Dharmanshu chouhan

Inland Waterways as Public Transportati

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INLAND WATERWAYS AS PUBLIC TRANSPORTATION

Master of Planning
(Transport Planning and Logistics Management)

Dharmanshu chouhan
[Sch. No. 2022MTPLM018]

SCHOOL OF PLANNING AND ARCHITECTURE, BHOPAL
NEELBAD ROAD, BHAURI, BHOPAL (MP)-462030

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Thesis submitted in partial fulfillment of the requirements for the award of the degree of

Master of Planning
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By
Dharmanshu chouhan
Scholar No. 2022MTPLM018

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Declaration

I **Dharmanshu chouhan**, Scholar No. **2022MTPLM018** hereby declare that the thesis titled **"Inland waterways as public Transportation"** submitted in fulfilment for the award of **Master of Planning**, at School of Planning and Architecture, Bhopal, India, is a record of bonafide work carried out by me. The matter/result embodied in this thesis is not been submitted to any other University or Institute for the award of any degree or diploma.

Signature of the Student

Date: _____

Certificate

This is to certify that the declaration of **Dharmanshu chouhan** is true to the best of my knowledge and that the student has worked under my guidance in preparing this thesis.

RECOMMENDED

_____
Signature of the Guide
Dr. Gaurav Vaidya

ACCEPTED

_____
Prof. Saurabh Popli
Head, Department of Transport Planning

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Abstract

India has an abundance of navigable waterways, including river systems, canals, backwaters, creeks, and tidal inlets. These waterways span approximately 14,500 km, of which 5600 km can be traversed by motorised vessels. Only a few States and specific locations have navigable waterways.

A network of rivers, canals, backwaters, and streams known as inland waterways can be utilised for transportation in addition to or instead of highways and railroads. Rivers have been useful conduits for moving people and things over great distances throughout history. Many nations still rely mostly on inland water transportation since it is less expensive, more dependable, and environmentally friendly than shipping cargo by rail or road. The Inland Water Transport (IWT) is functionally important in regions covered by the Brahmaputra and the Ganges in the North-East and Eastern parts of the country, Kerala, Goa and in the deltas of the rivers of Krishna and Godavari.

Prayagraj, formerly known as Allahabad, is located in the northern Indian state of Uttar Pradesh. Three rivers converge at the city's location: the Yamuna, the Ganges, and the fabled Sarasvati. The geography and culture of the city are fundamentally shaped by these rivers. The rivers that flow through Prayagraj are examples of interior waterways that have historically been important for trade and transportation. However, with the Indian government pushing to promote waterways as an efficient source of transportation, interest in their use for modern inland canal transportation has increased. Additionally, passenger ferries have a great deal of promise to advance resilient and sustainable transportation. As a result, it's important to consider passenger ferry services from the perspective of operations and policy, as this will assist define and preserve the current and planned water transport routes in addition to other forms of transportation.

A significant inland canal in India, National canal-1 (NW-1) spans the Ganges River from Haldia in West Bengal to Prayagraj in Uttar Pradesh. There are continuing development initiatives to improve the Ganges' navigability for both passenger and freight transportation.

The purpose of this thesis is to better understand how users and operators perceive the current quality of ferry service operations and to provide strategies for improving water transport in cities to increase the viability of both proposed new routes and current routes in response to future demand.

Table of Contents

Table of Figures

List of Tables

List of Abbreviations

IWT	Inland Water Transportation
IWAI	Inland Waterways Authority of India
CMP	Comprehensive Mobility Plan
CDP	City Development Plan
NW-1	National Waterway -1
NUTP	National Urban Transport Policy
PDA	Pryagraj Development Authority

1. INTRODUCTION

1.1 Background of the Study

India has a 7,551-kilometer coastline, with 13 major ports and over 200 smaller ones. Inland waterways in the form of rivers, canals, backwaters, and streams are widely distributed throughout the nation. There are 14,500 km of navigable length in total, of which 4000 km of canals and 5200 km of rivers are accessible to boats and mechanised vehicles. There are 20 river units in the nation, including 14 significant river basins. Six river units have been created from the remaining 99 river basins. The fact that 34% of the country's area is made up of the Ganga-Brahmaputra-Meghna basin, which provides roughly 59% of its water resources, is indicative of the decades-long neglect and inadequate planning of this sector.

Only 4% of the resources are found in the west flowing rivers that flow towards the Indus, which make up 10% of the territory, but 37% of the runoff is produced by the remaining 56% of the region. An affordable, fuel-efficient, and environmentally beneficial kind of transportation is inland water transportation (IWT). India boasts a vast network of rivers, lakes, and canals that might be utilised for commerce and navigation to create an effective inland transportation system. A successful transportation infrastructure with mobility, flexibility, and cost effectiveness will be provided by the best possible combination of land, air, and sea transportation.

Although the government has prioritised growing the road and rail industries thus far, it understands that in order for the IWT sector to contribute fairly to the intermodal mix of inland transportation, it must be aggressively promoted.

India boasts an extensive network of inland waterways, including backwaters, creeks, rivers, and a long coastline that is reachable by seas and oceans. They connect areas that are separated or separated by water channels and are designed for shipping and navigation. Compared to road, rail, or air travel, inland water transport (IWT) is a low-cost, fuel-efficient, environmentally benign, and economical means of transportation. The waterway is a naturally occurring feature, but in order to fully utilise it for transportation, one needs to be trained. Waterways provide reduced resistance to traction at an acceptable rate, which is its main transportation benefit. Since the channels are naturally occurring, maintenance costs are minimal (Sriraman, 2010). When both the origin and the destination are near a waterfront, water-based transport is particularly efficient (Raghram, Viability of Inland Water Transport in India, 2007). An estimated 14500 km of navigable inland waterways, comprising creeks, rivers,

canals, backwaters, and tidal inlets, may be found in India. These waterways are suitable for the operation of mechanised boats. According to records, 485 km of canal channels and roughly 5200 km of main rivers are appropriate for inland transportation (Jain, 2013). The government of India has designated these navigable waterways as National Waterways. Since logistical transit over these rivers is less expensive than via roads or aeroplanes, heavy to light commodities are transported there (Sriraman, 2010).

The Indian government established the Inland Waterways Authority of India (IWAI) to oversee inland waterways. With the goal of facilitating both commercial and non-commercial usage of channel systems, the organisation began operations in 1986 The construction and management of inland waterways for shipping and navigation is their primary goal. Furthermore, passenger ferry services and freight transportation both use these river systems. It has long been acknowledged that inland rivers are essential for transportation and communication. Despite its energy-efficient, cost-effective, and environmentally beneficial benefits, inland water transport in India makes up a very minor portion of the country's overall transportation network (P. K. Sarkar, 2007).

There are inland waterways and rivers where the ferry system operates in addition to officially designated National Waterways. The states are in charge of these waterways. Ferry crossings, small river segments, and tourism-based passenger traffic make up the majority of IWT-based passenger travel. Space constraints are the main cause of the low share of IWT traffic. According to P. K. Sarkar (2007), passenger ferry services on inland waterways are restricted to certain areas and are only functional when trip production and termination centres are situated near waterfronts for both the origin and the destination.

Assam, Goa, Kerala, and Mumbai are just a few of the Indian places where passenger ferry services are still operational. The sector appears to be marginalised outside of West Bengal, etc., and a few creeks in coastal areas where it has a natural advantage (P. K. Sarkar, 2007).

The urbanisation that is taking place in and around these cities is inextricably linked to transportation. The way that people travel and interact inside cities is facilitated by the transport sector, which is essential to the socioeconomic growth of cities. Examining the water transportation industry from the perspective of seamless and sustainable operations is crucial. By preserving the current water transportation services, this will generally force communities to transition to more environmentally friendly modes of transportation. Both passengers and operators will gain from it.

Prayagraj, which is located at the meeting point of the Yamuna, Saraswati, and Ganges rivers, has a rich history that is intricately entwined with its inland waterways. For ages, the city has relied on these bodies of water to facilitate trade, transit, and cross-cultural interchange. Developing Prayagraj's inland waterways and realising its potential for sustainability and economic growth has garnered more attention in recent times. Prayagraj's inland rivers have long been essential to the local economic and cultural legacy. Prayagraj has been connected to many regions of Northern India by the Ganges, in particular, which has been an important commercial route. Along these rivers, traditional wooden boats, or 'country boats', served as the main mode of transportation for both people and cargo. However, the importance of inland waterways gradually decreased as a result of the construction of contemporary transportation infrastructure, such as roads and railroads. Pollution and neglect presented further obstacles to their efficient use. In recent years, despite these obstacles, there has been an increasing awareness of the possible advantages of revitalising Prayagraj's inland waterways. (Sriraman, 2010).

Future Prospects:

Prayagraj's inland waterways appear to have a bright future thanks to a number of government regulations and development projects that support sustainable practices and revive water-based transportation. Important facets of the outlook for the future include: NW-1, or National Waterway Development: Prayagraj is located along NW-1, the path that crosses the Ganges River between Varanasi and Haldia. In order to make it easier for people and freight to move over this waterway, efforts are being made to improve its navigability, infrastructure, and communication.

Infrastructure Development: To improve the effectiveness and security of inland waterway traffic in Prayagraj, investments in updating infrastructure, such as river terminals, jetties, and warehouses, are essential. The goals of these advancements are to increase trade, draw in investment, and provide jobs.

Promotion of Water-Based Tourism: Prayagraj has a lot of potential for water-based tourism because of its beautiful riverfronts and cultural heritage sites. In addition to promoting the city's rich cultural legacy, initiatives to build tourist-friendly amenities, river cruises, and recreational opportunities can boost economic growth.

Environmental Sustainability: To protect Prayagraj's inland rivers and their ecosystems, conservation and pollution control methods are crucial. Development plans should incorporate sustainable practices, such as eco-friendly transportation systems, waste management, and water quality monitoring, to guarantee long-term survival.

Integration with Multi-Modal Transport Networks: By connecting inland waterways to current transportation networks—such as highways, trains, and airplanes—we can improve connectivity and make it easier for people to move freely between various forms of transportation. (Sriraman, 2010).

1.2 Need of Study

Based India's inland waterways are an important part of the nation's transport network and could have a big effect on the economy. India needs inland waterways for the following main reasons: Less Expensive Mode of Transportation: When it comes to bulk commodities, inland waterways are among the least expensive forms of transportation. One litre of petroleum may travel 215 tons-km on inland waterways, compared to 95 tons-km on rail and only 24 tons-km on highways, per RITES study. Waterways are therefore a very cost-effective and fuel-efficient choice. Decreased Logistics Costs: When compared to railroads and roadways, inland waterways may transport commodities at a 30% and 60% lower cost of logistics, respectively. This could increase the competitiveness of Indian goods abroad and boost supply chain effectiveness. Decongestion of Roads and Railways: India's rail and road systems are extremely crowded, which causes delays and increased expenses. Congestion in these networks can be reduced by moving freight to inland rivers, increasing the effectiveness of transportation as a whole. Environmental Benefits: Compared to road and rail transportation, inland waterways have a substantially smaller carbon footprint. Road transport emits 51–91 grammes of CO^2 per ton-kilometer, while waterways emit 32–36 grammes. This is in line with India's objective of encouraging sustainable growth and lowering its carbon footprint. Connectivity and Accessibility: There are 14,500 km of inland waterways in India, of which 5,685 km may be traversed by motorised boats. This offers connectivity to places that could be difficult to get to by car or train, particularly in the nation's hinterland and outlying districts. Multimodal Integration: To establish a smooth multimodal logistics network, inland waterways can be connected to other forms of transportation like ports, railroads, and roadways. This can streamline the movement of commodities across the nation and increase overall transportation efficiency. Regional Development: Inland waterway development has the potential to

provide employment and economic expansion in the areas it serves. It can ease the flow of industrial and agricultural goods, increase tourism, and enhance local populations' standard of living.

1.3 Aim of the study

The aim of my thesis was to promote water based public transport in the city of Prayagraj.

1.4 Objectives of the study

The following are the objectives of the thesis:

1. To assess the existing public transport practice and their challenges in study area.
2. To assess existing practices and infrastructure of water channel all along to study area.
3. To study the travel behaviour and perception of users through local ferry service.
4. To suggest a systematic inland water based public transport system with help of suitable planning interventions.

1.5 Scope of the Study

The total 309.17 square kilometre planning boundary is included in the study. Total channel length of the waterbodies in the planning area: about 12 km for the Yamuna and 19 km for the Ganga. As an alternative method of public transit, inland water travel will lessen the burden of road transport and all of its related issues. This might develop into a very strong substitute for road travel with the right research, inventions, and introduction of upgraded technology. A few fundamental infrastructural issues with using inland waterways as a public transport option can be resolved with some creative modification and adjustments that will improve the system overall. For the inland water transport system to serve a larger percentage of the population, its capacity must be raised. To meet the people's increasing demand, more boats such as shallow boats and streamer boats should be put into service. Inland water transport needed to connect more locations. Furthermore, places with strong population pressure require more frequent journeys. Provision for a number of amenities that are now lacking but allow ferry services to function flawlessly even after dark. Passengers must always feel comfortable and secure, which calls for adequate facilities and security measures.

1.6 Limitations of the Study

- Majorly the study focuses upon the ferry users who are coming to ghats regularly or very frequently.
- Due to time constrained and lack of resources Entire River stretch of Ganga and Yamuna is not included in the study.
- The primary data is collected during the mela season so it may vary during the other time of the year.
- Only cross-sectional data collected through primary survey is used for data analysis and recommendations.
- The study do not cover the existing public transport and IPT Network and routes. It is more focused on ferry routes.

In addition, there are several organisational, functional, and infrastructure issues with the inland water transportation system. The current workforce is far smaller than what is needed for a variety of tasks, including office work on ghats, labour on board ships, and different infrastructure tasks like moving ghats during flood season and creating new plans for ghat operations, among other things. There are issues with ferry and vessel maintenance as well. Many of the large streamer vessels are currently lying in various bank areas in a terrible, exhausted state. The state of the roads connecting the ferry ghats is one of the minor infrastructure issues. The situation gets worse during the monsoon season, which causes a lot of inconvenience for individuals.

The current inland water transport system is not being used to its full potential and is beset with numerous issues. The transport system's vessels are sufficiently ancient. These don't have engines that move quickly.

2. LITERATURE REVIEW

2.1 Introduction

The establishment of the Inland Waterways Authority of India (IWAI) in 1986 was a significant step towards the systematic development and regulation of inland water transport in India. Following recommendations from expert committees like the National Transport Policy Committee in 1980, the IWAI was formed to oversee the development and regulation of the extensive network of inland waterways in India, which spans over 14,500 km and includes rivers, canals, lakes, and estuaries. These waterways have the potential to transform the country's transportation sector by providing a cost-effective, environmentally friendly, and efficient alternative to the congested road and rail networks.

2.2 Historical Context and Neglect

Historically, India's inland waterways played a crucial role in the country's trade and commerce. The Ganges river system, for instance, was a bustling waterway that facilitated the movement of goods and people across the northern regions. However, the advent of railways and the development of road networks in the 20th century led to the gradual decline of this mode of transportation, as noted by Gupta et al. (2017). This shift in transportation priorities resulted in the neglect of inland waterways, with the government's focus primarily on expanding the road and rail infrastructure.

In recent years, the Indian government has recognized the untapped potential of inland waterways and has taken steps to revive this mode of transportation. The establishment of the Inland Waterways Authority of India (IWAI) in 1986 marked a significant milestone in this endeavor. The National Waterways Act of 2016 was a pivotal legislative move, declaring 111 rivers, river stretches, creeks, and estuaries as National Waterways. This act aimed to create large-scale commercial shipping and navigation systems, with the goal of boosting cargo and passenger traffic, tourism, and overall transportation efficiency.

2.3 Advantage of Inland Waterways

Inland waterways offer a host of advantages that make them an attractive mode of transportation in India:

1. **Cost-effectiveness**: Transporting goods via inland waterways is significantly more cost-effective compared to road and rail transport. According to a study by RITES, one litre of fuel can move 215 tonnes-km on inland waterways, compared to 95 tonnes-km on rail and just 24 tonnes-km on roads.
2. **Reduced Logistics Costs**: Inland waterway transportation can reduce logistics costs by 30% compared to railways and 60% compared to roads. This can enhance the competitiveness of Indian goods in the global market and improve supply chain efficiency.
3. **Decongestion of Roads and Railways**: India's road and rail networks are heavily congested, leading to delays and higher costs. Shifting cargo to inland waterways can help decongest these networks, improving overall transportation efficiency.
4. **Environmental Benefits**: Inland waterways have a much lower carbon footprint compared to road and rail transport. Waterways emit 32-36 grams of CO2 per tonne-km, versus 51-91 grams for road transport. This aligns with India's goal of reducing its carbon footprint and promoting sustainable development.
5. **Connectivity and Accessibility**: India's extensive network of inland waterways can provide connectivity to regions that may not be easily accessible by road or rail, especially in the hinterland and peripheral areas of the country.
6. **Multimodal Integration**: Inland waterways can be integrated with other modes of transportation, such as roads, railways, and ports, to create a seamless multimodal logistics network. This can improve overall transportation efficiency and facilitate the movement of goods across the country.
7. **Regional Development**: The development of inland waterways can spur economic growth and job creation in the regions they serve. It can facilitate the movement of agricultural and industrial products, boost tourism, and improve the livelihoods of local communities.

2.4 Challenges and innitiatives

Despite the numerous advantages of inland waterways, their development in India has faced several challenges, including:

1. **Infrastructure Gaps**: Inadequate infrastructure, such as cargo terminals, jetties, and navigation facilities, has been a significant hindrance to the growth of inland waterway transportation.

2. **Navigability and Seasonality**: The seasonal nature of many Indian rivers, with fluctuating water levels, poses challenges for year-round navigation and cargo movement.
3. **Technological Bottlenecks**: The lack of modern vessels, cargo handling equipment, and river information systems has limited the efficiency and competitiveness of inland waterway transportation.
4. **Regulatory and Institutional Challenges**: Coordination among various government agencies and the need for a robust regulatory framework have been identified as areas requiring improvement.

To address these challenges, the Indian government has undertaken several initiatives:

1. **National Waterways Development**: The National Waterways Act 2016 has declared 111 waterways as National Waterways, with a focus on developing the necessary infrastructure and services to facilitate commercial navigation.
2. **Multimodal Integration**: The government is working to integrate inland waterways with other modes of transportation, such as the Eastern and Western Dedicated Freight Corridors and the Sagarmala project, to create a seamless multimodal logistics network.
3. **Technological Upgradation**: Efforts are being made to modernize the inland waterway infrastructure, including the development of state-of-the-art River Information Systems, vessel repair and maintenance facilities, and the upgrading of aging locks and navigation aids.
4. **Public-Private Partnerships**: The government is encouraging public-private partnerships to drive the development of inland waterways, with private entities contributing to terminal development, cargo handling, and the construction of low-draft vessels.
5. **Capacity Building and Skill Development**: Initiatives are being taken to strengthen the institutional capacity of the Inland Waterways Authority of India and to develop the skills of personnel involved in inland waterway operations.

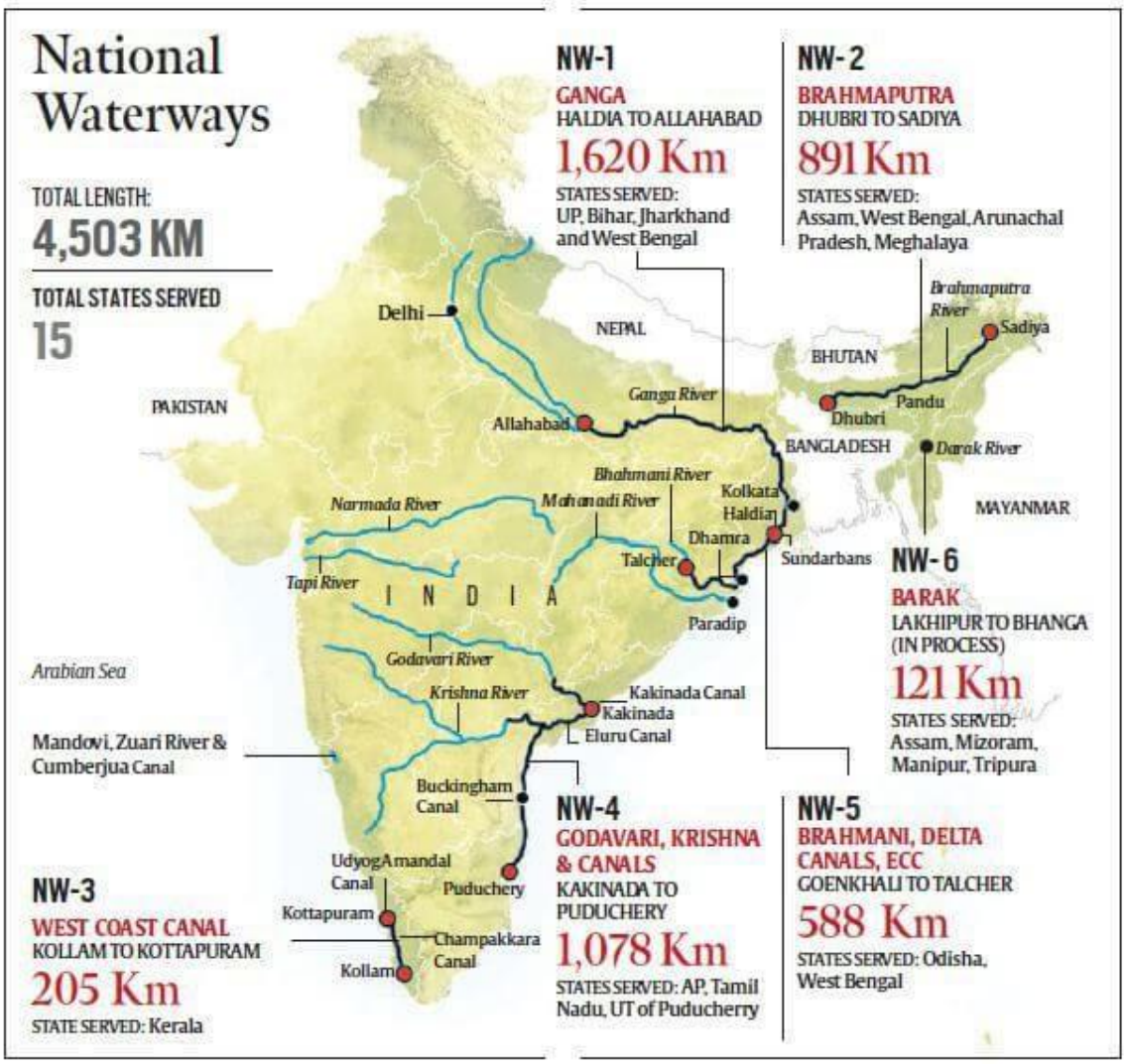

Figure 1 Major Inland Waterways by Inland waterways authority of India *(Source-IWAI)*

List of water Ways-

These waterways include Ganga -Bhagirathi-Hooghly river system (Allahabad-Haldia- 1620 kilometers) as NW-1, River Brahmaputra (Dhubri-Sadiya- 891 kilometeres) as NW-2, West Coast Canal (Kottapuram- Kollam) along with Udyogmandal and Champakara Canals- 250 kilometeres as NW-3, Kakinada-Puducherry canals along with Godavari and Krishna rivers (1078 kilometers) as NW-4. The NW-5 consists of East Coast Canal integrated with Brahmani River and Mahanadi delta Rivers (588 km).

2.4 Case Study 1 : National Waterway 1(Ganga-Bhagirathi-Hooghly)

One of the most prominent examples of the government's efforts to revive inland waterways is the development of National Waterway 1 (NW1), also known as the Ganga Waterway. This 1,620 km stretch of the Ganga-Bhagirathi-Hooghly river system, running from Prayagraj (Allahabad) to Haldia, has the potential to become a major artery of transportation in northern India1.The Capacity Augmentation of National Waterway 1 Project, supported by a World Bank loan of $375 million, aims to establish the necessary infrastructure and services to ensure the efficient and sustainable operation of this waterway. Key initiatives under this project include:

1. **Multimodal Freight Terminals**: The development of six multi-modal freight terminals at strategic locations, such as Varanasi, Ghazipur, and Haldia, to facilitate the seamless integration of waterways with other modes of transportation.
2. **Navigation Improvements**: Upgrades to the aging Farakka lock, the installation of night navigation facilities, and the marking of the central navigation channel to improve the safety and efficiency of vessel movement.
3. **River Information System**: The implementation of a state-of-the-art River Information System to enable real-time tracking of vessels, better logistics planning, and improved emergency response capabilities.
4. **Vessel Repair and Maintenance**: The establishment of a dedicated vessel repair and maintenance facility at Doriganj to support the upkeep of the waterway's fleet.

