

Article



# Sustainable Freight Transportation via Inland Waterways: Challenges and Strategic Solutions in Bangladesh

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**Abstract:** Inland water transport (IWT) is crucial for socio-economic development, facilitating rural connectivity, trade logistics, energy provision and tourism. Nevertheless, it is neglected due to historical underinvestment, inadequate infrastructure and regulatory inefficiencies in Bangladesh. This study evaluates the current state of freight movement via inland waterways, identifies key challenges and proposes strategies to improve sustainability. A mixed-method approach was used, including content analysis of secondary data (sourced from “Bangladesh Inland Water Transport Authority” (BIWTA) reports, government publications, academic journals and policy documents screened through a structured review process) and Focus Group Discussions (FGDs) to explore challenges and solutions. Three FGDs were conducted with 15 purposively selected experts across three stakeholder groups: Shipping and Ports Authority officials, academics, and shipping agents. A Likert scale average was applied to rank identified challenges. The findings will help policymakers formulate integrated strategies to promote sustainable economic growth and safeguard maritime activities. The outcome of the study suggests that a sustainable IWT system can be achieved if the challenges are mitigated and recommended strategies are implemented.

**Keywords:** inland water transport (IWT); sustainability; freight transportation; Bangladesh

## 1. Introduction

Sustainability is referred to as “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” [1]. The development and operation of inland waterways for the transportation of people and goods in a way that minimizes negative effects on the environment, promotes economic growth and maintains social well-being is known as sustainable inland water transport, or IWT [2]. Transportation plays a fundamental role in the socio-economic development of countries, especially in critical activities such as commuting, energy supply, goods allocation and tourism among others [3]. In order to build a robust and effective transportation system, environmentally sustainable procedures, effective logistics, and community involvement must all be combined.

In terms of the economy and the ecology, inland water transportation is a time-tested and dependable way to move commodities [4]. It offers access to public facilities and is the only means of transit in some areas. From unpowered boats to extremely intricate propulsion systems, the sector includes a variety of watercraft that traverse waterways from little streams to large rivers. Inland waterways play a critical role in economic growth, especially



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in remote areas. However, the particular provincial context which includes elements like the geographic environment, infrastructure, growth rate, and socioeconomic conditions has a significant impact on the industry's prospects for the future [5]. Lakes, canals and protected coastal water areas are all considered inland waterways. Inland water transportation is a popular kind of transportation in Bangladesh. It is more affordable than other modes of transportation and offers easy access to any location in the nation. Up until recently, the Bangladeshi government had not paid much attention to the industry and had only allocated a little amount of funds to support its expansion. Additionally, the majority of these resources were used to build the main waterways, which are mostly used by big, mechanized ships.

In Bangladesh, the need for freight transportation is growing. At the same time, the nation's logistics and transportation systems are nevertheless underutilized and in various states of disarray. The increasing demand has not been adequately met by investments in alternative modes of transportation, such as rail and waterborne freight. High traffic-related pollution levels, hazardous road conditions, and the alarming anticipated effects of climate change are the causes of these problems [6]. Consequently, Bangladesh's freight transportation system is almost unsustainable. Given Bangladesh's importance in the South Asian subregion and its population of over 160 million, it is imperative to evaluate the country's present level of sustainable freight transportation [7]. Bangladesh contains one of the greatest inland waterway networks globally, with over 700 rivers and approximately 24,000 km of waterways during the monsoon season, reducing to around 5200 km in the dry season. IWT in Bangladesh is more affordable than road or air transport and is the sole means of connectivity for many remote communities, making its sustainable development a national priority. The existing literature on IWT challenges spans Europe and Asia [5], yet Bangladesh-specific empirical investigations remain limited. Studies such as Hassan and Wang [8] and Saha et al. [6] highlight navigational decline and environmental concerns, while Islam et al [7] underscores connectivity gaps. However, a comprehensive mixed-method study that systematically ranks IWT challenges through stakeholder perspectives and proposes actionable strategies grounded in primary data collection is absent for the Bangladesh context. This study addresses that gap. In addition to analyzing the related challenges and possible solutions, the goal of this study is to clarify the idea of sustainable freight transportation over Bangladesh's inland waterways. Specifically, this study aims to: (1) assess the current situation of freight transportation by inland waterways in Bangladesh; (2) identify and rank the key challenges faced in inland waterway freight transportation; and (3) propose strategic measures to make inland waterways sustainable for freight transportation. The study employs a mixed-method approach combining content analysis of secondary data with primary FGD data to ensure both breadth and depth of understanding. The study's primary limitations include its exclusive concentration on inland waterways and freight transportation in Bangladesh, a relatively small FGD sample of 15 participants, and the potential underrepresentation of certain stakeholder groups such as cargo owners and terminal operators, which may affect the generalizability of findings. These limitations are acknowledged and discussed further in Section 5.

The remainder of this paper is organized as follows: Section 2 reviews the relevant literature on sustainable transportation and IWT; Section 3 describes the data collection methodology; Section 4 presents the analysis and findings including the current IWT situation, identified challenges, and strategic recommendations. Finally, Section 5 ends with the conclusion and directions for future research.

