuvadu bridge sections. The

share of land requirement in percentage is 28%, 29%, 19%, 10% and 14% respectively for Sections 1 to 5. Section 6 to 8 requires no additional land for canal development. **Table 6.23** shows the requirement of land for canal development and **Figure6.10** shows the percentage distribution of land requirement for Edapally canal.

Table 6.23 Land Acquisition – Edapally Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Starting Point of canal – Railway bridge	9754.08	9574.74	19328.82	5328.863	5123.398	10452.26
2	Railway bridge –NH Road bridge	10779.16	10597.37	21376.53	5263.231	5163.103	10426.33
3	NH Road bridge – Puravankara bridge	7388.6	7186.1	14574.7	3240.352	2939.546	6179.898
4	Puravankara bridge – Pipeline bridge	4011.88	3738.95	7750.83	1559.302	2255.614	3814.916
5	Pipeline bridge – Palachuvadu bridge	9819.063	8278.235	18097.3	1969.526	2253.163	4222.69
6	Palachuvadu bridge – Arakkakadavu bridge	284.815	353.4667	638.2817	0	0	0
7	Arakkakadavu bridge – KuzhuveliPalam	3.56	0	3.56	0	0	0
8	KuzhuveliPalam – End Point of canal	0	0	0	0	0	0
	TOTAL(sq.m)	42041.16	39728.86	81770.02	17361.27	17734.82	35096.1
	TOTAL (Ha.)	4.20	3.97	8.18	1.74	1.77	3.51

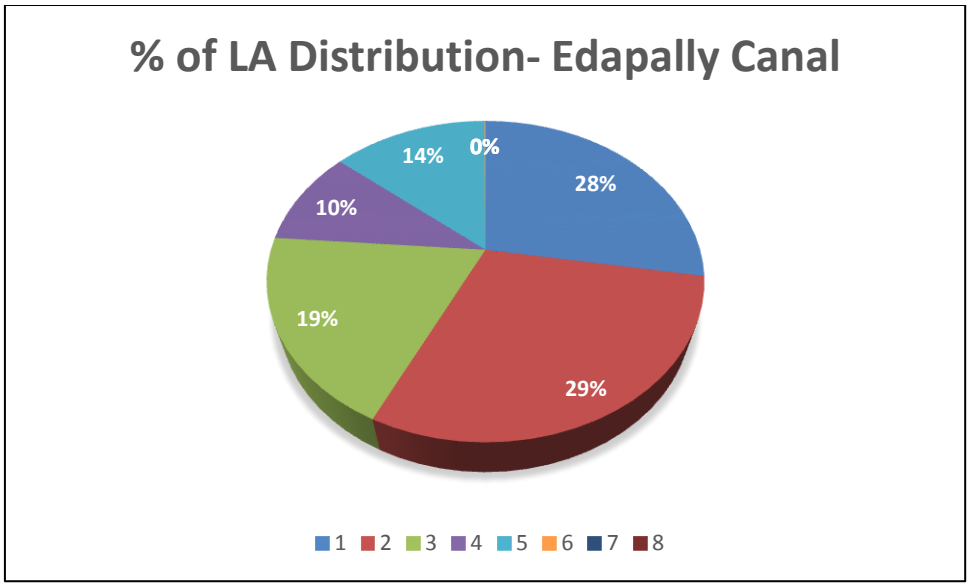


Figure 6.10 LA Distribution – Edapally Canal

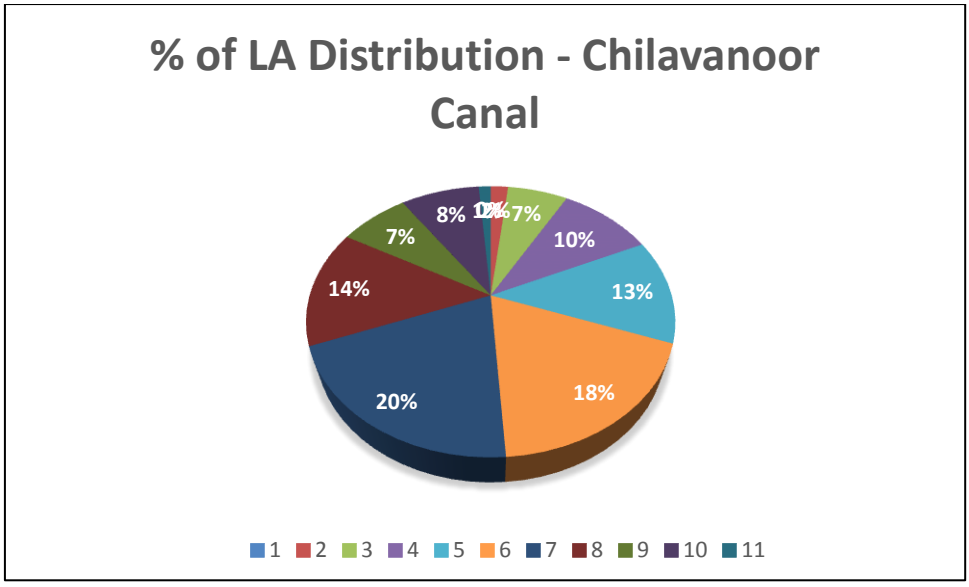


Figure 6.11 LA Distribution – Chilavanoor Canal

6.9.2 Chilavanoor Canal

The total land required for canal development into 20m and 12m fairway are determined as 16.19 Ha. and 9.43 Ha. respectively. The section wise land requirement is given in **Table 6.24.** No additional land is needed for section 1 and minimum amount of land is needed for section 11. **Figure 6.11** Shows the percentage distribution of land requirement for Chilavanoor canal.

Table 6.24 Land Acquisition – Chilavanoor Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		LEFT	RIGHT	TOTAL	LEFT	RIGHT	TOTAL
1	Canal starting point – Elamkulam bridge	0	0	0	0	0	0
2	Elamkulam bridge – SCB bridge	1655.46	1494.24	3149.7	634.26	586.5	1220.76
3	SCB bridge – Palathuruthu bridge	5466.6	5033.15	10499.75	2246.97	1970.29	4217.26
4	Palathuruthu bridge – Rly quarters bridge	8542.53	8125.99	16668.52	5654.22	5389.6	11043.82
5	Rly quarters bridge – Skyline bridge	10312.73	10657.76	20970.49	5335.71	5449.07	10784.78
6	Skyline bridge – Stadium Gate bridge	14373.28	14157.64	28530.92	9082.38	8835.33	17917.71
7	Stadium Gate bridge – Camradenagar	15366.21	15402.7	30768.91	10557.81	10501.1	21058.91
8	Camradenagar bridge – BTS road bridge	10806.29	10665.19	21471.48	7184.36	7034.81	14219.17
9	BTS road bridge – Ragavan Pillai road bridge	5875.05	5670.37	11545.42	3574.27	3447.72	7021.99
10	Ragavan Pillai road bridge – Railway bridge	7968.63	7534.15	15502.78	3225.19	2903.78	6128.97

11	Railway bridge – Canal end point	1573.03	1228.66	2801.69	454.82	227.81	682.63
	TOTAL (Sq.m)	81939.81	79969.85	161909.7	47949.99	46346.01	94296
	TOTAL (Ha.)	8.19	8.00	16.19	4.79	4.63	9.43

6.9.3 Thevara – Perandoor Canal

The land required for canal development is estimated and is given in **Table 6.25.** The canal consists of seven sections and the land is needed at all the sections. The minimum amount of land is needed for the section 1 i.e., Starting point of canal – Pottakuzhy bridge and the maximum is between Chemmani bridge – Salimrajan bridge section. The total land required for 20m waterway is 11.96 Ha. and 5.89 Ha is needed for 12m waterway. **Figure 6.12** Shows the percentage distribution of land requirement for Thevera – Perandoor canal.

Table 6.25 Land Acquisition – Thevara - Perandoor Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – Pottakuzhy bridge	790.93	941.77	1732.7	183.71	197.38	381.09
2	Pottakuzhy bridge – Sasta temple bridge	8562.6	8965.59	17528.19	4312.23	4393.24	8705.47
3	Sasta temple bridge – Chemmani bridge	10017.47	10219.59	20237.06	5929.7	6188.96	12118.66
4	Chemmani bridge – Salimrajan bridge	13263.28	13656.19	26919.47	8263.76	8571.08	16834.84
5	Salimrajan bridge – Kadavanthara market	7070.77	7789.43	14860.2	2834.7	3545.12	6379.82
6	Kadavanthara market bridge – Girinagar	9217.2	9860.77	19077.97	3356.11	3784.17	7140.28
7	Girinagar bridge – End point of canal	9386.93	9814.47	19201.4	3408.55	3903.62	7312.17
	TOTAL (Sq.m)	58309.18	61247.81	119557	28288.76	30583.57	58872.33
	TOTAL (Ha.)	5.83	6.12	11.96	2.83	3.06	5.89

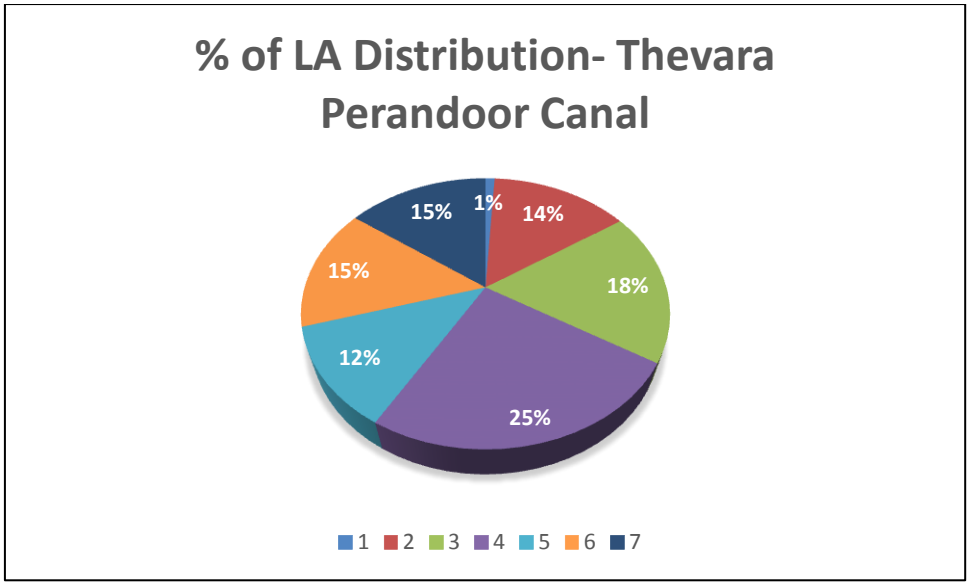


Figure 6.12 LA Distribution – Thevara – Perandoor Canal

6.9.4 Thevara Canal

The canal is considered as one section and the land required for canal development is determined for 20m and 12m fairways. The estimated land for 20m and 12m fairway is 1.52 Ha. and 0.45 Ha. respectively. The bank wise requirement of land for two fairways is given in **Table 6.26.**

Table 6.26 Land Acquisition – Thevara Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – End Point of canal	7385.46	7818.45	15203.91	2081.95	2388.25	4470.20
	TOTAL (sq.m)	7385.46	7818.45	15203.91	2081.95	2388.25	4470.20
	TOTAL (Ha.)	0.74	0.78	1.52	0.21	0.24	0.45

6.9.5 Market Canal

The canal is considered as one section and the land required for canal development is determined for 20m and 12m fairways. 1.10 Ha of land is required for 20m waterway and for 12m, 0.60 Ha. of land is required. **Table 6.27** shows the land requirement for Market canal development.

Table 6.27 Land Acquisition – Market Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		L	R	TOTAL	L	R	TOTAL
1	Canal starting point – End Point of canal	5353.33	5635.69	10989.02	2931.45	3066.23	5997.68
	TOTAL (Sq.m)	5353.33	5635.69	10989.02	2931.45	3066.23	5997.68
	TOTAL (Ha.)	0.54	0.56	1.10	0.29	0.31	0.60

CHAPTER VII

IMPROVEMENT PROPOSAL& COST ESTIMATION

7.1 CLEANING AND DESILTATION

The total dredging quantity for 20m waterway is 425602 cum and for 12m waterway is 184737 cum. respectively. The unit rate of dredging prescribed by Inland Water Authority of India (IWAI), 2016 is Rs.220/cum. The estimated amount for dredging is Rs. 936.33 lakhs for 20m waterway and Rs. 406.42 lakhs for 12m fairway. The breakup of the cost is described canal wise and shown in **Table 7.1**.

