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Research Article

Study on the Water Transport System in the Northern Region of Dhaka; the Capital City of Bangladesh

Md. Mashiur RAHAMAN[1], Nayeb Md. Golam ZAKARİA[2], Md. Wahidur RAHMAN[3]*

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Abstract

All the megacities in the world suffer from traffic jams at a certain period of the day but in the case of Dhaka with the addition of traffic jams, it also faces total traffic chaos and mismanagement. At different times, the Government of Bangladesh took different initiatives to mitigate this issue but the result was futile. Now various megaprojects are underway to reduce the burden on the roads. The northern region of Dhaka city is a focal point of various megaprojects of the government to diversify the accommodation for the city dwellers which will lead to the requirement of various modes of transportation. Mostly unused waterways in and around the northern region can play a significant role here to diversify the transportations. There are ample opportunities to develop a waterways network. The study aims at the development of a sustainable water transport system for the northern region of Dhaka city based on questionnaire surveys on total traffic movement hourly variation, movement during weekdays and weekends, physical surveys on the proposed route, etc. A steel body waterbus has been proposed for this route and it has been found that the proposed waterbus can ensure the movement of substantial portions of the people along this region and its surroundings without any hassle and traffic jam. The development of the water transport network will ensure affordable journey in the Northern Region of Dhaka city.

1. Introduction

Rapid and ongoing urbanization in Bangladeş has resulted in an extreme level of traffic congestions. Now, it is the most intolerable and burning issue for the country. This level of traffic congestion is hampering the economic growth and development of the country. According to research, the average speed of vehicles in Dhaka city has slowed down to only 4.5 kilometers per hour now from 21 kilometers per hour only in a decade (Saif, 2020). The city's traffic congestion eats up to 5 million man-hours every day. In another research, the annual loss due to traffic jams is estimated between Tk. 200 billion (1 USD=85.00 Tk.) and Tk. 370 billion and the average loss stands at Tk .370 billion a year (Correspondent, 2018). In the northern region of Dhaka city, several government and private planned townships are now either being under construction or at the planning phase to reduce the pressure of population in Dhaka city by creating opportunities for residential accommodation. "Purbachal new Town Project" is the biggest planned township among them, comprising the area of 6150 acres located in the north-eastern side of Dhaka (Rajuk, 2020). Now, residents of these townships still have to travel to the center of Dhaka on daily basis for different purposes, which will cause a ripple effect on the already overwhelmed road transportation system. The government undertook different policies to address this issue. One of them is "Mass Rapid Transport System (MRT)", work on MRT LINE 1 from Hazrat Shahjalal International Airport to Kamalapur Railway Station has already been started which will connect Purbachol with Notun Bazar too (Byron and Adhikary, 2019). Now, the northern region of Dhaka city also has a vast network of waterways which to this day still remains mostly unused for public transportation.

[1] Bangladesh University of Engineering and Technology, , Dhaka, Bangladesh.
* Sorumlu Yazar/Corresponding Author : Md. Mashiur RAHAMAN, mashiurrahaman@name.buet.ac.bd.
[2] Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.
[3] Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.

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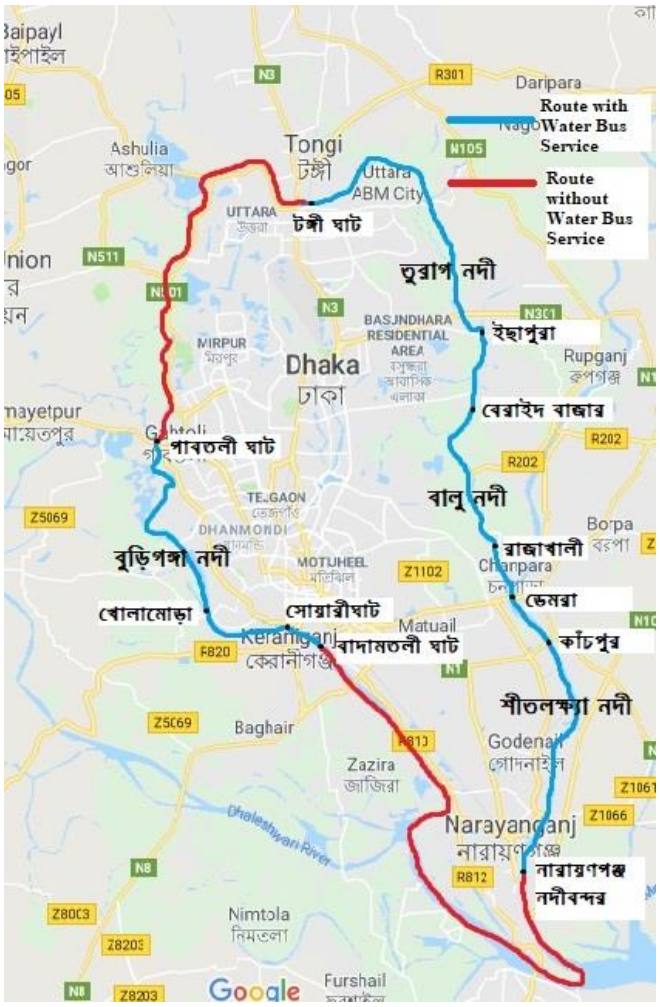
That is why with proper planning, by building water transportation systems in these untapped waterways integrated with already existing public transportation systems can substantially improve the traffic condition in this region.

