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Article

Promoting Circular Waterway Transport System for Recreational Water Environments and Integrated Urban Transportation Systems in Rajshahi City, Bangladesh

Anutosh Das[1*, 2], and Shajibul Haque[1, 3]

[1] Department of Urban & Regional Planning (URP), Rajshahi University of Engineering and Technology (RUET), Rajshahi-6204, Bangladesh.
[2]Department of Urban Planning and Design, The University of Hong Kong (HKU), Hong Kong.
[3]Research Assistant, Department of Environmental, Water Resources, and Coastal Engineering (EWCE), Military Institute of Science and Technology (MIST).
* Correspondence: Author: Email: anutosh@urp.ruet.ac.bd ,Contact: +8801984-875726

ABSTRACT: Rajshahi, blessed by the geographical advantage provided by the river Padma, is a beautiful and one of the cleanest cities in Bangladesh. It presents a spectacular image and stunning sight to its residents. But Rapid urbanization created immense pressure on the infrastructures and cityscape by rescinding most of the natural assets and scenic beauty it possessed historically. The growing pressure of population influx accompanied by unplanned urbanization threatens the survival of its waterbodies, wetlands, and greeneries, which many other contemporary cities strive to achieve with hard-hearted planning measures. Moreover, the city suffers from inadequate provision of quality outdoor recreational facilities. Yet because of the verdant resources, it still can set an example of becoming a green and fluid landscape. There are scopes to connect the city people to the urban landscape and blue-green infrastructures by applying proper planning and urban design techniques. For example, it can explore the potential and scope of a water-based transportation system to create outdoor recreation space for city dwellers as well as a transport mode in the city. This SECTION discusses the prospects and potential of enhancing recreational aspects of Circular Inland Waterways. It also analyzes the benefits of a network of waterways well-connected and integrated with the existing conventional transportation system to reduce pressure on land transport and promote a sustainable system. This research was conducted in two phases each involving a distinct approach. The first one was a macroscopic approach to probe the potential of the water transport system in Rajshahi city. The required data on traffic volume, traffic growth rate, roads and existing waterbodies were collected, and GIS and Remote Sensing tools were used to find the scope of waterway transport around Rajshahi City. In the second approach, a detailed design was proposed for a potential circular waterway network in the city. Results indicate that there is a huge prospect for introducing a circular waterway transport system around Rajshahi city to create a place of fluid landscape and minimize the pressure on the existing land transportation system.

Keywords: Circular Waterways; Outdoor recreation facilities; fluid landscape paradise; Blue-Green Infrastructure

01. INTRODUCTION

The financial well-being and quality of life of a nation's communities depend on a well-functioning and secure transportation framework. For case, taking after housing costs, transportation is one of the biggest costs confronted by an average household in Bangladesh and numerous other developing nations (Faisal *et al.*, 2020).

The accessibility and versatility given by transportation frameworks can impact land use designs and, hence, over time affect how we live. The transportation framework is a critical component of a successful modern community and economy. In this

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way, foreseeing the challenges and openings relating to transportation system execution is critical not only to future transportation framework adequacy but also to the financial and social well-being of our communities (Nahar et al., 2018; Hasan et al., 2018)

i. Organization of This Chapter

This Chapter is organized to reflect different levels of user familiarity with transportation planning. Not only do transportation planners need to know about the defining characteristics of the transportation system itself, but given a variety of transportation planning contexts, they must also understand the specific application contexts they are working in. In addition, this research has adopted phases each involving a distinct approach. The indicative outline of the study has been prepared to take into consideration the standard requirements. This chapter followed a structure, comprising the following sections;

What is transportation planning?

01: Introduction to Transportation Planning

What are the basic concepts for understanding transportation systems and their relationship to the community?

02: Travel Characteristics and Data

What are the types of tools and analysis methods used in transportation planning?

03: Travel Demand and Network Modeling

How does one plan for mode-specific transportation networks?

04: Planning for Waterway transport

How does one plan for multimodal transportation networks?

05: Waterway Route Planning

ii. Transportation Planning Process

Transportation issues seem to be one of the major concerns of any third-world country's development. But the way of keeping transport volume may vary from country to country. So, at this stage, extensive knowledge is required.

A. Major Steps in Transportation Planning

Primary data was collected from the field survey and secondary data was collected from several sources. A reconnaissance survey was conducted focusing on the structural condition alongside the water bodies, environment condition, existing water bodies, previous history of water bodies and road connection of adjacent station. The questionnaire comprised three major parts: the observatory survey (Traffic Volume Calculation) and the stakeholder's opinion survey. The outcome of the field tests was used to finalize the questionnaire. Secondary data was collected from several sources like google Maps, Landsat images and previous water bodies history of Rajshahi, BBS data and many more.

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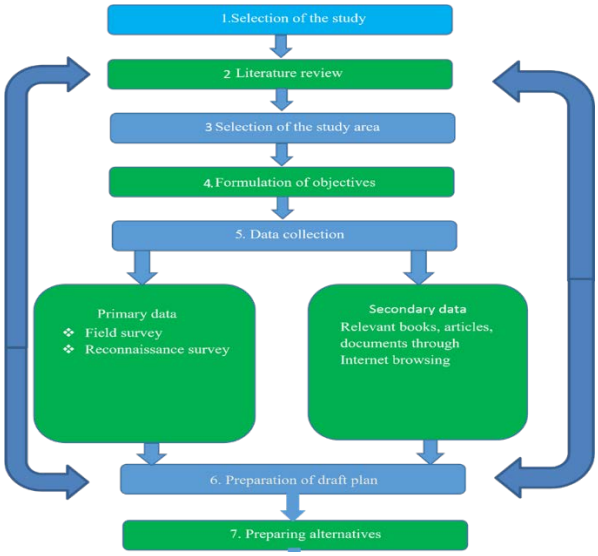

Figure 1-1: Flow chart of Methodology (Source: Prepared by Authors,2021)

B. Scope, goals and objectives

This study can be considered the first issue of analysis of transportation flow, since there were no in-depth studies and applied research conducted before, except for a few reports in different forms. Even though it may not be an exhaustive list of any in-coming solutions, it could be so nevertheless, the information compiled in this research can be a starting point for analyzing traffic flow considering inland transportation systems. The provisions of the recommendations suggested in the research can be applied to all transport management in Bangladesh.

Goals and objectives

- To assess the necessity and scope for installing a new mode of transportation i.e. waterway transportation in the study area.
- To assess the environmental and economic advantages and possible route network design for the proposed waterway transport system.

iii. Changing Context for Transportation Planning

Asian Development Bank figures reveal Bangladesh as having "an average the growth rate of 8% well over the Asian Average" implies that the government's the essential center lies within the financial development of the nation and the government is immovably committed to the country boosting up its rocketing industrialization process (Katharine *et al.*, 2019). Rajshahi is a major city in Bangladesh having a notable developing trend. It is situated on the north bank of the Padma River. The increasing number of people in this city need adequate transport facilities. Though the traffic growth rate is increasing day by day, the road surface increases hardly according to the needs of transport. As a result, severe traffic congestion is being happened in nearest future. This study focuses on the increasing traffic demand and therefore, introducing a waterway transport system and creating facilities for outdoor recreation for the urban dwellers.

02. TRAVEL CHARACTERISTICS AND DATA

Understanding how and why travel happens is one of the foremost vital assignments of transportation planning. Every planning ponder starts with an audit of the information accessible on the utilisation and execution of the current transportation framework. Not as it were are such information basic for recognizing where issues exist today or will likely

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exist in the future, this information is too regularly utilized to create investigation tools and models that anticipate future trip-making designs and behaviour. Methodology refers to the choices we make about the case to study methods of data gathering, forms of data analysis etc. in planning and executing the research design of the study. Both quantitative and qualitative approaches have been used for this study.

i. Transportation System Characteristics

Rajshahi city is known as a zero-carbon city for emitting a lower portion of carbon because there has plenty of use of electricity in the vehicle rather than gas. The situation is being changed day by day. To introduce a new mode of transport for reducing upcoming traffic flow and create a place of recreation "The Rajshahi City Corporation" area is selected as the study area.