Table 7.1 Canal Wise break up of Dredging Cost

S.NO	CANAL	DREDGING QUANTITY (m^3)		AMOUNT (IN LAKHS)	
		12M	20M	12M	20M
1	Edapally canal	46212.66	103154.42	101.67	226.94
2	Chilavanoor canal	79151.03	175716.38	174.13	386.58
3	Thevara-Perandoor canal	52318.68	126055.17	115.10	277.32
4	Thevara canal	2182.51	8521.71	4.80	18.75
5	Market canal	4872.35	12154.71	10.72	26.74
	Total	**184737.2**	**425602.39**	**406.42**	**936.33**

Before starting desiltation, the canals have to be cleaned by removal of floating waste, garbage and other wastes. Rs. 5 lakhs per km is assumed for cleaning of canals and the amount of Rs 170.43 lakhs is needed for cleaning activity.

7.2 BANK PROTECTION

The total lengths including both the banks of 20.15 km of the canals are to be protected. The type of bank protection selected for this study is Pile and Slab and the unit rate of bank protection is Rs.25,000/m length (IWAI Rates, 2016). Total cost of Rs.5038 lakhs is required to protect the banks. The canal wise cost of bank protection is given in **Table. 7.2.**

Table 7.2 Canal wise Bank Protection Cost

S.NO	CANAL	BANK		LENGTH (m)	AMOUNT (IN LAKHS)
		LEFT	RIGHT		
1	Edapally canal	5955	5860	11815	2953.75
2	Chilavanoor canal	3026	1916	4942	1235.5
3	Thevara-Perandoor canal	1365	1100	2465	616.25
4	Thevara canal	580	350	930	232.5
5	Market canal	0	0	0	0
	Total	**10926**	**9226**	**20152**	**5038**

7.3 CROSS STRUCTURES

The vertical clearance of 4m and horizontal clearance of 20m is recommended for cross structures. The total cross structures passing through the canals are 103. Out of 103 bridges, 12 structures are met the desired standard, 13 of them are structurally weak and it is recommended to dismantle, and 73 of them are recommended for reconstruction. The proposed width of a single span is 20m with 4m clearance on vertical from high tide line. The unit rate of Rs.8 lakh/m length is adopted for this study estimate the reconstruction cost and Rs. 1 lakh/No. is assumed for dismantle. The canal wise particulars are discussed in detail as follows;

At Edapally Canal, out of 18 cross structures, 6 bridges namely Muttarakadavu bridge, oriental timber bridge, Pipeline bridge, Ayyanad bridge 1&2 and Palachuvadu bridge are recommended for reconstruction. The temporary wooden bridge and Puravankara iron bridge are recommended to dismantle.

Chilavanoor canal is having 38 cross structures passing through the canal. Of 38 bridges, 33 are recommended for reconstruction and five are recommended for dismantling.

Total cross structures existing on Thevara – Perandoor canal is 40. Out of 40, 29 are recommended for reconstruction and 11 are suggested to dismantle.

Similarly, Thevara canal is having 3 cross structures and all are recommended for reconstruction. Four cross structures are passing through Market canal and two of them recommended for reconstruction.

For reconstruction of bridges Rs.11680 lakhs is required and to dismantle the structures Rs.18 lakhs is needed. The total cost involved in cross structures

reconstruction/dismantling is 11698 lakhs. The canal wise break-up cost on cross structures estimation is given in **Table 7.3.**

Table 7.3 Reconstruction/Dismantle Cost of Cross Structures

S. NO	CANAL	RECON STRUCT (NO.)	COST (IN LAKHS)	DISMAN TLE (NO.)	COST (IN LAKHS)	TOTAL COST (IN LAKHS)
1	Edapally canal	6	960.00	2	2.00	962
2	Chilavanoor canal	33	5280.00	5	5.00	5285
3	Thevara-Perandoor canal	29	4640.00	11	11.00	4651
4	Thevara canal	3	480.00	0	0.00	480
5	Market canal	2	320.00	0	0.00	320
	Total	**73**	**11680.00**	**18**	**18.00**	**11698**

7.4 SANITATION FACILITIES

Most of the settlers on canal banks are not offered with sanitation facilities like latrine, drainage etc. it causes serious environmental and health hazards to the people also it affects the nature of canal by discharging of the human excreta. So that, the community toilets at uniform interval, at least one unit at every alternate kilometer has to be constructed. The community toilet should consist of two latrines, two bath rooms, one overhead tank with pumping facility, septic tank and it should be connected with the designed drainage system network. 35 Nos. of community toilets are recommended for all the canals and the unit rate of Rs.5 lakh/unit is assumed for estimation. The total cost of Rs. 175 lakhs is estimated for construction community toilets along the canal.

7.5 SANITARY SEWERLINE

The layout of sanitary sewer pipeline will be designed in DPR stage. It will includes, the population of Project Influences Area (PIA), water demand, waste water generation of the base year. The sewer line for the projected population and demand will be proposed accordingly. The average daily flow (ADF), Peaking factor, Peak Design Flow will be estimated to obtain the nominal size of sewer. The minimum slope required to maintain the flow of sewer will be calculated based on the topography survey. Type of pipe like sand surround, concrete or gravel surround or concrete or grave encasement will be selected and location of pumping

stations and access chamber of pipeline will also be identified in DPR stage. The approximate cost estimation of sewer pipeline is done in this study.

The unit rate of Rs.85 lakhs/km/direction excluding sewage treatment plant is assumed to estimate the cost sanitary sewer and the total cost required is Rs.5780 lakhs.

7.6 REMOVAL OF WEEDS

Water hyacinth grows well in the climate of Kerala primarily in the fresh water zones in the study area. Eichomiacrassipes (water hyzcinth), Salviniamolesta (Afriacnpayal) and Nymphaeanouchalli are common species found in the project canals. The growth of others weeds in the study stretches is normal and under control.

The cost of removal of these weeds is assumed as 2 lakh/km and Rs.18 lakhs needed to remove the water weeds. The estimated hyacinth grown area and its removal cost are shown in **Table. 7.4.**

Table 7.4. Cost for removal of weeds

S.NO	CANAL	CHAINAGE	LENGTH (km)	TOTAL LENGTH (km)	AMOUNT (IN LAKHS)
1	Edapally canal	1800-2700	0.9	1.9	3.8
		2900-3500	0.6		
		6400-6800	0.4		
2	Chilavanoor canal	3800-6100	2.3	3.5	7.0
		8900-10100	1.2		
3	Thevara – Perandoor canal	1400-3100	1.7	3.6	7.2
		5000-6900	1.9		
			Total	**9.0**	**18.00**

7.7 JETTIES

Jetties are the one of the major infrastructure facility needed for inland navigation. Total number of 132 jetties is proposed for all the selected canals and its distribution on canal wise is given in **Table 7.5**. The unit rate of construction of jetty is assumed as Rs.10 lakh/No and the total amount of Rs.1320 lakhs is needed for jetties construction along the canals. The proposed location of the jetties at each canal is given in **Annexure III.**

Table. 7.5 Cost of Jetties Construction

S.NO	CANAL	BANK		TOTAL (NOs.)	AMOUNT (IN LAKHS)
		LEFT	RIGHT		
1	Edapally canal	13	13	26	260
2	Chilavanoor canal	23	23	46	460
3	Thevara-Perandoor canal	22	22	44	440
4	Thevara canal	4	4	8	80
5	Market canal	4	4	8	80
	Total	**66**	**66**	**132**	**1320**

7.8 NAVIGATIONAL AIDS

Navigational aids include buoys, light on cross structures and sign boards are proposed. The buoys will be deployed in the canal wherever the canal width is more and it directs the vessel to operate in navigational route network. The unit rate of installation of a buoy is Rs.75000/No. and total number of 50 buoys is proposed for all the canals. The estimated cost of buoys installation is Rs. 37.50 lakhs and the summarized results is shown in **Table 7.6**. The location wise details of buoys deployment is given in **Annexure IV.**

Table 7.6. Cost of Buoys Installation

S.NO	CANAL	BUOY (NOs.)	AMONUT (IN LAKHS)
1	Edapally canal	9	6.75
2	Chilavanoor canal	20	15.00
3	Thevara-Perandoor canal	13	9.75
4	Thevara canal	4	3.00
5	Market canal	4	3.00
	Total	**50**	**37.50**

It is estimated that the total number of 73 units of lights are proposed to mount on the structures. The lights will fit on both the facing sides, and beneath of structures. The unit rate of mounting is assumed as Rs.35000/unit and the total amount of Rs.25.55 lakhs is needed to carry out this activity. Establishment of signboards is the activity of navigational aids. It will give the directions to canal and road users. The unit rate of Rs.25000/No. is assumed for signboard construction and total amount of Rs.52.50 lakhs is estimated for its establishment. The cost estimation

for light on structures and sign boards are given in **Table 7.7** and **Table 7.8** respectively.

Table 7.7 Cost of Installation of Light on structures

S.NO	CANAL	LIGHT (UNIT)	AMONUT (IN LAKHS)
1	Edapally canal	6	2.10
2	Chilavanoor canal	33	11.55
3	Thevara-Perandoor canal	29	10.15
4	Thevara canal	3	1.05
5	Market canal	2	0.70
	Total	**73**	**25.55**

Table 7.8. Cost of Establishment of Signboards

S.NO	CANAL	BOARD (NOs.)	AMONUT (IN LAKHS)
1	Edapally canal	40	10.00
2	Chilavanoor canal	70	17.50
3	Thevara-Perandoor canal	65	16.25
4	Thevara canal	20	5.00
5	Market canal	15	3.75
	Total	**210**	**52.50**

7.9 BUILDING COST

The existing buildings within 28.5m and 20.5m buffer zone were classified into single floor RCC, double floor RCC, more than two floors RCC, sheet roofed, tiled roof and other types. The built-up area of each structure was measured and is represented section wise. The cost of building for each structure is estimated based on the current value given in the code of building rules. The canal wise building cost is described as follows;

EdapallyCanal

The number of buildings existing within 28.5m and 20.5m buffer zone are 86 and 40 respectively. The measured built-up area for 28.5m zone is 25896 m^2 and 4971 m^2 for 20.5m zone. The estimated building cost is Rs.4181.13 lakhs for 28.5m zone and Rs.802.61 lakhs for 20.5m buffer zone. The section wise estimation is given in **Table 7.9.**

Table 7.9 Building Cost – Edapally Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		BUILDINGS	AREA (m^2)	COST (IN LAKHS)	BUILDINGS	AREA (m^2)	COST (IN LAKHS)
1	Starting Point of canal – Railway bridge	14	1595	257.53	10	646	104.30
2	Railway bridge –NH Road bridge	24	4226	682.32	13	2309	372.81
3	NH Road bridge – Puravankara bridge	13	7022	1133.76	7	728	117.54
4	Puravankara bridge – Pipeline bridge	10	2126	343.26	3	194	31.32
5	Pipeline bridge – Palachuvadu bridge	25	10927	1764.26	7	1094	176.64
6	Palachuvadu bridge – Arakkakadavu bridge	0	0	0	0	0	0
7	Arakkakadavu bridge – KuzhuveliPalam	0	0	0	0	0	0
8	KuzhuveliPalam – End Point of canal	0	0	0	0	0	0
	TOTAL	**86**	**25896**	**4181.13**	**40**	**4971**	**802.61**

Chilavanoor Canal

Total number of 298 buildings are existing within 28.5m buffer zone and 184 buildings are in 20.5m zone. The measured built-up area for 28.5m zone is 69075 m^2 and 28206 m^2 for 20.5m zone. The cost of building cost estimated as Rs.11152.75 lakhs for 28.5m zone and Rs.4554.10 lakhs for 20.5m zone. The detailed building cost estimation for section wise is given in **Table 7.10.**

Table 7.10 Building Cost – Chilavanoor Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		BUILDINGS	AREA (m^2)	COST (IN LAKHS)	BUILDINGS	AREA (m^2)	COST (IN LAKHS)
1	Canal starting point – Elamkulam bridge	0	0	0	0	0	0
2	Elamkulam bridge – SCB bridge	7	1560	251.88	5	984	158.88
3	SCB bridge – Palathuruthu bridge	43	9780	1579.06	22	2661	429.64
4	Palathuruthu bridge – Rly quarters bridge	27	8519	1375.47	8	1767	285.30
5	Rly quarters bridge – Skyline bridge	29	2848	459.83	10	1116	180.19
6	Skyline bridge – Stadium Gate bridge	29	8430	1361.10	25	5163	833.61
7	Stadium Gate bridge – Camradenagar	56	11232	1813.50	44	6882	1111.16
8	Camradenagar bridge – BTS road bridge	56	16221	2619.02	44	6032	973.92
9	BTS road bridge – Ragavan Pillai road bridge	29	6678	1078.22	21	3233	522.00
10	Ragavan Pillai road bridge – Railway bridge	15	3402	549.28	3	260	41.98
11	Railway bridge – Canal end point	7	405	65.39	2	108	17.44
	TOTAL	**298**	**69075**	**11152.75**	**184**	**28206**	**4554.10**

Thevera – Perandoor Canal

There are 227 buildings are existing within 28.5m buffer zone and 115 buildings are in 20.5m zone. The built-up area of 28.5m and 20.5m zones are determined and is shown in Table 7.11. The built-up area of 28.5m and 20.5m zones are 80495 m^2 and 39620 m^2 respectively. The built up cost of Rs.12996.6 lakhs for 28.5m zone and Rs.6396.99 lakhs for 20.5m is estimated. The section wise details of building cost is given in Table 7.11.

