



PLANNING OF PUBLIC BUS SERVICES USING GIS IN RAJSHAHI CITY, BANGLADESH

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Abstract: Rajshahi, an expanding urban centre in Bangladesh, has no public bus services. The mass transportation system in the city is mainly based on rickshaws and bicycles (50% of total trips). This study reports existing transport system of the city and identifies possible public bus routes and stops using GIS through field survey. The trip generation and distribution behaviour and modal choice behavior of the city dwellers are also analyzed. A total of 35 bus stops were proposed for developing bus service in the city. Three routes have been proposed through analysis of alternatives considering mainly traffic flow characteristics. The service area of each bus stop was identified by generating buffers in a GIS. Then the possible number of trips from each stop to all other stops was estimated. This study reveals that public bus service is feasible for the city from technical, financial and socio-economic perspectives. This study recommends the construction of passenger sheds, terminal facilities and other facilities for the proposed bus services.

Key words: CBD, GIS, behaviour, proximity, transportation

Introduction

In our cities traffic congestion is a common phenomenon. Lack of sufficient, planned, well-managed public bus services is one of the major reasons for traffic congestion. For any populous city, appropriate planning essential because it reduces the travel time and cost of travel of the people and also pressure on road space (Papacostas, 1987). During the sixties, the city experienced rapid physical expansion and increase in population. But the rate of economic growth and the process of industrialization could not keep pace with it. Although Rajshahi was a Divisional Headquarter during British period, partition of India in 1947 and continuous rural-urban migration led to a sudden population boom in city and increased demand for infrastructural facilities and urban amenities. The population of city is about four lakh, which is less than Dhaka, Chittagong and Khulna metropolitan cities. The city has an area of 96.72 sq. km (Anon, 1993). The income level of

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the people in the city is very low in comparison to that in other cities of Bangladesh. Few people own a car and there is no public bus service in the city. Rickshaw is the major public transport in the city. The modes of transport for the city people for their daily trips are mainly rickshaws and bicycles. For daily trips about 33.6% people use rickshaw, 22.2% people use bicycles, 29.1% people move on foot 1% people use baby taxis or tempos and the rest by others means. Because of lack of public bus service rickshaws are increasing day-by-day. Although the number of registered rickshaws is 19,178, around 32,000 rickshaws operate in the city and create traffic congestion on different important roads and junctions, which causes inconvenience to the city dwellers. So, a need is felt to introduce public bus service in the city. Introduction of public bus service will presumably increase local mobility and reduce cost of transport for the general public. The objectives of the study are (i) to study the pattern of traffic and traffic flow characteristics in the city; (ii) to assess whether a public city bus service can improve the transport system in a feasible manner and (iii) to propose a suitable plan for a public bus service for the city.

Materials and Methods

Rajshahi city is located in the northern region of Bangladesh. A total of 100 passengers from three major categories of passengers were surveyed. In addition traffic count, origin and destination, bus and passenger survey, rail passenger survey etc. an extensive household socio-economic data were collected from field survey. The questions, were mainly on the purpose of the trip, mode used for each trip, origin and destination of each trip, time and cost of the trips. The collected data were analyzed in order to find out the major traffic generating areas, travel pattern, present land use pattern and present important routes and their traffic flow characteristics in the city. The major trip generation analysis depends on land use, population and economic activity analysis. Trip distribution analysis estimates the destination of the trips. The number of trips starting in each zone and ending in other zones is analyzed. Modal split analysis is the process of assigning person-trips to available modes of transportation. Traffic assignment constitutes the distributed volumes of trips, by mode, to individual network links (Johnson, 2003). On the basis of the analysis and findings the total transportation system was evaluated for judging whether a public city bus service can improve the transport system in a feasible manner. Demand for public bus service was calculated on the basis of analysis of trip generation, trip distribution, modal split and traffic flow assignment. The procedure identified tentative routes of public bus services and analysed the feasibility of public bus service on these routes. For financial assessment Walters' (1979) approach was followed to calculate total benefit of public bus service. On the basis of the findings and transportation system evaluation, a suitable plan for city bus service was prepared with proper designing and spacing of bus routes and stops.

Results

Existing public transportation, traffic flow characteristics and need for public bus services: The existing public transport system, existing mode of public transport, existing road network, existing traffic flow characteristics and passengers' attitude towards public

bus service have been analyzed. Then, on the basis of these analyses and socio-economic conditions the need for public bus services has been discussed.

Existing public transportation: In absence of public bus service in, rickshaws play a vital role as a public transport Rajshahi city. Most of the city people use rickshaws as the principal mode of their daily transport. Besides, tempos, baby-taxis and buses provide a small share of public transport. The role of different modes of public transport in Rajshahi city are discussed below:

(i) Rickshaws: The cycle rickshaw is by far the most common mode of transport in Rajshahi. There are about 32,000 rickshaws and around 124 rickshaw stands in Rajshahi city. Rickshaw stands are located on different city streets, each providing parking space for 20-25 rickshaws. About 45% of all vehicular passenger trips and a much higher proportion of goods trips are by rickshaw. Infact about 90% of all retail and wholesale food stuff in Rajshahi, are moved by rickshaw. Most of the commuters and students use rickshaw for their daily movement.