The city of Dhaka has a unique advantage of encircling the river Buriganga, Turag, Tongi, Balu, Sitalakhya, and Dhaleswari covering 110km shown in Figure 1. They have been playing a significant role in the carriage of goods and passengers particularly on the south, southeast, northeast, and west belt of the city. The water route from Munshiganj via Fatulla to Sadarghat and further to Mirpur is operable for carrying passengers and goods by various types of vessels motor launches, engine boats, and country boats. These circular waterways have a big potential to use it for the movement of goods and passengers. Unfortunately despite having huge potential, until now it is not possible to utilize it fully. A rather very limited portion of it is capacity is used now. The circulating waterways of Dhaka city are also linked with many khals/canals along with a few well-recognized lakes and water bodies (Gulshan, Banani, Baridhara, Moghbazar, and Dhanmondi, etc.). Historically, these khals and water bodies seem to have good transport links with the peripheral river contributing to the attractive environmental features of the city. But since the late 1940s with the rapid expansion of the city, ever-growing population, accelerated housing and business growth there had been a continuous tendency to infill the water bodies and khals for building structures, roads, and sewerage systems resulting in the complete or partial closure of almost all the khals and water bodies and today these intra cities khals (water bodies) hardly contribute anything to the transport to the transport network or environment, rather cause environmental pollution. The only surviving 6/7 canals and 4/5 water bodies are also in the grip of encroachment of the builders and developers due to the absence of well-defined policy and plan for city development and strong commitment for implementation of the plans and policies.

Figure 1. Current Water Transport Routes with Water Bus service in Dhaka City



The present study is focused on studying a route on the northern side of Dhaka. The name of the route is the Rampura-Khilgaon-Uttara route and it has been used in recent times for the movement of goods. It has not been utilized for passenger transportation in recent times. No significant research has been done in this particular route regarding the implementation of a water transportation system. Due to the recent development of housing projects,

many people are living in this area and they need to move to different parts of the city every day. So, the proposed route could be used as an alternate route for not only passengers but also for goods.

2. Rationale

Though the Rampura-Khilgaon-Uttara route is a complete waterway, it has not been utilized for passenger transportation in recent times. No significant research has been done in this particular route regarding the implementation of a water transportation system.

Proposed Rampura Bridge- Khilgaon - Uttara waterway includes a significant number of residential housing projects on both sides. Most of the housing projects do not have the facilities of continuous bus services from Rampura Bridge and Khilgaon.

Banasree and Aftabnagar site right near to Rampura canal portion (Rampura Bridge- Khilgaon Trimohini). They are one of the most populous regions of Dhaka city. Along the waterway, at a distance of about 10 Kilometers from Rampura Bridge 'Ruposhi Bangla Model Town' and 'Kaptotakkha Green City' housing projects sit right next to the Balu River. Traveling to these projects will take no longer than 35 minutes with the proposed waterbus at a speed of 10 Knots from Rampura Bridge but now at this moment, they have no continuous roadway transportation mode which causes both wastes of time and money. It requires almost 1 hour and 20 minutes to reach these projects through the shortest available roadway transportation modes. Right next to them at a distance of 13 Kilometers from Rampura Bridge, there is Beraid Boat Ghat. Beraid is also a densely populated area. No continuous bus service is available between these two points either. Using 100 feet Madani Avenue Road is the fastest route possible, it takes more than 50 minutes at usual traffic conditions. But using a waterbus will take about 40 minutes. Anondo Police Housing Society is located 16 kilometers apart from Rampura Bridge through the waterway. It will take around 55 minutes to reach the 300 ft road by waterway and an additional 0.5 Kilometer has to be traveled through another transportation mode to arrive at the destination while in roadways, it requires more than 1 hour and 30 minutes via Progoti Sarani - Debogram Road - Purbachal Express Highway.