## **2. Literature Review**

The term “sustainable transportation” refers to energy-efficient, low- or zero-emission, reasonably priced means of transportation, such as domestic fuels and electric and alternative-fuel cars. Definitions of sustainable transportation that are now in use can differ and favor one aspect over another, such as the environment (green transportation), society (inclusive transportation), or economy (competitive and efficient transportation). But in general, sustainable freight transportation seeks to achieve coherence, synergies, and complementarities by integrating the economic, social, and environmental aspects of the industry. According to a number of authors, sustainable transportation should efficiently and economically meet the basic needs of people and society while minimizing waste and emissions and consuming fewer non-renewable resources [9]. Furthermore, creating sustainable transportation necessitates both steps to lessen negative externalities and creative ways to enhance performance across the various modes [3]. Air, water, land, and noise pollution, greenhouse gas emissions, traffic jams, accidents, and excessive land usage are the primary topics of these externalities [10,11]. In light of the aforementioned, inland waterway transportation (IWT) is seen as a suitable instrument for the sustainable growth of transportation. In this paper, the term “sustainable IWT” encompasses all three dimensions—economic, environmental, and social—while terms such as “green” or “environmentally sustainable” refer specifically to the environmental dimension.

Calderón-Rivera et al. [5], through a systematic review of 51 IWT studies, identified the following five aspects as strategically important for implementing a sustainable inland waterway transportation system: (1) the qualities and behaviors of users; (2) the characteristics and behaviors of operators; (3) investment in infrastructure; (4) regulation and taxation; and (5) the role of government. These categories emerged from cross-case synthesis across multiple geographical contexts and form the analytical backbone of prior IWT sustainability research. Infrastructure investment and strategic planning were identified as requiring further investigation.

A comparison of intermodal freight transport in Japan and France is presented in the research conducted by Diziain et al. [12]. The authors place a special emphasis on the utilization of aquatic transport in metropolitan areas. In spite of the fact that it is a relatively insignificant method of transportation for both people and freight in France (Paris), they conclude that IWT is more reliable than other routes of transportation. The Japanese government has established a certification called the Eco-Ship Mark for shippers transitioning from road to sea freight. Moreover, incentives have been implemented to alleviate traffic congestion in metropolitan areas. The author contend that stringent governmental regulations are necessary to promote the adoption of sustainable transportation methods in urban areas.

Mihic et al. [13] state that governmental initiatives can substantially enhance the utilization of Inland Water Transport (IWT) in Serbia. Notwithstanding the problems encountered, they assert that IWT is a sustainable and feasible solution for improving urban mobility and trade throughout the European continent. The authors underscore the imperative of strategic governmental support to address these problems and maximize the advantages of IWT. Calderón-Rivera et al. [5] further confirm that governance and regulatory frameworks are decisive factors across different IWT contexts, corroborating findings from Serbia, Poland, and Norway. Kulczyk and Winter [14] examine the capacity of inland water transport (IWT) to alleviate roadway congestion and enhance urban logistics in Poland. The author references many measures by local authorities, such as the introduction of a National Program for the advancement of IWT and the formation of a specialized agency for its regulation and promotion. The research advocates for enhanced collaboration between public and commercial entities to optimize the advantages of IWT. Ydersbond et al. [15] highlight the importance of collaboration between public authorities and private stakeholders in developing smart mobility solutions in Nordic countries, including Norway and Finland. They also discuss challenges related to coordination, adoption technology and data governance in emerging transport systems.

Hendrickx et al. [16] emphasize the reliance of inland water transport on stable water levels, which are increasingly influenced by climate change. Fluctuations in water levels can diminish cargo capacity, elevate transportation expenses, and impair water infrastructure. They emphasize the necessity of mitigating these environmental concerns to sustain and enhance the efficiency of IWT in Belgium.

Trivedi et al. [17] identify significant obstacles to the implementation of Inland Water Transport (IWT) in India, such as insufficient infrastructure, absence of regulation, and a convoluted policy landscape. They suggest many initiatives to enhance inland water transport, including infrastructure development and the streamlining of municipal regulations. The authors assert that resolving these difficulties is essential for the advancement of IWT in India. Boudhoum et al. [18] formulate a model for decision-making on investments in inland waterway infrastructure in the United States. Their methodology evaluates elements like cost-benefit analysis, transportation value, risk, and environmental and social consequences. The authors contend that sustainable development must be a primary factor in investment decisions to optimize the advantages of IWT. Luca et al. [19] similarly demonstrate, through the case of the Bucharest–Danube Canal, how geographic and infrastructural factors shape IWT sustainability outcomes, reinforcing the need for context-specific analyses. Boulougouris et al. [20] examine activities by municipal authorities in Stavanger, Norway, aimed at improving intramodality, including the establishment of a Connected Mobility Hub that integrates cycling and electric automobiles. They recognize issues include insufficient coordination among parties and the necessity for enhanced data sharing and information exchange. The authors assert that surmounting these problems is crucial for the effective amalgamation of many transportation modalities.