(ii) Tempos and baby-taxis: At present only three routes are used for tempo and baby-taxi services in the city of which two routes are used by tempo and one by baby-taxis. The two routes of tempo service are *Noahata to Bindur Moar* and *Shaheb Bazar to Binodpur*. On an average 15-20 tempos operate from *Noahata to Bindur Moar* every day and an average of 12-15 tempos operate from *Shaheb Bazar to Binodpur* every day. The average capacity of a tempo is 10 persons.

(iii) Buses: There is no local public bus service in Rajshahi city. Only some inter-district buses serve a small share of the public transportation demand in the city. Inter-district buses operate each way along 12 routes daily. A certain number of trips of the commuters and students are made by this service.

Existing road network: There is about 375.83 km of road network within Rajshahi city of which about 65% is *pucca*. The major roads are Natore road, Old Natore road, Chapai Nawabganj road, Airport road and Greater road. These roads are mainly the arterial roads of the city. Besides, the Cantonment road, city Bypass road, Court Station road and Ramchandrapur road are the important roads of the city. These roads are managed by four different agencies namely RCC 4.3 km Asphalt Concrete; 204.63 km Bitumen; 85.68 km Herring Bone Bond; 40.34 km WBM, RDA 5.78 km Bitumen, RHD 16.50 km Bitumen and LGED 18.50 km Bitumen. Information on all major roads within RCC area, including those, which provide external links to other major cities were collected. The information includes length, pavement width and condition, condition of shoulder/footpath, the right of way etc. This information was used in determining the capacity of the roads.

Major traffic generating areas: There is an integral relationship between land use and traffic generation. From field observation and land use analysis (Map 1.) it is observed that like any other urban centre, in Rajshahi, the transport modes, commercial areas and work places are the major generators of traffic (Table 1).

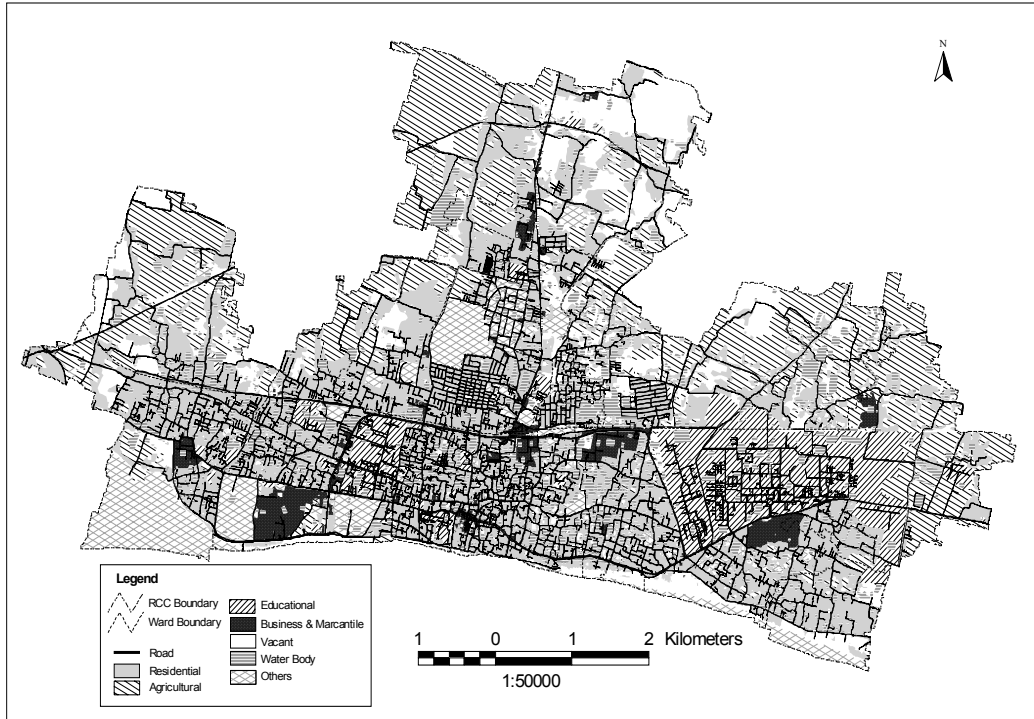
Table 1. The major traffic generating centres within the Rajshahi city.

