Chapter 1
Introduction

1. Introduction

1.1 Overview of the Logistics Sector

“Logistics is that part of the supply chain process that plans, implements, and controls the efficient, effective flow and storage of goods, services, and related information from the point-of-origin to the point-of-consumption in order to meet customers' requirements” (Waters, 2014). Rodrigue (2012) provides an alternative definition to logistics as a range of activities spanning from transformation, value addition to distribution of goods in the consumer market. Therefore, logistics refers to the entire gamut of activities related to safe movement, storage, acquisition and value addition of resources. Logistics is the link that connects suppliers to producers, producers to retailers and retailers to customers. In today’s globalized world, Logistics has emerged as an essential element of businesses, and developments in this sector have ushered in economic development and growth of the countries (Hayaloglu, 2015). Being an inherent part of supply chain management, logistics play a significant role as an enabler for international trade and businesses. In 2023, the size of the logistics market (globally) was estimated to be USD 8.96 trillion and the same is expected to reach USD 21.91 by 2033 at a CAGR of 9.35%. The rapid proliferation of global trade can be very well attributed to the advances in logistics infrastructure and processes. With the advent of E-commerce and freight forwarding, the significance of the logistics sector has increased manifold. Along with this growth, the era of digital technologies has catalyzed a transformation phase for the logistics sector. The industry must be able to harness the potential of Internet of Things, artificial intelligence, robotics, warehouse automation, data analysis, blockchain technologies, autonomous vehicles, and cloud computing (Kopishynska, 2020). One major challenge for the domain is to adapt to the new technologies and at the same time, balance the associated costs and service levels. Even in developed countries such as United States of America, global total logistics cost soared to 10.7% of GDP in 2020. Apart from other associated costs, logistics cost is an important determinant of product cost. In this regard, freight optimization, capacity utilization, proper mode selection and route planning can effectively bring down the overall logistics cost (Muha, 2019).

1.1.1 Introduction to Logistics Management

Logistics Management is the seamless coordination of all elements responsible for preparing, storing, and transporting products, resources, and information at the right time,

in the right condition to the right customer. It comprises of developing the right set of logistics strategies to manage the associated costs and meet customer demands. There exists complex decision-making scenarios in logistics which require practitioners to reflect upon perceived problems, uncertainties, trends and solutions which can be taken care of during routine work (Nilsson, 2006). Consignors, consignees, carriers, agents, government, and the public are few key stakeholders in the logistics decision making process and it is pertinent to have a collaborative approach for problem solving. With the advent of information technology, logistics companies look forward to decision support systems for analyzing cost implications and evaluate logistics key decisions involving resources and infrastructure. Neng Chiu (1995) recommended key steps for logistics success by overcoming logistics management barriers through an integrated approach involving automation systems and multiple stakeholders. One important aspect of logistics management is transportation mode selection and it is the mix and match of the different mode which ultimately leads to effective utilization of logistics capacity as well as higher returns. At the strategic level, logistics management is about taking key decisions in infrastructure development, policy level interventions, trade proliferation and foraging partnerships (Sum et. al, 2001).

1.1.2 Contribution of Logistics Sector to world economy

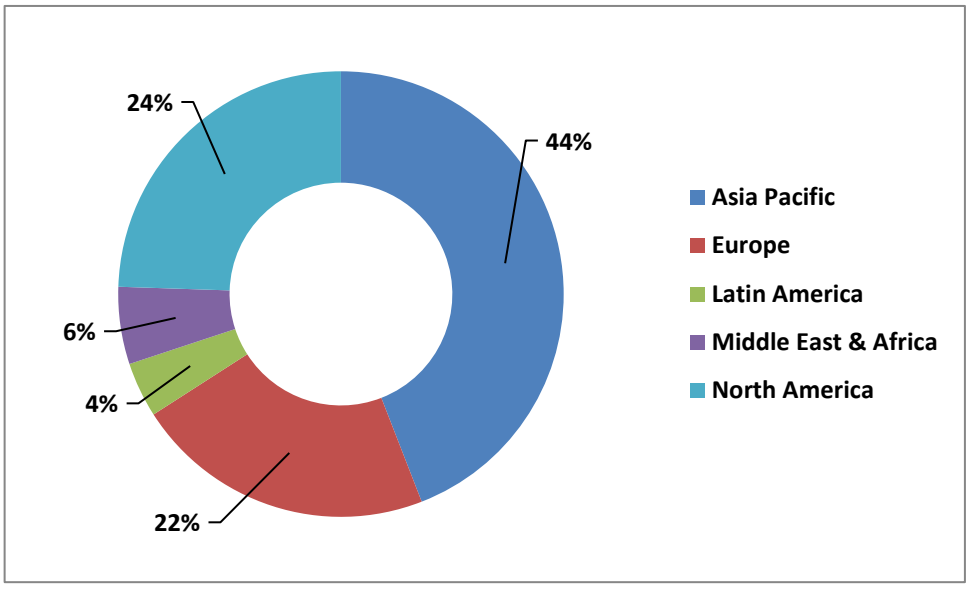
Berechman et al. (2006) considers transportation as an important factor for economic development by opening new markets while allowing competitive advantages. According to World Bank Trade Logistics Report (2018), logistics performance is one of the key drivers for economic growth and competitiveness of individual countries and the global turnover generated by logistics networks is a significant contributor of GDP. In today's globalized world, logistics sector has emerged as one of the key sectors fueling growth, employment, and trade opportunities.

Table 1.1: Logistics Market Revenue, by Region, 2020-2023 (US$ Billion)

By Region	2020	2021	2022	2023
Asia Pacific	3,145.16	3,319.43	3,480.71	3,952.34
Europe	1,636.81	1,697.05	1,748.34	1,955.51
Latin America	320.53	324.91	327.31	359.23
Middle East & Africa	440.22	448.98	455.05	502.6
North America	1,869.04	1,925.86	1,971.87	2,193.70

Source: https://www.precedenceresearch.com/logistics-market

Figure 1.1: Logistics Market Share, by Region, 2023



Source: https://www.precedenceresearch.com/logistics-market

The booming e-commerce market is a significant factor contributing to the growth of this sector. In the case of western regions such as North America, the logistics infrastructure is well developed and robust while increased demand driven by population is one of the factors impacting growth in Asia Pacific. Despite growth and contribution of the logistics sector, one poignant concern is accounting for the logistics cost. Liu (2016) studied the impact of logistics cost in relation to GDP and why special attention needs to be given on reducing the cost for economic development.

1.1.3 Global, national and regional Logistics policies

Leveraging competitive advantage of the global logistics industry is vital for the sector's growth. In this regard, government interventions such as policies and regulations positively impact the competitive advantage (Chang et. al, 2022). Policies lay down the roadmap for ramping up logistics infrastructure, processes and agreements. In the global context, logistics policies are largely dictated through international cooperation, treaties and agreements such as North American Free Trade Agreement (NAFTA), Regional comprehensive economic partnerships (RCEP), ASEAN Free Trade Area etc. Incoterms or International Commercial Terms, first published by International Chamber of Commerce (ICC) in the year 1936 and recognized by United Nations Commission on International Trade Law (UNCITRAL) laid down the definition and foundation for global logistics cooperation. Efforts taken up at international summits such as G7, G20, ASEAN, SAARC have emphasized on international collaborations and integrations for

intercontinental freight corridors, transport infrastructure development and resource sharing for logistics ease and optimization. Uniformity in EXIM policies, taxation regimes and documentation can pave the way for seamless logistics processes across borders. However, global logistics issues are not only confined to cross border issues but include intermodal transport, supply chain integration, global shipping network analysis, intelligent transport systems and information technology (Shibasaki et al., 2021). It is pertinent for the trade cooperation groups to address these elements while framing logistics policies. Marti et. al. (2014) highlights the significance of the Logistics Performance Index (LPI) published by the World Bank in international trade. Based on worldwide surveys and granular maritime shipping information, the interactive benchmarking tool LPI aids participating countries in identifying logistics challenges and opportunities, which lays the groundwork for policy formulations.

Table 1.2: LPI 2023 Top 25 countries

Country	LPI Score	LPI Rank
Singapore	4.3	1
Finland	4.2	2
Denmark	4.1	3
Germany	4.1	3
Netherlands	4.1	3
Switzerland	4.1	3
Austria	4	7
Belgium	4	7
Canada	4	7
Hong Kong SAR, China	4	7
Sweden	4	7
United Arab Emirates	4	7
France	3.9	13
Japan	3.9	13
Spain	3.9	13
Taiwan, China	3.9	13
Korea, Rep.	3.8	17
United States	3.8	17
Australia	3.7	19
China	3.7	19
Greece	3.7	19
Italy	3.7	19
Norway	3.7	19
South Africa	3.7	19
United Kingdom	3.7	19

Source: Data extracted from https://lpi.worldbank.org/international/global

The bilateral and multilateral policies across the globe have paved the way for individual nations to embark on their national logistics goals through policy interventions. In the Indian context, bilateral agreements with neighboring nations such as the Indo-Bangladesh Protocol, Kaladan multi modal transport project etc. have been significant for trade proliferation. The highly fragmented and unorganized nature of logistics activities in India attributes to a significantly higher logistics cost of around 14% compared to a global average of 8% (Rahman, et al., 2023). The National Logistics Policy (NLP) launched in September 2022 with the aim of reducing logistics cost and bringing the same at par with the developed nations comprises of a cross-sectoral and multipronged approach. Logistics efficiency, transport infrastructure development, integration of digital systems spanning different departments, Unified Logistics Interface Platform, capacity building are few of the key initiatives under NLP (Prajapati and Singh, 2024). Existing infrastructure development programmes such as Gati Shakti, Sagarmala, Bharatmala received a significant boost with the renewed focus on Logistics through the NLP 2022. In LPI 2023, India ranks 38 out of 139 countries while in the 2018 edition, India's rank was 44. India's improvement in rank by six places over the previous assessment year is a testimony of the national focus on improving logistics connectivity and optimizing logistics cost. Further to this, GoI's latest policy Comprehensive Logistics Action Plan (CLAP) provides action plans for NLP to be within top 25 countries in the upcoming edition of LPI.

Despite the overarching national focus on logistics cost optimization, initiatives under NLP and CLAP can be sustained only through collaborative efforts of the regional stakeholders. Accordingly, LEADS (Logistics Ease Across Different States) was conceptualized in 2018 to evaluate the different Indian states and union territories along the goals of Logistics as enshrined in the LPI and thereby, instilling healthy competition among the states. LEADS involve perception based as well as objective parameters to analyze the performance of states in terms of planning infrastructure augmentation, capacity building, digital initiatives, policy formulations, monitoring frameworks, sustainability measures and so on. In this regard, 23 States/UTs have notified their state level logistics policies in alignment with the goals of the NLP. The LEADS 2023 report based on the annual pan-India primary survey has indicated a positive shift across the States' performance across the key pillars of Logistics infrastructure, services and operating and regulatory environment. The fifth edition of the comprehensive study has

provided recommendation for the states and union territories in areas such as data driven planning, urban freight optimization, first mile/last mile infrastructure gap analysis, RTO efficiency, technology utilization, private sector participation and green logistics (LEADS 2023 Report). Considering the significance of the domain, "Logistics Sector" was newly incorporated in the Harmonized Master List of Infrastructure Sub-sectors for India (PIB Release dtd. 20.11.17).

