

Dedicated to
Deuta
Late Pradip Ranjan Baruah

DECLARATION

I, Prayash Baruah, Research Scholar in the Department of Business Administration, School of Management Sciences, Tezpur University, Assam, hereby declare that the thesis titled “Optimization Model for Inland Water Logistics Infrastructure system of River Brahmaputra and Barak” is a bonafide work carried out by me under the guidance of Dr. Tridib R. Sarma. I also declare that neither this work as a whole nor a part of it has been submitted to any other University or Institute for any other degree, diploma or award.



(Prayash Baruah)

Date:12-16-2024

Place: Tezpur

Registration Number TZ189857 of 2018

CERTIFICATE

This is to certify that the thesis entitled "Optimization Model for Inland Water Logistics Infrastructure system of River Brahmaputra and Barak" submitted to the Department of Business Administration, School of Management Sciences, Tezpur University in partial fulfillment for the award of the degree of Doctor of Philosophy in Management Sciences is a record of research work carried out by Mr. Prayash Baruah under my supervision and guidance.

All help and support received by him from various sources have been duly acknowledged.

No part of this thesis has been submitted elsewhere for award of any other degree.


(Dr. Tridib Ranjan Sarma)

Associate Professor

Department of Business Administration

School of Management Sciences

Tezpur University

PhD Supervisor
Department of Business Administration
Tezpur University

Dated 30th of August, 2024

Tezpur

ACKNOWLEDGEMENT

The Ph.D. journey is a challenging yet enriching one and without a supportive ecosystem, it is not possible to sustain the progress. It will be injustice to the success of this thesis if due acknowledgement is not expressed to the people who stood by me throughout the journey. First and foremost, I would like to express my gratitude to my supervisor Dr. Tridib Ranjan Sarma for his constant support and encouragement. I thank him for giving me full freedom to pursue my passion through my ideas and I thank him for his terrific ingenuity in troubleshooting every bottleneck that I faced.

With a sense of immense gratitude, I would like to thank Prof. Mrinmoy K. Sarma and Prof. Anjan Bhuyan who were a part of my doctoral committee at Tezpur University for their valuable suggestions and guidance throughout my journey. I would also like to take this opportunity to express my gratitude to the DRC members for providing me valuable feedback during every progress seminar.


My colleagues and seniors at the Department and University have motivated me immensely to fulfill my dreams and I thank each one of them for their constant support. I would also like to thank the support staff of the department for their help in any administrative matter. I also would like to express my sincere gratitude to Honorable Vice Chancellor's office including the administrative section for all the support extended to me during my PhD tenure.

The major portion of my work was carried out with the cooperation and support of various stakeholders from the Ministry of Ports, Shipping and Waterways, Inland Waterways Authority of India, Inland Water Transport-Assam, academic institutions such as AIT Bangkok, IIT Delhi to name a few and shipping organizations across the North East. I would like to acknowledge my sincere gratitude to all associated experts at the strategic and operational levels who have helped me in getting the much necessary data and support for my research. I would also like to thank officials at the inland water ports and divisional offices for accommodating me and providing access to the requisite information.

Most importantly, I would like to express my extreme gratitude to my pillars of strength- my wife and my little daughter who have made umpteen sacrifices for my research and have been a source of constant motivation for me. I would also like to thank my parents and especially my mother-in-law for their support and blessings. I would also like to

thank my family members, friends and well-wishers for their motivation and support all throughout the journey.

Thanking you all,

A handwritten signature in blue ink, appearing to read 'Prayash', with a long horizontal flourish extending to the right.

(Prayash Baruah)

List of Tables

Table No	Table Title	Page No
Table 1.1	Logistics Market Revenue, by Region, 2020-2023 (US\$ Billion)	2
Table 1.2	LPI 2023 Top 25 countries	4
Table 1.3	Performance Highlights from LEADS 2023	6
Table 1.4	Attribute wise comparison of transport modes	9
Table 1.5	Cost basis of transport modes	10
Table 1.6	Top 10 container ports (<i>globally</i>)	12
Table 1.7	Classification of Sea Transport Challenges	14
Table 1.8	Freight cost comparison for the three modes of transport	17
Table 1.9	Notification of five National Waterways	19
Table 1.10	Categorization of the National Waterways	20
Table 1.11	Classification of Waterways	20
Table 1.12	List of National Waterways (operational)	21
Table 1.13	List of National Waterways (feasible for cargo movement)	22
Table 1.14	Prominent Inland water ports/terminals across major waterways	24
Table 1.15	Indicative list of government owned equipments	25
Table 1.16	Major waterways and routes	32
Table 1.17	Inland water ports along major waterways for freight transport (Assam)	34
Table 1.18	Ports of call and extended ports of call (India) as notified in IBP	35
Table 2.1	Water Transport in terms of economic advantage	45
Table 2.2	Key Challenges of Inland Waterway Transport	46
Table 2.3	Inland Waterway Transport- Global and National Perspective	47
Table 2.4	Inland Water Transport- Regional and Assam studies	47
Table 2.5	Water Transport optimization measures- worldwide	48
Table 2.6	Multi Criteria Decision Techniques for Ranking	49
Table 2.7	Port Ranking and its antecedents	50
Table 4.1	AHP criteria and sub criteria	63
Table 4.2	9-point scale for pairwise comparison in AHP	69
Table 4.3	AHP pairwise comparison Scale (adapted)	70
Table 4.4	Pairwise Comparison Matrix (empty) on MS Excel tool	71