These initiatives are expected to transform the Ganga Waterway into a thriving logistics hub, connecting the densely populated and industrialized regions of northern India with the eastern seaports. The project's success could pave the way for the development of other national waterways and the realization of India's vision for a comprehensive inland water transportation network.Ganga Waterway (NW1)

2.5 Case Study 2: Kochi Water Metro

Kochi, a prominent port city located on the western coast of the Indian Peninsula, and it is also one of the most highly populated cities in Kerala. Over the past decade, Kochi has experienced increased economic growth, driven by strategic investments in various projects. These include the Vallarpadom International Container Terminal (VICT), a port-based Special Economic Zone, and industrial parks like

Smart City and Info Park. These investments have provided a significant boost to the regional economy and employment opportunities.

Project Area Profile

Flanked by the Arabian Sea to the west, the city, with a corporation area of 94.88 sq.km and a population of 6.02 lakh, has expanded beyond its limits along NH-47, NH-17, and NH-49 despite a declining population growth rate. The Greater Cochin Development Area, encompassing islands, spans 630 sq.km with a population of 21.2 lakh (Census of India, 2011). Recent census data shows higher growth rates in surrounding municipalities and villages compared to the city core, emphasizing the need to enhance connectivity between the mainland, adjoining municipalities, island communities, and Panchayat areas. Traffic studies emphasize increased investment in road connectivity, including bridges linking islands like Fort Kochi, Wellington, Vypeen, and Bolghatty. These studies also note a rise in automobiles in the city region while affordable public transport remains insufficient, despite holding a 51% modal share. To meet the cities growing travel demands and promote a shift to public transit, the Kochi Metro is being developed along a 25.61 km corridor from Aluva to Petta with 22 stations. Kochi Metro Rail Limited (KMRL), under the Ministry of Urban Development, Government of India, is leading the establishment of the Metropolitan Transportation Authority (MTA-KOCHI) to create a seamless multimodal transportation system in the Kochi City Region. MTA-KOCHI aims to develop a sustainable Water Transportation System for Kochi, aligning with international standards and integrating it with other modes of transport, including the metro, with a unified fare and timetable over time.

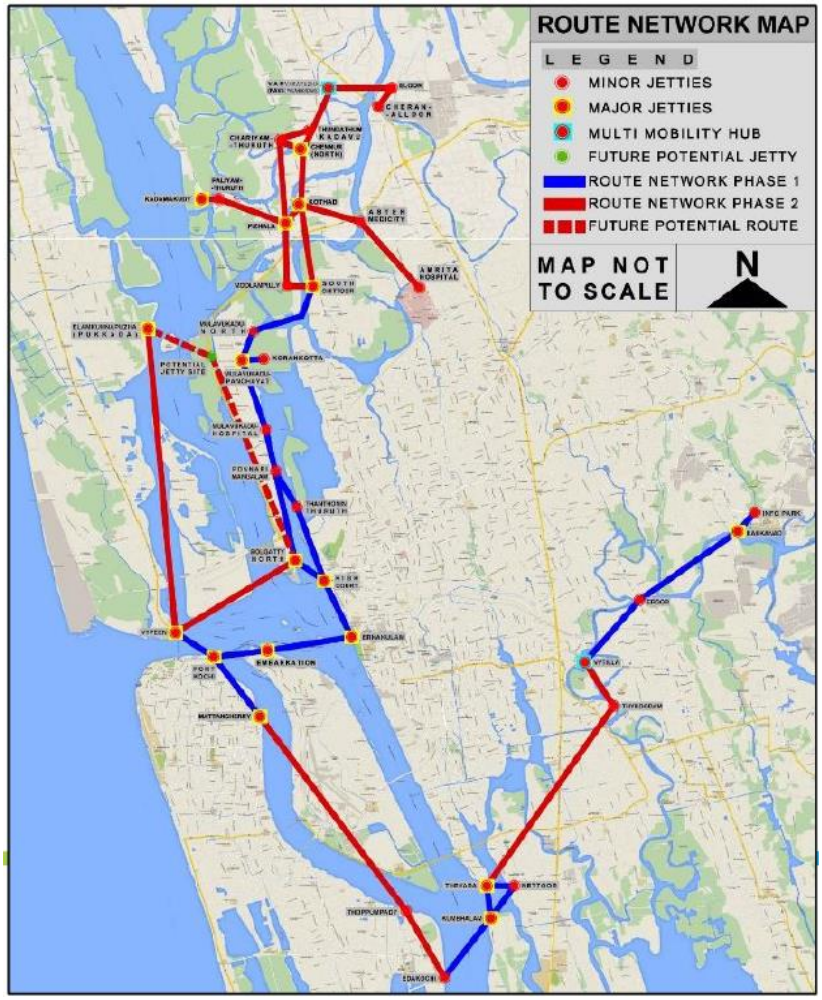

Figure 2. Proposed routes for Inland Water Transportation System for Kochi *(Source – kochi metro DPR 2015)*

2. RESEARCH METHODLOGY

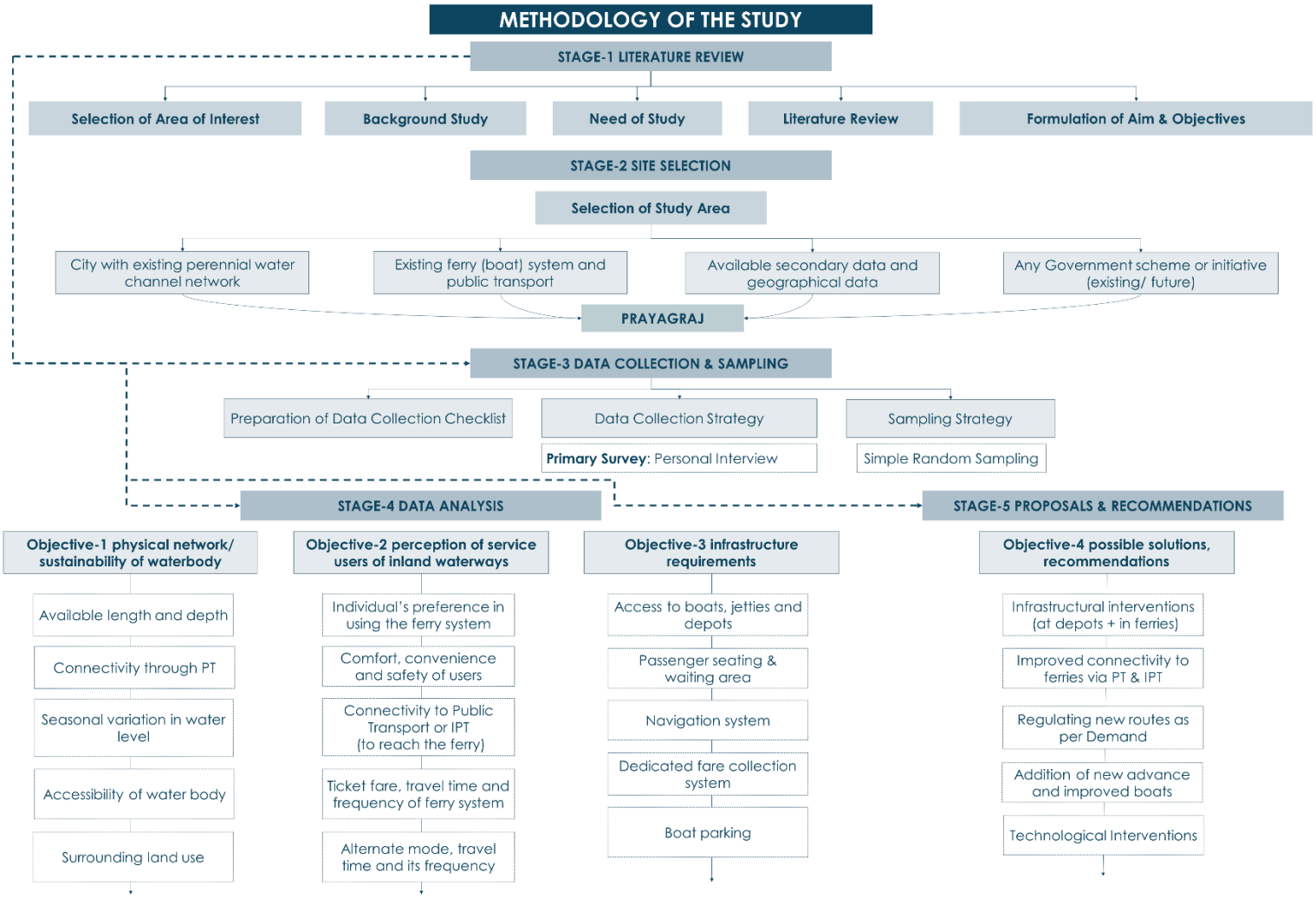

Figure 3. Methodology for research

3.1 Setting the Context of the Study

The study stars with setting the context in terms of transportation planning and its associated problems such as lack of connectivity in urban fringes and peri-urban areas to connect them to core city, traffic congestion in tier 1 and tier 2 cities, arising environmental problems due to air pollution and high carbon emissions generated and emitted through vehicles, vehicular accidents and safety measures to reduce the rate of accidents and parking problems due to increasing per capita car share. These problems could be addressed through increasing the use of public transport and shifting from road transport to inland waterways. Public transport is a larger domain consisting of various modes of transport namely, roadways, railways, airways and waterways. In past few decades we have seen a drastic improvement in roadways, railways and airways through government projects and public-private partnerships. But at the same time waterways is underutilized. India having a coastline of length more than 7000 km, so it is important to focus on this mode to address the problems and increasing pressure on road transport in more sustainable way.

3.2 Conceptual Framework of the Study

The study is divided into five stages namely,

- Learning from Literature Review
- Site Selection
- Data Collection and Sampling
- Data Analysis
- Recommendations, Suggestions and Proposals

3.2.1 Learning from lliterature Review

Majorly consists of detailed literature review for the study. Initially the area of interest was found. I started with my keen interest in domain of public transportation. So through studying some literature I listed down the major transportation problems in tier 1 and tier 2 cities. The last few years have seen an exponential increase in demand, which public transport systems in cities have not been able to

meet. Consequently, individuals have shifted to semi-private transportation options such auto-rickshaws, tempos, and taxis as well as personalised vehicles like automobiles, mopeds, scooters, and motorbikes. Cities cannot afford to serve solely private automobiles, and it must be widely acknowledged that policies should be created to encourage public transportation, especially the bus system, while decreasing the demand for individualised kinds of transportation. If public transport is to be a major part of a city's daily life, a lot of work needs to be done. To address these problems, best possible option available is shift from road transport to inland waterways as it is most economical and sustainable modes of transport available.

To better understand the inland waterways, various policy documents have been studied. Inland Waterways Policy 2001 by Inland Waterways Authority of India. This strategy emphasises the benefits of inland water transportation (IWT), including its affordability, fuel efficiency, and environmental friendliness. It suggests that the private sector play a significant role in building infrastructure and managing fleets. The main goal is to make inland canal transit a desirable substitute for road travel wherever it is practical. In order to pursue infrastructure development projects in the inland water transport industry, the IWAI was also allowed to form joint ventures with private parties who expressed interest.

National Urban Transport Policy (NUTP) 2006 is a major supporter of the development and usage of sustainable, indigenous means of transport like the ferry system since they would lessen public reliance on the already congested roadways and require less money for setup and maintenance. Integrating transport and land use would help reduce urban sprawl by helping to direct the city's expansion. Promoting inland waterways as a means of public transport would reduce pollution and help manage traffic on city streets.

The above policies helped in finding the need of the study inland waterways in India. As shift from road transport to IWT for both passengers contribute to more efficient use of resources and energy. It gives unique opportunities for the development of tourism. India also has target to be Net Zero Nation by 2070. The development of inland waterway transport is a key to ensure sustainability.

On the basis of the need of the study, the aim and four objectives of the study were formulated discussed in previous Chapter-1 in detail.

3.2.2 Selection of Study Area

In Stage-2 the study area was selected based on certain parameters. These parameters are:

- The city with existing perennial water channel network of rivers.
- The city should have existing ferry (boat) system used as mode of public transport.
- The geographical and secondary data should be available of the city for further stages of the study.
- The city should have ongoing or proposed Government Scheme or initiative (existing/ future) for improving the ferry system.

All the above mentioned parameters were fulfilled by **PRAYAGRAJ CITY.**

Reasons behind selecting the Prayagraj as Study Area:

- The city is located Location and expanded along the perennial rivers Ganga and Yamuna and their confluence famously known as Sangam.
- Major section of city's population is dependent on ferry system for their mobility on various ghats for different purposes.
- Currently the city is facing increasing pressure on existing road transport and congestion issue. So there is scope of decongestion of the city's traffic and lessening down the pressure on exiting public transport.
- The city has Site with significant religious and cultural importance. Every year and within a year we can see large concentration of floating population in the city creating additional burden on existing transportation system.
- The city is part of National Waterway-1 so both Central and State Governments along with local government are taking initiatives for boosting the water-based transport in the city by implementing various schemes and programs.

3.2.3 Data Collection Strategy and Sampling

In Stage-3 data collection and sampling is done. The data consists of both primary data and secondary data.

Primary Data Collection:

The primary data was collected through on-site primary survey conducted in the month of February 2024. The primary survey is done through personal interview by using questionnaire. Two different

questionnaires were prepared, one for ferry users and other for ferry operators. The questionnaires are attached in the Annexure-1 and Annexure-2 of the report.

For ferry users the questionnaire was divided into 3 sections. The first section consists of questions related to demographic details of the users such as- gender, age, occupation, educational attainment, income and vehicle ownership.

The second section of the questionnaire has questions related of user's travel behavior. The questions consists of- trip origin, trip destination, trip purpose, location of workplace, duration of working hours, daily travel time (to-and-fro), daily travel distance (to-and-fro), daily travel expenses, use of public transport, type of public mode used, use of personal vehicle, mode of personal vehicle used and frequency of mode used for commuting.

The third section consists of user perception. The five pointer Likert scale was used to study user perception of ferry users. In Likert Scale, 1 means strongly disagree, 2 means disagree, 3 means neutral, 4 means agree and 5 means strongly agree. The questions were related to travel time taken per trip, travel cost of per trip of the user, connectivity of the ferry with other modes of public transport ot intermediate public transport, accessibility of ghats and ferries by the user, designated waiting and seating space available at ghats and within ferries, safety of user in all the weather conditions.

Secondary Data Collection:

The secondary data is collected through various government websites, portals, reports, journals and stakeholders from different authorities of Prayagraj City. The list of stakeholders include-

- IWAI (Inland Water Authority of India)
- PDA (Prayagraj Development Authority)
- Prayagraj Municipal Corporation
- Mela Samity Kumbh
- Prayagraj Tirth Niwas
- Boat Club Prayagraj
- Water Police Uttar Pradesh
- Central Water Commission

The data collected from these stakeholders include- upcoming development projects (for Ganga and Yamuna rivers and its Sangam), infrastructure improvement regulations or policies, safety regulations for devotees and ferry users, government policies and initiatives related to development of existing

inland waterways, any other development plan/ report available, GIS data or statistical records, latest existing or proposed land use map (if available). GIS data include- available length and depth of the water body, seasonal variations in water level, surrounding land use near waterbody, accessibility through roads (road network), existing public transport (PT) routes and intermediate public transport (IPT) routes to reach ferry and distance between intermediate ferry stations.

Sampling Technique:

Simple random sampling is employed for sampling, where a random portion of the population is selected to form a simple random sample. Each individual in the population has an equal chance of being selected through this method. Among probability sampling methods, simple random sampling is the most straightforward as it involves just one random selection and requires minimal prior knowledge of the population.

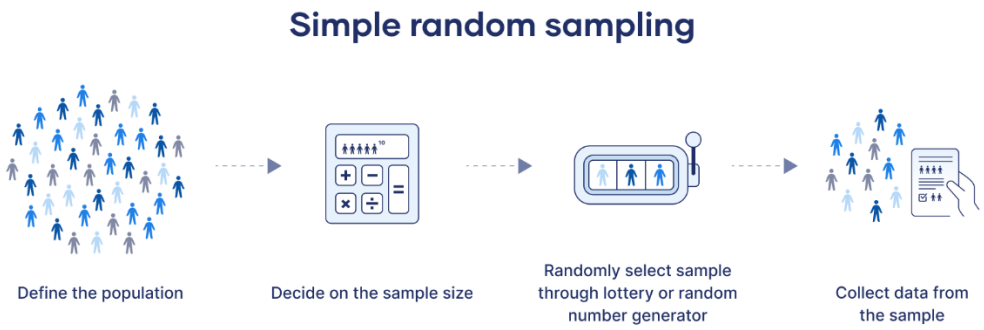

Figure 4. Simple Random Sampling (source: Scribber.com)

Sample Size Calculation:

The sample size (N) was calculated by following the approach outlined in Levin, Rubin, Siddiqui, and Rastogi's (2017) method for estimating population proportion, considering the impact of multi-stage sampling and potential non-responses.

$$N = \frac{Z^2_{a/2} \times P \times (1-p) \times D}{E^2}$$

In this context:

N represents the sample size.

P denotes the anticipated proportion of cases in the target population.

Z alpha signifies the critical z-value corresponding to a significance level of 0.05.

E stands for the margin of error, set at 5% or 0.05.

D is the design effect, accounting for potential information loss in multi-stage sampling compared to simple random sampling, with a value of 1.5 based on Elder (2009) and the World Health Organization (2017).

3.2.4 Approach to Data Analysis

In Stage-4 of the study, objective-wise data analysis have been done.

Objective-1 of the study is to assess the existing public transport practices and their challenges in the study area. In this objective the existing public transport of the Prayagraj city have been studied in detail. The public transport includes- City Bus Public Transport and Intermediate Public Transport includes autos and rickshaws along with major city bus service routes and major trip origin and trip destination of the users within the study area.

Objective-2 of the study is to assess the exiting practices and infrastructure of water channel along to study area. To fulfil this objective the availability of infrastructure in existing condition have been studied and a matrix have been prepared whether the infrastructure is available, partially available or not available at the ghats and the inferences have been made. Then the existing infrastructural problems have been listed out to find the gap in infrastructure. Based on the gap the required infrastructure and its related components have been listed out by referring the Kochi Metro Case Study. Then the conditions required for the water channel to proposed inland waterways have been studied and a comparative analysis have been done between the conditions required and existing conditions in study area. Then the variation in availability of water in the selected water channel have been studied for at 4 different months in the year 2023 namely, February, May, August and November by using satellite data and analysing in GIS Software.

Objective-3 of the study is to study the travel behavior and perception of users through local ferry service. In this objective the demographic data, travel behavior of users along with perception of ferry users and ferry operators have been studied and inferences were made. To do the perception study the 5-pointer Likert scale questions have been used ranging from strongly agree to strongly disagree. The questions were related to travel time taken per trip, travel cost of per trip of the user, connectivity of the ferry with other modes of public transport of intermediate public transport, accessibility of ghats and ferries by the user, designated waiting and seating space available at ghats

and within ferries, safety of user in all the weather conditions. To analyse the collected data, Multi-Nomial Logistic Regression technique have been used with total 9 variables. Out of which 3 were independent variables and 6 were dependent variables. Based on the output tables generated by using SPSS Software, the inferences were made.

3.2.5 Expected Outcomes

Objective-4 of the study is to suggest a systematic inland water-based public transport system with the help of suitable planning interventions. In this objective the inferences made from objective-1 were used to give proposals. Proposals include the new ferry routes, infrastructure to be proposed and improving the last mile connectivity of existing ferry services.

4. STUDY AREA

4.1. Site Selection Criteria

The study area was selected based on certain parameters. These are:

- The city with existing perennial water channel network of rivers.
- The city should have existing ferry (boat) system used as mode of public transport.
- The geographical and secondary data should be available of the city for further stages of the study.
- The city should have ongoing or proposed Government Scheme or initiative (existing/ future) for improving the ferry system.

All the above mentioned parameters were fulfilled by **PRAYAGRAJ CITY.**

Reasons behind selecting the Prayagraj as Study Area:

- The city is located Location and expanded along the perennial rivers Ganga and Yamuna and their confluence famously known as Sangam.
- Major section of city's population is dependent on ferry system for their mobility on various ghats for different purposes.
- Currently the city is facing increasing pressure on existing road transport and congestion issue. So there is scope of decongestion of the city's traffic and lessening down the pressure on exiting public transport.
- The city has significant religious and cultural importance. Every year and within a year we can see large concentration of floating population in the city creating additional burden on existing transportation system.
- The city is part of National Waterway-1 so Central and State Governments along with Local Government are taking initiatives for boosting the water-based transport in the city by implementing various schemes and programs.

4.2. Introduction of the Study Area

Prayagraj also known as Allahabad is the most populous district in the state of Uttar Pradesh—which is home to over 13 million people. It serves as the administrative centre of the Prayagraj Division. The Prayagraj High Court is the state's highest court, and the city serves as Uttar Pradesh's political and judicial centre. With an estimated 1.11 million people living in the city and 1.21 million in the surrounding metropolitan area, Prayagraj is the seventh most populated city in the state, twelfth most populous in Northern India, and thirty-sixth most populous in India as of 2011 Census population data.

It was listed as the 40th fastest-growing city in the world in 2011. After Lucknow and Noida, Allahabad was rated as the third most livable city in the state and the sixteenth most livable city nationwide in 2016. The city was formerly known as Prayagraj, which means "place of offerings" because to its location at the Sangam, or confluence, of the Yamuna, Sarasvati, and Ganga rivers. It is the second-oldest city in India and is mentioned extensively in Hindu texts. The Kuru kings of Hastinapur named Allahabad Kaushambi (now a distinct district), and they developed it as their capital. Since that time, Allahabad has served as the Doab region's administrative, cultural, and political hub.

Akbar, the Mughal ruler, dubbed it Allahabad, which the British subsequently altered to Allahabad. Prior to the territory's capital being transferred to Agra in 1835, it served as the seat of the Ceded and Conquered Provinces region in 1833. In 1858, Allahabad was briefly the capital of India before becoming the capital of the North-Western Provinces. During the fight for Indian independence, the city maintained its position as the nation's prominent centre and served as the capital of the United Provinces from 1902 to 1920.

Figure 5. Prominent Structures in the city. (Source: Prayagraj Municipal Corporation Website)

Figure 6.Kumbh Mela in Prayagraj. (Source: Prayagraj Municipal Corporation Website)

4.3. Civic Administration in the City

The Prayagraj Municipal Corporation is in charge of running Prayagraj City. It was established to provide infrastructure-related civic facilities as well as everyday necessities for the populace. Nonetheless, the CMP is designed for the region that falls within the purview of the Prayagraj Development Authority (PDA), which includes the rural areas, the urban spillovers, and the Prayagraj Municipal Corporation (PMC). Since its establishment in 1974 under the Uttar Pradesh Urban Planning

& Development Act 1973, the Prayagraj Development Authority (PDA) has grown from its modest beginnings to become a powerful force in the city's development landscape. In line with the goals of contemporary India, PDA seeks to develop the historic city in a planned and coordinated manner. This will allow Prayagraj to stand tall as the capital of the nation's largest state, which has been instrumental in the Freedom Struggle; expand urban infrastructure to withstand the demands of a rapidly evolving society; and create an atmosphere that will maximise satisfaction for all segments of its populace. In order to carry out its mandate, the Authority aims to collaborate in line with an all-encompassing Master Plan with the efforts of numerous other organisations engaged in the development and expansion of urban infrastructure. According to the master plan, the jurisdiction area is 769.6 sq. km, and its population is expected to reach 20.43 lakhs in 2021.

The Authority's goals are to ensure that the development area is developed in accordance with the plan, and to that end, it has the authority to acquire, hold, manage, and dispose of land and other property; to conduct mining, building, and engineering projects; to carry out work related to the supply of water and electricity; to dispose of sewage; to provide and maintain other services and amenities; and, in general, to do anything that is expedient for the advancement of the development area a With an exception that nothing in this Act may be interpreted as enabling the Authority to disregard any legislation, except as specified in the U.P. Urban Planning and Development Act.

The General Administration, which includes the Divisional Commissioner and District Magistrate, and the Police Administration, which includes the ADG, SSP, and SP police, oversee Prayagraj city’s administration in addition to the Municipal Corporation and Development Authority.

4.4. Regional Setting of the City

Located at the Yamuna and Ganga confluence, Prayagraj lies in the southern region of Uttar Pradesh. Originally referred to as the Kuru, the area was later called the Vats nation in antiquity. Bundelkhand lies to the southwest, Bundelkhand to the east and southeast, Awadh to the north and northeast, and the lower doab (of which Allahabad is a part) to the west. An east-west railway line splits the city in two. The British-built Civil Lines are located north of the railway, and the Old Chowk neighbourhood lies south of it. Prayagraj is strategically situated both geographically and culturally. Though it is technically near the mouth of the Yamuna and part of the Ganga-Yamuna Doab, culturally it marks the end of the Indian west. The city is close to the longitude of Indian Standard Time (25.15°N 82.58°E). In terms of wind and storm risk, Prayagraj is in a "low damage risk" zone, according to a UNDP analysis. Its soil

and water are mostly alluvial, same like the rest of the doab. The city is bounded to the North by Pratapgarh, to the East by Bhadohi, to the South by Rewa, to the West by Chitrakoot (formerly Banda), and to the North by Kaushambi, which was formerly a part of Prayagraj.