Table 1.3: Performance Highlights from LEADS 2023

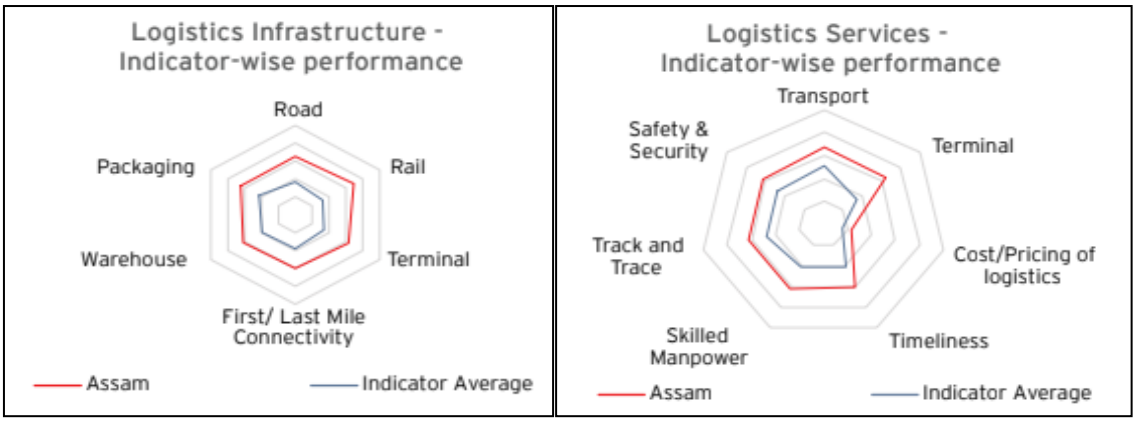
	COASTAL GROUP	**LANDLOCKED GROUP**	**NORTH-EAST GROUP**	**UNION TERRITORIES**
Achievers	Andhra Pradesh, Gujarat, Karnataka, Tamil Nadu	Haryana, Punjab, Telangana, Uttar Pradesh	Assam, Sikkim, Tripura	Chandigarh, Delhi
Fast Movers	Kerala, Maharashtra	Madhya Pradesh, Rajasthan, Uttarakhand	Arunachal Pradesh, Nagaland	Andaman & Nicobar, Lakshadweep, Puducherry
Aspirers	Goa, Odisha, West Bengal	Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand	Manipur, Meghalaya, Mizoram	Daman & Diu/ Dadra & Nagar Haveli, Jammu & Kashmir, Ladakh

Source: Data extracted from LEADS 2023 Report

Assam serving as the logistics gateway to the North East region has been placed consistently in the Achievers category. Despite being landlocked and connected to mainland India through the narrow Siliguri corridor commonly referred to as chicken neck, Assam through policy interventions is on the path of leveraging the advantage it holds through the South East Asian economies. Ghosh (2024) identifies the Act East policy as a paradigm shift for trade and commerce in the northeastern states and how it acts as a primer for India-ASEAN relations. Baruah (2020) highlights the impact of these policies in ushering in an economic development model which prioritizes physical infrastructure creation over social development. As enunciated by the researchers,

proximity to South East Asian markets provides impetus for exports and growth for the region. Assam also enjoys the privilege of being naturally endowed since colonial rule to cater to the growing international markets. Tea estates, coal mining, oil exploration and processing, plywood factories are few of the larger industrial segments in the state. The Export and Logistics Policy of Assam framed in 2019 aims at boosting exports though increased market penetration, infrastructure development, ease of doing business, capacity building and digitization measures. Regarding infrastructure development, the focus is on setting up state-of-the-art multi-modal logistics parks, inland container depots, river ports, border trade centers and railway stations etc. Besides identifying focus sectors for exports and extending institutional support for export promotion, the policy provides for incentives in terms of capital investment and freight subsides.

Figure 1.2: Parameter wise performance highlight of Assam from LEADS 2023



Source: LEADS 2023 Report

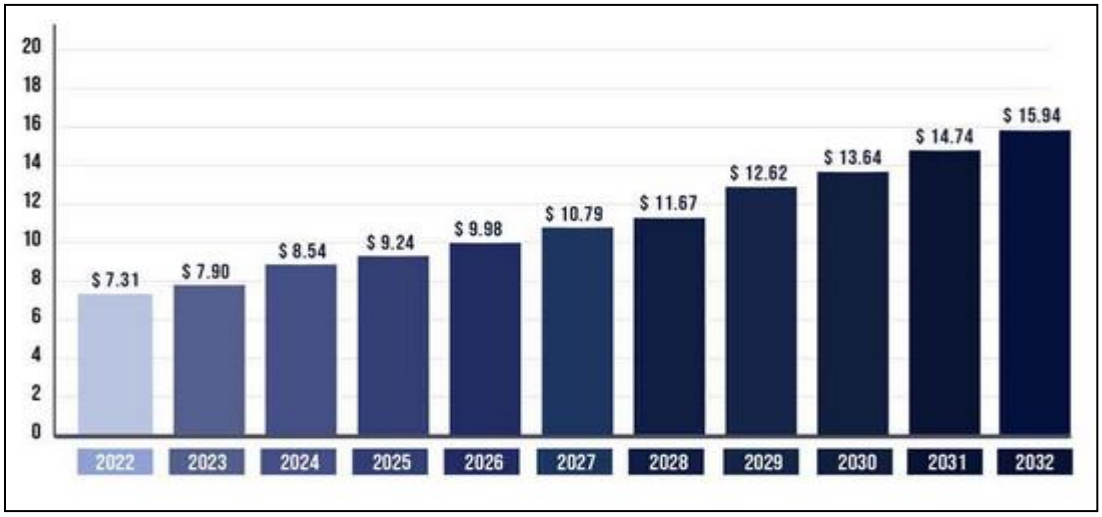
1.1.4 Introduction to transportation and transport infrastructure

Transportation, the largest component of logistics (Allen, 1997) refers to all the means by which physical movement of goods and people from one place to another takes place. People movement is commonly referred to as passenger transport while freight transport refers to the goods movement. Transportation acts as a key enabler of varied logistics functions and in the domain of trade and commerce, freight transportation assumes prime role. The size of the global transportation services market was estimated to be USD 7.31 trillion in 2022 and is estimated to grow at a CAGR of 8.11% during the period 2023-2032 (Precedence Research Report, 2023). From the cost perspective too, transportation accounts for the largest share of logistics cost and policymakers across the globe are looking forward to optimize this component of cost. Transportation decisions at the

strategic level involve infrastructure development decisions while at the tactical level, it involves day to day transportation mode selection and planning decisions. Transportation is fundamental to fostering economic growth and at the same time, this industry leads to emissions. The right balance is very much needed to optimize costs and uphold sustainability measures at the same time.

Prus and Sikori (2021) defines transport infrastructure as a factor that guarantees economic development and growth of a region. NLP 2022 has envisaged transport infrastructure creation/up gradation across the country through the transport mode specific schemes. Transport domain is a highly capital-intensive domain and transport infrastructure refers to the physical facilities which enable transportation elements. Railway stations, railways, roadways, airports, seaports, inland water ports, dry ports, terminals, warehouses, multi modal logistics facilities, etc are few of the infrastructural elements fostering transportation. Infrastructure directly or indirectly impacts the attainment of all the Sustainable Development Goals (Thacker et al., 2019). In the fiscal year 2024, a budgetary allocation upto 3.3% of GDP which amounts to approximately 11.42% of FY's total budget has been made for the infrastructure sector, particularly for the transport and logistics segments. Cervero (2009) however advocates for balancing the goals of economic productivity and community place making.

Figure 1.3: Transportation services market size, 2023 to 2032 (USD Trillion)



Source: https://www.precedenceresearch.com/ transportation-services-market

1.1.5 Overview of the modes of transportation

Transportation consists of majorly five modes- roadways, railways, airways, waterways, and pipeline mode. Meixell et al. (2008) emphasized the complexity of transport mode selection decisions for practitioners considering the cost and other impacts.

- **Roadways**- The only transport mode enabling last mile delivery of shipments. The freight is transported using trucks, trailers, container trucks, reefers on the highways, expressways, and freight corridors.
- **Railways**- One of the mass transport systems enabling carriage of goods on specialized railway wagons along the railway network.
- **Airways**- The fastest mode of transport which is also among the most reliable modes. The cost of shipping is the highest among the different modes.
- **Waterways**- One of the oldest modes of transport and also, it is considered as among the greenest mode. The cost of shipping is the cheapest.
- **Pipeline mode**- One of the non-conventional modes with a capability to handle specific material types in the liquid form. The initial capital investment is high but negligible operating expenses.

Each of the transport modes have merits and demerits and the same needs to be carefully analyzed for the transportation choice decision. Bloomberg (2002) defines attractiveness of the five transport modes based on the attributes of cost, speed, reliability, capability, capacity and flexibility.

Table 1.4: Attribute wise comparison of transport modes

Attributes	**Transportation Modes**				
	Roadways	**Railways**	**Airways**	**Waterways**	**Pipeline**
Cost *Freight Rates*	Moderate	Moderate	High	Low	Low
Speed *Shipment time*	Moderate	Moderate	High	Moderate	High
Reliability *Consistency of delivery*	Moderate	Low	High	Moderate	High

Capability *Ability to carry varied type of cargo*	Moderate	Moderate	Low	High	Low
Capacity *Volume of freight*	Low	Moderate	Low	High	Moderate
Flexibility *Volume of freight*	High	Moderate	Moderate	Low	Moderate

Source: Researcher's own compilation from Bloomberg (2022)

Infrastructural developments across the different modes vary and policy interventions need to have a far-sighted approach. For achieving the best benefits of the transportation network, it is pertinent to have uniform investments across all modes to support multimodal logistics capability and this is seen primarily in the case of the developed nations.

1.1.6 Cost implications for transportation modes

Average logistics costs amount to nearly 8% of GDP for the most efficient countries while for the developing nations, it can be significantly higher (Hofman, 2017). A major determinant of the logistics cost is the cost incurred in transportation which is again dependent majorly on the transport mode. Freight transport cost calculations are done on the basis of volumetric weight which basically helps to factor in the size of the shipment along with its actual weight. As shipping capacity in terms of space is an important cost determinant for the freight shipping industry, volumetric and actual weight comparison becomes pertinent. Volumetric weight is commonly referred to as the dimensional weight and can be calculated from the dimensions of the package being shipped.

Table 1.5: Cost basis of transport modes

Mode of Transport	Cost basis
Roadways	▪ Commodity specific rates ▪ Weight and distance specific rates (per tonne- km) ▪ Carrier type basis
Railways	▪ Commodity specific rate slabs ▪ Distance wise rate slabs (per tonne) ▪ Train load/wagon load basis

Airways	▪ Limited Commodity specific rates ▪ Weight basis rates (per kg)
Waterways	▪ Commodity specific rates ▪ Weight and distance basis rates (per metric tonne) ▪ Container/commodity type load basis
Pipeline	▪ Volume basis rates (per cubic metre)

Source: Researcher's own compilation

Road transportation on an average costs Rs. 1.5 per tonne-km, for railways it is Rs. 1.0 per tonne-km while for waterways, it can be estimated as 25-30 paisa per tonne-km (Press Information Bureau, 23 Oct 2017). Airway freight is significantly higher while pipeline mode is restricted for commodities having fluid properties. Among all modes of transport, the significance of water transport was highlighted way back by Ransdell (1927) where he had vouched for water transport over other modes claiming that it encountered relatively lesser friction and thus was much cheaper.

1.1.7 Introduction to integrated logistics and freight optimization models

Integrated logistics is a concept which involves integration of key supply chain components such as transportation, warehousing, and distribution. Daugherty et al. (1996) dwelled upon the significance of an integrated approach to logistics including internal and external functions to achieve logistics efficiency. This approach requires integration of the different stakeholders, supply chain activities and mix and match of the shipments vide the different transport modes to optimize on the cost and enhance service. Chiu (1995) proposed a framework for distribution companies to improve their logistics systems through integration of the supply chain. Most of the developed nations are developing heavily on creating multi modal infrastructure for supporting this integration. In India, 35 Multi Modal Logistics Parks (MMLPs) under Bharatmala Phase 1 has been envisioned by the Ministry of Road, Transport and Highways is developing. Out of these, construction activity for the first MMLP in India at Jogighopa (Assam) is presently underway. Through an integrated approach, the network of MMLPs help in optimizing the intermodal mix, provide support to logistics allied activities and removes bottlenecks in the supply chain (Gupta et al, 2024). Abbassi et al. (2019) proposed robust optimization models for intermodal freight transport problems using terminal capacities and transportation costs. Mixing shipments as per demand and selection of appropriate transport mode is of prime importance for the success of the integrated approach and in this context, researchers have

developed varied models. Liotta et al. (2015) conducted computational experiments to demonstrate the effectiveness of a proposed model for optimization of freight flows. Chadha (2022) found that supply chain logistics performance can be enhanced through shipment consolidation policies.

