A Comparative Study on the Operational Efficiency of Inland Waterways in Kerala and Goa with Specific Reference to Ro-Ro Service in NW-3

(Submitted for partial fulfilment of the requirements for the degree of)

MASTER OF BUSINESS ADMINISTRATION

In

International Transportation and Logistics Management

Submitted by:

GADHA BIJU

Registration no: 2303305016

Under the Supervision of

Dr. M. Sekar

Assistant Professor

SCHOOL OF MARITIME MANAGEMENT

INDIAN MARITIME UNIVERSITY

(A CENTRAL UNIVERSITY, GOVERNMENT OF INDIA)

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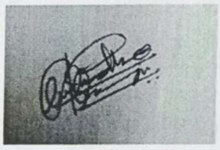
DECLARATION

I, **GADHA BIJU (Registration No.: 2303305016)**, student of School of Maritime Management of INDIAN MARITIME UNIVERSITY- CHENNAI CAMPUS, declare that the project report titled **"A COMPARATIVE STUDY ON THE OPERATIONAL EFFICIENCY OF INLAND WATERWAYS IN KERALA AND GOA WITH SPECIFIC REFERENCE TO RORO SERVICE IN NW-3"** is a bonafide record of work carried out by me under the supervision of **Dr. M Sekar**, Assistant Professor, School of Maritime Management, Indian Maritime University- Chennai Campus, submitted in partial fulfilment of the requirements for the award of the degree of Master of Business Administration in (International Transportation & Logistics Management). The information submitted is true to the best of my knowledge.



Place: Chennai

Date: 26/05/2025

GADHA BIJU
2303305016

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CERTIFICATE

This is to certify that the project report entitled "A COMPARATIVE STUDY ON THE OPERATIONAL EFFICIENCY OF INLAND WATERWAYS IN KERALA AND GOA WITH SPECIFIC REFERENCE TO RORO SERVICE IN NW-3.", submitted to the School of Maritime Management, Indian Maritime University, Chennai Campus., in partial fulfilment for the award of the degree of Master of Business Administration in International Transportation and Logistics Management, is a record of work carried out entirely by GADHA BIJU, Reg. No. 2303305016.

Dr. M. Sekar
Assistant Professor

Dr. Swaminathan
Associate Professor & Head, SMM

External Examiner:

Place: Chennai

Date: 26th May 2025

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INTRODUCTION

1.1 INLAND WATERWAYS TRANSPORT

Inland Waterways Transport (IWT) refers to the movement of people and goods on navigable inland waterways such as rivers, canals, lakes, and other inland bodies of water. Inland Waterways Transport is an economic, fuel efficient and environment friendly mode of transport. The development of Inland Waterways for shipping and navigation is crucial for the country to promote this environment friendly mode of transport and decongest the rail and road modes.

Inland waterways transportation (IWT) has been a significant mode of transport for centuries, particularly in regions with extensive river and canal networks. While its prominence may have fluctuated over time, it remains a vital component of many countries' transportation systems.

1.1.1 KEY REGIONS UTILIZING IWT

1. **Europe:**
    - **Rhine-Main-Danube Corridor:** One of the world's busiest inland waterway networks, connecting the North Sea to the Black Sea.
    - **Other European Rivers:** The Rhine, Danube, Volga, and Elbe are major waterways for transporting goods and passengers.
2. **Asia:**
    - **China:** A vast network of rivers and canals, particularly the Yangtze River, is used for transporting goods and people.
    - **India:** The Ganga-Brahmaputra-Barak River system is a major waterway, although its full potential is yet to be realized.
    - **Southeast Asia:** Countries like Thailand, Vietnam, and Indonesia have significant inland waterway networks, especially for agricultural and industrial transport.

3. **North America:**
    - **The Great Lakes and St. Lawrence Seaway:** This system connects the Great Lakes to the Atlantic Ocean, facilitating the transport of bulk commodities like iron ore, coal, and grain.
    - **Mississippi River:** One of the world's longest navigable rivers, it's used for transporting agricultural products, industrial goods, and petroleum.
4. **South America:**
    - **Amazon River:** The world's largest river system, it offers significant potential for IWT, though challenges like remoteness and seasonal variations limit its full utilization.
    - **Parana-Paraguay River System:** This system connects Brazil, Paraguay, Uruguay, and Argentina, facilitating the transport of agricultural products and other goods.

1.1.2 SERVICES OFFERED IN INLAND WATERWAYS

Inland waterways offer a range of services, primarily focused on transportation and tourism. Here are some of the key services:

Transportation Services

- **Cargo Transportation:**
    - **Bulk Cargo:** Transportation of large quantities of commodities like coal, iron ore, grains, and construction materials.
    - **Containerized Cargo:** Transporting goods in standardized containers, ensuring efficient handling and stacking.
    - **Project Cargo:** Moving oversized or heavy equipment, such as industrial machinery, over long distances.
- **Passenger Transportation:**

- **Ferry Services:** Transporting people across waterways, often connecting urban areas or islands.
- **Cruise Tourism:** Offering recreational trips along scenic waterways, combining sightseeing, dining, and entertainment.

Supporting Services

- **Port and Terminal Operations:**
  - Handling the loading, unloading, and storage of cargo.
  - Providing facilities for customs clearance, warehousing, and logistics.
- **Towage and Tugboat Services:**
  - Assisting vessels in maneuvering, docking, and undocking.
  - Towing barges and other vessels.
- **Pilot Services:**
  - Providing expert guidance to vessel captains in navigating complex waterways.
- **Maintenance and Repair Services:**
  - Repairing and maintaining vessels, engines, and other equipment.
  - Dredging waterways to ensure safe and efficient navigation.

1.1.3 USERS OF INLAND WATERWAYS

A wide range of entities use Inland Waterways Transport (IWT):

Industries and Businesses:

- **Manufacturing:** Companies involved in manufacturing and industrial production often use IWT to transport raw materials and finished goods.
- **Agriculture:** Farmers and agricultural businesses rely on IWT to transport crops, livestock, and agricultural products to markets.
- **Mining:** Mining companies use IWT to transport minerals and other extracted resources.
- **Logistics and Shipping Companies:** These companies specialize in transporting goods via waterways, often in bulk quantities.

Government Agencies:

- **Port Authorities:** Port authorities manage and operate ports and terminals, facilitating the transfer of goods between IWT and other modes of transport.
- **River Authorities:** River authorities are responsible for maintaining and managing waterways, ensuring safe and efficient navigation.
- **Customs and Border Control Agencies:** These agencies oversee customs procedures and border control for goods transported via IWT.

Individuals and Tourists:

- **Commuters:** In some regions, people use IWT for daily commuting, especially in areas with well-developed waterways.
- **Tourists:** IWT can be used for leisure and tourism, with boat tours and cruises being popular options.

1.1.4 ADVANTAGES OF IWT

- **Cost-Effective:** IWT is generally cheaper than road and rail transport, especially for long distances and bulk cargo.
    - 1% cargo shift from road to IWT can cause fuel saving of 3.22lakh kilometres or Rs. 580 Cr.
    - Has the potential to carry 5% of the cargo movement. (saving 16.10 lakh kilometres or Rs. 2900 Cr)

- **Environmentally Friendly:** IWT is an energy efficient and environment friendly mode of transportation as it produces fewer greenhouse gas emissions compared to other modes of transport.
- **Reduced Congestion:** It helps alleviate traffic congestion on roads and railways.
- **Ideal for Heavy and Large Cargo:** Perfect for moving large or heavy items that might not fit on rail tracks or roadways.
- **Increases Rural and Regional Connectivity:** Improves access in areas with inadequate road infrastructure and fosters inclusive growth by connecting rural and remote areas.
- **Energy Efficient:** IWT is energy efficient and consumes less fuel per ton-kilometer compared to road and rail transport.
    - One horsepower moves 150kgs by road, 500kgs by rail and 4000kgs by IWT.
    - One litre fuel moves 24 tonne-km by road, 85 by rail and 105 by IWT.

1.1.5 DISADVANTAGES OF IWT

- **Slow Speed**

  Compared to air, rail, or road transportation, IWT is slower.

  Not appropriate for emergency logistics or cargo with a tight deadline.

- **Seasonal Restrictions**
  Seasonal variations frequently impact navigation:
  Strong currents, route disruptions, and flooding are all possible outcomes of monsoons.
  Navigation may become impossible during dry seasons as the water depth decreases.
- **Restricted Geographic Reach**
  Only works in areas with rivers or canals that are passable.
  Requires intermodal transportation (such as road/rail links) and is unable to offer door-to-door connectivity.
- **Infrastructure Limitations**
  Operational efficiency is impacted by antiquated jetties, inadequate port facilities, and a dearth of contemporary terminals.
  The capacity to carry cargo is decreased by the underdevelopment or irregular dredging of many waterways.
- **High Development Initial Investment**
  demands significant financial outlays for waterway maintenance, vessel acquisition, terminal construction, and dredging.
  Lengthy time frame for returns.
- **Underutilization**
  In many regions of India, inland waterways are still underutilised despite their potential because of a lack of awareness, delayed policy, and a preference for road transportation.

1.2 INLAND WATER TRANSPORT IN INDIA

India has an extensive Network of 14,500 Kms of navigable and potentially navigable inland waterways. IWT offers wide scope for evolving an inter-modal approach to its development with the help of the private sector. Projects linking the inland waterways with the port could facilitate transportation of cargo between the hinterlands international trade without any diversion to either road or rail.

Government of India has a policy to declare important navigable waterways of the country as National Waterways namely, the Ganga (NW-1), the Brahmaputhra (NW-2) & West Coast Canal in Kerala (NW-3). Few more waterways in the States of Tamil Nadu, Andhra Pradesh & Orissa are under consideration for declaration and development as National Waterway.

Government of India through Inland Waterways Authority of India (set up in 1986 under the Ministry of Port, Shipping and Waterways) is keen to improve the availability of IWT sector for transportation of cargo. It is also endeavouring to tap resources from multilateral and external agencies as well as utilize their expertise in enhancing the reach and efficiency of IWT sector.

1.2.1 NATIONAL WATERWAYS ACT, 2016

Inland waterways for shipping and navigation are governed, developed, and maintained by the National Waterways Act, 2016, an Act of the Indian Parliament. Nitin Gadkari, Minister of Shipping, Road Transport, and Highways, introduced the Act in the Lok Sabha on May 5, 2015, and it became operative on March 25, 2016.

The National Waterways Act, 2016 is a significant piece of legislation in India that aims to promote inland waterways transportation. It consolidates and replaces five earlier Acts and declares 111 waterways as national waterways.

The main characteristics of the Act are:

- The Act gives the federal government the authority to designate specific inland waterways as national waterways in accordance with their development and transit potential. The Act identifies and declares 111 inland waterways as national waterways, including rivers, canals, and backwaters.

- In order to increase inland water transportation, lower transportation costs, foster economic growth, and improve regional connectivity, the Act seeks to develop inland waterways.
- The Act mandates the development of necessary infrastructure, such as terminals, jetties, and navigational aids, to facilitate smooth and efficient transportation.

- The Act seeks to give shippers and logistics participants an alternative to the road and rail.

The National Waterways Act, 2016, significantly expanded the network of inland waterways in India. It declared 111 waterways as national waterways, including 5 existing ones and 106 new ones.

Existing Waterways (Before 2016):

1. **National Waterway 1:** Ganga-Bhagirathi-Hooghly River System (Haldia-Allahabad)
2. **National Waterway 2:** Brahmaputra River (Dhubri-Sadiya)
3. **National Waterway 3:** West Coast Canal (Kottapuram-Kollam) [1]
4. **National Waterway 4:** Kakinada-Puzal-Vijayawada Canal
5. **National Waterway 5:** Buckingham Canal

Newly Declared Waterways (After National waterway Act, 2016):

The 106 new waterways cover a diverse range of rivers, canals, and backwaters across the country. Some of the notable additions include:

- Rivers:
  - Godavari, Krishna, Mahanadi, Narmada, Tapi, etc.
- Canals:
  - East Coast Canal, West Coast Canal extensions
- Backwaters:
  - Kerala backwaters, etc.

