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ANALYSIS OF TRAVEL BEHAVIOR AND MOBILITY PATTERN OF THE RESIDENTS WITHIN RAJSHAHI CITY CORPORATION AREA

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ABSTRACT

Understanding travel behavior and mobility pattern is the heart of the transportation planning process in the urban area. This research is an attempt to work out the human travel behavior and mobility pattern in Rajshahi City Corporation Area. In this research, travel behavior has been assessed through the analysis of trip generation, mode choice, and choice of routes for travel. Mobility pattern has been represented by a series of mobility maps. The research is mostly primary data based. Required primary data has been collected from questionnaire survey and travel diary which has been conducted in30 wards of Rajshahi City Corporation area. Secondary data has been collected from the relevant literature. The research only considered the intracity trip and found that students are the highest contributor to the average daily trip while auto rickshaw and rickshaw are the predominant transport mode. The study has also identified Shaheb Bazar, Laxmipur, and Talaimari as the three major attraction areas.

KEYWORDS: Mobility Pattern, Mode Choice, Travel Behavior, Trip Generation.

1. INTRODUCTION

An inherent part of a city's transportation planning involves the understanding of the travel pattern of its inhabitants. Travel behavior refers to the manner in which people move in the public realm by any means of travel and for any purposes (McGuckin, 2015:1). Activities, that people want to involve into satisfying their own basic personal needs or desires, are separated across space, which creates a demand for people to travel (Mitchel and Rapkin, 1954:38). Modeling travel demand, though challenging, is necessary for coherent and effective planning and evaluation of transportation systems (Kadiyali, 2004:663). Travel behavior analysis gives insight into the pattern of movement of people thus providing important information required to build travel demand forecasting model (Hyodo, et al., 2005:23). The study of travel behavior has advanced much over the last half-century and has brought forth critical understandings into the choices that individuals or households make about their daily travel, which in turn has contributed to the development of refined and sophisticated models to project travel demand and forecast changes in behavior responding to changes in the transportation system (Clifton and Handy, 2001:3).

Rajshahi is one of the major metropolitan cities of Bangladesh with a population of 3, 44,904 (BBS, 2011:109). In the last decade, travel pattern has changed significantly, both in regard of travel mode and trip number (Basri et al., nd.:3).To cope with this change, newer transport model is required, necessitating knowledge on the travel behavior of the citizens which is practically non-existent. Hence, data on factors affecting trip generation, mode choice and mobility pattern has been collected in this research by household travel survey-using questionnaire and travel diary-and traffic volume survey and analyzed to understand individual and household travel behavior. By collecting and compiling these data and information, this study endeavors to provide a reference for future study in the transport sector and transport planning of Rajshahi City Corporation.