Table 1. Distance of major cities from Prayagraj. (Source: Prayagraj Master Plan)

Cities	Distance from Prayagraj	Connectivity Mode
Lucknow (State Capital)	201 Km	Rail, Road
Kanpur	213 km	Rail, Road
Varanasi	120 km	Rail, Road
Gorakhpur	266 km	Rail, Road
Jaunpur	103 km	Rail, Road
Faizabad	161 km	Rail, Road
Mirzapur	85 km	Rail, Road
Rewa	138 km	Rail, Road
Chitrakoot	70 km	Rail, Road

Figure 7.Regional Setting of Prayagraj City. (Source: Prayagraj Master Plan)

4.5. Demographic Characteristics of the City

The Prayagraj Urban Agglomeration has 20,34 lakh residents, according to the 2011 census. It consists of the cantonment of Prayagraj and the region under the Prayagraj Municipal Corporation. Population has grown at the highest pace in the past 60 years, or 59%, when compared to a population of 12 lakhs in 2001. With the corresponding industrial expansion and the construction of industrial estates, commerce had a tremendous upsurge throughout the post-independence era, drawing people to the

city. The following Table and Figure show the population growth trends in the Prayagraj Urban Agglomeration since 1951.

Table 2 Population and Growth Rate of Prayagraj. (Source: Prayagraj Master Plan)

Year	Population (lakhs)	Growth Rate (%)
1951	3.32	-
1961	4.30	29.62
1971	5.13	19.11
1981	6.50	26.71
1991	8.44	29.92
2001	12.00	42.08
2011 (UA)	20.34	59.00

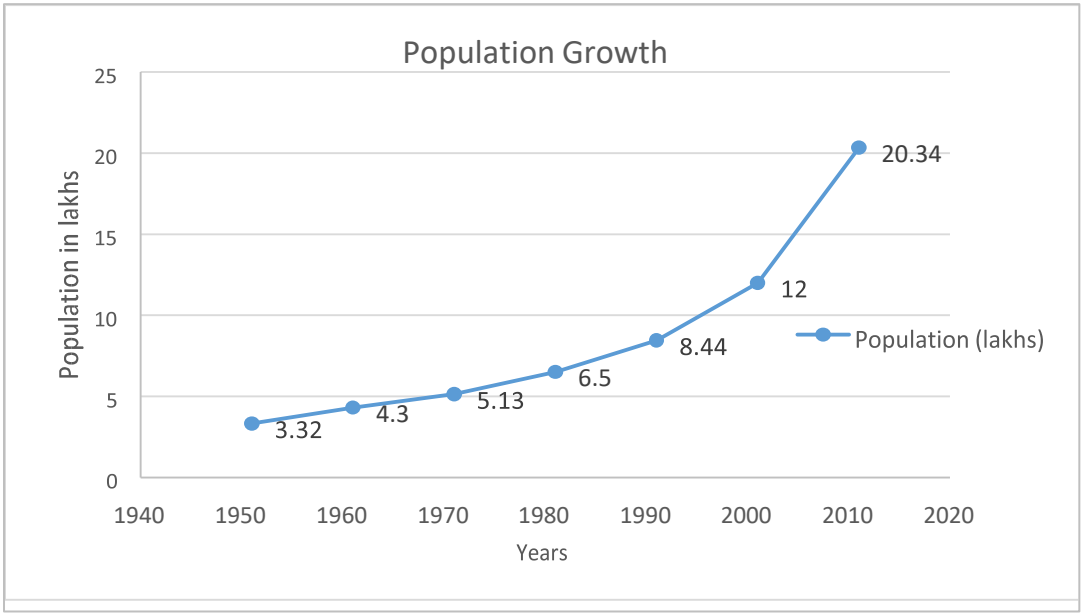

Figure 8.Decadal population growth of Prayagraj. (Source: Prayagraj Master Plan)

The following are some of the main demographic traits of the Allahabad Urban Agglomeration-

- Population is 20.34 lakhs
- Sex Ratio 901
- Average Literacy Rate is 86.5%

The central region of Allahabad is home to a sizable portion of the city's inhabitants and has a very high population density. Because of the nature of its land usage, the region under the control of the Allahabad Cantonment also has a comparatively lower population density. Nonetheless, there is little population in the outward expanding pockets. It is significant to note that, in accordance with patterns

of urban growth, there has been an increase in the number of settlements in certain areas close to major thorough fares.

4.6. Economy of the City

Overall, the economy of Prayagraj is quite stable and diverse, with a wide range of industries represented, including manufacturing, state and federal government offices, research and education facilities, real estate, retail, banking, tourism, and hospitality, as well as industries based on agriculture, railroads, transportation, and logistics, and various service sectors. The economy of Prayagraj is mostly centred on the construction industry. The third All India Census for Small Scale enterprises shows that there are over 10,000 unregistered small-scale enterprises in the city. Secondary manufacturers and services might be registered or unregistered. The Dedicated Freight Corridor Corporation of India has proposed to develop 1,200 acres (490 hectares) in Prayagraj into an integrated industrial complex. The glass and wire industries are also established in the city. The primary industrial zones in Prayagraj are Naini and Phulpur, home to several industries and offices of both public and private sector businesses. The largest state-owned oil corporation in India, Bharat Petroleum Corporation Limited, is building a refinery in Lohgara with a capacity of seven million tonnes per annum (MTPA) at an estimated cost of INR 62 billion. The city is home to the headquarters of Bharat Pumps & Compressors, A. H. Wheeler and Company, and Allahabad Bank, which opened for business in 1865. Reliance Industries, GE T&D, ITI Limited, BPCL, Dey's Medical, Food Corporation of India, Raymond Synthetics, Triveni Sheet Glass, Triveni Electroplast, EMC Power Ltd, Steel Authority of India, HCL Technologies, Indian Farmers Fertiliser Cooperative (IFFCO), Vibgyor Laboratories, Geep Industries, Hindustan Cable, Indian Oil Corporation Ltd, Baidyanath Ayurved, Hindustan Laboratories, and Prayagraj Enterprises are some of the major businesses in the city. The Central Organisation for Railway Electrification has its headquarters in this location as well. The city’s main economic sectors are tourism, fishing, and agriculture, and the city serves as a centre for India's farming sector. Due to the well-known Kumbh and Ardh Melas, Allahabad is also known for hosting the world's largest pilgrimage gathering. The Magh Mela, also known as the Ardh Kumbh Mela, is held at Prayag or Allahabad city every six years. Every twelve years, the Kumbh Mela takes place. At Triveni Sangam, where the Ganga, Yamuna, and the fabled Sarasvati rivers converge, ceremonial bathing is part of the fair/mela. With around 120 million attendees, the most recent Allahabad Kumbh Mela emerged as the world's largest religious event in 2013. The following one is stated for 2025, with the Ardh Kumbh Mela taking place in 2019.

Figure 9.Major economic hub, Civil Lines, MG Road, Prayagraj. (Source: Primary Survey)

5. DATA COLLECTION

5.1. Questionnaire Design

The study is mainly based on disaggregate level data. A structured questionnaire divided into three parts was used for collecting the primary data. The questionnaire is included in Appendix A.

The first part of the questionnaire includes questions regarding personal and household characteristics like gender, age, educational attainment, occupation and household size, vehicle ownership in the household and household income.

Gender has two categories, male and female. Four categories were included for age: 25-35 years, 36-45 years, 46-55 years and 56-65 years. Educational attainment includes four categories: Did not finish the primary school, finished primary schooling but did not matric, matric but not graduate/ diploma holder, graduate/diploma holder or above. For occupation eight categories were included: not working, daily wager, salesperson, household industry, self-employed professional, business, service and other working. Non-working category includes four categories: household duties, dependent, pensioner and others. Monthly household income includes four categories: up to INR 10,000, INR 10,001- 25,000, INR 25,001- 50,000, INR 50,000 and above. Income is treated as an ordered categorical variable in the study. The question related to vehicle ownership is open ended question.

The second section of the questionnaire has questions related of user's travel behaviour. The questions consists of- trip origin, trip destination, trip purpose, location of workplace, duration of working hours, daily travel time (to-and-fro), daily travel distance (to-and-fro), daily travel expenses, use of public transport, type of public mode used, use of personal vehicle, mode of personal vehicle used and frequency of mode used for commuting.

The third part of the questionnaire included graded responses statements for measuring attitudes, perceptions and preferences related to preference of using ferry system. Likert scale response statements were framed for each measurement item. The five-point Likert scale used in this study has an ordered set of values starting with 'Strongly Agree', and followed by 'Agree', 'Neutral', 'Disagree', and 'Strongly Disagree' which are coded as 1, 2, 3, 4 and 5 respectively.

The questions were related to travel time taken per trip, travel cost of per trip of the user, connectivity of the ferry with other modes of public transport or intermediate public transport, accessibility of ghats

and ferries by the user, designated waiting and seating space available at ghats and within ferries, safety of user in all the weather conditions.

5.2. Sampling Strategy and Data Collection

A primary survey was conducted in the Prayagraj at various Ghats in February 2024 shown in the map below.

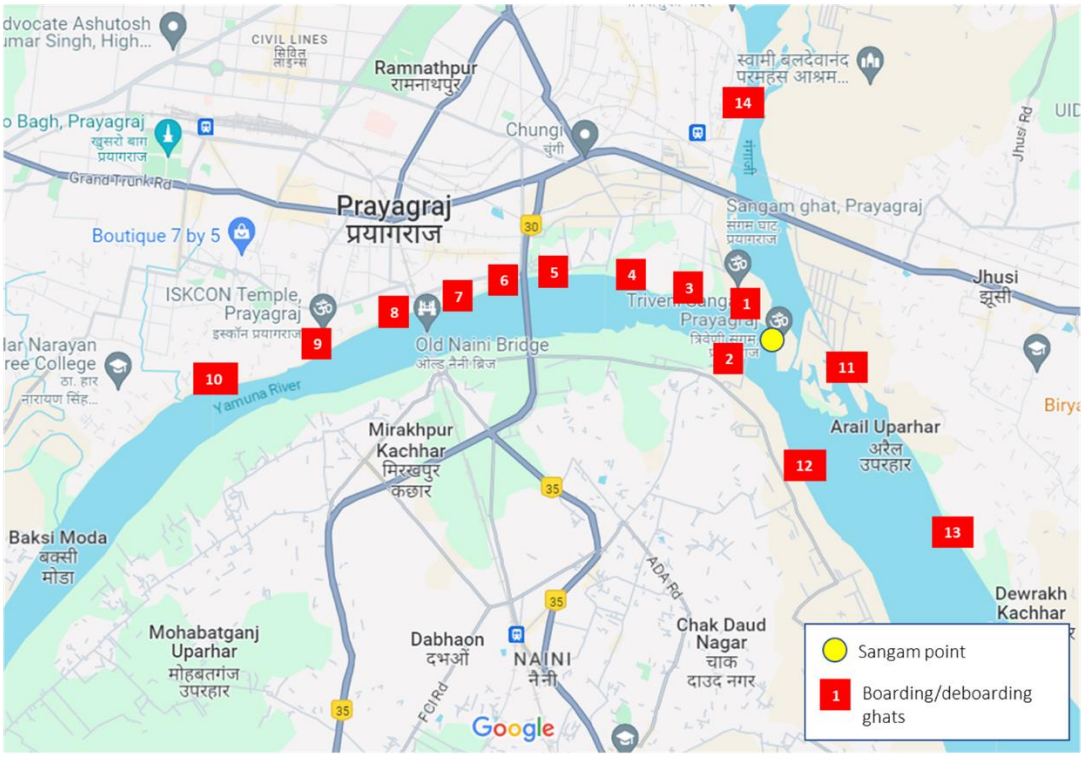

Figure 10.Primary Survey locations at Ghats in Prayagraj. (Source: Google maps and Primary Survey)

The structured questionnaire discussed in the previous section was used to collect data through primary survey conducted in the Month of February 2024.

The sample size (N) was determined as follows, using the method for determination of sample size for estimating population proportion used by Levin, Rubin, Siddiqui, and Rastogi (2017), and factoring in the effect of multi-stage sampling and possible non-responses:

$$N = \frac{Z^2_{\alpha/2} \times P \times (1-p) \times D}{E^2}$$

Where,

N= sample size;

P= expected proportion of cases in the population of interest;

Z alpha= critical value of z corresponding to a significance level of 0.05;

E= margin of error;

D= measure of design effect;

P is taken to be 0.5. The critical value of z corresponding to a significance level of 0.05 is found to be 1.96. Value of E is taken to be 0.05 and margin of error is 5%. A measure of design effect ‘D’ is included to address the possible loss of information in the multi-stage sampling process in which the sampling error is expected to be higher compared to simple random sampling, and its value is taken to be 1.5 (based on Elder (2009), and World Health Organization (2017)).

Based on the above, the sample size was determined to be 385, but due to time constrained for primary survey only 215 responses were collected.

The questions were communicated to respondents in Hindi and English both and the responses were recorded using google forms.

6. DATA ANALYSIS AND FINDINGS

6.1. The analysis of the study has been carried out objective-wise.

6.1.1. Objective-1 of the study is to assess the existing public transport practice and their challenges in study area.

The majority of the public transport in the study area is provided by roads. Currently, Prayagraj's main mass transit option is the bus, and the city's public transportation options are quite restricted. The city bus services are run by Allahabad City Transport Services Limited (ACTSL) and are primarily low floor, conventional midi buses and micro buses with no air conditioning. Regional Public Transportation Bus Services provide excellent connectivity in Prayagraj. Private bus firms and the Uttar Pradesh Road Transport Corporation (UPSRTC) both offer bus services that link Prayagraj City to all other major cities in the area. Additional services offered are Volvo bus services, semi-sleeper AC services, and luxury AC bus services. The three main bus stands for regional bus services in Prayagraj are Civil Lines Bus Stand, Leader Road Bus Stand, and Zero Road Bus Stand.

Figure 11 Civil Lines Bus Depot, Prayagraj. (Source: Primary Survey)

Total of 130 buses were purchased by the municipal bus service as part of the JNNURM 2009 bus funding programme. Only 125 of the 130 buses that were originally planned for usage in the city are currently operational due to the burning of five of those buses during some local riots. There are 125 buses available, which is a fairly small number for a city bus service. The current bus supply for a city the size of Allahabad is significantly less than the benchmark of 60 to 70 buses per lakh population.

Every bus complies with the Urban Bus Specifications that the government published at the time of purchase. The table below provides information on the number of buses and their category.

Table 3 Number of buses and their category in Prayagraj. (Source: CMP 2021, Prayagraj)

Sr No	Bus category	Number of buses
1	Non AC Low Floor Bus	10
2	Standard Non AC Midi Bus	60
3	Standard Non Midi Bus	60
	Total	130

Typically, between 120 and 125 buses are available for usage on both working and non-working days. Due to maintenance issues, the remaining fleet is either being repaired or left idle. Inside the buses and on board, tickets are purchased using handheld Electronic Ticket Vending Machines (ETVM). The majority of notable locations, including Civil Lines, Cantonment, Railway Stations, Sangam Ghat, University, High Court, Katchehary, IIIT, significant market areas, significant factories, parks, and recreational areas, are served by the city bus services' routes. Private city bus (mini and midi) services also serve suburban and peripheral riders on a few select routes. Table below provides information on city bus routes, fleet size for each route, and route length.

Table 4 Prayagraj City bus routes, fleet size for each route, and route length. (Source: CMP 2021, Prayagraj)

Sr No	Route Name	Route Length km	Bus type	No. of Buses
1	Trivenipuram to Happy Home	22	Standard	18
2	Raymond to Shantipuram	30	Standard	14
3	Civil lines to Pratappur	40	Standard	10
4	Bairana to Shankargarh	42	Standard	12
5	Railway Station to Lalgopalganj	42	Standard/Mini	10
6	Railway Station to Sohranva	25	Mini	4
7	Railway station to Todhi ka pura	42	Mini	2
8	Civil lines to Mauvama	33	Standard	4
9	Railway station to Bomapur	34	Mini	4

10	Railway station to Saghanganj	23	Mini	4
11	Railway station to Baharia	35	Mini	2
12	Railway station to Nayi Bazar	36	Mini	2
13	Railway station to Jame Bhita	36	Mini	1
14	Civil lines to Dandupur to Pratappur	48	Standard	2
15	Kutchery to Jasra	29	Mini	4
16	Kutchery to Kohdarghat	45	Mini	8
17	Govindpur to Mirapur	16	Mini	3
18	Govindpur to Dariabagh	17	Mini	1
19	Govindpur to IIIT	20	Mini	4
20	Dara Ganj to Bisona	26	Mini	3
21	Civil lines to Phoolpur to Jogia Shekhpur	38	Mini	2
22	Trivenipuram to Shantipuram (University)	28	Standard	1
23	Raymond Factory (Naini) to Shantipuram (University)	30	Standard	1
24	Shantipuram to Naini	30	Standard	1
25	Dara Ganj to Mirapur	15	Mini	1
26	Govindpur to Jhalwan	20	Mini	1
27	Govindpur to IIIT	20	Mini	2
28	Railway Station to Trivenipuram Haziganj	26	Mini	2
29	Sahson to Civil lines to Pratappur	28	Standard	2

The city bus routes span over 875 kilometres in total, with an average length of 30 km each route. The roads connect all of the main hubs and hubs of activity around the city. About 470 people are needed in total for the operation, upkeep, management, and monitoring of the city bus system. Staff members such as conductors, drivers, and administrators are included in the engagement. When compared to the money received, bus operating costs are extremely high. The approximate Income per Kilometre (IPKM) for a Low Floor Bus is Rs. 11/km, Standard Midi Bus is Rs. 6/km, and Mini Bus is Rs. 8/km. In addition to fee box money, city bus service also receives a certain amount of money from advertisements. Less than 5% of overall revenue comes from non-fare box sources.

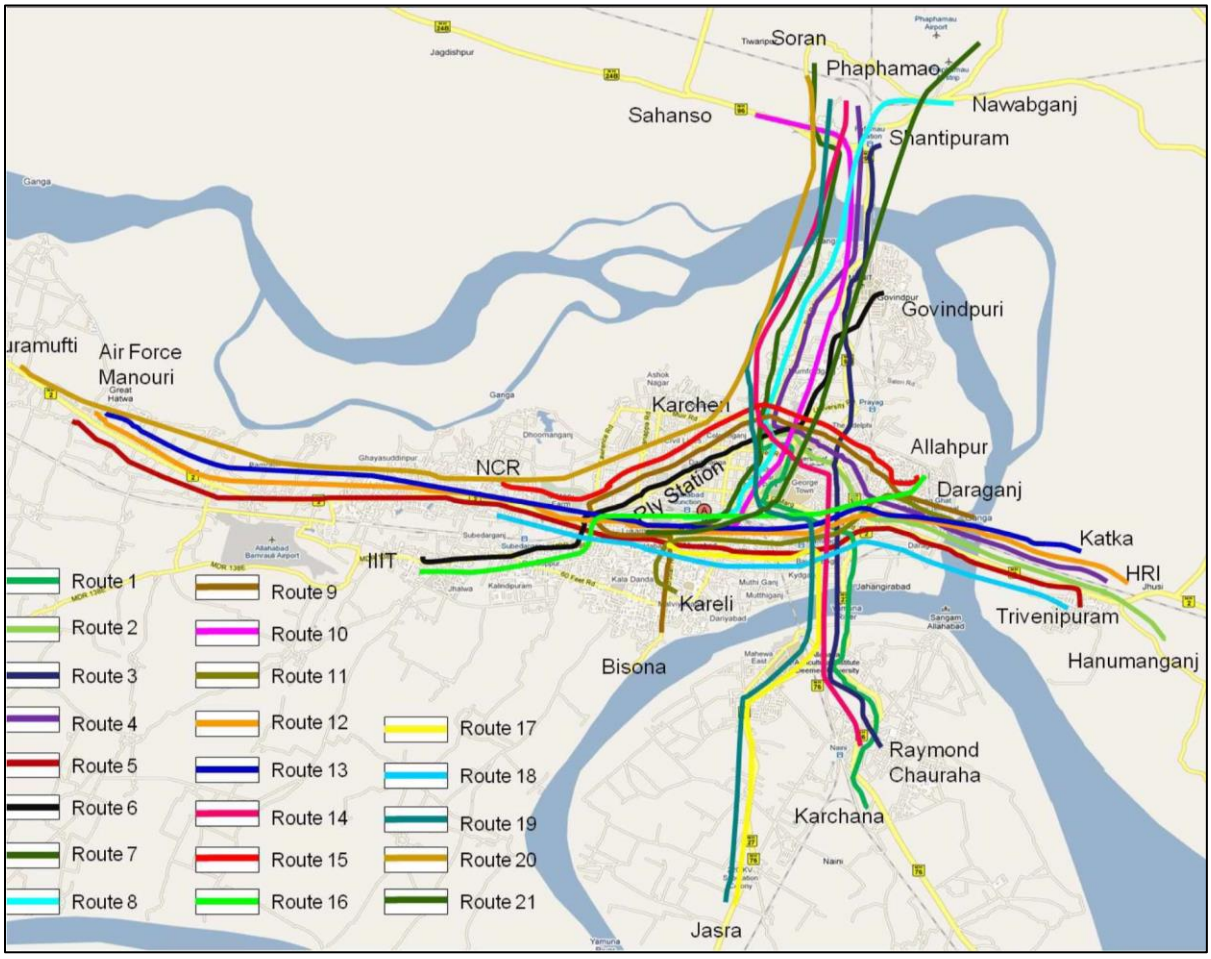

Figure 12 Major city bus routes in Prayagraj. (Source: CMP 2021, Prayagraj)

Due to a deteriorating fleet and inadequate maintenance facilities, the condition of the municipal buses is not satisfactory. There is just one depot, located close to Jhunsi Railway Station in Jhunsi, for 130 buses. In addition, the depot does not have the staff or facilities to maintain and run these 130 buses.

Around 150 bus stops are located across the city's service coverage area where passengers can board and stop.

The Prayagraj Municipal Corporation has constructed contemporary bus stops in a few locations and thoroughfares, including MG Road, the High Court, the train station, the university, the cantonment, etc. The former bus stops are in situ at various locations so people can board and get off. These bus stops are in extremely bad shape right now. The city bus system does not have the following functionalities: Integrated Ticketing System, Integrated Control Centre, Global Positioning System, Global Positioning System (GPS), General Packet Radio Services (GPRS), Intelligent Transport System (ITS), etc.

Figure 13 Boarding and Alighting in City Bus Service, Prayagraj. (Source: Primary Survey)

Figure 14 City Bus in Prayagraj. (Source: Primary Survey)

The Intermediate Public Transport (IPT) system, which consists of shared, private, cycle rickshaw, and e-rickshaw vehicles, forms the backbone of the city's transport network. The number of E-rickshaws in the city has increased dramatically recently. It's possible that e-rickshaws, which were primarily installed in Allahabad to reduce pollution, have instead made the city's traffic problems worse. These battery-powered vehicles have been in several accidents due to reckless driving and overcrowding; also, a large number of E-Rickshaws are not authorised.

The IPT system in Prayagraj competes with bus services by providing services along the same route, which results in a decrease in patronage to the city bus system, rather than enhancing the primary public transportation system like buses by feeding passengers. The rise in travel demand has exceeded the capacity of Allahabad's public transport infrastructure. Mobility in the city is chaotic due to a reliance on IPT for primary transport needs and an increase in private vehicle usage. The IPT serves commuters in the city and connects all of the main hubs with about 20 routes. The system's entire route length exceeds 180 kilometres. The city's IPT vehicle fleet consists of the Tata Magic, Ape CNG Auto, Bajaj CNG Auto, Vikram, and battery-operated rickshaws. In the city, IPT routes have an average length of roughly 9.5 kilometres. IPT services have a minimum cost of Rs 5 and a maximum fare of Rs 20 for urban areas as part of their fee structure. Table below shows the IPT system's route data.

Table 5 Route and its length for IPT in Prayagraj City. (Source: CMP 2021, Prayagraj)

Sr. No.	Route	Route Length in km
1	Railway Station to Kutchery	8.00
2	Railway Station to Mundera	9.00
3	Railway Station to Bamrauli	11.00
4	Railway Station to Bharwari	10.00
5	Railway Station to Daraganj	8.00
6	Railway Station to Sangam	9.00
7	Railway Station to Kareli	6.00
8	Civil Lines to Govindpur	8.00
9	Civil Lines to Kutchery	7.00
10	Civil Lines to Nawab Ganj	8.00
11	Civil Lines to Mansurabad	10.00
12	Civil Lines to Lal Gopal Ganj	11.00
13	Civil lines to Sohraon	10.00
14	Civil Lines to Maulama	9.00
15	Mansarovar to Naini	8.00
16	Civil lines to Jhunsi	15.00
17	Mansarovar to Ghoorpur	11.00
18	Chauphatka to Kutchery	8.00
19	Dhoomanganj to Jhalwa	6.00
20	Civil lines to Gangotri Nagar	14.00
	Total	**186.00**

Currently, over 10,000 IPTs, or three-wheelers, powered by petrol, diesel or CNG are travelling the city's different routes, linking the main hubs and nodes. Over 2000 battery-powered E-rickshaws are currently travelling the city's routes. Few battery-powered E-rickshaws have predetermined routes that include both the starting point and the end point. The majority of E-rickshaws run on a no-route system, allowing passengers to get on and off wherever in the city.

