Chapter 2
Literature Review

2. Literature Review

For the study, a systematic literature review exercise has been done by short listing relevant literature pertaining to the field of inland water transport. The review was carried out as per the following steps:

a. Search Strategy

Relevant literature, reports and documents pertaining to the field of inland water transport (both global and Indian context) were searched on Google scholar, Scopus and EBSCO databases using relevant key words such as water transport, inland water, ports, port ranking, MCDM ranking, port factors and so on. Additionally, the search was expanded to include planning commission GoI Reports, PIB Releases, World Bank Database, Inland Waterways Authority of India Reports, Centre for Public Policy Research, Open Government Data Platform, Water Resources Information System of India, Meteorological and Oceanographic Satellite Data Archival Centre (ISRO) and GIS data. Additionally, Boolean search operators, truncation symbols, wildcard symbols and parentheses has been utilized to broaden or narrow the search areas.

b. Inclusion and Exclusion criteria

The inclusion criteria for the review exercise was studies related to water transport, inland waterways, ranking methodologies and optimization measures while the exclusion criteria consisted of passenger transport elements and modes of transport apart from water transport. After discarding literature which has little or very less likelihood of having any impact on the research objective the next step involved logically categorizing the results into eight distinct categories. Based on the classification and insights of the researcher depending on the relevance of the work done in context of the study objective, the criteria and sub criteria for inland water port ranking are identified from literature.

c. Data Extraction

Manual data extraction techniques have been used to determine the fitment of the research work and identification of criteria based on contextual decision making of similarity of scenarios. Relevant research papers of this domain have been studied and classified as follows:

i. Water Transport in terms of economic advantage
ii. Key Challenges of Inland Waterway Transport
iii. Inland Waterway Transport- Global and National Perspective
iv. Inland Water Transport- Regional and Assam studies

v.Water Transport optimization measures- worldwide
vi.Multi Criteria Decision Techniques for Ranking
vii.Port Ranking and its antecedents

2.1 Water Transport in terms of economic advantage

Initial research related to water transport has concentrated primarily on the economics part and has dwelled upon its significance along with the reasons leading to its advantage over other modes. In today's context, with the focus on sustainability, the discussion by researchers holds particularly true for the greener mode of transport.

Table 2.1: Water Transport in terms of economic advantage

Researchers	**Key Findings**
Ransdell, 1927; Bonavia, 1936; Baird, 1998	Water transport recommended over other transport modes due to cost efficiency, less friction, easy capacity ramp up, maintenance free nature
Warf and Cox, 1989; Hesse and Rodrigue, 2004; Lakshmanan, 2011; Hayaloglu, 2015	Inland waterway transport and port networks act as economic catalysts and boost manufacturing; Need for governments to understand the economic consequences of transport infrastructure investments
Konings and Ludema, 2000	River sea linking has a distinct economic edge over other transshipment modes
ASSOCHAM-Resurgent India, 2016 (Report)	India can save $50 billion if logistics cost reduces from 14 percent to 9 percent of GDP.

Source: Researcher's own compilation

2.2 Key Challenges of Inland Waterway Transport

Inland water transport has its inherent share of challenges in terms of technology, infrastructure, management commitment, unpredictability of river flows and so on. Existing research has concentrated mainly on the problem areas and classification of the same, however, quantitative solution methods have not been explored.

Table 2.2: Key Challenges of Inland Waterway Transport

Researchers	Key Findings
Kelnhofer Jr., 1978	No definite formula to decide the net worth of inland waterway public investments
Caris et. al, 2008	Defined Intermodal freight planning problems and how agility and speed impacts planning decisions
Mehta and Mehta, 2013	Discussed political roadblocks in river interlinking, regulatory challenges in modal integration, lack of uniformity in legal and administrative issues
Caris et. al, 2014	Classification of research challenges in the relationship between transport geography and logistics
Li et. al, 2013; Sharma, 2017	Classification of IWT problems into four areas: terminal efficiency-related, barge-related, berth allocation problem and quay crane scheduling related
Boudhoum, 2015	Investment decisions must support flood safety, hydroelectricity generation, tourism, water supply and environmental impact benefits
Hekkenberg, 2015	Identification of technological challenges as well as developments in the European inland waterway transport system

Source: Researcher's own compilation

2.3 Inland Waterway Transport- Global and National Perspective

Considering historical perspective of inland water transport, research work has concentrated on significance of this mode as well as highlighting the policy interventions, sustainability, and developmental initiatives for infrastructure augmentation of inland waterways.