1.2 Overview of water transportation

Water transportation is the one of the oldest and most sustainable form of transport enabling freight movement across geographies. This mode of transport is the most cost effective and supports high volumes. Water covers almost 71% of the earth's surface and apart from the basic necessities of nurturing life, this wide expanse of water network provides opportunities for international trade and commerce. The usage of water bodies such as oceans, seas, rivers, lakes etc for the purpose of transporting passengers and cargo refers to water transportation. Almost 90% of global trade is realized using the shipping industry (Wilmsmeier and Monios, 2020). Sea trade has been a major source of GDP for nations and water transport infrastructure development continues to be a focal point for geo politics. The world's top ports have been developed by leading economies of the world. This is evident from the Container Port Performance index 2022 (World Bank) in which ports from China continue to occupy the top ranks. The country has been investing heavily on ports development since 1978 and the surging exports are met through the network of ports dotting the country's coastline and beyond. Considering the potential of water transport, the Indian government through flagship programmes such as Sagarmala has begun development and modernization of the seaports to bolster trade and commerce. There are 12 major ports and approximately 200 non-major ports in India. Under Sagarmala programme, a total outlay of 234 projects amounting to Rs. 2,91,622 crores have been envisioned.

Table 1.6: Top 10 container ports (*globally*)

Rank	Port	Volume in 2021 (Million TEU)
1	Shanghai, China	47.03
2	Singapore	37.49
3	Ningbo-Zhoushan, China	31.07
4	Shenzhen, China	28.77
5	Guangzhou Harbor, China	24.18
6	Busan, South Korea	22.71
7	Qingdao, China	23.71

8	Hong Kong, S.A.R, China	17.8
9	Tianjin, China	20.27
10	Rotterdam, The Netherlands	15.3

Source: Extracted from https://www.worldshipping.org/top-50-ports

Considering the huge potential of water transport, Government of India through flagship programmes such as SagarMala has begun development and modernization of the water port infrastructure network to bolster trade and commerce. There are 12 major ports and approximately 200 non-major ports in India. Under Sagarmala programme, a total budget outlay of Rs. 2,91,622 cr. has been envisioned for 234 projects (https://sagarmala.gov.in/).

1.2.1 Evolution of water transport and its role in global trade

Water transport has been attributed as the oldest means of transport and the origin can be traced back to around 3200 BCE wherein Egyptian coastal and sailships engaged in trade. Intra country trade gradually progressed to intercontinental trade by 1200 BCE. By the 10th century, the maritime trade routes such as the silk road and arab sea routes between Middle East and Asia were established. (Rodrigue, J. P., 2024). In the early 15th century, major trade expeditions were initiated by Chinese merchants but turned out to be short lived. This was followed by European colonial powers which first established a reliable global maritime trade network in the 16th century. With the advent of steam engines in the mid-19th century, the vulnerable sail ships transitioned to steam ships powering world trade. The next century saw a spurt in water transportation technologies and equipments such as containerization which is among the biggest innovations in this industry as well as opening of Suez Canal which addressed the geographical constraints. It is pertinent to note the significance of water transport in light of impacting geopolitics and how this mode was harnessed by the developed nations to reap benefits (Snedden and Fox, 2012; Khan, 2016). In the Indian context too, colonization was initiated by virtue of trading companies arriving on the country's shores via sea transport. From then till now, the role of water transport has been immense for the proliferation of trade and commerce across geographies.

1.2.2 Challenges in sea transport

Despite the advantages and opportunities, sea transport is constrained by its set of inherent challenges. Kahyarara, G., and Simon (2018, September) identifies port inefficiencies, lack of intermodal infrastructure and ICT, inadequate cargo volumes and

inadequacy in trained human resources as few challenges for the African seaport network. Low availability of new shipping vessels and equipment, non-conformance of freight distribution systems such as Euro with ISO, regulatory barriers or embargos and environmental barriers such as adverse weather have been highlighted as key challenges for the European waterway network (Baindur and Viegas, 2011). Antony (2022) found that vessel size, cargo imbalances, slow registration process, waterway depth and lack of infrastructure are few significant factors hindering the growth of sea transport in the Indian subcontinent.

Table 1.7: Classification of Sea Transport Challenges

Broad Categories	**Challenges**
Infrastructural	Port inefficiencies, lack of intermodal facilities, low availability of equipment, low availability of new shipping vessels
Commercial	Inadequate cargo volumes, vessel sizes, cargo imbalances, slow registrations, regulatory barriers
Technological	Nonconformance of Euro with ISO standards for transportation equipment, lack of ICT, inadequacy in trained human resources
Environmental	Adverse weather, waterway depth

Source: Researcher's own compilation

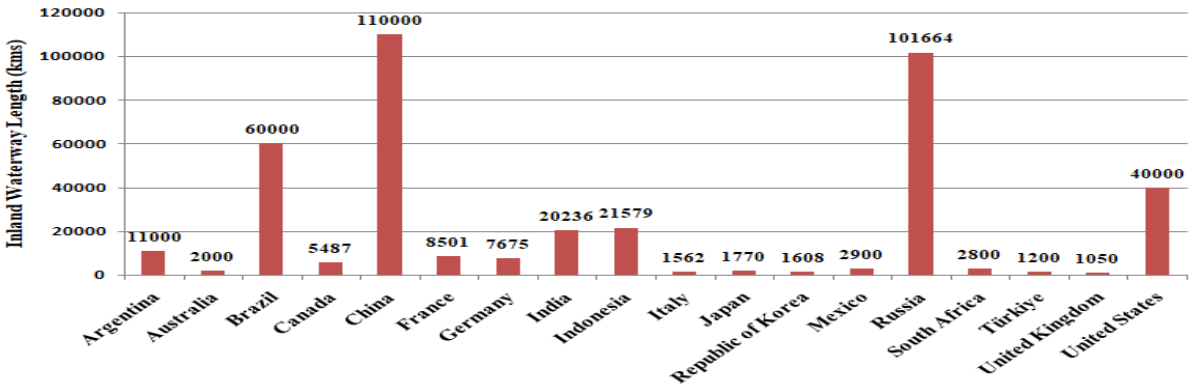
Infrastructural challenges may be mitigated through timely government intervention and stakeholder participation in terms of securing investments for development of the waterway sector with the objective of creating/modernizing freight supporting infrastructure and equipment. Optimization, freight planning, right sizing shipping loads and country policy level interventions may help in tackling the commercial challenges. The technological challenges may be offset by capacity building measures and unification of standards for service purpose. Although dredging and other techniques may help in mitigating water depth issues, however some of the environmental challenges are beyond control and for those, remedy may lie in building resilience and redundancies.

1.2.3 Inland water transportation and its significance

Transport of passengers and cargo by means of rivers, canals, and other navigable waterways within the geographical boundaries of a country is referred to as inland water

transport. Inland waterways shorten distance, utilize high capacity means of transport with ecologically accepted fuels and offer the cheapest tariffs (Mihic et al., 2011). De Barros et al. (2022) recognizes utilizing inland water transport as being energy efficient with lower emissions compared to all other modes of transportation and thereby, supporting fulfillment of six Sustainable development goals (SDG 3, SDG 6, SDG 7, SDG 9, SDG 10, SDG 13). Despite the inherent benefits, usage of inland water transport has gone down relatively for almost all geographies. Nam and Win (2014) found that road transport in Myanmar is more than three times more expensive than the inland water mode and in terms of capacity as well, a standard barge can carry thirty-seven times more than a standard truck size. Despite all associated benefits, even developed nations are yet to fully leverage on this cheap and sustainable mode of transport.

Figure 1.4: Inland waterway lengths of G20 member countries* (in kms.)



Source: Researcher's compilation from UNECE and World Bank open data portal

**Saudia Arabia does not have any permanent waterway*

1.2.4 Inland water transport supporting infrastructure

One of the major deterrents to inland water transportation is the lack of supporting infrastructure. Miloslavskaya and Plotnikova (2018) recommends public private partnership mode for financing inland water infrastructure after finding that even for developed nations such as USA, Russia and Germany, there exists a huge crunch of funds as well as maintenance issues of the fixed assets. A fully fledged inland waterway network consists of key infrastructural elements such as inland water ports, terminals, jetties, warehouses, container sheds/depots, ship maintenance facilities, dry ports and multimodal facilities.

- **Terminals** are the set of docks within the port where loading and unloading of freight takes place.

- **Jetties** are structures extending from shores to water for enabling docking of ships and to protect the port from erosion. Jetties can be of permanent nature or floating considering the water depth factor.
- **Warehouses** are storage locations within the port premises for holding the cargo and ensuring safety of the same.
- **Container sheds/depots** are stacking/stuffing area for transport containers. It may support repair of the same.
- **Ship Maintenance Facilities** are facilities to support repair and maintenance of the shipping vessels.
- **Dry ports** are inland intermodal facilities having direct connectivity to water ports and help in transshipment of cargo to inland destinations. Apart from customs clearance and other shipping processes, it helps in minimizing congestion at the main ports.
- **Multimodal Facilities** are enabling facilities along the inland water transport grid which supports transition of shipped cargo across multiple transport modes for shipping efficiency.

Jetties, terminals, warehouses, container depots, ship maintenance facilities are integrated with the inland water port itself while dry ports and multimodal facilities are essential for sustenance and efficiency of the port network system. The physical infrastructure must be supported by ICT facilities to enable digitization of supply chain operations.

1.2.5 Transport Economics for the sector

Researchers across geographies have vouched for the inland waterway transport mode over other modes primarily owing to the fact that it still offers the most economical option for freight transportation (Ransdell, 1927; Baird, 1998; Wilmsmeier and Monios, 2020). As per RITES Report (2014), an equivalent amount of fuel - one litre (on an average) is consumed for transporting 24 tonne-km using road transport, 95 tonne-km using rail transport and 215 tonne-km using inland water transport. Therefore, it is seen that by opting for inland water transport, there's a substantial increase in the transported load relative to other modes with the same level of expenditure.

Table 1.8: Freight cost comparison for the three modes of transport

Mode	Pre tax freight (Rs. per tonne km.)	Post service tax freight (Rs. per tonne km.)
Rail Transport	1.36	1.41
Road Transport	2.50	2.58
Inland Water Transport	1.06	1.06

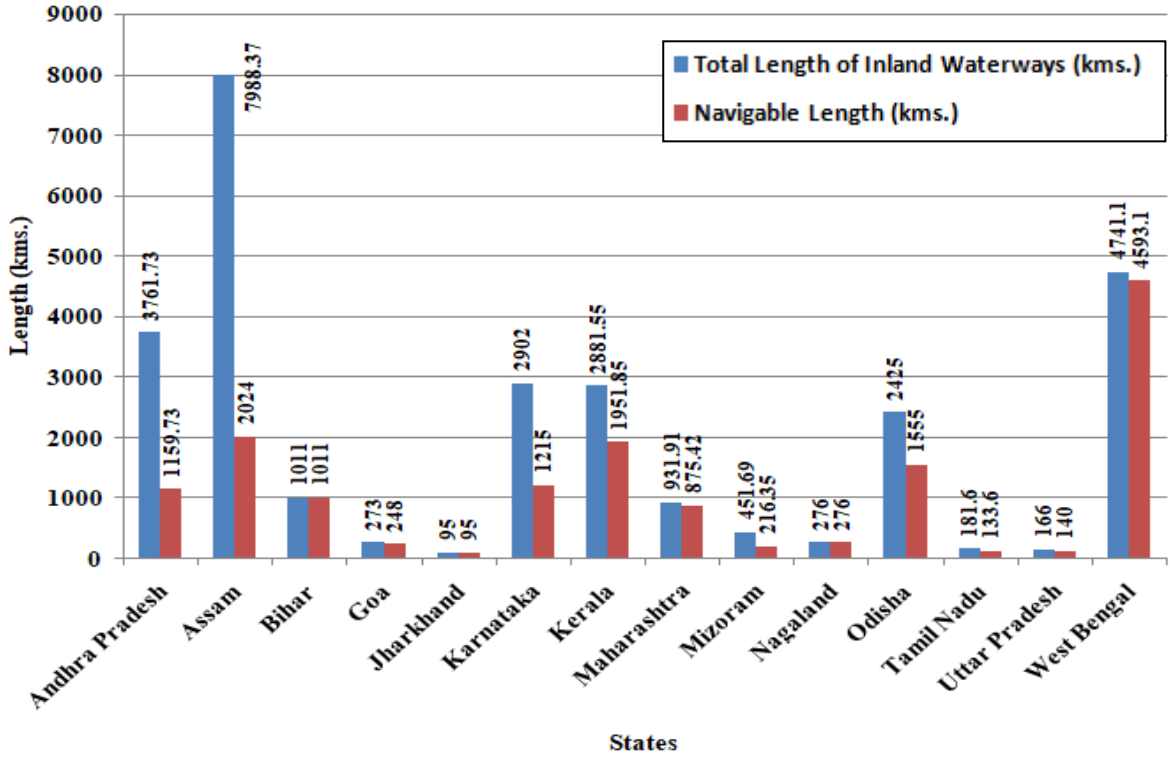
Source: GoI PIB Print Release, 20-Mar-2017

As per World Bank Estimates, the per km. cost associated with shipping one ton of freight is 1 cent via inland waterways, 2 cents via railways and 3 cents via roadways. Average capacity of a 10 wheeler truck (roadways) is 16 tons as compared to 2200 tons of a 40 wagon rake (railways) and 2000 tons of an inland water vessel (waterways). Apart from being cost effective, freight transported using IWT is exempt from GST as on present date.