Table 7.11 Building Cost – Thevara-Perandoor Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		BUILDINGS	AREA (m^2)	COST (IN LAKHS)	BUILDINGS	AREA (m^2)	COST (IN LAKHS)
1	Canal starting point – Pottakuzhy bridge	0	0	0	0	0	0
2	Pottakuzhy bridge – Sasta temple bridge	38	15241	2460.79	32	10094	1629.76
3	Sasta temple bridge – Chemmani bridge	43	29595	4778.36	18	13467	2174.36
4	Chemmani bridge – Salimrajan bridge	59	8742	1411.47	29	3134	506.01
5	Salimrajan bridge – Kadavanthara market	25	9127	1473.63	13	5743	927.26
6	Kadavanthara market bridge – Girinagar	22	5671	915.63	13	3950	637.76
7	Girinagar bridge – End point of canal	40	12119	1956.72	10	3232	521.83
	TOTAL	**227**	**80495**	**12996.6**	**115**	**39620**	**6396.99**

Thevara Canal

The number of buildings existing within 28.5m and 20.5m buffer zone are 61 and 31 respectively. The measured built-up area for 28.5m zone is 5172 m^2 and 2436 m^2 for 20.5m zone. The estimated building cost is Rs.835.06 lakhs for 28.5m zone and Rs.393.31 lakhs for 20.5m buffer zone. The canal is considered as one section and the details of built-up area and its cost is shown in **Table 7.12.**

Table 7.12 Building Cost – Thevara Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		BUILDINGS	AREA (m^2)	COST (IN LAKHS)	BUILDINGS	AREA (m^2)	COST (IN LAKHS)
1	Canal starting point – End Point of canal	61	5172	835.06	31	2436	393.31

Market Canal

Total numbers of 3 buildings are existing within 28.5m buffer zone and 2 buildings are in 20.5m zone. The measured built-up area for 28.5m zone is 2260 m^2 and 593 m^2 for 20.5m zone. The cost of building cost estimated as Rs.364.90 lakhs for

28.5m zone and Rs.97.74 lakhs for 20.5m zone. The detailed building cost estimation for the canal is given in **Table 7.13.**

Table 7.13 Building Cost – Market Canal

S. NO	SECTION	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
		BUILDINGS	AREA (m^2)	COST (IN LAKHS)	BUILDINGS	AREA (m^2)	COST (IN LAKHS)
1	Canal starting point – End Point of canal	3	2260	364.90	2	593	97.74

Summarised Cost for Buildings

The compensation cost for existing buildings along the canals is estimated. The total number of buildings existing within 28.5m and 20.5m buffer zone are 675 and 372 respectively. The built-up area of for 28.5m zone is 182898m^2 and 75826m^2 for 20.5m zone. The estimated compensation cost for the buildings is Rs.29530.44 lakhs for 28.5m zone and Rs. 12244.75 lakhs for 20.5m zone. The compensation cost for each canal with different buffer zones are given in **Table 7.14.**

Table 7.14 Summarised Compensation Cost for Buildings

CANAL	28.5m BUFFER ZONE			20.5m BUFFER ZONE		
	BUILDINGS	BUILT-UP AREA (m^2)	COST IN LAKHS	BUILDINGS	BUILT-UP AREA (m^2)	COST IN LAKHS
Edapally canal	86	25896	4181.13	40	4971	802.61
Chilavanoor canal	298	69075	11152.75	184	28206	4554.1
Thevara-Perandoor canal	227	80495	12996.6	115	39620	6396.99
Thevara canal	61	5172	835.06	31	2436	393.31
Market canal	3	2260	364.9	2	593	97.74
TOTAL	**675**	**182898**	**29530.44**	**372**	**75826**	**12244.75**

7.10 LAND ACQUISITION

To estimate the fair value of land, the rate of Department of Registration published in 01/04/2010 has adopted. The 50 percent increase as per the Gazette Notification SRO No. 698/2014 dated 14.11.2014 is also applied.

The land required for 20m fairway of Edapally canal, Chilavanoor canal, Thevara-Perandoor canal, Thevera canal and Market canal is 8.18Ha, 16.19Ha, 11.96Ha, 1.52Ha and 1.10Ha respectively.

Similarly, the land required for 12m fairway of Edapally canal, Chilavanoorcanal, Thevara-Perandoor canal, Thevera canal and Market canal is 3.51Ha, 9.43Ha, 5.89Ha, 0.45Ha and 0.60Ha respectively.

The average fair value of each village is determined and is given in canal wise as follows;

Edapally Canal

The Edapally canal is passing through Edapally North, Edapally South, Thrikkakara North, and Vazhakkala villages. The unit rate of fair value of land is Rs.9.03 lakhs/are, Rs.13.2 lakhs/are, Rs.4.93 lakhs/are and Rs.10.10 lakhs/are respectively for the above villages. The average fair value rate is estimated as Rs.931.48 lakhs/Ha. The total land required for 28.5m buffer zone is 8.18Ha and Rs.7619.51 lakhs is required as compensation cost of land acquisition. Similarly, the land requirement for canal development of 20.5m zone is 3.51Ha and Rs.3269.50 lakhs is estimated for compensation. The survey numbers involved in land acquisition for Edapally canal development is given in **Table 7.15.**

Table 7.15 Survey Numbers involved in LA- Edapally Canal

EDAPALLY NORTH
SURVEY NO
29
28
26
25
24
21
20
19
17
16
2
1

EDAPALLY SOUTH	
SURVEY NO	
156	21
155	20
144	24
143	17
120	18
118	27
117	28
116	20
100	16
115	13
114	12
113	11
112	2
111	1
110	3
109	
108	
106	
23	
22	

THRIKKAKAKRA NORTH	
SURVEY NO	
249	141
248	13
172	12
171	11
169	19
170	5
169	
168	
165	
164	
161	
158	
157	
155	
154	
150	
149	
144	
143	
142	

VAZHAKKALA	
SURVEY NO	
123	9
124	15
125	16
134	17
135	18
136	20
137	21
140	22
159	93
161	25
162	119
163	120
169	125
170	126
171	127
179	137
180	138
181	139
1	140
8	

Chilavanoor Canal

Chilavanoor canal falls in Edapally north, Edapally south, Elankulam and Poonithura villages. The major portion of the canal is lying on Elamkulam and Poonitura villages. The average fair value of these villages are Rs.10.61 lakhs/are, Rs.5.72 lakhs/are, Rs.10.33 lakhs/are and Rs.7.57 lakhs/are respectively. The unit rate of land is estimated as Rs.855.49 lakhs/Ha. The total land required for development of canal in 28.5m and 20.5m zone is estimated as 16.19Ha and 9.43Ha. The cost for land acquisition of 28.5m zone is Rs.13850.35 lakhs and for 20.5m zone it is estimated Rs. 8067.25 lakhs. The survey numbers involved in land acquisition for Chilavanoor canal is given in **Table 7.16.**

Table 7.16 Survey Numbers involved in LA- Chilavanoor Canal

PONNITHURA			
SURVEY NO			
1488	1464	801	226
1077	1463	323	225
1482	1462	342	164
1072	1460	1493	163
1481	894	1494	162
1480	890	1449	161
1479	1459	341	160
1478	1458	1435	159
1065	1457	337	103
1476	885	339	104
1475	884	232	4
1474	1456	233	1
1473	883	234	3
1472	490	235	5
1471	815	236	2
1470	1454	238	4
1468	810	224	
992	1452	228	
991	804	227	
1465	1450	229	

ELAMKULAM					
SURVEY NO					
503	569	549	516	166	111
507	568	548	514	165	107
485	567	547	513	157	106
487	566	546	511	156	100
488	564	545	500	155	99
424	564	544	503	154	97
316	563	543	507	153	16
495	561	1064	484	142	20
496	1058	534	485	141	21
497	560	533	486	140	22
505	559	532	424	139	25
502	558	529	423	138	26
17	557	531	317	135	27
18	556	530	316	134	
19	555	519	315	122	
23	554	518	495	121	
25	553	528	498	120	
24	552	520	504	155	
572	551	515	502	117	
571	550	517	501	112	

EDAPALLY SOUTH
SURVEY NO
11
10
14
16
6
7
3
10
11
12
12
13
182
178
181
183
185
186
187
189

EDAPALLY NORTH
SURVEY NO
107
108
109
110
112
113
114
115
116
117
118
119
120
122
129
130

Thevara – Perandoor Canal

Thevara-Perandoorcanal lies in Elamkulam, Ernakulam, Edapally south and Cheranallur villages. The fair value cost of these villages are Rs.13.52 lakhs/are, Rs.23.20 lakhs/are, Rs.3.38 lakhs/are and Rs.4.24 lakhs/are determined. The average fair value of land is Rs.1108.73 lakhs/Ha. The total land requirement for 28.5m zone is 11.96Ha and sum of Rs.13260.47 lakhs is needed as compensation. Likewise, the estimated land requirement for 20.5m zone is 5.89Ha and Rs.6530.45 lakhs of amount is required as compensation. The survey numbers involved in land acquisition for Thevara-Perandoor canal is given in **Table 7.17.**

Table 7.17 Survey Numbers involved in LA- Thevara-Perandoor Canal

ELAMKULAM						
SURVEY NO						
931	717	898	701	371	285	74
930	369	899	699	370	283	73
923	366	900	696	340	281	72
922	365	893	695	344	280	71
919	363	882	694	369	268	66
918	297	881	693	368	269	70
917	298	875	692	365	264	92
902	293	874	688	366	262	65
904	290	873	392	363	261	64
739	289	743	391	364	252	63
738	288	742	390	297	251	62
737	286	741	388	296	248	41
736	284	714	387	298	247	40
735	283	710	386	295	240	39
732	285	709	385	294	239	37
725	287	708	376	292	238	
731	281	705	375	290	237	
730	280	704	374	289	230	
727	268	703	373	288	95	
728	267	702	372	287	93	

ERNAKULAM		
SURVEY NO		
1013	370	84
923	364	82
922	363	
716	344	
691	342	
913	339	
559	338	
558	106	
557	107	
556	104	
555	103	
554	102	
553	101	
546	99	
377	93	
263	94	
376	90	
375	89	
374	88	
372	85	

CHERANALLOOR	
SURVEY NO	
1155	1084
1153	1083
1149	
1148	
1141	
1140	
1137	
1129	
1128	
1126	
1125	
1124	
1123	
1092	
1091	
1090	
1088	
1087	
1086	
1085	

EDAPALLY SOUTH
SURVEY NO
214
215
216
217
219
220
223
224

Thevara Canal

Thevara canal passesElankulam and Ernakulam villages. The estimated fair value of Elamkulam and Ernakulam villages are Rs.8.37 lakhs/are and Rs.21.84 lakhs/are respectively. The land requirement for 20m fairway is estimated as 1.52Ha and sum of Rs. 2296.49 lakhs is needed as compensation. For 12m fairway, the land requirement is 0.45Ha and the amount of Rs.679.88 lakhs is needed for land acquisition. The survey numbers involved in land acquisition for Thevara canal is given in **Table 7.18.**

Table 7.18 Survey Numbers involved in LA- Thevara Canal

ELAMKULAM	ERNAKULAM
SURVEY NO	SURVEY NO
1020	1096
980	1076
978	1079
972	1081
1046	1084
941	
940	
939	
935	
934	
1033	
1070	
934	
931	
898	
97	
1069	
1056	
827	

Market Canal

Market canal lies at Ernakulam village. The unit rate of fair value of land Rs.50.06 lakhs/are is estimated. The required land for 20m and 12m fairway is estimated as 1.1Ha and 0.6Ha respectively. The compensation cost of land acquisition is Rs.5506.20 lakhs for 28.5m zone and Rs.3003.38 lakhs for 20.5m zone is determined. The survey numbers involved in land acquisition for Market Canal is given in **Table 7.19.**

Table 7.19 Survey Numbers involved in LA- Market Canal

ERNAKULAM
SURVEY NO
775
785
460
459
1887
1111
469
468
467
466
1887

The total amount of 38.95Ha of land is required for 20m canal fairway development and sum of Rs.42533.02 lakhs is needed as land acquisition cost. Similarly, the required land and its cost for 12m fairway is also estimated. 19.88Ha of land has to be acquired for 12m fairway and the cost of land acquisition is Rs.21550.46 lakhs. **Table 7.20** indicates the detailed land acquisition cost for each canal.