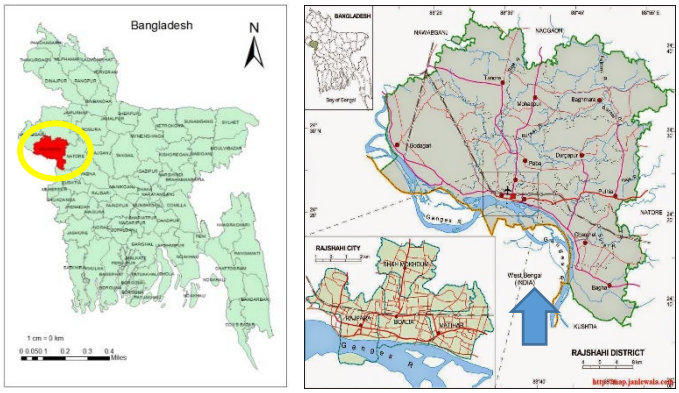

Figure 2-2: Location of Rajshahi in Bangladesh Map (Source: Prepared by Authors, 2021)

The area of Rajshahi City Corporation is 96.72 square kilometer, and it has a total population of 449756. The Padma River is the main waterbody of Rajshahi City

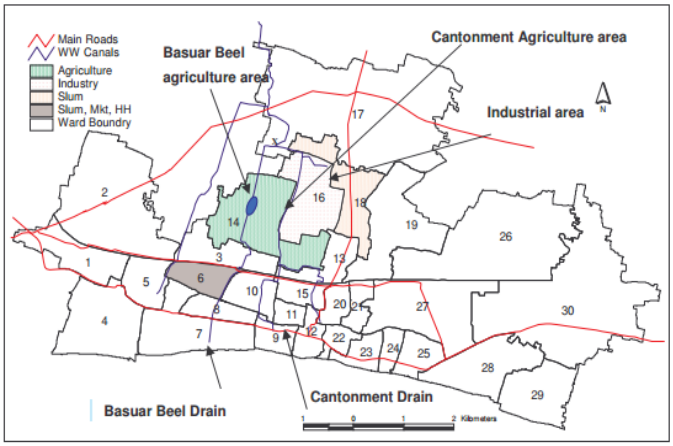

Figure 2-3: Basuar beel, Bashuar Beel Drain and the Cantonment Drain. (Source: Master Plan; Rajshahi, 2004)

Corporation area. Once there were a lot of ponds in Rajshahi city but for indiscriminate earth dumping and unplanned urbanization, almost 4,000 ponds are filled in the past few decades. Rajshahi city used to have 4,238 ponds, canals, and wetlands in 1961 which decreased to 2,271 in 1981 and in the year 2000 the number was 729. The water body is always a blessing for the city, but these are being destroyed rapidly without compromising the future.

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ii. SWOT Analysis

SWOT analysis is necessary for the evaluation of the current circumstances and as a reference guide for the proposed design.

Strength: • Geographical location • A homogeneous and similar type of activities	**Weakness:** • Lack of enough collaboration among LGED, R&D and BIWTA. • Cultural practice
Opportunity: • River training measures can help to keep water in the Padma course alongside the Rajshahi city. • Available governmental budget for traffic management.	**Threats:** • Lack of selecting priority base work schedule • Intermediary exploitation to wipe out the illegal occupancy.

iii. Existing Condition

a) Water Body

In this study area, there are mainly two types of water bodies. The amount of water and its locations are described below.

1.1. River:

The Padma River is the main waterbody of the Rajshahi City Corporation area. This city is situated on the north bank of the Padma River. Once the river was wide and abundant with water. But at present, there is less water remaining in the dry season. Sand bars are also visible in the dry season.

1.2. Ponds

Rajshahi city had 4,238 ponds, canals, and wetlands in 1961 which decreased to 2,271 in 1981 and the year 2000 the number was 729. Among the filled ponds, the greatest number (85.32%) were filled up privately by the owners of the ponds. Only 14.68% of lost ponds were filled up by state agencies (Rajshahi Development Authority, Rajshahi City Corporation, Rajshahi University, Bangladesh Railway, and other educational institutions, mainly for infrastructural, transportation and educational development (Haque, 2017).

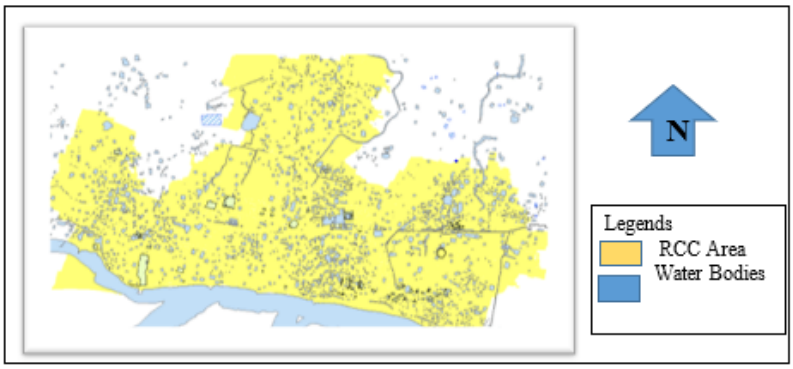

Figure 2-4: Existing Water Bodies of Rajshahi City Corporation Area (source: Prepared by Authors, 2021)

1.3. Other water bodies:

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Inside Rajshahi City, there is no canal but there is a "*Beel*" named "*Basuar beel*". This beel is approximately 15.3 feet wide. Water remains all over the year in this water body. So, this water may be a great resource for water transportation. Two drains that flow through the town of Rajshahi called the *Bashuar Beel* Drain and the Cantonment Drain meet the *Basuar beel*. But this water body is not connected with the Padma River. By using this *Basuar beel* the other proposed town centre canter (*Lalithar* and *Baze Silinda*) relate to the main city of Rajshahi by water mode of transport.

03. TRAVEL DEMAND AND NETWORK MODELING

Though mobility performance reflects the ease with which travellers can make a trip, availability relates to a traveller's ability to reach a goal and incorporates such measures as a percentage of work inside a certain separate transit station. In wide terms, mobility is more specifically impacted by the physical characteristics of the infrastructure and working characteristics of the framework. Details about demand forecasting are the major issues in this section. This chapter deals with quantitative data. Overall traffic demand has been discussed here in detail.

By the end of this section, we know about:

- Functional region calculation
- Influencing area identification
- Functional dependency categorization
- Trip distribution
- Traffic volume forecast

i. Rajshahi as an Influencing Area

Influencing area analysis is conducted to measure regional dependency. It may help further intercept the growth rate of Rajshahi. It also helps to realize the growth rate of traffic volume. A functional region is a kind of region which shows a functional coherence based on certain criteria. In this part of the study, for the delineation of the functional region by modified gravitational analysis method (Das *et al.,* 2019; Hasan *et al.,* 2020). For calculation, the Gravitational analysis method is used for the computation of influencing areas and unserved areas of *Upazilas*. A rank table was also prepared after that to compare these *Upazilas* which showed some significant changes between geographical area and influenced area. This study also tries to trace the reasons for changes in the ranking of different *Upazilas* i.e., highest and lowest ranked *Upazilas*.

The normal gravity model can be described as, the interaction between two Centres being directly proportional to the mass (such as education, health, income, employment etc) and inversely proportional to the distance between the centres.

$$T_{ij} = \frac{K P_i P_j}{d^2_{ij}} \qquad \text{(Glasson,1974)}$$

Where T_{ij} is the gravitational force between towns i and j, P_i and $P_{j\,are}$ the masses of two centres, d_{ij} is the distance between them and k is a constant.