2. STUDY AREA PROFILE

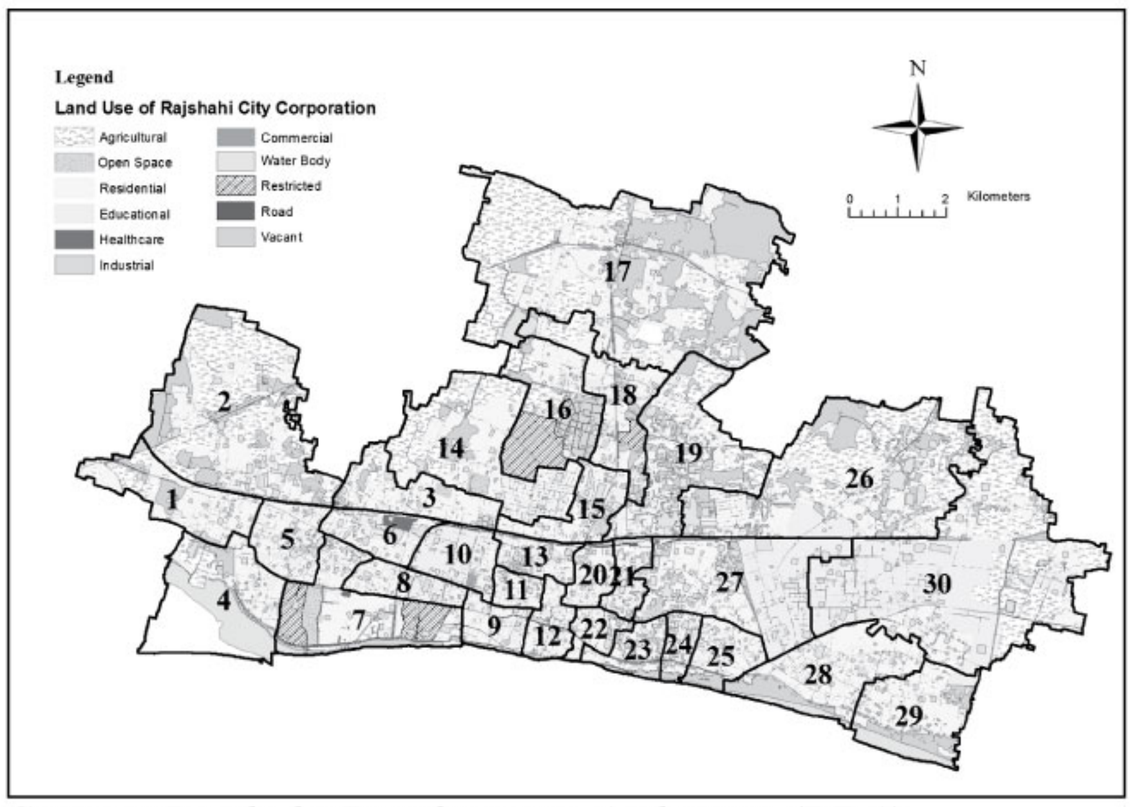
Rajshahi City Corporation area has been chosen to conduct this research. The structure of the city differs from most other large cities of Bangladesh like Dhaka, in terms of demography, land use, and economy.

Table 1: Administrative and Demographic Information on Rajshahi City Corporation

City Corporation	Thana	Ward	Mahalla	Household	Average Household Size	Population (000)			Density
						Male	Female	Total	
Rajshahi City Corporation	4	30	170	93545	4.81	232974	216782	449756	4318

Source: Population and Housing Census 2011, BBS

Unlike Dhaka which contains major commercial, industrial and administrative establishments, Rajshahi is known as educational city devoting more than 1300 acre land on the said purpose (BBS 2011). Apart from educational use, residential area presides over other land use, within RCC area. Furthermore, the city has not experienced any major industrial development yet. The only industrial area, Rajshahi BSCIC, is situated in Sopura, Ward 16.



Source: Rajshahi Development Authority, (RDA)

Figure 1: Landuse Map of Rajshahi City Corporation Area

The city is paratransit based. The most common mode of transport in Rajshahi has been rickshaw until 2008 when battery operated auto rickshaw was introduced as a new para-transit (Basriet.al., nd.). Now, according to an official survey, there are more than 5000 autorickshaws and 20,000 rickshaws in Rajshahi.

Table 2: Transportation Infrastructures of Rajshahi City Corporation

Length of Metalled Road	346 Kilometers
Length of Railway	14 Kilometers
Number of Railstations	3
Number of Bus Stands	2
Number of Registered Rickshaw	17161
Number of Registered Auto rickshaw	4900
Number of Non-registered Auto rickshaw	3089
Number of Non-registered Rickshaw	250

Source: BBS, 2011

As different land uses inflict different travel behavior (Mitchel & Rapkin, 1954: 38-40), all of these issues create unique mobility patterns differentiating the city than most other big cities of Bangladesh like Dhaka or Chittagong which rationalize the need for research.

3. OBJECTIVES AND METHODOLOGY OF THE STUDY

The primary objective of this study is to analyze the travel behavior and mobility pattern of the residents of Rajshahi City Corporation Area.

