INFLUENCING THE SHIFT OF TRAVELERS TO INLAND WATER TRANSPORTBY ENHANCING ITS ATTRACTIVENESS

PROJECT REPORT

Submitted by

MEENU G KRISHNAN

REG. NO.: TKM20CETE09

to

A P J Abdul Kalam Technological University

in partial fulfilment of the requirements for the award of the Degree

of

Master of Technology

in

Transportation Engineering

DEPARTMENT OF CIVIL ENGINEERING

T.K.M. College of Engineering, Kollam

July 2022

DECLARATION

I undersigned hereby declare that the project report "Influencing the Shift of Travelers to Inland Water Transport by Enhancing its Attractiveness", submitted for partial fulfilment of the requirements for the award of degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a bonafide work done by me under supervision of Dr. Munavar Fairooz C. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Kollam MEENU G KRISHNAN

07-07-2022

DEPARTMENT OF CIVIL ENGINEERING

T.K.M. COLLEGE OF ENGINEERING, KOLLAM

CERTIFICATE

Certified that this report entitled **"INFLUENCING THE SHIFT OF TRAVELERS TO INLAND WATER TRANSPORT BY ENHANCING ITS ATTRACTIVENESS"** is the report of the project (Phase I) presented by **MEENU G KRISHNAN, Reg. No.: TKM20CETE09** during **2021-2022** in partial fulfilment of the requirements for the award of the Degree of Master of Technology in Transportation Engineering of the A P J Abdul Kalam Technological University.

Guide	Coordinator	Head of the Department
Dr. Munavar Fairooz C Assistant Professor Dept. of Civil Engineering TKMCE, Kollam	**Dr. Kavitha Madhu** Associate Professor Dept. of Civil Engineering TKMCE, Kollam	**Dr. Sajeeb R.** Professor Dept. of Civil Engineering TKMCE, Kollam

ACKNOWLEDGEMENT

I take this opportunity to express my deep sense of gratitude and sincere thanks to all who helped me to complete the project successfully.

I am deeply indebted to my guide, **Dr. Munavar Fairooz C,** Assistant Professor, Department of Civil Engineering for his excellent guidance, positive criticism and valuable comments.

I am greatly thankful to my project coordinator, **Dr. Kavitha Madhu**, Associate Professor, **Prof. Meenu Tomson**, Assistant Professor and **Prof. Jijin A,** Assistant Professor, Department of Civil Engineering for their constant supervision as well as for providing necessary information regarding the project.

I am greatly thankful to **Dr. Sajeeb R**, Professor, Head of the Department of Civil Engineering for his kind support.

Finally, I thank my parents and friends who directly and indirectly contributed to the successful completion of my project.

MEENU G KRISHNAN

ABSTRACT

Vehicle volume on roadways has rapidly increased over the past few decades due to increasing urbanisation. Limited road capacity and rising vehicular traffic in emerging nations like India have an adverse impact on urban life in terms of externalities like traffic congestion, vehicular emissions and road accidents to name a few. It is time for rejuvenating existing potential modes of transport other than road transport infrastructure to develop a sustainable transportation system. Inland Water Transport is known to be the cheapest mode of transport, has low environmental pollution agents and low carbon emission. However, the lack of service quality results in poor patronage in IWT. The present study documents a rational approachto shifting travelers to IWT by enhancing its quality and attractiveness. A travel behavioural approach is proposed which includes the development of a mode choice model and generalized cost model and identification of operational viability of IWT with the improvements in service quality. The outcomes of this study will be crucial for enhancing IWT services in Alappuzha, Kerala, India. The methodology and strategy given shall be replicated in other areas to develop IWT as a demand management device, despite the fact that the study is case-specific.

Keywords: *Inland water transport, Travel behaviour analysis, Generalised cost, Scenario analysis*

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
INTRODUCTION

1.1 General

Transportation plays a crucial role in the development of any country and is a potent accelerator for an expanding economy. Growth in the population and high demand for transportation both directly and indirectly increase the number of vehicles. It is one of the most vexing urban issues, having a considerable effect on the quality of community life in terms of congestion, delay and emissions (Ghazali, 2019). Conventional physical constraints and space restrictions have enduring impacts on transport infrastructure. Therefore, the development of road infrastructure alone is no longer a sustainable solution (Rahul and Verma, 2018). To depreciate the ill effects of the surge in vehicular volume, it is necessary to identify alternate demand management strategies. Increasing the usage of public transportation has become a strategy for reducing the number of vehicles on the road, which will alleviate traffic congestion and emission levels (Cheranchery & Maitra, 2017). Sustainability also becoming an important aspect of the transportation sector. Hence, it is important to explore and regularize sustainable alternative modes of transport in addition to road road-based public transport systems (Sys et al., 2020; Wojewodzka-Krol,2018). Utilizing waterways for transportation of supplies and people directly support economic growth and sustainable development. Due to its intrinsic performance, inland water transportation uses less energy and emits fewer emissions per tonne of cargo than other modes, increasing sustainable development.

As one of the largest worldwide transportation networks, waterways are in third place behind railroads and roadways. Lakes, rivers, and canals are examples of navigable waterways, which are bodies of water that may be utilised for both passenger and freight transportation. There is more than 600000 km of navigable waterways worldwide, with the biggest networks found in China, Russia, Brazil, and the United States (Lambert, 2010).

India is home to a vast system of inland waterways including 111 nos. of National Waterways which cover a total length of 20,162.5 km spanning across the nation (Ministry of Ports, Shipping & Waterways Transport Research Wing, 2020). In Kerala, waterways have long been a significant means of transportation. There are around 1,900 kilometres of navigable waterways, and about 54% of those waterways are navigable rivers. The 41 westward-flowing rivers and backwaters in Kerala are an essential component of the state's inland water transportation network. Inland waterways in the State, including the West Coast Canal, travel through densely inhabited areas. Accordingly, the development of IWT is considered to be vital arteries for the transportation and communication of rural people (Sarkar et al., 2007).

1.2 Problem Statement

Although the State has plenty of resources for waterway networks, hardly 20% of them are in usable condition (Praveen & Rajakumar, 2015). The remaining sections become neglected of their periodic maintenance, thereby losing their charm as the prime-mover of men and materials. Only tourist boats have found some use in certain stretches of backwaters and wider canals. For increased social, economic, and environmental benefits, it is crucial to investigate the potential integration of IWT into the nation's mobility strategy.

The most important metrics for measuring any transportation mode's success are guaranteed patronage and operational viability (Hess, 2017). But despite several endeavours and advantages, the IWT of many states in the nation frequently fails to draw enough patronage to ensure operating profitability (Sarkar et al., 2007). This forces the government to regularly stop providing different IWT services in regions like Kollam and Alappuzha. Therefore, it is crucial to look into the causes of the IWT service's low usage and operational viability.

The diminishing demand for inland water service may primarily be attributed to the poor service quality in terms of long waiting times, delay, and lack of information, to list a few. In order to increase the benefits to society, it is crucial to improve the quality of inland water service with the right design. But any improvement of the service is associated with a cost to the operator. As most of these services are running on heavy subsidies, the Government is struggling to maintain the current service let alone the service improvement. Increasing the fare of inland water service without a substantial improvement may burden the users which might reduce the demand for service. The question is how to construct an inland water service while taking into account the accompanying costs and benefits. The present work demonstrates a rational approach to address these concerns by improving the service characteristics as per the requirements of users considering the costs and benefits associated with the service.

1.3 Objectives

The objectives of the proposed study are as follows:

- Travel behaviour analysis for the development of Mode choice model and Generalized cost model based on IWT in Alappuzha.
- Generation of alternative improvement scenarios for IWT.
- Evaluation of alternative scenarios and recommendations for improvement of IWT.

1.4 Scope

The scope of the study is limited to IWT accessible region in Alappuzha, Kerala, India. Even though the study is location-specific, the methodology is replicable to enhance IWT in additional places as well as to enhance services in diverse contexts. The responses for data collection were limited to those travellers who have accessibility to IWT.

There are numerous quantitative and qualitative attributes which describe the service quality of IWT. By considering the importance of attributes and cognitive burden on the respondents, only eight attributes were considered in the current study namely fare, in-vehicle travel time, headway, span, safety and security, transfer time, crowding level and travel information.

1.5 Research Significance

In India, traffic congestion has significantly worsened. Urban mobility was impacted by congestion, which can have a significant negative impact on both the quality of life and the economy. To overcome these issues, a mode shift is instrumental. From past studies (Sharma, 2017; Joseph, 2012), it is found that Inland water transportation has the potential to develop into a public transportation system if initiatives are taken for its improvement. Inland water transportation has a great deal of significance in tourism also. The initiatives taken by the Government including the Integrated Urban Regeneration and Water Transport System Project (IURWTSP) will help to broaden the application of IWT. But every step of the improvement should be in accordance with the need of the users. Hence to expand the wing of IWT successfully, it is necessary to analyse the travel behaviour of travellers so that improvements in service quality can be facilitated concerning it.

There are currently no studies on how travellers perceive inland water service in the context of Alappuzha city. The current work seeks to analyse the travel behaviour of travellers for the creation of a generalised cost model. Additionally, this study analyses various scenarios for enhancing inland water service to identify the most viable improvement scenarios.

1.6 Methodology

To accomplish these objectives, the following steps have been taken;

- **Literature Review**: An investigation was done to understand the current scenario of IWT in India as well as in Kerala. A thorough literature survey helped to identify the factors which are relevant to the service quality of IWT and the various challenges faced by IWT.
- **Data Collection:** A survey instrument was developed to collect the stated preference and revealed preferences of travellers. To collect the stated preference data, 16 choice sets were developed. With pilot research, the questionnaire's suitability was evaluated. From Alappuzha, 400 responses in total were gathered.
- **Database Development and Analysis**: The responses were coded to develop the database for model development. Using NLOGIT software the Joint SP-RP model was developed and willingness to pay estimates were done. To recommend an improvement scenario for the IWT service, a scenario analysis based on a cost-benefit analysis was executed.
- **Interpretation of Results and Discussion:** The results obtained are analysed and compared with past studies in a similar context. Based on the results, recommendations are made.

1.7 Organization of the Report

The report consists of 6 chapters as depicted in Figure 1.1

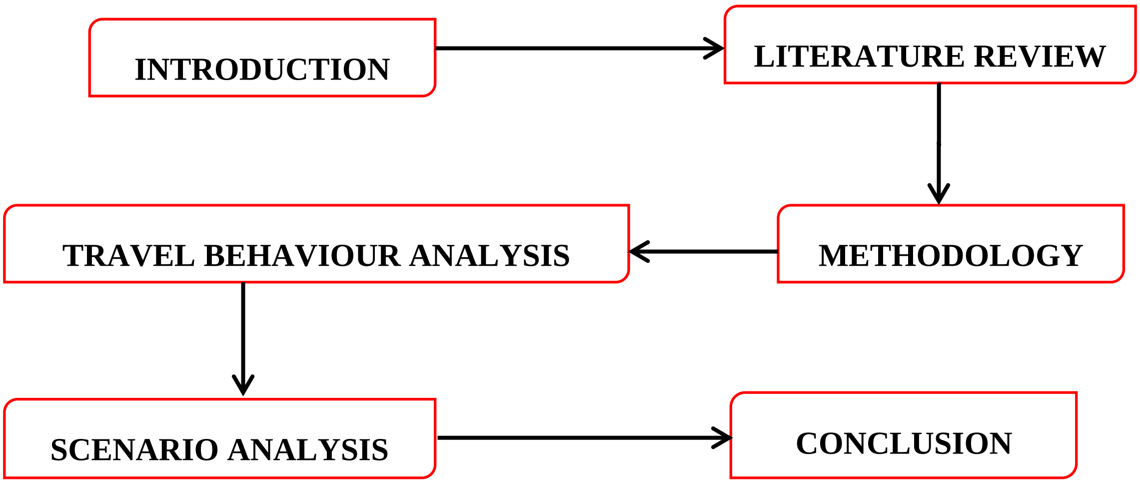

Figure 1.1: Organization of the Report

Chapter 1 (INTRODUCTION) deals with the background of the study along with the problem statement, research objectives and scope, the significance of the study and the basic methodology adopted for the study.