The main equation, which is used to calculate the influence area, is called the modified gravity model that is,

$$\text{Influencing area of region A} = \frac{Distance\ between\ two\ \ region\ of\ A\ and\ B}{1+\sqrt{\frac{Population\ of\ region\ B}{Population\ of\ region\ A}}} \qquad \text{(Glasson, 1974)}$$

Table 1: Rank table of 26 Upazilas based on criteria.

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Upazilla	Population	Rank	Geographical Area (sq.km)	Rank	Area of influence	Rank	AI/GA	Rank
Atrai	193256	16	246.78	16	160.19	19	64.91	22
Badalgachi	201342	15	220.53	19	189.45	16	85.91	12
Dhamoirhat	184778	19	317.56	10	276.35	8	87.03	11
Mahadevpur	363858	5	388.94	6	287.90	7	74.02	18
Manda	363858	6	406.00	5	383.15	3	94.37	4
Naoagaon Sadar	405148	4	282.15	13	252.54	10	89.51	6
Niamatpur	248301	11	444.32	4	335.10	4	75.42	17
Patnitala	231900	12	376.17	7	334.31	5	88.87	8
Porsha	132095	25	259.26	15	232.35	13	89.62	5
Raninagar	184778	20	262.40	14	163.49	18	62.31	23
Sapahar	161798	23	243.75	17	198.80	15	81.56	14
Bholahat	103301	26	125.86	25	111.72	24	88.77	9
Gomastapur	275823	10	319.27	9	249.80	11	78.24	15
Nachole	146627	24	287.06	12	158.30	20	55.14	24
Nawabganj S.	530592	2	467.83	2	458.40	2	97.98	3
Shibganj	591178	1	529.30	1	560.73	1	105.94	2
Bagha	184183	21	197.07	20	167.15	17	84.81	13
Bagmara	354664	7	363.83	8	261.00	9	71.74	19
Boalia	449786	3	105.79	26	116.11	22	109.76	1
Charghat	206788	14	173.25	23	154.19	21	89.00	7
Durgapur	185845	18	196.00	22	94.02	26	47.97	26
Godagari	330924	8	446.56	3	293.50	6	65.73	21
Mohanpur	170021	22	162.43	24	114.74	23	70.64	20
Paba	314196	9	241.86	18	213.90	14	88.44	10
Puthia	207490	13	196.16	21	105.81	25	53.94	25
Tanore	191330	17	298.67	11	232.65	12	77.90	16

(Source: Prepared by Authors, 2021).

To get a clear image of the Rajshahi City Corporation area though it is partially bounded by *Poba Upazila* the city corporation is situated within *Boalia thana* which is also measured. By rationing area of influence to the geographical area, *Boalia* thana has stood first in rank. It is clearly said that Rajshahi City Corporation's influence area is more for creating important measures.

A clear image can be found briefly by comparing the study area with the surrounding district headquarters

Table 2: Rank of Upazilas with district headquarters

District	Upazilla	Population	Rank	Geographical Area (sq.km)	Rank	Area of influence	Rank	AI/GA(%)	Rank
Rajshahi	Boalia	449786	3	105.79	26	116.11	22.00	109.76	1
Chapai Nawabganj	Nawabganj S.	530592	2	467.83	2	458.40	2.00	97.98	3
Naogaon	Naoagaon Sadar	405148	4	282.15	13	252.54	10.00	89.51	6

(Source: Prepared by Authors, 2021).

The functional dependency may occur for the following criteria

Table 3: Functional dependency criteria

Upazilla	Number of growth center	Number of hospital bed	Number of selected mills
Boalia	7	1410	93
Nawabganj S.	6	229	270
Naoagaon Sadar	9	394	307

(Source: Prepared by Authors, 2021).

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From the above discussion, Rajshahi City is a functionally developed area among the surrounding cities. People move here for medical treatment purposes, educational purposes, and economical activities.

ii. Population Growth Rate

Bangladesh has a current population of 157 million with a corresponding population density of more than 1,115 persons per square km (Das *et al.*, 2019). Bangladesh has seen massive population growth in the past fifty years. The overall condition of Bangladesh can be known by the population from the following data analysis.

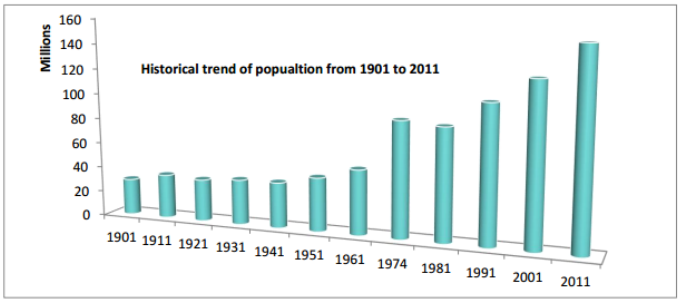

Figure 3-1: Historical Trend of Population:.

(Source: BBS Statistical Yearbook; 1991-2013)

From the above data, it is known that the total condition of the population increase. To be specified the growth rate of divisional cities is given below.

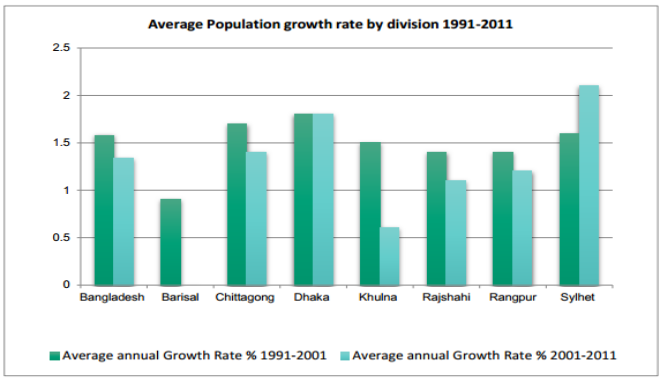

Figure 3-2: Average Population Growth Rate. (Source: BBS Statistical Yearbook; 1991-2013).

Here, it is known that the average population growth rate is being increased in Rajshahi day by day. The increasing population create more demand for transport facilities as well as another.

iii. Urban Travel Characteristics

In Rajshahi city, the road is shared by 8 major types of vehicles for both passenger and freight carrying purposes. Those vehicles are trucks, buses, Utility vehicles, cars, Auto rickshaws, Motorcycles, Bicycles, and rickshaws. The trip share of this vehicular traffic is shown below.

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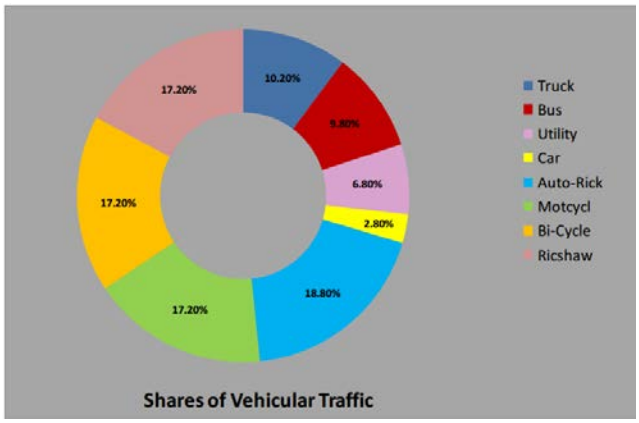

Figure 3-3: Modal Shares of vehicular Traffic in Rajshahi City (Source: Haque, 2014).

1. Trip Generation Purpose

Rajshahi city is the economic centre of the northwest portion of Bangladesh. Here there have various reasons for generating trips. The trip generates purpose as shown in Figures 3-4.

2. Trip Distance for Different Trip Purposes

Rajshahi city traffic has a great impact on educational institutions. Many students move here for higher study. The recreational purpose of these students influences the trip distance which is shown in figures 3-5.