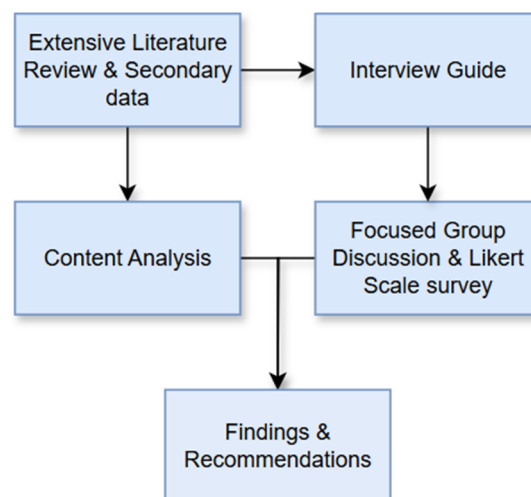
According to Wang et al. [21], the basins of the Rhine, Volga, Yangtze, Pearl, and Amazon rivers rank among the most significant inland waterways globally. The majority of the literature on the sustainable development of IWT is focused on countries in either Europe or Asia [5], with European institutions such as the European Commission developing policy documents to support modal shift from road to water [5,22]. When it comes to hinterland transportation, the road is currently the most reliable mode of transit. Nevertheless, there are social, economic, and environmental downsides linked to dependence on automobiles, including greenhouse gas emissions, dependence on oil, traffic congestion, and socioeconomic inequalities [22].

Within the Bangladesh context specifically, Hassan and Wang [8] document the challenges and prospects of the IWT system, noting that despite extensive river networks, navigability has declined due to siltation and

inadequate infrastructure. Saha et al. [6] highlight that environmental sustainability of inland freight has received insufficient attention, while Islam et al [7] identifies connectivity and integration deficits. Askari et al. [2,23] contribute empirical evidence on IWT accident factors, identifying overloading and poor navigational aids as primary causes. Calderón-Rivera et al. [5] note that country-specific geographical, social, economic, and political conditions create unique barriers, reinforcing the need for Bangladesh-specific research. Despite this body of work, no prior study has applied a systematic mixed-method approach combining content analysis with structured FGD-based stakeholder ranking to quantify the relative severity of IWT challenges in Bangladesh. This gap in the literature constitutes the primary motivation for the present study. The identified challenge dimensions mapped against environmental (navigational hazards, pollution), economic (infrastructure, investment, integration costs), and social (stakeholder awareness, regulatory coordination) sustainability dimensions inform both the research design and the analytical framework.

### 3. Data Collection and Methodology

This study employed a mixed-method approach incorporating both qualitative and quantitative techniques. Primary data were collected through Focus Group Discussions (FGDs) with selected experts and quantitative analysis was performed using a standard Likert scale averaging method to rank the challenges. Figure 1 indicates the procedure of this study.



**Figure 1.** The Procedure of The Study.

A purposive sampling method was used to select 15 respondents from relevant sectors with experience in Bangladesh's inland waterway freight system. The participants included officials from the Shipping and Ports Authority, academics, and shipping agents (see Table 1). Shipping and Ports Authority officials ( $n = 7$ ) were included because of their direct regulatory and operational oversight of IWT routes and infrastructure in Bangladesh. Academics ( $n = 3$ ) provided evidence-based and policy perspectives drawn from research on IWT systems. Shipping agents ( $n = 5$ ) represent the operational private sector interface with the IWT system, handling freight logistics on a daily basis. Together, these three groups represent the key institutional, academic, and commercial stakeholders whose decisions most directly affect IWT performance and sustainability.

Three FGDs were conducted with groups of seven, five, and three participants respectively, facilitated using a semi-structured questionnaire. The FGD guide was developed through a two-step process: first, a structured review of the secondary literature identified key IWT challenge domains (infrastructure, regulation, navigation, environment, technology, and awareness); second, these domains were translated into open-ended discussion questions designed to elicit stakeholder experiences and priorities. FGDs were audio-recorded with participant consent, transcribed verbatim, and analyzed thematically. Themes were developed inductively by identifying recurring patterns across the three groups and deductively by mapping responses against the literature-derived challenge domains. The thematic analysis was reviewed by two independent coders to ensure reliability.

The FGD guide covered the following thematic areas: (1) current perceptions of IWT performance and utilization in Bangladesh; (2) infrastructure challenges and navigational conditions; (3) regulatory and coordination barriers between transport modes; (4) environmental sustainability concerns; (5) stakeholder awareness and industry culture; (6) investment and funding constraints; (7) technology adoption and multimodal integration; and (8) strategic recommendations for IWT improvement. Questions were open-ended and semi-

structured to allow exploratory responses while ensuring coverage of all challenge domains identified in the literature review.