Chapter 2 (LITERATURE REVIEW) reports the literature survey on various factors about IWT and the theory behind travel behaviour analysis and scenario analysis.

Chapter 3 (METHODOLOGY) discusses the methodological framework of the study which includes questionnaire development, data collection method and database development followed by MNL model development and scenario analysis.

Chapter 4 (TRAVEL BEHAVIOUR ANALYSIS) involves the mode choice model development, willingness to pay estimation and generalised cost model development.

Chapter 5 (SCENARIO ANALYSIS) reports 12 scenarios considered for the analysis, the cost and benefit calculation and the selection of the most viable scenario.

Chapter 6 (CONCLUSION) gives a summary of the results, interpretation and recommendations for the improvement of IWT.

CHAPTER 2

LITERATURE REVIEW

2.1 Inland Water Transport in India

IWT is an important mode of navigation from ancient times which played an important role in the development of the country. As per the report of the Ministry of Ports, Shipping & Waterways Transport Research Wing, Govt. of India on statistics of inland water transport (2019-20), the percentage of navigable length to the total length of waterways of different states are shown in Figure 2.1.

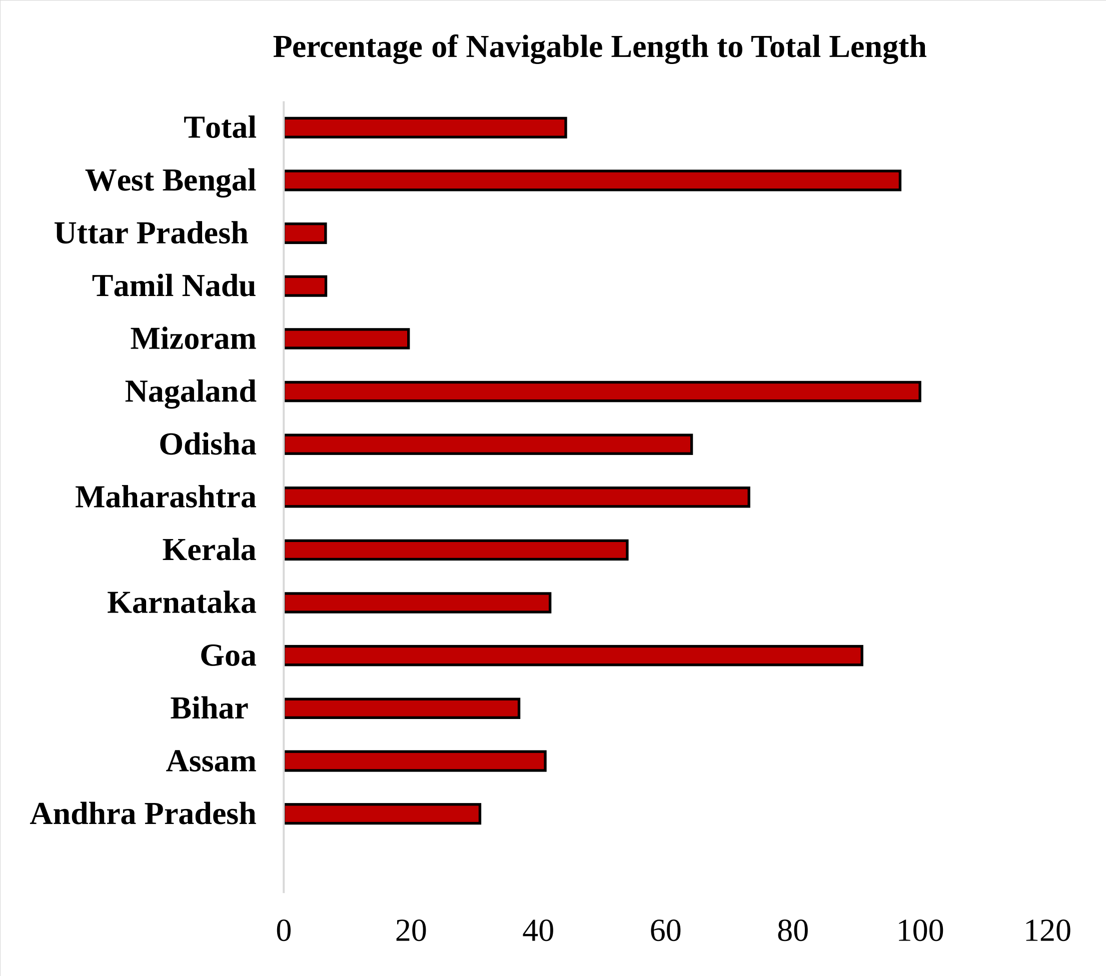

Figure 2.1: The Percentage of Navigable Length to The Total Length of Waterways of Different States in India
(Source: Ministry of Ports, Shipping & Waterways Transport Research Wing)

It is observed that West Bengal, Nagaland, Goa, Maharashtra and Kerala are the states with good inland water transport prospects. The development of railways and road networks made a dip in the growth of IWT in India in the late 20th century (Kerala State

Planning Board, 2017). Still, considering its numerous advantages, it was deemed that this area needs to be developed properly. The establishment of the Inland Waterways Authority of India (IWAI) is proof of the same. According to constitutional rules, the Central Government is just authorised to regulate those rivers that have been designated as National Waterways; all other waterways continue under the control of the relevant State Legislatures. The inland navigation waterways in India are shown in Figure 2.2.

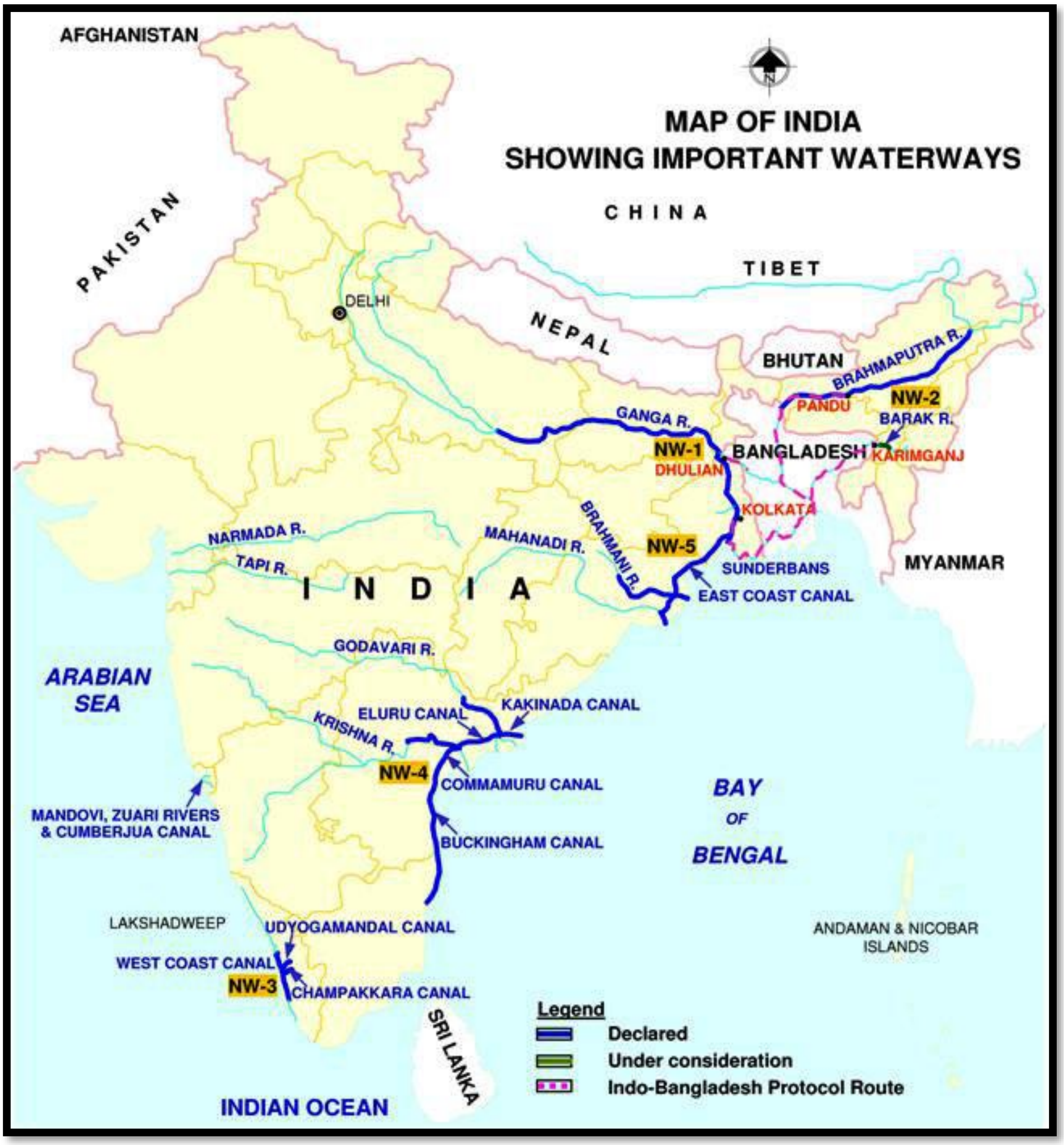

Figure 2.2: Inland Navigation Waterways in India

(Source:https://www.insightsonindia.com/national-inland-waterways /)

2.2 Inland Water Transport in Kerala

In Kerala, backwaters and rivers comprise the inland water transportation system. This has played a major role in transportation right from the olden period. According to the Kerala State Planning Board's report, which was based on the recommendations of the working group on inland water transport for the thirteenth five-year plan, Kerala has 41 rivers that flow westward alongside numerous backwaters as part of an 1895 km-long network of inland waterways. The West Coast Canal (WCC) system, which spans a distance of approximately 560 km, begins in Kovalam and continues all the way to Hosdurg in the north. The Central Government has already designated the Kollam-Kottapuram segment (168 km), the Champakkara (14 km), and the Udyogamandal canals (23 km) as National Waterway-3 (NW-3) and they are essentially fully operational. Recently, the Central Government announced that NW-3 would be extended between Kottapuram and Kozhikode (160 km). Moreover, the Central Government designated four canals as national waterways in April 2016: Alappuzha-Changanassery (28 km), Alappuzha-Kottayam- Athirampuzha (38 km), and Kottayam-Vaikom (42 km). With more than 50 boats, the State Water Transport Department is able to connect the people who live in Kuttanad's flooded areas.

