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Research Article

Optimizing Dry Port Locations Using Hub And Spoke Network Design - A Conceptual Framework For Inland Water Ports In Assam

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ABSTRACT

The Indian Freight and Logistics market is estimated to grow at 8.8% annually to USD 484.43 bn by 2029. This exponential rise in demand has to be supported by adequate investments across all modes of transport. However, only a miniscule 0.5% of freight movement within India occurs via waterways and this mode of transport is largely unutilized despite having over 15000 kms of navigable river systems. In recent years, with due diligence to cheaper, greener and efficient modes of transport, developed nations across the world have focused on building river transport infrastructure systems for proliferation of internal trade and commerce. Policymakers in India also are focusing on river connectivity improvement projects on the key waterways. It is significant to note that, under the ambit of Act East Policy, key investments are underway to connect South East Asian economies via Northeast India. The waterways of the region hold immense potential in terms of establishing efficient trade connectivity with neighboring countries; the key challenge lies in establishing a robust, resilient and effective water transport infrastructure system. To address this challenge, apart from developing inland water ports and port townships along major waterways, it becomes important to complement conventional transport infrastructure with intermodal capabilities at strategic locations for the switchover between rail, road and water mode of transport. In this context, the paper introduces the concept of dry ports as one of the means for intermodal capabilities and discusses the key considerations associated with a hub-and-spoke network design model for locating dry ports vis-à-vis key inland water ports along the two major waterways-Brahmaputra and Barak of the Northeastern region. Key contribution of the work lies in establishing key design considerations for the proposed hub-and-spoke design and providing a conceptual for optimizing the river transport infrastructure system.

Keywords: inland water transport, hub-and-spoke, dry ports, inland water ports

1. Introduction

Logistics sector performance has emerged as one of the key indicators for economic growth, trade proliferation and competitiveness of nations globally with logistics related turnover exceeding US$ 4.3 trillion (World Bank Trade Logistics Report-2018). In India, this sector has been the source of employment for more than 22 million people and the GDP growth rate w.r.t. transport demand is estimated to be 8 percent for the 13th (2021-22) Plan, 8.5 percent during 14th (2026-27) Plan and 9 percent in the 15th (2031-32) Plan (NTDPC Report, Planning Commision GoI). Accordingly, to cater to this estimated growth, substantial investment has been envisioned by the Indian Government through its varied policies across all modes of transport.

Ransdell (1927) had vouched for water transport over other modes for its key characteristic of being the cheapest and efficient transport mode while encountering minimal friction. A study by ASSOCHAM-Resurgent India (2016) revealed that India can affect a savings of over $50 billion if logistics cost is reduced from 14 percent to 9 percent of GDP; this can be made possible by utilizing the over 15000 kms of inland riverways which has largely been unutilized. With a strong realization of the potential of inland water transportation, during the last few years, significant steps in the form of water transport infrastructure development projects

such as Capacity Augmentation Project of the National Waterway- 1 from Varanasi to Haldia on the River Ganga (800mn USD) and similar projects has been undertaken to boost the infrastructural requirements of the inland water shipping sector (World Bank Report).