Based on the thematic findings, a structured questionnaire was developed to evaluate the severity of each identified challenge using a 5-point Likert scale. The Likert scale was administered to all 15 FGD participants as a follow-up exercise. While a sample of 15 is modest, it is appropriate for a purposive expert sample given the specialized nature of IWT operations in Bangladesh and the exploratory scope of this study. Findings are accordingly framed as stakeholder perceptions rather than population-level generalizations. The Likert scale scoring was as follows:

- 1 = Not Severe
- 2 = Slightly Severe
- 3 = Moderately Severe
- 4 = Severe
- 5 = Extremely Severe

Each respondent assigned a score from 1 to 5 for each listed challenge. The severity level of each challenge was quantified by calculating the mean score using the formula:

$$\text{Mean score} = \frac{\sum Xi}{n}$$

where:

$Xi$  = individual respondent score for the challenge

$n$  = total number of respondents (15)

The higher the mean score, the more severe the challenge is perceived to be. This method provides a direct and statistically valid basis for ranking the challenges based on stakeholder perceptions.

This approach allows clear identification of critical areas needing immediate attention and supports strategic planning for sustainable inland waterway freight transport in Bangladesh. In terms of sustainability dimensions, this study examines challenges across environmental (e.g., navigational hazards, water quality), economic (e.g., infrastructure deficits, integration costs, investment gaps), and social (e.g., stakeholder awareness, regulatory coordination) dimensions, consistent with the three-pillar framework [5,9].

**Table 1.** Detailed List of the Respondents.

| Sector                       | Years of Experience | Number of Respondents |
|------------------------------|---------------------|-----------------------|
| Shipping and Ports Authority | 3–10                | 7                     |
| Academics                    | 2                   | 3                     |
| Shipping agents              | 5–7                 | 5                     |
| Total:                       |                     | 15                    |

Source: Based on the data collection.

This methodology offers a comprehensive framework for examining the complex constraints and potential solutions related to sustainable freight transportation along inland waterways in Bangladesh. The study aims to provide a comprehensive understanding of sustainable freight transportation via inland waterways in Bangladesh, addressing both the human and systemic factors involved.

## 4. Analysis and Findings

### 4.1. The Current Situation of Freight Transportation by Inland Waterways

Bangladesh contains one of the greatest inland waterway networks globally, essential for commerce, transportation, and agriculture. The nation's socioeconomic advancement relies on the intricate system of rivers, canals, and tributaries that constitute these waterways. In the monsoon season, inland waterways span almost 24,000 km, whereas in the dry season, they extend approximately 5200 km [8]. This network is vital to Bangladesh's economy as it facilitates the movement of individuals and goods, especially in regions with limited or no access to roads and railways. Bangladesh's extensive riverine system comprises more than 700 rivers and approximately 24,000 km of waterways. Rivers, lakes, and canals collectively cover around 7% of the country's surface area. However, navigability varies seasonally due to water-level fluctuations and sedimentation. According to BIWTA data, approximately 3865 km of waterways remain navigable during the dry season, increasing to about 5968 km during the monsoon season [8]. The major organization in charge of regulating, maintaining, and expanding the vast network of inland waterways in the nation is BIWTA. Notwithstanding the strategic

significance of this means of transportation, BIWTA has several obstacles that have prevented Bangladesh's inland waterways from reaching their full potential. The slow decline in navigability along many river routes is one of the most urgent problems. The water depth has decreased over time due to siltation and sedimentation, particularly during the dry season, making it more challenging for vessels to operate [8]. The development and growth of inland water transportation have been significantly hampered by the decline in navigability, which has a negative impact on the movement of both passengers and goods [24].

During the monsoon season, Bangladesh boasts 5968 km of navigable waterways [8]. The major seaports and a few small and large river ports connect the entire network. According to BIWTA data, Bangladesh's naval connectivity utilizes only 16% to 25% of all accessible waterways, suggesting that Bangladesh's rivers are not being used to their full potential [8]. The capital city of Dhaka serves as the primary hub, with the majority of passenger transportation via inland waterways leaving Dhaka towards the south, southeast, and southwest regions. Bangladesh's busiest river port is Sadarghat in Dhaka. Other significant inland water transportation origins include Chandpur in the southeast, and Narayanganj and Barishal in the south. Certain routes are primarily utilized for freight movement, such as Bhairab, Baghabari, and Mirkadim. In summary, the current connectivity of water routes can only transport a limited number of people and goods, which is not sustainable without targeted intervention.

#### 4.2. Challenges Faced in Freight Transportation by Inland Waterways

Freight transportation by inland waterways are facing some challenges. A study of public and private sector stakeholders was carried out in order to determine and rank the main obstacles impeding the growth and integration of inland waterway transport (IWT) in Bangladesh the inland waterway freight sector in Bangladesh faces multiple interconnected challenges. To identify challenges FGD were conducted. Identified challenges are shown in Table 2. The FGDs were transcribed and analyzed thematically and a structured questionnaire was developed to evaluate the severity of key challenges using a 5-point Likert scale. Based on the Likert scale responses from the 15 stakeholders, the average severity score for each identified challenge is presented in Table 3 below.