Using a waterbus, it will take around 1 hour to reach Balu Bridge of Purbachal Express Highway. From this point, it will take another 25 minutes to reach Bashundhara Residential Area located next to Beraid. Through road transportation network it will take 30 minutes to reach Bashundhara Residential Area from Rampura Bridge but on the other hand from Khilgaon Trimohini the distance of Balu Bridge is around 13 Kilometers along the waterway but using road transportation from Khilgaon to reach Bashundhara Residential Area via Bir Uttam Rafiqul Islam Avenue and Madani Avenue will take 1 hour and 20 minutes at usual traffic condition, which makes the waterway more feasible from Khilgaon region.

Purbachal Residential Model Town is the biggest planned township in Bangladesh. The project area is located in between the Shitalakhya and the Balu River at Rupgonj thana of Narayanganj District and Kaligonj Thana of Gazipur District, in the northeastern side of Dhaka. From Balu Bridge of Purbachal Express Highway, it will take 20 minutes to reach Purbachal Residential Model Town and with roadway transportation, it does not have any continuous bus service and to reach the location via Progoti Sarani - Debogram Road - Purbachal Express Highway it will take no less than 1 hour and 30 minutes at usual traffic condition and reaching the location from Khilgaon will take much longer time but using waterway it will take even less amount of time than of traveling from Rampura Bridge.

Tongi is a thana (police station) within the Gazipur Sadar Upazila along with Joydebpur and is located immediately north of Dhaka. Many of the people who live in Tongi commute to Dhaka each day, mainly by bus. From Rampura Bridge it is located at a distance of around 27 Kilometers along the waterway and will take almost 1 hour and 30 minutes to reach the destination using waterbus whereas from Khilgaon it will take around 1 hour and 10 minutes. Continuous bus services are available in this route and it takes around 1 hour and 30 minutes from Rampura Bridge but from Khilgaon it takes almost 2 hours to 2 hours and 15 minutes at normal traffic conditions, which makes waterbus a feasible alternative to the bus.

The project of Rupayan City Uttara is the country's first mega gated community and is located at the end of Sonargaon Janapath, Uttara. This is also at the ending point of the proposed waterway at a distance of around 28.5 Kilometers from Rampura Bridge along the waterway and it will take 1 hour and 35 minutes via waterbus and additional 10 minutes via road transportation medium to reach the project, from Khilgaon Trimohini it will take around 1 hour and 10 minutes. Whereas in case of road transportation via Bir Uttam Rafiqul Islam Avenue -

Progati Sarani Road - Noyanogor Road it takes 1 hour and 30 minutes at average traffic condition and from Khilgaon region it takes around 2 hours to reach the project.

From the above discussion, it is conspicuous that these developing projects along the proposed waterway can be well integrated and interconnectivity can be more time-efficient with the development of a waterway transportation system. Waterway transportation might be marginally costlier than the road transportation system but the time efficiency it has over the road transportation system makes it a feasible alternative. Additionally, it is immutable to any traffic jam which frequently plagues the roadway transportation network at that situation even the above-mentioned times look like a distant goal. It will also reduce the burden from the existing networks and will work as a supplementary medium to better integrate the different locations and increase their efficiency.

3. Methodology

This research work reviews the overall transport scenario of the northern region of Dhaka city especially the Rampura-Khilgaon-Uttara area. The water bodies in the periphery of this particular part of the city have been examined along with the existing water transport activities going on in these waterways. This study includes data collection from various sources such as

i) Questionnaire survey on the movement of passengers in the routes identified
ii) Survey to understand the expectation and demand of the potential passengers on the character and quality of service
iii) Physical survey of the routes to identify the actual scenario with present status especially for the route starting from Rampura Bridge to Balu river junction
iv) Data collection from secondary sources such as earlier study reports, data, information, and statistics from BIWTA regarding particulars of the route from Balu river junction to Uttara.

The questionnaire-based survey has not only considered the total traffic movement but also the hourly variation, movement during weekends, etc. have been assessed.