Fig 1: Freight Movement (India) mode wise

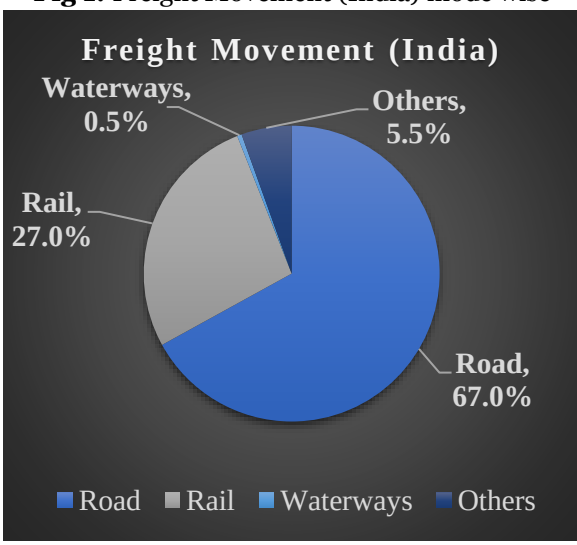
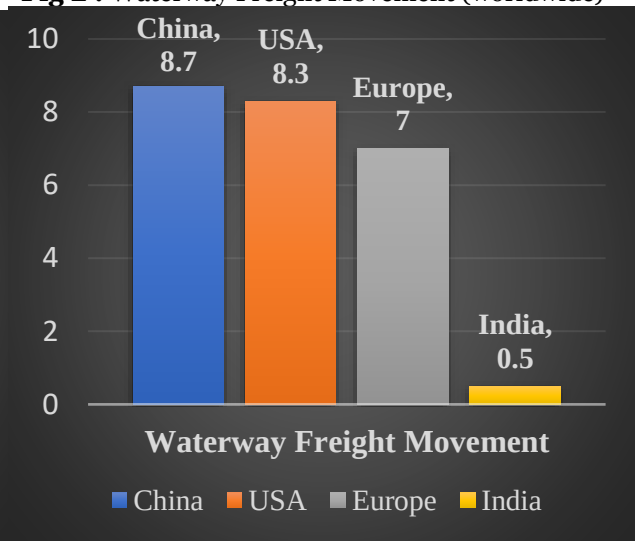


Fig 2 : Waterway Freight Movement (worldwide)



Source: World Bank Report on Water Transportation (2017)

Booth (2001) had opined on the significance of Southeast Asian countries in terms of global trade and commerce and in this regard, northeastern region of India holds a locational advantage in terms of establishing transport connectivity with the emerging economies. Recent Government initiatives such as Act East Policy have been majorly aimed at transport infrastructure investments to boost connectivity of North East States with the Southeast Asian countries. Water Transport measures in this context hold the key considering the rivers Brahmaputra and its tributaries crisscrossing the entire Northeastern Region and enabling connectivity among the remotely located regions. Under the ambit of the Act East Policy, a 150mn USD project has been envisioned for a long-term strategic plan and capacity building of Inland Water Transport (IWT) in Assam (World Bank Report). However, according to Lakshmanan (2011), governments need to justify public spending in terms of economic implications of transport infrastructure investments and thus, there is an immense need to have a robust blueprint of the inland water network design to ensure optimum utilization of public funded infrastructure.

In the context of inland water transport (IWT) investments, a lot depends on building the correct linkages for inland water ports and multimodal/intermodal facilities such as dry ports, container depots and so on. A dry port provides extended connectivity and terminal capacity increase to inland water ports (Roso, 2009). However, out of the 21 dry ports currently being developed in the country, none has been planned for Assam (PIB GoI Ministry of Shipping Notification dt. 08-02-18) while considering the effectiveness of proposed investment in Assam's IWT, identification and development of supporting infrastructure such as dry ports becomes important. This maybe primarily because of the lack of extensive research pertaining to IWT in Assam and adjoining areas. Again, in context of inland water dry port linkages, researchers across the world have dwelled upon multiple optimization models such as hub-and-spoke network systems for an efficient transport system. A hub system minimizes operating costs for the ports and enhances connectivity for the existing water ports.

2. Literature Review

According to Baumeister and Leary (1997), literature review helps in establishing the extent of progress of existing research in addressing a problem. With an aim of investigating the prospect of Inland Water Transport and understanding different methodologies of overcoming the challenges at global, national and regional levels, an extensive search of pertinent literature was carried out. The survey of literature was primarily focused at taking a deep dive into the concept of dry ports and its significance as transport infrastructure. The literature review was also aimed at exploring key design considerations associated with Hub-and-Spoke modelling and how researchers have modelled the same for similar water transport problems. The goal of the review process was to identify key decision factors for location sites of dry ports with respect to existing inland water ports.