6.1.2. Objective-2 of the study is to assess existing practices and infrastructure of water channel all along to study area.

To fulfil this objective the availability of infrastructure in existing condition have been studied and a matrix have been prepared whether the infrastructure is available, partially available or not available at the ghats and the inferences have been made. Then the existing infrastructural problems have been listed out to find the gap in infrastructure. Based on the gap the required infrastructure and its related components have been listed out by referring the Kochi Metro Case Study. Then the conditions required for the water channel to proposed inland waterways have been studied and a comparative analysis have been done between the conditions required and existing conditions in study area. Then the variation in availability of water in the selected water channel have been studied for at 4 different months in the year 2023 namely, February, May**,** August and November by using satellite data and analysing in GIS Software.

Initially to select the water channel the standards given by Inland Water Authority of India were referred and a comparative analysis between the conditions required and the existing condition in Prayagraj City is carried out. The table below shows the comparison between standards and existing condition in the study area.

Table 6 Conditions required for selection of water channel. (Source: IWAI)

Condition Required	**Existing scenario on Site (Prayagraj)**
It should possess capability of navigation and movement of ferries.	Yes, in existing there is ferry system used for tourism.
It should have about 45m wise channel and minimum 1.5m depth.	Maximum depth available at Ganga lies between 1.2-40m and at Yamuna lies between 10-45m.
It should be continuous stretch of 50km.	Stretch from Prayagraj to Ghazipur is 370km long.
It should pass through and serve the interest of more than one State.	The water channel passes through Uttar Pradesh, Bihar, Jharkhand and West Bengal.

It should connect a vast and prosperous hinterland.	The water channel connects Sangam, a place of regional importance for devotees of Kumbh Mela.
It should pass through a strategic region where development of navigation is considered necessary.	Development of water channel is important to cater the increasing traffic and congestion pressure on road transport for daily travellers.

The selected river stretch of Ganga and Yamuna river in Prayagraj City fulfils all the required conditions and hence it is suitable to propose ferry system as mode of public transport for mobility of the people.

According to IWAI, Maximum depth available at Yamuna lies between 10-45m and at Ganga lies between 1.2-40m. Depth below 1m is maintained at Sangam to facilitate religious activities. It is planned to maintain depth of 3 m all along the stretch at NW-1. Min. Depth required to operate Ferry service as per IWAI is 1.5m.

A primary survey was conducted on various Ghats along the river stretch of Ganga and Yamuna. The available depth was measured at various points. The map shows the selected locations to measure the available depth and the table below shows the available depth in meters.

Table 7 Available depth (in m) along Ganga and Yamuna river at selected locations shown in the map. (Source: Primary Survey, 4 February 2024)

Location	Available Depth (in m)
1	0.9
2	9-12
3	12-18
4	5-10
5	3-5
6	3-5
7	5-8

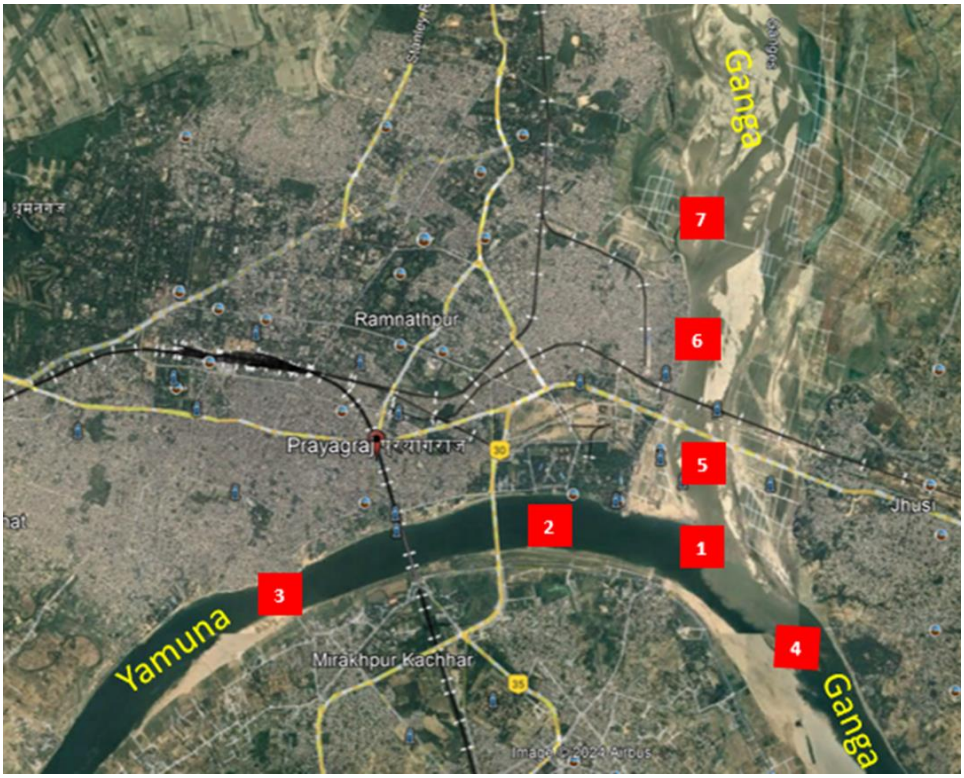

Figure 15 Selected locations to measure available depth along Ganga and Yamuna River in Prayagraj. (Source: Google Earth)

After measuring the available depth, the seasonality of available river stretch was studied with the help of satellite data for year 2023 at time period of every 3 month, namely February, May, August and November. The maps below show the seasonal variation in water channel.

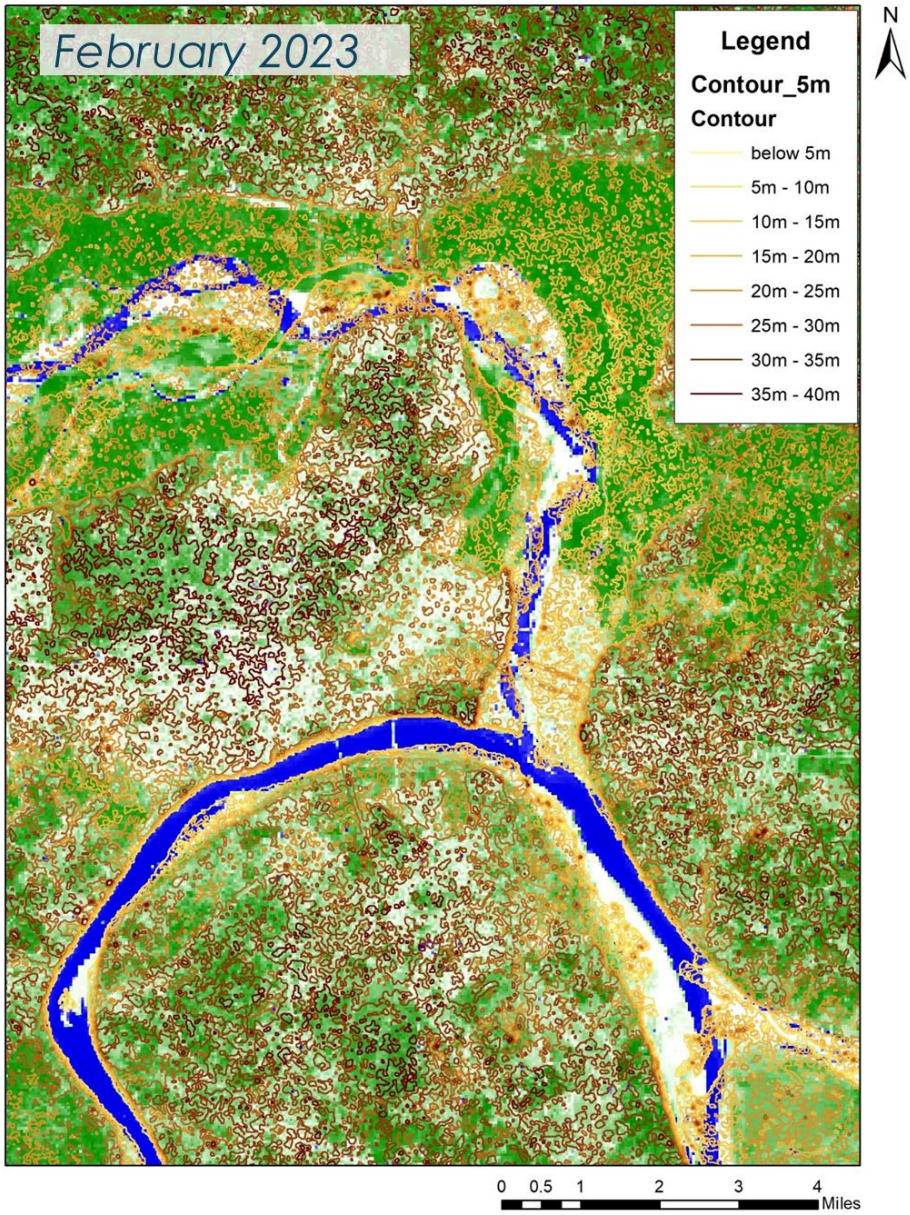

Figure 16 River flow in the month of 2 February 2023. (Source: GIS by using satellite data)

The above map shows the flow of river on 2nd February 2023, for which can be seen that Yamuna river has a depth up to 25m while ganga river has a depth up to 15m. The map was made using GIS based software and satellite images from past year.

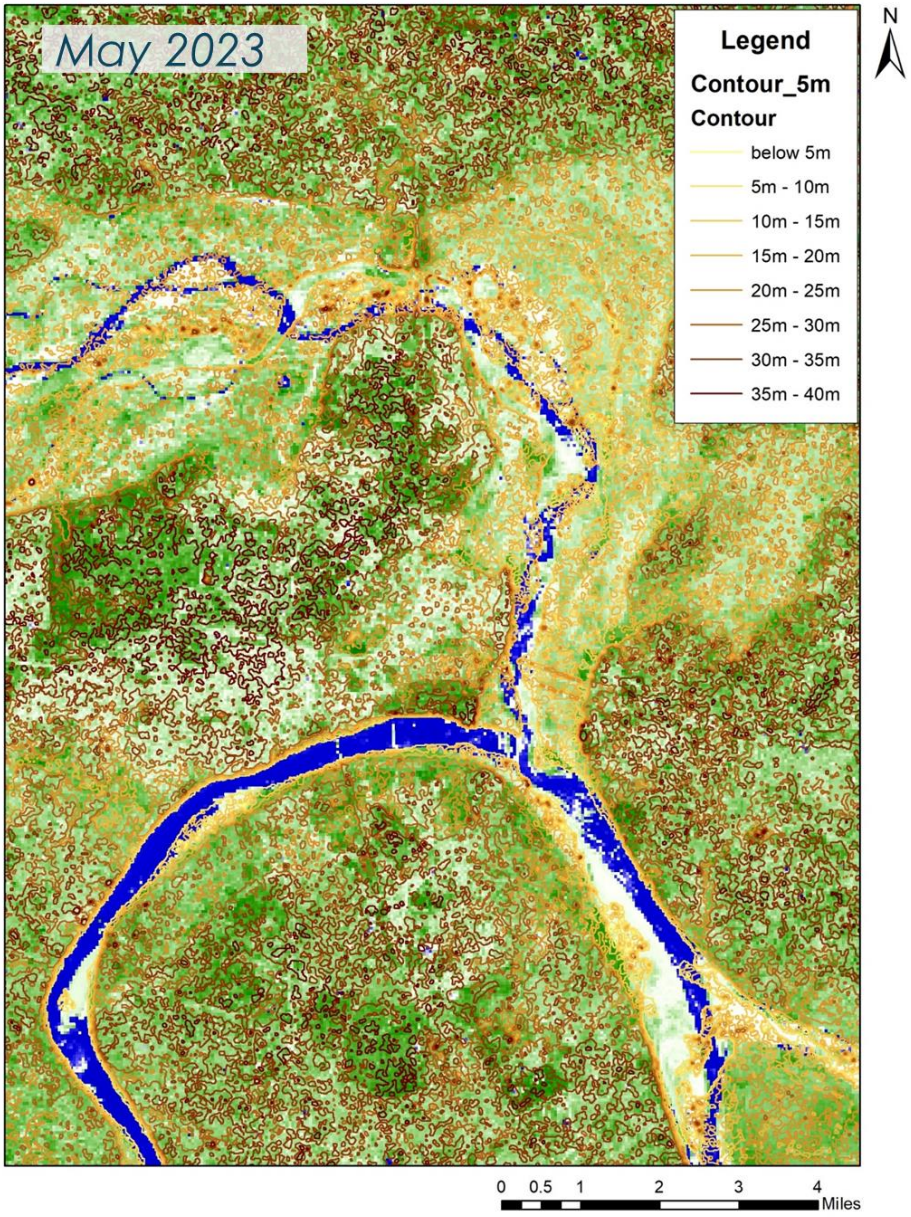

Figure 17 River flow in the month of May 2023. (Source: GIS by using satellite data)

The above map shows the flow of river on 15th may 2023, for which can be seen that Yamuna river has a depth up to 25m while ganga river has a depth up to 15m. The map was made using GIS based software and satellite images from past year.

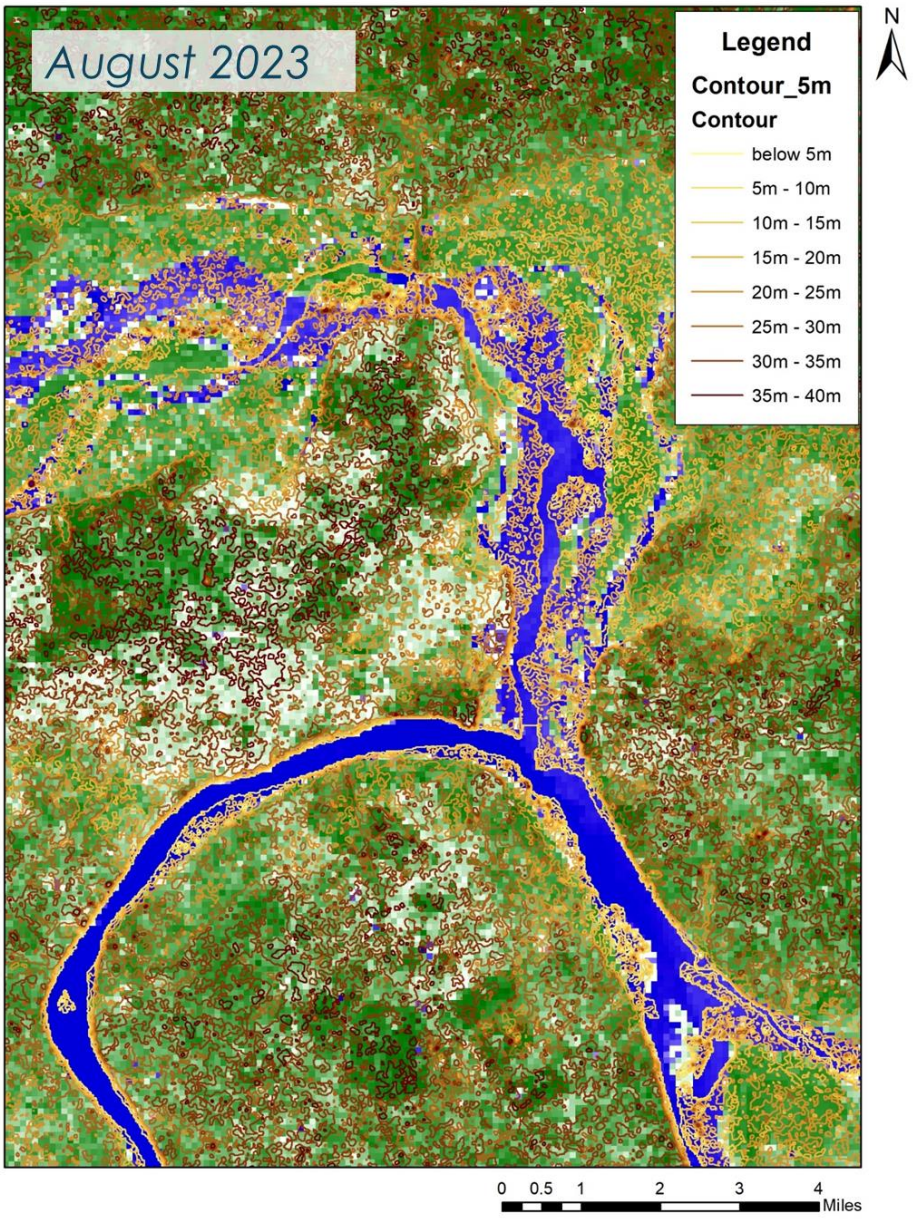

Figure 18 River flow in the month of August 2023. (Source: GIS by using satellite data)

The above map shows the flow of river on 18th August 2023, for which can be seen that Yamuna river has a depth up to 35m while ganga river has a depth up to 30m. The map was made using GIS based software and satellite images from past year.

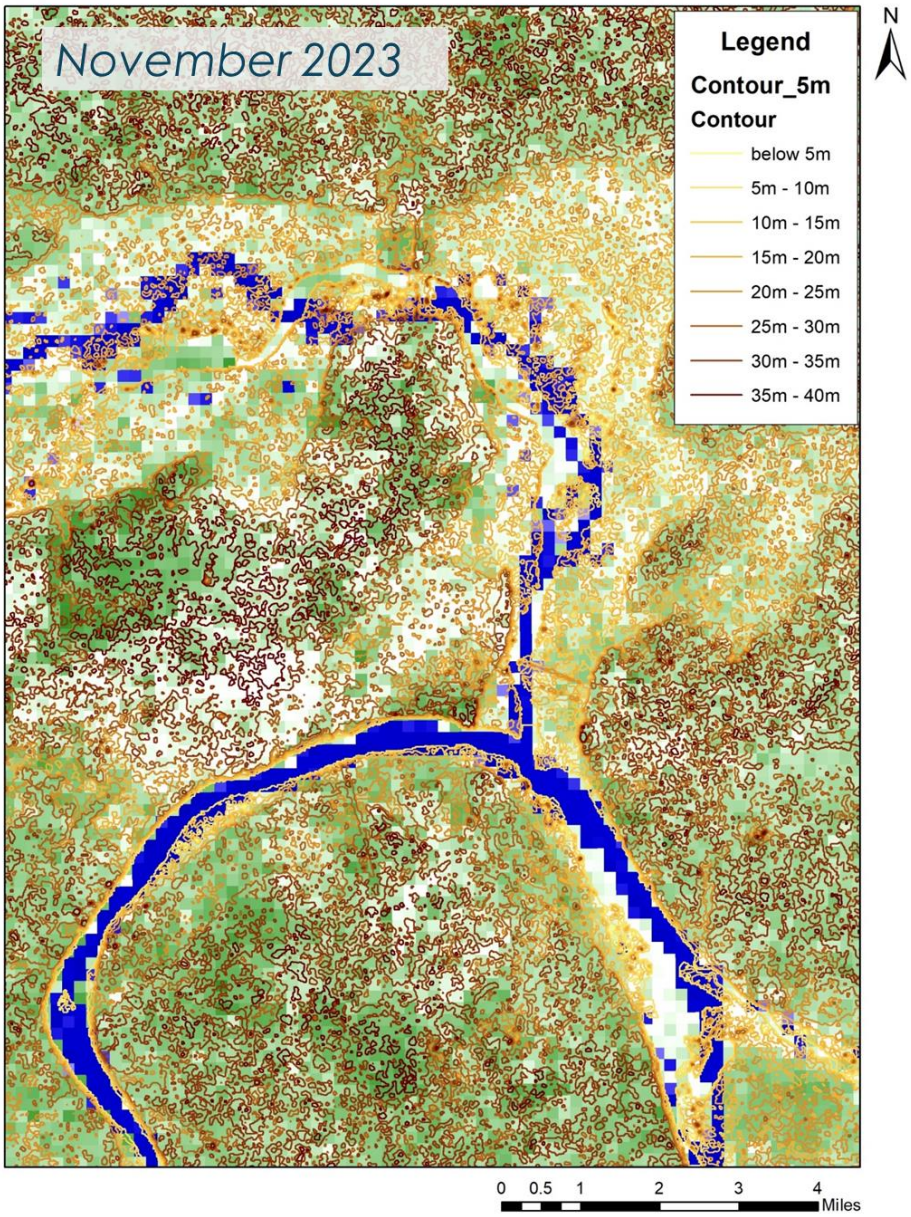

Figure 19 River flow in the month of November 2023. (Source: GIS by using satellite data)

The above map shows the flow of river on 23rd November 2023, for which can be seen that Yamuna river has a depth up to 25m while ganga river has a depth up to 15m. The map was made using GIS based software and satellite images from past year.

From the maps shown above, it is inferred that the minimum water flow is observed in the month of May and maximum in month of August.

After analysing the river flow and seasonality of selected stretch of Ganga and Yamuna River, the available infrastructure was also studied through primary survey at various ghats. This was done through observation survey and then tabulating it whether the infrastructure is available, partially available or not available. The table below shows the availability of infrastructure at Ghats.

Table 8 Availability of infrastructure at Ghats. (Source: Primary Survey)

GHAT NAME	Road Access to Ghat	IPT/PT Connectivity	Dock Area	Boat Parking	Boarding/ Deboarding area	Fromal ticketing system	Waiting area	Utilities toilets/ drinking	Vehicle parking	Safety Equipments
Kila Ghat										
Arail ghat										
Saraswati ghat										
Mankameshwar ghat										
Yamuna ghat										
Minto park ghat										
Boat club										
Gau ghat										
Balua ghat										
Bargahd ghat										
Ram ghat										
Someshwar ghat										
Parmanand ghat										
Daraganj ghat										

NOT AVAILABLE		PARTIALLY AVAILABLE		AVAILABLE

From the table above, it is inferred that dock area, ferry parking, boarding/ deboarding area and formalize ticketing system are the major infrastructural components not available at Ghats. Road access is partially available except at Gau Ghat, Balua Ghat and Barghad Ghat. Saraswati Ghat, Yamuna Ghat, Balua Ghat and Daraghanj Ghat lack in connectivity by public transport and intermediate public transport services.

Through the observation survey the problems at Ghats were listed out and various photographs have been taken to highlight the lack of existing infrastructure at Ghats. In existing problems are listed below:

1. Accessibility problems at boarding and deboarding stations.
2. Lack of safety measures and equipment for passengers during bad weather conditions or in case of any emergency situation.
3. Lack of jetty infrastructure at boarding and deboarding jetty stations.

4. Unavailability of boat parking for ferries.
5. No waiting and seating space available at boarding and deboarding stations.
6. No formal ticketing system available at Ghats.
7. Lack connectivity to other modes including public transport and intermediate public transport services.

Figure 20 Existing infrastructural problems at Ghats. (Source: Primary Survey)

From the primary survey, the existing infrastructure gap was identified. Through literature study of various Indian and Global best practices and case studies, different infrastructure and its sub-components are listed out which are needed to be provided to fulfil the existing infrastructure gap in ferry services in Prayagraj City. The table below shows the required infrastructure and its components.

Table 9 Required infrastructure at Ghats. (Source: Kochi Water Metro Report)

Required Infrastructure Facilities	Components of facilities
Dock	1. Internal movement and Circulation 2. Boarding and Deboarding points 3. Waiting and seating space
Connectivity of major boat hubs	1. Improved non-motorised transport 2. Feeder access to the boat jetty
Global Positioning System (GPS)	1. Location: Current and Target 2. Distance: Origin and Destination
Passenger Information System (PIS)	1. Passengers Announcement System (PAS) 2. Passenger Information Display System (PIDS)
Safety & Security	CCTV inside boats and at jetties / Hubs
Automatic Fare Collection System	1. On-board Smart card 2. Automatic Ticketing Solutions
Dispersal Plan	Boarding, alighting and movement at transit stations
Support Utility & Services	Toilets, Drinking Water Facility

6.1.3. Objective-3 of the study is to study the travel behavior and perception of users through local ferry service.

In this objective the demographic data, travel behavior of users along with perception of ferry users and ferry operators have been studied and inferences were made. To do the perception study the 5-pointer Likert scale questions have been used ranging from strongly agree to strongly disagree. The questions were related to travel time taken per trip, travel cost of per trip of the user, connectivity of the ferry with other modes of public transport of intermediate public transport, accessibility of ghats and ferries by the user, designated waiting and seating space available at ghats and within ferries, safety of user in all the weather conditions. To analyse the collected data, Multi-Nomial Logistic Regression technique have been used with total 9 variables. Out of which 3 were independent variables and 6 were dependent variables. Based on the output tables generated by using SPSS Software, the inferences were made. Starting with the demographic characteristics of ferry users and then followed by travel behavior of ferry users.