Table 7.20 Summarised Cost for Land Acquisition

CANAL	UNIT RATE (Per Ha.)	20m FAIRWAY		12m FAIRWAY	
		LAND (Ha)	COST (IN LAKHS)	LAND (Ha)	COST (IN LAKHS)
Edapally	931.48	8.18	7619.51	3.51	3269.5
Chilavanoor	855.49	16.19	13850.35	9.43	8067.25
Thevara-Perandoor	1108.73	11.96	13260.47	5.89	6530.45
Thevara	1510.85	1.52	2296.49	0.45	679.88
Market	5005.64	1.1	5506.2	0.6	3003.38
Total		**38.95**	**42533.02**	**19.88**	**21550.46**

The survey of the government property in the vicinity of canals are also collected from concern villages. The exact boundary of government property will be

demarcated in DPR stage. The list of survey numbers of the property is given in **Table 7.21.**

Table 7.21 Survey Numbers of Government Property

S.NO	CANAL	VILLAGE	SURVEY NUMBER
1	Edapally Canal	Edapally North	27,18
		Edapally South	232 C
		Thrikkakara North	Nil
		Vazhakkala	722 C
2	Chilavanoor Canal	Poonithura	1467,338,156,154,147,146,139,126,125,120, 121,123,122,110,109,108,107,105
		Elamkulam	Nil
		Edapally South	188
		Edapally North	Nil
3	Thevara-Perandoor Canal	Elamkulam	933,890
		Ernakulam	1002,690,689,528,105,1188,2101,842
		Cheranalloor	1150
		Edapally South	Nil
4	Thevara Canal	Elamkulam	Nil
		Ernakulam	1108
5	Market Canal	Ernakulam	2293,778,760,769,471,472,1119,1853,2306, 1832

7.11 LAND RECLAMATION

In addition to field investigations, data sources such as topographic sheets, Bhuvan Panchayth maps, lithomaps have been used to identify the land reclamation. An initial assessment on land reclamation is obtained from Google imageries which are mostly QuickbBird images. Google imageries of 2016, available in public domain and Panchayath maps of Bhuvan, were downloaded as different scenes with resolution zoomed to the required level. These are then merged in AutoCAD and geo-referenced. An overview of reclaimed lands in the vicinity of canal region is listed out and shown in **Table 7.22.**The detailed land reclamation will be done in DPR stage of the study.

Table 7.22 Overview of Reclaimed Lands

S.NO	VILLAGE	PLACE NAME	SURVEY NO.	YEAR OF RECLAMATION
1	Elamkulam	Puthanpalam	514	2005
2	Elamkulam	Chilavanoor	533	2005
3	Elamkulam	Chilavanoor	554	2005
4	Elamkulam	Chilavanoor	559	2005
5	Elamkulam	Chilavanoor	560	2005
6	Elamkulam	Vinoba Nagar	561	2005
7	Elamkulam	Chilavanoor	562	2005
8	Elamkulam	Vinoba Nagar	563	2005
9	Elamkulam	Vinoba Nagar	564	2005
10	Elamkulam	Vinoba Nagar	565	2005
11	Elamkulam	Vinoba Nagar	567	2005
12	Elamkulam	Vinoba Nagar	568	2005
13	Elamkulam	Neptune Colony	572	2005
14	Elamkulam	Neptune Colony	573	2005
15	Elamkulam	Vinoba Nagar	574	2005
16	Elamkulam	Vinoba Nagar	581	2005
17	Elamkulam	Vinoba Nagar	585	2005
18	Elamkulam	Vidhya Nagar	632	2005
19	Elamkulam	Vidhya Nagar	634	2005
20	Elamkulam	Vidhya Nagar	635	2005
21	Elamkulam	Chirakkal	636	2005
22	Elamkulam	Puthanpalam	874	2005
23	Elamkulam	Puthanpalam	884	2005
24	Elamkulam	Puthanpalam	885	2005
25	Elamkulam	Puthanpalam	886	2005
26	Elamkulam	Puthanpalam	887	2005
27	Elamkulam	Vidhya Nagar	888	2005
28	Elamkulam	Vidhya Nagar	893	2005
29	Elamkulam	Chirakkal	900	2005
30	Elamkulam	Chirakkal	935	2005
31	Elamkulam	Thevara	955	2005
32	Elamkulam	Mattummal	966	2005
33	Elamkulam	Mattummal	1008	2005
34	Elamkulam	Janatha	1011	2005
35	Poonithura	Janatha	1017	2004
36	Poonithura	Janatha	1019	2004
37	Poonithura	Janatha	1029	2003
38	Poonithura	Perumpadappu	1031	2003
39	Poonithura	Perumpadappu	1065	2005
40	Poonithura	Perumpadappu	1066	2003
41	Poonithura	Janatha	1073	2003

42	Poonithura	Iron Bridge	1407	2008
43	Poonithura	Iron Bridge	1408	2005
44	Poonithura	Iron Bridge	1430	2005
45	Poonithura	Chirakkal	1431	2005

In addition to the reclaimed area mentioned in Table 7.22, the potential for land requirement is further possible at vicinity of Edapally, Chilavanoor and Thevara-Perandoor Canals. The estimated land for reclamation is 30.6Ha, 2.93Ha and 4.17Ha for Edapally canal, Chilavanoor canal and Thevara-Perandoor canal respectively. The details of potential land reclamation is given in **Table 7.23.**

Table 7.23. Potential Land Reclamation

S.NO	CANAL NAME	CHAINAGE (m)	AREA (m^2)	BANK
1	Edapally Canal	0-200	5672.17	Right
2		200-500	18044.67	Right
3		300-400	5473.25	Left
4		700-900	7679.53	Right
5		4200-4400	7771.39	Right
6		5300-5500	7889.72	Left
7		6400-6500	8004.76	Left
8		6800-7200	32657.06	Left
9		7700-8200	128530.72	Right
10		8500-8800	84297.74	Left
			Total	**306021m^2**
11	Chilavanoor Canal	1000-1200	6276.30	Left
12		1600-1700	6739.25	Left
13		1700-1900	8186.21	Left
14		2100-2200	8116.34	Right
			Total	**29318.10 m^2**
15	Thevara-Perandoor Canal	0-100	14933.04	Right
16		100-200	15277.38	Right
17		700-1000	11521.44	Right
			Total	**41731.86 m^2**
			Grand Total	**377070.97 m^2**

7.12 BEAUTIFICATION OF CANAL

Canal beautification includes footpath, hand rails, concrete benches and other amenities are proposed along the identified canal stretches are proposed. The unit rate of Rs.5 lakh/km/direction is adopted and the total cost estimated for implementation is Rs.200 lakhs.

7.13 TOURISM AND RECREATIONAL FACILITIES

Tourism activities such as water sports which includes boating, garden, children's park and etc., are proposed based on the availability of land. Various tourism and recreational facilities are listed out and discussed below;

Edapally canal

The water sports and recreational activities are proposed between Ayyanad – End point section of Edapally canal. This wider portion is having potential on water sports and boating. Walkway with benches, statues of important persons along the canal banks and garden are also proposed.

Chilavanoor Canal

Water Sports arena in Chilavannoor canal between Sahodaran Ayyappan Road and Tank Bund Road is proposed. It can be accessed from Lane 1 of Toc H road. Other amenities like ticketing centre, waiting area, floating restaurant, commercial kiosks and parking area and a small children's garden with walkways are proposed in this area. The boating facilities like catamaran type luxury boat, speed boat (2 seater and 6 seater), water scooter, banana boats and pedal boats and lighting are proposed on both banks.

Thevara-Perandoor Canal

Small boats and pedal boats are proposed near the starting point of Perandoor Puzha. The recreation activities on right bank including walkway, concrete benches, children's park etc. are also proposed in the vicinity of starting point of the canal.

7.13 SUMMARISED COST ESTIMATE

The cost estimation for improvement of canal with 20m and 12m fairways has been done and the summarized results are shown in **Table 7.24** and **Table 7.25.**

Table 7.24. Option I – 20m Fairway

S.NO	ACTIVITY	UNIT	DESCRPTION	QUANTITY	TOTAL IN LAKHS
1	DREDGING	m^3	Edapally canal	103154.42	**936.33**
			Chilavanoor canal	175716.38	
			Perandoor canal	126055.17	
			Thevara canal	8521.71	
			Market canal	12154.71	
2	CLEANING	km		34.08	**170.40**
3	BANK PROTECTION	km		20.15	**5038.00**
4	CROSS STRUCTURES	Nos.		73	**11698.00**
5	LOCKS	Nos.		5	**2500.00**
5	SANITATION FACILITIES	Nos.		35	**175.00**
6	SANITARY SEWERLINE	km		34.08	**5780.00**
7	REMOVAL OF WEEDS	km		9	**18.00**
8	JETTIES	Nos.		132	**1320.00**
9	NAVIGATIONAL AIDS	Nos.	Buoy	50	**37.50**
		Nos.	Light	73	**25.55**
		Nos.	Signboards	210	**52.50**
10	BUILDING COMPENSATION	m^2	Edapally canal	25896	**29530.44**
			Chilavanoor canal	69075	
			Perandoor canal	80495	
			Thevara canal	5172	
			Market canal	2260	
11	LAND ACQUISITION	Ha	Edapally canal	8.18	**42533.02**
			Chilavanoor canal	16.19	
			Perandoor canal	11.96	
			Thevara canal	1.52	
			Market canal	1.1	
12	BEAUTIFICATION OF CANAL	km			**200.00**
13	TOURISM AND RECREATIONAL				**300.00**
			Total		**100314.74**

Sum of Rs.100314.74 lakhs is estimated for 20m fairway and for 12m, the estimated value for canal development is Rs.61516.58 lakhs.

Table 7.25. Option II - 12m Fairway

S.NO	ACTIVITY	UNIT	DESCRPTION	QUANTITY	TOTAL IN LAKHS
1	DREDGING	m^3	Edapally canal	46212.66	**406.42**
			Chilavanoor canal	79151.03	
			Perandoor canal	52318.68	
			Thevara canal	2182.51	
			Market canal	4872.35	
2	CLEANING	km		34.08	**170.40**
3	BANK PROTECTION	km		20.15	**5038.00**
4	CROSS STRUCTURES	Nos.		73	**11698.00**
5	LOCKS	Nos.		5	**2500.00**
5	SANITATION FACILITIES	Nos.		35	**175.00**
6	SANITARY SEWERLINE	km		34.08	**5780.00**
7	REMOVAL OF WEEDS	km		9	**18.00**
8	JETTIES	Nos.		132	**1320.00**
9	NAVIGATIONAL AIDS	Nos.	Buoy	50	**37.50**
		Nos.	Light	73	**25.55**
		Nos.	Signboards	210	**52.50**
10	BUILDING COMPENSATION	m^2	Edapally canal	4971	**12244.75**
			Chilavanoor canal	28206	
			Perandoor canal	39620	
			Thevara canal	2436	
			Market canal	593	
11	LAND ACQUISITION	Ha	Edapally canal	3.51	**21550.46**
			Chilavanoor canal	9.43	
			Perandoor canal	5.89	
			Thevara canal	0.45	
			Market canal	0.6	
12	BEAUTIFICATION OF CANAL	km		34.08	**200.00**
13	TOURISM AND RECREATIONAL				**300.00**
			Total		**61516.58**

CHAPTER VIII

SWOT ANALYSIS

SWOT is a quick and simple method to understand the overall benefits of the project vis-à-vis associated problems. SWOT analysis stands for Strengths, Weakness, Opportunities and Threats. It analyze strengths, minimize the threats and take advantage of opportunities. In general, Strengths and weakness look internally helps identify what a project can do. Threats and Opportunities are external helps see beyond the project walls. The SWOT analysis for feasibility study of selected canals in Kochi region has been done and represented in **Table 8.1.**