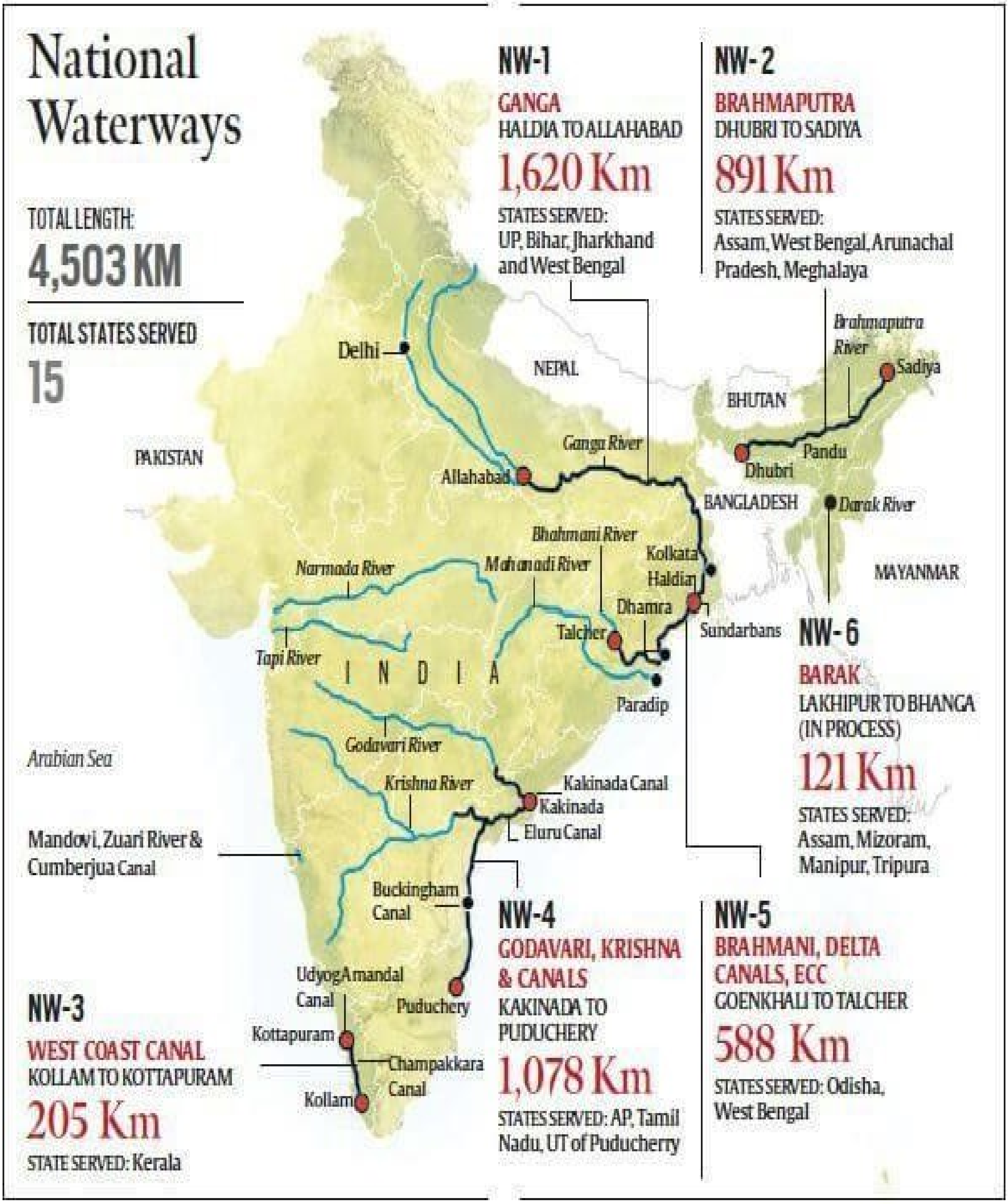

Fig 1. National Waterways in India

(Source: Google)

1.3 INLAND WATER TRANSPORT IN KERALA

Kerala's inland waterways, which provide a sustainable and affordable substitute for roads and trains, are an essential part of the state's transport system. The state is ideally situated for inland water transport (IWT) due to its vast network of rivers, backwaters, canals, and lagoons. The most notable waterway in the state is National Waterway-3 (NW-3), which stretches more than 205 km from Kollam to Kottapuram. Connecting towns, ports, and the hinterlands, this waterway and other state waterways serve as the foundation of Kerala's water-based transportation system.

Inland waterways in Kerala are utilised for both passenger and freight transportation. Particularly in and around Kochi, barges and Ro-Ro vessels are used to transport cargo like building supplies, food grains and petroleum products. Road traffic has decreased and cargo efficiency has increased thanks to the deployment of Ro-Ro ships like the MV Adi Shankara and MV C.V. Raman between Bolgatty and Willingdon Island. For thousands of people, particularly in places like Alappuzha and Kottayam, the State Water Transport Department's (SWTD) passenger ferries offer an inexpensive way to get to work every day.

These waterways sustain livelihood, tourism, and fishing in addition to transportation. Kerala's backwaters are a popular tourist destination both domestically and abroad, and they make a substantial economic contribution to the state. In places like Alappuzha and Kumarakom, houseboat tourism and canal cruises have taken off. In order to revitalise urban canals and enhance water connectivity, the government is modernising the waterways through initiatives like the West Coast Canal project and the Integrated Urban Regeneration and Water Transport System (IURWTS).

However, because of issues like siltation, encroachments, and inadequate maintenance, Kerala's inland waterways have not yet reached their full potential. The state government and the Inland Waterways Authority of India (IWAI) are working to upgrade terminal infrastructure, dredge channels, and repair locks. Kerala's inland waterways are predicted to grow into a key component of environmentally friendly, multimodal transportation in the upcoming years with more investment and careful planning.

SI. No	**National Waterway No.**	**River**	**Length (km)**	**Operational(Y/N/P)**
1	National Waterway 3	WEST COAST CANAL (KOTTAPURAM-KOLLAM), CHAMPAKARA & UDYOGMANDAL CANALS	205	Y
		WEST COAST CANAL (KOTTAPURA–KOZHIKODE)		
2	National Waterway 8	ALAPPUZHA-CHANGANASSERY CANAL	29	Y
3	National Waterway 9	ALAPPUZHA-KOTTAYAM-ATHIRAMPUZHA CANAL	40	P
4	National Waterway 59	KOTTAYAM- VAIKOM CANAL	28	N
		Total	302	

Table 1.1 List of National Waterways in Kerala

(Source: Ministry of Ports, Shipping and Inland waterways)

1.3.1 RECENT DEVELOPMENTS IN NW-3 (2023-2025)

- Improvements to the Infrastructure and Navigation

    1. Finishing the Navigable Channel

       The Inland Waterways Authority of India (IWAI) has dredged almost 85 km of shoal length as of March 2024, reaching the desired depth of two meters across NW-3. But in a 1.20 km section close to Chavara (the

Edapallykota-Kollam stretch), the navigation channel still needs to be widened to the necessary 32-meter width.

2. TrikkunnapuzhaNavigation Lock Reconstruction

   There have been delays in the restoration of the Trikkunnapuzha navigation lock, which is essential for the efficient passage of barges and bulk-cargo vessels. The operationalisation of NW-3 is hampered by the Irrigation Department's request for an extension until the end of December to finish the reconstruction.

- Ro-Ro Services and the Growth of Vessels

  Kochi's Third Ro-Ro Vessel's Introduction

  The Kochi Corporation has started building a third roll-on-roll-off (Ro-Ro) vessel to alleviate the frequent interruptions in the service between Bolgatty and Willingdon Island. By the end of 2025, the ₹15 crore project should be finished, improving traffic and passenger flow across Vembanad Lake.

- West Coast Canal (WCC) expansion Akkulam

  to Chettuva Stretch Commissioning

1. By the middle of 2025, a 235-kilometer section between Akkulam in Thiruvananthapuram and Chettuva in Thrissur is expected to be put into service. This construction is a component of the massive 590-kilometer West Coast Canal (WCC) project, which aims to improve Kerala's coastline's trade, tourism, and transportation.

2. Land Acquisition and Rehabilitation Activities In order to facilitate canal development, the Kerala state cabinet has approved compensation for 68 families who

live along the Parvathy Puthanar Canal in the Kovalam-Akkulam stretch. In addition to the structural value of their homes, each family will receive ₹11 lakh.

- Urban Canal Revitalization in Kochi

  Integrated Urban Regeneration and Water Transport System (IURWTS) The Kerala state government has approved the revised IURWTS project, which aims to improve water transport and address urban flooding by revitalising six major canals in Kochi. The project, which is currently costing ₹3,716.10 crore, includes the reconstruction of the Chilavannur Bund Road Bridge and beautification efforts on the Market Canal.

- Integration with National Waterway Network

  Extension of NW-3 to Kozhikode

  The Union government has included the 160-km stretch from Kottappuram to Kallayi in Kozhikode as part of NW-3, but development work has not started because of pending fund allocation. The state government is preparing a detailed project report for this extension, which aims to improve connectivity and cargo movement in northern Kerala.

1.4 INLAND WATER TRANSPORT IN GOA

Goa's inland waterways, notably the Mandovi and Zuari rivers, have historically been vital for transporting commodities such as iron ore, coal, and construction materials. Although the available sources do not provide specific cargo volume data for Goa, the Inland Waterways Authority of India (IWAI) reported a record-breaking 145.5 million tonnes of cargo movement on national waterways across India in the fiscal year 2024–2025, indicating a significant emphasis on improving inland water transport nationwide.

The Goa government and the Inland Waterways Authority of India (IWAI) have been collaborating to modernise and revitalise the state's inland waterways. Particularly, the Mandovi and Zuari rivers have been recognised as crucial transit routes for both passenger and freight ferries. A significant activity that connects Goa's mining hinterland to port areas is the barging of coal, iron ore, and building materials.

Additionally, Goa boasts a robust ferry system that serves the local population by linking islands and isolated villages with the mainland. The River Navigation Department (RND), Government of Goa, is in charge of these services. It runs a fleet of ferries that are essential for rural mobility, particularly in places without bridge connectivity.

Current projects seek to explore eco-tourism and cruise-based transportation, upgrade infrastructure, and introduce contemporary ships. Goa's potential to grow into a sustainable and integrated IWT hub is further enhanced by its inclusion under the National Waterways Act, 2016 (along with NW-68: Mandovi, NW-111: Zuari, and others).

Goa is in a good position to promote inland water transport as a safer, cleaner and more effective form of transport, enhancing its tourism and coastal economies, thanks to its advantageous location and natural waterways.

SI. No	**National Waterway No.**	**River**	**Length (km)**	**Operational(Y/N/P)**
1	National Waterway 25	CHAPORA RIVER	33	N
2	National Waterway 27	CUMBERJUA RIVER	17	N
3	National Waterway 68	MANDOVI RIVER	41	Y
4	National Waterway 71	MAPUSA/ MOIDE RIVER	27	N
5	National Waterway 88	SAL RIVER	14	N

6	National Waterway 111	ZUARI RIVER	50	Y
		Total	182	

Table 1.2 List of National Waterways in Goa

(Source: Ministry of Ports, Shipping and Inland waterways)

1.5 RO-RO TRANSPORT

Roll-on/Roll-off, or Ro-Ro, transport is a shipping method in which automobiles, trucks, and trailers are driven straight onto and off of a specially built ship. This system is very effective for moving wheeled cargo because it does not require the use of cranes for loading and unloading.

Key Features of Ro-Ro Transport:

- Direct loading drastically cuts down on labour expenses and handling time by having vehicles roll on at the origin and roll off at the destination.

- Time Efficiency: Ro-Ro operations are faster and better suited for short-distance routes, such as those that cross rivers or coastal regions, because cargo does not need to be lifted or containerised.

- Decreased Congestion: Ro-Ro services contribute to the decongestion of highways and the reduction of pollution by rerouting trucks from roads to waterways.

- Cost-Effective: Ro-Ro is cost-effective, particularly for moving large vehicles, because it uses less fuel and causes less damage to the infrastructure.

1.5.1 RO-RO TRANSPORT IN INDIA

In India, roll-on/roll-off, or Ro-Ro, transportation is a developing method of moving cargo, particularly as a result of the Ministry of Ports, Shipping, and Waterways' Sagarmala Program. In order to reduce loading time and handling expenses, Ro-Ro vessels are made to transport wheeled cargo, such as trucks, cars, trailers, and other vehicles that can roll on and off the vessel. In order to lower carbon emissions, road congestion, and logistics costs, this mode of transport is being promoted throughout major river systems and coastal areas.

Ro-Ro and Ro-Pax (passenger + vehicle) services have been introduced by the Indian government in a number of places, including:

1. Gujarat

Ghogha – Dahej (Gulf of Khambhat)

Hazira – Ghogha (Surat – Bhavnagar)

2. Maharashtra

Mumbai – Mandwa (Alibaug)

Rewas – Karanja (Proposed)

3. Kerala

Kochi (Bolgatty Island – Willingdon Island) on NW-3

4. Goa

Vasco and Cortalim(Proposed)

5. Uttar Pradesh / Bihar (National Waterway-1: Ganga River)

Varanasi – Haldia Stretch

6. Assam (National Waterway-2: Brahmaputra River)

Dhubri – Hatsingimari

Guwahati – North Guwahati

7. West Bengal

Kolkata – Haldia

8.Odisha (NW-5: Brahmani River and Mahanadi Delta)

Talcher–Paradeep industrial corridor (Proposed)

1.5.2 RO-RO IN KERALA (NW-3)

The West Coast Canal, or NW-3, is a crucial IWT corridor in South India that runs from Kollam to Kottapuram in Kerala. The one and only Ro- Ro service in NW- 3 is operating between Bolgatty and Willingdon Island in Kochi. Two modern Ro-Ro vessels, MV Adi Shankara and MV C.V. Raman, have been deployed here by the Inland Waterways Authority of India (IWAI).

By avoiding clogged city roads, these vessels make it easier for trucks and other cargo-laden vehicles to move. This promotes quicker and more environmentally friendly logistics in addition to relieving traffic congestion on the roads. The route also serves the Cochin Port, allowing cargo to be efficiently transferred between the port and inland destinations.

1.6 OBJECTIVES OF THE STUDY

- To study about the operations of Inland waterway of Kerala and Goa.
- To study the efficiency of operations in Inland waterway of Kerala and Goa.
- To study the vessel operations in the Inland waterway of Kerala and Goa.
- To study the Ro-Ro Vessel operations in NW-3.
- To examine the Ro-Ro service Utilization and efficiency in NW-3.
- To suggest findings from the above study.

1.7 SCOPE OF THE STUDY

Inland transportation's potential has grown over time, and it currently makes up a significant amount of the world's ton-kilometer movement. Every nation's economic success depends on having a functional transport system, especially when it comes to moving big goods.Inland rivers, pipelines, railroads, highways, and coastal ships are all important modes of transportation for bulk commodities. In a liberalised economy like India, where both the public and private sectors are expected to contribute significantly to GDP, the government must take the necessary steps to develop all of these modes of transportation so that businesses can offer consumers the lowest cost of production by utilising an ideal combination of transportation networks that, on an individual basis, capitalise on each mode's strengths.

Large-scale capacity growth is challenging due to the overcrowding and saturation of India's primary bulk-goods transportation networks, the rail and the road. IWT has the potential to replace crowded trains and congested roadways as a cost-effective, ecologically responsible, and fuel-efficient mode of transportation.

The study is on the efficiency of inland water transport in Kerala and Goa. By studying this data, we can comprehend how these rivers have performed thus far. There is a lot of space for growth and development in the inland waterway transportation system. Based on the effectiveness of these, what can be done and where can we make improvements? The need for more investment in this sector is clearly evident. There are several rivers, canals, streams, and other waterways in India that could be turned into economically feasible waterways that link the hinterlands and ports. The IWT mode must therefore be advanced to the point where it can contend in a multimodal transportation network. In conclusion, as long as issues like institutional support and infrastructure deficiencies are sufficiently addressed, inland transport has a promising future.