In order to attain the research objective, the required primary has been collected from household travel survey consisting of a short questionnaire and a seven-day long travel diary. The sample size was 196 households (943 individuals) at 95% confidence level and 7% confidence interval. Although 95% confidence level and 5% confidence interval are normally used, if that would be taken in the research, the sample size was too large (385 household or 1852 individuals) to cover within a short time and limited manpower. The sample has been distributed according to the proportion of the population in each ward as well as the presence of socio-economic infrastructures. After the completion of data collection, data was compiled, processed and analyzed with help of Microsoft Excel, SPSS, and Arc GIS.

4. LITERATURE REVIEW

Travel Behavior

Travel behavior can be defined as the process whereby individuals organize their day to satisfy these needs as best they can give space-time constraints, cognitive limitations, the needs of others, etc. can be thought of as travel behavior (Dunbar, 2016:1). A decision on transportation planning requires an understanding of travel behavior, utilization of the transportation system and aspects of potential improvements to a community's roadway infrastructures. To aid in this decision-making process, several computer-based and manual tools have been developed (Bayes, 2012: 20). One of which is the conventional four-step urban transport modeling used in forecasting future demand and performance of a transportation system and it is comprised of Trip Generation, Trip Distribution, Mode Split, and Traffic Assignment (Kadiyali, 2004:663 ; Wright, 1996:348).

Mobility Pattern

The evolution of urban mobility can be seen as the outcome of a complex and changing set of interactions (Jones, 2014:7-8). Human mobility in a street network consists of numerous flights (or jumps) from one street to another. Thus human mobility in a street network, a sort of network-constrained movement, is like a frog jumping from one street to another at the topological level, and like a turtle walking persistently along individual streets at the geometric level (Jiang et.al, n. d.:1-2). This human mobility is governed by individuals' decisions, habits and life experiences (Barchiesi, et.al, 2015:1-2). Most of the previous research on mobility pattern has been carried out based on the data obtained from the travel diary and questionnaire. But at present cell phone data is also being used to trace human mobility.

Travel surveys

Most researches on travel behavior use a travel diary and questionnaire to obtain data. Household (HH) travel surveys measure the travel (or activities) undertaken by members of a household on a regular weekday. These data can be categorized as household characteristics, personal characteristics and trip characteristics (Edwards, 1999:11). Travel diaries are used to understand the travel characteristics and patterns. They can be classified into three groups: trip-based diaries; place-based diaries; and activity-based diaries (Behrens and Masaoe, 2009:2-3).

A research (Ali, 2011:1-19) used household travel survey comprising of questionnaire and travel diary to analyze household trip patterns and travel characteristics in Lethbridge, Alberta. They found travel diaries to be vital in grasping the travel characteristics and evaluating the effectiveness of the former transportation plans and programs.

Another study led by Subbarao and Krishna (2013:98-108) used an activity-based travel diary to analyze household activity and travel behavior. It aimed to design a new survey instrument called activity-travel diary to help analyze the travel behavior in developing countries. Finally, the study identified some variables that have major explanatory power over decisions relating to mode choice.

5. DATA ANALYSIS AND INTERPRETATION

5.1. Analysis of Travel Behavior

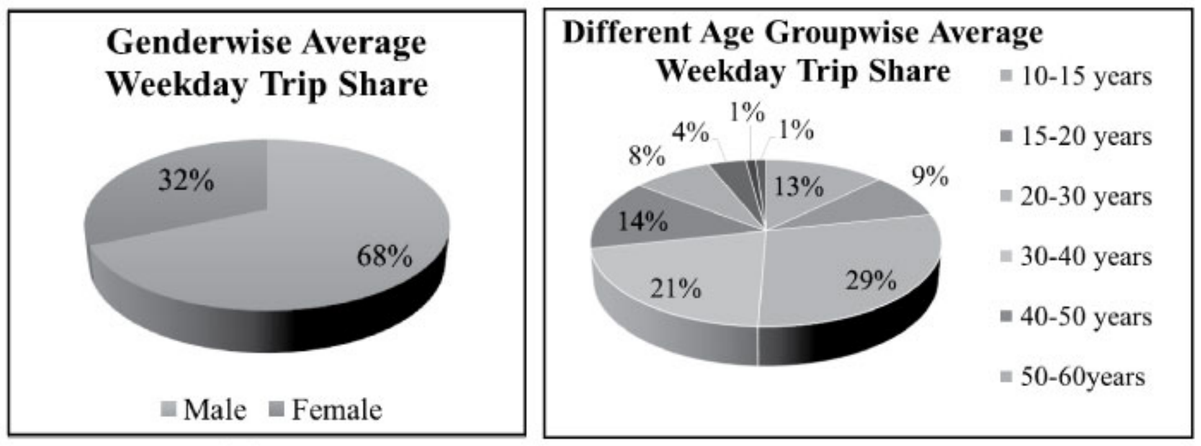
Human travel behavior analysis is a complex issue which has been assessed through the analysis of trip generation, mode choice, and choice of travel routes.