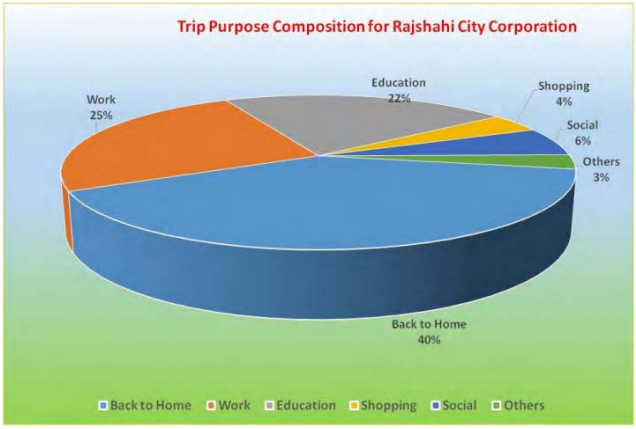

Figure 3-4: Trip generation purpose in Rajshahi City. (Source: Haque, 2014).

Figure 3-5: Trip distance according to different trip purposes in Rajshahi City (Source: Haque, 2014).

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3. Traffic Growth Rate

The traffic condition in Rajshahi City is based on commercial and non-commercial vehicles where commercial vehicles are trucks, buses, utility vehicles, auto-rickshaw, and rickshaws. The non-commercial Vehicles are private cars, motorcycles, and bicycles. The modal share of these types of vehicles is given below

- • Commercial vehicles - 63%
- • Non- Commercial Vehicles - 37%
- • The average annual growth rate for both categories together - is 6.1% (Haque, 2014)

The percentages of various types of vehicular mode share growth are increasing day by day. The situation is going to be worst in time. The overall traffic growth indicates that the increasing population need more traffic demand.

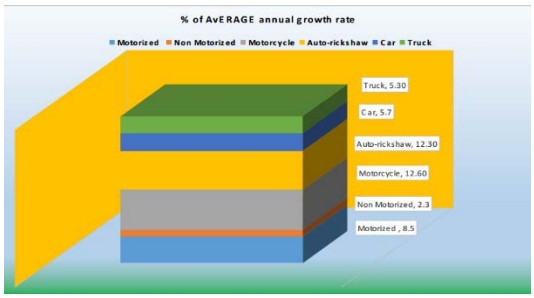

Figure 3-6: Percentage of the annual growth rate of vehicular Traffic in Rajshahi City.

(Source: Kafy et al., 2021)

iv. Traffic Volume Forecast

The traffic volume in Rajshahi city is being increased to meet the increasing demand of the population. The annual growth rate of traffic volume is 6.1% where it's creating a major impact on traffic conditions in Rajshahi city. The battery-driven auto-rickshaw is the major transport mode for Rajshahi city. The cleanest city in Bangladesh and the overall good condition for living made the Rajshahi city more attractive for migration. Therefore, every year a huge number of people move here. As a result, the condition of Rajshahi city is being changed to meet the increasing demand of the huge population. The rate of annual traffic growth may help to predict the future traffic volume forecast. The forecasted value helps to realize the overall condition of the traffic circulation. The traffic volume forecast data is given below.

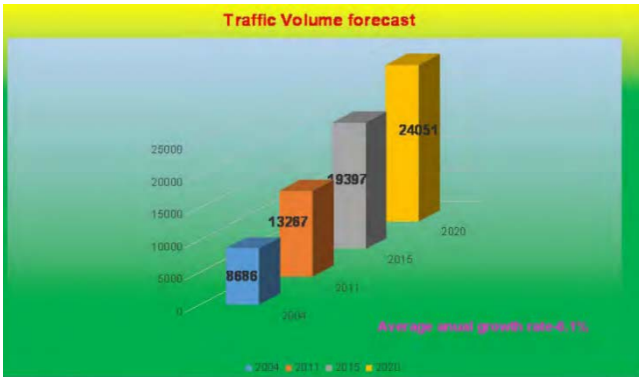

Figure 3-7: Traffic volume forecast for Rahshahi City (Source: Haque, 2014).

From the above chart, it is clearly shown that the traffic volume in 2020 year will create a great hamper on the existing condition of traffic circulation. The increasing traffic

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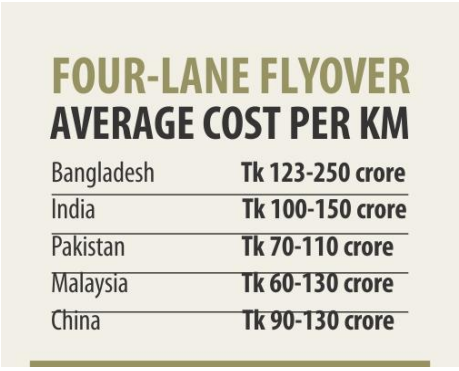
volume helps to create a great burden on the allocated road surface of the existing condition. To reduce the further traffic congestion on the road surface it is high time to think about the different modes of transport.

04. PLANNING FOR WATERWAY TRANSPORT

One of the major reasons often stated for investing in the transportation system is to promote economic development. The link between economic development and transportation is founded on the accessibility provided by transportation to the daily social and economic activities in a community.

i. Low maintenance cost:

The water transportation system does not require a higher amount of maintenance than the road infrastructure. As water is a natural resource it remains usable without any further human-induced contamination. So like road infrastructure, it does not have a higher cost to run the system.



(Source: The Daily Star, 2016)

In an article in a renowned newspaper of Bangladesh 'The Daily Star' the cost of constructing a flyover in Bangladesh was shown as costly (The Daily Star 2016). According to the DMTCL report, Bangladesh is constructing a 20.1km long metro rail for $2.7 billion or Tk22,000 crores. On average, per kilometre metro rail construction cost in India is $50-60 million, however, Bangladesh is building the first metro rail project for $135 million per kilometre. The first ever metro rail in Bangladesh is costlier even than a metro rail project in the city of India.

ii. Urban Heat Island Effect:

The river has the effect to reduce the urban heat island effect. A small river can mitigate 1 degree Celsius of temperature when it is more than 20 degrees (E.A. Hathway 2012). In Rajshahi city, most of the vehicles are battery driven. So that this city does not contribute to the urban heat island effect with the vehicle. But with the activity all around the city UHI is generated(Das, 2020; Nuruzzaman, 2015).

iii. Existing Water Body Vs Changes in Water Bodies

The course of Padma River changes is shown below for the last decades. The huge portion of the Padma River course takes to change. The internal waterbodies amount is also decreased with time.

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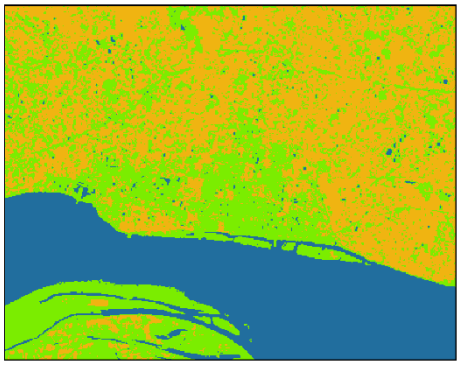

Figure 4-5: (a) Water body in 1996

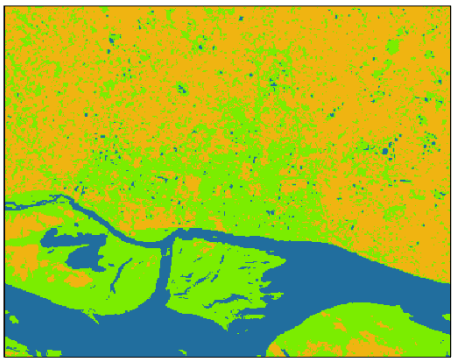

Figure 4-6: (b) Water body in 2006

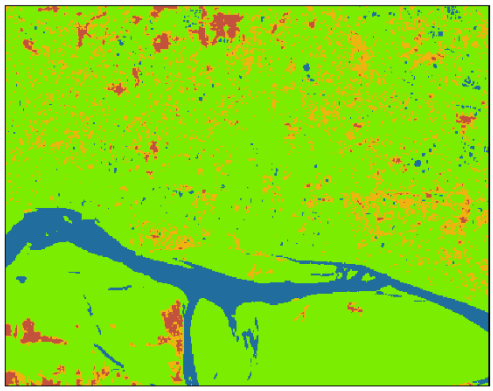

Figure 4-7: (c)Water body in 2021

(Source: Prepared by Authors)

The above three figures are showing the changes in the water body in Rajshahi city. All images are the final output of the water body extraction process from Landsat images which have been prepared in ArcGIS software. For the extraction of water bodies from Landsat images Normal Difference Water Index (NDWI) method is used.

iv. Water bodies change with time duration

The water bodies are decreasing with time. The rate of water bodies and other land uses has been shown below the chart.