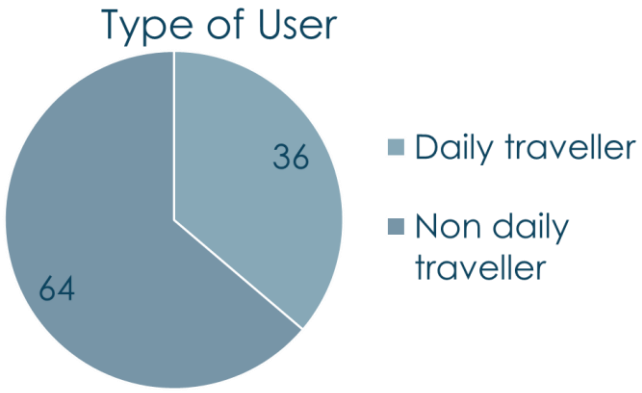

Figure 21 Type of traveller user surveyed. (Source: Primary Survey)

Out of total 127 ferry users surveyed, 36% (46 users) are daily travellers whereas 64% (81 users) are non-daily travellers. The major share of ferry users are non-daily travellers.

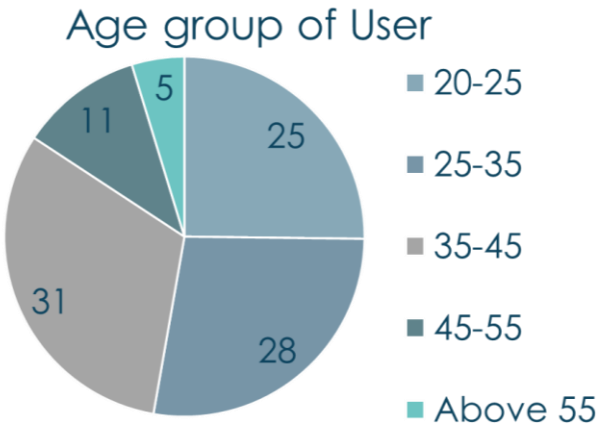

Figure 22 Age distribution of users surveyed. (Source: Primary Survey)

Out of total 127 ferry users surveyed, 25% (32 users) are in age group of 20-25 years, 28% (35 users) are in age group of 25-35 years, 31% (40 users) are in age group of 35-35 years, 11% (14 users) are in age group of 45-55 years and remaining 5% (6 users) are in age group of above 55 years. The major share of ferry users is between age group of 35-45 years.

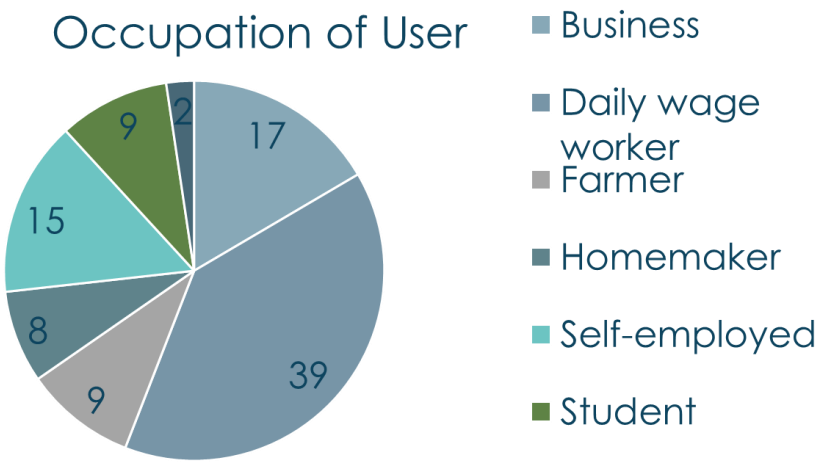

Figure 23 Occupation of users surveyed. (Source: Primary Survey)

Out of total 127 ferry users surveyed, 17% (21 users) are engaged in business, 39% (50 users) are daily wage workers, 9% (12 users) are farmers, 8% (10 users) are homemaker (majorly females), 15% (19 users) are self-employed, 9% (12 users) are students and only 2% (3 users) are into teaching profession. The major share of ferry users are daily-wage workers.

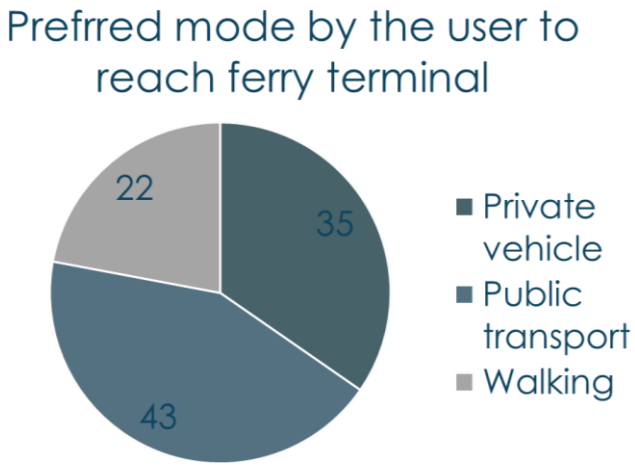

Figure 24 Preferred mode of the user. (Source: Primary Survey)

Out of total 127 users, 35% (44 users) prefer private mode, 43% (55 users) prefer public transport and rest 22% (28 users) prefer walking to reach ferry terminal. The major share is of public transport users.

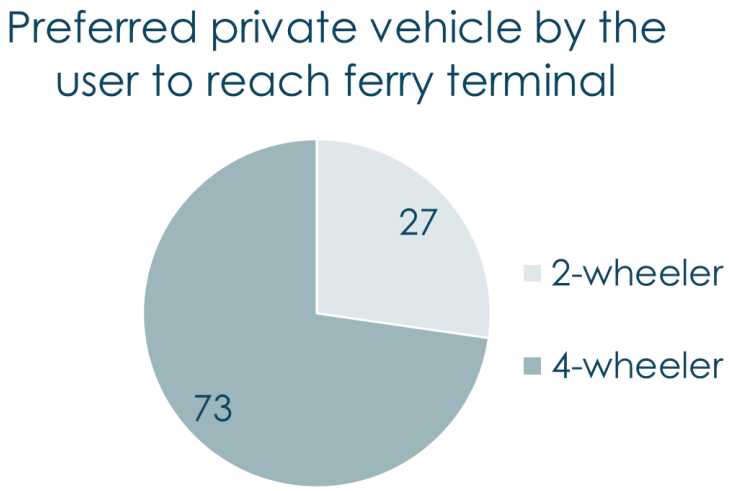

Figure 25 Preferred private vehicle to reach ferry terminal. (Source: Primary Survey)

Out of total 35% (44 users) private vehicle users, 27% (12 users) use 2-wheeler and 73% (32 users) use 4-wheeler to reach ferry terminal. The major share is of 4-wheeler users.

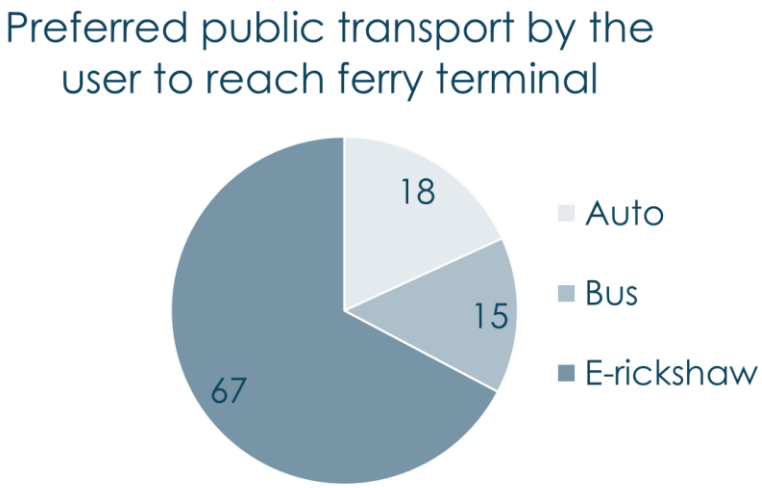

Figure 26 Preferred public transport to reach ferry terminal. (Source: Primary Survey)

Out of total 43% (55 users) public transport users, 18% (10 users) prefer auto, 15% (8 users) prefer bus services and 67% (37 users) prefer e-rickshaw to reach ferry terminal. The major share is of e-rickshaw users.

The ferry operator survey was also done to know about the issues and problems they face in ferry operations. A questionnaire was formulated with various questions including both open ended and closed ended questions attached in ANNEXURE-2 of the report. There were certain questions regarding the problems they face and the suggestions they gave to improve the existing ferry system.

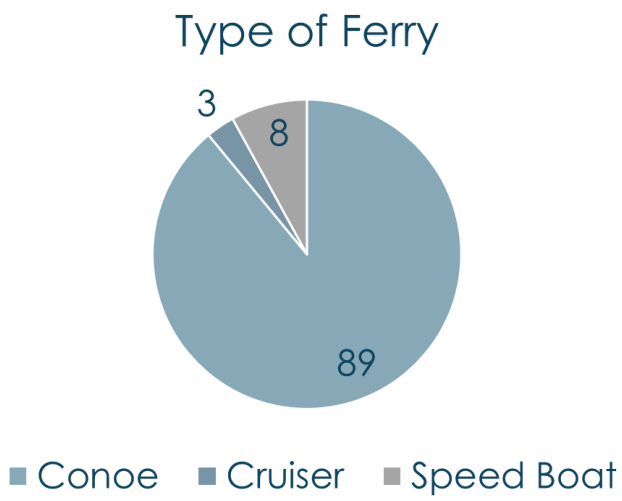

Figure 27 Type of Ferry. (Source: Primary Survey)

Maximum number of operators own the conoe. The major share is of conoe ferries (89%) followed by speed boat (8%).

Number of employees on ferry:

- Conoe: 1-2 employees
- Cruiser: 3-4 employees
- Speed Boat: 1-2 employees

The table below shows the boat capacity, average number of persons per trip and average number of trips per day.

Table 10 Boat capacity, average number of persons per trip and average number of trips per day. (Source: Primary Survey)

Type of Boat	Boat Capacity	Average number of persons per trip	Average number of trips per day
Conoe	8-12 persons	5.3	6.4
Cruiser	40 persons	25.7	1.5
Speed Boat	4 persons	2.4	18.3

Through primary survey, the ferry operators were asked to give their suggestions to improve the existing ferry services in the city. The suggestions are-

- New mechanised boats are needed to replace existing traditional ferries which requires more manual force to operate.

- Boat parking should be made available at deport ferry stations.
- Boat maintenance equipment are needed at depot stations and in ferries as well for maintenance of ferries.
- Safety equipment are required within boats both for ferry users and ferry operators in case of any emergency or bad weather conditions.
- The ferry operators should get adequate wages from the local government along with additional incentives to improve their living conditions.

To study the perception of users, the five pointer Likert scale questions were asked to the ferry users. Five-pointer Likert Scale- 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree). Multi-Nominal Logistic Regression Model have been used to predict which all variables affect user's willingness to shift or not on inland waterway. This model will help us to know how a person's current mode choice is affecting their willingness to shift on inland waterways. The sample size of 127 samples was used. A total of 9 variables were used, out of which 3 variables were independent including the type of traveler whether they are daily travelers or non-daily travelers, trip purpose include work trips, educational trips, religious trips, recreational trips and others, and alternative mode they use whether public transport or private vehicle if not using ferry services. The dependent variables were- travel time per trip, travel cost of per trip of the user, connectivity of the ferry with other modes of public transport of intermediate public transport, accessibility of ghats and ferries by the user, designated waiting and seating space available at ghats and within ferries, safety of user in all the weather conditions.
The table below shows the list of variables used in Multi-Nomial Logistic Regression Model.

Table 11 List of variable along with variable code.

S. No.	Graded Response Statement	Code	Measurement item/ observed variable
1	The ferry service should take less travel time to reach destination.	**V1**	Travel time
2	The ferry should connect with other public transport modes at boarding and deboarding station.	**V2**	Connectivity
3	The ferry service should be safe in all weather conditions.	**V3**	Safety
4	The ferry service should be accessible for the user.	**V4**	Accessibility
5	The designated waiting area and seating area should be available at boarding and deboarding stations.	**V5**	Designated Space
6	The ferry service should have less travel cost as compared to other modes.	**V6**	Travel Cost

The multi-nomial logistic regression analysis have been done by using the SPSS software with 127 samples. The table below is the output table.

The reference category is: 2 (Not willing to shift)

WTS is Willing to shift

TR is type of traveller (Daily/ Non-Daily Traveller)

TP is trip purpose (Work, Educational, Recreational, Religious)

TT is travel time

TC is travel cost

C is connectivity with other modes

A is accessibility of ferry stations

DS is designated waiting and seating space

S is safety

Table 12 Output of Multi-Nomial Logistic Regression Analysis. (Source: SPSS Software)

WTS		B	Std. Error	Wald	Sig.
2	Intercept	4.486	6.069	2.084	.061
	TR	.024	6.068	4.910	.027
	TP	-0.306	1.993	5.293	.021
	TT=1	0	0	0	0
	TT=2	0	0	0	0
	TT=3	.473	2.843	2.812	.872
	TT=4	-5.553	3.298	1.335	.042
	TT=5	-2.288	1.098	1.239	.037
	TC=1	0	0	0	0
	TC=2	-.387	3.195	0.15	.074
	TC=3	2.106	1.143	3.396	.065
	TC=4	1.251	1.519	2.935	.037
	TC=5	.581	1.092	2.206	.050
	C=1	0	0	0	0
	C=2	0	0	0	0
	C=3	0	0	0	0
	C=4	-.447	1.243	.743	.078
	C=5	2.602	3.221	1.452	.032
	A=1	0	0	0	0
	A=2	0	0	0	0
	A=3	-1.561	1.005	.156	.067
	A=4	.496	1.052	3.612	.051
	A=5	.561	2.341	3.891	.046
	DS=1	0	0	0	0
	DS=2	0	0	0	0
	DS=3	-.421	.289	2.433	.061
	DS=4	2.131	2.564	3.651	.022
	DS=5	2.714	2.651	4.267	.001
	S=1	0	0	0	0
	S=2	0	0	0	0
	S=3	-1.560	.760	.642	.072
	S=4	-.413	.781	.321	.081
	S=5	-.272	.518	2.541	.063

Table 13 Model Fit (Source: SPSS Software)

	Model Fitting Criteria -2 Log Likelihood	Likelihood Ratio Tests		
		Chi-Square	df	Sig.
Model	337.087			
Intercept	27.482	309.605	8	.023

Inferences:

- The model is statistically significant.
- From the table it is found that travel cost, travel time, connectivity, accessibility and designated space are significant.
- As per the statistical estimation, when we look at each category, it is found that- as the travel time and travel cost decreases the willingness of the user to shift on inland waterways increases.
- It is also inferred that as the connectivity, accessibility and infrastructure improves the willingness of the user to shift increases.

7. RECOMMENDATIONS AND PROPOSALS

7.1 Need of an improved water-based public transportation in the city

The city of Prayagraj currently has a relatively high public transport mode share of 21.7%. However, the city is facing a growing trend of private vehicle usage, which is putting pressure on the existing public transport system. The average travel time in Prayagraj is 24.8 minutes, and the average trip length observed was 6.16 km. The majority of trips done are for work purposes at 45%, followed by education trips at 39%, and other trips such as recreational, religious, and leisure purposes at 16%.This scenario suggests that the city's road network is experiencing an influx of private vehicles, which are competing for the available road space with the public transport system. The narrow and congested secondary and tertiary roads in the older parts of the city are further exacerbating the traffic issues, leading to increased travel times and reduced efficiency of the public transport network.

To address this challenge, Prayagraj will need to adopt a comprehensive approach that includes investments in public transport infrastructure, policies to discourage private vehicle usage, and initiatives to promote sustainable mobility options like and Improved water based public transport, cycling, and walking.

Enhancing the water transport system would not only retain current users but also attract individuals from both the road public transport system and a segment of private vehicle users. This shift would alleviate strain on the road network while expanding the pool of potential users for the water transport system.

Table 14 Mode share in Prayagraj City. (Source: CMP 2021, Prayagraj)

Mode Share	Percentage of Users
Four-wheeler	3.8%
Two-wheeler	37.0%
Auto	**16.1%**
Bus	**2.6%**
Mini Bus	0.1%
School Bus	2.6%
Cycle	13.5%
E-Rickshaw	**3.0%**
Train	0.1%
Walk	21.2%

7.2 Integrated Water-Based Public Transportation in Prayagraj

Achieving sustainability requires a comprehensive approach involving various measures. When focusing on the inland water transport system, key considerations for sustainability include accurately assessing travel demand. This assessment forms the basis for developing an efficient route plan based on proven concepts to enhance the water transportation system.

For sustainability, integration with other modes of public transport is crucial, along with providing the necessary infrastructure for maximum accessibility. Establishing a sustainable transport system necessitates seamless integration with existing and proposed transportation systems in the city area. Plans for an integrated public transportation system (road-based) and non-motorized transport, as well as an integrated intelligent transportation system (ITS), are currently in the planning and design stages in the city. Therefore, the water transport system is envisioned as an integral component of the overall public transportation network.

7.3 Demand Assessment for Water-Based Public Transportation

The travel demand assessment for water based public transportation in Prayagraj is a crucial step in ensuring the sustainability and effectiveness of the system. As previously discussed, integrating the water transit system having various activities within the city is vital for its long-term success. The travel demand assessment tends to identify the spatial distribution of travel patterns by dividing the city into zones tailored specifically for water transport. To achieve this, a comprehensive data collection process was undertaken, involving Boarding and Alighting surveys, Opinion surveys, and Household surveys. These surveys helped in defining the travel patterns and behaviour between various origin and destination points, providing valuable insights into the travel behavior and preferences of the population. The data collected from these surveys will be used to inform the planning and design of the water transport system, including the identification of optimal routes, frequencies, and infrastructure requirements. This will enable the city to create a more efficient and effective water transport network that meets the diverse travel needs of its residents. Furthermore, the travel demand assessment will also help in identifying areas where the water transport system can be optimized to better serve the population. This could involve the creation of new routes or the enhancement of existing services to better connect key destinations and activities within the city. By using the insights gained from the travel demand assessment, Prayagraj can develop a water transport system that is not only sustainable but also responsive to the needs of its citizens. This will contribute to a more efficient, environmentally friendly, and livable urban environment for the city's residents.

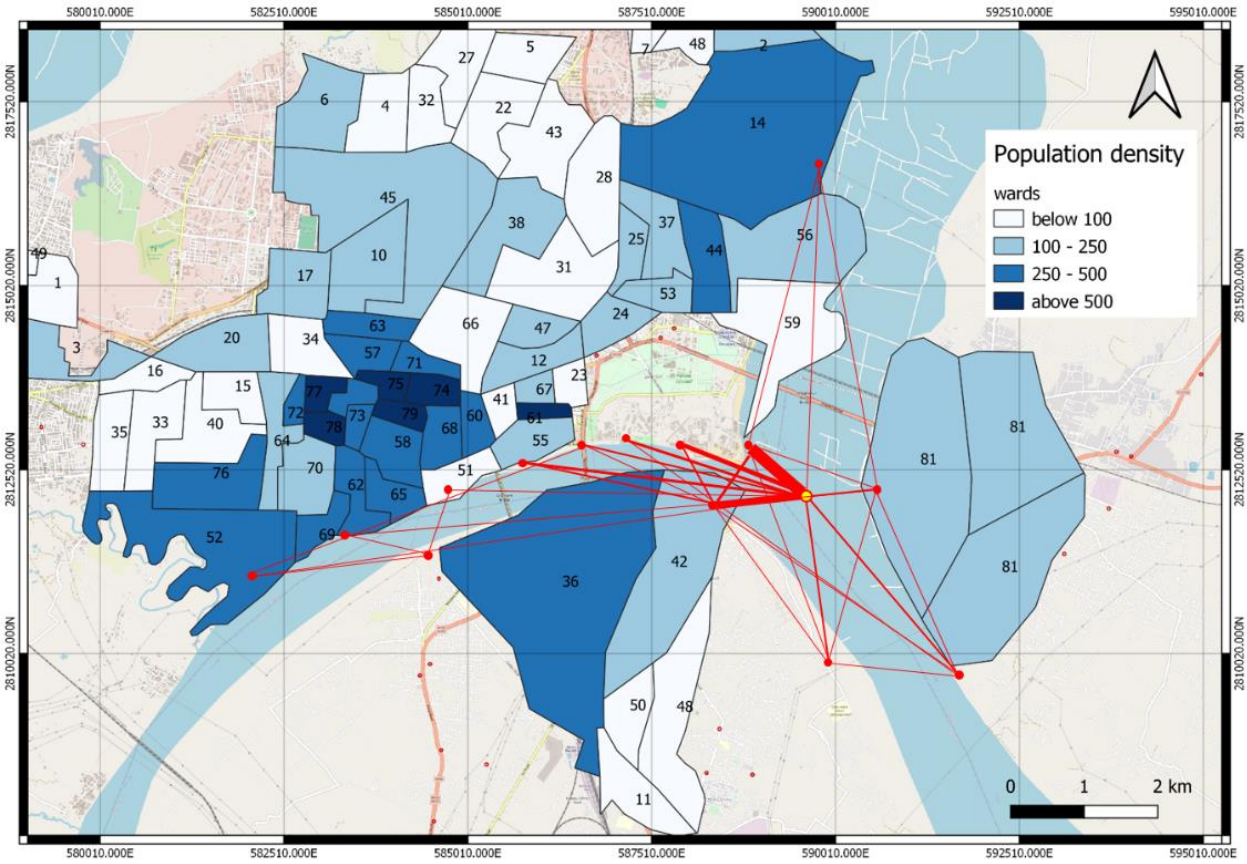

Figure 28 Desire Line Diagram showing a frequency of OD Trips in the delineated Study area (source- QGIS)

For the identification of the new routes and demand the wards which have high population density and lacks in public transport and intermediate public transport connectivity based on the survey done.

Various assumptions based on the existing studies and planning were considered to develop this model and network.

The search results provide a comprehensive overview of the key assumptions and estimation methods used in the assessment of the water transportation system for Prayagraj. Here's an expanded explanation of the main points:

Scenario Development -

The assessment considered three different scenarios to evaluate the water transportation system for the horizon years:

1. **Pessimistic Scenario**: This scenario assumes an annual growth rate of 3% for Prayagraj, which is in line with the observed population growth trends from the past years.
2. **Optimistic Scenario**: This scenario assumes an annual growth rate of 8% for Prayagraj, aligning with the current vehicular growth rate in the city.

3. **Realistic Scenario**: This scenario assumes an annual growth rate of 5% for Prayagraj, which is a middle ground between the pessimistic and optimistic scenarios.

Table 15 Scenario-wise growth rate in PT users.

Scenario	Growth Rate in total public transport users	Increased % of PT users
Pessimistic scenario	3%	23.08 %
Optimistic scenario	8%	25.38 %
Realistic scenario	5%	24 %

Trip Distribution Pattern -

Trip distribution pattern of various transport modes, including public transport (auto, bus, and rickshaw), was derived from the Feasibility Study and DPR for the Comprehensive Mobility Plan (CMP) of Prayagraj, conducted by the Urban Mass Transit Company (UMTC). This provided the baseline data for the assessment.

To Project the future demand for the water transportation system, the assessment assumed an optimal shift from the existing public transport users. Currently we have focused on **Public Transport Users** which includes auto, bus and rickshaw users making a total of **21.7% users.**

- 8% shift from E-rickshaw users
- 7% shift from 3 wheeler Auto users
- 4% shift from cityBus users

This shift in modal preference towards the water transport system was based on the assumption that it would provide a more efficient and attractive alternative for commuters.

Table 16 Population Forecasting. (Source CDP 2041 Prayagraj 2015)

Method	2021	2031	2041
Arithmetic	14,98,214	16,87,040	18,75,867
Geometric	16,87,005	21,73,526	28,00,356
Incremental	**16,70,863**	**22,04,988**	**29,11,763**

Table 17 Forecasting of PT Users. (Source: CDP 2041 Prayagraj 2015)

Method	Increased % of PT users	Total PT users in 2021	Total PT users in 2031	Total PT users in 2041
Pessimistic Scenario	23.08 %	3,85,635	5,08,911	6,72,034
Optimistic Scenario	25.38 %	4,24,065	5,59,625	7,39,005
Realistic Scenario	24 %	4,01,007	5,29,197	6,98,823

Yearly the inland waterways has to cater around 7 lakh population.

7.4 Identifying Operational Routes

The assessment also identified several water transport routes that were previously operational but had closed functioning in the recent past. These routes were included in the initial estimations and further modified using a hub and spoke model. In this model, each route has a major interchange ghats and smaller intermediate ghats to facilitate connectivity and accessibility from different parts of the river. By considering these assumptions and estimation methods, the assessment aims to provide a comprehensive and realistic projection of the future demand for the water transport system in Prayagraj. This information will be crucial in planning and designing an efficient and sustainable water based public transport network that caters to the diverse mobility needs of the city's residents.