2.3 Key Challenges in Inland Water Transport

Many countries across the world have a variety of deep rivers that can sustain inland water travel. Despite its numerous benefits, IWT is the method of transportation that is developing the least slowly when compared to roads and rail for a variety of reasons. The Volta Lake Transport Company (VLTC) -managed Ghanaian Inland Water Transport system was examined by Solomon et al., (2020). The report claims that Ghana encounters a number of challenges that can be categorised as administrative, commercial, logistical, and technology challenges. Due to lesser clientele and an unbalanced cargo flow, higher shipping costs are imposed for commodities transported by waterways as opposed to roads, making the inland water transport service unappealing. Logistic and Infrastructural Constraints like paucity of necessary cargo handling machinery on shore and in boats, older and rickety ferries, and lack of proper warehouses and storage systems result in uneconomical cargo delivery and damage to some perishable cargo. Technical limitations are exacerbated by tree stumps, deposition, and recurrent dredging. Additionally, some routes inherently lack a sufficient water level, which precludes the ferries from working year-round (Figure

2.3). Despite the fact that transport volumes are rising significantly overall, the road transport industry seems to be benefiting the most from this development (Sys et al., 2020). They discovered that overcapacity, unchecked expenses, and fluctuating freight rates were the primary reasons why the European inland navigation industry was squandering the competition for tonnage and market dominance with the other forms of transport.

Figure 2.3: Constraints of IWT (Source: Sys et al., 2020)

The general key concerns or obstacles in India's inland water transport sector were categorised by Praveen and Jegan (2015) as technical, regulatory, geopolitical, financial and integrated development approach issues (Figure 2.4). Inadequate depth, inadequate air draft, shortage of IWT vessels and lack of terminals are the major technical issues found in India. One of the main obstacles to successful operations in waterways is a lack of infrastructure including river information systems, night navigational capabilities, and markings. The system's expansion is hampered by the lack of multimodal transport hubs in inland water transport corridors and accurate mapping of waterways and industrial clusters. Rangaraj & Raghuram (2006) and Praveen & Rajakumar (2015) both identified the need for vessels and related infrastructure as well as adequate depth relative to the draught of the vessels in their studies on the viability of IWT in Kerala.

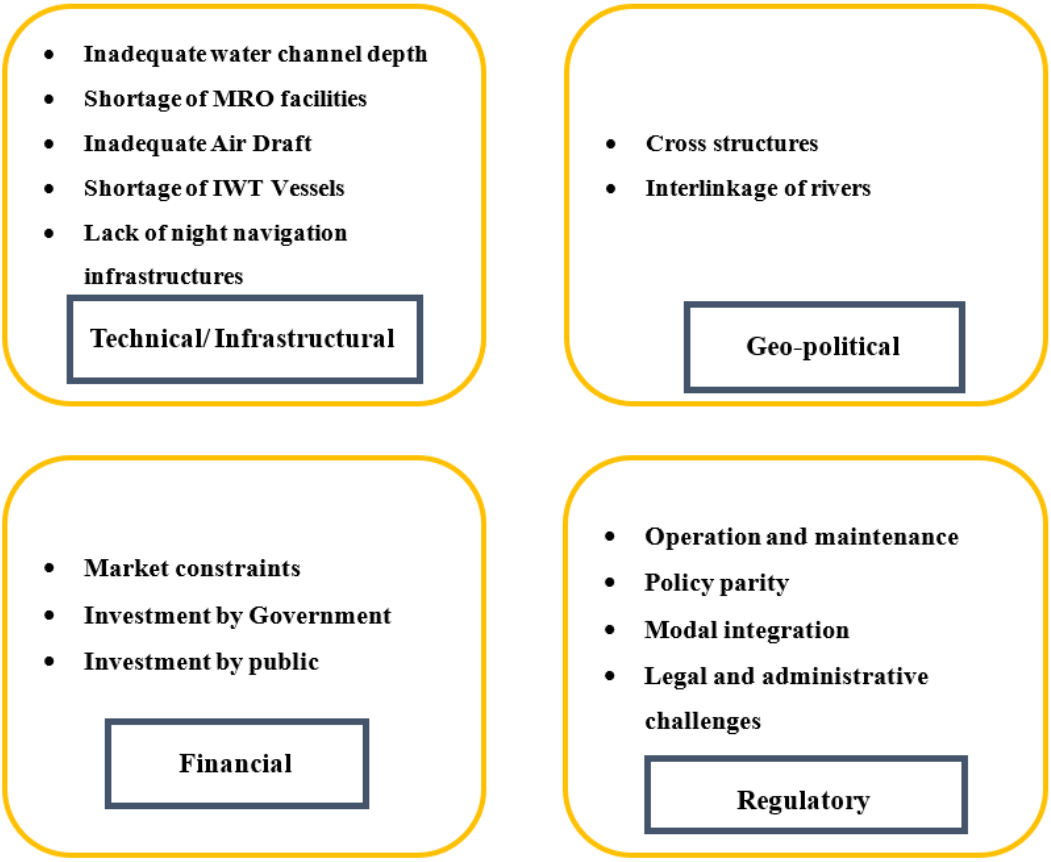

Figure 2.4: Major challenges faced by IWT in India
(Source: Praveen and Jegan, 2015)

2.4 Recommendations for Improvement of Inland Water Transport

Several studies which analyse the challenges faced by IWT also made some recommendations for the improvement of the same. Equipment for handling goods, various storage facilities, and carrying vessels all need to be enhanced for places where there could be cargo flow (Solomon et al., 2020). They also pointed out the need for modern steam engines and warehouses. It is advised that a legal agency be established to organise, coordinate, and manage IWT operations across the nation (Praveen and Jegan, 2015). In line with the above observations, Praveen & Rajakumar (2018) suggested combining inland terminals with a new automated Ro-Ro system, so that the cost of transhipment can be minimised to a great extent. Sys et al., (2020) formulated five pathways for the improvement of the market share of IWT in the European inland navigation sector such as technological/operational innovation, pooling resources, longer-term finance, increased collaboration throughout the industry and flexible regulation that adheres to contemporary laws. Recurrent dredging is an essential part of maintaining the IWT system because it can stop a reduction in water level caused by silt from various river systems. To ensure the interest of navigation, multipurpose hydro projects that are planned for the long term are required. Infrastructure investment by governments and corporate organisations is found to be less in the inland water transport sector than in the road and rail sectors (Praveen and Jegan, 2015).

It can be shown from kinds of literature that the majority of research tends to concentrate on the "infrastructure" concern. How is the system constructed? How will new operations enhance the organization and its utilisation, and what investment is required? Although the answers to these questions are crucial, the economy's limitations may still be the main challenge. In addition to moving cargo, IWT can be used successfully as a passenger transport method. One of the main challenges in the efforts to improve IWT is making it more appealing. High-quality public transportation networks with the capacity to draw more passengers must be established (Khan et al., 2021).

2.5 Service Quality Indicators of Transportation Service

Focus interest on the needs and expectations of customers is essential in the development of any public transport system to increase ridership. Hence user perception studies play an important role in transport planning (Cheranchery & Maitra, 2017). For transportation infrastructure planners, analysis with transport quality indicators would be huge assistance and guidance in optimising the transportation network and determining whether it runs efficiently enough or needs some changes, alterations, and route planning in some locations (Vabuolyte & Uspalyte-Vitkuniene., 2018). The importance given by the travellers to each attribute and their satisfaction with each factor will help to develop the service facilities as per their requirements.

The service quality factors influencing customer satisfaction for bus transit were examined by Eboli & Mazzulla (2007). The number of bus stops along the route, the distance to the bus stops, the frequency of service, the promptness of the buses, the availability of waiting shed and benches at bus stops, bus crowding, the neatness of the interior, the cost of the service, the availability of information, the security of the service, the helpfulness of the staff, the use of environmental-friendly vehicles, and the physical condition of the bus stops have all been taken into account. Vabuolyte & Uspalyte-Vitkuniene, (2018) selected attributes such as availability accessibility, information, time, customer care, comfort, security and environmental impact for evaluating the service quality of public transport in Klaipeda city.

Using Important Performance Analysis, Cheranchery et al., (2020) assessed the bus service priority issues in Kerala in the order of significance for the pre-pandemic and post-lockdown scenarios based on commuters' importance and satisfaction. Safety, bus stop facilities, cleanliness, crowding, fare, headway of service, in-vehicle travel time, number of transfers, onboard information, pedestrian environment, pre-trip information, security, span, staff behaviour, and ticketing system were the attributes selected for the study.

IWT sector hasn’t much explored the benefits of user perception studies. Marquez et al., (2014) conducted an analysis of how passengers' views of the service's comfort and safety affect their decision to travel by river. By taking into account indications like hull condition and safety conditions that were displaying the latent variable safety, a stated preference poll was carried out. Similar to how the latent variable space manifests in indications like seat quality, legroom, boat placement, and punctuality. Other factors, like the degree of caution, exercised when operating, the education level of the captain, user behaviour, and journey time, may also be related to latent variables or both.

Kalahe et al., (2020) want to investigate the perception of users of an understudied Inland Water Transit (IWT) system in Sri Lanka. The results suggest that service issues like cost, connectivity, and punctuality are less significant when taking IWT into account as a mode of public transportation than the latent factor "Amenities," which includes indicators like the availability of service information, customer service, online facilities, multiple counters, etc.

In a case study in Kerala, India, Cheranchery et al., (2021) carried out a thorough investigation to pinpoint potential intervention areas for improving the appeal of inland waterway transportation (IWT). Safety, security, employee behaviour, cleanliness, crowding level, transfer time, number of transfers, punctuality, headway, in-vehicle travel time, span of service, fare, ticketing system, wayside information, pre-trip information, onboard information, access egress time, Boat jetties facilities, entertainment, washroom availability, accessibility, food availability, type of seating, and type of flooring are the attributes taken into consideration. To find the regions that needed improvement for IWT, they used an important performance study with a fuzzy c means clustering approach. Accordingly, areas of intervention of IWT in the order of priority based on users' perception were obtained as (1) accessibility, (2) Boat jetties facilities (3) wayside information (4) headway (5) span of service (6) transfer time (7) on-board information (8) pre-trip information (9) availability of food (10) type of flooring (11) entertainment, and (12) availability of washroom.

Although these kinds of studies are contributory in identifying the focus areas for improving the quality of transportation service, a limited investigation was carried out to study the possible impact of any improvements on the patronage or operational viability aspects of transportation service. Peculiarly no investigation was carried out to study the improvement of service characteristics of inland water transport service based on the requirements of travellers and its net effect on improvement in ridership along with operational viability.

2.6 Travel Behaviour Analysis

The effectiveness of transportation infrastructure has a vital role in the development of society and the economy of every country. The planning of transportation infrastructures based on the characteristics of people using the transportation system is imperative for transportation planners and policymakers. In particular travel demand models are used to anticipate travel behaviour and the utilisation of transportation services in a variety of socioeconomic contexts and for various transportation service designs (Bhat & Koppelman, 1999).

Insights into how travellers perceive various travel attributes in the contexts of public and private transportation are provided by a substantial number of researchers. These studies are beneficial for assessing the effectiveness and improving the transport services based on travellers' points of view (Diana, 2012). Travel behaviour analysis examines how travellers behave in relation to various travel-related perspectives using conceptual and analytical frameworks (Axhausen, 2007). There are different approaches in travel behaviour analysis viz. activity-based approaches, attitudes, and approaches using segmentation, based on experiments and approaches involving the choices of travellers (Golob & Golob, 1983).

2.6.1 Discrete mode choice models

As reported by Golob & Golob (1983) in the choice approach of travel behaviour analysis, the focus is primarily on the choices of the individuals. In the transportation context, the discrete choice models predict a traveller's choice of one alternative over a finite set of alternatives (Konig & Grippenkoven, 2020). They forecast how travellers will make decisions. The choice model determines the relative influence of numerous qualities of alternatives and characteristics of decision-makers when they make choice decisions since each alternative is characterised by a variety of attributes and their levels. Travel data from revealed and expressed preference surveys can be used to estimate discrete choice demand models (Guzzo & Mazzulla, 2004).