1.8 METHODOLOGY

For this study, both primary and secondary data were gathered:

Secondary data on the number of vessels, navigable length, and volume of cargo handled in Kerala and Goa were collected from Inland Waterways Authority of India (IWAI), Kerala Shipping and Inland Navigation Corporation (KSINC), State Water Transport Department (SWTD), and River Navigation Department (Goa) reports and publications, as well as official government websites.

Primary data about Ro-Ro services operating in NW-3 (Kochi) was gathered by contacting the relevant offices directly through phone calls, emails, and reputable internet sources.

Statistical Analysis:

Chi-Square Test and **Hypothesis Testing** were used to compare the efficiency of waterways between Kerala and Goa based on navigale length of waterways, number of vessels and cargo volume handled during the period of 2015- 2024.

1.9 LIMITATIONS

India's inland water transport is a broad topic, and time has been a significant barrier to this study. All of the data gathered might not be precise since confidentiality regulations are applied to material that is primarily gathered from secondary sources. Only a few years' worth of data was analysed because there isn't any primary study on the topic. The study only looks at how well the inland waterways in Kerala and Goa work. This makes it hard to understand how efficient all of India's waterways are. In Kerala, there are just four operational national waterways, and in Goa, there are six national waterways, out of which only two are operational. We are therefore unable to investigate the exact effectiveness of every step and draw a conclusion.

CHAPTER 2

LITERATURE REVIEW

2.1 LITERATURE ANALYSIS

1. The development of inland water transport (IWT) in India is examined by Gupta, Anand, and Bansal (2017), who emphasise the IWT's cost-effectiveness, environmental advantages, and its 0.4% modal share in the nation's transportation system. The authors note that although there are many navigable waterways, post-independence policy-making has given little consideration to IWT. In order to improve IWT usage, their work highlights the necessity of infrastructure development, international benchmarking, and governance reforms. This has a direct bearing on the current study, which looks at Kerala and Goa, two states with functional national waterways that struggle with underutilisation. By exposing operational inefficiencies and inadequate service optimisation despite the availability of infrastructure, the case study on Ro-Ro services in Kerala's NW-3 further supports the concerns raised by (Gupta et al., 2017)
2. A long-term view of IWT in India is given by Sriraman (2010), who charts its decline as a result of the expansion of road and rail networks. He contends, however, that IWT still has potential for environmentally friendly transportation and can be extremely important for socioeconomic advancement, particularly in places with limited resources or that are less developed. This viewpoint is supported by the results of the current study, which show that despite their geographic advantages and historical reliance on waterways, Kerala and Goa are not making effective use of them. An example of low-cost and energy-efficient infrastructure that falls short of its potential in terms of operational execution is the Ro-Ro corridor in NW-3, which supports Sriraman's claim (Sriraman, 2010).
3. The operational and legal feasibility of IWT in India is evaluated by Narayan and Raghuram (2006). As important steps towards formal development, they highlight the designation of national waterways

like NW-1, NW-2, and NW-3 and stress its low cost and minimal environmental impact. Their research backs up the current project's focus, which is a thorough examination of Kerala's NW-3. Despite NW-3's legal and strategic recognition, actual operations—particularly those involving cargo and Ro-Ro services—fall short of expectations, highlighting a discrepancy between legal frameworks and field performance. Thus, the results of the study support and enhance the justification for comparative efficiency evaluations in states such as Kerala and Goa (Narayan & Raghuram, 2006).

4. According to Aritua, Cheng, van Liere, and de Leijer (n.d.), IWT is a low-carbon, sustainable transportation option that is underdeveloped in many nations despite its advantages. They contend that although IWT has more benefits over longer distances and higher volumes, its implementation is difficult because there aren't many effective models. This observation is extremely pertinent to India and the ongoing study, as Kerala's Ro-Ro service exhibits potential but is hampered by low demand stimulation, underutilisation, and a lack of multimodal integration. The necessity of reforming planning, vessel design, and stakeholder engagement in India's inland waterways is highlighted by their suggestion to take inspiration from global best practices (Aritua et al., n.d.).

5. Sabitha (2019) presents a feasibility analysis for waterway development in Thrissur, Kerala, demonstrating that inland waterways can offer a viable alternative to road and rail transport. Her study, based on traffic volume and economic viability, shows that reconstructing canal systems can solve local transport problems and promote economic growth. This resonates with the findings of the present study, which identifies underutilization of existing waterways in Kerala, especially in the Ro-Ro corridor, and underscores the need for localized planning and feasibility-based development models (Sabitha, 2019).

6. Jayakrishnan (2020) investigates the trends and challenges in tourism-oriented inland water transport in Kerala, focusing on passenger services under the Kerala State Water Transport Department (SWTD). The study highlights growing tourist demand but points out key barriers such as poor information availability and inconsistent service experience. Although not focused on cargo or Goa, the paper indirectly supports the current project's observation that operational gaps—such as service inconsistency and lack of user engagement—also affect freight services like Ro-Ro transport in NW-3 (Jayakrishnan, 2020).
7. Shallen and Varghese (2021) examine National Waterway 3, identifying it as a critical corridor for passenger and freight movement in Kerala. The paper notes that with proper management, NW-3 has significant potential to complement road and rail transport. This directly supports the current project's assessment of NW-3, which, despite its designation and existing infrastructure, suffers from inefficiencies and low utilization in Ro-Ro operations. The findings strengthen the argument for better planning, vessel scheduling, and stakeholder coordination to maximize NW-3's effectiveness (Shallen & Varghese, 2021).
8. Praveen and Jegan (2017) provide a national-level overview of the challenges facing the inland water transport sector in India. While the paper does not directly address Kerala and Goa, it identifies systemic issues such as lack of inter-state coordination, funding constraints, and weak integration with other modes of transport. These macro-level issues are mirrored in the current study, particularly in the fragmented planning and poor multimodal connectivity seen in both Kerala and Goa's waterways, impacting overall efficiency and utilization (Praveen & Jegan, 2017).
9. Mesquita and Kaisary (2007) explore the movement of iron ore in Goa through inland waterways using barges along the Mandovi and Zuari estuaries. Though the paper focuses more on the movement

process than detailed analysis, it highlights the role of Goa’s waterways in supporting bulk commodity transport. This background supports the current study by illustrating that Goa’s waterways have historically supported industrial cargo, which contrasts with Kerala’s diverse yet underutilized waterway operations. The efficient use of Goa’s estuarine routes underscores the potential that Kerala’s NW-3 corridor can also tap into for freight and cargo transportation if strategically optimized (Mesquita & Kaisary, 2007).

10. Shaikh, Tripati, and Shinde (2012) investigate the traditional sewn-plank boats of Goa, highlighting their significance in the region’s inland water transport history. These boats, being both river- and sea-worthy, reflect the indigenous maritime knowledge and practical boat-building techniques that sustained regional connectivity. Though the study is historical in nature, it informs the current research by reinforcing the idea that inland waterway transport has long-standing relevance in Goa. The contrast with Kerala’s modern Ro-Ro services—which suffer from underutilization—emphasizes that while vessel types and technologies have evolved, efficiency still depends on operational management and integration (Shaikh, Tripati, & Shinde, 2012).

11. Aravind and Sudheer (2024) present a futuristic and sustainability-focused design for an electric Roll-On/Roll-Off (Ro-Ro) ferry system on National Waterway 3. The proposed system integrates solar-electric propulsion to reduce CO_2 emissions and improve operational efficiency. This paper is highly relevant to the current study’s case analysis of Ro-Ro inefficiencies in Kerala, providing an innovative alternative to conventional diesel-powered ferries. The proposed model aligns with global trends in green transport and offers a sustainable pathway to revitalizing NW-3’s Ro-Ro services, reinforcing the project's suggestion for service modernization and environmental improvement (Aravind & Sudheer, 2024).

12. Morales-Fusco and Saurí (2009) propose a methodology to evaluate Ro-Ro terminal performance using service-level indicators from the ship's perspective. Their study, although based in Spain, provides a structured framework to measure terminal efficiency by analyzing quality factors like ship arrivals and terminal response times. This directly complements the present study by offering analytical tools that could be applied to assess the performance of Ro-Ro terminals in Kerala and Goa. With underutilization and inefficiency being key issues in NW-3 operations, such performance metrics could provide actionable insights for future improvements (Morales-Fusco & Saurí, 2009).

13. Due to its affordability and ease of use, Bangladesh's Inland Water Transportation (IWT) system is among the most important forms of transportation. Despite Bangladesh's geographical advantage of having a vast network of interior waterways, this industry has serious safety issues. The data from accidents that occurred in Bangladesh's inland waterways between 2005 and 2015 has been examined in this study. The Bangladeshi Department of Shipping (DOS) provided the accident data. A variety of factors have been taken into consideration when analysing the incidents, including the types of vessels involved, the locations and times of the events, the final state of the vessels following the accidents, and more. 229 unintentional occurrences in all were taken into account for the research. Based on the frequency of accidents, the Geographic Information System (GIS) is used to determine the locations and waterway routes that are most vulnerable to waterway accidents. According to the investigation, collisions, storms or Nor'westers, overloading, instability failure, high current, and bottom damage are the main causes of waterway accidents. According to the data, compared to other types of boats, cargo and passenger ships experience a higher number of accidents. It was also noted that a large number of incidents and pertinent data frequently go

unreported. Furthermore, the information collected on waterway accidents is not very useful for performing routine research projects. In order to develop a safer canal transportation system for Bangladesh and to support additional study and studies, a few recommendations are made at the end. (Uddinetal.,2017)

14. When compared to other modes, Inland Waterway Transport (IWT) is acknowledged for its energy efficiency, reduced greenhouse gas emissions, and substantial freight capacity. As a result, IWT contributes to the achievement of the 2030 Agenda's Sustainable Development Goals (SDGs), which have to do with sustainable transportation. Environmental, social, and economic concerns must all be considered in transportation sustainability assessments. In order to identify gaps in the literature for further research and to give a conceptual definition of sustainable inland waterway transport that links to the SDGs, this paper examines previous research. In order to complete this assignment, a taxonomy based on cluster analysis was constructed using an intuitive method and peer reviewed publications that were published between 2015 and 2020. Twelve clusters of IWT sustainability issues that were connected to the SDGs and their targets were created 26 from the sample. The findings point to growing interest in eco-friendly activities among scientists. Social issues are still not given enough credit, though. As required by the 2030 Agenda, we define sustainable IWT and outline the directions for future research to reach higher sustainability levels. (Barros et al., 2022)

15. India has 14,500 kilometres of navigable inland rivers. But as a percentage of total transportation movement, it is less than 1% [Raghuram G, 2004]. Inland waterways present a chance for businesses to increase their bottom line due to the rising cost of logistics. The price of shipping by waterways is determined by a number of variables, including the accessibility of one-way or two-way navigation, night navigation, and the state of the infrastructure,

including the availability of mechanised handling at the terminals [S. 2010] Sriraman. This article compares the costs of IWT (inland water transport) with other current forms of travel, such roads and trains, using both qualitative and quantitative methods. Companies are able to determine the most appropriate method of transportation for their goods' transit based on this comparison. Methodology: A link between cost per tonne and distance travelled in kilometres was derived using secondary data about the cost of transportation using IWT between several geographical areas in India that are feasible [TCS, 2004]. The elements pertaining to the availability of automated handling and night navigation at ports are also taken into consideration by this connection. There are from-to charts that show the cost per tonne that is incurred when moving cargo between major terminals on NW-1, 2 and 3. This report also discusses the benefits of using Bangladesh's waterways to connect NW-1 and NW-2 and highlights their advantages. To demonstrate how NTPC and the cement industry may work together to cut costs overall and take advantage of two-way navigation, a case study has been conducted. Conclusions: The study's findings indicate that nearly all national waterways have night sailing capabilities. The analysis indicates that mechanising the processing of goods at terminals can result in a 20.6% reduction in the fixed cost of transportation per tonne for one-way navigation. Additionally, improvising from one-way to two-way navigation reduces transportation costs by 16% for fixed costs and 50% for variable costs. If cargo handling at terminals is automated for two-way navigation, the fixed cost of transportation can be further decreased by 35.3%. This paper's main objective is to evaluate how a business can lower its transportation costs by working with a different business that travels the same route and by anticipating return loads. In conclusion, this article will give businesses a method for comparing several available modes of transport 30 with IWT for specific routes in a qualitative and quantitative manner. In order to maximise the advantages of inland water transportation, businesses might also evaluate how partnering with other businesses for two-way navigation might be investigated (Mishra et al., n.d.).

16. Multiple advancements can be observed in the inland waterway industry. The European Federation of Inland Ports The EFIP report provides an analysis of the current trends in Inland Ports and the policy developments within the European Union in 2014. The prevailing patterns encompass urban logistics, biomass transportation, and the conveyance of bulky items. The 2011 Transport White Paper aimed to achieve a more than 50% shift in freight transport from road to rail and inland waterways (IWW) by the year 2050. The technological, organisational, and logistic changes outlined are analysed in terms of their influence on the model variables of various transportation models and tools used. Technological improvements have a significant influence on organisational and logistics matters and cannot be analysed separately from these subjects. The study is conducted separately for each trend, without considering the varying durations and interconnections among the examined trends.(Benga et al., 2019)

17. Gus-Puszczewicz (n.d.) emphasizes the critical role of inland waterways in promoting sustainable cargo transportation, particularly within the European Union. The study reveals that inland shipping accounted for only 6.3% of total cargo transport in tonne-kilometers across the EU-28 in 2015. It identifies key development drivers such as improving navigational conditions through infrastructure investments like dredging and canalization, and aligning waterway standards with international norms. Although the paper is European-focused, its findings are directly applicable to the Indian context, especially in Kerala and Goa, where similar underutilization trends exist. The study reinforces the need for standardization, policy support, and infrastructure upgrades to enhance the operational

efficiency of inland shipping—core concerns also highlighted in the case of Ro-Ro services on NW-3 (Gus-Puszczewicz, n.d.).