1.3 Overview of Inland water transportation in India

India as a country has been endowed naturally with a coastline of approximately 7517 kms. and an extensive network of rivers and canals with a total length of 20,085.95 kms, out of which 15,494.05 is navigable (Statistics of Inland Water Transport, 2022-23). The Indian waterways comprise of river systems, canals, back waters, creeks and tidal inlets. Although there is a significant length of waterways, the country is yet to leverage fully on the waterway network and only a minor portion of inland trade happens through this mode. Realizing this potential, an institutional push in recent years has been observed towards developing the inland water transportation infrastructure through different government initiatives and investments. By virtue of international treaties and waterway connectivity, the major rivers Ganges and Brahmaputra in the eastern part of the country account for majority of the inland water trade followed closely by rivers in Kerala, Maharashtra and Goa in terms of cargo movement. The state of Assam has the maximum length of inland waterways (7988.37 kms.) in the country, however only 25.34% of the total length is navigable. There are other states with lesser length of waterways but better conversion to navigable ones by virtue of investments in inland water transport.

Figure 1.5: Total and Navigable Length of Inland Waterways- State wise (in kms.)



Source: Researcher's compilation from Statistics of Inland Water Transport, 2022-23

1.3.1 National waterways and its classification

As per the National Transport Policy Committee (1980), an inland waterway could be declared as a National Waterway if it fulfills the following criteria:

- **Navigability**: The waterway must facilitate mechanically propelled vessels having a minimum capacity of 300 tonnes (DWT) and dimension 45m×8m×1.2m.
- **Channel Width**: In case of rivers, the fairway must have a minimum of 40m width with 1.4m depth while canals must have a minimum channel width of 30m with 1.8m depth.
- **Waterway length:** The waterway must be a continuous stretch of 50kms.
- **Connectivity:** The waterway must serve more than one state or act as connecting link between land locked regions and a major port or strategic locations.

Based on above criteria and in order to promote the inland water transport domain in India, lawmakers introduced different policies in this regard. The National Waterway Acts and amendments of 1982, 1988, 1992 and 2008 led to the notification of five inland waterways as National Waterways.

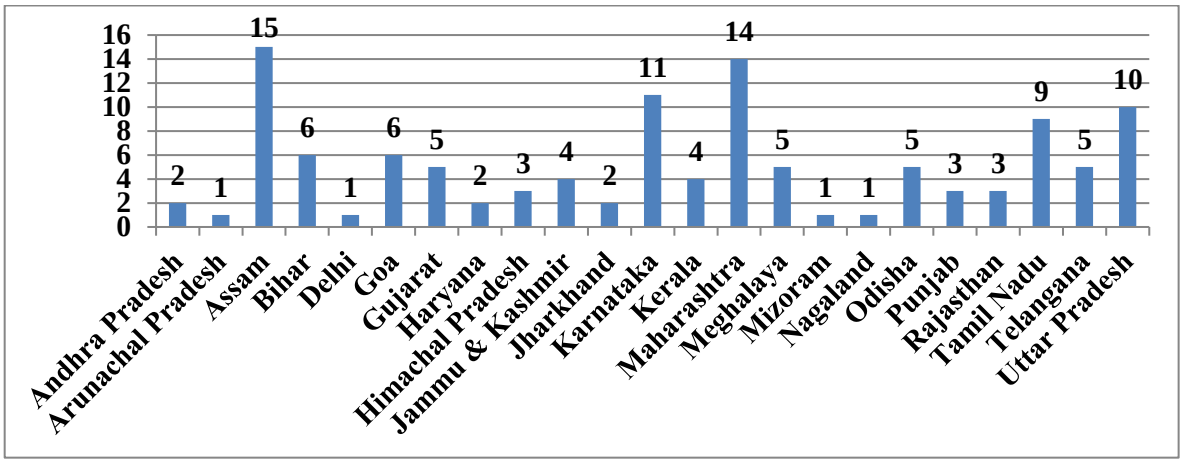
Table 1.9: Notification of five National Waterways

National Waterway	Waterway details
NW1	Allahabad-Haldia Stretch of the Ganga Bhagirathi-Hooghly River)
NW2	Sadiya-Dhubri Stretch of Brahmaputra River
NW3	Kollam-Kottapuram Stretch of West Coast Canal and Champakara and Udyogmandal Canals
NW4	Talcher-Dhamra Stretch of Rivers, Geonkhali-Charbatia Stretch of East Coast Canal, Charbatia-Dhamra Stretch of Matai River and Mahanadi Delta Rivers
NW5	Kakinada-Puducherry Stretch of Canals and the Kaluvelly Tank, Bhadrachalam-Rajahmundry Stretch of River Godavari and Wazirabad-Vijayawada Stretch of River Krishna

Source: Researcher's compilation from "The National Waterways Act, 2016"

However, in order to address the skewed modal mix of freight transport in India and promote inland water transport, policy makers felt an imminent need to develop further waterways in addition to the existing five National waterways. Accordingly, after identification of viable waterways in India for their phased development, the National Waterways Act, 2016 was enacted which repealed the previous acts and instead created 106 new waterways.

Figure 1.6: Total no. of National Waterways- State wise*



Source: Researcher's compilation from iwai.com waterways data

*Few waterways are in multiple states

As part of the initial feasibility studies, the 106 new waterways have been categorized into three categories as provided in the following table for facilitating priority of development.

Table 1.10: Categorization of the National Waterways

Categories	Waterway Details	Action Plan
Category-A 18 NWs	Most viable waterways with cargo	▪ Development in Phase I ▪ Consultancy assignments
Category-B 25 NWs	Waterways with only tourism prospect	▪ Stage I Feasibility studies ▪ Stage II DPR awarded
Category-C 63 NWs	Waterways in remote and less viable regions	▪ Feasibility studies

Source: Researcher's compilation from Statistics of Inland Water Transport (2022-23)

On the basis of water depth and waterway physical attributes, the waterways have been categorized into seven classes. Depending on the classes, the plying capacity in terms of Dead Weight Tonnage and vessel dimensions are regulated. To maintain the depth of the waterways as per class, dredging needs to be carried out on routine basis and the fairway maintained to support the draught of the plying vessels.

Table 1.11: Classification of Waterways

Type	Waterway Class Physical Attributes	I	II	III	IV	V	VI	VII
Rivers	**Depth**	1.2 m	1.4 m	1.7 m	2.0 m	2.0 m	2.75 m	2.75 m
	Bottom Width	30 m	40 m	50 m	50 m	80 m	80 m	100 m
	Bend Radius	300 m	500 m	700 m	800 m	800 m	900 m	900 m
	Vertical Clearance	4 m	5 m	6 m	8 m	8 m	10 m	10 m
	Horizontal Clearance	30 m	40 m	50 m	50 m	80 m	80 m	100 m
Canals	**Depth**	1.5 m	1.8 m	2.2 m	2.5 m	NA	3.5 m	NA
	Bottom Width	20 m	30 m	40 m	50 m	NA	60 m	NA
	Bend Radius	300 m	500 m	700 m	800 m	NA	900 m	NA
	Vertical Clearance	4 m	5 m	6 m	8 m	NA	10 m	NA
	Horizontal Clearance	20 m	30 m	40 m	50 m	NA	60 m	NA

Source: Researcher's compilation (The Gazette of India Part III Section 4, 16-Dec-22)

1.3.2 Key trade and transport routes

The Indo-Bangladesh Protocol (IBP) initiated in the year 2015 as a bilateral agreement between India and Bangladesh for inland waterways infrastructure sharing, has led to significant gains for the trade and commerce sector. The routes under the protocol or those connecting to those routes have emerged as key inland water trade routes for the country. Existing trade routes as per 2nd Addendum to the IBP is summarized as follows:

- Kolkata- *Narayangonj* - Silghat
- Silghat- *Narayangonj* - Kolkata
- Kolkata - *Ghorasal* - Badarpur
- Badarpur - *Ghorasal* - Kolkata
- *Aricha* - *Sultanganj* - Dhulian
- Dhulian - *Sultanganj* - *Aricha*
- Silghat - *Ghorasal*- Silghat
- Silghat - *Ghorasal*- Badarpur
- Sonamura - *Daudkandi*
- *Daudkandi* - Sonamura

For each of the trade routes, only the source, destination and prominent port of calls have been mentioned and italics have been used to demarcate the inland water ports in Bangladesh. Apart from the IBP routes, presently 13 NWs are operational for which development work is already undertaken and 25 NWs found feasible for cargo/passenger movement.

Table 1.12: List of National Waterways (operational)

NW#	National Waterway details
NW 1	Ganga-Bhagirathi-Hooghly River System (Haldia - Allahabad)
NW 2	Brahmaputra River (Dhubri - Sadiya)
NW 3	West Coast Canal (Kottapuram-Kollam), Champakara and Udyogmandal Canals
NW 4	Krishna River (Vijayawada – Muktyala)
NW 10	Amba River
NW 68	Mandovi River
NW 73	Narmada River
NW 83	Rajpuri Creek
NW 85	Revadanda Creek - Kundalika River System
NW 91	Shastri river–Jaigad creek system
NW 97	Sunderbans Waterway
NW 100	Tapi River
NW 111	Zuari River

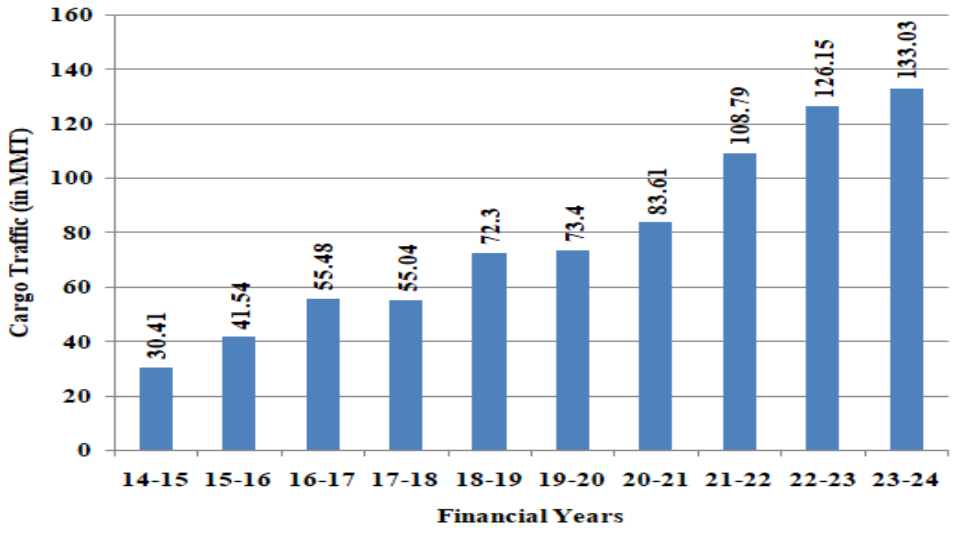
Source: Researcher's compilation from PIB notification (27 Dec 2018)

Table 1.13: List of National Waterways (feasible for cargo movement)