2.6.2 Types of data

In general, two types of preference data are used in the field of behavioural analysis i.e., Revealed Preference (RP) data and Stated Preference (SP) data. RP data represents data collected on choices that are made in a current market (Kono et al., 2018). Empirical estimation of individuals' preferences has received much attention in the literature. Different fields viz. health, tourism, and transportation make use of these preference evaluation techniques. Stated-Preference (SP) and Revealed-Preference (RP) approaches or combinations of these approaches have been used (Arentze & Molin, 2013; Basu & Maitra, 2006; Johnson, 2013).

RP data represents a collection of data on real-life choices where individual decision-makers are bound to market constraints (Cheranchery & Maitra, 2019). Nevertheless, it is restricted to the current situation and is not appropriate for researching traveller preferences under possible future circumstances. Herein lies the importance of SP data. In the SP experiment, values of each attribute can be combined systematically to disclose new opportunities (i.e., new travel scenarios) concerning the current conditions (Basu & Maitra, 2006). Both design-based bias and discrepancies between people's actual choices and SP choices plague SP data.

In order to take full advantage of the benefits of SP and RP datasets, researchers have developed a variety of estimating techniques for using a combination of SP and RP data sets (Cheranchery and Maitra, 2019).

2.6.3 Discrete choice experiment (DCE)

The collection of stated preference data is carried out through an important step called the discrete choice experiment. The approach of creating certain combinations of attributes and levels that respondents assess in response to the choice questions is known as experimental design (Hensher et al., 2005; Johnson et al., 2013; Terris-

Prestholt, 2019). This is an attribute-based survey method for measuring the utility associated with each attribute.

The keystone in the DCE is the development of choice sets which contain hypothetical scenarios of two or three alternatives. The different combinations of attribute levels of each alternative will give rise to the choice set (Perez-Troncoso, 2020). Hence each alternative is described by a set of attribute levels. The respondents are asked to select a particular alternative from the choice set so that their preferences of attributes will reveal through their choice. This theory states that, a person thinking rationally would assess the range of available options and select the option that provides the highest relative utility (Mangham et al., 2009).

There are two general types of DCEs: 1) unlabelled and 2) labelled (Klojgaard et al., 2012). Unlabelled DCEs use generic titles (A and B) for the alternatives and labelled DCEs use alternative-specific titles for the alternatives (Car, Bus). The decision as to whether to use labelled or unlabelled DCEs is an important one. Statistical modelling can be used to evaluate the relative importance of the attributes and the trade-offs made between them in both labelled and unlabelled DCEs (Kruijshaar et al., 2019).

2.6.4 Multinomial logit model (MNL)

The Random Utility theory is used to describe the joint SP-RP models. Based on the principle of random utility, if and only if the utility of alternative 'i' is higher than or equal to the utility of all alternatives 'j' in the choice set, 'C', then individual 'n' will select it from a group of alternatives (Hensher et al., 1998; Basu & Maitra, 2006). It can be represented as shown in equation (2.1).

$$U(X_i) \geq U(X_j) \quad \forall j \Rightarrow i \succ j, \forall j \in C \qquad \textbf{(2.1)}$$

The utility function of every alternative has two components i.e. a deterministic component (V_i) and a random error component (ε_i), as shown in equation (2.2).

$$Ui = V_i + \varepsilon_i \qquad \textbf{(2.2)}$$

Different types of probabilistic models can be created using various assumptions about the distribution of random error terms (Hensher et al. 1998). If the random error component takes a type I extreme-value (or Gumbel) distribution, the resulting model is called Multinomial Logit Model.

According to Hensher et al., (1998), the expression for the probability of choosing an alternative (P_i) from a set of alternatives based on the MNL model is as in equation (2.3).

$$P_i = \frac{e^{vi}}{\sum_{j \varepsilon C} e^{vj}} \quad \textbf{(2.3)}$$

Due to its benefits in computation, the multinomial logit (MNL) model has become the most used econometric model for modelling discrete choices in travel behaviour analysis (Cheranchery and Maitra, 2019).

2.6.5 Generalized cost model

The attributes taken into account in the utility equation created by the MNL model include attributes that are measured in various units. The relative relevance of each feature compared to the others can be compared or estimated by converting these attributes into a common unit. A summation of these attributes will give a generalised cost (Kumar et al., 2004; Basu & Maitra, 2006). It helps in the rational estimation of user benefits since a reduction in GC indicates user benefits (Chintakayala & Maitra, 2010).

2.7 Scenario Analysis

Scenario analysis is a technique for forecasting the likelihood of an event or the effects of a circumstance, under the assumption that an event or a trend would persist in the future (Kishita et al., 2016). In order to boost patronage and lower the subsidy for premium bus service in Kolkata metro city, Cheranchery & Maitra (2019) conducted a scenario analysis to find an economically feasible scenario with the minimal GC to the passengers. To identify the operationally viable option for replacing old taxies in Kolkata, Chintakayala & Maitra, (2010) also made use of scenario analysis.

CHAPTER 3

METHODOLOGY

3.1 General

The methodology adopted for the study is depicted in Figure 3.1.

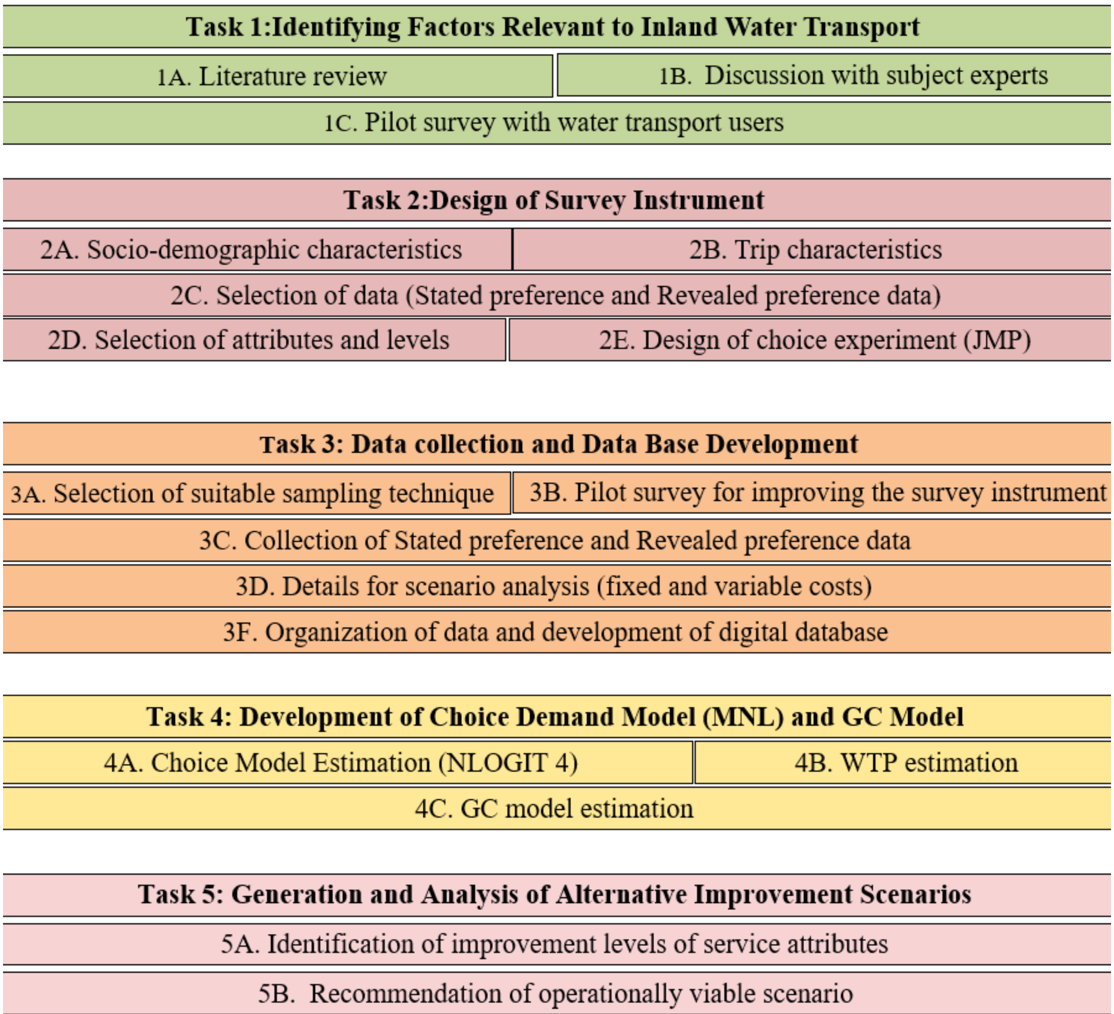

Figure 3.1: Methodology

3.2 Identifying Factors Relevant to IWT

There are several attributes which indicate the service quality of a transport service. The factors which are relevant for IWT were identified from a thorough literature review followed by a discussion with subject experts and water transport users. A detailed review of the attributes describing the service quality of IWT was reported in chapter 2. Two major kinds of attributes, namely quantitative and qualitative attributes, were suggested by the existing research. Fare, headway of service, and span of service are examples of quantitative qualities. Qualitative attributes include safety, security, travel information etc.. In the analysis of travel behaviour, choosing important attributes to serve as explanatory variables is crucial. When there are too many attributes, respondents may find it difficult to make cognitive trade-offs between different combinations of the attributes, while there may not be enough attributes to fully describe the service. Therefore, a list of 8 attributes was chosen for the current study taking into account the qualitative and quantitative characteristics of the IWT, as shown in Table 3.1.

Table 3.1: The Attributes and Description

Attributes	Description
Fare	It is the actual money a traveller must spend to travel by any mode.
In-vehicle travel time	It is the overall period a traveller stays inside the vehicle while on a journey.
Crowding level	This refers to the volume of crowding inside the vehicle
Transfer Time	It is the time taken for changes from one vehicle to another before reaching the destination.
Safety and security arrangement	Taking preventative measures to lower the chance of vulnerability to danger, or injury from accidents and heavily guarded arrangements within vehicles and waiting sheds, like security from pickpockets and intoxicated individuals.
Travel information	The information available to travellers related to schedule, route, delays etc.
Headway	It is the time gap between two successive vehicles (along the same route).
Span of operation	It is the number of hours during a day when service is provided along the route.

3.3 Design of Survey Instrument

A survey instrument in the form of a pen and paper mode of questionnaire developed to collect the responses from travellers of Alappuzha. It consists of four sections namely socioeconomic characteristics, trip characteristics and Revealed Preference (RP) data, Stated Preference (SP) and description of attributes. Socioeconomic characteristics include age, gender, income, and education level. Trip characteristics such as mode of travel, frequency of travel, and travel expenditure were collected. The next subsections cover the specifics of RP and SP data.

3.3.1 Revealed preference data

The RP portion of the survey was created to gather information about five important modes, including bus, boat, car, and two-wheeler. The information included fare, in-vehicle travel times, number of transfers, and crowding level. With the exception of crowding level, all characteristics were quantitative. Four levels of crowding were used to measure it: 1) Standing in an overcrowded condition 2) Standing in a crowded condition 3) Comfortable standing and 4) Occupying a seat.