Based on the data, information, statistics, opinions gathered during the survey, outline design of the various alternative crafts has been prepared. The various limitations such as draft restriction, maneuvering constraints, etc., have been considered in this study. The speed requirement has also been determined. The procurement cost of the vessels has been estimated. The operating cost, repair and maintenance cost, financial costs, and other costs have also been estimated. These data, information, and estimated figures have been used to perform an economic analysis of the alternative vessels operating in the routes in terms of IRR, NPV, B/C ratio.

3.1 Survey

3.1.1 Route and Particulars

This specific route stretches from Rampura Bridge to Khilgaon to Uttara (Sumiya et. Al., 2018). It connects some of the busiest transportation hubs in the Northern Region of Dhaka city. Detailed particulars at several points along the waterway according to several physical surveys and hydrographic charts collected from the BIWTA are mentioned in Table 1. In Figure 2, the complete route is shown, an orange line indicating the waterway whereas a blue sailing symbol shows all the proposed stoppages along the waterway.

3.1.2 Existing facilities and present scenario of public transport

Public buses can carry about 40 passengers on average. Approximately 200 buses depart for Uttara per hour from Khilgaon and Rampura with a combined maximum capacity of carrying approximately 136000 passengers per day. At 70% of overall capacity, 95200 passengers travel daily. As all the passengers do not travel the whole roadway, it is considered in present analysis that an average of 25% of passengers travels for the region concerned which amounts to approximately 23800 passengers per day from Khilgaon to Uttara. With a fleet of 25 waterbuses (each one having a capacity of 40 passengers), 4000 passengers (approximately 17%) can be diverted at maximum capacity.

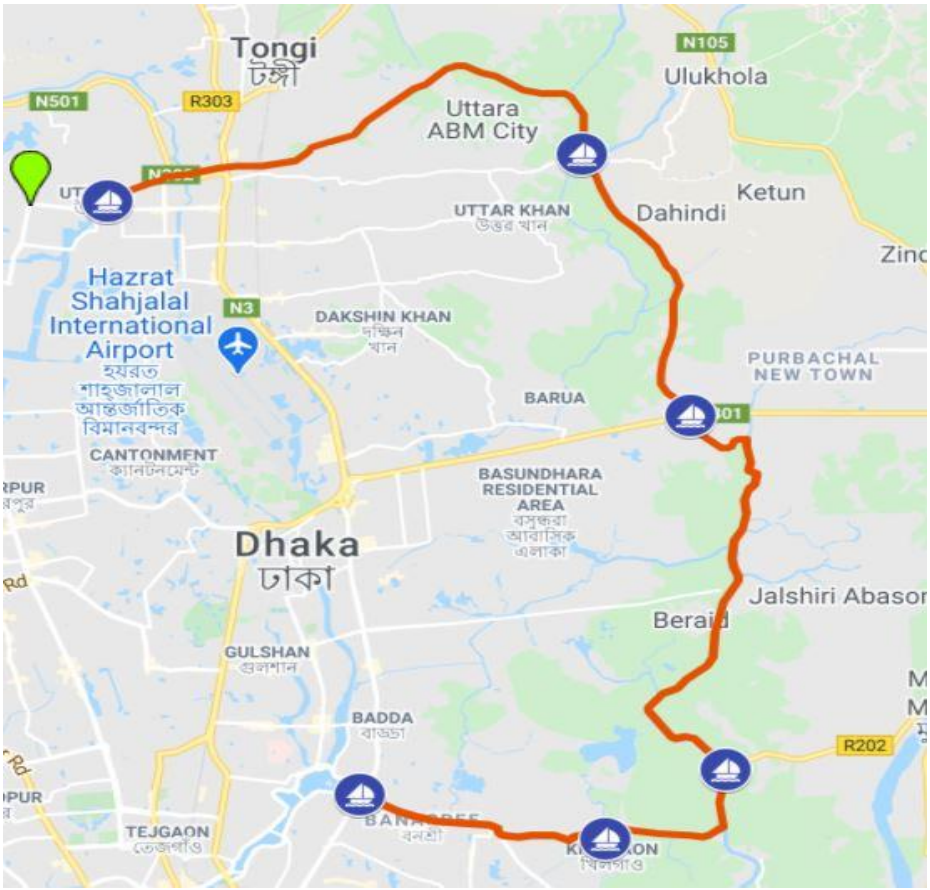
At present, access through road vehicles (public and private) is the only mode of transport for the passengers moving in and out of the Rampura-Khilgaon-Uttara area. Local bus service (Great Turag), Counter bus service (Raida, Anabil, Victor Classic, Asmani, Akash, etc.) and Air-Conditioned bus service (Iqbal, Green Dhaka) are available as common public transportation whereas CNG, Ridesharing apps (UBER, PATHAO, OBHAI, etc.) are there for personal use.