Based on the 8 variables identified for Inland waterways public transportation, there is a significant potential demand for travel between the river communities and the mainland. The identified routes are carefully aggregated to merge with current routes, ensuring efficient connectivity and accessibility for commuters. Here are the expanded details of the identified routes:

1. **Route 1 (5.2 km)**:
    - Starting from Ram ghat, this route passes through Kila ghat, Saraswati ghat, Yamuna ghat, Boar Club, and ends at Gau ghat. This 5.2 km route provides a crucial link between multiple key locations along the waterways, facilitating smooth and convenient travel for passengers.
2. **Route 2 (4.8 km)**:
    - This 4.8 km route begins at Nishad park ghat and continues through Barghad ghat, Balua ghat, Gau ghat, and ends at Hanuman ghat. It serves as a vital connection between different areas, enhancing accessibility and connectivity for commuters traveling along the waterways.
3. **Route 3 (6.4 km)**:
    - Covering Kila ghat, Arail ghat, Someshwar ghat, Parmananda ghat, and Mawaiya Ghat, this 6.4 km route offers a strategic link between various important points along the water

transport network. It plays a key role in facilitating efficient travel and transportation between these locations.

4. **Route 4 (8.8 km)**:

- Starting from Kila ghat, this 8.8 km route passes through Daraghanj ghat, Govind ghat, and Ganga ghat. It serves as a crucial connection between these significant locations, providing a seamless travel experience for passengers commuting between the island communities and the mainland.

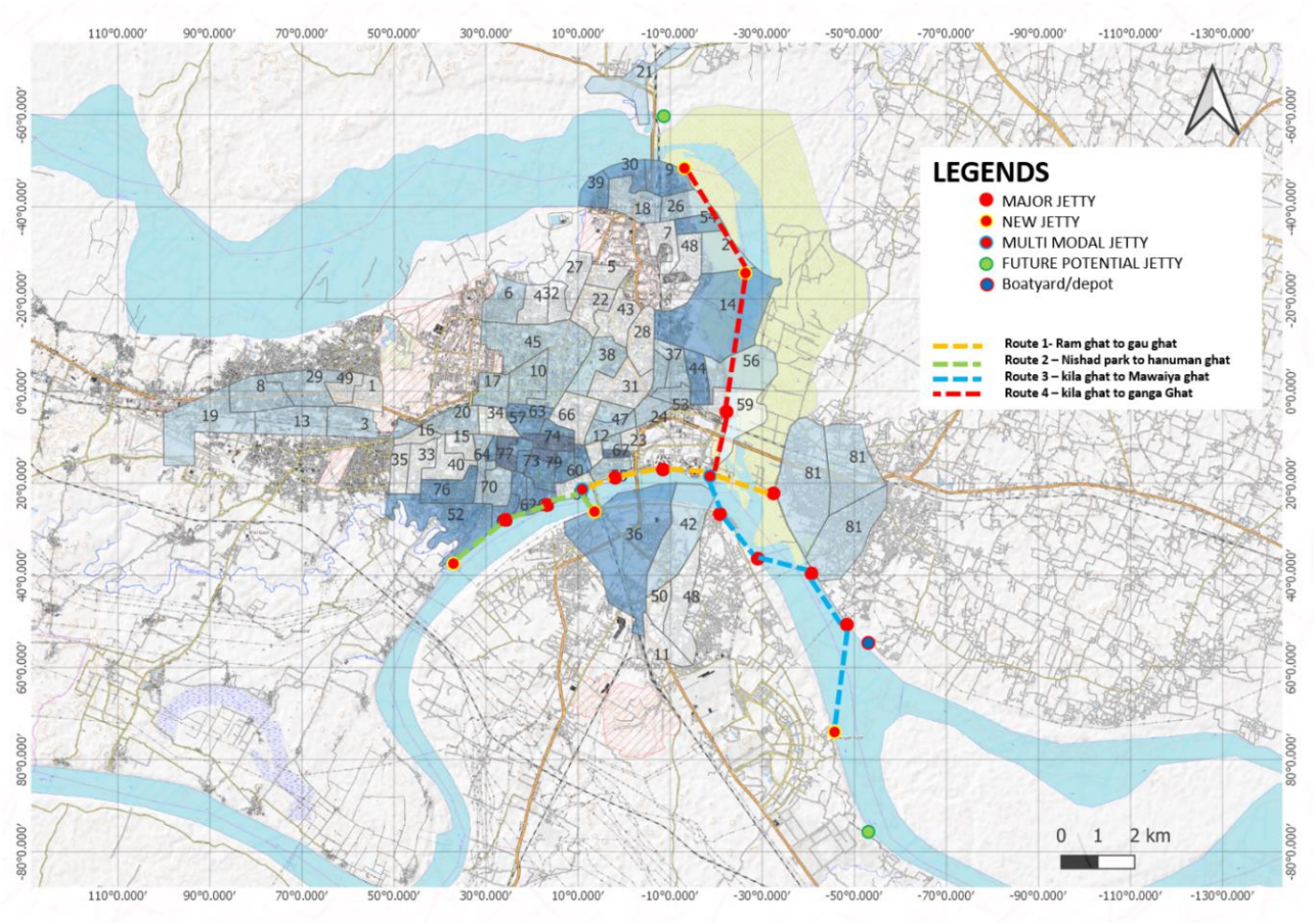

Figure 29 Identified Water Transport Network Map. (Source: QGIS)

7.5 Infrastructure Assessment

Water Transport Corridor- The waterways in the region fall under the National Waterway 1 (NW-1) as identified by the Inland Waterways Authority of India (IWAI). The widths of the waterways and channels vary across the length and breadth of the city region. For the proposed routes of the water transportation system project, it is recommended to demarcate a dedicated water transport corridor

with a minimum width of 20 meters. This dedicated corridor will be delineated through physical segregation using anchored buoys, which will also create designated points for local boat operators to cross the corridor. The proposed speed for the water transportation system within this dedicated corridor is 8 knots. However, with the creation of the dedicated corridor, the potential speed can be increased to 12 knots. This is because the waterways within the corridor will be reserved solely for the fleet movement of the water transportation system, without interference from other waterway activities. To ensure the efficient and uninterrupted operation of the water transportation system, the movement of local fishermen, the use of nets, and the presence of other boats will be controlled and regulated within the dedicated water transport corridor. By establishing this dedicated water transport corridor with the recommended specifications, the water transportation system can operate at higher speeds, provide more reliable and efficient services, and coexist safely with other waterway users in the region. This dedicated corridor is a crucial element in the overall planning and implementation of the water transportation project.

Dredging of Waterways - Discussions with various departments and authorities responsible for waterway maintenance have revealed varying degrees of silt accumulation in the waterways. To address this issue and ensure a min. vertical draft of 1.5 meters, it is advised to conduct dredging operations throughout the entire network. The Department of the Inland Waterways Authority of India (IWAI) are authorized entities capable of undertaking the dredging activities. The IWAI is known to uphold a consistent depth of 1-2 meters with a bottom width of 32 meters along the National Waterway 1 (NW-1). As per IWAI, the planned routes and traffic channels on NW-1 undergo regular dredging, and the installation of navigation aids such as buoys has been successfully completed. Special attention is needed for dredging in the areas between the channel route and the ghats to maintain navigational safety and operational efficiency. The dredged silt and mud should be appropriately collected at designated locations to ensure proper disposal and environmental management. It is recommended that the Prayagraj Development Authority (PDA), which is also observed to be the operating agency for the water transportation system, arranges for dredging through contractual agreements as needed and when required. This proactive approach to dredging and maintenance is crucial for sustaining safe and navigable waterways to support the effective operation of the water transport system.

Jetty Stations or Piers - The current Ghats are constructed using a combination of sand, cement slopes, and mud, and are in a deteriorated state. The plan is to introduce new and improved jetties

through a phased development approach. The reconstruction and enhancement of piers are allowed under the River Regulation Zone (RRZ) regulations that are in effect. Expanding on this, the deteriorated condition of the existing Ghats poses challenges in terms of safety, functionality, and aesthetics. By introducing new and renovated jetties in a phased manner, there is an opportunity to enhance the infrastructure, improve accessibility, and revitalize the waterfront areas. The phased development approach allows for systematic upgrades while ensuring that the operations of the water transport system are not significantly disrupted. Under the RRZ regulations, which govern development along riverbanks and water bodies, the redevelopment and improvement of piers are permitted. This regulatory framework ensures that any modifications or enhancements to the piers comply with environmental and safety standards, contributing to the overall sustainability and resilience of the water transport infrastructure. By adhering to these regulations, the redevelopment of piers can proceed in a manner that is both legally compliant and environmentally responsible, fostering the safe and efficient operation of the water transport system.

Major and minor jetties- In alignment with the Hub and Spoke model, the plan entails establishing a major jetty on each island to serve as the central Hub, with the remaining jetties designated as minor jetties. The proposal includes the development of 14 major jetties and 5 minor jetties. The list of the 19 jetties earmarked for development is detailed in the provided Table.

Table 18 Major and minor jetties at ghats. (Source:author)

S.no	Ghat name	Type of ghat
1	Kila Ghat	Major
2	Arail ghat	Major
3	Saraswati ghat	Major
4	Mankameshwar ghat	minor
5	Yamuna ghat	Major
6	Minto park ghat	minor
7	Boat club	Major
8	Gau ghat	Major
9	Balua ghat	Major
10	Bargahd ghat	Major
11	Ram ghat	Major
12	Someshwar ghat	Major
13	Parmanand ghat	Major
14	Daraganj ghat	Major
15	Govind ghat	Major
16	Ghanga Ghat	Major
17	Mawaiya Ghat	minor

18	Nishad park	minor
19	Hanuman ghat	minor

Jetty Development- The plan involves developing the jetties as floating pontoons equipped with automated mechanical docking systems for boats. These floating pontoons are designed to accommodate up to two boats at major jetties, utilizing a slot system with a spacing of 1.5 meters. To enhance passenger comfort, it is recommended that the floating pontoons be covered with roofs or retractable sheds, particularly to provide shelter during the rainy season and facilitate easy boarding and disembarking from boats. Each jetty location is proposed to feature an Automated Docking Mechanism integrated with smart jetty architecture. Furthermore, the jetties are intended to be categorized as major boat ghats and minor boat ghats. The major boat hubs are envisioned as integrated developments resembling transit station setups, encompassing property development, enhanced non-motorized transport options, and feeder access to the boat jetty. This comprehensive approach aims to create multifunctional hubs that not only facilitate boat operations but also contribute to the overall connectivity and convenience for passengers using the water transport system.

Figure 30 Floating pontoons to be covered with sheds. (Source: google)

Boatyard and depot- The plan is to enhance and establish a boatyard with complete repair and maintenance facilities for regular upkeep of vessels. This new boatyard at, named Devrakh Khachhar, will be a floating dock designed specifically for scheduled annual maintenance purposes.

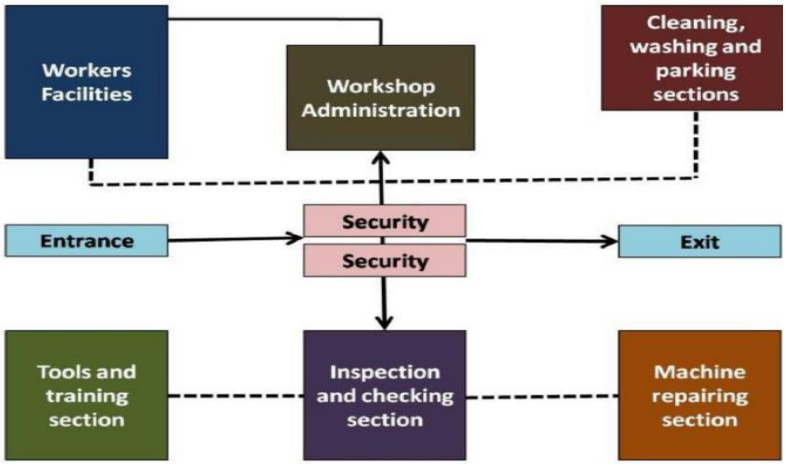

Figure 31 Suggested programme of facilities.(source- kochi Water metro DPR 2015)

Intelligent Transportation and Navigation System - The Intelligent Transportation System (ITS) proposed for the water transportation project includes advanced functionalities like GPRS (4G)-based Intelligent Navigation & Cruise control, GPS Tracking, Passenger Address and Information Systems, dedicated two-way voice/data communication, on-board surveillance cameras, and on board multi-SIM WiFi Hotspot. This system is designed to improve operational efficiency and enhance passenger experience within the water transport project. A cellular communication based intelligent transportation and navigation system, utilizing GPRS/LTE technology, is recommended for seamless integration of boats with other transportation modes such as Metro Rail and Bus services. The ITS implementation comprises various components like Global Positioning System (GPS) for on board and off board use, Passenger Information System (PIDS/PAS) for on-board and at Boat ghats, Master Clock, CCTV surveillance inside boats and at ghats, Automatic Fare Collection System, and a Central Operational Control Center. These ITS elements, in conjunction with boat procurement under the project, are key recommendations detailed in the Detailed Project Report (DPR). All project boats will be outfitted with state-of-the-art ITS equipment and navigation systems, enabling real-time monitoring and data transmission to the Central Operational Control Center. This holistic approach ensures that the water transport system is equipped with cutting-edge technology to enhance safety, efficiency, and passenger services.

Accessibility and last mile connectivity - It encompasses the ease of reaching goods, services, activities, and destinations, collectively known as opportunities. It represents the potential for interaction and exchange within a given environment. In the realm of social planning, accessibility pertains to individuals' capacity to utilize services and opportunities effectively. Expanding on this concept, the

development of access roads plays a crucial role in enhancing accessibility by providing physical pathways that connect various locations and facilitate movement. Additionally, the implementation of a Non-Motorised Transport plan contributes to accessibility by promoting pedestrian and cycling infrastructure, reducing reliance on motor vehicles, and improving mobility options for all individuals.

Creating Disabled-Friendly Access points is essential for ensuring that individuals with disabilities can navigate and utilize facilities and services without hindrance. This includes features like ramps, elevators, and designated parking spaces to accommodate diverse needs.

Feeder Service Development involves establishing efficient transportation links that connect peripheral areas to major hubs, enhancing connectivity and accessibility for residents across different parts of the city.

Parking Provisions are integral to accessibility, ensuring that individuals have convenient and safe spaces to park their vehicles when accessing various amenities and services.

Effective Signage plays a vital role in guiding individuals and providing information about routes, facilities, and services, enhancing navigation and accessibility within a given environment. Street Safety Provisions are essential for creating a safe and secure environment for pedestrians, cyclists, and motorists, promoting accessibility by reducing risks and ensuring smooth traffic flow.

Lastly, Waterfront Development initiatives contribute to accessibility by creating vibrant and accessible public spaces along water bodies, offering recreational opportunities and enhancing the overall quality of urban environments.

ANNEXURE A

Questionnaire

Data to be collected for User Travel Behaviour

Demographic Data

1. Age
2. Gender
3. Educational Attainment
4. Occupation
5. Income
6. Number of household members
7. Number of working members in the household
8. Total number of mopeds/scooters/motor cycles in your household
9. Total number of cars/jeeps in your household

Travel Behaviour Data

1. What is your trip origin……..
2. What is your trip destination…….
3. What is the trip purpose?
   i) For workplace
   ii) For shopping
   iii) For entertainment purpose
   iv) Any other purpose
4. What is the location of your workplace?
5. What is duration of work hours?
   Start Time……
   End Time……..
6. What is your daily travel time (To and Fro)?
   i) Less than 1 hour
   ii) 1-2 hours
   iii) 2-3 hours
   iv) More than 3 hours
7. What is total distance travelled daily (To and Fro)?
   i) Less than 10 km

ii) Within 10 km
iii) Within 20 km
iv) Within 30 km
v) Mora than 30 km

8. What are the daily travel expenses?
   i) Less than INR 100
   ii) Between INR 100-200
   iii) Between INR 200-300
   iv) More than INR 300
9. Do you personally use public transport for commuting?
   Yes
   No

If YES?

10. Frequency of using public transport
    i) Multiple times in a week
    ii) At least once a week
    iii) At least once a month
    iv) Other
11. Which is preferred mode of public transport?
    i) Bus
    ii) Auto
    iii) E-Rickshaw
    iv) Shared Transport (cab/ pooled car)
    v) Metro
12. What are the reasons for choosing public transport (Rank 1,2,3……)
    i) Affordable
    ii) Clean/ Hygiene
    iii) Safe
    iv) Secure
    v) Convenient
    vi) Always on time
    vii) User friendly
    viii) Better connectivity throughout the city

Any other reason, please specify……..

If NO?

13. What is the regular mode used for commuting?
    i) 2-wheeler
    ii) 4-wheeler
    iii) Any other……..
14. What is the frequency of using regular mode?
    v) Multiple times in a week
    vi) At least once a week
    vii) At least once a month
    viii) Other
15. What are the reasons for not choosing public transport? (Rank 1, 2, 3……..)
    i) Due to status in society
    ii) Poor Cleanliness/ Unhygienic
    iii) Unsafe
    iv) Not Secure
    v) Inconvenient
    vi) Not on time
    vii) Not user friendly
    viii) Poor connectivity throughout the city

    Any other reason, please specify……..

PERCEPTION RELATED QUESTIONS

(Using 5 point Likert scale coded 1 to 5, where 1= Strongly Agree, 2= Agree, 3= Neutral, 4= Disagree and 5= Strongly Disagree)

1. Comfort and convenience of the mode

1) It is convenient to carry bags and luggage
2) The seats are comfortable and cushioned
3) The mode is neat and tidy as compared to other means of public transport
4) The mode is dust and pollution free mode

2. Safety of the mode

1) The mode is inconvenient for users having water fear
2) The user feels uncomfortable due to past incidences of over loading of ferries

3) The mode is not reliable in bad weather conditions like during heavy rainfall

3. Concern of the commuter about travel cost and travel time

1) Due to increasing fuel prices it is convenient mode with less travel cost
2) This mode reduces the travel time with more connectivity to main city areas
3) Due to unavailability of parking area and high parking charge, it is convenient mode for users
4) It reduces toll charge paid by the users for other modes
5) The users will get some monetary benefit in form of incentives if they switch to inland waterways

Operator's survey

1. Survey location
2. Type of Ferry
    - Conoe
    - Speed boat
    - Electric boat
    - Cruiser
    - others
3. Passenger capacity of boat
    - Less than 5
    - 5-10
    - 10-15
    - Above 15
4. Number of employees on boat
    - 1
    - 2
    - 3
    - 4
    - More than 4
5. Working hours
    - Less than 4 hours
    - 4-8 hours
    - 8-12 hours
    - More than 12 hours
6. Total number of trips made per day
    - Less than 10
    - 10-20
    - 20-30
    - 30 and above
7. Average person per trips
    - 1-5
    - 5-10
    - 10-15
    - 15 and above
8. Fare per trips
    - Less than 50
    - 50-100
    - 100-150
    - 150-200
    - More than 200
9. Major trip Destinations
10. Need of Infrastructure improvement
11. Any new ferry routes to be proposed

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- City Logistics plan – Allahabad – 2020 UMTC
- City Development Plan for Allahabad, 2041 - Capacity Building for Urban Development project (CBUD)

BACKGROUND OF THE STUDY

The Inland Waterways Authority of India *(Policy 2001)*

1. The core objective of developing the inland waterway transportation sector into an **attractive alternative for road transportation** wherever possible.
2. The IWAI was also permitted to enter **into joint ventures with interested private entities** in order to take up infrastructure development projects in the inland water transportation sector.

The National Urban Transport Policy *(2006)*

1. **Encouraging inland waterways as public transport:** This would help control the congestion on city roads and also bring down pollution levels.
2. It strongly advocates the development and use of indigenous and sustainable modes of transport such as the ferry system since they would help in **reducing the dependence of the public on the already clogged roads, besides being low on expenditure** relating to setting-up and maintenance.

Shift from road transport to IWT for both passenger contribute to more efficient use of resources and energy.

Unique opportunities for the development of tourism.

India also has target to be net-zero nation by 2070. The development of inland waterway transport is a key to ensure sustainability.

Figure: India's new and upcoming waterways

NEED OF THE STUDY

Inland Water Transportation is, by all means, the most **economical of all modes** for transportation of people and cargo.

Source : Asian Development Bank 2007

•Passenger movement by waterways is **highly underutilized in the country** as compared to other developed European Countries.

Source : Indian Infrastructure 2004, ADB

IWT has received **large funding in both the ninth and tenth five-year plans** but has not been able to effectively utilized. It continues to be a focused area for investments, such as a Rs 300 crore investment planned by the Asian Development Bank.

Source : Planning Commission 2001

AIM & OBJECTIVES OF THE STUDY

AIM: To promote water-based public transport in City of Prayagraj.

OBJECTIVES:

1. To assess the existing public transport practice and their challenges in study area.
2. To assess existing practices and infrastructure of water channel all along to study area
3. To study the travel behaviour and perception of users through local ferry service
4. To suggest a systematic inland water based public transport system with help of suitable planning interventions.

METHODOLOGY OF THE STUDY

STAGE-1 LITERATURE REVIEW

- Selection of Area of Interest
- Background Study
- Need of Study
- Literature Review
- Formulation of Aim & Objectives

STAGE-2 SITE SELECTION

Selection of Study Area

- City with existing perennial water channel network
- Existing ferry (boat) system and public transport
- Available secondary data and geographical data
- Any Government scheme or initiative (existing/ future)

→ **PRAYAGRAJ**

STAGE-3 DATA COLLECTION & SAMPLING

- Preparation of Data Collection Checklist
- Data Collection Strategy
  - **Primary Survey**: Personal Interview
- Sampling Strategy
  - Simple Random Sampling

STAGE-4 DATA ANALYSIS

Objective-1 physical network/ sustainability of waterbody

- Available length and depth
- Connectivity through PT
- Seasonal variation in water level
- Accessibility of water body
- Surrounding landuse

Objective-2 perception of service users of inland waterways

- Individual's preference in using the ferry system
- Comfort, convenience and safety of users
- Connectivity to Public Transport or IPT (to reach the ferry)
- Ticket fare, travel time and frequency of ferry system
- Alternate mode, travel time and its frequency

Objective-3 infrastructure requirements

- Access to boats, jetties and depots
- Passenger seating & waiting area
- Navigation system
- Dedicated fare collection system
- Boat parking

STAGE-5 PROPOSALS & RECOMMENDATIONS

Objective-4 possible solutions, recommendations

- Infrastructural interventions (at depots + in ferries)
- Improved connectivity to ferries via PT & IPT
- Regulating new routes as per Demand
- Addition of new advance and improved boats
- Technological Interventions

LITERATURE REVIEW

TITLE	AUTHOR	YEAR	KEY FINDINGS
A Study on Inland Water Transportation in Kochi City Region	Yogi Joseph	2012	Provide basic Infrastructure facilities,Timely dredging, Improving accessibility,Introduce technological advances in IWT, Provide end-to-end connectivity ,last-mile connectivity, Improving accessibility, Reduce turnaround time for ferries, Involve the citizenry more actively in the planning and rebranding of the ferry system.
China in transition: institutional change at work in inland waterway transport on the Yangtze River	J.Y. Li, T.E. Notteboom , W. Jacobs	2014	**Theoretical foundations and conceptual framework**-Institutions and institutional change (sets of legally enforced rules and regulations at various levels). **Conceptual model: institutional design and regional development path** -The theoretical basis for the discussion on the role of governance and institutions in IWT development. **Institutional analysis of IWT development on the Yangtze River, China-**The IWT development on the Yangtze River constitutes an interesting empirical case. The central government, local governments, shipping lines and terminal operators form the main agents in the process of change. The roles and functions of governments and IWT operators change frequently
DEVELOPMENT OF WATERWAYS IN INDIA	Lok Sabha Secretariat Parliament Library And Reference, Research, Documentation And Information Service	2015	BENEFITS OF INLAND WATER TRANSPORT - Cost savings,Environment friendly,Supplementary mode. DEVELOPED NATIONAL WATERWAYS- NW-1 Ganga-Bhagirathi-Hooghly river system, NW-2 River Brahmaputra, NW-3 West Coast Canal (Kottapuram-Kollam), NW-4 Kakinada- Puducherry canals along with Godavari and Krishna rivers, NW-5 East Coast Canal with Brahmani river and Mahanadi delta rivers
National Inland Waterways in India A Strategic Status Report	Shripad Dharmadhikary, Jinda Sandbhor	2017	**IMPACTS OF CREATING, MAINTAINING AND OPERATING INLAND WATERWAYS**, Capital Dredging,Physical Modification of and Damage to Habitats,Turbidity of Water due to Dredging,Construction of Jetties, River Ports. Assessing Viability of Waterways, **Funds and Financing, INTEGRATING WITH OTHER PLANS -** Inter Linking of Rivers, Ganga River Basin Management Plan. **FUTURE ASPECTS** - Creating a Larger Public Discours, Bringing Out a Vision and Policy Document,Using the Naturally Available Depth and Width, Mandatory Environmental and Social Impact Assessment

SCOPE & LIMITATIONS OF THE STUDY

SCOPE: The study includes **total planning boundary** of **area 309.17 sq. km**. Total channel length of the waterbody in planning area, **Yamuna 12 km** approx. and **Ganga 19km** approx.