Table 8.1 SWOT Analysis for Canals in Kochi Region

ITEM	STRENGTH	WEAKNESS	OPPORTUNITY	THREAT
Transportation through Waterways	Availability of perennial water bodies and its vast connectivity through the city regions; Edapally canal, Chilavanoor canal and Thevara-Perandoor canal connects Kochi metro rail corridors; Market canal connects Kochi Market with emerging tourist destination of Marine Drive; Thevara canal connects Thevara – Perandoor canal in its mid and provides connectivity with IWT Maradu Terminal and also with National Waterway- 3.	Neglected access; siltation in canals; existence of low level bridges, land acquisition; encroachers and settlements; Water transport facilities are not fully developed.	If properly developed, the IWT would provide an environment friendly, cost effective and efficient alternative mode of transportation.	As many agencies are involved in the development of IWT and if not properly coordinated it will not deliver the desired results.
Land acquisition	Most of the stretches land is available for developing a fairway of adequate width and depth	Removal of encroachment and acquiring land for widening within the city limits is a major problem. R & R is	Widening the canal to the required dimension will improve the IWT prospects and also facilitate natural flood	Clearing encroachment and rehabilitation may require substantial effort and resources. It may invite objection from the local public.

		difficult	control measures.	
Integration with other modes	Due to the existence of many cross roads, it can provide easy integration with other modes viz. road, metro rail etc.	Number of low level bridges constructed across the canals is very high and hence its reconstruction is a difficult programme. Exponential increase in personal vehicles and Intermediate Public Transport (IPT). Chronic parking problems in core areas, road side parking etc cause traffic block	Efficient public transport facilities could reduce the dependence on personal and IPT vehicles. Introduction of IWT will minimize the problem to certain extent.	Reconstruction of cross structures may cause difficulty to the public in their day to day commutation. It may also cause traffic congestion.
Sewerage		The existing sewerage system covers only 5% of the Kochi Corporation area. Due to high water table septic tanks, two pit latrines, etc. do not function properly ; besides, within the urban area the extent of residential and other activities are very high so that the septic tank system does not work leading to water and	Decentralised options and technologies that require less land for treatment are to be introduced. If considerable attention is paid and resources mobilized, the issue could be tackled. JNNURM and ADB funded projects would considerably improve the situation.	Implementation and maintenance of a proper collection, transportation, treatment and disposal of sewage demand huge investment and expertise/ management capabilities.

		soil pollution. Flat terrain makes natural gravitational flow difficult - the soil is mainly loose sand and clayey, making open cutting difficult – high water table necessitates sewage-pumping stations at frequent intervals.		
Solid Waste Management	Kochi has a major SWM treatment and disposal site at Brahmapuram.	Poor waste collection and transportation. No segregation of waste at source. Treatment and disposal facilities are to be stabilised. Difficulty in getting disposal sites for decentralised option. Waste dumped into natural drains cause stagnation of water in drains, water logging and mosquito menace.	The ongoing JNNURM supported comprehensive SWM project would improve the situation.	Public awareness is critical. Centralised disposal site has only limited life. Alternate sites or options have to be identified and developed.
Storm Water Drainage	Excellent network of natural canal system supplemented by man - made drains.	Decreased carrying capacity of the system causes frequent floods and water logging. encroachment,	With the increased importance now given to IWT, primary canals would be conserved and improved.	Flat terrain of the region make drainage planning difficult. Public

		conversion of canals to roads, waste dumping, obstruction due to utility lines and siltation contribute to this. Only 60% of the Kochi Corporation area is covered by storm water drains leading to frequent flooding of roads. Incidents of septic tank overflows/ effluents into open drains is high.	Sewerage and SWM projects being implemented would contribute to reduce pollution levels in the canal system. A comprehensive drainage plan could be prepared and implemented.	awareness is critical. Maintenance of the system demand high level coordinated effort and management.
Preservation of water bodies	Kochi has a good network of inland waterway system consisting of backwaters, canals and lagoons. The Arabian sea together with the inland water bodies can play a vital role in the socio-economic and environmental upliftment of the region.	Canals are polluted – more than 200 mld of urban sewage directly enters the estuary - 260 mld of trade effluents reach the Periyar estuary from the industrial belt. culverts and bridges across the canals have been constructed with inadequate clearances.	The ongoing sewerage and MSW projects and the proposed IWT developments would improve the situation.	Relocation of industries is difficult. Hence it would be necessary to formulate a comprehensive programme for preservation of water bodies along with modernization of the effluent emission sources.
Tourism aspects	Natural facility is available and it can be developed for canal side	Difficulty in coexistence of the existing system and the new systems.	Canal side development and introduction of water	Objections anticipated from local residents

	development as well as for water tourism.		tourism will boost up the overall development of the region. It would be an added asset. Waterfront if properly developed would also improve the environmental, recreational and overall hygiene in the region.	
Employment generation	Additional job opportunity easily available within the urban area due its location advantage	Since development of IWT is a time consuming project, more time will take for full fledged development and commissioning of the waterway project along with tourism and canal side developments.	Once the project is come up lots of direct and indirect job opportunity will be there, particularly in the field of boat operation, water sports, tourism, new commercial ventures to be set up on canal banks and in PPP projects.	Delay in land acquisition and removal of encroachment, trade union activities, opposition from local public and other existing vendors for commercialization , government policies etc.

CHAPTER IX

FINANCIAL ANALYSIS

9. Financial Feasibility Analysis

The financial feasibility study of a project aims at ensuring that the project is financially viable, in that sufficient funds are available to cover the cost of implementing the project according to the planned schedule as well as to generate adequate returns on principal invested. The financial study gains further relevance and importance when a project is to be developed through Public-Private Partnership, using a Build, Operate and Transfer (BOT) process or any of its variants. The financial viability analysis considers the factors that affects its implementation as either a Public-Private Partnership (PPP) project or as a Government/Public Enterprise undertaking.

A financial appraisal is carried out with the objective of determining scenario under which a project would achieve the greatest financial return – thereby making it as an attractive investment proposition to all concerned.

The financial feasibility study attempts to evaluate the monetary costs of project implementation and operation and the estimated revenues from the project over a predetermined contract/concession period. The analysis focuses on the annual cash flows arising from the project, as well as forecasted yearly profit and loss accounts and balance sheets in order to determine profit and tax implications with greater accuracy. Finally the Internal Rate of Return (IRR) of net cash flow is determined in order to understand the extent of financial return available to investors.

9.1. Indicators of financial strength

Financial tools namely, Internal Rate of Return (IRR) and Average Debt Service Coverage Ratio (ADSCR) are generally used to evaluate a project's financial viability and its financial strength.

Internal Rate of Return (IRR): Internal Rate of Return method is a discounted cash flow technique, which takes account of the magnitude and timing of cash flows. Other terms used to describe the IRR method are yield of investment, marginal efficiency of capital and rate of return over cost, time-adjusted rate of return and so on. It is the discount rate at which the present value of an investment's cash inflows and outflows equates. IRR is used in such investments where, the investment is made in one time and its revenue is expected to be generated in future years of operation. IRR method recognizes the time value of money and it considers all cash flows occurring over the entire life of the project to calculate its rate of return. IRR would help in identifying whether the current investment could be justified through future cash flows. IRR is expressed in terms of percentages (%). Higher the percentage, more the project's capability in justifying the investment as it could surpass the investment along with the allied cost (Cost of debt, Maintenance cost, annuity Payments etc) attached to investment. IRR of a project could be healthier by incorporating more revenue streams, reducing cost or by allowing more in number of cash flows (years, here) to justify the investment. In the last case, the revenue from the extended duration would be adequate enough to overcome the cost associated with the extension. In fact, the IRR of a project should at least be well above the cost involved in external financing.

Average Debt Service Coverage Ratio (ADSCR): Repayment of debt component is considered to have prime importance in project financing. In fact, project revenue streams must be capable of at least meeting the standing obligations to the creditors. ADSCR is computed to evaluate whether the revenue streams could service debt after meeting other expenses. It is also known as fixed charge coverage ratio. The ratio indicates the extent to which the earning may fall without causing any embarrassment to the project regarding the payment of the interest charges and principal repayment. The repayment instalments of the proposed project are fixed at 10. Hence the Debt Service Coverage Ratio (DSCR) of all the repayment years are taken into account for estimating its average for identifying the project's ADSCR. The nominal rate of Debt service ratio is two times to that of interest and repayment

schedules. A higher ratio is desirable but too high a ratio indicates that the project is not utilizing the possible debt financing sources. A lower ratio indicates excessive use of debt or inefficient operation of the project. Debt Service Coverage Ratio is calculated by:

DSCR = {Revenues – (maintenance cost + annuity payment (if any)

+operating cost} / (interest + repayment)

The Average Debt Service Coverage Ratio is calculated by averaging the Debt Service Coverage Ratios of cash flows in which interest on debt and repayment of principal is carried out by number of instalment. Thus ADSCR is calculated by

ADSCR = DSCR/number of interest & repayment Instalments made

9.2. Stakeholders in an infrastructure project

When an infrastructure project is intended for development on a commercial basis, the achievement of comfort of the various stakeholders in the project plays a crucial part in determining the success of the project. The key stakeholders in an infrastructure project being developed on a commercial basis include the Government, the Potential Bidder or Developer, Equity Investors and Lenders. Each one will approach the project financial appraisal in a slightly different manner and with different objectives, as are described below:

- **The Government** will tend to estimate the monetary costs and benefits as the first stage of an overall economic appraisal. The financial appraisal allows it to test whether project cash flows alone are likely to give a sufficient financial return to a private sector sponsor or whether a contribution in the form of grant / subsidy will be required from the public sector.
- **Potential sponsors or bidders** will look at both the operational and financial cash flows in order to check the project's financial viability and to assess whether the company will be able to meet all its financial obligations, including debt service. From the financial appraisal, the potential bidders will seek to estimate the size of

any funding gap that may have to be met by Government or Public Sector enterprise in the form of grant or subsidy.

- **Equity investors** will need to be satisfied that the project's expected equity return on investment is acceptable in comparison with returns they could obtain from other investments with similar risk.
- **Lenders** will want to be satisfied that the project will be able to service its debt with sufficient allowance to cover any contingencies. They will normally require that the sensitivity analysis, considering different risk structures, should always show a sufficient debt service coverage ratio to ensure uninterrupted debt servicing over the term of the loan. While some lenders may be content to examine the sponsor's financial appraisal and test the assumptions underlying the project's financial feasibility study, other financial institutions will wish to undertake their own independent appraisal

9.3. Scope of present study

The scope of the present study is confined to the financial evaluation of the proposed development schemes of five canals in Kochi City. The analysis has been conducted from the point of view of assessing its viability for developing the same on commercial basis either by Government/ Public Enterprise or through a Public-Private Partnership. In addition, the financial viability of the project has been assessed under various scenarios in order to analyse its attractiveness for commercial development under different assumptions.

In order to make the project financially viable, various revenue generating measures have been included as part of the project which include operation of boat services, canal side advertisement, development of commercial areas in the immediate vicinity of canals etc. The financial viability analysis has accordingly been carried out on the basis of this configuration. The possible concession period for the project has been arrived at on the basis of the return offered by the project (for commercial development) in terms of the IRR for the time interval considered.

9.4. Critical factors in financial evaluation

The critical factors that will influence financial viability of this project are:

(i) Costs

- Development Cost including land acquisition and purchase of equipments
- Operation and maintenance cost

(ii) Revenue

- Operation of boat services
- Canal side advertisement
- Commercial area development

(iii) Means of finance

(iv) Concession period

All these factors are examined in detail below.

(i) Cost of project

(a) Development/ Procurement cost: The cost of a project broads consists of the cost of construction, preliminary and pre-operative expenses and interest accrued on the debt instrument during the period of construction. They are the major critical factors in the financial viability of a project. In the present case, the cost of construction of the project has been broadly estimated based on the prevailing market rates. The cost of land acquisition has also been included in the cost estimate. Apart from this, boat services are proposed to be operated in the five canals from the point of view of passengers and tourists. Accordingly, cost for boats has also been included in the project cost.

(b) Operation and maintenance cost: Apart from the project cost, the operation and maintenance cost of an infrastructure are also important in the project evaluation.

Operating cost: In order to operate and maintain the canals, a work force consisting of officer-in-charge, Project Engineers, and Assistants are required. In addition, miscellaneous expenditures like electricity; stationery etc. will be incurred during the operation of the system. To account for the expenditures in this regard, yearly provision is made in the project cost estimate. To operate boat services, a total crew

of three people are proposed to be employed and their cost is included as operating cost.

Maintenance Cost: Yearly maintenance cost for the building and miscellaneous items is provided at the rate of 2 % of the project cost in the cost stream. In the case of equipments, the maintenance cost is taken as 8% of the equipment cost.

(ii) Revenue

The major sources of revenue for the proposed development are the following;

(a) Operation of boat services

(b) Advertising on boats, boat jetties and canal banks.

(c) Commercial development along canal side

(a) Operation of boat services: Because of tourist importance as well from the point of view of first mile/ last mile connectivity of commuters, it is visualized that substantial number of passengers and tourists will be available in the boats proposed to be operated in the canals. Based on limited traffic surveys, tourist data and local enquiries, the patronage for the boat services have been estimated. The fare for the services have been worked out considering the novelty of the boat services within the city core and the connectivity angle of the major land uses in the City.