5.1.1. Trip generation

Trip generation is the generalized term used in the transportation planning process to cover the field of calculating the number of tips ends in a given area. The objective of the trip generation stage is to understand the reasons behind the trip making behavior. It also aims at producing a mathematical relationship to synthesize the trip making pattern on the basis of observed trips, land use data and household characteristics (Kadiyali, 2004:664). This section represents the influence of socio-economic factors, such as gender, age, household size, vehicle ownership, etc. on trip generation in Rajshahi City Corporation Area.

Influence of Gender

Figure 2 depicts that, women's contribution in average weekday trip is much less than the men. They make up only 32% of the daily trips rest 68% is made by men. One of the major reason behind this is, very negligible percentage of women population of Rajshahi City Corporation area is engaged in non-home based income generating or financial activities. Their contribution in total trip share (32%) is comprised of local bazar trip or drop off or pick up of children from educational institutes (Field survey 2016).



Source: Field Survey,2016

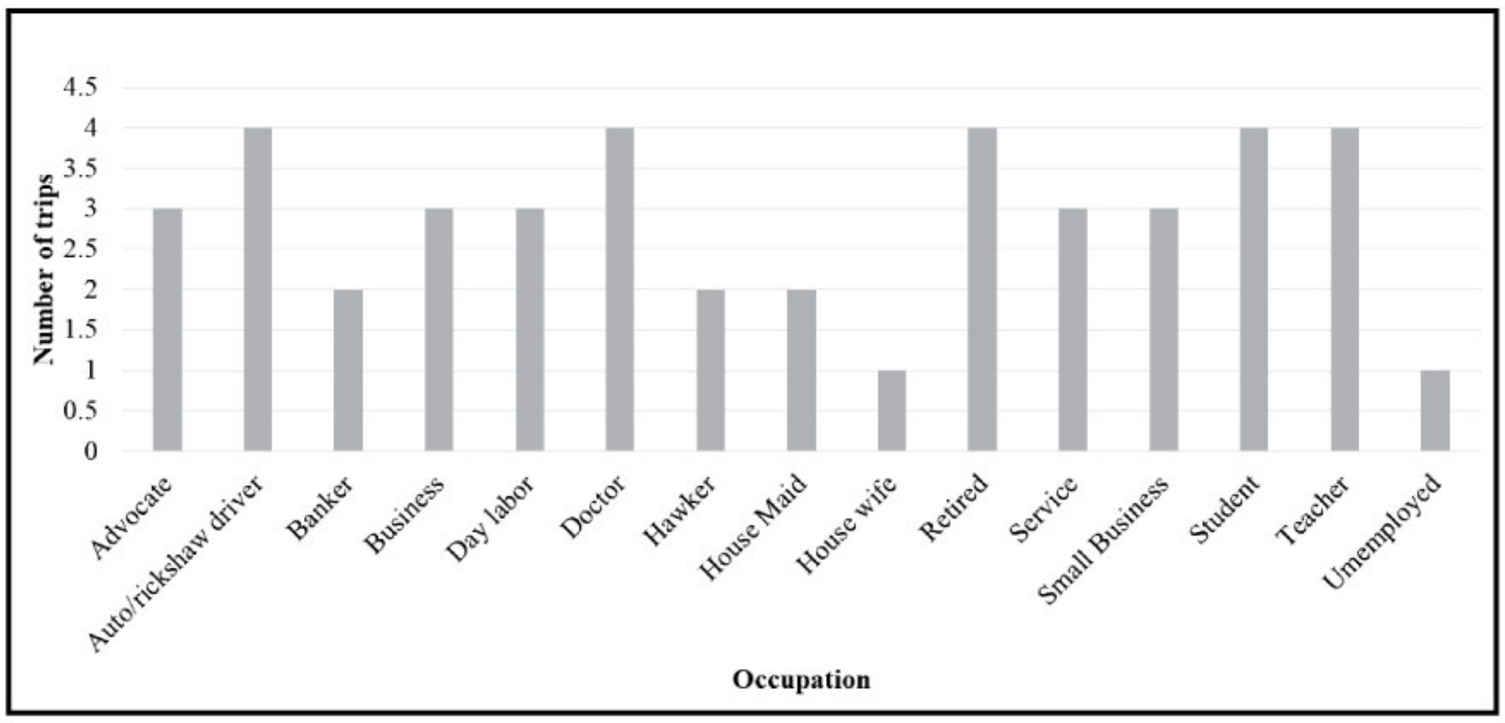
Figure 2: Gender and Age group wise Average weekday Trip Share