2.2 Literature Gap

Numerous studies have explored the potential and environmental advantages of inland water transport in India. Even though the economic and environmental advantages of this form of transport are well known, comparative regional analyses are still lacking, especially when comparing high-potential states like Kerala and Goa. Without exploring the operational metrics and efficiency indicators of state-level waterways, the majority of previous research has concentrated on more generalised evaluations or larger policy frameworks.

Additionally, there aren't many studies evaluating Ro-Ro (Roll-on/Roll-off) services on particular routes like National Waterway 3 (NW-3). In-depth operational data analysis and performance benchmarking are lacking for vessel services such as those that operate in Kerala between Willington Island and Bolgatty. The current literature lacks a comparative lens between states with different geographic and infrastructure configurations, and it fails to sufficiently analyse the annual trends in vessel usage, cargo throughput, or service consistency.

By providing a thorough operational efficiency comparison of the inland waterways in Kerala and Goa, this project fills in these gaps. It also focusses on Ro-Ro services in NW-3, which are frequently disregarded even though they are crucial to the goals of modal shift and cargo movement. This research contributes to a more comprehensive understanding of inland water transport in India by offering new insights into utilisation patterns, inefficiencies, and regional best practices through the use of statistical tools and time-series analysis.

CHAPTER 3

COMPANY AND INDUSTRY PROFILE

3.1 INLAND WATERWAYS AUTHORITY OF INDIA

Fig 3.1 Logo-IWAI

(Source: IWAI)

The Inland Waterways Authority of India (IWAI), a statutory body under Ministry of Ports, Shipping and Waterways, Government of India, was established on 27th October 1986 through the Inland Waterways Authority of India Act, 1985. The main objective of the IWAI is development, maintenance and management of National Waterways for the purpose of shipping and navigation. IWAI is the apex body for promotion of Inland Water Transport (IWT) in India. The headquarters of IWAI is located at Noida, Uttar Pradesh. It advices the Central Government in all matters relating to inland waterway transportation. The Functions & Powers of the IWAI are laid down in IWAI Act 1985. The IWAI has its regional offices at Patna, Kolkata, Guwahati and Kochi and sub-offices at Allahabad, Varanasi, Farakka, Sahibganj, Haldia, Swroopganj, Hemnagar, Dibrugarh, Dhubri, Silchar, Kollam, Bhubaneshwar and Vijayawada.

3.1.1 OBJECTIVES AND FUNCTIONS

- Development, maintenance and management of navigable National Waterways (NWs).
- Constructing and maintaining facilities such as fairways, jetties, terminals and navigational aids.

• Promoting the use of inland waterways for passenger and freight transportation.
• Technical assistance and advice for private companies and state governments.
• The establishment of inland water transport (IWT) public-private partnerships (PPP).
• Ensuring inland waterway projects are environmentally sustainable.

3.1.2 RECENT DEVELOPMENTS (2024–2025)

- IWAI reported **145.5 million tonnes** of cargo movement on national waterways in FY 2024–25 — its **highest ever**, showing the growing relevance of inland water transport.
- The agency continues to develop terminals, install navigation aids, and digitize operations to enhance efficiency and sustainability.

3.1.3 ROLE OF INLAND WATERWAYS IN KERALA

Fig 5.1 NW 3

(Source: iasgyan)

- The ever-green State of Kerala is endowed with a network of rivers, canals, backwaters and lagoons extending over miles at a stretch adding to the beauty of the landscape and affording easy and cheap means of communication at the same time.

- Kerala's distinctive geography of interconnected rivers, lakes, canals, and backwaters makes inland waterways an essential part of the state's transport ecosystem. Kerala boasts one of India's largest water transportation networks, with more than 1,900 km of navigable waterways. In isolated, water-locked locations with little access to the road, these waterways are essential for daily commuting. Every day, thousands of people benefit from the reasonably priced ferry services offered by the State Water Transport Department (SWTD), which guarantee connectivity for rural communities, employees, and schoolchildren.
- Inland waterways are economically beneficial to a number of industries, such as local trade, tourism, and cargo transportation. The West Coast Canal (WCC) and National Waterway-3 (NW-3) were built to ease the traffic on clogged roads by facilitating the transportation of bulk commodities. At the same time, Kerala's well-known backwater tourism sector flourishes on these waterways and makes a substantial financial contribution to the state. A vital component of livelihood and regional development, inland water transportation also sustains local jobs in fishing, boat building, and small-scale commerce.
- With a view to decongest the traffic on road system of the Kerala and to provide cheaper mode of transport, the Central Government declared the West Coast Canal in the stretch from Kollam-Kottapuram (168 Kms) along with Champakara Canal (14 Kms) and Udyogmandal Canal (23 Kms) as National Waterway with effect from 1st February, 1993. This 3rd National Waterway of the country is the first in South India and the first National Waterway in the country with 24-hour navigation facilities along the entire stretch
- National Waterway in Kerala comprises of Champakkara & Udyogmandal Canals in the suburbs of Kochi and Kottapuram- Kollam Stretch of West Coast Canal for a total length of 205 km. The route connects important commercial centers like Kottapuram, Eloor,

Ambalamugal, Kochi, Vaikkom, Alappuzha, Kayamkulam, Chavara and Kollam.

- A navigational channel of 38m width in wider reaches and 32m in narrow reaches with 2 m depth is to be developed for navigation in NW-3.
- Inland waterways provide a sustainable and environmentally beneficial substitute for road transport. Kerala has led the way in lowering carbon emissions and promoting green mobility by launching solar-powered ferries like Aditya. In order to achieve effective, multimodal connectivity, projects like the Kochi Water Metro further integrate water transportation with urban mobility solutions. In addition to its everyday utility, inland water transport is essential for emergency services and relief during natural disasters like floods.

3.2 KERALA SHIPPING AND INLAND NAVIGATION CORPORATION Ltd. (KSINC)

Fig 3.2 Logo-KSINC

(Source: KSINC)

The Kerala Shipping and Inland Navigation Corporation Ltd. (KSINC), a public sector enterprise established in 1975 through the merger of the Kerala Shipping Corporation and the Kerala Inland Navigation Corporation

(KINCO). The Department of Transport, Government of Kerala, is in charge of KSINC's administrative operations. It is one of the few state-owned businesses in India that operates inland waterways and ships, offering services related to infrastructure development, tourism, and transportation.

3.2.1 OBJECTIVES OF KSINC

• To buy, charter, hire, and construct ships, tankers, and other vessels; to create, maintain, and run shipping services.
• To engage in and conduct the trade and business of shippers, ship owners, ship brokers, ship agents, underwriters, ship managers, and shipping and forwarding agents.
• To create, manage, and run first-rate services for the transportation of goods in Kerala's inland waters as well as the Kerala Coastal Region.
• To plan, carry out, and oversee workshops, repair shops, and service stations for the upkeep and repair of marine vessels in Kerala or elsewhere.
• To create, supply, maintain, and operate labs and research and training facilities.
• To play a significant role in the travel and tourism industry.

3.2.2 KEY SERVICES AND OPERATIONS

1. Cargo and Shipping Services

- Provides cargo transportation services via coastal shipping and inland waterways.
- Provides logistics services for moving building supplies, petroleum products, and bulk goods.
- Serves both public and private customers, such as KSEB and the Food Corporation of India (FCI).

2. Inland Navigation

- Manages and runs Kerala's passenger ferry services.
- Provides backwater and canal services, particularly in the Kochi and Alappuzha areas.
- Encourages inter-island communication between inland and coastal districts.

3. Travel and Tourism Services

- To encourage water-based tourism in Kerala, KSINC has built and runs opulent cruise ships and houseboats.
- Among the notable vessels are:

Nefertiti: A Kochi-based opulent cruise ship.
Sagararani I & II: Well-liked for dinner and sunset cruises.

4. Shipbuilding and Repair

- Runs a shipyard in Kochi that can construct houseboats, barges, tugs, and inland vessels.
- Performs vessel retrofits and repairs for both private operators and government agencies.

3.3 STATE WATER TRANSPORT DEPARTMENT- KERALA

Fig 3.3 Logo- State Water Transportation Department
(Source: SWTD)

The State Water Transport Department (SWTD) is a unique governmental body under the Government of Kerala, dedicated exclusively to providing passenger transport services via inland waterways. SWTD, which was founded in 1968, headquartered in Alappuzha. It is administratively overseen by the Transport Department, is essential to maintaining accessible, reasonably priced, and environmentally responsible water transport services throughout the state.

Kerala is the perfect place for inland water transportation because of its extensive system of rivers, canals, and backwaters. As a lifeline for thousands of daily commuters, SWTD uses this network to run scheduled ferry services throughout several districts, particularly in the districts of Alappuzha, Kottayam, Kollam, Ernakulam, and Pathanamthitta.

With operational zones and divisions backed by core departments that manage operations, administration, technical support, and modernisation, SWTD operates as a decentralised organisation.

1.Functions of the Administration Department:

- oversees personnel and general administration.
- oversees the hiring, transferring, and leaving of human resources.
- Carries out laws and compliance guidelines.

- Works in tandem with the Transport Department and other governmental entities.

2. Traffic and Operations Department Activities:

- Arranges and plans passenger ferry services on a number of routes.
- Oversees crew deployment and keeps an eye on ferries' daily operations.
- Guarantees route effectiveness and modifies services in response to seasonal demand.
- Coordinates service-related complaints and feedback with the public and local authorities.

3. Functions of the Mechanical & Maintenance Department:

- Responsible for vessel maintenance, repair, and inspection.
- Ensures adherence to safety regulations by conducting routine surveys and inspections.
- Oversees the scheduling of docking and servicing.
- Works closely with boatyards (like KSINC and private shipyards) for overhauls and construction.

4. Functions of the Technical and Project Department:

- Oversees the fleet's modernisation, including the installation of solar and electric vessels.
- Creates and carries out plans for the construction and improvement of new vessels.
- Creates and assesses technical specifications for tenders and procurement.
- Works in tandem with the Kerala Infrastructure Investment Fund Board (KIIFB) and engineering consultancies.

5. Department of Finance and Accounts Operations:

- Keeps track of finances, budgets, and audits. Handles fund allocations, vendor payments, and employee salaries.
- Creates reports for use in government projects and audits.

6. Safety and Security Wing Features:

- Guarantees adherence to safety rules for inland water transportation.
- Trains ferry staff and boat masters in safety protocols and emergency handling.
- Carries out tests and exercises to get ready for mishaps or natural disasters.

7. Grievance Cell and Public Relations Activities:

- Handles public communication, feedback, and complaints.
- Distributes fare information, route modifications, and service updates.
- Carries out community outreach and awareness campaigns, particularly in island areas.

8. District and Zonal Office Operations:

- Operations in districts such as Alappuzha, Ernakulam, Kollam, Kottayam, and Pathanamthitta are managed by regional control centres.
- Decentralised service coordination and complaint handling. Communicate with the police department, local government agencies, and panchayats.

3.4 RIVER NAVIGATION DEPARTMENT - GOVERNMENT OF GOA

Fig 3.4 Logo-River Navigation Department Government of Goa

(Source: RND)

One important government agency under the Government of Goa is the River Navigation Department (RND), which is in charge of offering inland water transport (IWT) services across the state's rivers and backwaters, primarily via ferries. The department was created in 1961 to preserve the essential connectivity that Goa's rivers offer, particularly in areas where bridge construction was either impractical or impossible.

With more than 250 km of navigable waterways and several estuarine rivers, including the Mandovi, Zuari, and Chapora, Goa is a riverine state that primarily depends on river transportation, particularly in its rural and island areas.

Core Functions of RND

1. Passenger and Vehicle Ferry Services
2. Maintenance of Ferries and Terminals
3. Fleet Management
4. Infrastructure Development
5. Revenue Collection and Regulation

Significance of RND in Goa's transport ecosystem

- Connect remote or island communities.
- Provides an alternate form of transportation, which lessens traffic on the roads.
- Facilitates access to backwater routes and heritage islands, which increases local tourism.
- Serves as a last-mile connection for the movement of goods, students, and daily commuters.
- Supports the state's objectives for sustainable transportation.

3.4.1 ROLE OF INLAND WATERWAYS IN GOA

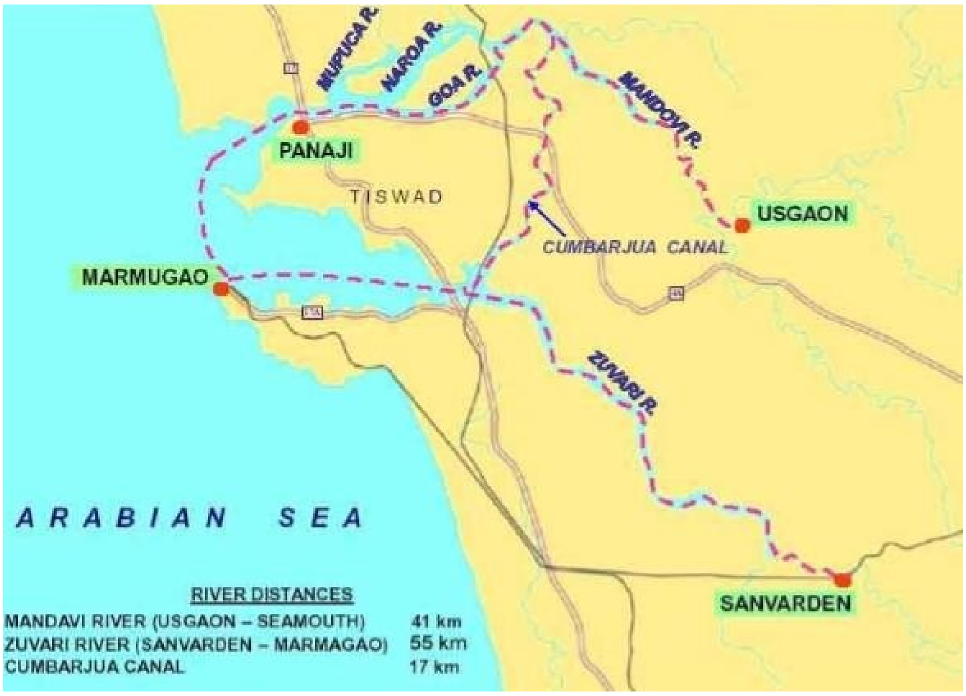

Fig 3.5 Mandovi- Zuari river system

Using Goa's natural network of rivers, estuaries, and backwaters, inland waterways are an essential part of the state's transportation system. Major rivers like the Mandovi, Zuari, Chapora, and Sal flow through the state and have long been used as routes for the transportation of both people and goods. In order to preserve connectivity, particularly in places without bridges or where bridge construction is not feasible, the Goan government has established ferry operations through the River Navigation Department

(RND). Inland water transport is still a vital component of Goa's rural and island connectivity system, with more than 17 ferry routes and about 40 ferryboats operating.