NW#	Details of Waterways
NW 1	Ganga-Bhagirathi-Hooghly River System (Haldia - Allahabad)
NW 2	Brahmaputra River (Dhubri - Sadiya)
NW 3	West Coast Canal (Kottapuram - Kollam), Champakara and Udyogmandal Canals
NW 4	Krishna River (Vijayawada – Muktyala)
NW 5	Dhamra-Paradio via Mangalagadi to Pankopal
NW 8	Alappuzha- Changanassery Canal
NW 9	Alappuzha-Kottayam – Athirampuzha Canal
NW 10	Amba River
NW 16	Barak River
NW 25	Chapora River
NW 27	Cumberjua River
NW 28	Dabhol Creek Vasisti River
NW 37	Gandak River
NW 40	Ghagra River
NW 44	Ichamati River
NW 52	Kali River
NW 57	Kopili River
NW 68	Mandovi River
NW 73	Narmada River
NW 85	Revadanda Creek - Kundalika River System
NW 86	Rupnarayan River
NW 94	Sone River
NW 97	Sunderbans Waterway
NW 100	Tapi River
NW 111	Zuari River

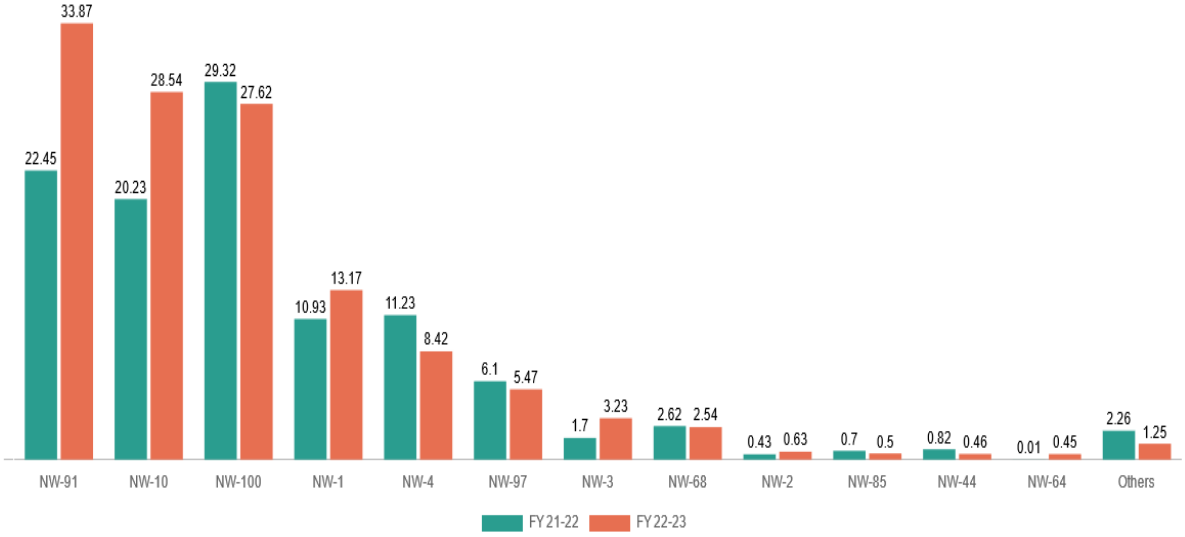
Source: Researcher's compilation from PIB notification (04 Feb 2022)

Figure 1.7: Cargo Traffic on inland waterways (in Million Metric Tons) for last 10 years



Source: Researcher's compilation from IWAI CAR-D Portal for FY2014-24

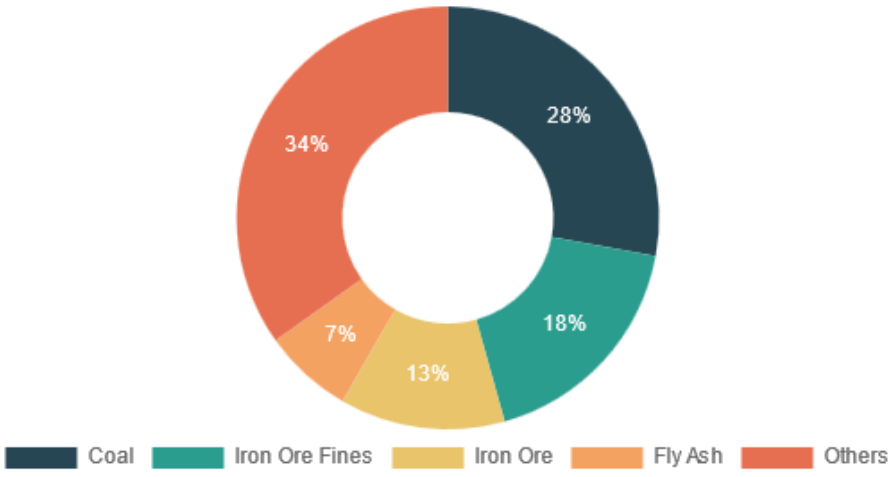
Figure 1.8: Cargo Traffic comparison on Major NWs (in Million Metric Tons-MMT)



Source: Extracted from IWAI CAR-D Portal for FY2021-22 and FY2022-23

Data extracted from the CAR-D (Cargo Data) Portal reveals that the inland waterways in Maharashtra (NW-91 and NW-10) and Gujarat (NW-100) are leading in terms of cargo traffic. The reason may be attributed to availability of trade centres along the waterways as well as accessibility of import/export cargo through the seaports of JNPT, Mumbai, Mundra and Kandla.

Figure 1.9: Major Commodity/Cargo Type on NWs for FY 2022-23



Source: Extracted from IWAI CAR-D Portal

Out of the total cargo traffic of 126.15 Million Metric tons (MMT) for FY 2022-23, it is seen that coal, iron ore fines and iron ore are having predominant shares as individual commodities being shipped via the national waterways.

1.3.3 Major inland water ports and supporting infrastructure

The inland water ports, terminals and jetties located all along the national waterways provide the basic infrastructural support for transport of cargo. Investment efforts through flagship projects such as Jal Marg Vikas Project (JMVP) and others are aimed at capacity building and modernization of the port terminals. An investment of Rs. 15,200 crores has been committed at the Global Maritime India Summit (Mumbai-October, 2023) to ramp up the inland waterway port infrastructure for cargo transport (PIB Release dtd. 08-Jan-2024). Public private partnership model has also been initiated with private parties for developing/managing select inland water terminals on the basis of supply, operate and maintain model.

Table 1.14: Prominent Inland water ports/terminals across major waterways

NW	**Inland water ports/terminals**
NW 1	Haldia, BISN Jetty, Shantipur, Swaroopganj, Farakka, Rajmahal, Samdaghat, Bhagalpur, Munger, Semaria, Buxar, Ghazipur, Varanasi, Allahabad, Patna
NW 2	Pandu, Dhubri, Hatsingimari, Jogihopa, Tezpur, Silghat, Biswanathghat, Neamati, Bogibeel, Sengajan, Dibrugarh, Oriumghat
NW 3	Kottapuram, Aluva, Kakanadu, Maradu, Vaikkom, Thanermukkom, Alappuzha, Thrikunnappuzha, Kayamkulam, Chavara, Kollam, Willingdon Island
NW 4	Ibrahimpatnam, Harischandrapuram, Muktyala, DurgaGhat, Bhavani Island, Amravati, Vedadri (*proposed*)
NW 5	Talcher, Jenapur , Dhamra, Paradip, Balasore, Nasirabad, Geonkhali (*proposed*)
NW 16	Karimganj, Badapur, Silchar

Source: Researcher's compilation from IWAI portal

Unlike the seaports, majority of the inland water ports across the country lack mechanized infrastructure and equipments required for efficient material handling. In the present context, none of the Indian inland water ports are adequately equipped for handling container transport; container loading/unloading fixed overhead cranes are not available. Instead, the entire inland water port operations in based on Roll-on-Roll-off (Ro-Ro) and

Lift-on-Lift-off (Lo-Lo) concepts wherein prime movers such as container trucks are utilized for container transport. Limited vessels, tugs and equipments for material handling, dredging and fairway construction, towing, loading/unloading is owned by the government. Depending on cargo load and service demand, the equipment requirements are sourced from private service providers and vessel operators.

Table 1.15: Indicative list of government owned equipments

Equipment Type	Quantity
House Boats/Accommodation Boats	13
Cargo Vessels	7
Other Vessels	4
Patrol Boats	7
Survey Vessels	18
Tug Boats	26
Container Crane	2
Crane Pontoons	9
Shore Cranes	12
Dredgers	20
Floating Jetties	35
Anchor Pontoons	13
Floating Platforms	3
Forklifts	8

Source: Researcher's compilation from IWAI data portal (2017)

1.3.4 Stakeholders in transportation decisions

The classical approach by Taniguchi and Tamagawa (2005) classifies stakeholders in transportation decisions into five groups namely freight carriers, shippers, administrators, infrastructure operators and public. Rześny-Cieplińska and Szmelter-Jarosz (2021) found that stakeholder voices are essential factors in planning, making new investments and creating public infrastructure. Inland water transportation in its emerging state of development relies on the stakeholders as follows:

Freight carriers or private cargo vessels provided by private organizations such as Eastern Navigation Pvt. Ltd., Assam Bengal Navigation, Reach Asia etc help in augmenting the existing fleet capacity for inland water transport. The private leased vessels are responsible for carrying significant load of cargo on the waterways.

Revenue for inland water transport sector comes primarily from the **Shippers** and the load providers mainly the logistics service providers, manufacturers, import export companies to name a few. Trade routes, incentives, GST exemptions are designed to meet requirements of the shippers. In 2023, Amazon Seller Services Private Limited has entered into an agreement for transporting customer shipments via inland waterways (PIB Press Release 22 Nov 2023).

Administrators in the domain of inland water transportation domain in India refers to executives from the Ministry of Ports, Shipping and Waterways (MoPSW) including central entity of Inland Waterways Authority of India (IWAI), state specific entities-Inland Water Transport (IWT) and investment organizations such as World Bank to name a few. This group also includes consultants engaged for providing specialized services. These stakeholders play pivotal role in policy formulations, investment decisions and chalking out roadmaps for the inland water transportation domain.

Infrastructure operators include the port and allied infrastructure operators and employees from government agencies and private players engaged in public private partnership (PPP) model. Revenue sharing model with PPP partners leads to augmented capacity handling capabilities, higher productivity and efficiency in operations by virtue of their expertise in the field.

Public is yet another important stakeholder which impacts major transportation decisions. Rapid investments in developing the inland water supporting infrastructure has led to enhanced land acquisitions in which public plays key role. There are other areas as well such as environmental impact, supporting ecosystem, employment avenues wherein the requirements of this stakeholder need to be considered.

In order to promote inland waterways as transportation mode of choice, stakeholder consultative meetings were carried out in FY-20 at six different locations across the country. In addition to this, nine conferences were organized in India during FY-21 to understand stakeholder expectations as well as get feedback on enhancing NW traffic (PIB Release dtd. 01-Apr-2022)

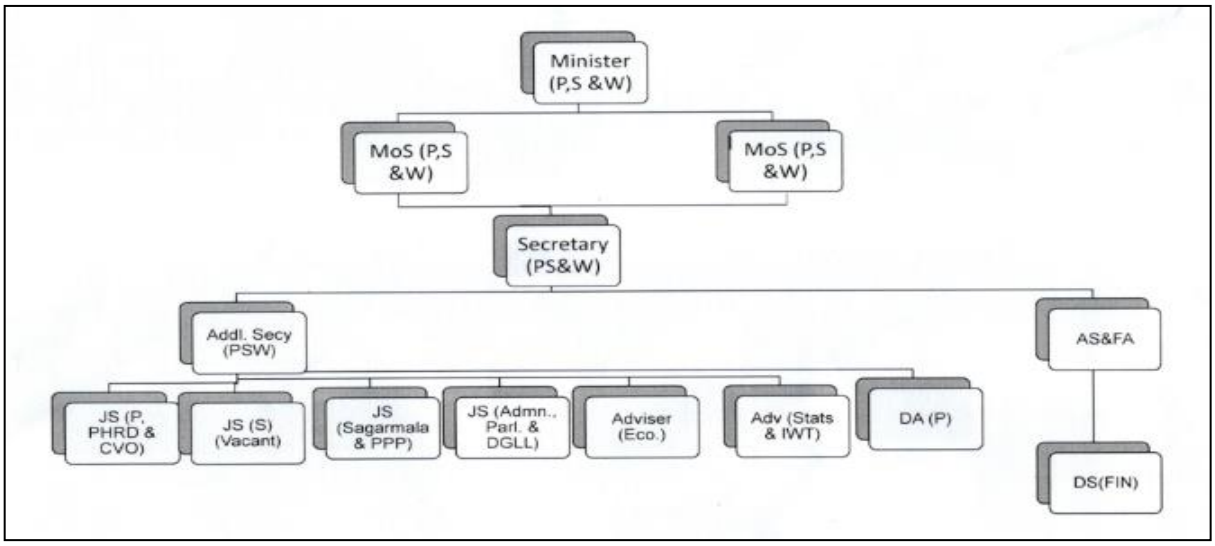
1.3.5 Ministry of Ports, Shipping and waterways

Originally initiated in the year 1942 as the department of war transport, the ministry of ports, shipping and waterways is the nodal government authority for maritime transport in

the country. This ministry is responsible for the ports, shipping and waterways sector which includes sea ports (major ports), national waterways, inland water transport infrastructure and ship building. The key role of this ministry is to formulate policies, guidelines and execute programs addressing the different issues concerning the domains related to waterway transport. A major thrust of the ministry lies in bringing in investments for the sector.