Table 4.5	Standardized Matrix on MS Excel Tool	71
Table 4.6	Consistency calculation on MS Excel Tool	72
Table 4.7	Dry Port attributes comparison (region specific)	76
Table 4.8	Hub-and-spoke model for the port network (region specific)	77
Table 5.1	Key Inland Water Ports (for ranking)	79
Table 5.2	Coding of the Criteria/Sub Criteria	83
Table 5.3	Pairwise Comparison matrix for Sub criteria of Criterion 1	84
Table 5.4	Pairwise Comparison (standardized) matrix for Sub criteria of Criterion 1	84
Table 5.5	Calculation of weights and ranks for Sub criteria of Criterion 1	85
Table 5.6	Pairwise Comparison matrix for Sub criteria of Criterion 2	86
Table 5.7	Pairwise Comparison (standardized) matrix for Sub criteria of Criterion 2	86
Table 5.8	Calculation of weights and ranks for Sub criteria of Criterion 2	86
Table 5.9	Pairwise Comparison matrix for Sub criteria of Criterion 3	87
Table 5.10	Pairwise Comparison (standardized) matrix for Sub criteria of Criterion 3	87
Table 5.11	Calculation of weights and ranks for Sub criteria of Criterion 3	87
Table 5.12	Pairwise Comparison matrix for Sub criteria of Criterion 4	88
Table 5.13	Pairwise Comparison (standardized) matrix for Sub criteria of Criterion 4	88
Table 5.14	Calculation of weights and ranks for Sub criteria of Criterion 4	89
Table 5.15	Pairwise Comparison matrix for Sub criteria of Criterion 5	89
Table 5.16	Pairwise Comparison (standardized) matrix for Sub criteria of Criterion 5	90
Table 5.17	Calculation of weights and ranks for Sub criteria of Criterion 5	90
Table 5.18	Pairwise Comparison matrix for the Main Criteria	91
Table 5.19	Pairwise Comparison (standardized) matrix for Main Criteria	91
Table 5.20	Calculation of weights and ranks for Main Criteria	91
Table 5.21	Random Index (RI) Table	93
Table 5.22	Consistency Check for Pairwise Comparison of Criterion 1 sub criteria	93
Table 5.23	Consistency Check for Pairwise Comparison of Criterion 2 sub	93

	criteria	
Table 5.24	Consistency Check for Pairwise Comparison of Criterion 3 sub criteria	94
Table 5.25	Consistency Check for Pairwise Comparison of Criterion 4 sub criteria	94
Table 5.26	Consistency Check for Pairwise Comparison of Criterion 5 sub criteria	94
Table 5.27	Consistency Check for Pairwise Comparison for main criteria	95
Table 5.28	Calculation of global weights for the twenty sub criteria	95
Table 5.29	Global ranks of the sub criteria	97
Table 5.30	Data Details for calculating sub criteria score for the inland water ports	98
Table 5.31	Stakeholder scores (out of 10) for sub-criteria IE, PM, SM and CE	99
Table 5.32	Distance measurement (in kms.) for sub-criteria HR, DP and PC	100
Table 5.33	Area measurement for sub-criteria TA, TS and PD	101
Table 5.34	Time measurement for sub-criteria BW, BT and WC	102
Table 5.35	Cost estimation for sub-criteria DC, HC, LU and TX	103
Table 5.36	LAD information (average for the year 2023) for sub-criteria WD	104
Table 5.37	Port Equipment information for sub-criteria PE	104
Table 5.38	Loading/Unloading rate (2023) for sub-criteria LE	105
Table 5.39	: Consolidated sub-criteria wise comparison of the inland water ports	106
Table 5.40	Calculation of total scores for the selected inland water ports	107
Table 5.41	Final Ranking of the inland water ports	108
Table 6.1	Key Inland Water Ports as feeder ports	109
Table 6.2	Prospective dry port locations (hubs)	110
Table 6.3	Distance Matrix for inland water and dry port alternates	111
Table 6.4	1 Hub Scenario Model (with existing dry port at Amingaon)	112
Table 6.5	1 Hub Scenario Model (alternate)	112
Table 6.6	2 Hub Scenario Model	113
Table 6.7	3 Hub Scenario Model	114
Table 6.8	3 Hub Scenario Model (alternate)	114
Table 6.9	3 Hub Scenario Model (with existing dry port)	115