Influence of Age

As Rajshahi is often referred to as the city of education, students with age group (20-30 years) hold the largest share in average weekday trip (Figure 3). The second dominant trip making age group is 30-40 years. This age group is often comprised of employed members of the households who make most of the work trips. Elders above 60 years and children below 5 years makes the least amount of daily average trip.

Influence of Occupation

Figure 3 shows that doctors, teacher, students, auto rickshaw/ rickshaw drivers and retired persons make the highest number (4) of average daily trips. Where the housewives and unemployed makes the least number of trips. One of the interesting findings is that most of the housewives stay at home and not engaged in any activity outside the home.

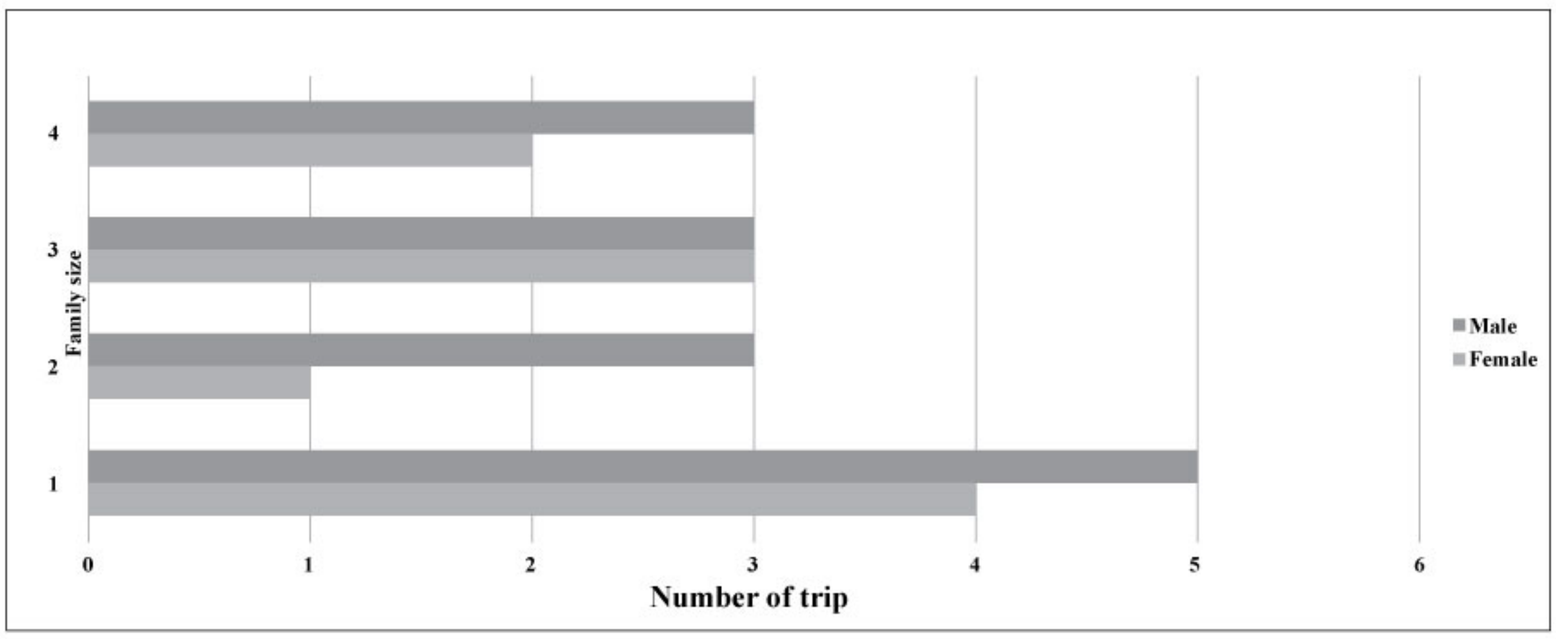


Source: Field Survey, 2016

Figure 3: Average Weekday Trip Distribution by Different Occupation

Influence of Household size

Figure 4 represents that, one membered family mostly students makes the highest number of average weekday trip. Male students make five numbers of the trip on a weekday where female students make four numbers of the trip. In a single-family household with two members, male members make a higher number of trips than female. In this case, the female members (housewives) make only one trip on an average which is local bazar trip. But in a single family with three members conventionally spouse and a child, both male and female members make an equal number of weekday trip. This is due to the addition of drop-off or pick-up a trip to educational institutions of housewives with local bazar trip. Again, in four-membered households the number of weekday trip of female drops than the male members.