Vision Statement "To be recognized globally as a highly effective, efficient, responsible, and progressive maritime administration" (Vision, Ministry of Ports, Shipping and Waterways)

Fig 1.10: Organization Chart- Ministry of Ports, Shipping and Waterways



Source: https://shipmin.gov.in/about-us/organizational-chart (2024)

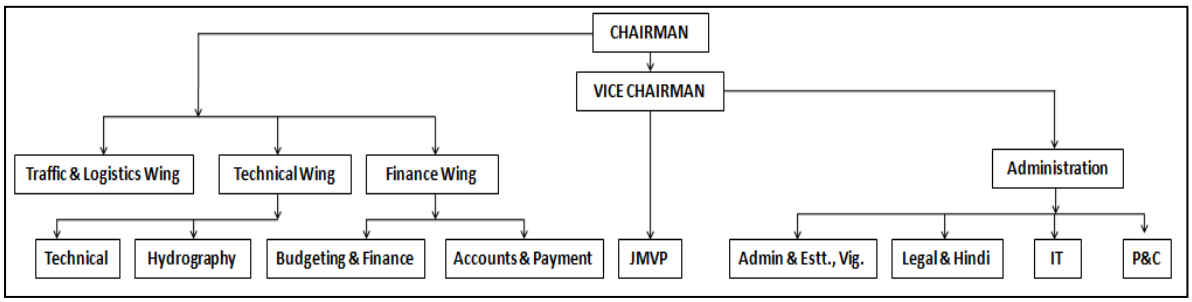
1.3.6 Inland Waterway Authority of India (IWAI)

The Inland Waterway Authority of India (IWAI) was established in the year 1986 under the Union Ministry of Ports, Shipping and Waterways as a nodal agency to develop and maintain the National Waterway infrastructure of the country. With the government's focus on tapping the potential of waterways, IWAI aims at a significant increase in the modal share of inland waterways and augment infrastructure through investments to support more than 500MMT traffic volume for the inland waterways by 2047.

Headquartered at Noida, IWAI has regional office at Patna, Kolkata, Guwahati and Kochi and sub-offices at Allahabad, Varanasi, Farakka, Sahibganj, Haldia, Swaroopganj, Hemnagar, Dibrugarh, Dhubri, Silchar, Kollam, Bhubaneswar and Vijaywada. The

general functions of IWAI include classification of waterways, hydrographic surveys, advising central government and assisting state government in matters of inland waterway transport, consultancy, research and development. While National Waterway related functions comprise of surveys, navigation, fairway and infrastructure development, pilotage, regulation and coordination with other transport mode. Keeping pace with technology advancements, IWAI is also responsible for introducing and managing digital initiatives such as PANI (Portal for Asset and Navigational Information), RIS (River Information System), LADIS (Least Available Depth Information System), FOCAL (Forum of Cargo-owners and Logistics-Operators), Car-D (Cargo Data Portal) for greater accessibility and utility.

Fig 1.11: Organisation Chart- Inland Waterway Authority of India (IWAI)



Regular Employees Strength						
	Admin	**Technical**	**Hydro**	**Finance**	**Sectt.**	**Total**
IWAI	61	97	90	24	3	275
Head Office	34	29	11	15	7	96

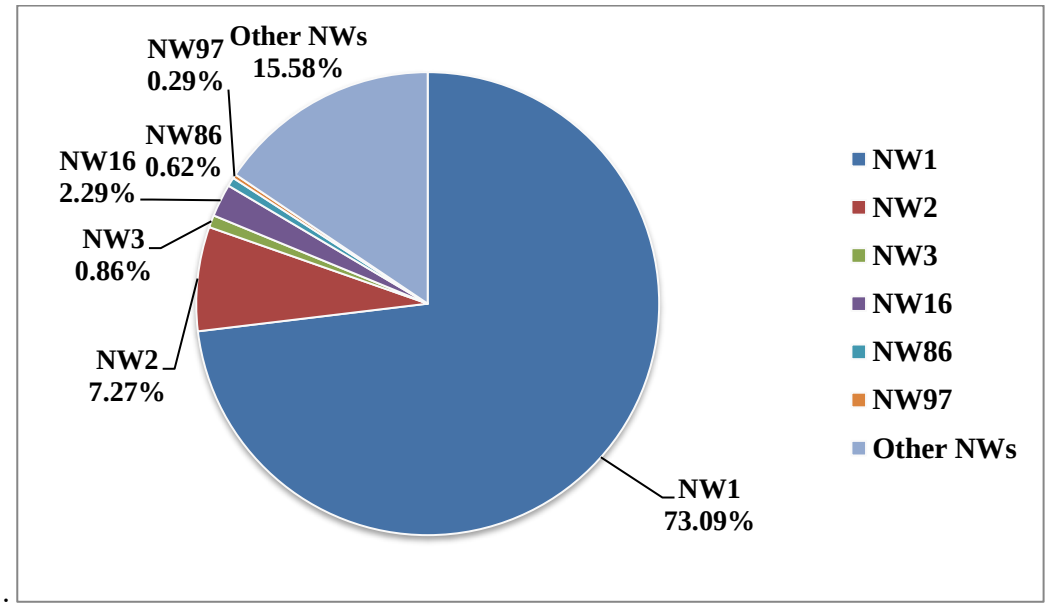
Source: Researcher's compilation from IWAI Organisation Chart (15.03.2024)

1.3.7 Major projects and developmental initiatives

Recent years have witnessed significant investment in the domain of inland water transport in order to fulfill the long-term goals set for the sector. Based on techno-economic feasibility studies and detailed project reports (DPRs), major projects have been envisioned by IWAI for development and capacity augmentation of the declared National Waterways. These projects are funded primarily by the government exchequer (budgetary allocation) along with financial assistance from World Bank and through public private partnership model. As per PIB Release (02-Aug-2022), an estimated total of Rs. 6340 crores have been earmarked for major projects across the national waterways.

Out of this, the ambitious Jal Marg Vikas Project (JMVP) has an outlay of Rs. 4634 crores (approx.) for capacity augmentation of NW 1 (Ganga-Bhagirathi-Hooghly River System). The first phase of the project included construction of multi-modal terminals at Varanasi, Sahibganj, Haldia, a Navigational Lock at Farakka, Terminal at Kalughat and fairway creation of LAD 3m for certain stretch of the waterway. JMVP-II includes DPR studies and development of 62 community jetties and 10 Ro-Ro terminals. A total of Rs. 461 crores has been earmarked for 17 developmental activities on NW2 (Bramhaputra river) out of which three are capital investment projects such as development of multimodal Jogighopa terminal, alternative road to Pandu port and ship repair facility at Pandu. The remaining fourteen activities are recurring and include annual maintenance costs related to infrastructure, vessels, navigational aids, training and fairway development. For NW16 (Barak River), an allocation of Rs. 145 crores has been made for comprehensive development of the IBP route and consists of three activities of permanent nature namely construction of Sonamura (Gumti river), Maia (Ganga river) terminals and upgradation of Badarpur and Karimganj terminals. The rest seven activities include annual operations and maintenance expenditure, consultancy, fairway development and amenities at Port of Call. In a similar manner, budgetary resources have been reserved for developing NW3, NW4, NW5, NW8, NW9, NW27, NW68, NW86, NW97 and NW111.

Fig 1.12: Financial Outlay of National Waterway Development Projects (in Crores)



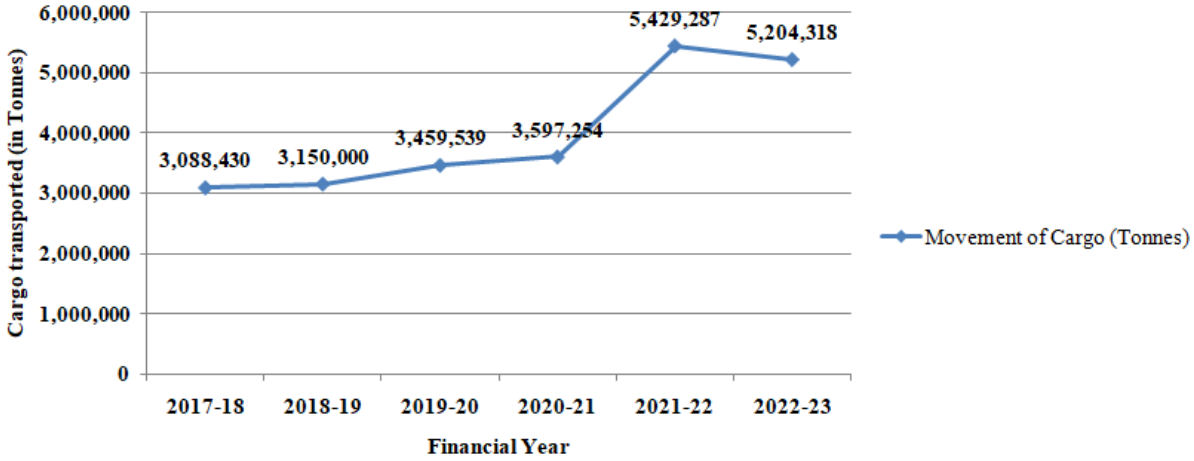
Source: Researcher's compilation (PIB Release dtd. 02-Aug-2022)

1.3.8 Prospects of the sector in fostering trade and commerce

In the pre-independence era, cargo movement of commodities such as tea, jute and spices in the eastern part of the country was accomplished primarily through inland water transport and thus, this sector was among the early contributors towards international trade. Post independence, this sector lost prominence primarily due to myopic vision and lack of focus of the policymakers towards this mode of transport. With today's renewed focus on developing inland water transport, this sector promises to promulgate trade and commerce in a significant manner. Cheaper operating costs, eco friendliness, larger capacities and international agreements are few drivers that shall help in fostering trade. As compared to 2014-15 data, a growth in cargo movement of almost 152.75% has been achieved in the year 2023-24 for National Waterway 1. The major transported commodities include fly ash, coal, construction material, food grain etc. (PIB Release dtd. 17-Mar-2023).

The inland water transport sector has significantly supported free trade agreements and trade protocols with the neighboring nations. The Indo-Bangladesh Trade protocol operational since 1972 has been a forerunner in terms of utilizing the potential of the inland waterways networks with 11 ports of call and 2 extended ports of call spanning across NW1, NW2 and NW16. This network greatly supports international trade of commodities such as coal, iron ore, fertilizers from India to Bangladesh.