**Table 2.** Challenges Identified by Interviewed Respondents.

| SI No. | Challenges                                             | Sustainability Dimension |
|--------|--------------------------------------------------------|--------------------------|
| 1.     | Coordination & Regulatory Issues (IWT integration)     | Social                   |
| 2.     | Navigational Hazards (e.g., sandbars, low bridges)     | Environmental            |
| 3.     | Poor Infrastructure (ports, terminals, cargo handling) | Economic                 |
| 4.     | Limited Awareness and Stakeholder Acceptance           | Social                   |
| 5.     | High Integration Costs                                 | Economic                 |
| 6.     | Technological Challenges                               | Economic                 |
| 7.     | Regulatory Issues (independent of integration)         | Social                   |
| 8.     | Resistance from Existing Transport Sectors             | Social                   |
| 9.     | Lack of Multimodal Infrastructure                      | Economic                 |
| 10.    | Lack of Investment and Funding                         | Economic                 |

**Table 3.** Ranking of Identified Challenges (Based on Mean Likert Score).

| Rank | Challenge                                              | Mean Score | Severity Level |
|------|--------------------------------------------------------|------------|----------------|
| 1    | Coordination & Regulatory Issues (IWT integration)     | 4.53       | Very High      |
| 2    | Navigational Hazards (e.g., sandbars, low bridges)     | 4.20       | High           |
| 3    | Poor Infrastructure (ports, terminals, cargo handling) | 4.07       | High           |
| 4    | Limited Awareness & Stakeholder Acceptance             | 3.53       | Moderate–High  |
| 5    | High Integration Costs                                 | 3.20       | Moderate       |
| 6    | Technological Challenges                               | 3.13       | Moderate       |
| 7    | Regulatory Issues (independent of integration)         | 2.80       | Low–Moderate   |
| 8    | Resistance from Existing Transport Sectors             | 2.60       | Low–Moderate   |
| 9    | Lack of Multimodal Infrastructure                      | 2.47       | Low            |
| 10   | Lack of Investment & Funding                           | 2.20       | Low            |

Respondents ranked Coordination and Regulatory Issues concerning IWT integration are the most significant challenge, attaining the highest mean score of 4.53. This indicates the stakeholders' significant apprehension regarding inadequate inter-agency cooperation, redundant mandates, and regulatory discrepancies between inland water transport and other transport modalities, including road, rail, and ports. This finding is consistent with Trivedi et al. [17], who identified regulatory fragmentation as the primary IWT barrier in India, and with Mihic et al. [13], who emphasized

the role of government policy in the European context. The primacy of regulatory and coordination issues in Bangladesh reflects the absence of a unified multimodal transport authority with clear jurisdictional mandates.

The second most critical issue, with an average score of 4.20, is Navigational Hazards. These encompass natural and artificial impediments, such as sandbars, submerged obstacles and low-clearance bridges, which undermine the safety and reliability of aquatic freight transportation. This aligns with Hassan and Wang [8], who document the progressive decline in navigability due to siltation as one of the most pressing IWT challenges in Bangladesh, and with Hendrickx et al. [16], who link water-level fluctuations to reduced cargo capacity in Belgium.

Poor infrastructure is ranked third (mean score 4.07), underscoring issues related to antiquated ports, poor cargo handling facilities, and insufficient terminal capacity, all of which constrain operating efficiency and service quality. This is comparable to findings by Trivedi et al. [17] in India and Boudhoum et al. [18] in the US, who both identify infrastructure gaps as key barriers to IWT efficiency. The relatively low ranking of Lack of Investment and Funding (mean 2.20) is a notable and potentially counter-intuitive finding. Stakeholders appear to view funding not as the root cause but as a downstream constraint: structural and regulatory issues must first be resolved before investment can be effectively deployed. This interpretation merits attention from policymakers, who may otherwise prioritize funding mechanisms over institutional reform.

Additional fairly severe concerns encompass Limited Awareness and Stakeholder Acceptance (mean score 3.53), wherein insufficient awareness with the advantages of IWT among logistics firms, shippers, and municipal authorities leads to its inadequate utilization.

Significant Integration Costs (3.20) and Technological Challenges (3.13) have surfaced as prominent obstacles, highlighting the financial and technical impediments related to the development of cohesive multimodal transport systems, including the lack of automated scheduling, tracking systems, and standardized handling equipment.

Challenges including Regulatory Issues unrelated to integration (2.80), Resistance from Existing Transport Sectors (2.60), and Lack of Multimodal Infrastructure (2.47) were regarded as having a comparatively lesser although still significant impact on the sector's growth.

The least severe obstacle identified was insufficient investment and funding, with a mean score of 2.20. Although financial constraints are recognized, they are not presently considered the most pressing barrier compared to other structural and regulatory challenges.

The challenges are summarized in Table 3. These findings highlight the immediate necessity for extensive legislative reform, infrastructure modernization, improved stakeholder collaboration, and augmented investment in multimodal integration to guarantee the long-term viability and sustainability of inland waterway freight transit in Bangladesh. Notably, the Shipping and Ports Authority group tended to rank regulatory and coordination challenges highest, while shipping agents emphasized infrastructure and cost barriers. This divergence reflects differing positional interests and may have implications for how reform agendas are framed across stakeholder groups.