In Goa, passenger transport is one of the most important functions of inland waterways. Every day, thousands of commuters, including tourists, employees, and students, depend on the ferries run by RND. They offer free or inexpensive river and estuary transportation, especially in places with limited road access like Divar, Chorao, and San Jacinto islands. In some areas, the ferry system shortens travel times and eases traffic congestion by ensuring smooth community mobility and reducing reliance on road networks. Initiatives to update ferries with solar and electric power also seek to increase the sustainability and efficiency of this form of transportation.

The importance of moving cargo through Goa's inland waterways has also increased, particularly in light of state and federal initiatives to resurrect historic waterways. Goa's role in inland and coastal shipping is being expanded by the Inland Waterways Authority of India (IWAI) and the Mormugao Port Authority (MPA). Bulk goods like coal, iron ore, petroleum products, building supplies, and agricultural products are transported via rivers like the Mandovi and Zuari. Compared to road transport, this mode is especially advantageous because it is economical, uses little fuel, and can move large volumes with little environmental impact.

Additionally, by connecting inland terminals with national waterways and coastal ports, Goa's inland waterways facilitate multimodal logistics. In order to incorporate Goa's rivers into the broader national water transportation system, the state is a part of National Waterway-68 (NW-68). The state can lower highway traffic and improve environmental compliance by enticing industries to switch to water transport for a portion of their logistics. The capacity of Goa's inland water transport industry to handle cargo is anticipated to grow further with the construction of contemporary jetties, floating terminals, and cargo-handling infrastructure.

In summary, Goa's inland waterways serve as a means of facilitating both passenger and freight movement. The revival and modernisation of cargo transport via rivers offer a substantial opportunity for sustainable economic growth, even though ferry services continue to be essential for locals' daily lives and contribute to the state's social connectivity. Inland water transport in Goa has the potential to grow into a more effective, environmentally friendly, and essential part of the state's transport and logistics infrastructure with careful investments and incorporation into national waterway development plans.

3.5 RO-RO SERVICE IN NW-3

Fig 3.6: RORO Vessel of NW-3

(Source: Primary Data)

In Kerala, the Inland Waterways Authority of India (IWAI) launched the Ro-Ro (Roll-on/Roll-off) service on National Waterway-3 (NW-3), which is run and maintained by KSINC. NW-3 is a 205-kilometer route that runs from Kollam to Kottapuram via the West Coast Canal, Champakkara Canal, and Udyogamandal Canal.

Trucks and other vehicles can be directly loaded onto specially built ships, transported via inland waterways, and then rolled off at their destination thanks to the Ro-Ro service. This is beneficial:

- Lower fuel consumption and traffic congestion
- Reduce carbon emissions
- Save money on transportation and time.

Trucks can move across water with ease thanks to a major Ro-Ro route in Kerala that runs between Kochi's Bolgatty and Willingdon Island.

CHAPTER 4

DATA ANALYSIS AND INTERPRETATION

4.1 OBSERVATIONS, ANALYSIS AND INTERPRETATONS

4.1.1 ANALYSIS AND INTERPRETATION OF TOTAL AND NAVIGABLE LENGTH OF WATERWAYS (2015–2024)

Year	Total Length of the Rivers/ Canals/ Lakes in State (Km.)		Navigable Length (Km.)		Percentage of Navigable Length to Total Length	
	KERALA	GOA	KERALA	GOA	KERALA	GOA
2015-2016	2779	274	845.2	249	30.41	90.88
2016-2017	3311	274	1772	249	53.52	90.88
2017-2018	3553.46	274	1967.25	249	55.36	90.88
2018-2019	3256.13	274	1897.49	249	58.27	90.88
2019-2020	2988.61	274	1613.24	249	53.98	90.88
2020-2021	2920.62	273	1866.92	248	63.92	87.91
2021-2022	2948.25	273	1926.87	248	65.35	87.91
2022-2023	2881.55	273	1951.85	248	67.73	87.91
2023-2024	2881.01	274	2004.21	249	69.56	90.88

Table 4.1 Total and Navigable length of waterways

(Source: Statistics of Inland water transport by Ministry of Ports, Sipping and Inland waterways)

This table compares the navigable lengths of Kerala and Goa's rivers, canals, and lakes between 2015–16 and 2023–24. A crucial measure of the effectiveness and usability of each state's inland water transport (IWT) infrastructure is the proportion of navigable length to total length, which is also included.

With total lengths varying over time from 2,779 km to 3,553 km, Kerala continuously boasts a far larger network of water bodies. In contrast, Goa's smaller geographic size is reflected in its relatively constant total waterway length of 273–274 km.

From 845.2 km in 2015–16 to 2,004.21 km in 2023–24, Kerala’s navigable length exhibits a notable upward trend. Nearly the whole waterway system in Goa is navigable and already heavily used, as evidenced by the relatively constant navigable length of the state, which is between 248 and 249 km.

Kerala's percentage of navigable length to total length increased significantly from 30.41% in 2015–16 to 69.56% in 2023–24. This increase is a result of major efforts by the Kerala government and organisations like IWAI to develop and revitalise water transportation routes, including the West Coast Canal and the National Waterway-3 (NW-3).

On the other hand, Goa already maintains a high navigability ratio, regularly surpassing 87% and recently hitting 90.88%. This demonstrates how effectively Goa uses its smaller but more concentrated river system, particularly the Mandovi and Zuari.

Inland waterway strategies that are complementary but different are highlighted in this data-driven comparison. While Goa's model stresses efficient and nearly complete use of a smaller network, Kerala's recent improvements demonstrate a shift from underutilisation to progressive development. These patterns offer important information for upcoming infrastructure projects, policy decisions, and cooperative learning between the two states.

4.1.2 ANALYSIS AND INTERPRETATION OF CARGO MOVEMENT DATA (2015–2024)

Year	Cargo Moved (tonnes)		Number of Vessels		Efficiency (Cargo moved/No.of vessels)	
	KERALA	GOA	KERALA	GOA	KERALA	GOA
2015-2016	1061000	4975000	13819	159	76.77834865	31289.30818
2016-2017	1033000	15768000	5556	311	185.925126	50700.96463
2017-2018	428000	11162000	7656	266	55.90386625	41962.40602
2018-2019	420000	3772000	5953	250	70.55266252	15088
2019-2020	546000	2952000	5590	244	97.6744186	12098.36066
2020-2021	738000	8461000	5018	265	147.0705460	31928.30188
2021-2022	1695000	4578000	5248	233	322.980182	19648.06866
2022-2023	3228000	2929000	5892	253	547.861507	11577.07509
2023-2024	3293000	3521000	6679	277	493.037879	12711.19133

Table 4.2 Cargo moved and No. of vessels

(Source: Statistics of Inland water transport by Ministry of Ports, Sipping and Inland waterways)

Using three metrics—cargo moved (in tonnes), number of vessels deployed, and vessel efficiency (cargo moved per vessel annually)—this dataset sheds light on how vessels are used to move cargo through Keralan and Goan inland waterways.

Based on the number of vessels and the amount of cargo carried in tonnes, an efficiency calculation was performed. The efficiency was computed between 2015 and 2024. We are attempting to determine the average volume of cargo carried by each vessel throughout the course of the corresponding years through this efficiency computation.

Efficiency = Volume of Cargo Carried/ Number of Vessels

Throughout the period, Goa has continuously recorded higher cargo volumes than Kerala, reaching a peak of 15.76 million tonnes in 2016–17. Kerala transported 3.29 million tonnes, while Goa transported 3.52 million tonnes, even in the most recent year (2023–24).

Since 2019–20, Kerala has shown an impressive upward trend, rising from 546,000 tonnes to over 3.29 million tonnes in 2023–2024. This points to a resurgence and expansion of Kerala's IWT cargo industry, perhaps as a result of multimodal integration initiatives and NW-3 operationalisation.

Compared to Goa, Kerala regularly uses more vessels. For instance, there was a significant operational disparity between Kerala and Goa in 2015–16, with Kerala using 13,819 vessels and Goa using just 159.

Kerala significantly decreased the size of its fleet starting in 2016–17 (it was 5,556 in 2016–17), which is probably a sign of improved fleet management and modernisation. With between 233 and 311 ships, Goa's fleet size stayed steady and modest.

In the early years, Goa performs better than Kerala in terms of tonnage per vessel, which may be due to higher-capacity ships or improved logistics.

However, Kerala surpasses Goa in efficiency starting in 2020–2021. Kerala's cargo per vessel increased dramatically to 322.98 tonnes in 2021–2022, then to 547.86 tonnes in 2022–2023 and finally to 493.04 tonnes in 2023–2024.

In contrast, Goa's efficiency decreases over time, going from 50,700 tonnes per vessel in 2016–17 to 12,711 tonnes in 2023–24. This suggests that either fewer shipments are made or that more vessels are transporting lighter loads.

According to the data, Kerala's inland cargo movement industry has seen a notable transformation, with notable gains in both cargo volume and efficiency. Despite starting out as a dominant player, Goa's performance has been declining recently. Other states looking to revitalise their inland water transport systems might find inspiration in Kerala's fleet reduction and efficiency improvements approach.

4.1.3 CHI-SQUARE TEST

Chi-square test is a valuable tool for analysing categorical differences, especially ones that are nominal in character.

The extent of the discrepancy between actual and observed values determines the value of 2. It can also be used to compare the fit of an actual frequency distribution to a theoretical frequency distribution.

In order to understand the performance of the inland waterways of Kerala and Goa, a Chi square test is done by taking the cargo moved in lakh tonne and the navigable length of rivers in each state.

In the year 2015-2016, Goa had 249 km navigable Inland waterway. Through that length, they carried 49.75 lakh tonnes of cargo. Keeping this as a benchmark, we are trying to calculate an expected value for the cargo carried along the Inland waterway of Kerala. The navigable length was 845.2 km during 2015-2016. Thus, the expected value was calculated as follows:

$$\text{Expected value} = \frac{(\text{Navigable length of Kerala} \times \text{Cargo moved in Goa})}{\text{Navigable length of Goa}}$$

With the above equation, keeping Goa as a benchmark, an expected value for the cargo moved in Inland waterways of Kerala is calculated. The results are shown in the table below.

Years	Navigable Length (Km.)		Cargo Moved (lakh tonnes)		Expected value
	KERALA	GOA	KERALA	GOA	
2015-2016	845.2	249	10.61	49.75	168.87
2016-2017	1772	249	10.33	157.68	1122.12
2017-2018	1967.25	249	4.28	111.62	881.86
2018-2019	1897.49	249	4.2	37.72	287.44
2019-2020	1613.24	249	5.46	29.52	191.25
2020-2021	1866.92	248	7.38	84.61	636.94
2021-2022	1926.87	248	16.95	45.78	355.69
2022-2023	1951.85	248	32.28	29.29	230.52
2023-2024	2004.21	249	32.93	35.21	283.41

Table 4.3 Expected cargo movement in Kerala

(Source: Statistics of Inland water transport by Ministry of Ports, Sipping and Inland waterways)

With the obtained expected value and the original values of cargo moved along the Inland waterways of Kerala, a Chi square test is done to understand the performance of Inland waterways of the states.

The discrepancy between the observed and expected frequencies of the outcomes of a set of events or variables is measured by the chi-square statistic.

The formula of Chi square is:

$$\chi^2 = \sum((o - e)^{\wedge 2})/e$$

Where,

o = Observed value

e = Expected value

4.1.4 HYPOTHESIS TESTING

A statistical technique for drawing conclusions or judgements about a population from sample data is the hypothesis test. There are two theories involved:

Null Hypothesis (H_0): Assumes there is no effect or difference.

Alternative Hypothesis (H_1 or Ha): Assumes there is an effect or difference. The test establishes whether there is sufficient evidence in the observed data to disprove the null hypothesis. This is accomplished by utilising a p-value or a test statistic and comparing it to a critical value. The alternative hypothesis is accepted if the p-value is less than the selected significance level, which is typically 0.05.

The Hypothesis for the calculation is as follows:

Hypothesis: There is no significant difference between the observed values and expected values.