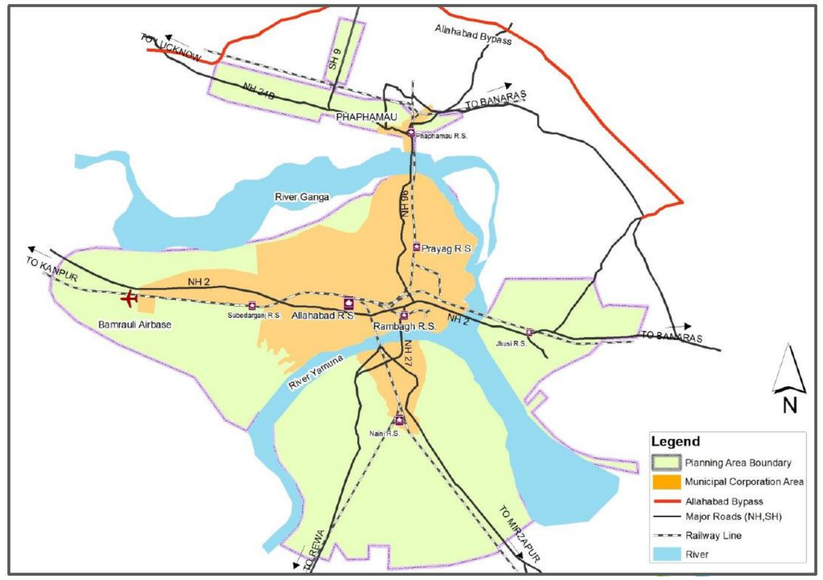
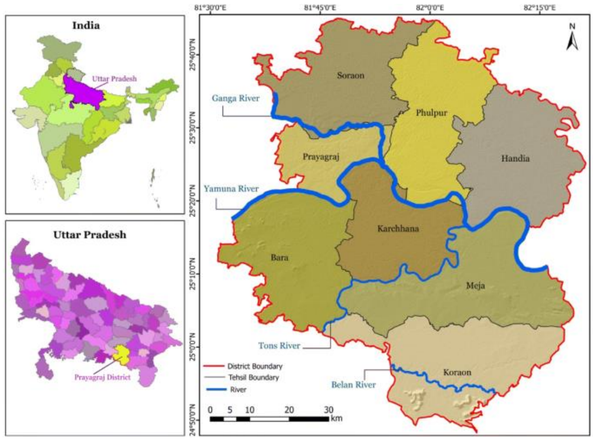


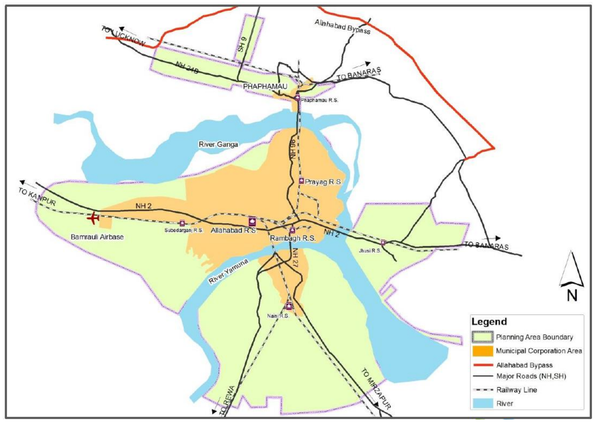
Figure: Planning Area boundary of Prayagraj.
Source: CDP Prayagraj 2041

LIMITATIONS:

- Majorly the study focuses upon the ferry users who are coming to ghats regularly or very frequently.
- Due to time constrained and lack of resources entire river stretch of Ganga and Yamuna is not included in the study.
- The primary data is collected during the mela season so it may vary during the other time of the year.
- Only cross-sectional data collected through primary survey is used for data analysis and recommendations.
- The study do not covers the existing public transport and IPT Network and routes. It is more focused on ferry routes.

SITE SELECTION





WHY PRAYAGRAJ?

- Lies on the **National Waterway-1** of IWAI
- Conflict point of 2 major rivers- **Ganga & Yamuna**
- Ancient heritage in **water-based transport** through ferries
- One of the **major tourist attractions** in India

- **Prayagraj** is located at the **confluence of Rivers Ganga and Yamuna** in the North-Central Indian State of Uttar Pradesh.
- According to Census 2011, the **total population** of the city is **13.2 lakhs.**
- It is located at an **altitude of 98 m** above the mean sea level.
- The **total planning boundary area is 309.17 sq. km**.

NEED OF WATER-BASED PUBLIC TRANPORTATION IN THE CITY

- Location and expansion of city around the perennial rivers.
- Public dependency on water-based transportation for mobility in the city.
- Site with significant religious and cultural importance and large concentration of floating population.
- Scope of decongestion of the city traffic and exiting public transport.
- Ongoing or future Government initiatives for boosting the water based transportation

DATA COLLECTION & SAMPLING

Data Collection Strategy

Secondary Data:
1. Govt. Stakeholders
2. Reports
3. Development Plans
4. Govt websites & portals

Primary Data:
1.Personal Interview
2.Questionnaire

Sampling Strategy

Simple Random Sampling

Sample Size Calculation

Calculated Sample Size= 384
Collected Samples= 215

- Ferry Users: 127 samples
- Ferry Operators: 88 samples

Primary Survey-14 Ghats

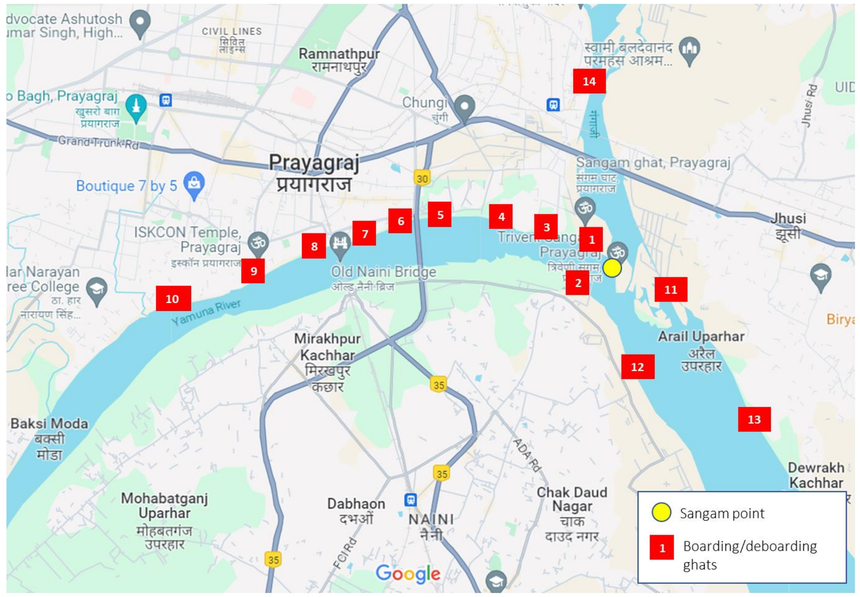


Figure: Primary survey locations along the Ganga and Yamuna River
Source: Google Maps *(Survey- February 2024)*

DATA ANALYSIS: OBJECTIVE-1

OBJECTIVE-1 To assess the existing public transport practice and their challenges in study area.

City Bus Public Transport

1. **Allahabad City Transport Services Limited (ACTSL)** operates the city bus services consisting of **non AC buses** and mainly low floor, standard **mini buses**.
2. The total length of the city bus routes is approx. 875 kms with average length of approx. 30 km per route
3. Civil Lane bus terminal and Zero Road terminal are the major Boarding and Deboarding stops
4. Major trip destination in the city is Trivenipuram, shantipuram, naini and gaysiddinpur
5. Base Year Total Trips **by Bus is 74325**, By **mini bus is 32631**, by **Auto is 489761**and by **E-rickshaw is 86939**.
6. Share of Work purpose trips is 31.7% followed by education trips which is 16.4%. The Business trips and social/ health trips contribute 9.2% & 15.3% respectively, while other trips are 12.6%. And Tourist 14.8%.

TABLE - CITY BUS ROUTES & OPERATIONS IN PRAYAGRAJ

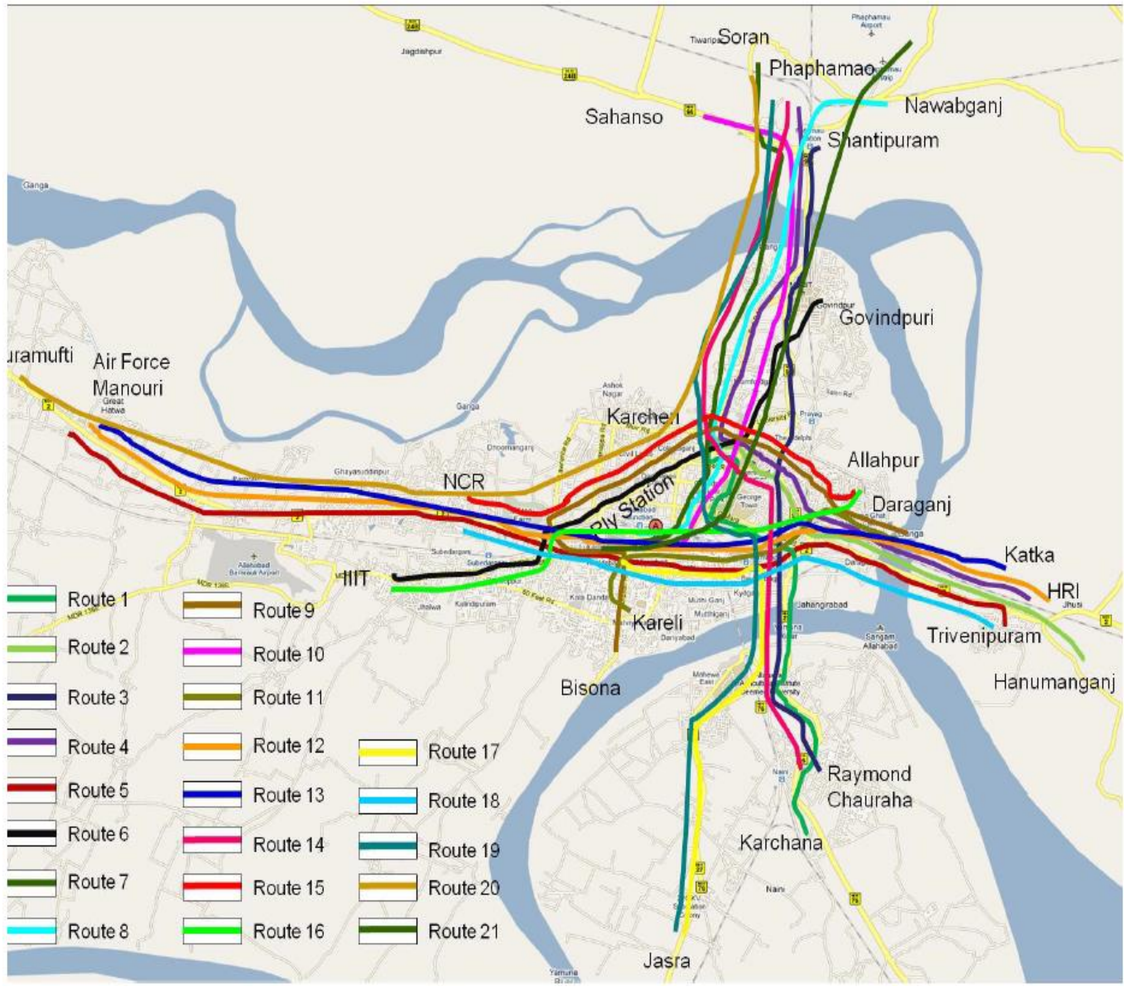
SN	Route Name	Route Length (Km)	Bus Type	No. of Buses
1	Trivenipuram - Happy Home	22	Standard	18
2	Raymond - Shantipuram	30	Standard	14
3	Civil lines - Trivenipuram - Pratappur	40	Standard	10
4	Bairhana - Shankargarh	42	Standard	12
5	Railway Station - Lalgopalganj	42	Standard/Mini	10
6	Railway Station - Soranv	25	Mini	4
7	Railway Station - Todhi ka Pura	42	Mini	2
8	Civil Lines - Mauiama	33	Standard	4
9	Railway Station - Bomapur	34	Mini	4
10	Railway Station - Saghanganj	23	Mini	4
11	Railway Station - Baharia	35	Mini	2
12	Railway Station - Nayi Bazar	36	Mini	2
13	Railway Station - Jame Bhita	36	Mini	1
14	Civil Lines - Dandupur - Pratappur	48	Standard	2
15	Katchurey - Jasra	29	Mini	4
16	Katchurey - Kohdarghat	45	Mini	8
17	Govindpur - Mirapar	16	Mini	3
18	Govindpur - Dariabagh	17	Mini	1
19	Govindpur - IIIT	20	Mini	4
20	Dara Ganj -Bisona	26	Mini	3
21	Civil Lines Phoolpur - Jogia Shekhpur	38	Mini	2
22	Trivenipuram - Shantipuram	28	Standard	1
23	Raymond Naini - Shantipuram	30	Standard	1
24	Shantipuram - Naini Raymond	30	Standard	1
25	Daraganj - Mirapur	15	Mini	1
26	Govindpur - Jhalwan	20	Mini	1
27	Govindpur - IIIT	20	Mini	1
28	Railway Station - Trivenipuram Haziganj	26	Mini	2
29	Sahson - Civil Lines - Pratappur	28	Standard	2

TABLE –City Bus Category and Numbers

S. no	Category of bus	No. of Buses
1	Non AC Low Floor bus	10
2	Standard Non AC mini bus	60
3	Standard Non mini bus	60
	Total	**130**

Intermediate Public Transport

1. At present, **more than 10000 diesel, petrol and CNG** fuelled IPT or Three Wheelers are operating in the city on various routes connecting major hubs or nodes.
2. More **than 2000** battery operated **E-Rickshaws** are operating on various routes of city.
3. the **minimum** fare of IPT services is **Rs 5.00** and maximum fare is **Rs 30.00** for **urban area**



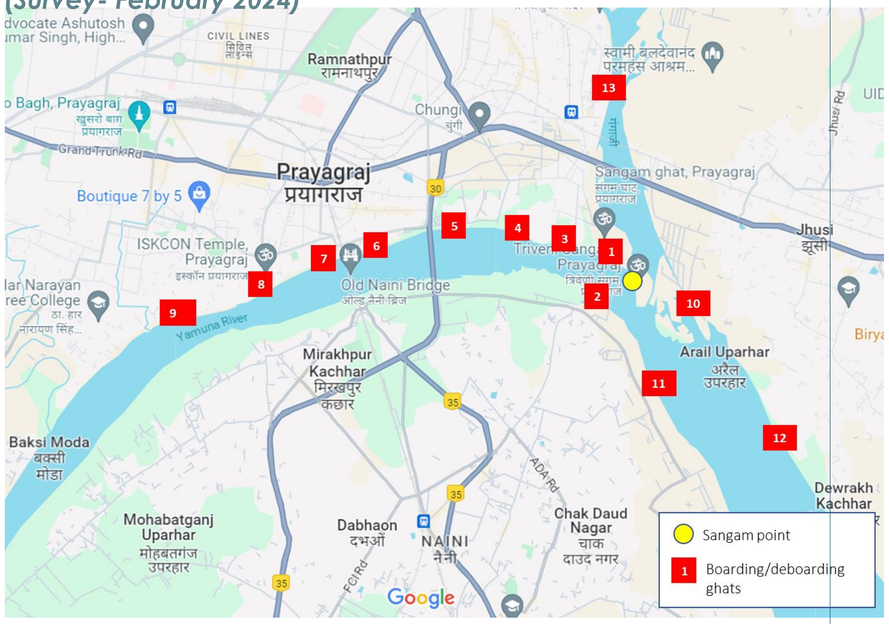
Map showing major bus routes in Prayagraj

Source – Comprehensive Mobility Plan Allahbaad 2020

DATA ANALYSIS: OBJECTIVE-2

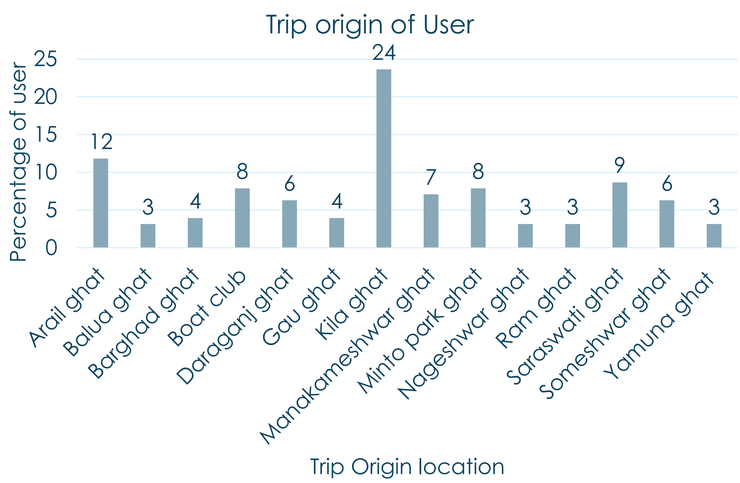
OBJECTIVE-2 To assess existing practices and infrastructure of water channel all along to study area

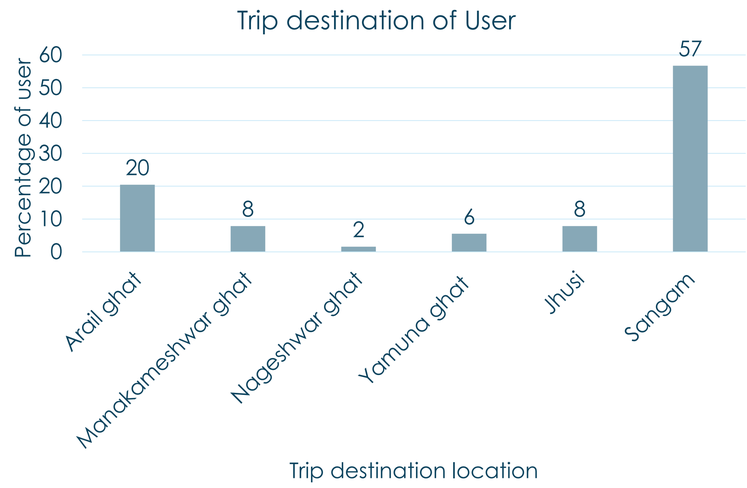
Figure: Primary survey locations along the Ganga and Yamuna River (Survey- February 2024)



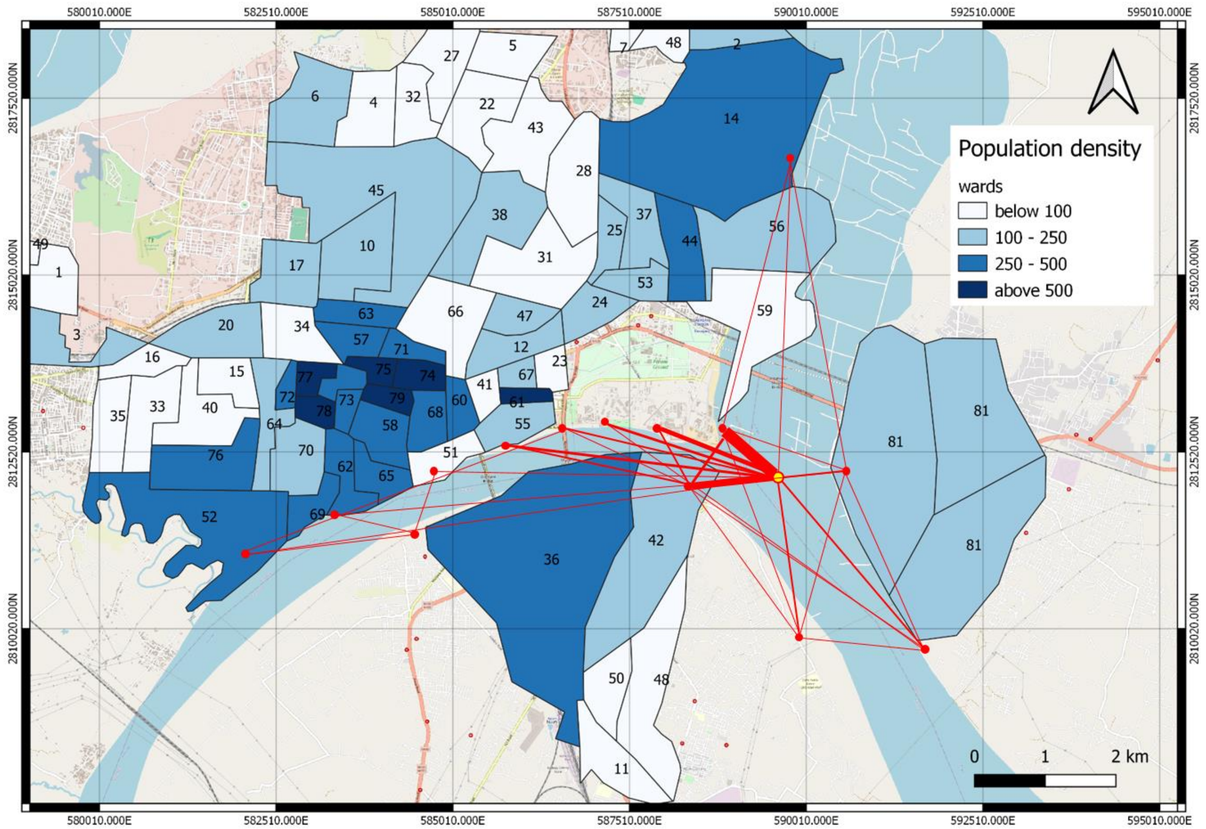
Identified Ghat	Distance from Sangam	Distance to nearest Ghat
Within 1 km		
1. Kila Ghat	1.2 km	800m
2. Arail Ghat	700 m	800
Within 2 km		
3. Saraswati Ghat	2.2 km	1km
10. Ram Ghat	1.2 km	1.8 km
11. Someshwar Ghat	1.9 km	1.5 km
Within 3 km		
4. Mankameshwar Ghat	2.4 km	250m
5. Yamuna Ghat	3 km	530 m
12. Pamanand Ghat	3 km	1.6 km
13. Daraganj Ghat	2.4 km	2.8 km
Within 4 km		
6. Boat Club	3.6 km	600 m
7. Gau Ghat	4.3 km	600 m
Within 5 km		
8. Balua Ghat	5.4 km	1.08 km
Within 6 km and above		
9. Bargahd Ghat	6.6 km	1 km

Trip Origin and Destination of Ferry Users





Desire Line Diagram showing a frequency of OD Trips in the delineated Study area



INFERENCE-

Majorly the trips are originated from Kila Ghat and Arail Ghat.

The trip destination of 20% users is Arail ghat, 8% users is Mnakameshwar ghat, 2% users is Nageshwar ghat, 6% users is Yamuna Ghat, 8% is Jhusi and 57% is Sangam.

Sangam and Arail Ghat are major trip destination of users.

DATA ANALYSIS: OBJECTIVE-2

OBJECTIVE-2 To assess existing practices and infrastructure of water channel all along to study area

TABLE: Availability of existing infrastructure at Ghat

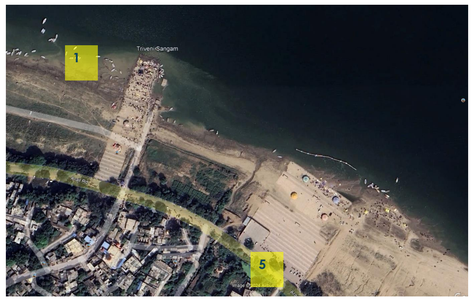
GHAT NAME	Road Access to Ghat	IPT/PT Connectivity	Dock Area	Boat Parking	Boarding/ Deboarding area	Fromal ticketing system	Waiting area	Utilities toilets/ drinking	Vehicle parking	Safety Equipments
Kila Ghat										
Arail ghat										
Saraswati ghat										
Mankameshwar ghat										
Yamuna ghat										
Minto park ghat										
Boat club										
Gau ghat										
Balua ghat										
Bargahd ghat										
Ram ghat										
Someshwar ghat										
Parmanand ghat										
Daraganj ghat										

NOT AVAILABLE		PARTIALLY AVAILABLE		AVAILABLE

INFERENCE:

1. Dock area, ferry parking, boarding/deboarding and formalize ticketing system area majorly Infrastructural components missing and Ghats.
2. Road access is partially available except Gau Ghat, Balua Ghat and Barghad Ghat.
3. Saraswati ghat, Yamuna Ghat, Balua Ghat and Daraghanj Ghat lack in IPT/PT connectivity.

Existing infrastructural problems at Ghats



1. Accessibility problems at boarding and deboarding stations
2. Lack of safety measures and equipment for passengers
3. Lack of jetty infrastructure
4. Unavailability of boat parking
5. No waiting and seating space available at boarding and deboarding stations.
6. No formal ticketing system
7. Lack connectivity to other modes (PT & IPT).