Location	Characteristics
(i) Shaheb bazar	Main activity area or CBD of Rajshahi city. Wholesale and retail markets of different communities such as textiles, household goods, electronics, cosmetics, crockeries, groceries and fruits are located in this area. About 1087 shops are there in this area

	and about 3117 people work here. Old Natore road has passed through this area.
(ii) Monichattar	Also located on the old Natore road and is very close to Shahab Bazar area. An important nodal point of the city. New market, Malopara, Kadirganj, Rajshahi College are well linked with this area. Different types of shops and commercial centers are located here.
(iii) Rajshahi central bus terminal and Rajshahi railway station	Rajshahi central bus terminal and rail station are located opposite to each other. It is located on the Greater road. All types of inter district bus services and local, mail and inter district trains operate from this place.
(iv) Kadirganj	An important wholesale market in Rajshahi city. Rajshahi Newmarket is also located in this area and is well linked with Shaheb Bazar and Monichattar area.
(v) Binodpur bazar	Close to Rajshahi University and serves as an important commercial centre for this area and its surrounding.
(vi) Laxmipur	Different types of hospitals, Clinics, diagnostic centres are located in this area. People from different parts of the city and from different areas of North Bengal come here for better medical care.
(vii) Rajshahi court	Located at Bhularpur area and on the old Chaipai Nawabgang road. People from different area of Rajshahi district gather here for litigation-related work. Based on the court different activities have grown up in this area. Haragram Bazar is located in this area.
(viii) Barnali moar	An important junction or nodal point where Cantonment road, Hatem Kha road and Greater road meet each other. Some commercial centre and clinics are also located here.
(ix) Bindur moar	An important junction or nodal point where Airport road, Newmarket road and Greater road meet each other. It is very close to Newmarket and central bus terminal.
(x) Shalbagan	This is a big Katcha Bazar of Rajshahi city. It is a big market for different types of vegetables, fishes, fruits etc. People from Upashahar Housing Estate, Sopura Industrial area and Choto Banogram area mainly come here for shopping.
(xi) Talaimari	A very important junction point where Greater road meets Natore road near RUET. Some commercial activities are also generated in this area.
(xii) C&B Moar	An important junction where Greater road meets Natore road near Rajshahi Radio Transmission Center and very close to <i>1 Badh of</i> Padma River which is the major recreation centre of Rajshahi city.

Trip distribution: Trip distribution is the process of distributing trips generated in each zone to all possible destinations. The destination of a major portion of trips is Shaheb Bazar which is the central business district (CBD) of city. Court station, Lakshmipur and Sopura are also important destinations of trips. Based on the information about origin and destination of trips made on the day before the survey, a desire line diagram has been prepared.

Mode of trips: Within RCC area it was found that rickshaws are the most popular mode of transport and about 33.6% of the total population use rickshaw as a mode of transport, followed by walking, while bicycles are also used quite extensively. It has been observed that among all trips 6.5% are made by bus. Bus services are used mainly by the students and by people going out of or coming into the city. Trains are used only by people going out of or coming into the city. The modes of choice for trips made by the people are different in different wards. In Wards 7, 12, 16 and 17 trips made on foot constitute the largest modal share whereas in Wards 10, 13, 20, 22 and 24 the distinction belongs to trips made by rickshaws.



Map 1. Land use information of Rajshahi city.

Purpose of trips: It was found that destination of nearly 69% trips were either home or work place, About 15% were made to school/colleges/universities, 2.8% were made for social/recreational/sports purposes, 2.5% were made for shopping, only 1.3% were made to change travel mode and the rest for other different purposes.

Distance of trips: It has been observed that 17.81% of trips were made within 2-3 km distance and 11.14% were less than a 1 km. Only 7.81% of trips flow within 1.1-2.0 km range, 10.71% of trips were made within 3.1-4.0 km range, 16.40% of trips within 4.1-5.0 km, 8.86% of trips within 5.1-6.0 km, 9.47% of trips within 6.1-7.0 km. distance and about 17.81% of trips went beyond 7 km. distance. Within the area it is found that the distance of trips varies with the mode of trips. It is observed that most trips on foot range within 3 kms, while trips made by tempos and cars/jeeps go above 4 km. distance.

Duration of trips: As Rajshahi is a low density and traffic congestion free area the travel time for the trips were low. About 26.55% of trips take 15-30 minutes and about 73% of the total trips end within 60 minutes. Only 13.48% of total trips took more than 60 minutes.

Traffic flow characteristics: On the basis of land use around that location, traffic flow varies with hours of the day. Depending on the land use and socio-economic characteristics of the city, there can be one or more peak hours in a day. Sometimes this peak period could be more than an hour. For this study the traffic flow of different major roads were counted and converted to PCE value (Table 2). The PCE values of different

modes are Bus/Truck 3, Car/Jeep/Microbus 1, Auto Rickshaw1, Motor Cycle 0.25, Rickshaw/Rickshaw Van 0.50, Bicycle 0.15, Animal Cart/Thela 3 and Tom-tom 1 respectively. The traffic flow in PCE at both peak hour and off peak hour on different major roads of city (Table 2). From the table it is observed that the highest volume of traffic flows from Dhaka Bus Stand to Bindur Moar, the second highest volume of traffic is observed on Bhadra to Dhaka Bus Stand link. Another important analysis undertaken was to determine the traffic composition during peak hour at certain intersections. Depending on the relative importance of the road link, whether it forms part of a regional or local route, and the type of land use around the intersection, traffic composition varies. Rickshaws and bicycles were found to be the most dominating mode of transport in the city. On Bindur Moar-Airport road, rickshaws and bicycles formed 67-72% of the traffic, buses and trucks formed 13-18% of the traffic, and only 8% of the traffic was formed by auto rickshaws and the rest by other modes.