Table 4: Water bodies change with time in Rajshahi.

Year	Water Bodies (in Percentages)	Other Land Use (in Percentages)	Total
1996	14.3	85.7	100
2006	11	89	100
2021	8	92	100

(Source: Prepared by Authors, 2021).

v. Water management:

1. Efficient use of water and reuse of the water:

Rajshahi city dwellers should be more concerned about the efficient use of water. For that dwellers might reuse the water they used earlier for their household chores.

2. Enhance the water storage (Ponds, water bodies):

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Water storage such as ponds and other water bodies can produce a great deal of water in water storage.

3. Retain the stormwater:

Stormwater is known as rainwater run over heavy rainfall in general people. This project is mainly constructed depending on the stormwater

vi. Origin-Destination Study for Locating Station Point

To find out the proper location of station point of station the origin-destination survey has been collected for the 30 wards among the Rajshahi city corporation. The following matrix may help to find out the proper location of station point.

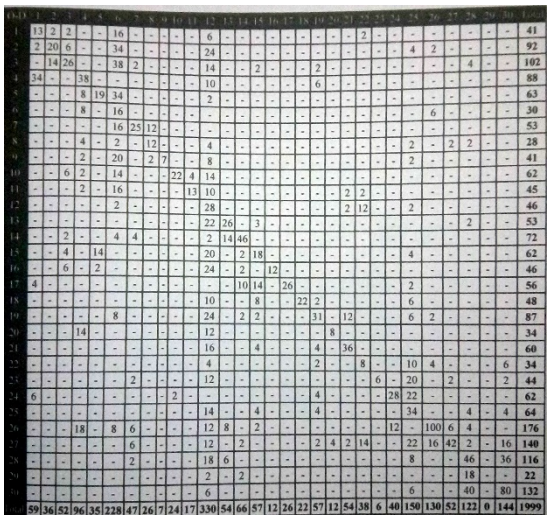

Figure 4-4: Origin-destination survey among the Rajshahi City Corporation Area Source: Unpublished thesis, Dept. of URP; (Zinia & Jahan, 2016).

vii. Functional relationship among the wards

By following the above origin-destination matrix a functional relationship is found. The functional relationship shows the interaction among the wards. Here the functional relationship shows that 26 no. ward creates the highest number of trips among the wards therefore, it is shown in the centre as the primary node. The flow chart also denotes the secondary and minor nodes.

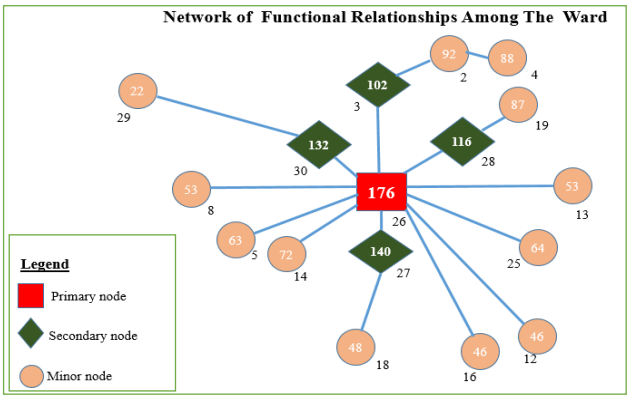

Figure 4-5: Functional relationship among the wards (Source: Prepared by Authors, 2021).

viii. Functional relationship among the wards geographically

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The total findings of the above diagram to find out the primary, secondary and minor nodes of the waterway transport. If the diagram is converted into a geographical location the station point may be found.

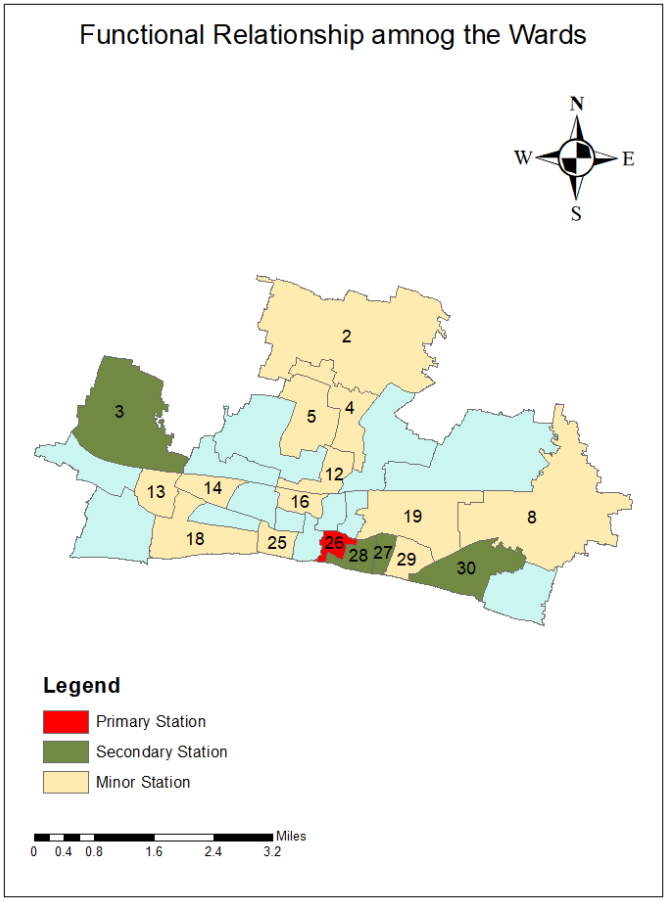

Figure 4-6: Functional relationship among the wards geographically.

(Source: Prepared by Authors, 2021)

Here it is found that 26 no. ward creates the highest number of trips which is denoted as the primary node. 26 no. ward is in the location of *Merchandise*. The cause behind this finding is large numbers of people from *Mehrchandi* come to the city for daily work. The secondary station point of waterway transport is ward no. 3, which is known as *Baharampur*, ward no. 27 (locally known as *Tikapara*), ward no. 28 named *Talaimari* and ward no. 30 named *Mohonprt*. Another point of the waterway transport system denotes the minor node of the map.

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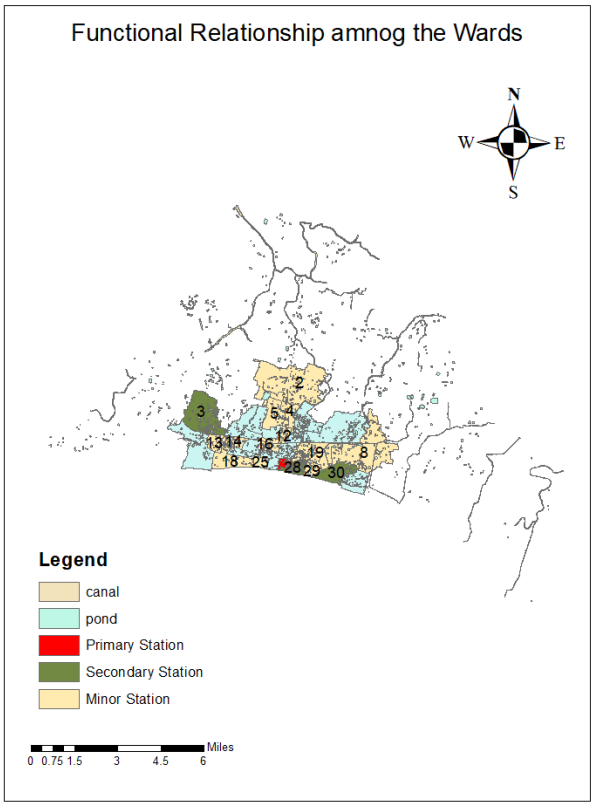

Figure 4-7: Scope for connecting the Functional dependence wards geographically.