(b) Advertising revenue: Although the proposed canal development is mainly intended for beautification of the canals, it is prima facia observed that it would not financially viable. Hence in order to enhance its financial viability, it is proposed to generate revenue from advertisement of various institutions/ enterprises. The advertisements are proposed to be put up three areas viz: (i) Boats (ii) Boat jetties and (iii) canal banks.

(C) Commercial Development: The third source of revenue shall emanate from development of open areas by reclaiming the waste land by the side of bank canal and putting them into commercial uses. Leasing of these areas to private entrepreneurs who will develop their own commercial ventures is expected to generate substantial revenue. Private developers shall take the area on lease and pay

a fixed sum as lease amount for a tenure of say five or 10 years and on completion of the tenure, they will surrender the area and get back the lease amount. The amount of interest on the lease amount shall form the revenue for the project.

(iii) Means of finance

The project may attract private investors due to the advantage of being within the city core and connects important land uses in the city. However, for simplicity city of analysis, it is assumed that the project will be financed exclusively by government source without any external funding or debt component.

(iv) Concession period

Project concession period is determined by evaluating the time frame required for the project to be financially viable as well as be sufficiently attractive for commercial implementation. Operation period of 10/15/20/25 years has been considered, excluding construction period of three years.

9.5. The Financial model

The financial model has been evolved on a cash flow chart format.

9.5.1. Project Cost:

The total project cost including land acquisition, development of canal to a width of 20m and procurement of boats is estimated at Rs. 6,734.4 million, which include cost of construction, cost of fleet and cost of installation.

9.5.2. Maintenance Cost:

Yearly maintenance cost for the building and miscellaneous items is provided at the rate of 2% of the project cost in the cost stream. In the case of equipments, the maintenance cost is taken as 8% of the equipment cost.

9.5.3. Operating cost

In order to operate and maintain the boats, a work force consisting of office in charge, crew, accountants, helpers are required. In addition, miscellaneous expenditures like electricity, stationery etc. will be incurred during the operation of the system. To account for the expenditures in this regard, yearly provision is made

in the project cost estimate. An amount of Rs 9.24 million is accounted for operating expenditures in the base year.

9.5.4. Depreciation and amortisation:

It is assumed that the entire construction / project cost will be amortised equally over the operation period in order to provide for its depreciation. The project depreciation has been factored in to allow for a BOT procurement (by either government and/or private operator), since the facility has to be returned to Government at the expiry of concession period at zero cost and as such the project should reflect zero value with the project company at the time of transfer. The pre-operative expenses and interest during construction period has been capitalised and amortised over the project period. As the facility shall remain at the end of project period for further commercial use, after providing for 25% depreciation at the end of 10 years at the rate of 2.5% per year, the remaining project cost is credited as project benefit at the end year.

9.5.5. Inflation and indexation

All costs and revenues have been priced at current prices. Based on the detailed analysis of past trend and projection of future trend for WPI, future inflation growth trend based on step-down approach has been adopted. These rates are used for the calculation of expenditure items in current terms. The rate adopted is 7%.

9.6. Revenue model

The major sources of revenue for the proposed development are the following;

(a) Operation of boat services

(b) Advertising on boats, boat jetties and canal banks.

(c) Commercial development along canal side

(a) Operation of boat services Operation of boat services is one of the sources of revenue for the proposed development of canal in Kochi City. The rates per km adopted for the boat services in different canals are given below;

Table 9.1. Passenger Fare Rate

S.No	Name of Canal	Rate/km(Rs)
1	Edapally Canal	4
2	Chilavanoor Canal	3
3	Thevara-Perandoor Canal	4
4	Thevara Canal	6
5	Market Canal	2

It is estimated that daily patronage of about 900 riders shall be available per day in the base year at various canals in the city as shown below;

Table 9.2 Ridership for boat services

S.No	Name of Canal	No. of riders
1	Edapally Canal	500
2	Chilavanoor Canal	100
3	Thevara-Perandoor Canal	100
4	Thevara Canal	100
5	Market Canal	100

It is estimated that a sum of Rs 113.95 lakhs can be generated from the operation of boat services in the base year.

For projecting the revenue for future years, ridership is projected to rise by 5% every year and fare rate by 7% every year.

(b) Advertising on boats, boat jetties and canal banks.

The second major source of revenue is expected from advertisement on boats, boat jetties and canal banks. Differential rates for these three areas and the canal are adopted as shown below;

Table 9.3. Revenue from Advertisement

S.No	Name of Canal	Rate/sq.m (Rs)		
		Boat	Boat Jetties	Canal Banks
1	Edapally Canal	400	800	1200
2	Chilavanoor Canal	300	600	900
3	Thevara-Perandoor Canal	400	800	1200
4	Thevara Canal	600	1200	1800
5	Market Canal	200	400	600

It is estimated space to the tune of 3,550 sq m will be available for advertisement during the project period as shown below;.

Table 9.4. Space Available for Advertising

S.No	Name of Canal	Space in sq.m		
		Boat	Boat Jetties	Canal Banks
1	Edapally Canal	10	20	500
2	Chilavanoor Canal	10	20	500
3	Thevara-Perandoor Canal	10	20	500
4	Thevara Canal	10	20	500
5	Market Canal	10	20	500

From the development of commercial areas, it is expected that revenues to the tune of Rs 29.45 lakhs could be generated in the base year.

For projecting the revenue for future years, advertising rate per sq m is projected to rise by 7% every year.

(c) Commercial development along canal side

By developing commercial areas by the side of canals, it is proposed to generate revenue for the development of Kochi canals. The lease amount per sq m of area coming under different canals is shown below;

Table 9.5. Lease Amount

S.No	Name of Canal	Rate/sq m (Rs)
1	Edapally Canal	800
2	Chilavanoor Canal	600
3	Thevara-Perandoor Canal	800
4	Thevara Canal	1200
5	Market Canal	400

Total space available for commercial development is worked out as 25,000 sq m as given below;

Table 9.6. Commercial Space Available

S.No	Name of Canal	Area (sq m)
1	Edapally Canal	5000
2	Chilavanoor Canal	5000
3	Thevara-Perandoor Canal	5000
4	Thevara Canal	5000
5	Market Canal	5000

Total revenue generated from development of commercial spaces is expected to be 22.80 lakhs in the base year and for the next 10 years.

9.7. Financial evaluation results

The financial indicators evolved from the analysis under normal conditions are summarized below;

Project cost: 466.5 crores

Benefit: Rs 166.2 lakhs

Construction period: Three years

Project period: 10 years

Equity IRR: -4.07%

9.8. Sensitivity analysis of financial evaluation

As the normal conditions may not generally exist, a sensitivity of the financial analysis was carried out for the proposed project. It considered variation up to 15% in the key project parameters ie. project cost, revenue generation, project period.

Sensitivity test carried out to the financial feasibility indicators (FIRR) for the Kochi canals is summarised below in **Tables 9.7.**

Table 9.7. Sensitive Analysis

Sl.No.	Scenario	Rate of IRR (%) for project period (years) of			
		10	15	20	25
1	Normal	1%	2%	2%	3%
2	15 % increase in cost	0%	1%	1%	2%
3	15% decrease in benefit	0%	1%	1%	2%
4	15 % increase in cost and 15 % decrease in benefit	0%	0%	0%	1%

The sensitivity analysis indicates that under totally unfavourable conditions namely the combined effect of cost escalation, revenue decrease, increase in project period, the project will not generate any returns to the investor.

CHAPTER X

CONSTRAINTS AND RECOMMENDATIONS

10.1 CONSTRAINTS FOR IMPROVEMENT OF CANAL

The major constraints for improvement of canal are listed out below;

- Missed links
- Cross structures
- Encroachment
- Inadequate width
- Water hyacinth
- Sewage and Sewerage discharge
- Solid waste disposal

Edapally canal, Thevara canal and Market canal does not have any missed links. In Chilavanoor canal, no connectivity is there at Kaloor stadium Jn. and the canal is covered with RCC slabs at Kaloor KSEB sub-station premises due to which the flow in the canal is obstructed. Similarly, missing link is there near PVS memorial hospital and at railway marshalling yard for Thevara-Perandoor canal. Due to Kochi metro construction, the canal flow is restricted at Kaloor stadium Jn. and PVS memorial hospital Jn.

Existing cross structures are the other major constraint for improvement of the canals. Especially most of the railway bridges are not having required horizontal and vertical clearances for navigation. Even the reconstruction of these structures can only fulfill the requirement of uninterrupted navigation but the vertical rail alignment has to change accordingly. Less possibility of redesign in rail alignment appears to be a major bottleneck for canal improvement.

The settlers on canal banks within the desired buffer zone are key players in canal improvement. The demarcated boundary of individuals will be prepared in DPR stage and actual Project Affected People (PAP) will also be assessed including the ownership.

The required width for canal development is insufficient at Muttar bridge-Ayyanad bridge section of Edapally canal, SCB bridge-Edapally Ragavan Pillai bridge section of Chilavanoor canal and Pottakuzhy bridge-End point of Thevara-

Perandoor canal. Widening of canal in these sections required additional land acquisition which is the major concern of canal improvement.

Fresh water species such as water hyacinth and aquatic weeds spreaded over the wider portions of the canal causes the restriction of boat movement, mosquito breeding and water stagnation.

Sewage, sewerage and solid waste generated not only by the settlers but the whole city waste discharge and disposal poses serious threat to canal improvement. The disposal of waste into the canal affects the canal ecosystem which includes the flora and fauna and causes various health hazards to human being. It also allows to deposit the waste minerals on canal beds and it becomes barrier thereby restrict the canal flow.

The canal wise constrains on canal improvement is summarized and given below;

Edapally Canal

- Inadequate width of canal section between Muttar bridge and Ayyanadbridge (5.1 km).
- Near Lulu mall, the canal flow is blocked due to metro construction.
- Out of 18 cross structures only 8 are having sufficient vertical and horizontal clearances. The vertical clearance of Railway bridge at chainage 1.1km is inadequate.
- Water hyacinth/weeds spread over to 1.9 km restricts the vessel operation.
- Waste discharge/disposal from the residential and commercial activities.

Chilavanoor Canal

- Missed link at Kaloor Stadium Jn.(100m) i.e., Kaloor-Kadavanthara Road.
- Canal is covered with RCC slab at KSEB, Kaloor Sub-station premises (600m).
- SCB bridge to EdapallyRagavan Pillai bridge section having length of (7.0 km), the width of canal is inadequate.
- All 38 cross structures including one rail bridge at chainage 10.6 km passing through the canal does not have required vertical and horizontal clearances.

- 3.5 km length of the wider portions of canal is covered by water hyacinth and aquatic weeds.
- Waste discharge/disposal into the canal from various sources.

Thevara-Perandoor Canal

- Missed link Near PVS Memorial Hospital (50m), due to metro construction.
- Missed link at Railway marshalling yard (60m).
- Pottakuzhy road bridge to end point (7.63km)of the canal, the width is not sufficient.
- All 40 cross structures including one rail bridge at starting point existing across the canal does not have required vertical and horizontal clearances.
- Length of 3.6km is spreaded with water hyacinths and aquatic weeds.
- Waste discharge from the residential, commercial and other activities.

Thevara Canal

- Absence of tidal action, the siltation is more at both ends of the canal.
- Out of 3 Cross structures, one is not having desired clearances.
- Turning radius at Thevara-Perandoor canal connecting point.
- Waste discharge from the residential and commercial activities.

Market Canal

- Canal is closed at end point and the siltation is more towards the end.
- Two cross structures are not having sufficient clearances.
- Waste discharge from the residential and commercial activities.

10.2 RECOMMENDATIONS/SUGGESSTIONS

In order to improve the canals for navigation, tourism and recreational promotion the recommendations are made with the consideration of existing conditions. Laying of sanitary sewer line and advanced solid waste disposal methods are recommended for all the canals. Periodical dredging, weeds removal, infrastructure facilities such as jetties, buoys, lightings, navigational aids, sign boards and tourist amenities are recommended. The canal wise recommendations/suggestions for development are summarized below;

Edapally Canal

- Entire stretch is recommended for passenger and cargo movement having width of 20m fairway.
- Reconstruction of 6 cross structures and dismantling of 2 structures are recommended.
- Construction of pile and slab type bank protection measure is suggested for 11.82 km length.
- The wider canal portion i.e., Ayyanad bridge-Eroor bridge section is recommended for tourism promotion.
- Recreational activity like water sport is recommended at Eroor bridge region.
- 2m wide foot path along both banks is recommended.
- Fencing of canal bank within the city region and at facing side of every cross structure are proposed.
- Community toilet is proposed at every 1 km interval throughout the canal.