#### 4.3. Strategic Measures to Make Inland Waterways Sustainable for Freight Transportation for Bangladesh

The extensive network of rivers in Bangladesh, comprising around 5968 km of navigable waterways, is crucial to the nation's transportation infrastructure [8]. The government has initiated and implemented several plans to enhance the Inland Water Transport (IWT) sector, acknowledging the strategic importance of these waterways [8,24]. This comprehensive plan encompasses regional collaboration, institutional enhancement, environmental sustainability, and infrastructure advancement. Respondents and professionals from survey assert that a multifaceted strategy is essential to tackle difficulties and improve the efficacy of sustainability in inland waterways freight transportation in Bangladesh.

**Infrastructure Development and Maintenance:** Establishing and sustaining navigable rivers is a fundamental aspect of the IWT concept, as asserted by experts. The government has conducted extensive dredging work on the Padma, Meghna, Jamuna, and Brahmaputra rivers, as well as their tributaries: the Dharla, Arial Khan, Kushiya, Gorai, and Manu. BIWTA should prioritize completion of year-round dredging programs within a 5-year horizon, with clear performance benchmarks for navigable kilometers maintained. Responsible agencies: BIWTA in partnership with the Ministry of Shipping. Expected sustainability outcome: restored environmental navigability and enhanced economic freight capacity. These programs aim to provide year-round navigability by facilitating the movement of individuals and goods while fostering economic activity in riverine areas. In addition to dredging, it is important to establish and maintain river ports, landing stations, and ferry terminals. These facilities improve the overall efficiency of the IWT system by serving as hubs for passenger services and cargo management.

**Regulatory Reform and Institutional Coordination:** Given that Coordination and Regulatory Issues ranked as the most severe challenge (mean 4.53), the most critical strategic priority is the establishment of a unified multimodal transport coordination body with cross-agency authority. This body should have the mandate to

harmonize IWT regulations with road and rail frameworks, resolve jurisdictional overlaps, and implement streamlined licensing and enforcement protocols. Responsible agency: Ministry of Shipping with inter-ministerial coordination. Implementation priority: immediate (0–2 years). Expected sustainability outcome: reduced transaction costs for freight operators, improved compliance, and enhanced social equity of access.

**Environmental Sustainability and Pollution Control:** A crucial element of the IWT strategy is the sustainable maintenance of water quality. Short-term initiatives include establishing appropriate water supply systems in ports and vessels and promoting hygienic practices. Medium-term undertakings involve implementing water supply and sanitation systems at ports and vessels. Long-term goals (5–10 years) necessitate the establishment of advanced wastewater treatment facilities at all major ports and vessels, with monitoring systems to track environmental indicators such as water quality indices and vessel emission levels.

**Regional Cooperation and Transboundary Water Management:** From the interview of professionals, the suggested that effective waterway management requires regional cooperation because many river systems are shared. In order to resolve transboundary water issues, improve navigability, and guarantee the fair use of shared water resources, the government actively participates in discussions with its neighbors. Maintaining downstream navigability, identifying cost-effective and efficient transportation chains, and connecting with other forms of transportation are the key goals of collaborative efforts.

**Private Sector Engagement and Public-Private Partnerships:** The government promotes private sector involvement in the IWT sector, acknowledging the role that the private sector plays in fostering efficiency and innovation. Dredging operations can be leased to private companies, freeing up BIWTA to concentrate on strategic planning and supervision. PPP frameworks should also target terminal modernization, digital tracking systems, and standardized cargo handling equipment, directly addressing the technological and infrastructure challenges identified by stakeholders.

**Safety Enhancement:** Ensuring comprehensive safety is crucial for sustainable freight operations. Research findings emphasize the necessity of regulating overloading, improving navigational aids, and alleviating hazards from permanent obstructions to decrease IWT accidents [23].

The aforementioned comprehensive interventions illustrate Bangladesh's commitment to developing a robust, efficient and sustainable inland water transportation infrastructure. Successful implementation will require clear assignment of responsibilities, time-bound milestones, and dedicated funding mechanisms, ideally supported through public-private partnership arrangements.

## 5. Conclusions

Inland water transport (IWT) in Bangladesh holds considerable promise as a sustainable and affordable mode of freight movement. The country possesses one of the largest inland waterway networks in the world, spanning approximately 24,000 km during the monsoon season and around 5200 km in the dry season [8]. Despite this natural advantage, the sector has long been constrained by underinvestment, inadequate infrastructure, declining navigability, and weak institutional coordination. A master plan for sector development was established in 2009, yet implementation has remained incomplete owing to insufficient funding, outdated hydrographic data, and poor inter-agency coordination.