Fig 1.13: Movement of cargo (in Tonnes) on India-Bangladesh inland waterways



Source: Researcher's compilation (Statistics of Inland Water Transport 2021-22)

1.4 Overview of Inland water infrastructure in Assam

Assam has been naturally endowed with inland waterways along the length and breadth of the state. By virtue of the presence of natural resources and transport connectivity, the state had a prosperous economy in the pre-independence era however, closure of transportation links with the then East Bengal resulted in a sharp decline of trade. Introduction of policy measures such as Act East Policy (AEP) has renewed stakeholder efforts in developing the potential of the waterway network for accessing the South East Asian markets. Bhattacharjee (2021) evaluates the significance of Assam's waterways in context of the AEP goals and emphasizes improvement of intra-regional, inter-regional and trans-national connectivity. Waterways in Assam play a pivotal role in the Indo Bangladesh protocol and a significant number of the ports of calls and the extended ones lie along the major waterways. Passenger transport by means of ferry services, Ro-Ro vessels continue to dominate the inland waterways, while freight transport holds great opportunities in context of the planned infrastructure development. Assam is among the states which is highest in terms of total waterway length (kms), yet the length of navigable waterways is significantly lesser. The Union Ministry of Ports, Shipping and Waterways has envisioned investments to the tune of more than Rs. 645 crores under the flagship Sagarmala programme for developing the inland water infrastructure in Assam (PIB Release dtd. 15-March-2024). This includes construction of terminals (passenger and cargo), multimodal logistics parks, tourist jetties, procurement of water transport equipments, upgradation of existing inland water ports and maintenance of fairways through dredging.

1.4.1 Major waterways and routes

Assam with fifteen designated national waterways has the highest share of waterways among the states in the country. The Brahmaputra (NW2) and Barak (NW16) are two major national waterways in the state and account for majority of the inland water freight movement. The Brahmaputra and Barak crisscrosses the state and connects the major trade centers. Both the rivers are significant from the perspective of freight transport in the entire region (including international trade) and infrastructure development along the two waterways have gained a lot of impetus in the recent years. Significance of the two rivers is such that the state is comprised of two valleys- the Brahmaputra valley and the Barak valley.

Table 1.16: Fifteen National Waterways (Assam)

River	State	Approx. Length (km)
Brahmaputra (NW2)	Assam	891
Barak (NW 16)	Assam	121
Dehing (NW 30)	Assam	114
Subansiri (NW 95)	Assam	111
Dhansiri (NW 31)	Assam	110
Lohit (NW 62)	Arunachal, Assam	100
Tiwang (Dhaleshwari) (NW 102)	Assam, Mizoram	86
Beki (NW 18)	Assam	73
Puthimari (NW 82)	Assam	72
Aai (NW 6)	Assam	71
Dikhu (NW 32)	Assam	63
Gangadhar (NW 38)	Assam	62
Doyans (NW 33)	Assam	61
Kopili (NW 57)	Assam	46
Jinjiram (NW 50)	Assam, Meghalaya	43

Source: iwai.gov.in

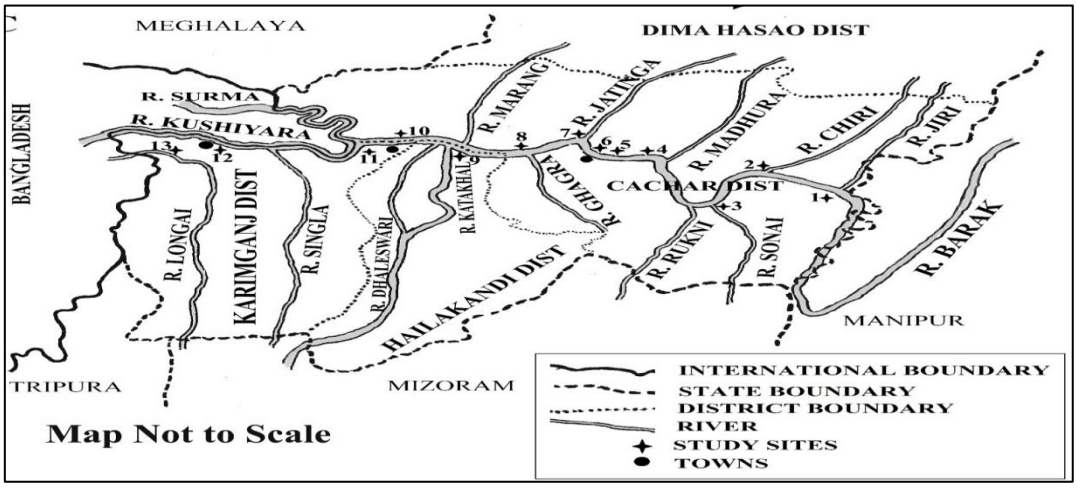
With its source in the Kailash range of the Himalayas, the Brahmaputra flows through Tibet, Arunachal Pradesh to enter the state of Assam and finally merges with Bay of Bengal through Bangladesh. The stretch of 891 kms from Sadiya in Assam to the Bangladesh border has been designated as National Waterway 2 (NW2). Brahmaputra is an essential part of the Ganga and Meghna river network system and forms a connecting link for freight transport. With a network of thirty three tributaries, this river continues to have a profound impact on the social and economic life of Assam and its people. (Nayak and Panda, 2016).

Fig 1.14: Route Map of the Brahmaputra (NW-2)

Source: iwai.gov.in

The river Barak with its origin in Manipur flows through Mizoram to reach the Barak valley and finally enters Bangladesh merge into the Surma and Kushiyara rivers. As per the Waterways Act 2016, a total length of 121 kms of the Barak river (Lakhipur-Bhanga stretch) has been designated as NW16. The waterway is significant from the perspective of International connectivity through the Indo Bangladesh protocol.

Fig 1.15: Route Map of the Barak (NW-2)



Source: Mazumder et. al. (2014)

1.4.2 Inland water ports along the major waterways

The major waterways of the region NW2 (Brahmaputra) and NW16 (Barak) along their respective routes are dotted with ghats for passenger transport (ferry and Ro-Ro service) while for cargo, a limited number of permanent and floating jetties are available. In context of passenger transport, e-ticketing has been introduced for ferry services on 63 ghats across the different divisions of the state administered inland water transport infrastructure. For freight transport, there are 12 jetties (permanent and floating) on NW2 and 3 major jetties on NW16 for facilitation of transport vessels (Directorate of Inland Water Transport).

Table 1.17: Inland water ports along major waterways for freight transport (Assam)

Brahmaputra (National Waterway 2)	Barak (National Waterway 16)
Pandu	Karimganj
Dhubri	Badarpur
Hatsingimari	Silchar
Jogighopa	
Tezpur	
Silghat	
Biswanathghat	
Neamati	
Bogibeel	
Sengajan	
Dibrugarh	
Oriumghat	

Source: Researcher's compilation based on data from IWAI

The inland water ports primarily are controlled by IWAI for freight transportation while passenger transport and cargo transport using ferries and Ro Ro vessels is managed by Assam Inland Water Transport. The associated port infrastructure is accordingly managed by the central and state department counterparts.

1.4.3 Transport policies and trade protocols

Policy level interventions such as Act East Policy, Central and state level logistics policies as well as trade agreements with neighboring countries have played key role in promotion of the inland water transport infrastructure across the state. Infrastructure development was one of the key focus areas of the export and logistics policy of Assam (2019) and this area received a renewed impetus through the Assam Logistics and Warehousing Policy (2022). These policies have outlined the need for infrastructure development, standardization of processes, capacity building in terms of skilling, public private partnership investment models and technology usage in the domain of inland water

transportation. In the initial phase, Advantage Assam Global Investors Summit (2018) also highlighted the significance of connecting South East Asian economies through the national highways and waterways of Assam. Considering the strategic location of the state, the Ministry of Ports, Shipping and Waterways along with Inland Waterways Authority of India (IWAI) organized Waterways Conclave 2022 in Dibrugarh Assam. The conclave attended by various stakeholders from waterways ecosystem dwelled upon technicalities of inland water infrastructure augmentation in the region and aimed at speedy development of the multimodal logistics projects in the North Eastern Region (PIB Release dtd. 08-Apr-2022). To transform the inland water scenario (particularly ferry infrastructure) of the state, Government of Assam (GoA) has undertaken a project 'Assam Inland Water Transport Project' with support from World Bank and formed a Society 'Assam Inland Water Transport Development Society' for execution of the project goals. In terms of bilateral agreements, the Indo Bangladesh Protocol has been instrumental in attracting infrastructure development investments along the protocol routes on NW2 and NW16 in the state. The route is being developed jointly at an estimated cost of Rs. 305.84 crores and aims to provide connectivity for all North Eastern states (PIB Release dtd. 15-Mar-2024).

Table 1.18: Ports of call and extended ports of call (India) as notified in IBP

Ports	Classification	State
Kolkata	Port of Call	West Bengal
Tribeni (Bandel)	Extended Port of Call	West Bengal
Haldia	Port of Call	West Bengal
Karimganj	Port of Call	Assam
Badarpur	Extended Port of Call	Assam
Pandu	Port of Call	Assam
Silghat	Port of Call	Assam
Dhubri	Port of Call	Assam
Dhulian	Port of Call	West Bengal
Maia	Port of Call	West Bengal
Kolaghat	Port of Call	West Bengal
Sonamura	Port of Call	Tripura
Jogighopa	Port of Call	Assam

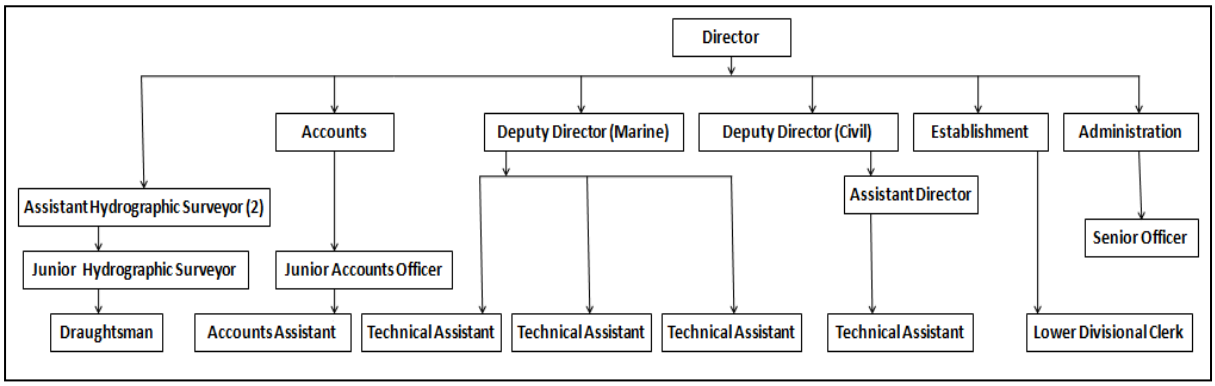
Source: Researcher's compilation (Refer Appendix C)

1.4.4 IWAI Divisional offices and port infrastructure

The IWAI regional office for the North East is located within Pandu Port complex in Guwahati and is responsible for the developing and maintaining IWAI infrastructure in

the region. The office is headed by Director who is assisted by Deputy Director (Marine) and Deputy Director (Civil). Inland water port operations and day-to-day activities for the region are managed by officials from this office.

Fig 1.16: Organisation Chart- IWAI Guwahati Regional Office



Source: Researcher's compilation (2022)

In the state of Assam, the regional office is augmented by sub offices in Dibrugarh and Dhubri for NW2 while Badarpur for NW16. In the other inland water ports and ferry ghats, the IWAI officials work jointly with Assam Inland Water Transport department officials. The regional and divisional offices of IWAI are primarily responsible for tactical and day-to-day operations planning while the strategic decisions are taken at Ministry level. The officials are involved in execution of the schemes and budgets as per plan for facilitating the inland water infrastructure of the region. Fairway maintenance, data upload to the digital platforms, vendor management and managing infrastructural and manpower requirements at the inland water ports are few of the key roles played by officials at the sub offices.

1.4.5 Assam Inland Water Transport

Assam Inland Water Transport was established in the year 1958 with its headquarters at Shillong. Initially, the office had a very small number of ferry ghats for inland water transport and the operations were managed with a skeletal staff headed by a director. In the year 1963, the headquarters was shifted to Guwahati and slowly, it expanded into a fully fledged Directorate under the Transport Department Government of Assam. Inland Water Transport Assam has three divisional offices- one each at Guwahati, Jorhat and Silchar while there are five Sub-Division offices at Guwahati (PPC), Dhubri, Jorhat, Dibrugarh and Hailakandi. Additionally, there's a crew training centre at Guwahati for training of IWT crew and staff. The department of transport is headed by the state

minister for transport and the Directorate consists of a Director, Additional Director, Joint Directors, Deputy Director, Executive Engineers, Assistant Executive Engineers, surveyors, commercial officers, other technical and administrative staff. The Directorate of Inland Waterway Transport Assam (DIWTA) presently has around 4,330 regular staff across the state.