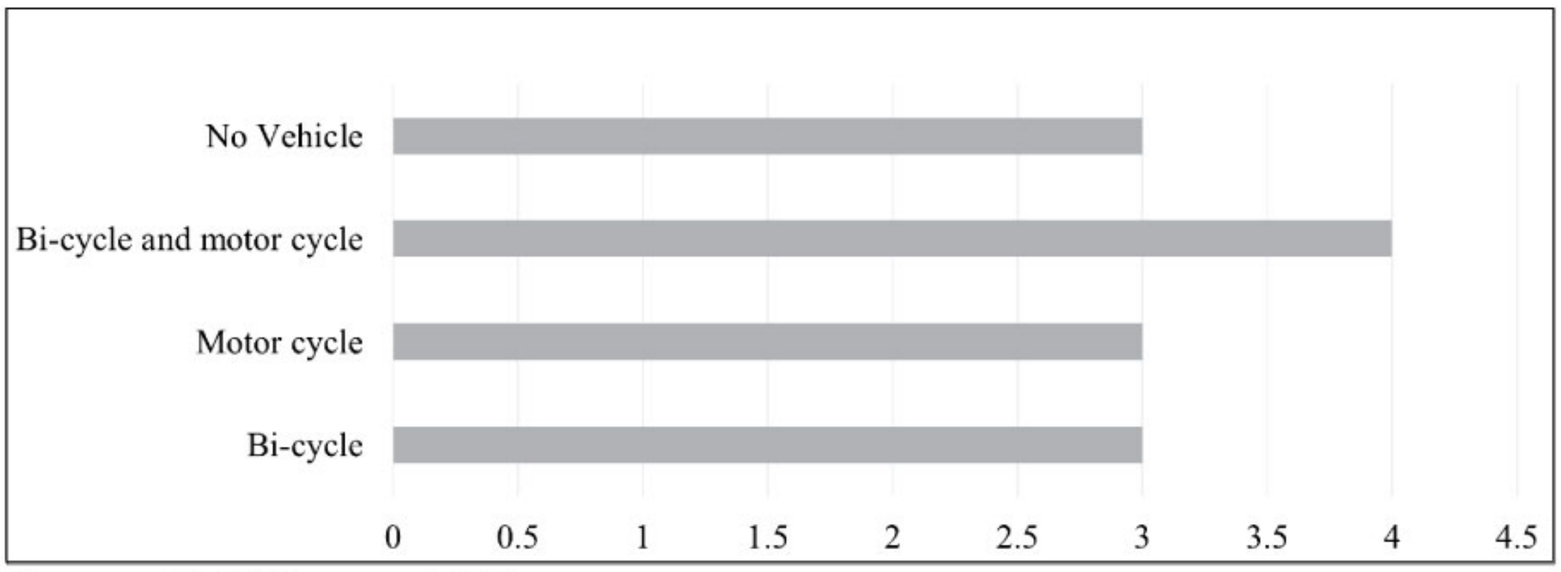


Source: Field Survey, 2016

Figure 4: Gender wise Average Weekday Trip Distribution by Household Size

Influence of Vehicle ownership

An interesting finding of the research is that average daily trips of male members do not vary with the ownership of a bicycle or motorcycle.