(Source: Prepared by Authors, 2021)

ix. Probable Network

The probable route for water transport mode is shown below by joining the internal water bodies and restoring the water surfaces of the study area. The route network also is prioritized the minimum travel distance therefore sometimes it may encourage to excavate the low land and also the unplanned or non-build up area.

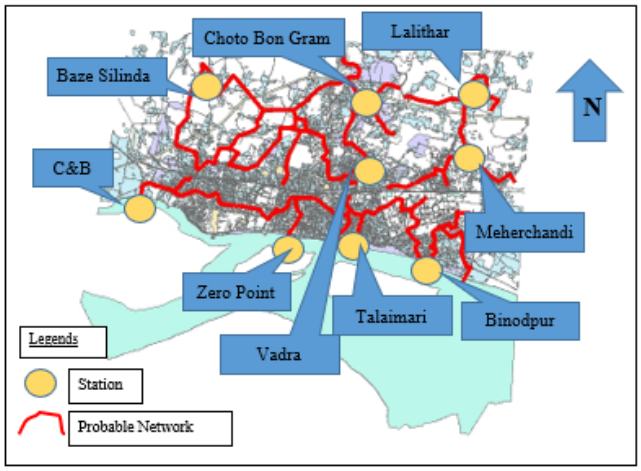

Figure 4-8: Probable Route Network to introduce the Waterway Transport.

(Source: Prepared by Authors, 2021)

x. Environmental Advantages of Waterway Transport

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Water transport has great environmental advantages. At present environmental degradation is the most important issue as it is a threat to the extinction of plant and animal life. Some of the most pervasive and intrusive sources of noise and air pollution are transportation systems.

Water transport, conversely, causes far less air pollution than trucking, and less or comparable amounts, than rail. Cumulatively, it has a relatively minor effect on air quality, consumes much less energy (and as a result, produces less air pollution) per ton-mile of freight carried than either rail or truck.

xi. Economic Advantages of Waterway Transport

Create employment: A new mode of transportation is a gateway to a huge amount of employment. It not only creates employment related to water transportation but creates a new opportunity for the people who are thinking to have a job of their own.

Table 5: Employment in IWT.

Table 4: Employment in IWT

IWT Employers	Employed
Public Sector	
Bangladesh Inland Water Transport Authority	4,000
Bangladesh Inland Water Transport Corporation	5,000
Department of Shipping	60
Private Sector	
Landing Stations	668,000
Inland vessels	75,000
Dockyards	101,000
Country boat and Mechanized country boat	5,500,000
Country boat yard	10,000
Total	6,363,000

Source: *Consultancy Services for development of IWT system in Bangladesh*, by Parvez Ali Anwar Khan

(Source: Consultancy Services for development of IWT system in Bangladesh).

In recent years IWT abbreviated from Inland Water Transport create 6 million job opportunities. The new mode that is considered for Rajshahi city can affect the employment of the city intensely.

xii. Social Advantages

Recreational facilities also help improve a community's image, and socioeconomic status and enhance the area's desirability. Violent crime in urban areas continues to be a concern for Rajshahi. Recreation facilities help reduce crime in a community. Recreation facilities help promote social bonds by uniting families, building cultural tolerance, and supporting individuals with disabilities and seniors.

05. WATERWAY ROUTE PLANNING

Visits to recreational areas and major parks have been one of the fastest-growing travel markets in the country. Designing the waterway route there has been followed by design criteria which have been considered as a place of recreation. This section describes the unique characteristics of transportation planning for recreational communities, with a primary focus on connectivity. The importance of communication with both recreational visitors and with surrounding communities is explained in this section.

i. Design Principles

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To design the route network, the following principles have been followed for sustainable route design.

1. Preservation

In this approach, the available and existing water bodies are preserved. Includes all the policies, strategies, and activities to sustainably manage the natural resource of fresh water, protect the hydrosphere, and meet the current and future human demand.

2. Conservation

The goals of water conservation efforts include:

1) Ensuring the availability of water for future generations where the withdrawal of fresh water from an ecosystem does not exceed its natural replacement rate.
2) Energy conservation as water pumping, delivery and wastewater treatment facilities consume a significant amount of energy. In some regions of the world, over 15% of total electricity consumption is devoted to water management.
3) Habitat conservation where minimizing human water use helps to preserve freshwater habitats for local wildlife and migrating waterfowl, but also water quality.

3. Restoration

This is the process of carrying on alterations and repairs to a waterbody to restore it to its original form, often involving reinstatement of missing or badly damaged parts, so it usually includes replication. As far as possible, efforts are made to replicate the materials and construction techniques of the original in this endeavor.

ii. Route Design

From the origin-destination survey, it is clearly shown that the primary, secondary and minor station locations. In short, it is told that to develop a waterway transportation point the following route should be considered at Rajshahi City.

1. Talaimari to Vodra

To connect Talaimari to Vodra the selected route (shown on the map) is considered. In this way, the maximum water bodies are connected, and further spaces should be excavated. In this way, minimum excavation is required.

Figure 5-1 (a): Probable Route Talaimari to Vodra.

In this route network, the major intersection meets on the Dhaka-Rajshahi highway near RUET. Considering this phenomenon, a design approach has been taken to reduce this problem. The probable route is near to RUET campus. The strength of this route is that there has already a lack near RUET though it has been abandoned without any attention.

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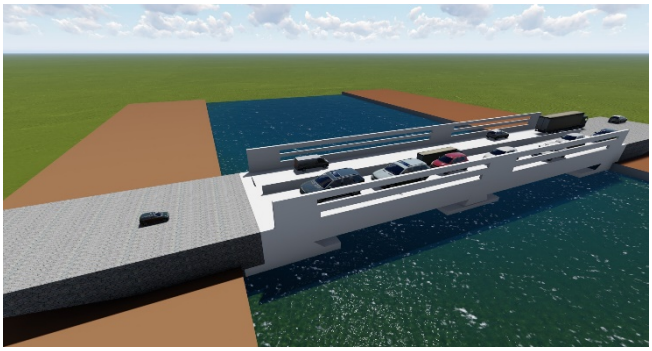

Figure 5-2: Major intersection near RUET (Side View).

2. Station Design:

Probable Route Talaimari to Vodra meets two station points. One station is near Talaimari (near Fultola) and another station will be near Padma Residential Area. This station has already been shown on the map.

These stations are designed to create external recreational facilities. There introduce many activities as well as create a place of recreation.

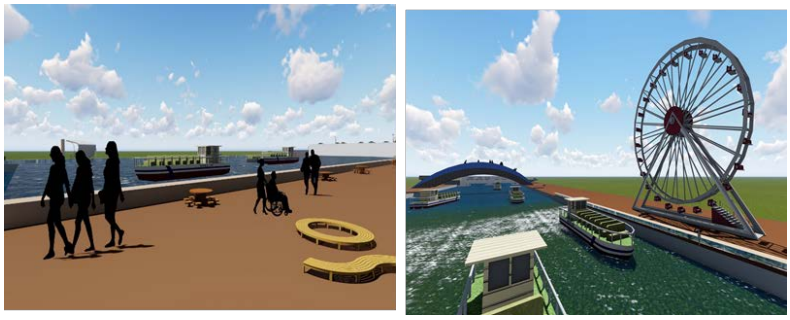

Figure 5-8: (d): Proposed Station Design near *Talaimari (Fultola)*

3. Vodra to Meherchandi

To connect Vodra to Meherchandi the selected route (shown on the map) is considered where soil excavation is less. In this way, the maximum water bodies connect to establish a sustainable network. This route is proposed near a residential area. In this way, there have enough water bodies to establish this network.