2.1 Concept of dry ports and its significance

Exponential growth in international freight transport in Asian countries over this decade has resulted in substantial revenue and environmental impact and this has led to proliferation of intermodal transport for efficient freight transport operations. This has led to substantial development of intermodal interfaces such as

dry ports to complement the existing operations of water ports. Ng and Gujar (2009) defined dry ports as inland transport infrastructure with cargo-handling facilities that support key logistics functions such as consolidation, distribution, temporary storage, customs clearance and thus, facilitating private public institutions for supply chain interactions. Roso et. al (2009) gave the definition of dry port as: "an inland intermodal terminal that is directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport."
Hanaoka and Regmi (2011) examined the emergence of dry ports and the resulting intermodal transport opportunities in selected Asian countries. Establishing transport links, services and strategically locating nodes play key role in developing the intermodal capabilities of a region. However, in the Asian continent, twelve countries are landlocked and thus, the very development of intermodal transport requires setting up of dry ports. Roso et. al (2009) attributes the need of dry ports to enhance rail and road connectivity with seaports so that container transport becomes efficient with utilization of energy efficient traffic modes and provide improved transportation solutions for shippers in the land locked regions of the county. In their study, emphasis was given on extending the dry port concept and defining three dry port categories namely distant, midrange and close. On the other hand, Notteboom & Rodrigue (2009) classified dry ports on the basis of satellite terminals, transmodal centers and inland load centers while Wilmsmeier et. al (2011) divided dry ports on the basis of directional development.

The potential benefits of having dry ports as discussed by different researchers can be summarized as below:
- Easy extension to inland water ports capacity
- Proximity to rail and roadways
- Access to customs and other related documentation facilities
- Easy transfer, distribution, break bulk or consolidation point for freight
- By virtue of modal shifts, dry ports would help in easing traffic congestion and emissions

In case of developed nations such as Europe and North America, dry port developments are envisioned by seaport operators with the aim of easing out capacity constraints, natural barriers and other external elements at seaports for improving accessibility. However, for developing nations and regions like India and South East Asian economies, Ng & Cetin (2012) opined that dry port development is aimed at improving the inland logistics efficiency through measures of freight consolidation for the water ports. In this respect, the critical issue of dry port development is location site selection which determines the degree of efficiency. Some of the key factors in the dry port location analysis are total logistics cost, initial setup cost and qualitative location factors involving supply chain stakeholders such as operators, users and community. Despite the different location analysis models, Nguyen and Notteboom (2016) opines that dry port locations in developing economies might be more 'cluster-oriented' rather than 'supply chain oriented'.

2.2 Hub-and-Spoke Network model along with key design considerations

A Hub-and-Spoke (HS) network model simplifies a network of routes; the central hub connects the different ports by means of the spoke like connecting feeder services (Fakapelea, 2013). For some HS models, liner services connecting regional terminals and hubs are the spokes while at the hubs, the containerized cargo is transferred from one liner to the next one transporting the shipment to the destination. Ideally, the location of hubs are near the centre of transport demand with a motive of minimizing the trip times and distances between origin and destination. Such a system may also be designed to consolidate small loads departing and arriving from multiple directions, thereby improving upon economies of scale in the transportation domain. Effective HS systems customized to a region's specific need improves the quotient of logistics service while ensuring operational efficiencies of resources employed (Wei et. al, 2017). In the global shipping arena, during the last decade, gateway hubs like Yantian-Shenzhen, and Shanghai, transshipment hubs like Algeciras, Malta, and Tanjung Pelepas, and mixed hubs like Dubai, Port Klang, and dominant hub ports like Singapore have revolutionized the Hub-and-Spoke Network designs and brought in higher efficiencies and effectiveness (Lam and Iskounen).
For the hinterland regions of the country, export and import shipments possess uncertain characteristics, owing to which, a direct transport model for the same from inland regions to inland water ports may lead to an increase in logistics costs and misallocation of resources. Wei et. al (2017) proposed a hub-and-spoke logistics network based on a two-stage logistical gravity model for the inland regions in China to cope with the disadvantage of the direct transport model.
However, in order to sustain an efficient HS system, the spokes have to keep up with the improvement of the hub. The dry ports need to keep up with the advancements in the inland water ports and cater effectively as per their throughput. In this context of developing inland water ports dry ports in a hub-and-spoke network design, studies have revealed the following considerations:
- Distance minimization: The relative distance between the dry ports (hubs) and the inland water ports need to be minimal so that the time required to traverse along the spokes are minimized
- Cost minimization: While considering the region, overall initial setup costs need to be low for enabling a low initial investment for the hub ports.