Chilavanoor Canal

- 20m fairway is recommended for 2.4km stretch between Starting point and SCB road bridge for passenger movement and tourism promotion.
- 12m fairway between SCB road bridge and Kaloor Stadium having length of 4.46km for passenger movement which connects Kochi Metro.
- 12m fairway recommended for cleaning between Kaloor stadium and Edapally Ragavan Pillai road bridge (2.45km) to maintain the flow in the canal.
- 20m fairway between EdapallyRagavan Pillai road bridge and End of the canal (1.72km) for passenger, cargo movements and tourism promotion.

- Reconstruction of 33 cross structures and dismantling of 5 structures are recommended.
- Construction of pile and slab type bank protection is recommended for 4.94km.
- The foot path having 2m width is recommended for entire canal banks.
- Two locks at starting and ending points of the canal are proposed to regulate the canal flow.
- Recreational activity like Water sport or theme park at starting and end point of the canal.
- Fencing of canal bank within the city region and at facing side of every cross structure are proposed.
- Community toilet is proposed at every 1 km interval throughout the canal.

Thevara-Perandoor Canal

- 20m fairway is recommended for PerandoorPuzha – Kaloor section 3.8km in length for passenger movement and tourism promotion. It is also connecting Kochi metro.
- 12m fairway is recommended between Kaloor and Marshalling yard (1.56km) to maintain the flow in the canal. One Lock at marshalling yard is suggested to preserve the canal movement.
- 12m fairway between Marshalling yard and End Point (4.48km)of canal is recommended for passenger movement. One lock is recommended near the end point water regulation.
- Two more locks at starting and ending point of the canal are recommended to regulate the flow in canal.
- 29 cross structures are recommended for reconstruction and 11 are suggested to dismantle.
- 2.47 km length of banks are recommended to protect with pile and slab type measure.
- The foot path having 2m width is recommended for entire canal banks.
- Recreational facilities at starting point of canal i.e., Perandoor Puzha is recommended.
- Fencing of canal bank within the city region and at facing side of every cross structure are proposed.
- Community toilet is proposed at every 1 km interval throughout the canal.

Thevara Canal

- Entire stretch is recommended for passenger and cargo movement having width of 20m fairway.
- 3 cross structures are recommended for reconstruction.
- Construction of pile and slab type bank protection is recommended for 0.93km length of banks.
- 2m wide foot path along both banks is recommended.
- Fencing of canal bank within the city region and at facing side of every cross structure are proposed.
- Community toilet is proposed at every 1 km interval throughout the canal.

Market Canal

- 12m fairway is recommended for entire canal stretch.
- The cargo movement through rainbow bridge up to market i.e., 300m in length is recommended.
- 2 cross structures are recommended for reconstruction.
- The existing bank protection and fences has to be maintained.
- The foot path having 2m width is recommended for entire canal banks.

10.3 IMPLEMENTATION MECHANISM

Various activities such as land acquisition, resettlement & rehabilitation, cleaning of canal, dredging of canal, modification/reconstruction/dismantling of cross structures, construction of landing facilities, navigational aids, and other commercial buildings, installation of navigational aids, sanitation facilities, sanitary sewer line, beautification of canal and tourism & recreational activities are involved in the implementation program.

Different departments such as Irrigation Dept., Public Works Dept., Revenue Dept., Environment Dept., Tourism Dept., Survey and Land Records, Kochi Corporation, GCDA, NGO's and other agencies comprised on implementation of development of canals in Kochi region. It is also recommended to constitute a Special Purpose Vehicle (SPV) consisting the above agencies for easy implementation of the project. However, this can be firmed up at DPR stage. The implementation period is assessed as three years and **Figure 10.1** shows the bar chart of implementation mechanism.

ACTIVITY	DURATION(MONTHS)																																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
LAND ACQUISTION																																				
RESETTLEMENT & REHABILITATION																																				
CONSTRUCTION/MODIFICATION/DISMANTLE OF CROSS STRUCTURES																																				
CLEANING OF CANAL																																				
DREDGING OF CANAL																																				
CONSTRUCTION OF LANDING FACILITIES																																				
NAVIGATIONAL AIDS																																				
SANITATION FACILITIES																																				
CONSTRUCTION OF SANITARY SEWERLINE																																				
BEAUTIFICATION OF CANAL BANKS																																				
TOURISM & RECREATIONAL ACTIVITIES																																				

Figure 10.1. Implementation Mechanism

CHAPTER XI
CONCLUSION

The development of waterways have several qualitative advantages like decongestion of roads, environmental up gradation, sustainable development, better mechanism of flood control, opportunities for fishing industry and promotion of domestic and international tourism activities. The project involves the study of Edapally canal, Chilavanoor canal, Thevera-Perandoor canal, Thevera canal and Market canal in Kochi region. The study includes detailed surveys for assessing the physical condition and hydrological parameters and suggest suitable developmental works with a view to revive the canal for navigation. The major findings of the study to make the canals for navigation, tourism and recreational purposes are summarised below.

- The estimated dredging quantity of 20m, 12m fairways are 4.26 lakhs cum and 1.85 lakhs cum respectively. The dredging cost is estimated for 20m, 12m fairways are Rs 936.23 lakhs and Rs 406.42 lakhs respectively.
- Before desiltation the canals has to be cleaned and an amount of Rs 170.43 lakhs is estimated for the cleaning activity.
- The water samples at 15 locations were collected along the study stretches. The physical, chemical and biological parameters shows serious threat to the canal ecosystem mainly due to water stagnation, disposal of sewage, sewerage and solid waste in to the canal. Hence suitable treatment methods for waste water and solid wastes are recommended.
- In addition to the existing bank protection, 20.15 km length pile and slab type protective measures at an estimated cost of Rs 5038 lakhs is recommended.
- Out of 103 cross structures, 73 are recommended for reconstruction and 18 are suggested to dismantle. The total cost involved in cross structures reconstruction and dismantling is Rs 11698 lakhs.
- Five locks at appropriate locations are proposed to regulate the water flow in the canals and also to maintain the required depth at an estimated cost of Rs 2500 lakhs .

- The project affected buildings for 28.5 m buffer zone and 20.5 m buffer zone are 675 and 372 respectively. The estimated compensation cost for the building is Rs 29530.44 lakhs for 28.5 m zone and Rs 12244.75 lakhs for 20.5 m zone.
- The project affected people is identified as 4073 and 1840 respectively for 20 m and 12 m fairway.
- Land acquisition to the tune of 38.95 hectares is estimated for 20 m fairway and 19.88 hectares for 12 m fairway. The cost of land acquisition for 20 m and 12 m fairways is Rs 42533.02 lakhs and Rs 21550.46 lakhs respectively.
- The potential land reclamation is possible at the outer skirt areas of study region and is assessed at 377 hectares.
- Tourism activities such as water sports, water theme park, garden, children's parks etc are proposed depending on availability of land.
- The sanitation facilities which include overhead tanks, community toilet with septic tank facilities, at every km is recommended at a cost of Rs 175 lakhs.
- The sanitary sewage line which connects with the treatment plant is proposed at an estimated cost of Rs 5780 lakhs.
- The stretches where threat of water hyacinth and aquatic weeds is identified and its removal is recommended at an estimated cost of Rs 18 lakhs.
- The canal infrastructure facilities like jetties, navigational aids viz, buoys, lights, signboard etc are proposed at an estimated cost of Rs.1435.55 lakhs.
- Beautification of canal banks including provision of footpath, handrails, benches and tourism amenities are proposed at a cost of Rs 500 lakhs.
- The overall project cost is estimated at Rs 100315 lakhs for 20 m fairway and Rs 61517 lakhs is for 12 m fairway.
- The IRR of the total project is estimated at -4.07.% So it is concluded that revival/ improvement of Edapally canal, Chilavanoor canal, Thevera-Perandoor canal, Thevera canal and Market canal in Kochi region is technically and financially feasible and beneficial to the society and hence recommended for implementation. However, a detailed project report (DPR) study is recommended for firming up the quantity, costing and drawing up suitable implementation strategies.

ANNEXURE I

CLASSIFIED BUILDING DETAILS

(28.5M BUFFER ZONE)

EDAPALLY CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT		RIGHT	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Starting Point of canal – Railway bridge	1 RCC	4	8	3	6
		2 RCC	1		0	
		G+2 AND ABOVE	1		0	
		SHEET	0		2	
		TILED	1		1	
		OTHERS	1		0	
2	Railway bridge –NH Road bridge	1 RCC	2	13	5	11
		2 RCC	9		3	
		G+2 AND ABOVE	0		0	
		SHEET	0		2	
		TILED	1		1	
		OTHERS	1		0	
3	NH Road bridge – Puravankara bridge	1 RCC	0	7	2	6
		2 RCC	2		0	
		G+2 AND ABOVE	2		1	
		SHEET	3		0	
		TILED	0		1	
		OTHERS	0		2	
4	Puravankara bridge – Pipeline bridge	1 RCC	0	3	2	7
		2 RCC	3		2	
		G+2 AND ABOVE	0		0	
		SHEET	0		2	
		TILED	0		0	
		OTHERS	0		1	
5	Pipeline bridge – Palachuvadu bridge	1 RCC	0	5	3	20
		2 RCC	1		13	
		G+2 AND ABOVE	0		1	
		SHEET	2		0	
		TILED	0		0	
		OTHERS	2		3	
6	Palachuvadu bridge – Arakkakadavu bridge	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	

7	Arakkakadavu bridge – Kuzhuveli Palam	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
8	Kuzhuveli Palam – End Point of canal	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
		TOTAL		36		50

CHILAVANOOR CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Canal starting point – Elamkulam bridge	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
2	Elamkulam bridge – SCB bridge	1 RCC	1	5	0	2
		2 RCC	2		0	
		G+2 AND ABOVE	0		0	
		SHEET	2		2	
		TILED	0		0	
		OTHERS	0		0	
3	SCB bridge – Palathuruthu bridge	1 RCC	9	28	2	15
		2 RCC	13		8	
		G+2 AND ABOVE	0		4	
		SHEET	1		0	
		TILED	2		0	
		OTHERS	3		1	
4	Palathuruthu bridge – Rly quarters bridge	1 RCC	4	15	2	12
		2 RCC	7		6	
		G+2 AND ABOVE	2		3	
		SHEET	2		1	
		TILED	0		0	
		OTHERS	0		0	
5	Rly quarters bridge –	1 RCC	6	21	4	8
		2 RCC	8		1	

	Skyline bridge	G+2 AND ABOVE	0		1	
		SHEET	4		1	
		TILED	1		1	
		OTHERS	2		0	
6	Skyline bridge – Stadium Gate bridge	1 RCC	6	20	3	9
		2 RCC	11		0	
		G+2 AND ABOVE	1		2	
		SHEET	0		1	
		TILED	2		1	
		OTHERS	0		2	
7	Stadium Gate bridge – Camrade nagar	1 RCC	14	41	5	15
		2 RCC	17		8	
		G+2 AND ABOVE	6		1	
		SHEET	3		1	
		TILED	0		0	
		OTHERS	1		0	
8	Camrade nagar bridge – BTS road bridge	1 RCC	10	26	12	30
		2 RCC	9		12	
		G+2 AND ABOVE	3		1	
		SHEET	3		2	
		TILED	1		3	
		OTHERS	0		0	
9	BTS road bridge – Ragavan Pillai road bridge	1 RCC	4	13	7	16
		2 RCC	4		5	
		G+2 AND ABOVE	2		0	
		SHEET	2		1	
		TILED	1		3	
		OTHERS	0		0	
10	Ragavan Pillai road bridge – Railway bridge	1 RCC	0	6	3	9
		2 RCC	4		2	
		G+2 AND ABOVE	0		1	
		SHEET	0		1	
		TILED	1		2	
		OTHERS	1		0	
11	Railway bridge – Canal end point	1 RCC	3	7	0	0
		2 RCC	1		0	
		G+2 AND ABOVE	0		0	
		SHEET	2		0	
		TILED	1		0	
		OTHERS	0		0	
		TOTAL		182		116