Table 2.3: Inland Waterway Transport- Global and National Perspective

Researchers	Key Findings
Garrett, 1987	Attributes creation of United States and writing of the constitution due to Potowmack canal project issues
Palmer, 1998; Fellinda, 2006	Established inland water transport as one of the oldest means of ferrying goods with low per ton/km, environmentally friendly and highlighted need for development
Sys et. al, 2020; Barros et. al., 2022;	Defined sustainable IWT, identified pathways for sustainable future and also found that there is increased interest in eco-friendly processes over the years
Behera, 2005; Roso, 2009	Concept and significance of dry ports and its distribution model with inland water ports

Source: Researcher's own compilation

2.4 Inland Water Transport- Regional and Assam studies

Literature search for regional and state level studies have yielded limited literature primarily concerning the geographical, ecological, economic, and engineering aspects of the rivers Brahmaputra and Barak. The studies are primarily qualitative in nature and do not yield conclusive evidence. Government Reports and database provide details of the investment plans across the region and state.

Table 2.4: Inland Water Transport- Regional and Assam studies

Researchers	Key Findings
Nayak and Panda, 2016	Socio economic impact of the Brahmaputra and an insight into the numerous operational ghats flanking the mighty river
Borah, 2017	Basic infrastructural problems of the region's IWT and traffic intensities at the different ghats dotting Guwahati city
World Bank Project Database	Details of the 150-million-dollar project in the pipeline to modernize the state inland water terminal infrastructure of Assam
Press Release, Govt.	Highlighting the significance of the 1000 crore IWT project with

of Assam, 2018	support from World Bank for development of water terminals, river fronts, jetties and port cities at Jogighopa, Neamatighat, Dibrugarh, Biswanath and Silchar

Source: Researcher's own compilation

2.5 Water Transport optimization measures- worldwide

Research carried out in the domain of water transport particularly related to optimization has been limited. However, research evidence has been found in context of multi criteria decision making and algorithms. In context of optimizing sea ports and related transport infrastructure, researchers have used quantitative models and multi criteria decision making tools such as AHP, GRA, heuristics etc.

Table 2.5: Water Transport optimization measures- worldwide

Researchers	**Key Findings**
Koh, 2001	Used heuristic algorithm to develop optimal investment models for inland container transportation systems
Ting and Tzeng, 2003	Quantitative model for ship scheduling and cost analysis for route planning
Teng et. al, 2004	Grey relational analysis (GRA) was also used to measure overall competitiveness of eight Asian ports
Woxenius et. al, 2004; Ng and Gujar, 2009	Modelling location of dry ports; Significance of dry ports in Indian context
Ng and Cetin, 2012	Spatial dynamics of Indian dry ports are different from advanced economies due to geographical diversifications
Rahimi et. al, 2008; Feng et. al, 2013	Location-allocation model for the dry port- sea port optimization problem- Los Angeles, Taiwan Strait

Source: Researcher's own compilation

2.6 Multi Criteria Decision Techniques for Ranking

In an era of having substantial number of choices, prioritization of policy interventions and investment decisions becomes important. Ambitious plans for development/modernization of the inland waterway network must be supported by

justified decision making in terms of site selection for optimum return on investments. Although evidence for same has not been found for Indian inland water ports, researchers elsewhere have applied multi-criteria decision making (MCDM) techniques for port selection decisions. However, for MCDM tools, selection of criteria, sub-criteria and alternatives and subsequent validation is extremely important for providing quality insights for Decision Support systems.

Table 2.6: Multi Criteria Decision Techniques for Port Ranking

Researchers	**Key Findings**
Sinuany-Stern, Mehrez and Hadad, 2000	Utilised a hybrid AHP DEA evaluation for ranking organizational units having multiple inputs and outputs. The study was carried out without any subjective assessment of decision maker.
Hanson et. al, 2011	On the basis of population and exposure based analysis, a ranking of port cities globally was carried out considering climate extremities
Ke, Li and Hipel, 2012	Integration of AHP and GMCR methods for addressing Canadian west coast congestion through preference ranking approach
Asgari et. al, 2015	Using AHP for sustainability ranking of UK Major Ports while considering the environmental and economical aspects
Nallusamy et. al, 2015	Studied the lastest MCDM techniques such as AHP, FL and ANN in context of supplier selection DSS and finally application of AHP for supplier ranking decision
Ceballos, Lamata and Pelta, 2016	Empirical study of MCDM techniques such as MOORA, TOPSIS, VIKOR and the similarity of rankings generated
Asadabadi, Chang and Saberi, 2019.	Provided a critical review of AHP and ANP MCDM techniques in terms of ranking exercises and at the same time, highlighted the significance of Consistency ratios in establishing validity of the calculated ranks
Majidi, Al-E-Hashem, and Zolfani, 2021	Used MCDM techniques to find that economic, environmental, and social criteria have a significant role in the sustainability ranking of Iranian major ports