In the case of sitting and air-conditioned service, at peak hours (8-10 A.M.,5-8 P.M.) it takes around two hours to reach Uttara from Khilgaon whereas at off-peak hours it takes around one hour and fifteen minutes. In the case of local bus service, at peak hours (8-10 A.M.,5-8 P.M.) it takes around three hours to reach Uttara from Khilgaon and at the off-peak hour, it takes around two hours.

Table 1. Detailed locations and particulars of the selected route.

Selected Route	Different Segments	Total Length [km]	Breadth [m]	Depth [m]
Rampura Bridge-Khilgaon-Uttara	Rampura Bridge to Trimohini. (Hydrographic Chart unavailable)	4.40	Highest – 24.39 Lowest – 7.32	2.44-3.05 in August 1.52-2.13 in December
	Trimohini to Balu river junction. (Hydrographic Chart unavailable)	2.20	Highest –34.76 Lowest – 9.33	3.66-4.27 in August, 2.44-2.74 ft in December.
	Balu river (UptoKayetpara)	1.20	Highest – 60.98 Lowest – 54.57	3.96-5.49
	Balu river (Kayetpara to Ichapura)	8.00	Highest – 64.33 Lowest – 56.40	4.27-5.49
	Turag River	0.012	Highest – 57.93 Lowest – 39.63	3.66-4.57

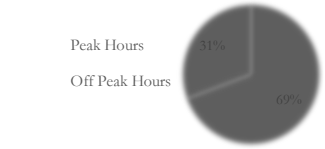
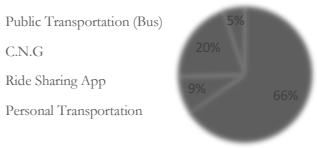
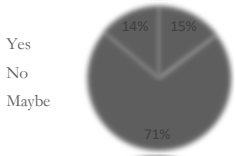
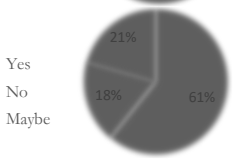
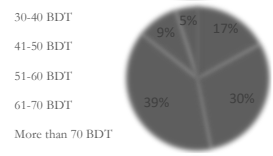
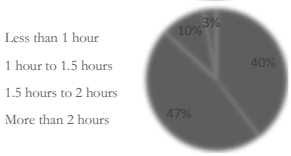
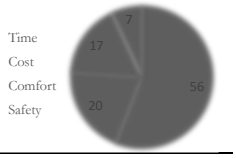
Figure 2. Selected Route.



3.1.3 Passengers' survey

According to a questionnaire-based survey by present authors on 100 randomly selected passengers, 66% of the respondents use public transportation systems on regular basis and 61% of the respondents will consider using waterbus in this route if properly implemented. A significant percentage of the passengers in this route can be diverted by ensuring less travel time with almost similar cost. A detailed parameters considered for this questionnaire-based survey with survey results are shown in Table 2.

Table 2. Detailed locations and particulars of the selected route.

Sl. No.	Parameters	Survey Results
1	Travel Time	
2	Mode of Transport	
3	Satisfaction with current facilities	
4	Consideration of Waterbus	
5	Expected Cost to be incurred	
6	Expected Time to travel	
7	Priority	

4 Design criteria for selecting particulars and speed of the waterbus

The displacement type monohull craft is considered in the present study. This is one of the oldest types, the simple design, and technology of building such type vessel is well known. It can also be constructed in places other than conventional shipyards. Hull form and configuration have been designed based on minimum resistance and low wash for its operating speed. The craft possesses good stability which will provide a fear-free, comfortable ride. It should have good maneuverability and be capable of negotiating sharp bends as well as obstacles quickly and efficiently so that the craft can be operated in confined and/or congested areas also. The boat is designed to run at a moderate 10-knot speed to avoid huge waves which may cause high bank erosion in narrow canals and rivers and may also cause damage to flora and fauna.