3.3.2 Stated preference data

In the current investigation, the specified priority areas of IWT services based on Cheranchery et al., (2021) were used as the main criteria for selecting attributes for the SP study. Since a large number of attributes causes a cognitive burden on the respondents, the number of attributes has to be kept to a minimum for the SP experiment. By giving priority to attributes which are relevant for WTP calculation and omitting the attributes which are already considered in RP data, six attributes were shortlisted in which fare and in-vehicle travel time are common for both RP and SP data.

The attributes and their levels are shown in Table 3.2. Based on a review of the literature, the state of the environment, and the viability of implementation, the levels of the chosen attributes were specified.

3.3.3 Design of choice experiment

The choice question format outlines how respondents will be given several alternatives from among all possible configurations of attribute-level combinations. The proposed choice-model specifications are included in the analysis criteria. The experimental design is based on the attributes and levels, the structure of the choice questions, and the analytic needs. JMP software is used to develop the decision sets. Each respondent receives 4 of the total 16 choice sets that were created. The choice sets are given in APPENDIX I.

Table 3.2: The Attributes and Their Levels

Attributes	Levels
1. Fare (Rs. /km)	• 2 • 1.75 • 1.5 • 1.25
2. In-vehicle travel time(minutes)	• T+5 • T • T-5
3. Headway (minutes)	• 40 • 30 • 20 • 10
4. Span of service(hours)	• 13 • 14 • 15 • 16
5. Safety and security	• Inadequate safety and security arrangement • Adequate lifesaving jacket only • Lifesaving jacket + CCTV cameras at waiting shed • Lifesaving jacket + Automatic Rescue System + CCTV cameras at waiting shed and vehicle
6. Travel information	• Static information at waiting sheds • Static information at waiting sheds+ web-/mobile-based static information • Dynamic information at waiting sheds + web-/mobile-based static information • Dynamic information at waiting sheds + web-/mobile-based dynamic information

3.4 Data Collection

The responses were collected from different parts of Alappuzha such as Kainakari, Edathua, and Pulincunnu (Figure 3.2). To collect responses from travellers, a simple random sampling technique was adopted. However, responses collected from those who are ignorant of the IWT may not be useful considering the purpose of the study. Therefore, the responses from those who do not consider IWT as either a secondary mode of transport or a future potential mode of transport are ignored. The respondents are selected such that they have access to IWT as well as other modes of transport.

To check the adequacy of the questionnaire and to avoid any ambiguity, a pilot survey was conducted. Based on these observations, some modifications are made to the questionnaire and data collection method. To identify potential users of IWT, a household survey is preferred along with a survey with travellers. To get a response from people who are willing to use IWT in future, an additional question, “Are you willing to shift to IWT if its service is improved? To fill the questionnaire by the respondents themselves, a detailed description is provided for each section and a description of attributes.

Under trip characteristics, the respondents were questioned regarding the following trip characteristics: the primary mode of transportation, the next most likely alternative mode, the frequency of travel, the purpose of the trip, length of the journey, and the origin and destination. Age, gender, educational attainment, occupation, monthly income, and monthly travel expenses were the socioeconomic characteristics that were gathered.

Before collecting responses, the attributes considered for RP and SP data were explained to each respondent. Then they were asked to specify their most frequently used method and the closest alternative, which may be either a bus, boat, two-wheeler or car. The details such as fare, in-vehicle travel time, transfer time and crowding level for both modes were collected under RP data.

SP information was gathered from the respondents. Each respondent was provided with four SP choice sets (Figure 3.2) and asked to select between two modes A and B for different combinations of attribute levels. A sample questionnaire is attached in APPENDIX I.

Figure 3.2: Data Collection at Alappuzha

3.5 Database Development

To create a digital database for the model estimate, the responses gathered from travellers were coded. While, the quantitative attributes like, fare, in-vehicle travel time, headway, and span of operation were entered in cardinal linear form. To capture the influence of categorical attributes, the qualitative factors like safety and security, travel information, and crowding level was dummy coded. The four levels of qualitative attributes were coded using three dummy variables. Safety and security Arrangement IV (Lifesaving jacket + ARS + CCTV cameras at waiting shed and vehicle), Travel information IV (dynamic information at waiting shed and web and mobile-based dynamic information), and crowding IV (occupying a seat), respectively, were deemed the baseline levels for safety and security arrangement, Travel information, and crowding and were coded as (0,0,0). Level III of each attribute was coded as (0,0,1) and level II was coded as (0,1,0). The level I of attributes was coded as (1,0,0). A pooled database was built using the gathered RP and SP data to estimate the combined SP-RP model in the current study using the sequential estimation technique (Morikawa, 1994; Bradley and Daly, 1997). It is essential to replicate a respondent's RP data to match the number of SP data when creating a pooled database for the joint estimation (Hensher et al., 2008). The socio-economic characteristics of the respondents are given in Table 3.3.

Table 3.3 Socio-economic Characteristics of the Respondents

Variable	No.	Variable	No.
Gender		**Occupation**	
Male	182	Student	26
Female	218	Service/job	171
Age		Business	54
<20	32	Self-employment	50
20-35	161	Other	99
35-55	158	**Monthly expenditure for travel**	
>55	49	<1000	172
Education		1000-2000	131
10	75	2000-3000	7
12	108	3000-4000	46
Graduate	163	>4000	44
Masters/above	99		

3.6 Development Mode Choice Model and GC Model

Using the coded database, the mode choice model was developed using the econometric software NLOGIT 4 (Irfan et al., 2018). A sequential estimation method is adopted. The model is analysed based on the signs of the coefficients, the statistical significance of the coefficients, and the predictability of the model. From the coefficient estimates of attributes, the willingness to pay values were determined followed by a generalised cost model.

CHAPTER 4
TRAVEL BEHAVIOUR ANALYSIS

4.1 Mode Choice Model (MNL Model)

The mode choice model i.e., the Multinomial Logit Model using the combined SP and RP data was developed using NLOGIT software as shown in Table 4.1.

Table 4.1: Multinomial Logit Model Using SP-RP Data

Attributes	**Coefficients**	**P[|Z|>z]**
Fare	-0.42003742	.0024
Transfer time	-0.17508896	0.001
In-vehicle travel time	-0.47401339	.0030
Headway	-0.2597164	.0240
Span of operation	0.18352617	.0180
Safety & Security arrangement I	-0.55569615	.0041
Safety & Security arrangement II	-0.1921231	.0054
Safety & Security arrangement III	-0.14996613	.0346
Travel information I	-0.5486252	.0108
Travel information II	-0.25382192	.0218
Travel information III	-0.0406413	.0387
Crowding Level I	-0.0801353	.0217
Crowding Level II	-0.0505475	.0408
Crowding Level III	-0.0198154	.0468
Boat	-.75609658	0.034
Car	-3.3308265	0.025
2W	3.3145891	0.047
ρ^2	0.251	

The results indicate that all attribute estimates are significant at a 95% confidence interval. The overall quality of fit is considered using ρ_2 (Louviere et al., 2000). A ρ^2 value of 0.251 clearly indicates that the model is in good fit. The attribute estimations' signs match the study area's actual state and are consistent with expectations. The coefficient of each attribute represents the disutility associated with them. The negative signs of the quantitative attributes indicate that the disutility for travellers increases with an increase in the magnitude of corresponding attributes. Similarly, the positive sign indicates that the utility of the attribute increases with the increase in its magnitude.

From Table 5, it can be seen that only the span of operation has a positive coefficient, whereas the coefficients for the other attributes are all negative. The observations are realistic with the actual condition. For qualitative attributes, the disutility are estimated by comparing with their base levels. Hence the levels of qualitative attributes that have a negative sign are less useful than the base levels.

As can be seen, security arrangements I, II, and III were deemed to be of lower utility than security arrangement IV, which served as their baseline (CCTV Surveillance at the waiting shed and vehicle). The travellers regard security arrangement I (no security arrangement) to be of greater disutility, followed by security arrangement II and security arrangement III. Travel information and crowding level also follow the same trend. Travel information IV (dynamic information at waiting shed and web/mobile-based dynamic information) was seen as having higher utility, and Travel information I (static information at waiting shed) was seen as having lower utility. While considering the crowding level, crowding I (standing in overcrowded conditions) was perceived as the highest disutility compared to the base level (occupying a seat).

Except for significance and goodness-of-fit, it is not easy to interpret model coefficients. Hence willingness to pay estimates is carried out.

4.2 Willingness to Pay Estimation

The MNL model takes into account several attributes with various measuring units. The ability to compare or estimate the relative value of each attribute to the others is made possible by converting these attributes into a common unit. The Willingness to Pay Estimation (WTP) approach calculates the maximum price that users will pay for a new service or higher-quality version of an existing service. It displays the variations in utility brought about by changing attributes in terms of monetary units. It is calculated by taking the ratio of utility for an attribute under consideration and the utility of the fare of travel. When dealing with qualitative variables, the WTP pays to improve the variable from one given level to another (Duran-Roman et al., 2021). In this section, the WTP for raising the standard of IWT is calculated.

Table 4.2: Willingness to Pay Estimate for Attributes

Attributes	WTP	Unit
Transfer time	0.416841338	INR/minute
In-vehicle travel time	1.128502765	INR/minute
Headway	0.618317292	INR/minute
Span of operation	0.436928143	INR/hours
Safety &Security arrangement I	1.322968201	INR/km
Safety &Security arrangement II	0.457395201	INR/km
Safety &Security arrangement III	0.357030405	INR/km
Travel information I	1.306134106	INR/km
Travel information II	0.604284066	INR/km
Travel information III	0.096756379	INR/km
Crowding Level I	0.190781336	INR/km
Crowding Level II	0.120340397	INR/km
Crowding Level III	0.047152554	INR/km

It may be observed from Table 4.2, the ratio of the coefficient estimates for in-vehicle travel time over the coefficient estimate for travel cost of 1.128 INR per minute is the estimated WTP value of in-vehicle travel time. For headway and transfer time the WTP are 0.618 INR/minute and 0.4168 respectively. The travellers are ready to pay up to 0.436 INR for one hour of span of operation. For qualitative attributes, safety and security and travel information have higher willingness to pay values. The WTP value indicates the amount of money they are willing to pay to shift from each level to its base level. For instance, travellers are willing to pay 1.322 INR/km to shift from safety and security arrangement level I (inadequate safety and security arrangement) to level IV (Lifesaving jacket + ARS + CCTV cameras at waiting shed and vehicle).

Among various attributes, the WTP value is much higher for in-vehicle travel time. It indicates the necessity of immediate attention to the improvement of travel time. A careful examination of the WTP values for each attribute reveals that the in-vehicle travel time was valued by travellers as roughly 1.8 times higher than headway and 2.7 times higher than transfer time. This indicates that the travellers are willing to give up 1.8 minutes of headway in exchange for saving a minute of in-vehicle travel time, or the opposite. This observation is in-line with the actual condition of the study area. The major factor which pull-back people from the usage of IWT is the higher travel time. On some routes, the IWT takes 30 to 60 minutes more time than other modes of transport.

The WTP values found in this study show that in addition to quantitative factors, the utility of the service highly relies on qualitative factors like safety and security and travel information. Among qualitative attributes, safety and security arrangement have a higher willingness to pay a value of about 1.322 INR/km to 0.357 INR/km. Even though similar studies are absent in the context of IWT, the studies conducted regarding other modes such as bus service, taxies etc. in the Indian context are in line with the above observations. For instance, the investigation of the improvement of taxies in Kolkata (Chintakayala & Maitra, 2010) and rural bus users in West Bengal (Kumar et al., 2004) shows the significance of considering in-vehicle travel time, and service headway along with qualitative attributes.