THEVARA-PERANDOOR CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Canal starting point – Pottakuzhy bridge	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
2	Pottakuzhy bridge – Sasta temple bridge	1 RCC	2	15	2	23
		2 RCC	8		9	
		G+2 AND ABOVE	3		6	
		SHEET	1		1	
		TILED	1		1	
		OTHERS	0		4	
3	Sasta temple bridge – Chemmani bridge	1 RCC	4	19	2	24
		2 RCC	5		16	
		G+2 AND ABOVE	9		6	
		SHEET	1		0	
		TILED	0		0	
		OTHERS	0		0	
4	Chemmani bridge – Salim rajan bridge	1 RCC	9	21	8	38
		2 RCC	9		17	
		G+2 AND ABOVE	0		6	
		SHEET	2		6	
		TILED	1		0	
		OTHERS	0		1	
5	Salim rajan bridge – Kadavanthara market	1 RCC	6	7	6	18
		2 RCC	0		4	
		G+2 AND ABOVE	0		5	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	1		3	
6	Kadavanthara market bridge – Giri nagar	1 RCC	4	13	1	9
		2 RCC	2		3	
		G+2 AND ABOVE	1		3	
		SHEET	5		2	
		TILED	1		0	
		OTHERS	0		0	
7	Giri nagar bridge – End point of canal	1 RCC	9	27	1	13
		2 RCC	7		2	
		G+2 AND ABOVE	2		8	
		SHEET	6		0	
		TILED	3		0	

		OTHERS	0		2	
		TOTAL		102		125

THEVARA CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Starting Point of canal – End Point of canal	1 RCC	20	45	6	16
		2 RCC	5		4	
		G+2 AND ABOVE	1		1	
		SHEET	7		1	
		TILED	11		4	
		OTHERS	1		0	

MARKET CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Starting Point of canal – End Point of canal	1 RCC	0	0	1	3
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		2	
		TILED	0		0	
		OTHERS	0		0	

ANNEXURE II

CLASSIFIED BUILDING DETAILS

(20.5M BUFFER ZONE)

EDAPALLY CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Starting Point of canal – Railway bridge	1 RCC	3	5	2	5
		2 RCC	1		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		2	
		TILED	1		1	
		OTHERS	0		0	
2	Railway bridge – NH Road bridge	1 RCC	1	6	2	7
		2 RCC	3		3	
		G+2 AND ABOVE	0		0	
		SHEET	0		2	
		TILED	1		0	
		OTHERS	1		0	
3	NH Road bridge – Puravankara bridge	1 RCC	0	4	0	3
		2 RCC	2		0	
		G+2 AND ABOVE	0		0	
		SHEET	2		0	
		TILED	0		1	
		OTHERS	0		2	
4	Puravankara bridge – Pipeline bridge	1 RCC	0	1	1	2
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	1		1	
		TILED	0		0	
		OTHERS	0		0	
5	Pipeline bridge – Palachuvadu bridge	1 RCC	0	3	0	4
		2 RCC	0		3	
		G+2 AND ABOVE	0		0	
		SHEET	2		0	
		TILED	0		0	
		OTHERS	1		1	
6	Palachuvadu bridge – Arakkakadavu bridge	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	

		OTHERS	0		0	
7	Arakkakadavu bridge – Kuzhuveli Palam	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
8	Kuzhuveli Palam – End Point of canal	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
		TOTAL		19		21

CHILAVANOOR CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Canal starting point – Elamkulam bridge	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
2	Elamkulam bridge – SCB bridge	1 RCC	0	3	0	2
		2 RCC	1		0	
		G+2 AND ABOVE	0		0	
		SHEET	2		2	
		TILED	0		0	
		OTHERS	0		0	
3	SCB bridge – Palathuruthu bridge	1 RCC	6	18	0	4
		2 RCC	7		3	
		G+2 AND ABOVE	0		0	
		SHEET	1		0	
		TILED	1		0	
		OTHERS	3		1	
4	Palathuruthu bridge – Rly quarters bridge	1 RCC	1	6	0	2
		2 RCC	2		1	
		G+2 AND ABOVE	1		1	
		SHEET	2		0	
		TILED	0		0	
		OTHERS	0		0	
5	Rly quarters	1 RCC	2	7	1	3

	bridge – Skyline bridge	2 RCC	3		0	
		G+2 AND ABOVE	0		1	
		SHEET	0		1	
		TILED	1		0	
		OTHERS	1		0	
6	Skyline bridge – Stadium Gate bridge	1 RCC	6	19	1	6
		2 RCC	11		0	
		G+2 AND ABOVE	0		2	
		SHEET	0		1	
		TILED	2		1	
		OTHERS	0		1	
7	Stadium Gate bridge – Camrade nagar	1 RCC	9	30	4	14
		2 RCC	17		8	
		G+2 AND ABOVE	0		1	
		SHEET	3		1	
		TILED	0		0	
		OTHERS	1		0	
8	Camrade nagar bridge – BTS road bridge	1 RCC	8	18	10	26
		2 RCC	7		10	
		G+2 AND ABOVE	0		1	
		SHEET	2		2	
		TILED	1		3	
		OTHERS	0		0	
9	BTS road bridge – Ragavan Pillai road bridge	1 RCC	2	8	6	13
		2 RCC	3		4	
		G+2 AND ABOVE	0		0	
		SHEET	2		1	
		TILED	1		2	
		OTHERS	0		0	
10	Ragavan Pillai road bridge – Railway bridge	1 RCC	0	1	1	2
		2 RCC	1		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		1	
		OTHERS	0		0	
11	Railway bridge – Canal end point	1 RCC	1	2	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	1		0	
		TILED	0		0	
		OTHERS	0		0	
		TOTAL		112		72

THEVARA-PERANDOOR CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Canal starting point – Pottakuzhy bridge	1 RCC	0	0	0	0
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		0	
		TILED	0		0	
		OTHERS	0		0	
2	Pottakuzhy bridge – Sasta temple bridge	1 RCC	2	14	2	18
		2 RCC	8		8	
		G+2 AND ABOVE	3		4	
		SHEET	0		0	
		TILED	1		1	
		OTHERS	0		3	
3	Sasta temple bridge – Chemmani bridge	1 RCC	2	8	0	10
		2 RCC	5		8	
		G+2 AND ABOVE	0		2	
		SHEET	1		0	
		TILED	0		0	
		OTHERS	0		0	
4	Chemmani bridge – Salim rajan bridge	1 RCC	4	8	5	21
		2 RCC	3		8	
		G+2 AND ABOVE	0		2	
		SHEET	1		5	
		TILED	0		0	
		OTHERS	0		1	
5	Salim rajan bridge – Kadavanthara market	1 RCC	3	5	4	8
		2 RCC	0		1	
		G+2 AND ABOVE	0		1	
		SHEET	1		0	
		TILED	0		0	
		OTHERS	1		2	
6	Kadavanthara market bridge – Giri nagar	1 RCC	1	9	0	4
		2 RCC	1		2	
		G+2 AND ABOVE	1		2	
		SHEET	5		0	
		TILED	1		0	
		OTHERS	0		0	
7	Giri nagar bridge – End point of canal	1 RCC	1	5	0	5
		2 RCC	0		1	
		G+2 AND ABOVE	0		4	
		SHEET	4		0	
		TILED	0		0	

		OTHERS	0		0	
		TOTAL		49		66

THEVARA CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Starting Point of canal – End Point of canal	1 RCC	12	23	2	8
		2 RCC	0		3	
		G+2 AND ABOVE	0		1	
		SHEET	3		1	
		TILED	8		1	
		OTHERS	0		0	

MARKET CANAL

SL No	SECTION	TYPE OF BUILDING	LEFT BANK		RIGHT BANK	
			NUMBER	TOTAL	NUMBER	TOTAL
1	Starting Point of canal – End Point of canal	1 RCC	0	0	0	2
		2 RCC	0		0	
		G+2 AND ABOVE	0		0	
		SHEET	0		2	
		TILED	0		0	
		OTHERS	0		0	

ANNEXURE III

PROPOSED BOAT JETTIES

EDAPALLY CANAL

CHAINAGE(m)	LEFT BANK	RIGHT BANK
0	Starting point	Starting point
650	Near Indraji bridge	---
1480	Near Chembakkadavu bridge	Near Chembakkadavu bridge
2000	Near Lulu mall	Near Lulu mall
2500	Near Edapally NH bridge	Near Edapally NH bridge
2830	Near Marattichuvadu bridge	Near Marattichuvadu bridge
3700	---	Near Puravankara
4150	Near pipeline bridge	Near pipeline bridge
4800	Near Assisi Public School	Near Assisi Public School
5100	Near Ayyanad bridge	Near Ayyanad bridge
7200	Near Palachuvadu bridge	Near Palachuvadu bridge
9200	Near Arakkakadavu bridge	Near Arakkakadavu bridge
10400	Near Kuzhuvelippalam	Near Kuzhuvelippalam
11150	Ending point of canal	Ending point of canal
TOTAL	**13**	**13**

CHILAVANOOR CANAL

CHAINAGE(m)	LEFT BANK	RIGHT BANK
0	Starting point	Starting point
700	Near Cochin Gymkhana club	Near Cochin Gymkhana club
1550	Near Elamkulam bridge	Near Elamkulam bridge
2400	Near SCB road bridge	Near SCB road bridge
2900	Near Palathuruthu bridge	Near Palathuruthu bridge
3100	Near Railnagar bridge 2	Near Railnagar bridge 2
3950	Near Railway quarters bridge	Near Railway quarters bridge
4800	Near Karnakoodam bridge	Near Karnakoodam bridge
5350	Near IMA house bridge	Near IMA house bridge
5850	Near Trinity Eye hospital	Near Trinity Eye hospital
6300	Near Stadium comples gate bridge	Near Stadium comples gate bridge
6600	Near Stadium bridge	Near Stadium bridge
6900	Near Kaloor stadium Jn.	Near Kaloor stadium Jn.
7300	Near Greenz villa bridge	Near Greenz villa bridge
7850	Near Camrade nagar	Near Camrade nagar
8300	Near Keerthi nagar	Near Keerthi nagar
8750	Near BTS road bridge	Near BTS road bridge
9100	Near Jayaraj Pipe traders	Near Jayaraj Pipe traders
9300	Near Ragavan Pillai road bridge	Near Ragavan Pillai road bridge

9900	Near Champion School	Near Champion School
10600	Near Railway bridge	Near Railway bridge
10800	Near Amirtha Hospital	Near Amirtha Hospital
11023	End Point of canal	End Point of canal
TOTAL	**23**	**23**

THEVARA-PERANDOOR CANAL

CHAINAGE(m)	LEFT BANK	RIGHT BANK
0	Starting point	Starting point
1000	Near Anganwadi	Near Anganwadi
1700	Near Saraswathy Public school	Near Saraswathy Public school
2200	Near Pottakuzhy bridge	Near Pottakuzhy bridge
3400	Near Sastha Temple	Near Sastha Temple
3600	Near Vegetable market	Near Vegetable market
3800	Near PVS Memorial hospital	Near PVS Memorial hospital
4400	Near Chemmani road bridge	Near Chemmani road bridge
4850	Near Church road bridge	Near Church road bridge
5000	Near Pullepady road bridge	Near Pullepady road bridge
5300	Near Central Excise Bhavan	Near Central Excise Bhavan
5800	Near Salim rajan road bridge	Near Salim rajan road bridge
6000	Lakshdweep guest house	Lakshdweep guest house
6500	Near Karshaka road bridge	Near Karshaka road bridge
6800	Near Kadavanthara market bridge	Near Kadavanthara market bridge
7500	Near GCDA Complex	Near GCDA Complex
7700	Near elders forum bridge	Near elders forum bridge
8300	Pamanpilly-Giri nagar bridge	Pamanpilly-Giri nagar bridge
8700	Panampilly link road	Panampilly link road
9100	Kochu Kadavanthara bridge	Kochu Kadavanthara bridge
9600	Kadavanthara KSEB Sub station	Kadavanthara KSEB Sub station
9840	End point	End point
TOTAL	**22**	**22**

THEVARA CANAL

CHAINAGE(m)	LEFT BANK	RIGHT BANK
0	Starting Point	Starting Point
200	fish market	fish market
900	Near Railway bridge	Near Railway bridge
1410	End point of canal	End point of canal
TOTAL	**4**	**4**

MARKET CANAL

CHAINAGE(m)	LEFT BANK	RIGHT BANK
0	Starting Point	Starting Point
100	Shanmugom bridge	Shanmugom bridge
300	Near Market	Near Market
600	End point	End point
TOTAL	**4**	**4**

ANNEXURE IV

LOCATION OF BUOYS

CANAL	CHAINAGE (m)	Nos.
EDAPALLY CANAL	0	2
	6500	2
	8400	1
	8700	1
	9100	1
	11000	2
	TOTAL	**9**
CHILAVANOOR CANAL	0	1
	1200	11
	1800	2
	3000	1
	10400	2
	10900	1
	11023	2
	TOTAL	**20**
THEVARA-PERANDOOR CANAL	100	1
	400	2
	600	1
	1000	1
	1400	1
	1700	2
	1800	1
	2100	1
	2500	1
	2600	1
	5600	1
	TOTAL	**13**
THEVARA CANAL	0	2
	1410	2
	TOTAL	**4**
MARKET CANAL	0	2
	300	2
	TOTAL	**4**