Expected value	Observed value	o - e	(o - e)^2	((o - e)^2)/e
168.87	10.61	-158.26	25046.32	148.3169
1122.12	10.33	-1111.79	1236087	1101.55943
881.86	4.28	-877.585	770155.9	873.326013
287.44	4.2	-283.243	80226.63	279.104432
191.25	5.46	-185.796	34520.3	180.492277
636.94	7.38	-629.56	396345.8	622.265519
355.69	16.95	-338.74	114744.8	322.597767
230.52	32.28	-198.24	39299.1	170.480218
283.41	32.93	-250.48	62740.2	221.376098
	Chi square value			**3919.518654**

Table 4.4 Chi square table

(Source: Author's Data)

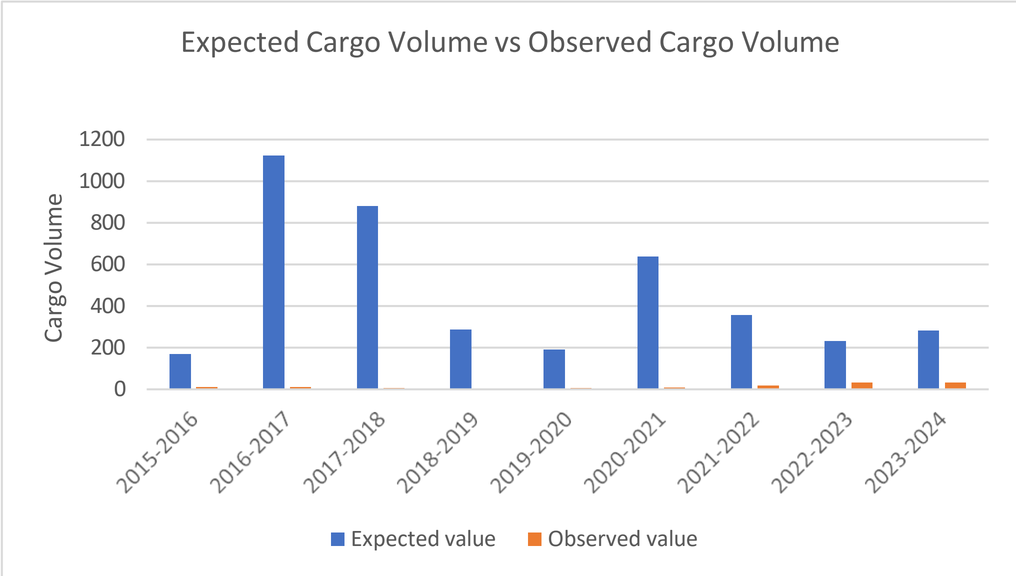

Fig 4.1 Expected cargo volume and Observed cargo volume in Kerala Waterways

(Source: Author's Data)

With the calculated expected values and the original observed values, Chi value is calculated.

The Chi value obtained is 3919.518654.

The degree of freedom for the above table is:

Degree of freedom = (No. of column-1) × (no. of row-1)

= (2-1) × (9-1)

= 8

With this degree of freedom, the table for Chi square at a 5% significant level is 15.507.

Calculated Chi square value = 3919.518654

Table value for Chi square = 15.507

i.e.; **Chi square table value < Chi square calculated value**

Hypothesis rejected – There is significant difference between the observed value and the expected value.

There is a significant difference between the cargos moved along the inland waterway of Kerala by keeping the cargo movement in Goa as a benchmark. If Goa is moving 49.75 lakh tonne of cargo along the 249 km navigable inland waterway, then Kerala should move 168.870 lakh tonne of cargo through 8452 km length waterway. But the amount of cargo actually moved in that year is only 10.61 lakh tonne. There is a huge difference between the cargo movements.

CHAPTER 5

CASE STUDY ON RORO SERVICE IN NATIONAL WATERWAY 3

5.1 CASE STUDY ON RORO SERVICE BETWEEN WILLINGTON ISLAND AND BOLGATTY ON NATIONAL WATERWAY 3

Fig 5.1, 5.2: RO-RO Service between Willington Island and Bolgatty

(Source: Primary Data)

One important project to encourage inland water transport in Kerala is the Ro-Ro (Roll-on/Roll-off) service operated by the Inland Waterways Authority of India (IWAI) on National Waterway 3 (NW-3).

Two Ro-Ro vessels- MV Adi Shankara & MV C.V Raman having a capacity of transporting 15 TEUs was constructed through Cochin Shipyard Ltd and taken over successfully on 28.09.2020. These vessels were deployed for transporting the Container Trailers between Willingdon Island and Bolgatty Island on NW- 3, through an Operation & Maintenance (O & M) contract with Kerala Shipping and Inland Navigation Corporation Ltd (A Govt. of Kerala Undertaking). The commencement of Ro-Ro service will decrease the road congestion/ container traffic from the city roads of Kochi and to reach the destination at ICTT, Vallarpadam Container Terminal through IWT mode.

With the commencement of the Ro- Ro services, container carrying vehicles can take the Ro- Ro service from Willingdon Island jetty to Bolgatty from where vehicles can access ICTT, Vallarpadam by road. Similarly, outward loaded/ empty vehicles from ICTT can take the same service from Bolgatty to Willingdon Island for onward road movement. The service reduces the travel distance from current 25-30 km on road to 3.5km on waterways, thereby benefitting the trade with reduced transportation cost and transit time. Importantly the service brings much needed relief to the city of Kochi by reducing congestion level on road and contribute to public safety.

The vessels have a capacity to carry nine 40 ft containers or eighteen 20 ft containers in a voyage.

5.1.1 RORO SERVICE ROUTE

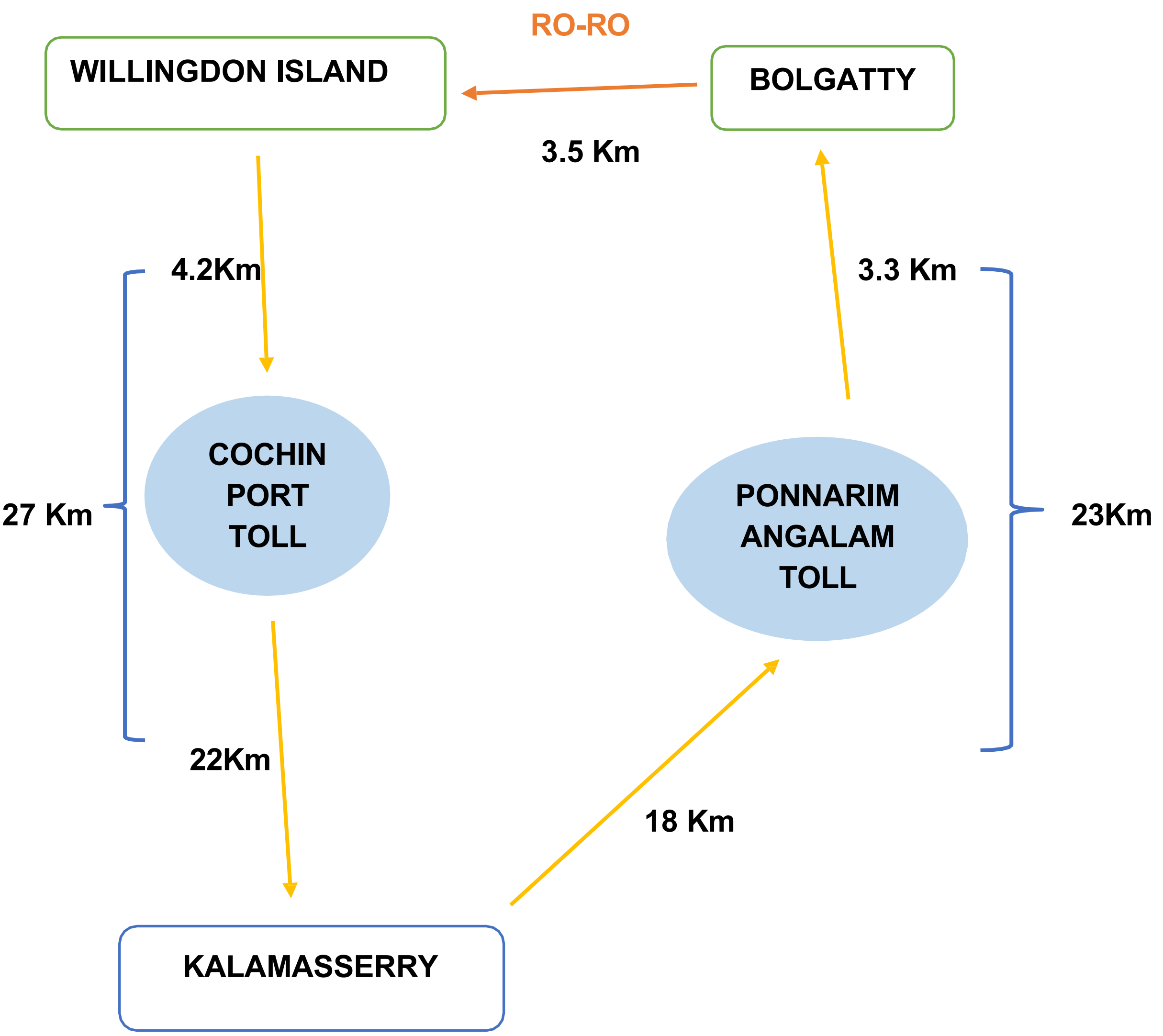

Fig 5.1 RORO Service Route

(Source: Author's Data)

By using RORO service, travelling distance of approximate 32km from Vallarpadam terminal to Willingdon Island can be reduced to 3.5 km. It also helps to avoid tollpayment in Cochin Port Toll and Ponnarimangalam Toll.

5.1.2 RO- RO TIME SCHEDULE

Bolgatty	Willingdon Island
7:30am	8:10AM
9:10am	9:40AM
10:40am	11:15AM
12:00 Noon	12:30PM
Lunch Break (1pm- 1:40pm)	
1:40PM	2:30PM
3:05PM	3:35PM
4:00PM	4:40PM
5:30PM	6:15PM
8:00PM	8: 30PM
9:05PM	9:30PM

Table 5.1 Time Schedule of RORO Service

(Source: Primary data collected from RORO Operators)

Sunday (Holiday)

The above mentioned time schedule may change if there is any delay or unavoidable

events occur.

5.1.3 CHARGES

Vehicle	Charges	
	With load	Without load
20 ft Container Truck	800	400
40 ft Container Truck/ Trailer	1200	600
Two Axle Truck	600	450
3- 4 Axle Truck	800	600
Car/ Jeep/Three-Wheeler	200	150

Others	Charges
Two Wheelers	30
Passengers	10

Table 5.2 RORO Service Charges

(Source: Primary data collected from RORO Operators)

5.1.4 BENEFITS OF RO-RO

- **Reduced Distance:** Travelling distance of approximate 32km from Vallarpadam terminal to Willingdon Island can be reduced to 3.5 km.
- **Reduces Fuel Cost**: Reduces fuel consumption of the container trucks by travelling through the Ro-Ro subsequently reduces the fuel cost for the companies.
- **Time Saving:** By reducing the travel distance, it enables considerable time saving for the truck drivers.
- **Decreases Traffic Congestion:** Traffic congestion can be reduced in the city by transporting cargoes through the Ro-Ro services.
- **Less Road Accidents:** Road accidents can be reduced by opting transportation through Ro-Ro.
- **Less Pollution:** Pollution can be reduced.
- **Discount:** There is a 10% Discount for daily customers of Ro-Ro service.
- **Increased Productivity of Drivers:** Instead of driving, the drivers can rest during the time while using the Ro-Ro service. It will increase their productivity.
- **Toll Payment:** Toll payment in can be excluded.

5.1.6 CHALLENGES OF RORO

- **High Investment:** Ro- Ro implementation and upgradation requires high investment of money.
- **High Operational Costs**: The operating costs including fuel, labour, repair & maintenance etc. need high amount of money.
- **Water Pollution:** Emission and waste management should be properly managed.
- **Shortage of Skilled Labour:** The efficiency and service quality may be affected if there is a shortage of skilled labours in operating & maintaining Ro-Ro vessel.

- **Adverse Weather Condition:** Adverse weather and other natural calamities like flood, cyclone etc. may affect the functioning of Ro-Ro.
- **Alternate Transport Mode:** The availability of road transport as an alternative mode may reduce the use of Ro-Ro service.

5.2 RORO VESSEL OPERATION ANALYSIS (2021-2025)

The given below table shows the Number of trips and Cargo movement in tonnage of RORO vessels operating in NW-3, between Willington Island and Bolgatty during 2021-2025.

Year	MV ADISHANKARA		C.V.RAMAN		Total trips (Adishankara& CV Raman)	Total Tonnage (Adishankara& CV Raman)
	Tonnage	Trips	Tonnage	Trips		
2021-2022	358109.6	1516	496037.5	1195	2711	854147.1
2022-2023	426821.3	2440	628863.35	3349	5789	1055685
2023-2024	235450.6	1225	528066.77	2982	4207	763517.4
2024-2025	0	0	771473	3974	3974	771473

Table 5.3 No. of Trips and Cargo movement of RORO Vessels Adhishankara & C.V Raman during 2021-2025

(Source: Primary data collected from IWAI RO, Kochi)

5.3 ANALYSIS AND INTERPRETATION OF NUMBER OF TRIPS OF RORO VESSELS (2021- 2025)

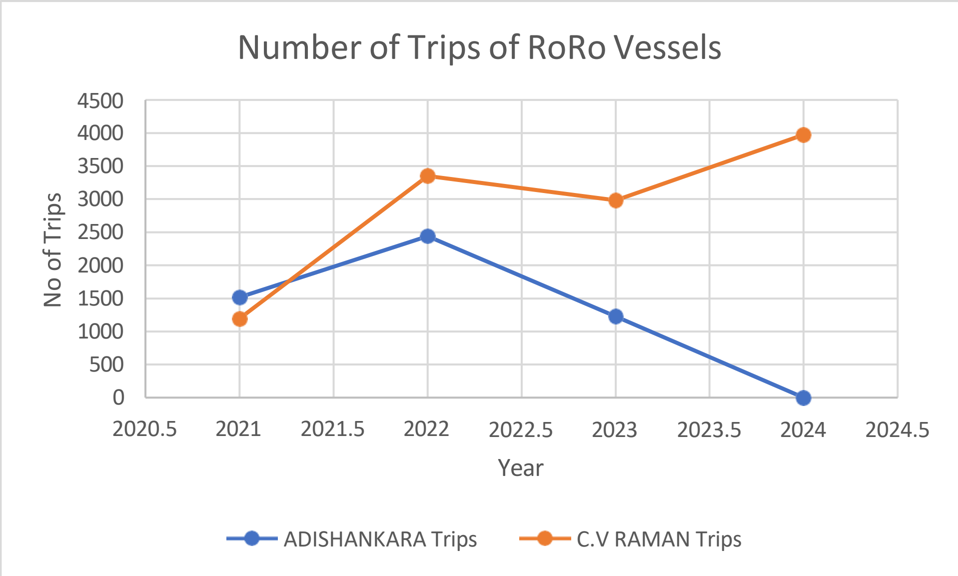

Fig 5.2 No. of Trips done by RORO Vessels

In the starting year of 2021, M V Adhishankara done more trips than C.V Raman. But in the same year itself, C.V Raman came above MV Adhishankara due to its stopping of service. Possible problems like poor demand, maintenance failures, or administrative inefficiencies are indicated by the decline and eventual cessation of Adishankara trips. In the meantime, selective optimisation is evident in C.V. Raman's continuous operations. This highlights the inefficiency in managing Ro-Ro services and furthers the imbalance in vessel utilisation and operational planning on NW-3.