Passenger attitude towards proposed bus services: A survey was conducted to learn about passenger attitude towards a city bus service. About 100 passengers of three major modes were surveyed. From the survey it was observed that about 87% passengers of city thought that there was a necessity for public bus service. About 68% (27 out of 40 passengers) rickshaw passengers opined that if there were public bus service, they would prefer the service to their existing mode. Among the passengers who use bicycle, about 57% (17 out of 30 passengers) thought that if public bus service was introduced they will prefer the service to their existing mode. About 43% (13 out of 30) pedestrians that if public bus services are introduced they would prefer the service to their existing mode. To introduce public bus service waiting time for the service is also a important consideration. It is observed that more than half of the total passengers may wait for the bus for 10 to 20 minutes, 31% passenger may wait for less than 10 minutes, 12% passenger may wait 20-30 minutes and only 2% passenger may wait for the service for more than 30 minutes. From the passenger attitude survey the passengers' willingness to pay for the services was also identified. About 42% passenger are willing to pay up to 1.00 Tk/ km travel, 16% passenger are willing to pay up to 0.50 Tk/ km travel, 36% passenger are willing to pay up to 1.50 Tk/ km travel and only 6 % passenger are willing to pay more than 1.50 Tk/ km travel.

Need for public bus services: Planned and effective public transportation is a major element for city development (Bruton, 1975). Buses are the most prominent public transport in our country and they account for 90% of public transport movement in the world (Anon, 2000). The analysis of the socio-economic condition, population and travel character of the city we can find out a strong logic towards necessity of public bus service that is described below: Being the fourth largest Metropolitan city and a growing urban center of the country there is a large number of daily passengers. At present as there is no city bus service they are traveling by different other modes of transport. From passenger attitude survey it was observed that about 87% passengers think that there is a necessity of public bus service. As the income level of people of the city is low so there is a demand for the cheapest mode. University students in the city mainly depend on the scheduled bus of the university. Public bus service would increase the mobility of the students and other sections of the community. Speed of transport is also another consideration for the choice of mode. From the analysis it is observed that more than 50% of total trips made

go above 4 km which is not very convenient for walking and time consuming on foot or by rickshaw. The people of the fringe area need more money and time to come into the CBD area of the city without a public city bus service. The urban transport system of Rajshahi is dominated by or biased towards non-motorized traffic. Rickshaws the most common form of NMT dominate the system and form more than half of all vehicular person trips. Rickshaws are increasing day by day and creating traffic congestion in the city. If a public bus service is introduced Non Motorized Vehicles (NMV) can be substantially reduced and thus traffic congestion will reduce. Since public bus service is safer, secured and convenient than other modes there is a need for this service in the city. As they have no alternative, people are forced to walk or ride rickshaws. If bus service is introduced it will increase the safety, security and convenience of the people. Besides, if a public bus service is introduced, the increased mobility of the people will increase economic activity. A number of people will find employment in the transport sector, which will also gear up the present level of economic activity. From the analysis of the existing situation of public transportation, traffic and traffic flow characteristics, it is observed that there is a necessity for public bus services in the city and if it is introduced it will provide mobility for work, social and recreational needs of the people.

Discussion

Designing of bus stop's and routes: Designing a transit network involves determination of spacing between routes. For designing of bus routes and stops in any city, analysis of major road links, trip generation, trip distribution and traffic flow assessment are important factors, which should be taken into consideration.

Selection of roads for bus routes: At first all possible roads, which may be used for the proposed bus routes are identified. The major roads are selected for using as future routes. The major roads of Rajshahi city are Natore road, Old Natore road, Chapai Nawabganj road, Airport road and Greater road. The bus routes have been selected on the basis of traffic flow characteristics and on major roads.

Selection of bus stops: All the bus stops are proposed on the selected roads for bus routes. For selection of bus stops major traffic generating areas, locational importance, nodal/junction points and distance between the nearest two stops are taken into consideration. At first the nearest point of twelve identified major traffic generating areas (Shaheb Bazar, Monichattar, Bindur Moar, Laxmipur Moar etc.) on the major roads are selected as bus stops. The stops are proposed in such a way that the distance between two stops will be about half kilometer. Table 3 shows the locations of the proposed bus stops for Rajshahi city.

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Table 2. Peak hour flow and 14 hour total flow of traffic (in PCE).