The capacity of the waterbus is kept same like average passengers no. i.e., 40 were found from the survey. For the fixing principal particulars of the waterbus, passenger comfort is considered and seats are arranged in seven rows wherein each row, there are six seats except the front (bow) row which has four seats and a space equal to 1 m for walking. The breadth of each seat is 0.45m. Then six seats need (6 × 0.45) = 2.7 m space which enables passengers to move comfortably inside the water bus. Allowing other spaces, the breadth of the boat is taken as 4.50 m. The length of each seat is 0.45m and the space between two rows is 0.35 m in the longitudinal direction. So, total seating space = (0.45 × 7) + (0.35 × 6) + 0.9 (wash cabin) + 0.9 (space between front rows and collision bulkhead) = 7.05 m. Steering space is 2.0 m and space for the engine is 2 m. Peak Tank space is 1.8 m. So, the total space required in the longitudinal direction is 12.85 m. Therefore, the length of the ship is taken as 13 m. Since, as per survey data, the minimum depth of the route is 1.5 m, the draft of the boat is taken as 0.80 m.

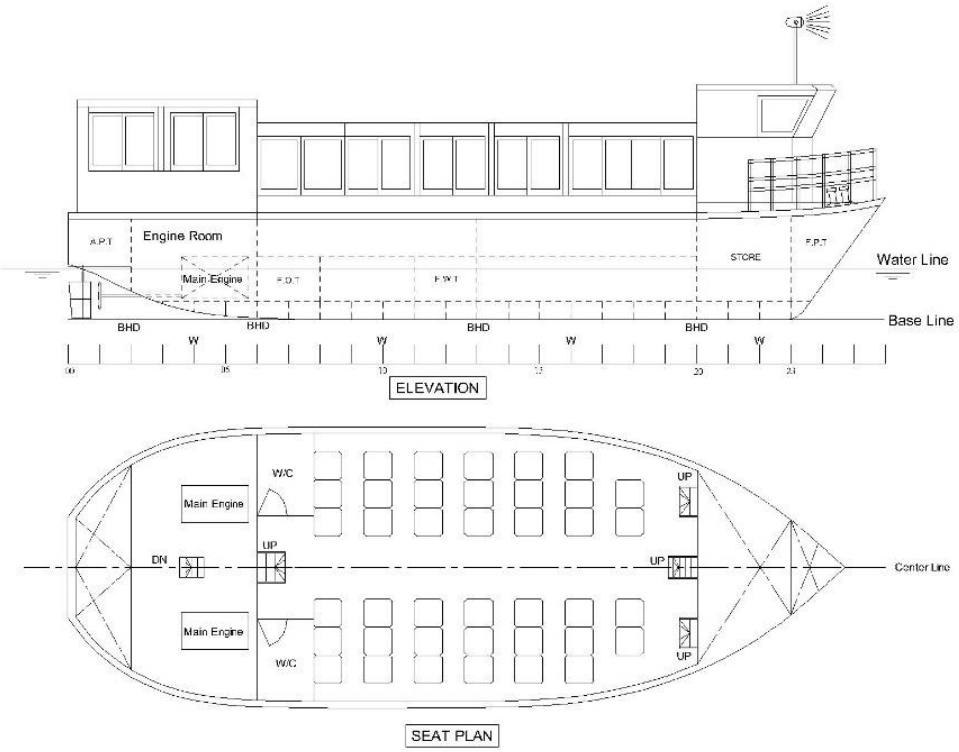
Considering the travel time required by road transports, the safety of the smaller boats and households at the riverbank of the waterways, the average speed is taken to be 10 knots. The travel time required by road transports in the proposed area is about 105 minutes at peak hours. At 10 knots speed, the required travel time by waterbus for a trip is about 90 minutes. The principal particulars of the proposed waterbus are described in Table 3.

Table 3. Principal Particulars of the Waterbus

Particulars	Value	Unit
Length Overall	13.00	Meter
Length Between Perpendiculars	11.95	Meter
Breadth Mld	4.50	Meter
Depth Mld	1.70	Meter
Draft	0.80	Meter
Speed	10	Kn.
Capacity	40	Nos.

Figure 3. shows the General Arrangement (GA) of the waterbus, which is designed for the Rampura Bridge-Khilgaon-Uttara route.