Key functions of the DIWTA Assam comprises of ferry services, river conservancy including dredging and crew training. It is also responsible for enforcement of acts related to water transportation across the state. Presently, IWT is operating 67 nos. of ferry services on NW2 (Brahmaputra) and 22 nos. on NW16 (Barak) across the 102 designated ferry service routes. In addition to this, there are numerous other routes licensed by the local (village) and district councils. Primarily dealing with passenger transport, IWT Assam also manages break bulk non containerized cargo movement on the major waterways and its tributaries. Recently, IWT has introduced digital platform and mobile application for online ferry ticket bookings. Although infrastructure investment has been envisioned for the sector and lot of modernizations are underway, the present state of terminal facilities and navigational aids in the state is inadequate considering the passenger and cargo load.

1.4.6 Opportunities and Challenges

The inland waterway transport sector in the Northeastern Region of the country and particularly, for the state of Assam holds great potential, however as rightly opined by Kaushal (2018), it shall require a far sighted and collaborative approach to leverage the benefits. A detailed analysis of the strengths, weaknesses, opportunities, and threats of the inland water transportation sector (Assam) becomes pertinent to formulate key strategies and plan investments.

Strengths

- Geographical location of Assam as the gateway to South East Asian nations and Assam affirmed as the ‘Springboard’ of the Act East Policy (Barma, 2021). Assam shares border with seven Indian states and two foreign countries for facilitation of trade and commerce.
- Assam with fifteen national waterways is one of the states with the highest number of designated national waterways and the total length of waterways is also among the highest.

- With six ports of call (including extended ports of call) on the Indo Bangladesh Protocol, the waterways NW2 and NW16 of the state plays a significant role in international trade for the country.
- Presence of oil and gas, tea, cement, indigenous textile industries in the state provides impetus for freight transportation
- Inland water transport based trade on the Brahmaputra (NW2) was prevalent in Assam even before independence and most of the inland water ports are being developed along the existing ones.
- Present day political and economic scenario being conducive for businesses. Digital platforms and initiatives put in place by the State Government for 'Ease of doing Business'

Weaknesses

- Despite having the highest cumulative length of waterways among the states, only about 25% has been navigable till date (IWAI Data Portal).
- Due to sedimentation and other related factors, the Brahmaputra has been unstable in its course and depths (Coleman, 1969). Erratic channel depths and width across the year and course for the major waterways of the state which leads to uncertainty in inland water port operations and requires substantial operational expenses in fairway maintenance. This acts as a limitation for bigger freight vessels.
- Uncertain climatic conditions, especially the monsoons impact movement of trade vide the waterways. The operational time is in months for many of the existing ports.
- Lack of infrastructure and equipment at the existing inland water ports which is essential for efficient material handling
- Shortage of skilled/semi-skilled manpower for handling port operations which can be addressed only through capacity building initiatives.
- Aging and poorly equipped fleet of vessels and barges which leads to substantial downtime and loss of service.
- Relatively lesser coordination among the multiple stakeholders responsible for development, maintenance, and operations of the inland waterways. An integration of efforts is very much essential for realizing the goals of investments.

- Public private partnerships (PPPs) are popular in developing and managing transport infrastructure (Little, 2011). However, in the state of Assam, there have been limited public private partnerships in the domain of water transport.
- Assam has only one dry port in Amingaon (Guwahati) and despite the infrastructure investments across different waterways, no further addition to dry ports have been planned.
- Due to earlier insurgency and other problems, there has been a lagged growth in the industrial sector of the state leading to relatively lesser presence of major industries in the region.

Opportunities

- Envisioned investments for infrastructure augmentation of the state waterways; Rs. 645 crores has been planned under Sagarmala programme (GoI) for developing ten waterway projects and the State government has also taken up World Bank assisted projects for development and modernization of the port infrastructure.
- Policy initiatives such as Act East Policy which has brought administrators, investors and stakeholders attention towards leveraging the geographical advantages of the state.
- The present ecosystem provides a conducive environment for investors and businesses in the state
- Tax waivers and incentives for the inland waterway transport sector. As per notification no. 1212017- Central Tax (rate) dtd. 28.06.2017, service of transportation through inland waterways is exempted from GST.
- Increasing focus on sustainability and lower emissions-based mode of transport.

Threats

- Changes to river morphology impedes inland water operations (Fearnside, 2015). Flooding and erosion have been perennial problems for Assam and the northeastern states which reduces the fairway for inland water vessels, thereby necessitating huge expenditure on dredging.
- Extreme weather conditions such as events associated with monsoons and natural disasters lead to stoppages in the waterway related services (Lemke and Piotrowski, 2016). This is particularly true for the eastern part of the Indian subcontinent considering its proximity to the sea.

- Large-scale inland water operations is prohibited to a great extent by congestion (Krcum et. al., 2015). The course of waterways such as NW2 and NW16 are non-uniform and relatively narrower for bigger vessels or containerships.
- Rising fuel costs pushing up the operational expenses associated with the sector of inland water transport is minimizing the transporter's leverage.
- Informal sector operating traditional country boats and carrying freight without supporting infrastructure and safety precautions.
- The presence of inland waterways infrastructure in the urban landscape poses an additional risk of emissions. Although the emission level is significantly lesser than the other modes, yet the environmental impact and sustainability quotient must be considered for the feasibility studies (Bachok and Kader, 2015).

1.4.7 Major developmental initiatives

In the recent decade, a multipronged approach has been undertaken by the Union ministry as well as the state government in association with funding agencies and private players for infrastructure development and maintenance of the inland waterway network system of Assam. To enhance riverine infrastructure across the Brahmaputra, the Ministry of Ports, Shipping and Waterways has envisioned over Rs. 645 crores spanning 10 waterway projects under the Sagarmala Programme. Development of the country's first international multimodal logistics park in Jogighopa at an investment of around Rs. 693 crores is key another significant project in this region. Key developmental initiatives have been highlighted through the following points (PIB Release dtd. 15-Mar-2024):

- Construction of slipways at strategic locations in Dhubri and Majuli districts.
- Construction of passenger terminals in North Lakhimpur, Barpeta, Goalpara, Guijan, Kurua, Dhubri, Disangmukh and Matmora for facilitation of seamless transportation within the region
- Development of seven tourist jetties at Oriumghat, Bhupen Hazarika Setu, Koliabhomora bridge, Bogibeel bridge, Dikhow Mukh, Kalongmukh and Uzanbazar (Guwahati) for river tourism and watersports along Brahmaputra.
- Development of eastern waterways connectivity transport grid comprising four key waterways-NW1, NW2, NW16 and Sunderbans and few international routes spanning 5000 kms for boosting trade with South East Asian economies. Additionally, this would provide seamless connectivity of Northeastern India with rest of India through Bangladesh, Bhutan and Nepal through multimodal transport.

- Development of Jogighopa inland waterways terminal at an estimated cost of Rs. 64 crores.
- First Ship Repair facility at Pandu (Guwahati) being developed at an investment of Rs. 208 crores through Hooghly-Cochin Shipyard Limited (HCSL)
- Introduction of Passenger-cum-Cargo terminal at Bogibeel (Dibrugarh) at an investment of Rs. 50 crores
- Upgradation of Karimganj and Badarpur terminals at an investment of Rs. 6.40 crores.
- Construction of an integrated office for Immigration, Customs and IWAI at Bogibeel.
- Transformative projects including construction of six tourist jetties at Jogighopa, Tezpur, Biswanathghat, Neamatighat, Sadiya and Bindakota.
- Procurement of two Electric Catamarans worth Rs. 36 crores from Cochin Shipyard Limited and nineteen passenger vessels for NW2 and NW16 along with construction of two floating pontoons on NW2 at a total cost of Rs. 25 crores.
- Construction of alternative road from Pandu Port to NH-27 for enabling last mile connectivity undertaken at a investment of Rs. 180 crores.
- Maintenance of fairway through Dredging operations spanning critical stretches has been provisioned at a cost of Rs. 124 crores.

In addition to the above, the Indo Bangladesh Protocol route has been developed jointly by the two countries at a cost of Rs. 305.84 crores (jointly shared in 80:20 ratio between India and Bangladesh) wherein key waterways in Bangladesh are developed to connect to NW2 and NW16. Under the Central Sector Scheme, the state government is implementing construction of 71 floating terminals across prominent ghats on NW2 and NW16 at an estimated cost of Rs. 37.11 crores. (PIB Release dtd. 29-Mar-2022).

In tandem with the central government schemes, the state government too has envisaged developmental initiatives to promote regional integration for the inland waterways sector. With an assistance of approximately Rs. 1000 crores from the World Bank, Government of Assam established an apex autonomous body ‘Assam Inland Water Transport Development Society (AIWTDS)’ for executing the Assam Inland Water Transport Project. The main objective of the project is to upgrade ferry infrastructure, modernize fleet, and improve terminal infrastructure, navigational aids and last mile connectivity.

1.4.8 Partners supporting the sector

The Ministry of Ports, Shipping and Waterways plays the predominant role in inland waterways development activities and is responsible for envisioning the goals to be achieved while providing budgetary allocations. The Inland Waterways Authority of India (IWAI) acts as the nodal agency under the ministry responsible for preparing and executing development plans for the inland waterways. The Government of Assam through the Directorate of Inland Water Transport and Assam Inland Water Transport Development Society is primarily responsible for development of passenger transport elements and supports the central government initiated developmental initiatives in the execution phase. The other government entities supporting the sector are the Ministry of Trade and Commerce, Ministry of Road Transport and Highways, Ministry of Railways, Ministry of External Affairs and Central Board of Indirect Taxes and Customs, Container Corporation of India, National Technology Centre for Ports, Waterways and Coasts, Cochin Shipyard Limited to name a few.

The shippers, vessel, equipment, and fleet owners play a significant role in supporting the government agencies through their inland water shipping services. Some of the prominent fleet providers in the region are Eastern Navigation, Assam Bengal Navigation etc. In a similar manner to the PPP mode for public infrastructure projects, the inland water ports are also being planned to be run in the build and operate model with the association of major private players in the country.

1.5 Chapterization of the Study

The Thesis is organized into eight chapters. The summary of each chapter has been provided in this section.

Chapter 1: Introduction: The chapter broadly introduces the domain and context of the thesis. While providing an overview of the logistics sector, water transportation and inland water transportation elements, the first chapter dwells upon the significance of the inland waterways, the transport economics of the sector and the motivation behind the current work.

Chapter 2: Literature Review: The chapter provides an elaborate review of pertinent literature. Existing research in the domain has been broadly classified into seven categories which helps in understanding the research gaps. Evidence of port ranking exercises and optimization measures have been highlighted in the global, national, and

regional context. Key contribution of the chapter lies in identification of the appropriate multi criteria decision making tool as well as ascertaining criteria and sub-criteria from relevant literature for the purpose of inland water ranking.

Chapter 3: Objective, Scope and Limitation: The chapter highlights the basic purpose of the study and introduces the three objectives of the study. The scope of the work has been defined in terms of the prominent national waterways in the state. The chapter presents the limitations of the present study.

Chapter 4: Research Methodology: The chapter provides a detailed description of the methodology adapted for the inland water port ranking and optimization study. The Analytic Hierarchy Process (AHP) has been described elaborately along with selection and validation methods for AHP criteria and sub-criteria. The chapter also discusses the data details, assumptions and tools for the methodologies adapted for the research work.

Chapter 5: Identification and Ranking of Key Inland Water Ports: The chapter presents the analysis associated with the primary objective of inland water port ranking. Starting with selection rationale of the ten inland water ports across two national waterways to description and comparison of the ports, the chapter finally concludes with the calculated ranks for the shortlisted inland water ports using AHP methodology.

Chapter 6: Identification of Dry Port locations and optimization of the network: The chapter addresses the second and third objectives in terms of identifying dry port locations using hub and spoke network design and subsequent optimisation of the network. The different scenarios for the inland water port- dry port network system for the two waterways has been provided. The chapter highlights best-case scenarios for optimisation of the port network system.

Chapter 7: Findings and Discussion: The chapter consolidates the findings from the previous two chapters and provides a summary of the same. The chapter further highlights the interpretation and significance of the findings. The conclusion as well as recommendations and scope of future work is provided.