Source – *Primary Survey (Feb 2024)*

TABLE: Required Infrastructure

Required Infrastructure Facilities	Components of facilities
Dock	1. Internal movement and Circulation 2. Boarding and Deboarding points 3. Waiting and seating space
Connectivity of major boat hubs	1. Improved non-motorised transport 2. Feeder access to the boat jetty
Global Positioning System (GPS)	1. Location: Current and Target 2. Distance: Origin and Destination
Passenger Information System (PIS)	1. Passengers Announcement System (PAS) 2. Passenger Information Display System (PIDS)
Safety & Security	CCTV inside boats and at jetties / Hubs
Automatic Fare Collection System	1. On-board Smart card 2. Automatic Ticketing Solutions
Dispersal Plan	Boarding, alighting and movement at transit stations
Support Utility & Services	Toilets, Drinking Water Facility

DATA ANALYSIS: OBJECTIVE-2

OBJECTIVE-2 To assess existing practices and infrastructure of water channel all along to study area

TABLE: Conditions required for selection of water channel

Condition Required	Existing scenario on Site (Prayagraj)
It should possess capability of navigation and movement of ferries.	Yes, in existing there is ferry system used for tourism.
It should have about 45m wise channel and minimum 1.5m depth.	Maximum depth available at Ganga lies between 1.2-40m and at Yamuna lies between 55-82m.
It should be continuous stretch of 50km.	Stretch from Prayagraj to Ghazipur is 370km long.
It should pass through and serve the interest of more than one State.	The water channel passes through Uttar Pradesh, Bihar, Jharkhand and West Bengal.
It should connect a vast and prosperous hinterland.	The water channel connects Sangam, a place of regional importance for devotees of Kumbh Mela.
It should pass through a strategic region where development of navigation is considered necessary.	Development of water channel is important to cater the increasing traffic and congestion pressure on road transport for daily travellers.

Source: IWAI

TABLE: Available depth of water channel

Location	Available Depth (in m)
1	0.9
2	9-12
3	12-18
4	5-10
5	3-5
6	3-5
7	5-8

Source: Primary Survey (4 Feb 2024)

Stretch	Least available depth
Prayagraj to Ghazipur	1.2m to 1.5m *Source: IWAI*

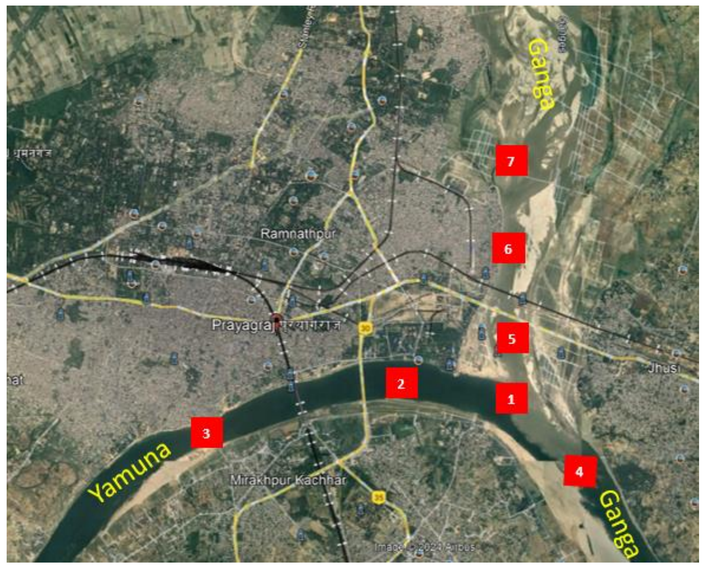
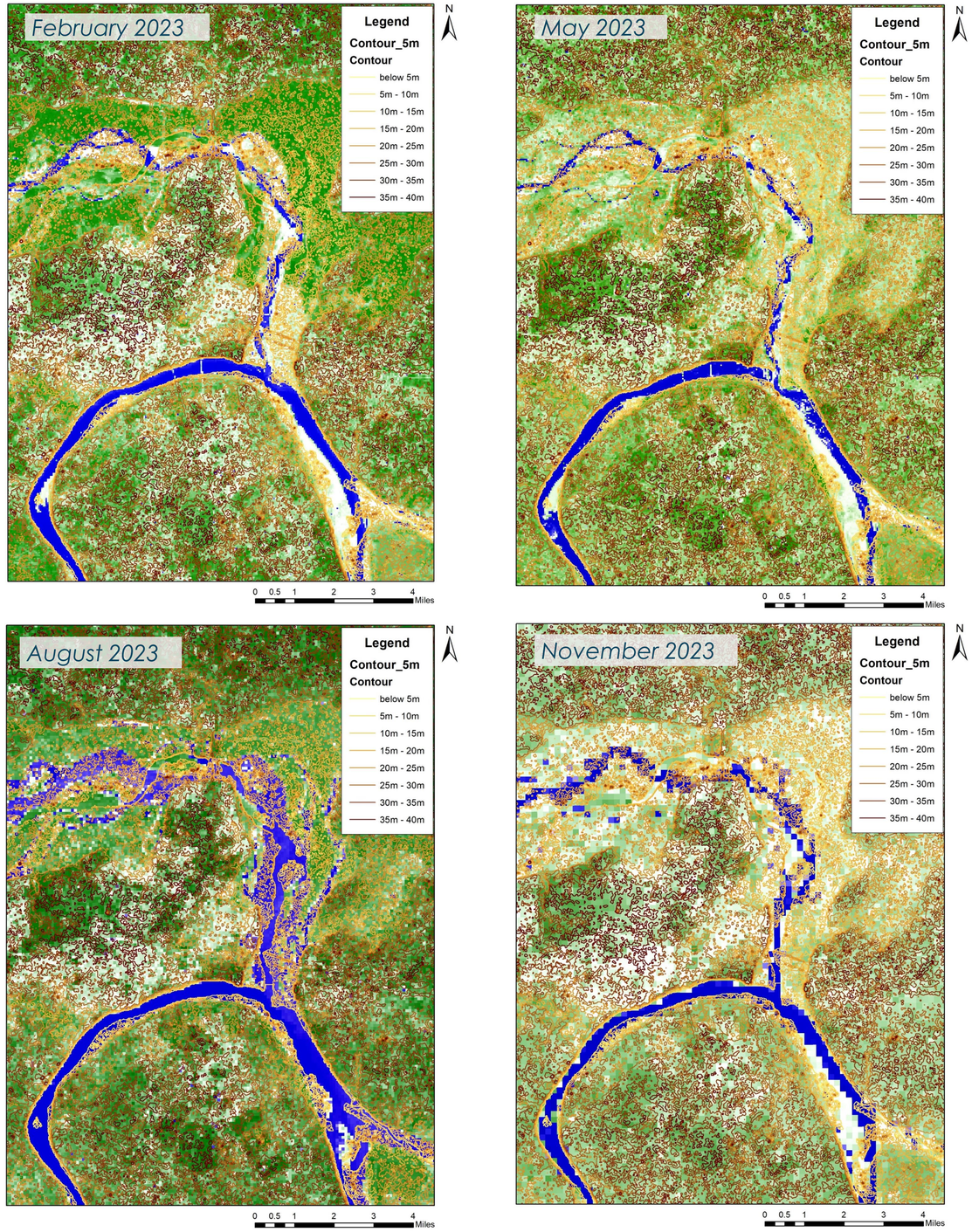


Figure: Locations points to measure available depth of Ganga and Yamuna River

- Maximum depth available at Yamuna lies between 55-82m and at Ganga lies between 1.2-40m.
- Depth below 1m is maintained at Sangam to facilitate religious activities.
- It is planned to maintain depth of 3 m all along the stretch at NW-1.
- *Min. Depth Required to operate Ferry service as per IWAI is 1.5m.*

Source: IWAI

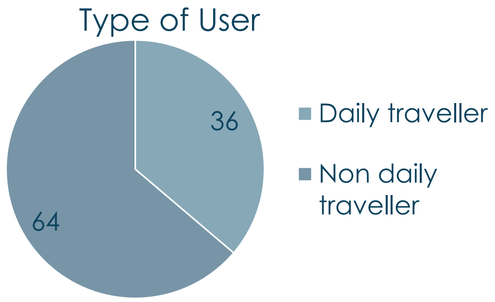
Figure: Variation in river flow over the year (2023)



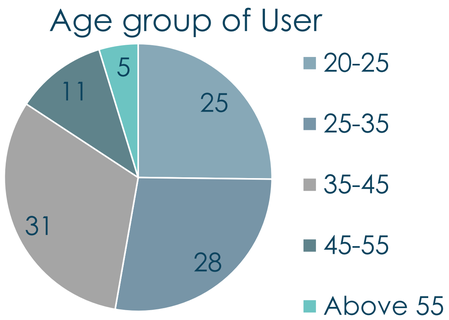
DATA ANALYSIS: OBJECTIVE-3

OBJECTIVE-3 To study the travel behaviour and perception of users through local ferry service

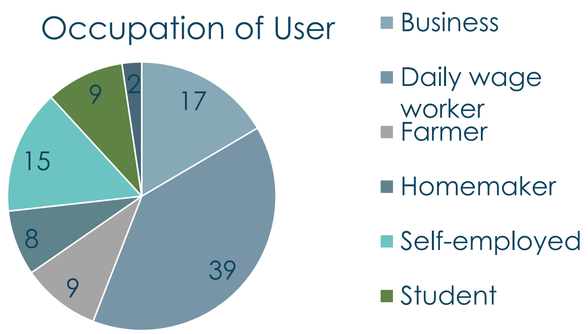
Demographic Profile of Ferry Users



The major share of ferry users are non-daily travellers.

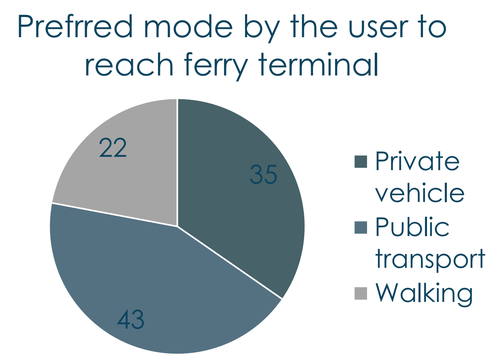


The major share of ferry users is between age group of 35-45 years.

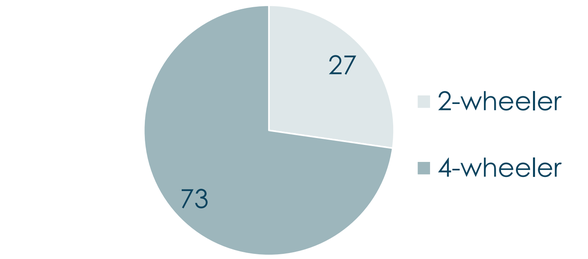


The major share of ferry users are daily-wage workers.

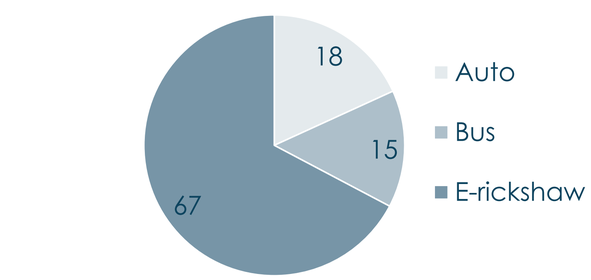
Mode choice of Ferry Users



The major share is of public transport users.

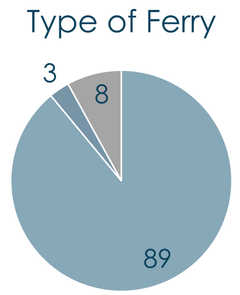


The major share is of 4-wheeler users.



The major share is of e-rickshaw users.

Ferry Operators (88 samples)



Number of employees:
Conoe: 1-2 employees
Cruiser: 3-4 employees
Speed Boat: 1-2 employees

The major share is of conoe ferries (89%) followed by speed boat (8%).

Type of Boat	Boat Capacity	Average number of persons per trip	Average number of trips per day
Conoe	8-12 persons	5.3	6.4
Cruiser	40 persons	25.7	1.5
Speed Boat	4 persons	2.4	18.3

Suggestions by Ferry Operators

- New Mechanised Boats
- Boat Parking at depots stations
- Boat maintenance equipments
- Safety equipments
- Incentives and improved wages

Source – *Primary Survey (Feb 2024)*

DATA ANALYSIS: OBJECTIVE-3

OBJECTIVE-3 To study the travel behaviour and perception of users through local ferry service

Table: Multinomial Logistic Regression Model

AM		B	Std. Error	Wald	Sig.
2	Intercept	4.486	6.069	2.084	.061
	TR	.024	6.068	4.910	.027
	TP	-0.306	1.993	5.293	.021
	TT=1	0	0	0	0
	TT=2	0	0	0	0
	TT=3	.473	2.843	2.812	.872
	TT=4	-5.553	3.298	1.335	.042
	TT=5	-2.288	1.098	1.239	.037
	TC=1	0	0	0	0
	TC=2	-.387	3.195	0.15	.074
	TC=3	2.106	1.143	3.396	.065
	TC=4	1.251	1.519	2.935	.037
	TC=5	.581	1.092	2.206	.050
	C=1	0	0	0	0
	C=2	0	0	0	0
	C=3	0	0	0	0
	C=4	-.447	1.243	.743	.078
	C=5	2.602	3.221	1.452	.032
	A=1	0	0	0	0
	A=2	0	0	0	0
	A=3	-1.561	1.005	.156	.067
	A=4	.496	1.052	3.612	.051
	A=5	.561	2.341	3.891	.046
	DS=1	0	0	0	0
	DS=2	0	0	0	0
	DS=3	-.421	.289	2.433	.061
	DS=4	2.131	2.564	3.651	.022
	DS=5	2.714	2.651	4.267	.001
	S=1	0	0	0	0
	S=2	0	0	0	0
	S=3	-1.560	.760	.642	.072
	S=4	-.413	.781	.321	.081
	S=5	-.272	.518	2.541	.063

The reference category is: 2 (Public Transport)
AM: Alternate Mode (Here 1 is Private Vehicle)

8 variables

127 Samples

Five-pointer Likert Scale- 1 (strongly disagree), 2 (disagree), 3 (neutral), 4 (agree), 5 (strongly agree).

- TR is type of traveller (Daily/ Non-Daily Traveller)
- TP is trip purpose (Work, Educational, Recreational, Religious)
- TT is travel time
- TC is travel cost
- C is connectivity with other modes
- A is accessibility of ferry stations
- DS is designated waiting and seating space
- S is safety

	Model Fitting Criteria -2 Log Likelihood	Likelihood Ratio Tests		
		Chi-Square	df	Sig.
Model	337.087			
Intercept	27.482	309.605	8	.023

- Multi-Nominal Logistic Regression Model have been used to predict which all variables affect user's willingness to shift or not on inland waterway.
- This model will help us to know how a person's current mode choice is affecting their willingness to shift on inland waterways.

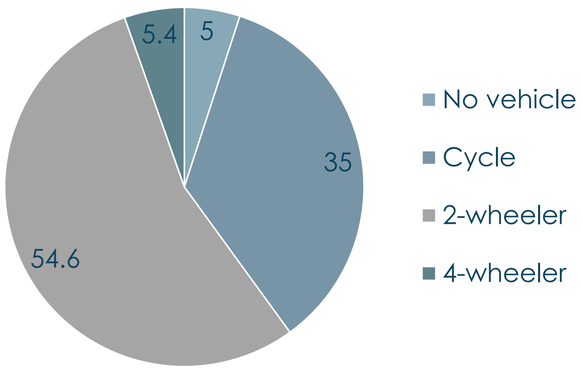
INFERENCE:

- The model is statistically significant.
- From the table it is found that travel cost, travel time, connectivity, accessibility and designated space are significant.
- As per the statistical estimation, when we look at each category, it is found that- as the travel time and travel cost decreases the willingness of the user to shift on inland waterways increases.
- It is also inferred that as the connectivity, accessibility and infrastructure improves the willingness of the user to shift increases.

PROPOSALS & RECOMMENDATIONS: OBJECTIVE-4

OBJECTIVE-4 To suggest a systematic inland water based public transport system with help of suitable planning interventions.

Vehicle Ownership in Prayagraj City



Source – *CMP Prayagraj, 2020*

- **Average Travel Time** – Average travel time in city is 24.8 minutes.
- **Average trip length** – Average trip length is observed to be 6.16 Kms.
- **Trip By Purpose – 45% of the trips were work trips,** 39% were education trips and 16% were other trips.

Source – *CMP Prayagraj, 2020*

TABLE: Mode share in Prayagraj City

Mode Share	Percentage of Users
Four-wheeler	3.8%
Two-wheeler	37.0%
Auto	**16.1%**
Bus	**2.6%**
Mini Bus	0.1%
School Bus	2.6%
Cycle	13.5%
E-Rickshaw	**3.0%**
Train	0.1%
Walk	21.2%

Source – *CMP Prayagraj, 2020*

Currently we have focused on **Public Transport Users** which includes auto, bus and rickshaw users making a total of **21.7% users.**

As referred from Kochi Metro DPR, 2015- To estimate the future demand of the inland waterways in Prayagraj, optimal shift from the existing commuters is assumed. For the current study, the induced demand is assumed to be as follows:

8% shift from the E-Rickshaw Users
7% shift from the Auto Users
4% shift from the Bus Users

TABLE: Scenario-wise growth rate in PT users

Scenario	Growth Rate in total public transport users	Increased % of PT users
Pessimistic scenario	3%	23.08 %
Optimistic scenario	8%	25.38 %
Realistic scenario	5%	24 %

Source – *Kochi Metro DPR, 2015*

TABLE: Population Forecasting

Method	2021	2031	2041
Arithmetic	14,98,214	16,87,040	18,75,867
Geometric	16,87,005	21,73,526	28,00,356
Incremental	**16,70,863**	**22,04,988**	**29,11,763**

Source – *CDP 2041 Prayagraj, 2015*

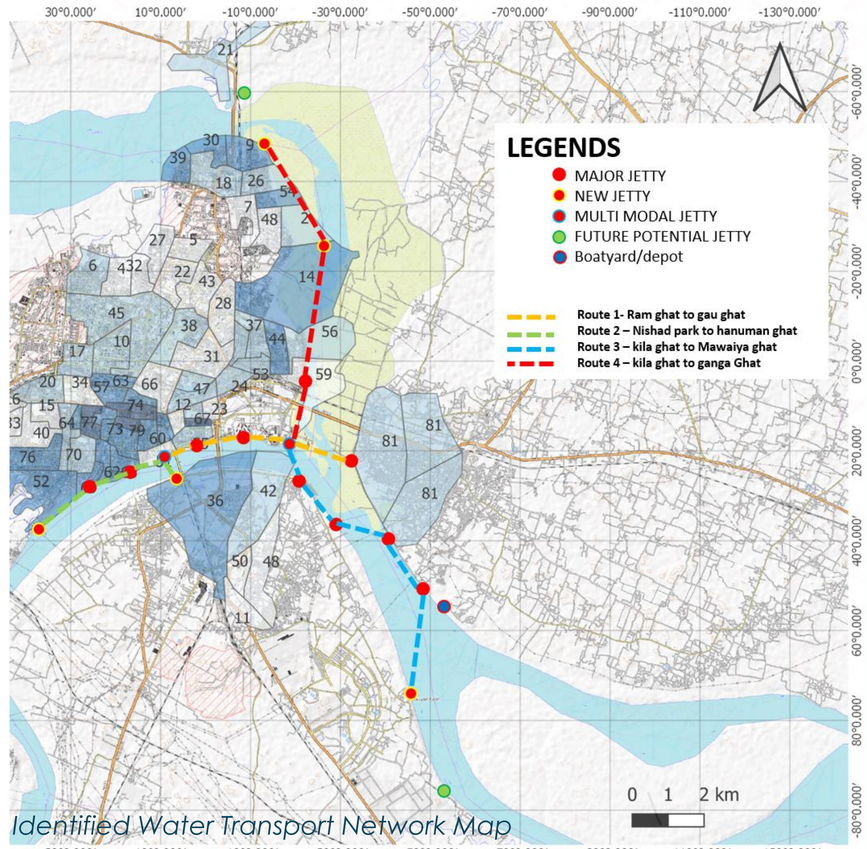
TABLE: Forecasting of PT users

Method	Increased % of PT users	Total PT users in 2021	Total PT users in 2031	Total PT users in 2041
Pessimistic scenario	23.08 %	3,85,635	5,08,911	6,72,034
Optimistic scenario	25.38 %	4,24,065	5,59,625	7,39,005
Realistic scenario	24 %	4,01,007	5,29,197	6,98,823

Yearly the inland waterways has to cater around **7 lakh population.**

Proposed routes

Based on the 8 variables identified for Inland waterways public transportation , There is a potential demand for travel between the island communities and the mainland and the identified routes were aggregated to merge subset routes



Identified Water Transport Network Map

1. **Route 1 (5.2 km)** – Ram ghat – Kila ghat – Saraswati ghat – Yamuna ghat – Boar Club – Gau ghat
2. **Route 2 (4.8 km)** - Nishad park ghat – Barghad ghat – Balua ghat – Gau ghat – Hanuman ghat
3. **Route 3 (6.4 km)** – Kila ghat – Arail ghat – Someshwar ghat – Parmananda ghat – Mawaiya Ghat
4. **Route 4 (8.8km)** – Kila ghat –Daraghanj ghat –Govind ghat – Ganga ghat

PROPOSALS & RECOMMENDATIONS: OBJECTIVE-4

OBJECTIVE-4 To suggest a systematic inland water based public transport system with help of suitable planning interventions.

INFRASTRUCTURE ASCESSMENT

1. **Dedicated Water Transport Corridor-** The Region waterway comes under the NW-1 as identified by IWAI. The waterways' and channel widths vary across the length and breadth of the city region. For the proposed routes of the water transportation system project, it is recommended to demarcate a dedicated water transport corridor with minimum **20 m width.**

2. **Dredging of Waterways -** Dredging is recommended on entire network to ensure a **minimum vertical draft of 1.5m**. Dredging may be carried out by Department of Irrigation or the Inland Waterways Authority of India.

3. **Jetty Stations or Piers -** manner. The redevelopment and upgradation of piers is permissible under the RRZ regulation

Major and minor Jetty at Ghats

S.no	Ghat name	Type of ghat
1	Kila Ghat	Major
2	Arail ghat	Major
3	Saraswati ghat	Major
4	Mankameshwar ghat	minor
5	Yamuna ghat	Major
6	Minto park ghat	minor
7	Boat club	Major
8	Gau ghat	Major
9	Balua ghat	Major
10	Bargahd ghat	Major
11	Ram ghat	Major
12	Someshwar ghat	Major
13	Parmanand ghat	Major
14	Daraganj ghat	Major
15	Govind ghat	Major
16	Ghanga Ghat	Major
17	Mawaiya Ghat	minor
18	Nishad park	minor
19	Hanuman ghat	minor

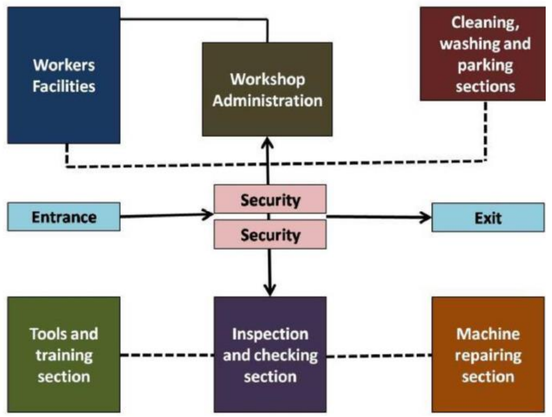
Jetty Development

The jetties are proposed to be developed as floating pontoons with automated mechanical docking of boats, the floating pontoons are proposed to accommodate a maximum of two boats at major jetties

Floating pontoons to be covered with sheds

4. Boatyard/Depot

The boatyard proposed to be upgraded and developed with all repair and maintenance infrastructure for periodic maintenance and upkeep of the vessel ,this new boatyard is proposed Devrakh Khachhar which will be a floating dock with provisions for schedule annual maintenance only.



Suggested Programme of Facilities

5. Intelligent Transportation and Navigation System

GPRS (4G) based Intelligent Navigation & Cruise control, GPS Tracking, Passenger Address and Information Systems, dedicated 2 way voice/data communication, on-board surveillance cameras, on-board multi SIM WiFi Hot spot is recommended for the water transport project's ITS.

6. Accessibility Infrastructure and Last Mile Connectivity

Accessibility is defined as the ease of reaching goods, services, activities and destinations, which together are called opportunities. It can be defined as the potential for interaction and exchange. In social planning, accessibility refers to people's ability to use services and opportunities.

- Development of Access Roads
- Non-Motorised Transport plan
- Disabled Friendly Access
- Feeder Service Development
- Parking Provisions
- Signages
- Street Safety Provisions
- Water Front Development

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