This study employed a mixed-method approach combining content analysis of secondary data with Focus Group Discussions involving 15 purposively selected experts. A five-point Likert scale was used to rank ten identified challenges across environmental, economic, and social sustainability dimensions. The findings reveal a consistent and policy-relevant pattern. Coordination and Regulatory Issues emerged as the most severe challenge, with a mean score of 4.53, reflecting deep stakeholder concern about the absence of a unified multimodal transport authority and regulatory inconsistencies across transport modes. This confirms findings by Mihic et al. [13] and Trivedi et al. [17] in the European and Indian contexts, though the problem is more acute in Bangladesh due to the absence of any supranational coordination mechanism. Navigational Hazards ranked second (mean 4.20), with siltation and physical obstructions identified as operationally critical barriers across all three stakeholder groups, extending the work of Hassan and Wang [8] through a stakeholder-weighted quantification. Poor Infrastructure ranked third (mean 4.07), consistent with infrastructure-focused findings from India and the United States [17,18]. A notable and counter-intuitive result is the lowest ranking assigned to Lack of Investment and Funding (mean 2.20). This suggests that stakeholders perceive structural and regulatory failures as more fundamental than financial constraints, implying that additional investment without prior governance reform is unlikely to yield the expected improvements in IWT performance.

The Bangladesh government has pursued several strategic responses, including dredging programs, environmental sustainability measures, transboundary water management, public-private partnerships, and safety

regulation. These represent meaningful steps forward, but their effectiveness will depend on coordinated institutional reform, time-bound implementation milestones, and consistent stakeholder engagement. A notable divergence was observed between stakeholder groups: Shipping and Ports Authority officials prioritised regulatory and coordination challenges, while shipping agents emphasised infrastructure and cost barriers. This divergence has direct implications for how inclusive reform agendas should be designed and communicated.

This study contributes to the IWT literature by providing the first mixed-method, stakeholder-ranked assessment of IWT challenges in Bangladesh, offering both a quantified challenge hierarchy and qualitatively grounded strategic recommendations. The results provide an evidence base for policymakers at BIWTA and the Ministry of Shipping to prioritise regulatory coordination as the most immediate reform lever.

This study is subject to several limitations. The FGD sample of 15 participants, while appropriate for purposive expert sampling, restricts statistical generalizability. Cargo owners and terminal operators were absent from the sample, which may have led to underrepresentation of demand-side perspectives. The focus on inland waterways and freight in Bangladesh limits transferability to other modes or national contexts.

Future research should address these gaps through four directions. First, longitudinal evaluation studies should track how challenge severity changes as policy interventions are implemented. Second, the stakeholder base should be broadened to include cargo owners, terminal operators, and community representatives. Third, quantitative modelling should be applied to examine the economic and environmental sustainability impacts of IWT development. Fourth, the role of digital technologies and smart logistics in addressing the technological challenges identified in this study warrants dedicated investigation.

### Author Contributions

M.H.R.C.: Conceptualization, methodology, investigation, data collection, data curation, formal analysis, visualization, supervision and writing—original draft preparation; F.A.F.: Conceptualization, methodology, formal analysis, validation, literature review and writing—review and editing; K.F.: Data collection, investigation, formal analysis, visualization and writing—review and editing; M.A.A.A.: Conceptualization, methodology, validation, supervision, project administration and writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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### Institutional Review Board Statement

Not applicable.

### Informed Consent Statement

Not applicable.

### Data Availability Statement

An anonymized version of the dataset may be made available from the corresponding author upon reasonable request, subject to appropriate ethical and confidentiality requirements.

### Conflicts of Interest

The author Muhammad Hasemur Rahaman Chowdhury is an employee of Bangladesh Inland Water Transport Corporation (BIWTC). The author declares that the company did not exercise control over the study design, data collection, data analysis, and interpretation of results, manuscript preparation, or the decision to submit the article for publication. The remaining authors declare no conflicts of interest. The authors take full responsibility for the content of the published article.

### Use of AI and AI-Assisted Technologies

ChatGPT (Version 4.0) was used solely for language editing and grammatical correction of the manuscript. The authors carefully reviewed, verified and edited all AI-generated suggestions before incorporating them into the final version of the manuscript. The authors take full responsibility for the accuracy and integrity of the content.