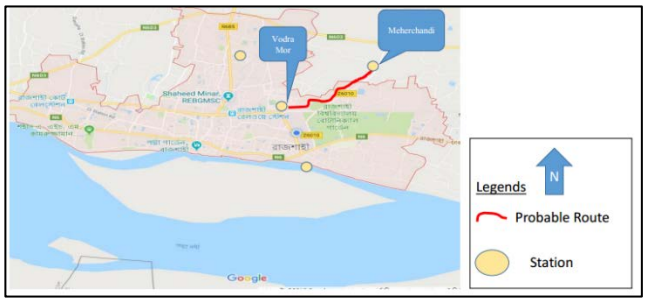

Figure 5-4: Probable Route Vodra to Meherchandi.

(Source: Prepared by Authors, 2021)

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This route network is proposed alongside the residential area. Therefore, there meets many assess road intersections which is an obstacle to designing the network. In this circumstance, the tunnel and small size bridge is provided.

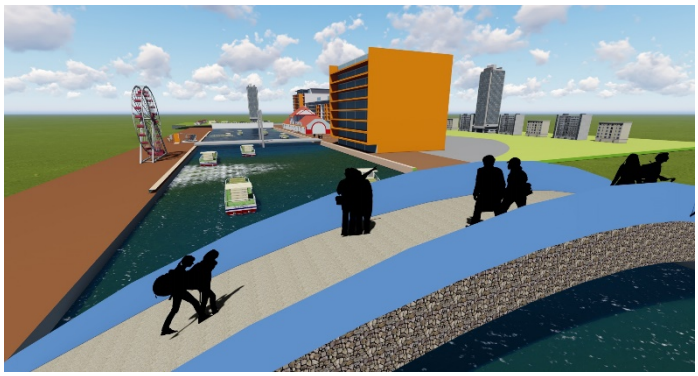

Figure 5-5: Probable Route Vodra to Meherchandi (Intersection point Design) (Source: Prepared by Authors, 2021).

4. Vodra to Chotobongram

By designing the approach, the probable network is shown to minimize the cost. In this way, the maximum water bodies connect to establish a sustainable network.

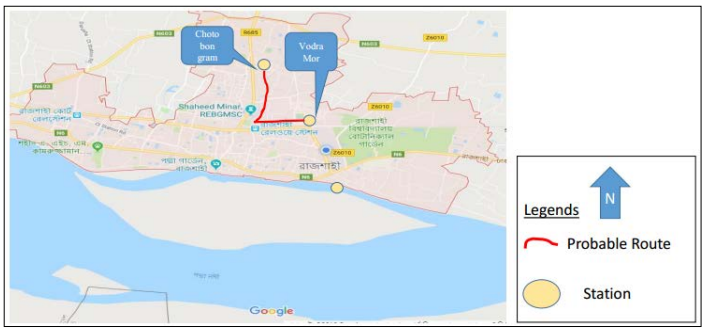

Figure 5-6: Probable Route Vodra to Chotobongram (Source: Prepared by Authors, 2021).

5. Talaimari Mor to Zero Point

Talaimari Mor and *Zero Point* are two very important road intersections in RCC. *Talaimari Mor gives access to Vodra and Shaheb Bazar.* RUET, the important educational institution of Rajshahi is located beside *Talaimari Mor*. *Zero Point* is located in the city's core commercial area. So, both intersection points are very important for the transportation system of RCC.

To have access from *Talaimari Mor* to *Zero Point* via water transport, the easiest route will be the Padma River. There will be two water taxi terminals adjacent to *Talaimari mor* and *Zero Point*. The water transport route between these two road intersection points will reduce the pressure on the surface transportation system. This will also make the journey safer and cheaper for citizens.

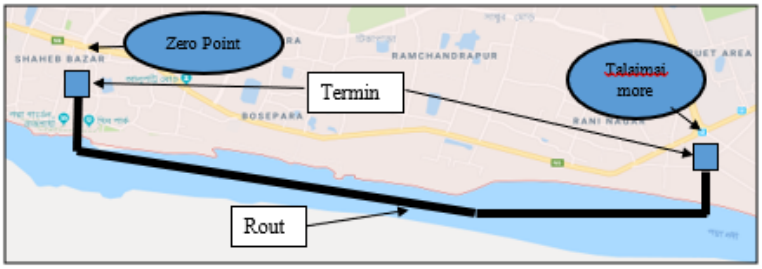

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Figure 5-7: Probable Route *Talaimari Mor to Zero* Point (Source: Prepared by Authors,2021).

Figure 5-8: Proposed Station Design near Talaimari (Source: Prepared by Authors,2021).

6. Zero Point to C&B Mor

C&B Mor is another important road intersection of RCC. C&B *Mor* gives direct access to some important administrative institutions and hospitals. So, to have access to C&B *Mor* from Zero Point Padma river would be the best favourable route. A terminal adjacent to *Simla* Park is proposed. So that the citizens will have direct access to recreational facilities and administrative institutions as well as C&B Mor.

Figure 5-9: Probable Route *Zero Point* to C&B *Mor* (Source: Prepared by Authors, 2021).

7. Connecting Three Town Center

In the master plan of Rajshahi City Corporation, three town centres are proposed for future development and the expansion of the city. This study is aimed at the planning of water transport as a future mode of transportation. So, these three town centres should be of concern to this study. The three town centres are named *Baze Silinda*, *Choto Bon Gram* and *Lalitha*. These three centres are connected through an existing pond and *beel* as the excavation of a new canal is very expensive.

According to the master plan Rajshahi, there have been proposed three town centres for further expansion.

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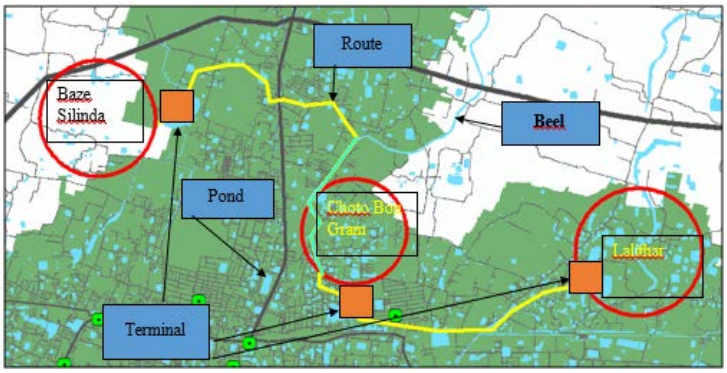

Figure 5-10: Probable Route Connecting Three Town Center (Source: Prepared by Authors,2021).

iii. Others Consideration

To establish a sustainable network, the following things have been considered. The discussion about those factors is given below

1. Safety

To ensure safety the route near residential provided a barrier so that the children and old people can be safe from the sinking or any other accident.

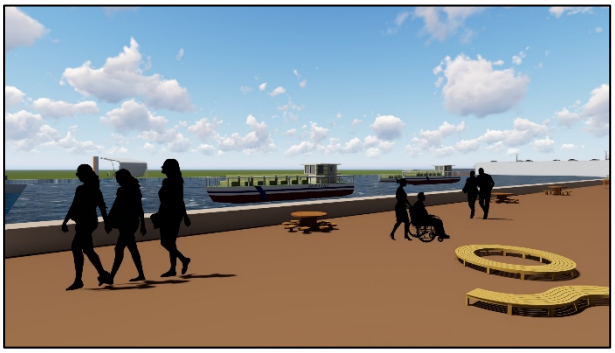

Figure 5-11: Ensure safety measures provide a barrier.