The use of rickety boats, the presence of tree stumps along the route etc. increase the chance of accidents. Therefore, sufficient safety and security arrangements are necessary during mishaps if any occurred. The travel information also has importance from the point of view of travellers. Currently, the boards which indicate the schedule of services are the only available travel information. These highlights the requirement for a strategy for transportation improvement that also appropriately takes into account the significance of qualitative attributes in creating and evaluating transportation development plans.

4.3 Generalised Cost Model

The GC model for the travellers based on the knowledge of willingness to pay estimation is given in equation (4.1).

$$\mathbf{GC_{nij} = \alpha_{tt} \times TT + \alpha_{ivtt} \times IVTT + \alpha_{hw} \times HW - \alpha_{sp} \times SP + (\alpha_{ss} + \alpha_{ti} + \alpha_{cl}) \times d_{nij} + f_{nij}} \quad \mathbf{(4.1)}$$

Where;

GC_{nij}	=	Generalized cost to a passenger travelling from stop i to j
TT	=	Transfer time in minutes
IVTT	=	In-vehicle travel time in minutes
HW	=	Headway in minutes

SP	=	Span of operation in hours
α_{tt}	=	User cost associated with transfer time = 0.4168 INR/min
α_{ivtt},	=	User cost associated with IVTT = 1.128 INR/min
α_{hw}	=	User cost associated with headway = 0.618 INR/min
α_{sp}	=	User cost associated with span = 0.437 INR/hr
α_{ti}	=	User cost associated with travel information
d_{nij}	=	Distance between stops i and j
f_{nij}	=	Fare paid by a passenger to travelling from stop i to j

4.4 Summary

The travel behaviour analysis was conducted by developing a discrete mode choice model and a generalised cost model was also developed in the context of IWT in Alappuzha. The signs and values of the attributes obtained in the MNL model are rational and it shows the disutility associated with each attribute. The WTP values indicate the necessity of improvement of travel time and headway. Also, qualitative attributes show a significant impact on travellers' preferences. The generalised model developed can be used to estimate the user benefits associated with different levels of attributes.

.

CHAPTER 5
SCENARIO ANALYSIS

5.1 General

Every system is characterised by several parameters. The changes in the value of these parameters and their combination generate a scenario. Scenario analysis is the process of analysing the possible impact of certain events or scenarios on the system so that by considering both the likelihood that a scenario will occur and its potential effects, strategic plans can be developed for the improvement of the system (Balaman and Balaman, 2019). The primary goal of the analysis is to make suggestions for the improvement of IWT services while taking into account the costs and benefits associated with it.

The various operational costs for inland water service were tallied together with the generalised costs of the various scenarios taken into consideration to move forward with scenario analysis. The benefit is determined by taking the difference between the generalised cost of the base scenario and the generalised cost of the scenario under consideration. The benefit-to-cost ratio is calculated. The scenario which results in the great benefit-to-cost ratio will be highlighted as the improvement scenario. The benefit-cost analysis is an economic method used in public decision-making that aims to quantify the benefits and costs connected to certain project.

5.2 Application of Scenario Analysis in a Single Route

The approach is broken down into three steps: (i) creating alternative scenarios; (ii) analysis of each alternative scenario; and (iii) making recommendations to improve IWT services. The analysis it is applied to a single route.

5.2.1 Study route

The water transport route which connects Alappuzha and Kottayam (Figure 5.1) was selected for the analysis. Alappuzha - Kottayam boat service is one of the oldest transportation routes in Central Travancore, which was restored in 2017 after being disrupted for five years. The ferry service, which provides daily transportation to Kottayam has always benefited from regular commuter support. There are five services from Alappuzha to Kottayam, each with a return trip. The fare of a trip between

Alappuzha and Kottayam is 29/- and the running period is roughly two and half hours for a distance of 29 km.

Figure 5.1: Study Route

5.2.2 Generation of alternate scenarios

To generate alternate scenarios for the improvement of IWT, different combinations of attribute levels were considered. Eight attributes in total, with four levels each, are taken into consideration for the creation of the generalised cost model. Thus, there will be 4^8 potential combinations in all. Limiting the number of levels taken under consideration the number of scenarios reduced.

For instance, only the best levels of safety and security and travel information were considered. Also, the span of service is fixed to 16 hours. The three levels of IVTT and four levels of headway were considered making a total of 12 scenarios. The levels of IVTT are T+10, T and T-10 where T is the current IVTT. The headway was taken as 30, 40, 50 and 60 minutes. The total number of trips per day is obtained by dividing roundtrip time by headway and the number of boats per day is obtained by dividing the span of operation by headway. A layover time of 30 minutes is considered along with IVTT. The minimum fare that should be assigned to prevent any loss was also calculated. For the base scenario, the existing levels of attributes were noted. The attribute levels in the base scenario and levels selected for scenario analysis are shown in Table 5.1.

Table 5.1: Attribute Levels for Scenario Analysis

Base Scenario	
In-vehicle travel time	150
Headway	140
No. of transfers	0
Span of operation	11 hours
Safety and security	Lifesaving jackets and lifebuoys
Travel Information	Static information at sheds
Crowding level	Occupying seat
Levels for Scenario Analysis	
In-vehicle travel time	140, 150, and 160
Headway	30, 40, 50 and 60
No. of transfers	0
Span of operation	16 hours
Safety and security	Lifesaving jacket + ARS + CCTV cameras at Boat jetties and vehicle
Travel Information	Dynamic information at waiting sheds + web-/mobile-based dynamic information
Crowding level	Occupying seat

Taking the different combinations of attribute levels, 12 scenarios were generated as shown in Table 5.2.

Table 5.2: Generation of Alternative Improvement Scenario

Scenario	IVTT (min)	Roundtrip Time	Span	Headway	No. of Trips	No. of Boats
Base	150	330	660	140	5	3
1	160	350	960	30	32	12
2	160	350	960	40	24	9
3	160	350	960	50	20	7
4	160	350	960	60	16	6
5	150	330	960	30	32	11
6	150	330	960	40	24	9
7	150	330	960	50	20	7
8	150	330	960	60	16	6
9	140	310	960	30	32	11
10	140	310	960	40	24	8
11	140	310	960	50	20	7
12	140	310	960	60	16	6

5.2.3 Data collection and database development

The operator's fixed and variable costs, route and boat characteristics, service characteristics and user coefficients are the variables needed for the scenario analysis. As secondary data, the operator provided the fixed and variable cost details. Dedicated surveys and staff interviews were used to gather information on the boat’s characteristics.

Safety during the journey is the primary concern in the operation of IWT for both employees and passengers. Adequate usage of safety equipment on the boat provides additional protection to employees and passengers. Common safety equipment in the boat comprises life-saving jackets and lifebuoys. Around 75 life jackets are present in a single boat. Lifebuoys are ring-shaped floating devices for keeping people afloat in an emergency.

Throughout the year, mishaps on inland waterways in developing nations frequently result in fatalities, injuries, financial losses, and a sizable number of individuals going missing. As a result, many families are losing loved ones, which causes great suffering. For emerging nations, this calls for an intelligent, secure, and trustworthy water transport infrastructure. Providing an automatic rescue system with lifeboats will be helpful under such circumstances. To ensure security in boats and weighting sheds, CCTV cameras have to be provided.

It is assumed that the new boat was acquired with financial institution loan support. Instalment is the sum of money paid in small parts in a fixed period. The non-operating cost also involves the insurance premium which helps to provide financial protection for the boat and its contents, liability protection etc.

A single boat is operated by a total of five workers; a driver, boat master, 2 sranks and an operator. Since the boat runs on diesel propulsion, the fuel cost is calculated based on the mileage and cost of diesel. In addition to fuel, gear oil and engine oil are also used for the operation.

Current travel information includes static boards which display the service schedule in boat jetties. Also, the details of the service schedule and route places are provided on the website of KSWTD. For improvement in the IWT services, both static and dynamic information systems are proposed which include vinyl board, LED display and web/mobile-based application.

The low crowding level in the current condition is due to the prohibition of travellers in a standing condition. Also due to the lack of patronage, the travellers are always occupied with seats. The data collected for scenario analysis is aggregated in Table 5.3.

Table 5.3: Data Collected for Scenario Analysis

Operators' cost		Unit
Non-operating cost		
EMI	300000	INR/Year
Insurance	40000	INR/Year
Fixed cost (fixed wages)	100000	INR/Month
Fuel and lubricant cost	16000	INR/Day
Cost of maintenance	600000	INR/Year
Additional costs due to safety and security arrangements and travel information		
Life jackets	2500	INR/Unit
Lifebuoys	1500	INR/Unit
Rescue boat	130000	INR/Unit
CCTV Cameras in boat and weighting shed	20,000	INR/Month
Information (web-/mobile-based dynamic information and dynamic information at bus stops)		
Vinyl Board (Static Information)	8000	INR/Month
LED Display (12' x 8') (Dynamic Information at Bus Stop)	100000	INR/Month
Web/mobile-based application (Dynamic Information)	5000	INR/Month
Boat and Route characteristics		
Maximum passenger capacity	75	No.
Route length	29	km

5.2.4 Cost analysis

For all the scenarios under consideration, taking care of the different levels of attributes, the cost associated with IWT operation is calculated as shown in Table 5.4. It includes the operating, non-operating, fixed and variable costs.

Table 5.4: Total Cost Analysis

Instalment	Insurance	Wage	Fuel	Maintenance	Security	Safety	Travel Information	Total cost
2500.00	3333.33333	10,000	171216	5000.000	0.00	599.58	800.00	1,93,449
10000.00	13333.3333	40,000	4383130	20000.000	26.67	4470.56	4520.00	44,75,480
7500.00	10000.000	30,000	2465510	15000.000	76.67	3370.97	3390.00	25,34,848
5833.33	7777.77778	23,333	1598016	11666.667	60.00	2637.92	2636.67	16,51,962
5000.00	6666.66667	20,000	1095782	10000.000	48.89	2271.39	2260.00	11,42,029
9166.67	12222.2222	36,667	4017869	18333.334	43.33	4104.03	4143.33	41,02,548
7500.00	10000.000	30,000	2465510	15000.000	71.11	3370.97	3390.00	25,34,842
5833.33	7777.77778	23,333	1598016	11666.667	60.00	2637.92	2636.67	16,51,962
5000.00	6666.66667	20,000	1095782	10000.000	48.89	2271.39	2260.00	11,42,029
9166.67	12222.2222	36,667	4017869	18333.333	43.33	4104.03	4143.33	41,02,548
6666.67	8888.88889	26,667	2191565	13333.333	71.11	3004.44	3013.33	22,53,209
5833.33	7777.77778	23,333	1598016	11666.667	54.44	2637.92	2636.67	16,51,956
5000.00	6666.66667	20,000	1095782	10000.000	48.89	2271.39	2260.00	11,42,029

5.2.5 Benefit-cost ratio analysis

The benefit associated with each scenario was determined by comparing the generalised cost of the base scenario and the scenario under consideration. The ratio of the total cost calculated in section 5.2.4 and the benefit is calculated to find out the most viable scenario. The estimation is depicted in Table 11.