## References

1. Moore, J.E.; Mascarenhas, A.; Bain, J.; et al. Developing a comprehensive definition of sustainability. *Implement. Sci.* **2017**, *12*, 110. <https://doi.org/10.1186/s13012-017-0637-1>.
2. Askari, H.R.; Chowdhury, M.M.H.; Shaheen, M.M.A.; et al. Coastal and inland waterway transport accidents: A systematic literature review. *Mar. Syst. Ocean Technol.* **2025**, *20*, 46. <https://doi.org/10.1007/s40868-025-00192-x>.
3. Rodrigue, J.-P. *The Geography of Transport Systems*, 5th ed.; Routledge: Abingdon, UK; New York, NY, USA, 2020. <https://doi.org/10.4324/9780429346323>.
4. Knoflacher, H.; Himanen, V. *Transport Policy between Economy and Ecology*; Valtion Teknillinen Tutkimuskeskus: Espoo, Finland, 1991.
5. Calderón-Rivera, N.; Bartusevičienė, I.; Ballini, F. Sustainable development of inland waterways transport: A review. *J. Shipp. Trade* **2024**, *9*, 3. <https://doi.org/10.1186/s41072-023-00162-9>.
6. Saha, R.C.; Sabur, H.M.A.; Saif, T.M.R. Environmental Sustainability of Inland Freight Transportation Systems in Bangladesh. *Int. Supply Chain Technol. J.* **2023**, *9*, 1–21. <https://doi.org/10.20545/iscstj.v9i9.300>.
7. Islam, S.; Ahsan, H.M.; Shibly, M. An analysis of inland water transportation in Bangladesh: Connectivity and integration. In Proceedings of the 6th International Conference on Civil Engineering for Sustainable Development (ICCESD 2022), Khulna, Bangladesh, 10–12 February 2022.
8. Hassan, M.M.; Wang, X. The Challenges and Prospects of Inland Waterway Transportation System of Bangladesh. *Int. J. Eng. Manag. Res.* **2022**, *12*, 132–143.
9. Rohács, J.; Simongáti, G. The role of inland waterway navigation in a sustainable transport system. *Transport* **2007**, *22*, 148–153. <https://doi.org/10.1080/16484142.2007.9638117>.
10. Demir, E.; Huang, Y.; Scholts, S.; et al. A selected review on the negative externalities of the freight transportation: Modeling and pricing. *Transp. Res. Part E Logist. Transp. Rev.* **2015**, *77*, 95–114. <https://doi.org/10.1016/j.tre.2015.02.020>.
11. Macharis, C.; Melo, S.; Woxenius, J.; et al. (Eds.) *Sustainable Logistics*, 1st ed.; Emerald Group Publishing Limited: Bingley, UK, 2014.
12. Diziani, D.; Taniguchi, E.; Dabanc, L. Urban Logistics by Rail and Waterways in France and Japan. *Procedia-Soc. Behav. Sci.* **2014**, *125*, 159–170. <https://doi.org/10.1016/j.sbspro.2014.01.1464>.
13. Mihic, S.; Golusin, M.; Mihajlovic, M. Policy and promotion of sustainable inland waterway transport in Europe—Danube River. *Renew. Sustain. Energy Rev.* **2011**, *15*, 1801–1809. <https://doi.org/10.1016/j.rser.2010.11.033>.
14. Kulczyk, J.; Winter, J. *Śródlądowy Transport Wodny [Inland Water Transport]*; Oficyna Wydawnicza Politechniki Wrocławskiej: Wrocław, Poland, 2003. Available online: <https://www.oficyna.pwr.edu.pl/ksiazki/srodladowy-transport-wodny/> (accessed on 1 July 2026).
15. Ydersbond, I.M.; Auvinen, H.; Tuominen, A.; et al. Nordic Experiences with Smart Mobility: Emerging Services and Regulatory Frameworks. *Transp. Res. Procedia* **2020**, *49*, 130–144. <https://doi.org/10.1016/j.trpro.2020.09.012>.
16. Hendrickx, C.; Breemers, T. The Effect of Climate Change on Inland Waterway Transport. *Procedia-Soc. Behav. Sci.* **2012**, *48*, 1837–1847. <https://doi.org/10.1016/j.sbspro.2012.06.1158>.
17. Trivedi, A.; Jakhar, S.K.; Sinha, D. Analyzing barriers to inland waterways as a sustainable transportation mode in India: A DEMATEL-ISM based approach. *J. Clean. Prod.* **2021**, *295*, 126301. <https://doi.org/10.1016/j.jclepro.2021.126301>.
18. Boudhoum, O.; Oztanriseven, F.; Nachtmann, H. Value-Focused Inland Waterway Infrastructure Investment Decisions. *Eng. Manag. J.* **2022**, *34*, 265–280. <https://doi.org/10.1080/10429247.2021.1884451>.
19. Luca, G.G.; Guju, D.I.; Comănescu, L. The Development of Inland Waterway Transport as a Key to Ensuring Sustainability: A Geographic Overview of the Bucharest–Danube Canal. *Sustainability* **2025**, *17*, 4438. <https://doi.org/10.3390/su17104438>.
20. Boulougouris, E.; Papanikolaou, A.; Dahle, M.; et al. Implementation of Zero Emission Fast Shortsea Shipping. In Proceedings of the SNAME Maritime Convention, Providence, RI, USA, 27–29 October 2021; p. D021S002R003. <https://doi.org/10.5957/smc-2021-030>.
21. Wang, H.; Zuo, L.; Lu, Y.; et al. Waterway carrying capacity assessment: Model development and application in the lower Yangtze River, China. *Ecol. Indic.* **2022**, *142*, 109177. <https://doi.org/10.1016/j.ecolind.2022.109177>.
22. Schiller, P.; Bruun, E.; Kenworthy, J. *An Introduction to Sustainable Transportation: Policy, Planning and Implementation*; Earthscan: London, UK, 2010.
23. Askari, H.R.; Shaheen, M.M.A.; Chowdhury, M.M.H.; et al. Analyzing factors contributing to inland waterway transport accidents in Bangladesh. *Mar. Syst. Ocean Technol.* **2025**, *20*, 27. <https://doi.org/10.1007/s40868-025-00170-3>.
24. Islam, M. Regional Connectivity: Current Challenges for Bangladesh. *Bangladesh J. Political Econ.* **2017**, *31*, 19–50.