Name	Name of Link	Direction of Flow	ofPeak Flow	Hour14 Hour Total Flow	Name	Name of Link	Direction of Flow	ofPeak Flow	Hour14 Hour Total Flow
Rajshahi	-Talaimari	- W-E	1092	9849	Greater	Barnali	-E-W	624	7303
Natore	Natore road	E-W	896	7980	road	Lakshmipur	W-E	614	6937
Road		bothway	1988	17829			bothway	1238	14240
Old	NatoreTalaimari	- E-W	372	2750	Greater	Lakshmipur	-N-S	430	4206
road	Shaheb Bazar	W-E	394	4384	road	C & B Junction	S-N	397	3931
		bothway	766	7134			bothway	827	8137
Greater	Talaimari	-To S-N	741	7039	Airport	Bindur Moar	-N-S	1521	12022
road	Bhadra	To N-S	855	7380	road	Airport	S-N	762	10069
		bothway	1596	14419			bothway	2283	22091
Greater	Bhadra - Dhaka	E-W	1191	10122	Court	Lakshmipur	-E-W	363	4547
road	bus stand	W-E	711	10911	Station road	Court Station	W-E	458	4149
		bothway	1902	21033			bothway	821	8696
Greater	Bindur Moar	-E-W	741	7330	Old	NatoreC & B - Court	E-W	800	5611
road	Dorikharbona	W-E	803	8690	road	Bazar	W-E	913	6664
		bothway	1544	16020			bothway	1713	12275
Greater	Dhaka bus stand	E-W	1134	10469	Old	NatoreC & B - Moni	W-E	688	7612
road	- Bindur Moar	W-E	886	11625	road	Chattar	E-W	789	7603
		bothway	2020	22094			bothway	1477	15215
Greater	Dorikharbona	-E-W	733	6676	Old	NatoreMoni Chattar	-W-E	653	7528
road	Barnali	W-E	577	7486	road	Shaheb Bazar	E-W	677	6033
		bothway	1310	14162			bothway	1330	13561

Table 3. The location of proposed bus stops in Rajshahi city.

stop no.	Location	stop no.	Location	stop no.	Location	stop no.	Location
01	* Binodpur	10	* Monichattar	19	city bypass Moar	28	WDB Moar
02	RU Main gate	11	Sheikpara	20	Medical Bandogate	29	* Shalbagan
03	Kazlagate	12	Jailkhanar Moar	21	* Barnali Moar	30	BDR
04	* Talaimari	13	* C&B Moar	22	* Dorikharbona Moar	31	Ferozabad
05	Baze Kazla	14	Betiapara	23	* Bindur Moar	32	ShahmadumThararMoar
06	Ramchandrapur	15	Rajpara Moar	24	* Dhaka Busstand Moar	33	Postal Academy
07	Ahamedpur	16	* Court Station	25	Petrol pump Moar	34	Rod Nawdapara
08	Kalponar Moar	17	Guripara	26	Vadra	35	By pass Moar
09	* ShahBazar Zoupt	18	* Laxmipur Moar	27	Debisngpara		

Note: * = Bus stop near major traffic generating areas

Trips served by the stops: To identify the number of trips that may be served by each stop, a GIS based locational proximity analysis was done. Similar type study was done by Anderson (1987) who used buffers of bus stop with population data to identify the best locations for bus stops. A buffer zone was created for each potential bus stop. The population density within this buffer was then calculated. A set of bus stops was identified which maximized the overall population catchment areas. There are thirty wards in RCC area. The number of trips generated by sample households in each ward was identified. By GIS analysis 35 thiesen polygons were made for 35 stops. In this analysis it is assumed that the polygon made for each stop is the catchment area for that stop. To identify the number of trips covered by each stop, the trips made by the catchment areas have been estimated. For that, the area covered by the polygon from each ward is calculated. The number of trips generated in each ward is redistributed among the bus stop catchments polygon according to the proportion of the ward area included in that polygon.

Characteristics of trip flow: From table 4 it is observed that in Rajshahi city the residence of Wards 17 and 19 produce the share number of trips, 7.11% and 7.13% respectively. On the other hand the population of ward 11 (1.20%) and ward 25 (.99%) produce the lowest numbers of trips. In Rajshahi city, mainly ward 12 attracts trips, which is the CBD. It is observed that among all trips that flow between different wards of the city, the highest share of trips flow to Ward 12 (15.60%) whereas only 0.99% of trips flow to Ward 29. The second highest numbers of trips flow to Ward 13 (7.31%). About 10.55% of total trips flow within the ward and only 3.03% trips go outside the ward. From the study it is observed that trips made by the different wards are mainly to the CBD area (Ward 12). The other wards that attract trips are Ward 13 (New Market-Kadirganj area), ward 4 (Court Bazar area), ward 6 (Laxmipur area) and Ward 15 (Shalbagan –Bindur Moar area). To propose the bus services the flow of trips from one stop to another is very essential. In the present study the flow of trips form one stop to another different stop was calculated in three steps. In the first step the portion trips of different wards covered by each stop was calculated. Then their flows to other different wards were distributed among different wards and finally the distributed trips among the other bus stop catchments polygon according to the proportion of the ward area included in that polygon were calculated. It is observed that stop 1 will attract the highest number of produced trips (5.55%), 4.92% trips by stop 8 and 4.46% by stop 9 and rest by other different stops. On the basis of the existing trip flow characteristics and proposed bus stop an extensive analysis was done to identify the expected pattern of flow between the stops. The study

reveals that the highest numbers of trips flow to the Stops 9 (16.96%), 10 (4.75%), 13 (3.85%), 16 (4.03%) and 23 (4.89%).