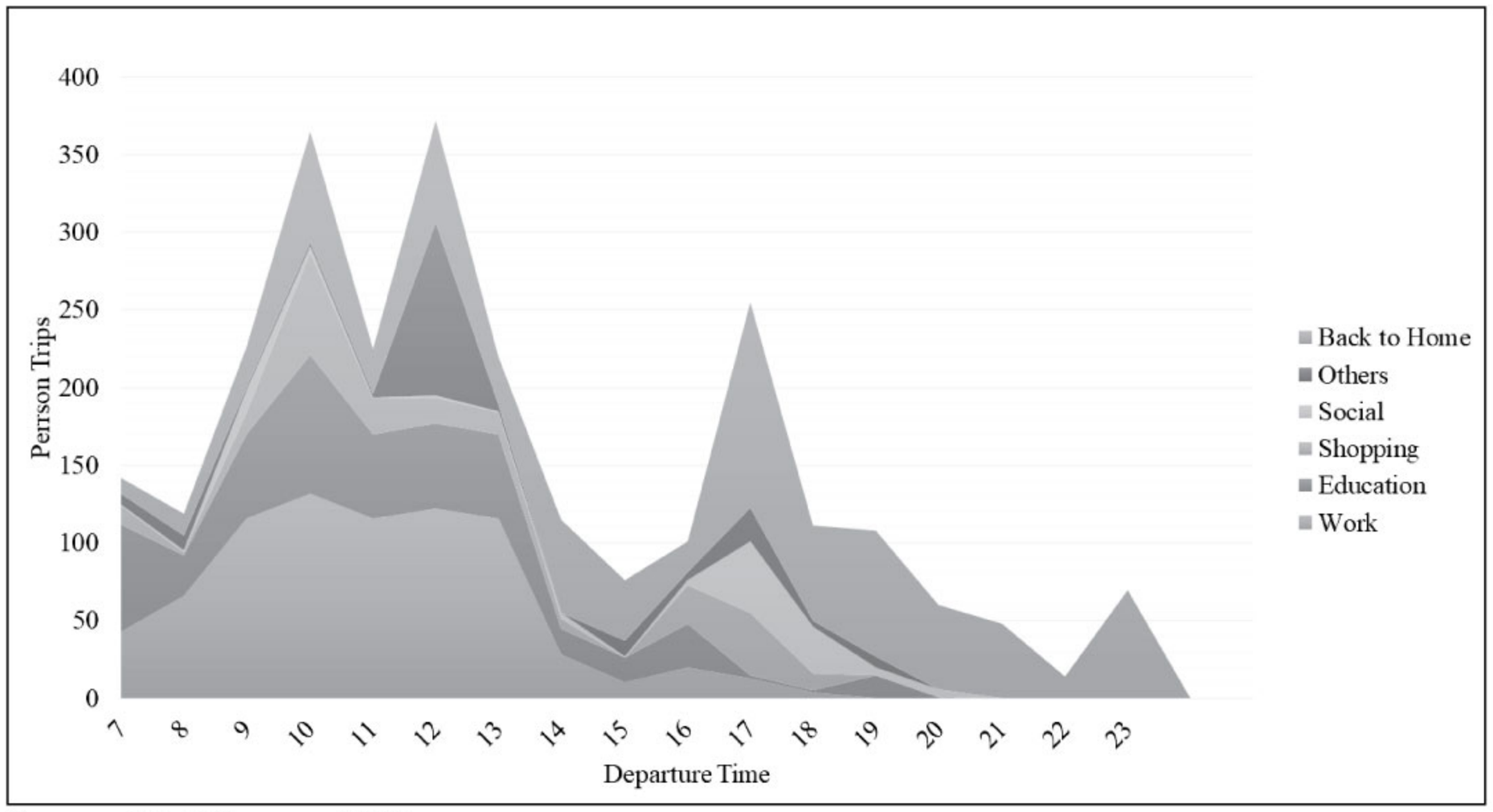


Source: Field Survey, 2016

Figure 5: Average Household Trips by Male Members by Vehicle Ownership

Hourly fluctuation of trips

Figure 6 indicates that back to home trip has four major peaks; one is at 9-11am due to returning of children and housewives home from school and bazaar. The second peak occurs at lunch hour and a third peak at evening due to returning home from the office or another workplace. Education trips mostly occur within 8am-1pm. Another concentration of education trip is seen within 3pm-5pm due to private tuitions and coaching.