Table 6.10	Comparison of cumulative distances for the simulated networks	116
Table 6.11	Hub-and-spoke model for the port network	116

List of Figures

Figure No	Figure Title	Page No
Figure 1.1	Logistics Market Share, by Region, 2023	3
Figure 1.2	Parameter wise performance highlight of Assam from LEADS 2023	7
Figure 1.3	Transportation services market size, 2023 to 2032 (USD Trillion)	8
Figure 1.4	Inland waterway lengths of G20 member countries* (in kms.)	15
Figure 1.5	Total and Navigable Length of Inland Waterways- State wise (in kms.)	18
Figure 1.6	Total no. of National Waterways- State wise*	19
Figure 1.7	Cargo Traffic on inland waterways (in Million Metric Tons) for last 10 years	22
Figure 1.8	Cargo Traffic comparison on Major NWs (in Million Metric Tons- MMT)	23
Figure 1.9	Major Commodity/Cargo Type on NWs for FY 2022-23	23
Figure 1.10	Organization Chart- Ministry of Ports, Shipping and Waterways	27
Figure 1.11	Organisation Chart- Inland Waterway Authority of India (IWAI)	28
Figure 1.12	Financial Outlay of National Waterway Development Projects (in Crores)	29
Figure 1.13	Movement of cargo (in Tonnes) on India-Bangladesh inland waterways	30
Figure 1.14	Route Map of the Brahmaputra (NW-2)	33
Figure 1.15	Route Map of the Barak (NW-2)	33
Figure 1.16	Organisation Chart- IWAI Guwahati Regional Office	36
Figure 4.1	AHP Methodology	61
Figure 4.2	AHP Fundamental Framework	62
Figure 4.3	AHP Conceptual Framework for inland water port ranking	66
Figure 4.4	Hub and Spoke Theoretical framework	76
Figure 5.1	Respondent profile for the AHP questionnaire	82
Figure 5.2	Weights for Sub criteria of Criterion 1	85
Figure 5.3	Weights for Sub criteria of Criterion 2	86
Figure 5.4	Weights for Sub criteria of Criterion 3	88
Figure 5.5	Weights for Sub criteria of Criterion 4	89

Figure 5.6	Weights for Sub criteria of Criterion 5	90
Figure 5.7	Weights for the Main Criteria	92
Figure 5.8	Global weights of the sub criteria	96

Glossary of Terms/Acronym

Acronym	Description
AEP	Act East Policy
AHP	Analytic Hierarchy Process
ASEAN	Association of South East Asian Nations
CAGR	Compound Annual Growth Rate
CAR-D	Cargo Data Portal, IWAI
CI	Consistency Index
CLAP	Comprehensive Logistics Action Plan
CR	Consistency Ratio
DEA	Data Envelopment Analysis
DWT	Deadweight tonnage
EXIM	Export Import
FY	Financial Year
GDP	Gross Domestic Product
HS	Hub and Spoke
IBP	Indo Bangladesh Protocol
ICC	International Chamber of Commerce
ICT	Information and Communication Technologies
ISO	International Organisation for Standardization
IWAI	Inland Waterways Authority of India
IWT	Inland Water Transport
JMVP	Jal Marg Vikas Project
LEADS	Logistics Ease Across Different States
Lo Lo	Load on Load off
LPI	Logistics Performance Index
MCDM	Multi-Criteria Decision-Making
MMLP	Multimodal logistics park
MMT	Million Metric tons
NAFTA	North American Free Trade Agreement
NLP	National Logistics Policy
NW	National Waterways
PIB	Press Information Bureau

RCEP	Regional comprehensive economic partnerships
RI	Random Index
RITES	Rail India Technical and Economic Service
Ro Ro	Roll on Roll off
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goals
UNICTRAL	United Nations Commission on International Trade Law