Table 4. Trips between different stops of the study area.

Stops	Trips	%	Stops	Trips	%	Stops	Trips	%	Stops	Trips	%
stop-01	106	0.93	stop-10	542	4.75	stop-19	322	2.82	stop-28	160	1.40
stop-02	131	1.15	stop-11	263	2.31	stop-20	179	1.57	stop-29	335	2.94
stop-03	165	1.45	stop-12	133	1.17	stop-21	252	2.21	stop-30	248	2.18
stop-04	248	2.18	stop-13	439	3.85	stop-22	347	3.04	stop-31	54	0.47
stop-05	148	1.30	stop-14	166	1.46	stop-23	557	4.89	stop-32	73	0.64
stop-06	175	1.53	stop-15	338	2.96	stop-24	348	3.05	stop-33	55	0.48
stop-07	95	0.83	stop-16	460	4.03	stop-25	295	2.59	stop-34	35	0.31
stop-08	276	2.42	stop-17	77	0.68	stop-26	247	2.17	stop-35	70	0.61
stop-09	1934	16.96	stop-18	332	2.91	stop-27	247	2.17			

Planning of routes: On the basis of analysis the possible flow of trips between different proposed stops on bus routes has been designed. There are three major regional road links in city and the growth of the city has been influenced by these roads. It has been observed that most trips coming from the fringe areas of the city flow to the old part of the city (Shaheb Bazar area). For designing the routes the trip flow characteristics are the main consideration. The trip flow characteristics indicate the volumes of trips in different areas. The spacing between routes is also considered for designing of the routes (Ortuzar, and Willumsen, 2002). On the basis of consideration of all the issues which are discussed above two alternative plans may be proposed for the city public bus service routes (Table 5).

Table 5. Proposed two alternative plans for Rajshahi city.

Route	Locations	
	Alternative 1:	Alternative 2:
Route 1 (Up & Down)	Binodpur -Kazla -Talaimari - Shaheb Bazar - C& B Moar - Court Station- Guripara.	Binodpur -Kazla -Talaimari - Shaheb Bazar-C& B Moar-Court Station- Guripara.
Route 2 (Up & Down)	Bypass Moar- Shalbagan - Bindur Moar - Bhadra Moar - Talaimari Moar - Shaheb Bazar- C&B Moar -Laxmipur- Barnali- Bindur Moar- Shalbagan- Bypass Moar.	Bypass moar- Shalbagan - Bindur Moar - Shalbagan- Bypass Moar.
Route 3 (Up & Down)	Bindur Moar-Laxmipur Moar-C& B Moar- Bhadra Moar Shaheb Bazar-Talaimai Moar- Bindur Moar.	Bindur Moar-Laxmipur Moar-C& B Moar- Bhadra Moar Shaheb Bazar-Talaimai Moar- Bindur Moar.

In each alternative three routes are proposed. Routes 1 and 3 are identical in both alternatives. Only route 2 is different. Evaluating the two alternatives based on the criteria convenience (judged subjectively by the researcher) the two alternative options, Alternative 1 appear more suitable because in this plan people can come to the CBD area from the fringe area without break of journey. In Alternative 2 route 2 is a small distance route for the bus service and in this alternative there is a break of journey within a short distance. So, Alternative 1 is proposed for the city (Map 2).

Feasibility assessment: As there is no public bus service in city today, there is a need to study the feasibility of the new service in the context of technical, financial and socio-economic perspectives. This study gives some very preliminary idea about the feasibility

of the services because for detailed feasibility an extensive survey and analysis is essential.

Technical feasibility: Technical feasibility indicates the condition and capacity of the roads proposed for bus routes. The bus routes for city have been proposed on the five major roads of the city which are Natore road, Old Natore road, Chapai Nawabganj road, Airport road and Greater road. Table 6 reveals that all of the roads have adequate capacity and the average spare capacity of the roads is 40% of the total capacity. If the bus service is introduced in an appropriate way it will improve efficiency of road usage, because people will use the new motorized mass transport, which will reduce the number of non-motorized vehicles.