(Source: Prepared by Authors,2021)

2. Recreation Facilities

To create a place of recreation there have provided many recreational zones and created activity centres. Therefore, many people get together in these places.

Figure 5-12: Proposed recreational zone.

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(Source: Prepared by Authors, 2021)

Hatirjheel Project: Yet another success story of Dhaka, by following this project Rajshahi city can develop a similar type of project that can create recreational facilities and outdoor activities.

There has enough possibility for creating an outdoor recreational zone with proper landscape design.

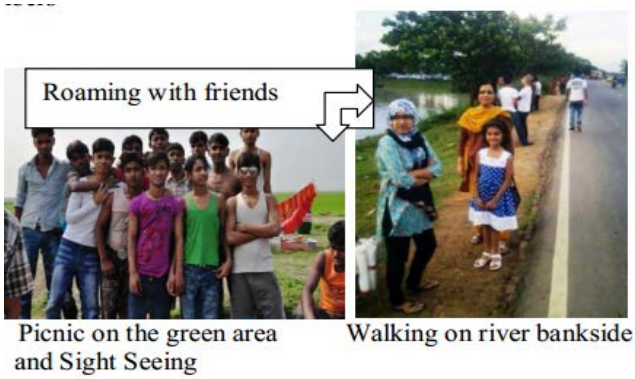

Figure 5-13: Proposed recreational zone.

(Source: Field Survey, 2021)

06. CONCLUSION & WAY FORWARD

This chapter describes key components of the transportation planning process and presents tools that transportation planners can use to provide information for those who make decisions. Any transportation planning process consists of multiple steps, with the scope and scale of each step depending on the context of a planning study.

Transportation planning depends on collecting and analyzing data, both on the transportation system and system users. Understanding the basic characteristics of urban transportation systems is fundamental to discerning the challenges these systems face today and will likely face in the future. Similarly, knowing the underlying variables that influence urban travel, such as population characteristics and resulting travel patterns, is a foundation for analyzing the likely consequences of strategies to influence travel behavior. The rest of this chapter describes key components of demand forecasting for transportation planning. Relevant tools and equations have been used for getting the proper scenario of the study area.

The connection between land use and transportation planning has been a fundamental relationship that has guided both the process of planning as well as the technical tools planners and engineers rely on. In recent years, however, land-use and urban design strategies have become important components of the tools that planners and elected officials can use to enhance community accessibility and mobility. This chapter has provided an overview of the overall factor for introducing new transport. With the help of secondary sources, this chapter also gives the idea about the path of a waterway.

References

1. Alam. M. (2014). Malaysia's Proactive Economic Zone Regime as a Model to emulate for the success of Bangladesh Economic Zone Scheme, The Journal of Developing Areas, Vols. Vol. 48, no. 2, pp. pp 399-407, Spring 2014.
2. Bang, K.-L., and Carlsson, A. (1996). *Traffic Study for Malaysia*. Highway Planning Unit, Ministry of Public Works, Kuala Lumpur, Malaysia.
3. Bang, K.-L., and Hai-Long, G. (1999). Traffic performance modelling for intersections on interurban and township roads in PRC. Proc., *Third Conference of the Eastern Asia Society for Transportation Studies (EASTS),* Taipei, Taiwan, September 1999.
4. BBS. (2011) Population & Housing Census 2011. Available at: https://www.bbs.gov.bd/pageWebManuContent.aspx?MenuKey=337 [Accessed on 29 October 2021]

5. Das, A., Salan, S. A., Zubayer, M. S. (2019). Regional Competitiveness Analysis: A Prime Focus on Region's Spatio-Functional Gap and Median Population Threshold Assessment", International Conference on Urban and Regional Planning, Organized by Bangladesh Institute of Planners (BIP), Dhaka, Bangladesh, 05-06 October, 2019, PP. 541-549.
6. Das, A. (2020). Low Carbon Growth, Climate Change and Sustainable Development Nexus: The Tale of Hong Kong, Journal of Environmental Engineering and Its Scope, Vol. 2(3), pp. 1–10.

DOI: http://doi.org/10.5281/zenodo.3598294

7. E.A. Hathway, S. S. (2012). The interaction of rivers and urban form in mitigating the Urban Heat Island effect: A UK case study. (313).
8. Faisal, A, A., Akter, A., Chowdhury, N., Das, A., F, A, Zinia. (2020). Dependency of Urban People on Private Motorized Vehicles: A Critical Measurement in Bangladesh, Journal of Geographical Studies, 3 (1), pp. 24-35.
9. Glasson, J. (1978). An introduction to regional planning: concepts, theory and practice. Hutchinson Educational.
10. Haque, A. (2014). Transport situation in Rajshahi. Prepared for United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP).
11. Hasan, M., Ganguly, B.,Chowdhury, S. R., Rahman, G. A., Sami,S., Sultana, J., Kafy, A., Das, A. (2018). Analyzing the Impact of Land Use and Roadside Informal Activity on Transportation System: A Case Study in Rajshahi City Corporation, Bangladesh, International Journal of Transportation Engineering and Traffic System, Vol. 04, No. 02, 2018, pp.18-31, eISSN 2456-2343.
12. Hasan, M. M., Alam, A., Mim, A. M., & Das, A. (2020). Identifying User Satisfaction Level of Road services: A Focus on Rajshahi City Bypass Road, Bangladesh, Transportation Research Procedia, 48, pp. 3132-3152.
13. Leutzbach, W. (1968). Testing the applicability of the theory of continuity on traffic flow after bottlenecks. KarlruheTechnische Hockschule, International Symposium– Traffic Flow.
14. Mamun, S. (2021). Why is metro rail construction costlier in Bangladesh? *Dhaka Tribune*.
15. McClelland, A., & Macdonald, F. (1998). *The Social Consequences of Unemployment*.
16. Morgan, N. (n.d.). The Social Advantage. Retrieved from https://www.careerplug.com/the-social-advantage/
17. Nuruzzaman, M. (2015). Urban Heat Island: Causes, Effects and Mitigation Measures - A Review. *International Journal of Environmental Monitoring and Analysis*.
18. Nahar, A., Chakma, R., Uddin, N., Das, A. (2018).Existing Situation of on Street Parking and Impacts on Effective Carriageway Width and V/C Ratio: A Case Study of Rajshahi City Corporation Area, International Journal of Science, Technology and Society, Volume 6, No. 2, 2018, pp. 33-42. doi: 10.11648/j.ijsts.20180602.12
19. Rajshahi Development Authority. http://rda.rajshahidiv.gov.bd/en [Accessed on 29 October 2021].
20. Reader, C. (2017, September 26). What Are the Advantages of Full Employment? Retrieved November 01, 2021, from https://bizfluent.com/info-7743400-advantages-full-employment.html
21. Roads and Highway Survey. (2013). The Roads Manage and Measurement System. Retrieved from http://www.rhd.gov.bd/RMMS
22. Rooney Katharine, Senior Writer, Formative Content, World Economic Forum, *"Here's what you need to know about Bangladesh's rocketing economy."* 19 November 2019, https://www.weforum.org/agenda/2019/11/bangladesh-gdp-economy-asia/ Retrieved on Feb 1, 2021.
23. Schwarzenegger, A., Chrisman, M., & Coleman, R. (2005). An Element of the California Outdoor Recreation Planning Program. *The Health and Social Benefits of Recreation*.
24. Todosiev, E.P., and L.C. Barbosa (1964). "A proposed model for the Driver-Vehicle System." Traffic Engineering 34, 17-20.
25. Tusher, H. J. (2016). Flyover Puzzle for Bangladesh: Costliest in South Asia. *The Daily Star*.