Figure 3. General Arrangement of Waterbus



5 The initial cost for waterbus with economic analysis

5.1 Initial cost

Depending on the hull materials, the construction cost of the waterbus may be varied. In the present study, 3 different hull materials have been considered for the construction of monohull-type water buses. Hull materials considered here are steel, aluminum, and GRP. A market survey for the construction of this waterbus had been conducted to get the total construction cost of the waterbus. It is to be mentioned here that depending upon technological know-how availability cost is varied among the 3 hull materials considered in the present study. Table 4 shows the lightweight, deadweight, and engine power of the boat made of three different hull materials considered in the present study.

Table 4. Lightweight, deadweight, and engine power of the boat made of three different hull materials

Particulars	Hull materials			Unit
	Steel	Aluminum	GRP	
Lightship	19.40	12.50	12.30	Ton.
Deadweight	5.51	5.48	5.48	Ton.
Displacement	24.91	17.98	17.78	Ton.
Draft at full load	0.80	0.54	0.53	Meter
Resistance at 10 Kn.	8.33	6.63	6.59	KN
Engine Power	2 × 63.50	2 × 50.50	2 × 50.00	HP

5.2 Projected economics of operation

To have a quick look into the possible economic performance of the vessels in this particular route, the projected economic analysis has been prepared and presented here. It is to be noted that though the factors affecting the economics as well as the transport demands are the same in a particular route, three vessels of the same size but different hull materials have been considered and the projected economic performances are evaluated separately. However, the following assumptions are common in all cases.

(i) When an individual vessel starts commercial operation, it generally operates at a rate lower than the full capacity. In the present study, it is considered that all vessels operate at 100% load.
(ii) The annual escalation rate is as in Table 5.
(iii) The rates of depreciation of hull and machinery have been assumed to be 2%
(iv) It is also assumed that the operator will acquire the vessels with no down payment (100% on loan).
(v) Ship life is considered 20 years and at the end of project life scrap value is considered 20% of the invested cost.

The following economic indices of performance have been presented for each type of vessel in individual routes

- Internal Rate of Return (IRR)
- Net Present Value (NPV) of the investment based on 10% discount rate and
- The benefit-cost ratio (BCR) is based on a 10% discount rate.

Table 5. Annual rates of escalation

Items	Increase (%)
Hull Maintenance	1.0
Engine and Machinery Maintenance cost	2.0
Fuel and Lubricating oil cost	5.0
Insurance, Registration, Port charges etc.	1.0
Passenger fare	5.0
Crew wages	5.0

The projected economic performances based on the IRR, NPV, and B/C ratio of vessels operating in the route are given in Table 6. The analysis is carried assuming the fare rate is 75 taka per person.

Table 6. Economic performance of Water Taxi for different hull materials

Items	Hull materials of Water Taxi

	Steel	Aluminum	GRP
Length (m)	13.00	13.00	13.00
Breadth(m)	4.50	4.50	4.50
Depth(m)	1.70	1.70	1.70
Vessel cost (Tk.)	38,02,000	54,91,000	55,35,452
Eng. Power (HP)	127	101	100
Capacity (nos)	40	40	40
Speed (Knot)	10	10	10
NPV (Tk.)	2508	12311	13962
BCR	1.035	1.202	1.24
IRR	15.20%	36.94%	39.46%

1 USD = 85.00 Tk.

From the economic analysis, it appears that the Aluminium boat and GRP boat are more economically viable and this is due to less power is required for these two boats and hence operating cost is lower than steel hull water bus. On the other hand, the initial cost of a steel body water bus is less and it is 30% cheaper than an Aluminium boat and GRP boat. Considering the social perspective of Bangladesh, the initial cost usually dominates regarding the choice of the ship. Again from a repair and maintenance point of view steel body water bus is the most favorable one.

6 Conclusion

Different megacities around the world adopted multiple approaches to building an integrated transportation system in and around the city where waterways played a crucial role. At present different projects are underway to develop the connectivity between Dhaka city and its outskirts. In the northern region of Dhaka, these untapped waterways can play a significant role to reduce the burden on-road transportation systems. In this study, a steel body waterbus has been found suitable considering initial cost, repair and performance point of view throughout its life of 20 years. It is expected that this type of waterbus can also provide a feasible alternative to other networks and integrating them can be a potential solution to the unbearable traffic jams this megacity is facing. A proposed designed waterbus can play a key role in mitigating these issues.

7 Limitations and Future Works

This study has been confined to the following aspects:

- Only monohull vessels have been considered in present study. Catamaran vessels may be included in the future to check the performance.
- The speed effects could be considered for evaluating the ship's performance analysis.
- Sensitivity analysis could be done.

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