Table 5.5: Benefit-Cost Ratio Analysis

Scenario	Total Cost	Min. Fare	GC	Benefit	Benefit/Cost
Base	1,93,449	2.000	270030.000		
1	44,75,480	4.019	493723.140	-223693.140	-0.0500
2	25,34,848	4.047	378674.491	-108644.491	-0.0429
3	16,51,962	4.069	322385.264	-52355.264	-0.0317
4	11,42,029	4.102	263623.512	6406.488	0.0056
5	41,02,548	4.019	475676.272	-205646.272	-0.0501
6	25,34,842	4.047	365138.182	-95108.182	-0.0375
7	16,51,962	4.069	311105.264	-41075.264	-0.0249
8	11,42,029	4.102	254599.512	15430.488	0.0135
9	41,02,548	4.019	457628.272	-187598.272	-0.0457
10	22,53,209	4.047	351603.178	-81573.178	-0.0362
11	16,51,956	4.069	299824.867	-29794.867	-0.0180
12	**11,42,029**	**4.102**	**245575.512**	**24454.488**	**0.0214**

5.3 Summary

Among the different scenarios considered, scenario 12 has the highest benefit-cost ratio of 0.0214. The description of the scenario includes an IVTT of 140 minutes for a one-way trip, 16 hours of operation, 60 minutes of headway and the best levels of safety and security arrangement, crowding level and travel information. The total number of trips in this scenario was 16 and the total number of boats employed is 6. The minimum fare to be incurred should be increased to INR 4.102/km.

CHAPTER 6
CONCLUSION

6.1 General

Inland water transport is such a sustainable transportation mode which had a golden era in the late 19th and early 20th centuries in India. With the development of other modes of transport along with deterioration in the service quality of water transport, Inland water transport lost its pride. However, to mitigate the ill effects of rapidly growing transportation demand and congestion, it is essential to develop sustainable modes of transport like IWT. Understanding the behavioural responses of users is vital for the success of any system. Transportation agencies also look for exhaustive policies and recommendations to meet transportation demand and associated problems demand with due consideration of travel behaviour. The current works aim to understand how people value various travel attributes which is crucial to developing logical enhancement proposals for the improvement of IWT service.

The study was conducted at Alappuzha, Kerala, India in four steps. The factors which describe the service quality of attributes were identified from thorough literature and discussion with IWT users. The revealed, as well as the stated preference of the travellers, were collected with the aid of a questionnaire based on well-defined choice sets. A travel behavioural analysis was conducted for the development of a discrete mode choice model and generalised cost model. Using the joint SP-RP data, a multinomial logit model was developed. The willingness to pay values for the improvement of the attributes was estimated followed by the development of a generalised cost model. Finally, improvement levels of attributes were recommended for an operationally viable scenario by conducting a scenario analysis on the Alappuzha-Kottayam boat service route.

6.2 Key Findings and Recommendations

- A methodological frame work was developed to identify how users value various travel attributes to develop a logical improvement plan for IWT in India.
- The implementation of the suggested methodology on IWT routes of Alappuzha city revealed the importance of travel behaviour analysis in the improvement of service quality attributes of IWT services.

- The mode choice model and willingness to pay estimates will be an essential input in the analysis of various transportation policies. They help to calculate the disutility associated with each attribute experienced by the travellers for any service condition of IWT.
- The higher WTP value of in-vehicle travel time necessitates the recommendations for the improvement of travel time. The use of old rickety boats and the presence of water hyacinth in waterbodies hits the travel speed. Implementation of more modern vessels like water taxis will help to a reduction in the travel time.
- The waiting due to the higher headway between successive services also increases the disutility of travellers. The qualitative attributes like safety and security arrangement and travel information also have higher WTP values for their improvement. Therefore, when suggestions and policies are made for improvements to IWT services, all these factors should be taken into account.
- The generalised cost model that has been created in this investigation was crucial in demonstrating the effects of improvement of various attributes in the benefits of the users in terms of reduction in GC. Hence it is possible to identify improvements that will maximise user advantages.
- The scenario analysis shows a combination of attribute levels for an operationally viable IWT system in the Alappuzha- Kottayam route. As per the benefits-cost analysis, the scenario having 140 minutes of travel time,16-hour span of operation, 60 minutes headway and the best levels of safety and security arrangement, crowding level and travel information will be operationally feasible. The total number of trips in this scenario was 16 and the total number of boats employed is 6. The minimum fare to be incurred should be increased to INR 4.102/km.
- The findings of the present work will be instrumental in the improvement of IWT services in Alappuzha.

6.3 Scope for Future Works

- Only service-related attributes are included in the econometric models in the current work. However, socio-economic characteristics can also influence the mode choice behaviour of travellers. Future works can incorporate such characteristics also to identify their impact.
- Only eight attributes are included in the GC and demand models due to the cognitive load on responders. By conducting a users' perception survey in the respective study area, more significant service attributes can be considered in future research.

REFERENCES

- Aayog, N. I. T. I. (2017). Government of India. *Nourishing India—National Nutrition Strategy*.
- Arentze, T. A., & Molin, E. J. (2013). Travellers' preferences in multimodal networks: design and results of a comprehensive series of choice experiments. *Transportation Research Part A: Policy and Practice*, *58*, 15-28.
- Axhausen, K. W. (2007). Concepts of travel behaviour research. In *Threats from car traffic to the quality of urban life*. Emerald Group Publishing Limited.
- Balaman, Ş. Y., & Balaman, S. Y. (2019). Uncertainty issues in biomass-based production chains. *Decision-making for biomass-based production chains*, *77*, 112.
- Basu, D., & Maitra, B. (2006). Development of generalized cost model for private car trip makers under traffic information. *Journal of the Indian Institute of Science*, *86*(6), 681.
- Bhat, C. R., & Koppelman, F. S. (1999). Activity-based modelling of travel demand. In *Handbook of transportation Science* (pp. 35-61). Springer, Boston, MA.
- Bradley, M. A., & Daly, A. J. (1997). Estimation of logit choice models using mixed stated preference and revealed preference information. *Understanding travel behaviour in an era of change*, 209-232.
- Cheranchery, M. F., & Maitra, B. (2017). Priority areas of intervention for improving urban bus services: Experience in Kolkata, India. *Transportation Research Record*, *2634*(1), 17-27.
- Cheranchery, M. F., & Maitra, B. (2019). Improving ridership and reducing subsidy for premium bus service in Kolkata Metro City. *Journal of Transportation Engineering, Part A: Systems*, *145*(7), 04019030.
- Cheranchery, M. F., Noushad, A., Choyimadathil, A., Jose, J. T., Padu, K., & Nivedita, S. (2021). Identifying areas of intervention for enhancing the attractiveness of Inland waterway transport based on users' perception: A case study of Kerala. *Case Studies on Transport Policy*, *9*(3), 1006-1014.
- Chintakayala, P. K., & Maitra, B. (2010). Modelling generalized cost of travel and its application for improvement of taxies in Kolkata. *Journal of Urban Planning and Development*, *136*(1), 42-49.

- Diana, M. (2012). Measuring the satisfaction of multimodal travellers for local transit services in different urban contexts. *Transportation Research Part A: Policy and Practice*, *46*(1), 1-11.
- Duran-Roman, J. L., Cárdenas-García, P. J., & Pulido-Fernández, J. I. (2021). Tourists' willingness to pay to improve sustainability and experience at destination. *Journal of Destination Marketing & Management*, *19*, 100540.
- Eboli, L., & Mazzulla, G. (2007). Service quality attributes affecting customer satisfaction for bus transit. *Journal of public transportation*, *10*(3), 2.
- Ghazali, W. N. W., Zulkifli, C. N. A., & Ponrahono, Z. (2019, December). The effect of traffic congestion on quality of community life. In *4th International Conference on Rebuilding Place*.
- Golob, J. M., & Golob, T. F. (1983). Workshop on travel behaviour characteristics and analysis. Classification of approaches to travel-behaviour analysis. *Transportation Research Board Special Report*, (201).
- Guzzo, R., & Mazzulla, G. (2004). Modal choice models estimation using mixed revealed and stated preferences data. *WIT Transactions on The Built Environment*, *75*.
- Hansson, J., Pettersson, F., Svensson, H., &Wretstrand, A. (2019). Preferences in regional public transport: a literature review. *European Transport Research Review*, *11*(1), 1-16.
- Hensher, D. A., Rose, J. M., Rose, J. M., & Greene, W. H. (2005). *Applied choice analysis: a primer*. Cambridge university press.
- Hensher, D., Louviere, J., & Swait, J. (1998). Combining sources of preference data. *Journal of Econometrics*, *89*(1-2), 197-221.
- Hess, D. B. (2017). Decrypting fare-free public transport in Tallinn, Estonia. Case studies on transport policy, 5(4), 690-698.
- Hoang-Tung, N., Kojima, A., Kubota, H., 2014. Recognising customers' patterns of bus service patronage using a loyalty framework. IATSS Research 37 (2), 148–156.
- Hrelja, R., Khan, J., &Pettersson, F. (2020). How to create efficient public transport systems? A systematic review of critical problems and approaches for addressing the problems. *Transport Policy*, *98*, 186-196.

- Inland Waterways Authority of India (2008). Annual Report [2008-2009]-Published by Department of Shipping-Ministry of Shipping, Road Transport and Highways. Noida-India, pp.
- Irfan, M., Khurshid, A. N., Khurshid, M. B., Ali, Y., & Khattak, A. (2018). Policy implications of work-trip mode choice using econometric modeling. *Journal of Transportation Engineering, Part A: Systems*, *144*(8), 04018035.
- Johnson, F. R., Lancsar, E., Marshall, D., Kilambi, V., Mühlbacher, A., Regier, D. A., & Bridges, J. F. (2013). Constructing experimental designs for discrete-choice experiments: report of the ISPOR conjoint analysis experimental design good research practices task force. *Value in health*, *16*(1), 3-13.
- Joseph, Y. (2012). A study on inland water transportation in Kochi City Region. *Centre for Public Policy Research (CPPR) Working Paper Series*.
- Kalahe, K. P., & Mudunkotuwa, R. (2020). Research Article Passenger Perceptions Towards Inland Water Transportation: A Sri Lankan Perspective. *Int. J. Curr. Res*, *12*(1), 9433-9439.
- Khan, J., Hrelja, R., &Pettersson-Löfstedt, F. (2021). Increasing public transport patronage–An analysis of planning principles and public transport governance in Swedish regions with the highest growth in ridership. *Case Studies on Transport Policy*, *9*(1), 260-270.
- Kishita, Y., Ohishi, Y., Uwasu, M., Kuroda, M., Takeda, H., & Hara, K. (2016). Evaluating the life cycle CO2 emissions and costs of thermoelectric generators for passenger automobiles: a scenario analysis. *Journal of Cleaner Production*, *126*, 607-619.
- Klojgaard, M. E., Bech, M., & Sogaard, R. (2012). Designing a stated choice experiment: the value of a qualitative process. *Journal of Choice Modelling*, *5*(2), 1-18.
- Konig, A., & Grippenkoven, J. (2020). Modelling travellers' appraisal of ridepooling service characteristics with a discrete choice experiment. *European Transport Research Review*, *12*(1), 1-11.
- Kono, T., Kishi, A., Seita, E., & Yokoi, T. (2018). Limitations of using generalized transport costs to estimate changes in trip demand: a bias caused by the endogenous value of time. *Transportmetrica A: Transport Science*, *14*(3), 192-209.