- Ownership: Most of the secondary ports (dry ports) in Africa, America and parts of Asia are under government ownership model. However, such ports being operated in a non-commercial manner are not inclined towards customer service. Thus, privatizing such ports may lead to increased operational efficiencies.
- Customs practices: Frameworks involving customs practices to that particular nation are also one of the considerations concerning the design of a HS network design.
- Equipment maintenance: Dry ports involving transshipment traffic require robust maintenance schedule for the overhauling and container loading equipment. State owned dry ports may suffer from poor equipment maintenance while privatized ones have robust mechanisms for equipment maintenance.

The above considerations play key role in the hub-and-spoke model design concerning inland water and dry port networks.

3. Research Gap

From the literature review, evidence of minimal research has been found for the Indian inland water transport sector and the existing studies have focused mostly on the ecological and environmental aspects. In the Indian context, 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; Aziz et. al, 2018). 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. However, this research is based on empirical data related to sea port network. Thus, there seems to a significant research gap in terms of optimizing the performance of the 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. Research work relating to inland water mostly concentrated on the geological and ecological aspects (Chakravartty and Sharma, 2014; 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. Research problem lies in assessing the present inland water infrastructure system along the two major rivers of North East India and thereafter, coming up with a conceptual framework for inland water port and dry port network using hub and spoke modelling approach.

4. Research Methodology

The methodology comprised of preliminary research carried out to understand the existing inland water infrastructure setup along the two major waterways of Assam- Brahmaputra and Barak. The subsequent work comprised of an extensive literature review pertaining to the various hub-and-spoke network and dry ports. The study primarily focused on exploring the hub-and-spoke network design considerations with respect to connecting Assam's inland water ports. After identification of the key inland water ports, prospective locations of dry port were identified based on factors identified during the review exercise. The locational attributes have been utilized to prepare the conceptual framework for the proposed hub and spoke network model. The results of the study can be validated with actual data which can serve as a decision support system for government agencies, funding bodies and related stakeholders in making justified investment decisions regarding infrastructure development, dry port location selection and supply chain network designs for inland water transport in Assam.

5. Results and Discussion

Based on interaction with officials from Inland Waterways Authority of India and Inland Water Transport-Assam, the operational inland water port locations have been identified along the two major waterways of Assam- Brahmaputra and Barak. These two major rivers crisscross the state and are responsible for majority of the passenger and freight flow. Existing and proposed inland water ports along the selected rivers are considered for the research. Also, ports of call and extended ports of call on the Indo Bangladesh trade protocol route has been given due importance while shortlisting inland water ports for hub-and-spoke network design.

Table 1: Key Inland Water Ports (along the selected waterways)

Brahmaputra (NW 2)	Pandu, Dhubri, Jogighopa. Silghat. Biswanathghat, Neamati, Dibrugarh
Barak (NW 16)	Karimganj, Badarpur, Silchar

Source: iwai.gov.in

For the identified inland water port locations, an assessment was carried out to identify prospective dry port locations which fulfills the criteria as identified through literature review and accordingly, the following locations have been identified. The dry ports shall be located at appropriate hinterland locations supporting multimodal connectivity. Even though few prospective dry ports may be in the vicinity of the inland water ports, it would be regarded as separate facility. Each of the prospective dry port locations have been classified on a scale of high, moderate, and low in terms of fulfilling the identified criteria.