Financial feasibility: For planning any type of public bus service financial assessment is a vital issue. According to Walters (1979), total benefit of bus service can be derived from the summation of bus user's benefit and operator's benefit.

a) Operators' benefit: Analysis of the benefit of the operators depends on the number of passengers who may use the service. It has been found that about 40% of the trips involve a distance more than 4 km and the average distance for trips is 4 km. About 33.6% of the total trips are made by rickshaw, 22.2% trips are made by bicycles, 29.1% on foot and other by different modes. To estimate the total numbers of passengers per day it is essential to estimate the total numbers trips made by the city people. Total

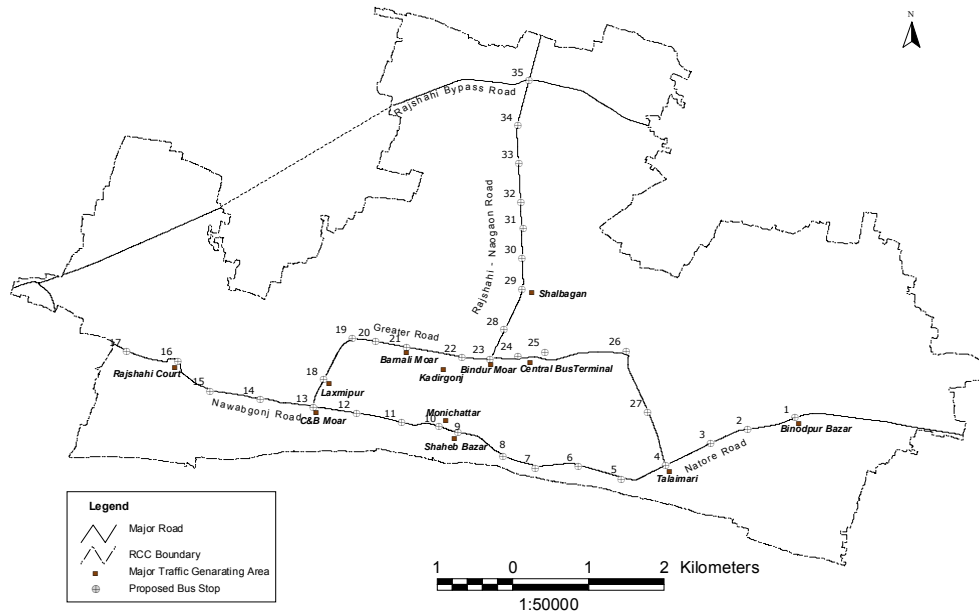
Table 6. Adequacy of existing roads in Rajshahi city.

Road name	Links of the roads	Peak hr. flow (both ways, PCE)	Pavement width (m)	Design capacity for mixed traffic (PCE)	Remarks
Natore road	Talaimari-Natore Rd.	1988	11.89	2400	Adequate
Old Natore road	Talaimari-Shaheb Bazar	966	9.76	1800	Do
	Shaheb Bazar- Monichattar	1330	21.95	4000	Do
	Monichattar- C & B Junct.	1477	10.98	2000	Do
Greater road	Talaimari-Bhadra	1596	15.63	3000	Do
	Bhadra-Dhaka Bus Stand	1902	15.63	3000	Do
	Dhaka Bus Stand-Bindur Moar	2020	15.63	3000	Do
	Bindur Moar-Dorikharbona	1544	19.51	3000	Do
	Dorikhar-Barnali	1310	13.41	2400	Do
	Barnali-Lakshimpur	1238	12.80	2400	Do
	Lakshimpur-C & B Junction	827	14.33	2400	Do
Airport road	Bindur Moar-Airport	2283	15.85	3000	Do
Chapai	C & B Junct.-Coart Bazar	1713	10.06	2000	Do
Nawabganj	Court Bazar-Kasyadanga	493	12.19	2400	Do

numbers of trips=Total number of households* Number of trips in sample households/Sample size. It has been observed that the total number of household in RCC area is 64134 and a total of 173769 trips are generated by those households. After calculation of the total number of trips in the city it is essential to identify the number of trips which may be attracted by the proposed bus service. From the passenger attitude survey it was observed that about 87% of all passengers think that there is a necessity for public bus services and about 68% of rickshaw passengers, 57% of bicyclists and 43% of pedestrians think that if this service is introduced they will prefer the service to their existing mode of travel. Besides, about 50% trips made above 4 km distance may be attracted by the proposed public bus services. From the analysis of distance, time, mode