- Kruijshaar, M. E., Essink-Bot, M. L., Donkers, B., Looman, C. W., Siersema, P. D., &Steyerberg, E. W. (2009). A labelled discrete choice experiment adds realism to the choices presented: preferences for surveillance tests for Barrett esophagus. *BMC medical research methodology*, *9*(1), 1-10.
- Kumar, C. V., Basu, D., & Maitra, B. (2004). Modeling generalized cost of travel for rural bus users: a case study. *Journal of Public Transportation*, *7*(2), 4.
- Lambert, B. (2010, May). The economic role of inland water transport. In *Proceedings of the Institution of Civil Engineers-Civil Engineering* (Vol. 163, No. 5, pp. 8-14). Thomas Telford Ltd.
- Louviere, J. J., Hensher, D. A., & Swait, J. D. (2000). *Stated choice methods: analysis and applications*. Cambridge university press.
- Mangham, L. J., Hanson, K., & McPake, B. (2009). How to do (or not to do) Designing a discrete choice experiment for application in a low-income country. *Health policy and planning*, *24*(2), 151-158.
- Marquez, L., Cantillo, V., &Arellana, J. (2014). How are comfort and safety perceived by inland waterway transport passengers? *Transport policy*, *36*, 46-52.
- Ministry of Ports, Shipping & Waterways Transport Research Wing (2021). Statistics of Inland Water Transport
- Perez-Troncoso, D. (2020). A step-by-step guide to design, implement and analyze a discrete choice experiment. *arXiv preprint arXiv:2009.11235*.
- Praveen, S., & Jegan, J. (2015). Key issues & challenges for inland water transportation network in India. *Int J Sci Res Dev*, *3*(10), 2321-0613.
- Rahul, T.M., Verma, A., 2018. Sustainability analysis of pedestrian and cycling infrastructure–A case study for Bangalore. Case Stud. Transport Policy 6 (4), 483–493.
- Rangaraj, N., & Raghuram, G. (2006). Viability of inland water transport (IWT) in India.
- Sarkar, P.K., Mathur, V., Maitri, V., Kalra, K., 2007. Potential for economic gains from inland water transport in India. Transp. Res. Rec. 2033 (1), 45–52.
- Sharma, K. (2017). Inland water transportation: growth and challenges perspective in India. In *International Conference on Science, Technology and Management* (pp. 111-118).

- Solomon, B., Otoo, E., Boateng, A., & Koomson, D. A. (2021). Inland waterway transportation (IWT) in Ghana: a case study of volta lake transport. *International Journal of Transportation Science and Technology*, *10*(1), 20-33.
- Sriraman, S., 2010. Long Term Perspectives on Inland Water Transport in India. RITES J. 12 (1), 18–21.
- Statistics of Inland Water Transport 2011-12, Transport Research Wing, Ministry of Shipping, Government of India, New Delhi
- Sys, C., Van de Voorde, E., Vanelslander, T., & van Hassel, E. (2020). Pathways for a sustainable future inland water transport: A case study for the European inland navigation sector. *Case Studies on Transport Policy*, *8*(3), 686-699.
- Terris-Prestholt, F., Neke, N., Grund, J. M., Plotkin, M., Kuringe, E., Osaki, H., &Wambura, M. (2019). Using discrete choice experiments to inform the design of complex interventions. *Trials*, *20*(1), 1-11.
- Vabuolyte, V., &Uspalyte-Vitkuniene, R. (2018). Indicators of service quality of public transport. *Mokslas–Lietuvosateitis/Science–Future of Lithuania*, *10*.
- WB, 2005. *China Inland Waterway Project* Worldbank
- Wojewodzka-Krol, K., &Rolbiecki, R. (2018). Innovative solutions for inland waterway transport. *Transport Economics and Logistics*, *80*, 245-255.

APPENDIX I

Questionnaire for Investigating Travel Behaviour of Trip makers of Alappuzha

Dear Respondent,

I am a student of TKM College of Engineering, Kollam, currently pursuing M. Tech in Transportation Engineering in T.K.M. College of Engineering, Kollam. As part of project work, I am conducting a study to improve the boat services in Alappuzha. I will be thankful to you if you spend a little part of your precious time in filling this questionnaire. Your response will be kept confidential and only be used for academic purpose/research work.

Part-A: Trip Characteristics (Please **Tick (√)** against appropriate one)

1. Predominantly used mode for travel:

   (a) Bus (b) Boat service (c) Private Car (d) Two-wheeler (e) Autorickshaw (f) Other (mention:__)
2. What is your immediate next alternative mode for travel?

   (a) Bus (b) Boat service (c) Private Car (d) Two wheeler (e) Autorickshaw (f) Other (mention:_____)
3. How frequent do you make trip (two-way) by any mode in a week?

   (a) Less than 3 trips (b) 3 to 4 trips (c) 5 to 6 trips (d) more than 6 trips
4. How frequent do you use Boat service for making your trip?

   (a) Never (b) Rarely (c) Sometimes (d) Often (e) Always
5. Trip Purpose for the most recent trip by Boat service:

   (a) Work/Office (b) Business (c) Education (d) Recreation or Social (e) Other
6. Length of Travel -------------------- (km)
7. Origin:_______________ Destination:____________________

B: Socio-Economic characteristics

1. Gender: (a) Male (b) Female (c) Other
2. Age: (a) < 20 years (b) 20 to 35 years (c) 35 to 55 years (d) > 55 years
3. Education: (a) up to 10th Standard (b) 12th Standard (c) Graduate (d) Masters/Above
4. Occupation: (a) Service/Job (b) Business (c) Self-employment (d) Student (e) Other
5. Monthly expenditure for travel (a) 1000/- (b) 2000/- (c) 3000 (d) More than 4000/-
6. Number of Persons in the Household (including you):____________________
7. No. of cars in the household: (a) 0 (b) 1 (c) 2 (d) More than 2
8. No. of motorized two wheelers in the household: (a) 0 (b) 1 (c) 2 (d) More than 2

C: Revealed Preference Data

Attributes \ Alternatives	Bus	Boat	Car	2W	Others
Transfer Time (minute)*					
In-vehicle Travel Time (minute)*					
Fare (Rupees)*					
Crowding (Level 1/2/3/4)					

*For one-way trip only

(Crowding level: 1) Standing in Overcrowded condition 2) Standing in crowded condition 3) Comfortable standing and 4) Occupying a seat

Attribute	Description
Fare	It is the actual out-of-pocket cost spent by a trip maker to accomplish the journey by a vehicle.
In-vehicle travel time	It is the total amount of time that a trip maker spends inside the vehicle during a trip.
Crowding	This refers to the volume of crowding inside the vehicle
No. of transfers &Transfer Time	It is the total number of changes from one vehicle to another before reaching the destination.
Safety and security	Taking precautions to reduce the risk of exposure to danger, or injury from accidents and qualitative Security arrangement inside the vehicle and waiting shed, for example, Security from pick pocketing, from drunken people
Travel information	Information available to trip makers related to schedule, route etc.
Headway	It is the time gap between two successive vehicles (along the same route).
Span of service	It is the number of hours during a day when service is provided along the route.

- Are you willing to shift to IWT if its service improves?

D: SP Data

Let A and B be two options of improved boat service facilities available for you. By comparing the features of both, mark the choice that you will select to make a trip?

LA 1

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.2.0/km	T+10	10	13	Adequate lifesaving Jackets+ ARS+ CCTV cameras at waiting shed and vehicle	Static information at waiting sheds	
Option B	Rs.1.75/km	T-10	30	16	Adequate lifesaving jacket only	Dynamic information at waiting shed + web-/mobile-based static information	

LA2

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.25/km	T-10	10	15	Adequate lifesaving jacket only	Static information at waiting shed + web-/mobile-based static info	
Option B	Rs.1.5/km	T+10	30	16	Adequate lifesaving jackets+ ARS+ CCTV cameras at waiting shed and vehicle	Dynamic information at bus stops + web-/mobile-based dynamic information	

LA 3

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.75/km	T	10	15	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Dynamic information at bus stops + web-/mobile-based dynamic information	
Option B	Rs.1.25/km	T+10	20	16	Adequate lifesaving jackets + ARS+ CCTV cameras at waiting shed and vehicle	Static information at waiting shed + web-/mobile-based static info	

LA 4

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.25/km	T	20	14	Inadequate safety and security arrangement	Dynamic information at waiting shed + web-/mobile-based static information	
Option B	Rs.1.5/km	T-10	40	15	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Static information at waiting shed + web-/mobile-based static info	

LB 1

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.2/km	T+10	40	16	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Dynamic information at bus stops + web-/mobile-based dynamic information	
Option B	Rs.1.75/km	T	30	14	Adequate lifesaving jacket only	Static information at waiting sheds	

LB 2

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.5/km	T	20	16	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Static information at waiting sheds	
Option B	Rs.1.75/km	T-10	40	14	Adequate lifesaving jackets + ARS+ CCTV cameras at waiting shed and vehicle	Dynamic information at bus stops + web-/mobile-based dynamic information	

LB 3

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.25/km	T+10	30	15	Adequate lifesaving jackets+ARS+ CCTV cameras at waiting shed and vehicle	Dynamic information at bus stops + web-/mobile-based dynamic information	
Option B	Rs.1.75/km	T	10	14	Inadequate safety and security arrangement	Static information at waiting shed + web-/mobile-based static info	

LB 4

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.25/km	T+10	10	16	Adequate lifesaving jacket only	Static information at waiting sheds	
Option B	Rs.2/km	T-10	20	13	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Dynamic information at bus stops + web-/mobile-based dynamic information	

LC 1

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.2/km	T-10	40	13	Adequate lifesaving jacket only	Static information at waiting sheds	
Option B	Rs.1.25/km	T	20	15	Inadequate safety and security arrangement	Dynamic information at waiting shed + web-/mobile-based static information	

LC 2

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.5/km	T	30	13	Adequate lifesaving jacket only	Static information at waiting shed + web-/mobile-based static info	
Option B	Rs.1.25/km	T-10	40	16	Inadequate safety and security arrangement	Static information at waiting sheds	

LC 3

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.2/km	T	40	14	Adequate lifesaving jackets+ ARS+ CCTV cameras at waiting shed and vehicle	Static information at waiting sheds	
Option B	Rs.1.75/km	T+10	10	16	Adequate lifesaving jacket only	Dynamic information at waiting shed + web-/mobile-based static information	

LC 4

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.2/km	T-10	30	15	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Static information at waiting sheds	
Option B	Rs.1.25/km	T	40	13	Inadequate safety and security arrangement	Dynamic information at waiting shed + web-/mobile-based static information	

LD 1

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.25/km	T+	10	15	Adequate lifesaving jacket only	Dynamic information at waiting for shed + web-/mobile-based dynamic information	
Option B	Rs.2/km	T+10	30	14	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Static information at waiting shed + web-/mobile-based static info	

LD 2

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.25/km	T+10	20	15	Adequate lifesaving jackets +ARS+ CCTV cameras at waiting shed and vehicle	Static information at waiting shed + web-/mobile-based static info	
Option B	Rs.1.5/km	T-10	10	13	Inadequate safety and security arrangement	Dynamic information at bus stops + web-/mobile-based dynamic information	

LD 3

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.25/km	T+10	10	14	Adequate lifesaving jackets+ CCTV cameras at waiting shed and vehicle	Static information at waiting shed + web-/mobile-based static info	
Option B	Rs.1.75/km	T-10	40	13	Adequate lifesaving jackets+ARS+ CCTV cameras at waiting shed and vehicle	Static information at waiting sheds	

LD 4

	Fare	In-vehicle travel time (minutes)	Headway (minutes)	Span of service (hr)	Safety and Security	Travel Information	Choice
Option A	Rs.1.5/km	T-10	20	14	Adequate lifesaving jackets +ARS+ CCTV cameras at waiting shed and vehicle	Dynamic information at waiting shed + web-/mobile-based static information	
Option B	Rs.1.25/km	T+10	30	13	Inadequate safety and security arrangement	Static information at waiting shed + web-/mobile-based static info	