Table 2: Dry Port locations (*prospective*)

Dry Ports Locations (*prospective*) Attributes	**Jogighopa**	**Tezpur**	**Dibrugarh**	**Badarpur**
Easy extension to inland water ports	High	Moderate	Moderate	High
Proximity to rail and roadways	Moderate	High	High	Moderate
Access to Customs	High	Moderate	Moderate	High
Ease of transfer and distribution	Moderate	High	High	Moderate

Source: Researcher's own compilation

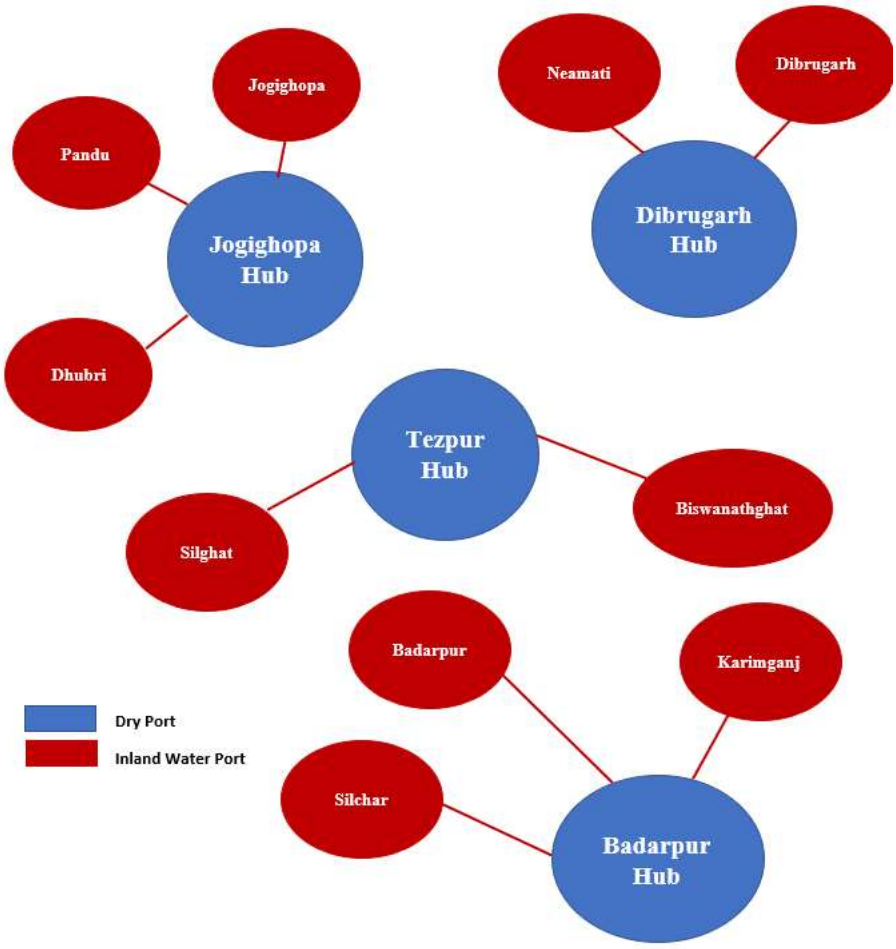
Based on the consideration of relative distances between the selected inland water ports and geographical proximity to rail-road connectivity, the following hub-and-spoke network model of inland water port - dry port has been proposed.

Table 2: Hub-and-spoke model for the port network (*proposed*)

Dry Ports Locations (*prospective*)	**Spokes connecting the inland water ports**
Jogighopa	Pandu, Dhubri, Jogighopa
Tezpur	Silghat, Biswanathghat
Dibrugarh	Neamati, Dibrugarh
Badarpur	Karimganj, Badarpur, Silchar

Source: Researcher's own compilation

Fig 3: Conceptual Framework for the Hub and Spoke network design



Source: Researcher's own compilation

6. Conclusion and Scope of Future Work

The basic premise of a robust water transport network system lies in effectively connecting the different regions by means of a combination of water ports, dry ports and other transport infrastructure. The study yielded substantial evidence of hinterland countries building efficient linkages by means of hub-and-spoke network model. In the Indian context, the Northeast region holds enormous importance in terms of trade proliferation to South East Asian nations and thus, the proposed model involving dry ports and inland water ports held together by the HS model needs to be validated by means of cost benefit calculation. The validated conceptual model shall have profound implications for the Act East Policy which is driving water logistics investments in the region of North East India. Based on validation of the proposed model, similar water transport connectivity models can be replicated for other inland water networks in the country.

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