Source: Researcher's own compilation

2.7 Port Ranking and its antecedents

Researchers globally have dwelled upon decision prioritizing models for developing decision support for practitioners. Analytic Hierarchy Process (AHP) has been used extensively for arriving at port selection decision and evidence has been found to be more for the Asian sea ports. AHP has been preferred by researchers primarily due to its versatility and hierarchical structure. In the national context, weighted average method has been adapted for major sea ports (Chudama, 2009) while no studies for prioritizing inland water ports have been carried out.

Table 2.7: Port Ranking and its antecedents

Researchers	**Key Findings**
Chudasama. 2009	Carried out ranking of Indian major ports through a weighted score method based on operational efficiency and physical capacity
Hanson et. al, 2011	On the basis of population and exposure based analysis, a ranking of port cities globally was carried out considering climate extremities
Lirn et. al, 2004; Ugboma et. al, 2006; Cruz et. al, 2013; Dyck and Ismael, 2015	Used AHP to analyse transshipment port selection decisions made by shippers and carriers (West Africa, Nigeria and other geographies)
Ke, Li and Hipel, 2012	Integration of AHP and GMCR methods for addressing Canadian west coast congestion through preference ranking approach
Asgari et. al, 2015	Using AHP for sustainability ranking of UK Major Ports while considering the environmental and economical aspects
Majidi, Al-E-Hashem, and Zolfani, 2021	Used MCDM techniques to find that economic, environmental, and social criteria have a significant role in the sustainability ranking of Iranian major ports
Georgoulas et al., 2023	Explored AHP as a port ranking methodology and

	developed an AHP based decision support system for practitioners'

Source: Researcher's own compilation

2.8 The Research Gap

At the global level, mostly among developed and certain developing nations, a large thrust lie on water mode of transportation and significantly higher investments have been made in the infrastructure development of this transport mode. This is also evident from the quantity and quality of research work already done in this direction. The focus of research in international arena is concerned more with sustainability (Mihic et. al, 2011) and optimizing the inland water network systems (Feng et. al, 2013; Crainic et. al, 2015, Nyugen and Notteboom, 2016). Researchers globally have also arrived at decision support systems for shippers and other stakeholders based on seaport and dryport ranking mechanisms (Lombaerde and Verbeke, 1989; Causa and Brauers, 2014). In the Indian context of water transportation, evidences in the form of research papers are substantially lesser and mostly research work is found in the form of projects taken up by government agencies such as Planning Commission, Inland Waterways Authority of India, Centre for Public Policy Research and World Bank to name a few. Some researchers have worked on the role, viability and perspectives of the Inland Water Transport system in India (Rangaraj and Raghuram, 2007; Sriraman, 2010). In context of port supporting infrastructure, Ng and Gujar (2009) have thrown light on government policies impacting dry ports and Haralambides and Gujar (2012) have done a DEA analysis on the dry port sector of India. Although evidence of port ranking is found for Indian Subcontinent (De and Ghosh, 2003; Wu and Lin, 2008; Chudasama, 2009), the evaluation has been restricted to seaports only and no significant quantitative studies have been done for inland water ports.

Although a large potential lies in Northeast India and Assam in connecting South East Asian trade and commerce to the mainland by means of water transport, research evidence concentrating purely on this subject matter seems to have not been undertaken. Rangaraj (2007) and Sriraman (2010) have provided distinctive evidence of the Brahmaputra- Barak valley but none to substantiate the potential that this region holds. In recent years though, government agencies through initiatives such as Act East Policy, Advantage Assam has focused on drawing investor's attention by highlighting

infrastructural requirements and areas of development for inland water transport. Research work relating to inland water mostly concentrated on the geological and ecological aspects (Deka et al., 2011). Therefore, in absence of concrete and quantitative research work in this domain of Inland Water Transport for the region of Assam, a substantial research gap exists. Furthermore, research carried out on the major waterways of the state- Brahmaputra and Barak have been limited to morphology, river dynamics, remote sensing and GIS based studies.

Thus, there lies huge scope in exploring the inland water transport system for Assam along the operational and non-operational waterways of the region. Also, since the domain is in its nascent stage of development, significant work can be carried out with respect to supply chain network design and optimization models for the regional port infrastructure system. In context of the magnitude of investments envisioned for the key waterways of the state, it becomes necessary to carry out quantitative based research to serve as key guidance for policymakers, practitioners and stakeholders in the domain.