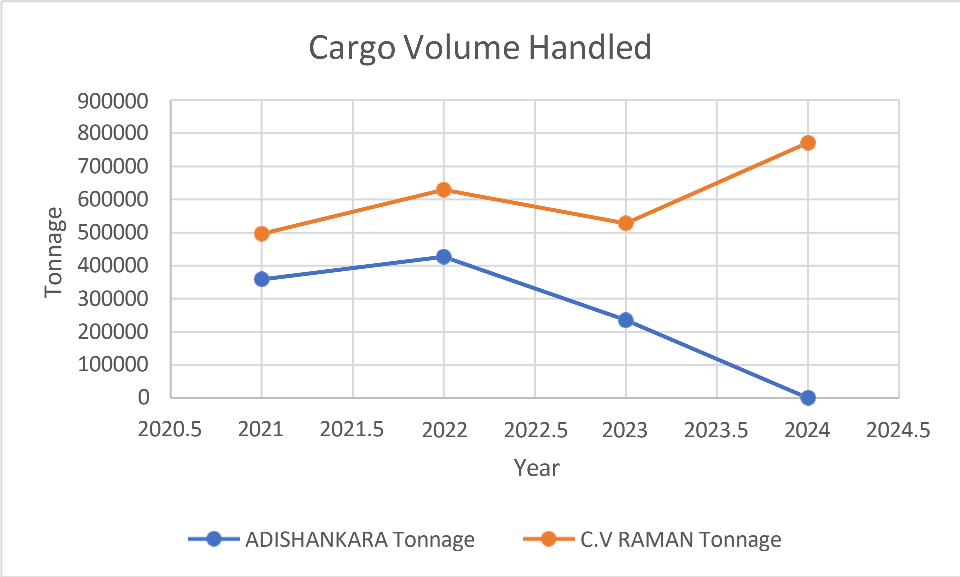

Fig 5.3 Cargo volume handled by RORO Vessels

In every year, the C.V. Raman vessel has routinely carried more cargo than the Adishankara. After reaching a peak of over 426,000 tonnes in 2022, Adishankara saw a steep decline. Adishankara handled no cargo by 2024, a sign of total withdrawal or suspension of operations. In contrast, C.V. Raman continued to rise steadily, reaching a notable peak of about 771,000 tonnes in 2024.

The irregular use of the Adishankara Ro-Ro vessel is shown in this chart, which suggests poor performance or discontinuation by 2024. On the other hand, C.V. Raman exhibits a better operational record and growing efficiency, indicating that the service is not being used uniformly or optimally despite NW-3's potential. One vessel's discontinuation highlights NW-3's inefficiency and underutilisation of resources.

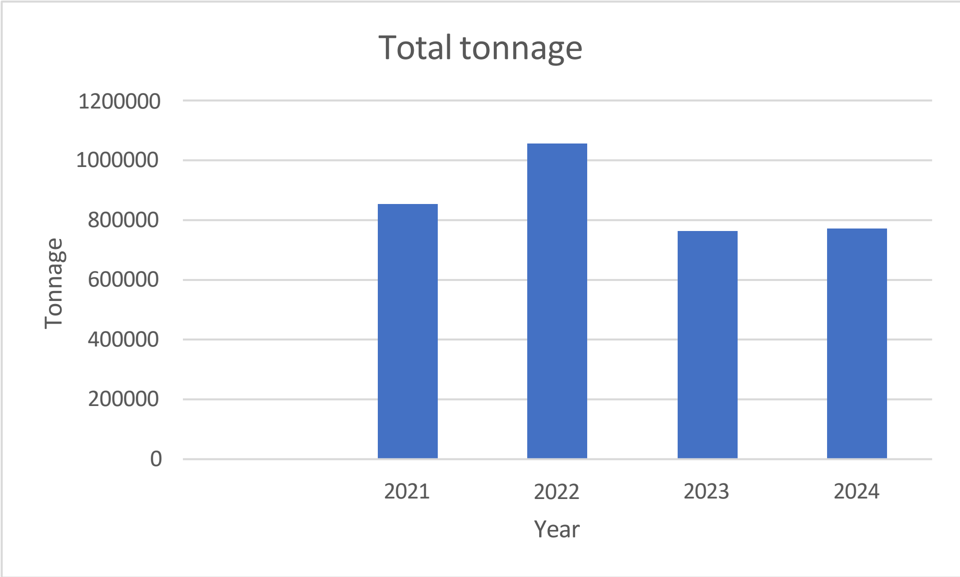

Fig 5.4 Total Cargo Tonnage carried by RORO Vessels

Over 1 million tonnes were handled in 2022, up from about 854,000 tonnes in 2021. But after that, there was a sharp drop in 2023 (about 763,000 tonnes), which remained unchanged in 2024 even though C.V. Raman's contribution increased.

Despite the ongoing increase in C.V. Raman's operational trips, the total cargo handled plateaued following a peak in 2022. The stop service of Adishankara is directly related to the decrease in total tonnage, demonstrating that even with one vessel operating, NW-3's entire capacity is not being used. This highlights a missed chance to increase inland cargo movement in the area, systemic inefficiencies, and a lack of redundancy planning.

5.4 TREND ANALYSIS OF RORO VESSEL (2025-2030)

Using historical data from 2021 to 2024, a trend analysis has been carried out to assess the future scope and operational performance of Ro-Ro vessel services between Bolgatty and Willingdon Island on National Waterway-3 (NW-3). The goal of this analysis is to predict how much tonnage will be handled overall and how many trips the two Ro-Ro ships, Adishankara and C.V. Raman, will operate over the course of the next six years, until 2030. This section offers important information about the anticipated growth, operational effectiveness, and use of Ro-Ro services in this corridor by looking at historical trends and predicting future performance using forecasting models with confidence intervals.

5.4.1 FORECASTING OPERATIONAL TRENDS OF RO-RO VESSEL TRIPS ON NW-3 (2025–2030)

Year	Total trips(Adishankara& CV Raman)	Forecast(Total trips(Adishankara& CV Raman))	Lower Confidence Bound(Total trips(Adishankara& CV Raman))	Upper Confidence Bound(Total trips(Adishankara& CV Raman))
2021	2711			
2022	5789			
2023	4207			
2024	3974	3974	3974.00	3974.00
2025		4705.940479	1806.35	7605.53
2026		5204.764033	2248.31	8161.21
2027		5703.587587	2623.45	8783.72
2028		6202.411141	2914.20	9490.62
2029		6701.234695	3112.26	10290.21
2030		7200.058249	3217.94	11182.18

Table 5.4 Operational Trends of RORO Vessel Trips

(Source: Author’s Data)

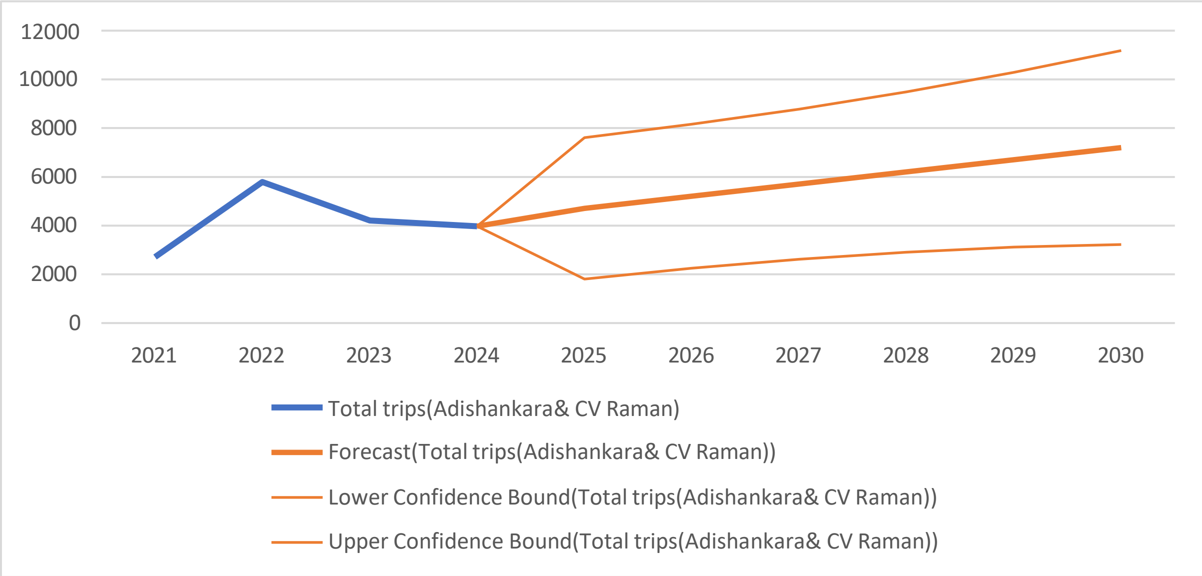

Fig 5.5 Trend Analysis of RORO Vessel Trips

- Year → The year on which Ro-Ro trips are observed or predicted.
- Total Trips (CV Raman & Adishankara) → The actual total number of trips that both Ro-Ro vessels made during that year.
- Forecast (Total Trips) → Based on past patterns, the anticipated total number of trips for upcoming years.
- Lower Confidence Bound (Total Trips) → The bare minimum of trips that can be predicted with 95% confidence, taking risk and variability into account.
- Upper Confidence Bound (Total Trips) → The 95% confidence level for the maximum anticipated number of trips, which represents optimistic utilisation.

ANALYSIS & INTERPRETATION

The trend analysis above shows how many trips the Ro-Ro ships Adishankara and C.V. Raman have made in the past and are expected to make on National Waterway 3, which runs between Willingdon Island and Bolgatty.

Historical Trend (2021–2024): The total number of trips peaks in 2022 at 5789, after which it steadily declines in 2023 and 2024, reaching 3974 trips in 2024. This decrease can be a sign of operational inefficiencies or underutilisation.

Projected Trend (2025–2030): According to the forecast, the overall number of trips will rise steadily from 4705 in 2025 to 7200 by 2030. This encouraging expansion may be the result of enhanced demand, improved operational efficiency, or government initiatives to support inland water transport.

Confidence Bounds: Growing uncertainty in projections for subsequent years is indicated by the growing difference between the lower and upper confidence bounds. Even the conservative projections, though, point to some growth, which supports the optimistic long-term outlook.

Implication: NW-3 could see a large increase in Ro-Ro usage if operational and policy changes are made; however, the projections might not come to pass if current inefficiencies are not addressed, as evidenced by recent declining trends.

5.4.2 FORECASTING OPERATIONAL TRENDS OF RO-RO VESSEL TONNAGE ON NW-3 (2025–2030)

Year	Total tonnage	Forecast(Total tonnage)	Lower Confidence Bound(Total tonnage)	Upper Confidence Bound(Total tonnage)
2021	854147.1			
2022	1055685			
2023	763517.4			
2024	771473	771473	771473.00	771473.00
2025		729910.1338	476624.76	983195.51
2026		698553.3137	440301.45	956805.18
2027		667196.4935	398140.53	936252.46
2028		635839.6733	348607.58	923071.77
2029		604482.8532	290978.37	917987.34
2030		573126.033	225279.81	920972.26

Table 5.5 Operational Trends of RORO Vessel Tonnage

(Source: Author's Data)

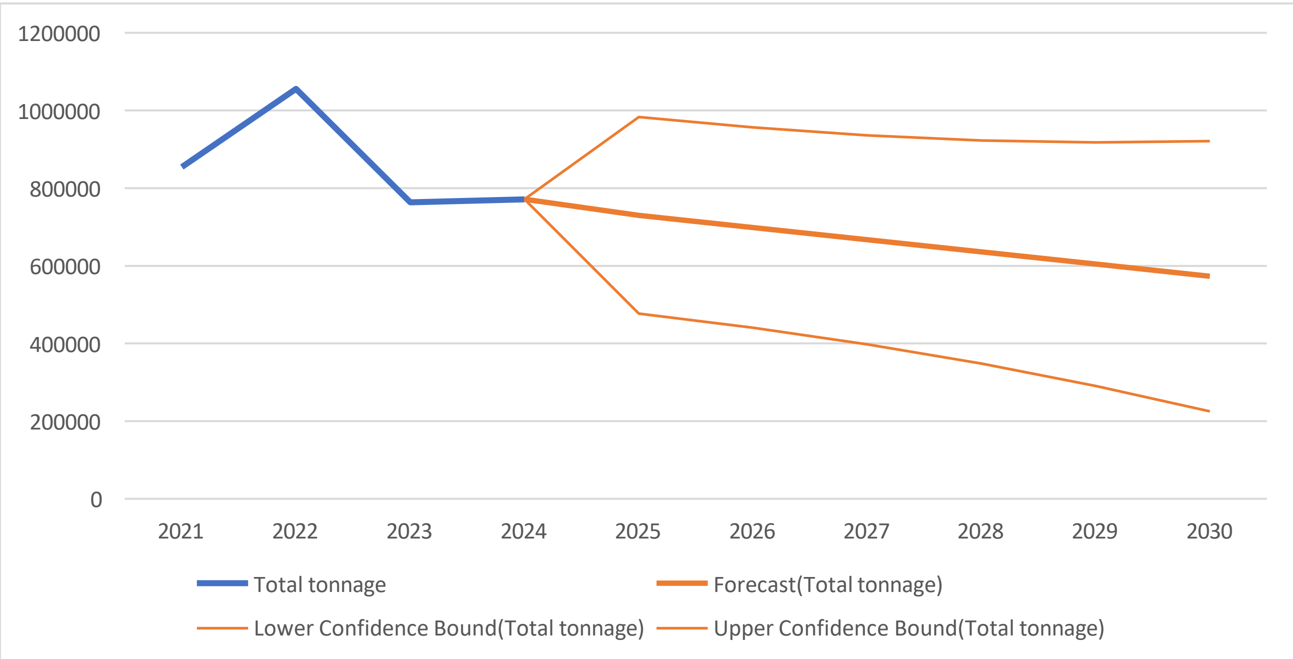

Fig 5.6 Trend Analysis of RORO Vessel Tonnage

- Year → Denotes the particular year in which the data is forecasted or recorded.
- Total Tonnage → The actual total amount of cargo that Ro-Ro ships carried in that year, expressed in tonnes.
- Forecast (Total Tonnage) → The anticipated cargo tonnage for upcoming years as determined by trend analysis of past data.
- Lower Confidence Bound (Total Tonnage) → The lower bound of the estimated tonnage range, signifying a minimum expected volume or a conservative scenario.
- Upper Confidence Bound (Total Tonnage): This represents the most optimistic forecast scenario for that year and represents the upper limit of the estimated tonnage range.