and passenger attitude, it is conservatively assumed that if a bus service is run then at least 30% of total trips may be attracted by the service. If consider a possible demand level for the service network of 52130 (30%) passengers per day and assume Tk. 4 ticket⁻¹ flat fare (Considering passenger attitude and different public bus service fair study of different metropolitan city of Bangladesh at a rate of Tk 1.00 km⁻¹ travel proposed for Rajshahi city) it is observed that, this yields a revenue of Tk. 2,08,520 per day. If that level of demand can be maintained for the equivalent of 300 days (250 working days plus 100 days at one-half), annual revenue would be about Tk.6.26 crores. Given the current fare regime (around Tk. 4 for an average public transport trip of 4 km long), a fare of Tk. 4 would appear to be quite affordable to existing bus passengers, and would also be attractive to owners. Operating costs are different for different types of buses. As Rajshahi is a comparatively low density small city, initially a fleet of minibuses with small occupancy would be sufficient. It would increase the frequency of the services and reduce waiting time of passengers, which is an important factor of attraction to the city dwellers. Operating costs for mini buses (with 33 seats) are typically around Tk. 15 bus⁻¹ kilometer⁻¹ or less (Berger, 2004). This figure usually includes bus maintenance, but not depreciation and financing for the rolling stock, which will vary depending on the cost of the bus. To identify the number of buses that may serve the trips, the number of passengers, occupancy, distance of trips and vehicle km. per bus per day has been identified. For small buses the occupancy per bus is 33, the average distance per trip for Rajshahi city is 4 km and vehicle km bus⁻¹ day⁻¹ is about 210 km. Considering 52130 passengers (30% of daily trips, each of the trips considered here as a passenger) per day and the criteria discussed above, by sample it is deduced that there needs to be about 30 buses per day for the city. The total distance moved by the buses will be about 6300 km. The estimated operating cost per day will be around Tk. 94,500. The total operating cost per year will be about 2.84 crore. If each bus is valued at Tk. 20,00,000 and is depreciated over 10 years. So, cost for 33 buses will be Tk. 6,60,00,000. As the life time of each bus is considered 10 years so, an additional capital depreciation cost of around Tk. 60,00,000 year⁻¹ would result, but profits would still exceed Tk. 3.42 crore year⁻¹. While it is likely that the government would pay for infrastructure such as depots, passengers shed, etc. The private sector should provide the buses and fare collection equipment and should be able to operate the system at an affordable fare without subsidies, on a profitable basis.

b) Bus users' benefit: As there is no bus service in the city, people use mainly rickshaws, which is not affordable to the low-income group. It is observed that per kilometer rickshaw fare is about Tk. 2-3. For proposed public bus service in city Tk. 1 kilometer⁻¹ travel has proposed which is about 2 to 3 times less than rickshaw fare. So, if public bus services was introduced it would reduce transport cost of the city people. At present the average time per trip of the city people is about 30 minutes. More than 50% of the daily trips are made by rickshaws and bicycles, which are non-motorized slow moving vehicles. As the average speed of bus is 5-10 times higher than any type of non-motorized vehicle and city is a congestion-free area the proposed bus service will reduce the time for travel. Thus, it is evident that the proposed service would be beneficial for both the operators and users as it is financially feasible.



Map 2. Proposed bus stops for Rajshahi city.

Socio-economic feasibility: Like other metropolitan cities if public bus service is introduced in Rajshahi it will bring a radical change to the socio-economic sector of the city. With the introduction of the service the movement of people will be easier and more convenient. As the city's income level is low the proposed public transport will attract people of the city who cannot afford other more expensive modes such as rickshaw, motorcycles or cars. This service will attract people and will generate more trips. If a public bus service is introduced the city people's and students' mobility will increase. A number of people will be employed in the transport sector and support services, which will also gear up the present economic activity. With the change of the mobility pattern, trade and commerce, city will increase which in turn will increase the GDP of the city. From the analysis it is observed that planning of public bus service in city in the context of technical, financial and socio-economic perspectives is feasible.

Recommendation

Two alternative plans for bus route have been proposed for Rajshahi city. It is observed that alternative 1 is more suitable than alternative 2. So, considering the present situation alternative 1 can be the route plan for the public bus services of the city (Map 2). The 35 bus stops which were selected on the basis of the nearest point of major traffic generating areas, locational importance, proximity to major intersections and distance between stops can be the stops for proposed bus services.

Conclusion

Mostly buses, minibuses, taxi, auto-tempos, rickshaws ply in urban areas. For Rajshahi city, bus services can be most efficient and inexpensive public transportation. Transportation planners aim to increase the person-capacity characteristics of vehicles, which is only possible by the public transportation system. Public bus transportation

system will reduce the vehicle density on the roads and ease traffic congestion and parking problems. Although Rajshahi city at present experience very little traffic congestion, increased economic activity due improved road and rail access to Dhaka may create such problems in future unless polices and measures are adopted to encourage the use of public transport over private transport. A public transportation service must satisfy the requirements of the travelers. It needs to run on the correct routes, offer a high frequency, be reliable and quick, use quality vehicles and staff and be affordable. As there is no public bus services in Rajshahi city this research was an attempt to provide a plan for public bus services for the city. From this study it was observed that there is a demand for public bus service. In this study 35 demand oriented bus stoppages and three bus routes were identified. It was revealed that an effective plan of public bus service with appropriate policy measures can positively change the present transport system of Rajshahi city which may bring overall socio-economic benefit for the city.

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