ANALYSIS AND INTERPRETATION

Based on actual data from 2021 to 2024 and projected data for 2025 to 2030, the trend analysis for Ro-Ro vessel tonnage on National Waterway 3 (NW-3) shows a consistent drop in cargo tonnage over the anticipated time frame.

Historical Data Insight (2021–2024): The tonnage reached a peak of more than one million tonnes in 2022, but it fell precipitously to 763,517.4 tonnes in 2023 and stayed relatively constant at 771,473 tonnes in 2024. This suggests that Ro-Ro services are underutilised or inconsistently operated.

Projected Trend (2025–2030): The forecast indicates a yearly decrease from 729,910.13 tonnes in 2025 to 573,126.03 tonnes by 2030. This declining trend suggests possible inefficiencies or a reduction in the use of Ro-Ro transportation.

Confidence Bounds: If corrective action is not taken, there is a considerable risk of further underperformance, as the lower confidence bound drops sharply, reaching as low as 225,279.81 tonnes in 2030. Even though it is stable, the upper confidence bound is still far below the 2022 peak tonnage.

Conclusion: It is anticipated that the operational tonnage of the Ro-Ro service between Bolgatty and Willington Island will continue to decline if current trends continue, underscoring the urgent need for operational enhancements, policy changes, or strategic repositioning to guarantee the best possible use of NW-3.

5.5 UTILIZATION ANALYSIS

This gauges how much of the vessel's or waterway's actual capacity is being utilised. For that, Period Based Utilization Analysis method is chosen.

5.5.1 PERIOD- BASED UTILISATION ANALYSIS

The Period-Based Utilisation approach determines how efficiently a vessel operates over a given time period, such as a month or a year. By dividing the total cargo volume moved by the total available capacity (the number of trips multiplied by the vessel's cargo capacity), and then multiplying the result by 100, it calculates the percentage of the vessel's total available capacity that was actually used. This aids in determining how well the service is being utilised.

$$\text{Utilization (\%)} = \left(\frac{\text{Total Cargo Volume}}{\text{Total Available Capacity}}\right) \times 100$$

Where;

Total Available Capacity= No. of Trips× Vessel Capacity

The maximum capacity of the Ro-Ro Vessel- 18*2oft container .

The approximate gross weight of a 2oft container is about 24,000 kg (24 metric tons), including the container's weight.

Therefore, Vessel Capacity (in metric ton) = 18* 24000= 432000

Total Available Capacity= No. of Trips* No: of days of service in a month* Vessel Capacity

= 20*30*432000

=259200000 metric tons

Months	Tonnage	Utilization (%)
01-04-2024	64926	0.02504861
01-05-2024	59670	0.02302083
01-06-2024	65054	0.02509799
01-07-2024	66638	0.02570910
01-08-2024	65155	0.02513695
01-09-2024	60908	0.02349846
01-10-2024	79430	0.03064429
01-11-2024	68911	0.02658603
01-12-2024	65651	0.02532831
01-01-2025	67711	0.02612307
01-02-2025	47187	0.01820486
01-03-2025	60232	0.02323765

Table 5.6 Utilization Analysis of RORO Vessel

(Source: Primary Data)

ANALYSIS AND INTERPRETATION

A very low level of operational efficiency is revealed by the period-based utilisation analysis of the Ro-Ro vessel service between Willingdon Island and Bolgatty (NW-3). From April 2024 to March 2025, the utilisation percentage continuously stays between 1.8% and 3.0% based on the specified maximum vessel capacity (432,000 metric tonnes) and total available capacity for each month (calculated using 20 trips per day for 30 days).

The actual cargo moved each month, which ranges from about 47,000 to about 79,000 metric tonnes, shows that the service is severely underutilised in comparison to its capacity, even with the infrastructure and cargo potential. Over 96% of the available capacity is still unused, as evidenced by the highest utilisation of 3.06% in October 2024.

The average monthly utilisation is less than 2.6%, indicating persistent underutilisation.

The system's poor performance indicates either low cargo demand, ineffective scheduling, or shippers' ignorance or underutilisation.

Systemic inefficiencies are evident in the Ro-Ro vessels' failure to provide value commensurate with their intended capacity, even though they are operational.

Conclusion: This utilisation analysis supports the broader case study finding of inefficiency and subpar operational performance by confirming that the Ro-Ro service on NW-3 is significantly underutilised. To support the ongoing investment in this service, strategic actions are needed to enhance cargo volumes, scheduling, and integration with multimodal logistics.

5.6 FINDINS OF THE CASE STUDY

- To ease traffic and enhance cargo logistics via NW-3, two Ro-Ro vessels, MV Adhishankara and C.V Raman, were put into service. Although both vessels were initially in service, Adhishankara’s operations drastically decreased after 2022 and came to an end by 2024.C.V Raman, on the other hand, carried on with operations that were more efficient anf frequent, exposing unequal fleet capacity utilisation.
- After reaching a peak of more than one million tonnes in 2022, the total cargo tonnage fell sharply to about 763,000 tonnes in 2023 and then levelled off in 2024.Overall tonnage was directly impacted by Adishankara's operations ceasing, suggesting that NW-3's capacity is not being fully utilised.

- Even though C.V. Raman continued to operate, the overall number of Ro-Ro trips fell to 3974 in 2024 from a peak of 5789 in 2022. This could indicate a lack of redundancy planning to offset the withdrawal of one vessel, decreased demand, or operational inefficiencies.
- By 2030, the cargo tonnage is expected to drop to as low as 573,126 tonnes, according to trend analysis from 2025 to 2030. The lower bound predicts a significant underperformance (as low as 225,279 tonnes). The tonnage is expected to decrease despite an increase in the number of trips, which suggests inefficient loading procedures and a low cargo volume per trip.
- The service offers substantial advantages for trade and traffic reduction by cutting land travel from 25–30 km to just 3.5 km via water and avoiding tolls. The current usage pattern highlights underutilisation of infrastructure and policy gaps despite its strategic advantages, as it does not reflect optimal resource allocation or market tapping.
- Although the operational schedule and fare structures are easily accessible and well-defined, the irregular vessel service and Adishankara's discontinuation demonstrate a lack of dependability and continuity in the service. This reduces user confidence and limits the possibility of switching from road-based logistics to water-based logistics.

In conclusion, the case study unequivocally shows that although the infrastructure and intention behind the Ro-Ro services on NW-3 are praiseworthy, underutilisation, discontinuities, and inefficiencies plague their actual implementation. Better fleet management, policy realignment, and strategic intervention are desperately needed to fully reap the benefits of inland water transport in this corridor.

CHAPTER 6

CONCLUSION

6.1 FINDINGS

- Compared to Goa, Kerala boasts a far more extensive system of navigable waterways. While Goa has a smaller but more regularly used network, Kerala's waterways are still largely underutilised despite the larger infrastructure.
- Although there are national waterways in both states, Kerala exhibits more infrastructure but less overall operational efficiency, particularly when it comes to consistent cargo handling. Goa exhibits more targeted and localised efficiency in passenger ferry services, despite its limited reach.
- The available vessel and waterway capacity in Kerala, particularly in the case study corridor, greatly outweighs the actual cargo moved. The system's potential was severely underutilised, as evidenced by the average monthly capacity utilisation of less than 3%.
- The case study emphasised times when service was reduced or stopped, which could be attributed to inadequate planning, maintenance problems, or a lack of demand forecasting. Long-term cargo commitments are deterred and service reliability is impacted.
- The low tonnage per trip, despite some consistency in the number of trips, points to ineffective loading procedures, return trips that are empty or only lightly loaded, and inadequate cargo consolidation.
- The use of inland waterways is not sufficiently promoted by industries and logistics providers. Despite the higher costs, road transport is preferred by many shippers because it is convenient, predictable, and visible.
- Despite a moderate increase in trips, trend analysis points to a declining pattern in cargo tonnage over the next five years in the

case study area. This suggests that there hasn't been any sustained or new demand for IWT in the area.

- Goa and Kerala both lack established multimodal logistics hubs that link roads, trains, and waterways. This reduces inland water transportation's ability to compete, especially for commercial cargo.
- Navigability and trust in waterway operations are further diminished by delays in dredging, lock reconstruction, and terminal improvements. This is especially noticeable in Kerala's NW-3 corridor, which in certain places is still not operationally complete.
- Although the federal and state governments have formulated ambitious policies pertaining to inland waterways, their actual implementation is either limited or dispersed, particularly with regard to monitoring, performance feedback, and service quality.

6.2 SUGGESTIONS

- Better utilization of available rivers / canals /creeks / backwaters of Kerala.

- To improve cargo uptake and last-mile connectivity, connect inland waterways via road and rail.

- To increase cargo operators' interest in using NW-3, make sure maintenance is ongoing, fleet usage is balanced, and promotional activities are conducted.

- In both states, promote private involvement through PPP models and offer discounts or subsidies to regular cargo users.

- Reduce operational barriers, particularly in Kerala, by expediting dredging, terminal development, and navigation digitisation.

- Educate traders and logistics participants about the time, money, and environmental advantages of IWT.

- Increse the width of the waterway between Willington Osland and Bolgatty for enabling two RORO vessels to operate at the same time.

- Optimal utilization of vessels can be done by carrying more cargo in one trip so that the operating expenses will be reduced.

- Extending scope – more dependency on one single firm will affect the vessel operation since vessels will be idle on non-working days for the firm.

- Further utilization of container and cargo movement through National Waterway 3, beyond scope of Kochi making it cheaper for clients and time saving and safer transportation compared to land or road transport.

- Benchmark against the best competitor in the field across all metrics. This will assist in identifying areas for improvement.

- There are NW's which are non-operational. Activities along these should be initiated.

- Government policies and regulations should be implemented and made effective faster.

- There is a huge scope of using inland waterways as a part of tourism in both states.

- Increase the quantity and size of boats using Goa's waterways in order to accommodate the increasing demand for cargo, particularly iron ore.

- To ensure uninterrupted navigation even during low tides, dredge shoals, sand bars, and shallow patches to a minimum depth of 3.6 meters.

- Increase the vessel's capacity to 3000 DWT in order to effectively manage increased cargo volumes.

- To facilitate the safe passage of larger 3000 DWT vessels, make sure the Least Available Depth (LAD) is at least 3.9 to 4.0 meters.

- To improve safety and visibility for 24-hour vessel movement, install navigational aids and nautical markers.

- Put in place appropriate traffic management systems to deal with the anticipated congestion brought on by an increase in barge activity.

- To increase operational readiness, create waiting berths and safe anchoring areas for barges in all tidal conditions.

6.3 CONCLUSION

The operational effectiveness, navigable length, vessel usage, and cargo handling of the inland water transport systems in Kerala and Goa have all been compared in this project. Although both states have enormous potential, it was discovered that their infrastructure maturity, service models, and performance metrics vary. Despite having a larger network and more cargo movement, Kerala experiences operational underutilisation and maintenance errors, which are especially noticeable in the NW-3 Ro-Ro services. Goa maintains consistent performance in passenger ferry services with room to grow into cargo, despite having few operational routes.

Systemic inefficiencies in NW-3 were brought to light by the Ro-Ro case study, which demonstrated a sharp underutilisation of capacity and inadequate service continuity. The findings highlight the necessity of marketing, planning, and strategic interventions to improve India's use of inland waterways. If they are managed and modernised as part of a comprehensive multimodal transportation framework, inland waterways have a bright future.

Rapid economic growth in India has led to an increase in the country's transport needs, necessitating a bulk goods movement method that is economical, environmentally friendly, and efficient. With more than 14,500 km of navigable waterways, inland water transport (IWT) presents a viable option because of its affordability, security, and low environmental impact. Significant unrealised potential in the inland waterways of both Kerala and Goa is revealed by the comparative study of these two states. However, their full potential is hampered by underutilisation, inadequate infrastructure, irregular operations, and a lack of multimodal integration. Coordination between the public and private sectors, as well as investments in contemporary infrastructure, ship design, and integration with coastal shipping systems for smooth, large-scale freight movement, are necessary to improve performance and realise this potential.

6.4 DIRECTION FOR FUTURE RESEARCHER

India's inland waterways are still developing, which makes this area a vibrant area for further study. Though their operational efficiencies differ greatly, Kerala and Goa both offer substantial unrealised potential for the transportation of people and goods via inland waterways. By including a more thorough examination of vessel performance according to vessel type, age, ownership (central vs. state), and technology integration, future researchers can build on this work.

To provide a more comprehensive understanding of the efficiency of inland waterways nationwide, future research could compare other states such as Assam, West Bengal, or Uttar Pradesh. Route planning and pricing can be influenced by a thorough examination of the economics of waterway transportation, loading cycles, and cargo types. Analyse how well inland waterway performance is affected by government policies, subsidy programs, and PPP involvement. Examine sustainability metrics, pollution reduction, and carbon savings to support the argument for switching from land to water transportation. Cost-benefit and route optimisation models for Ro-Ro and Ro-Pax vessels under different demand scenarios can be investigated further.

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