Source: Field Survey, 2016

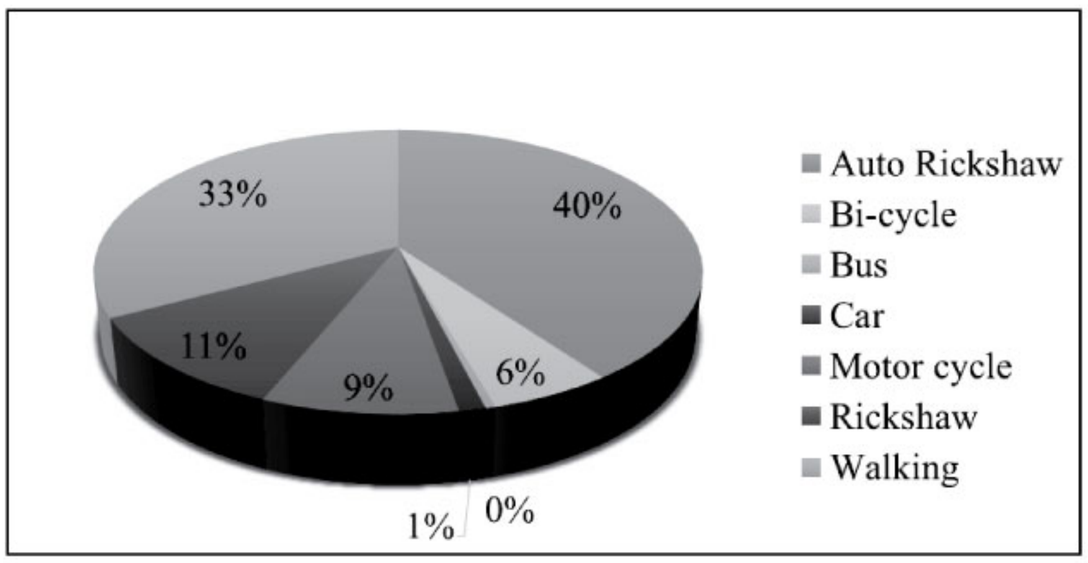
Figure 6: Hourly Fluctuation of Trips by Trip Purpose

5.1.2. Mode choice

Mode choice analysis another important component in the analysis of travel behavior. This analysis is concerned with the trip maker's behavior regarding the selection of the travel model (Wright, 1996:381). In a typical travel situation, trip makers can select between several travel modes including driving, riding with someone else, walking etc.

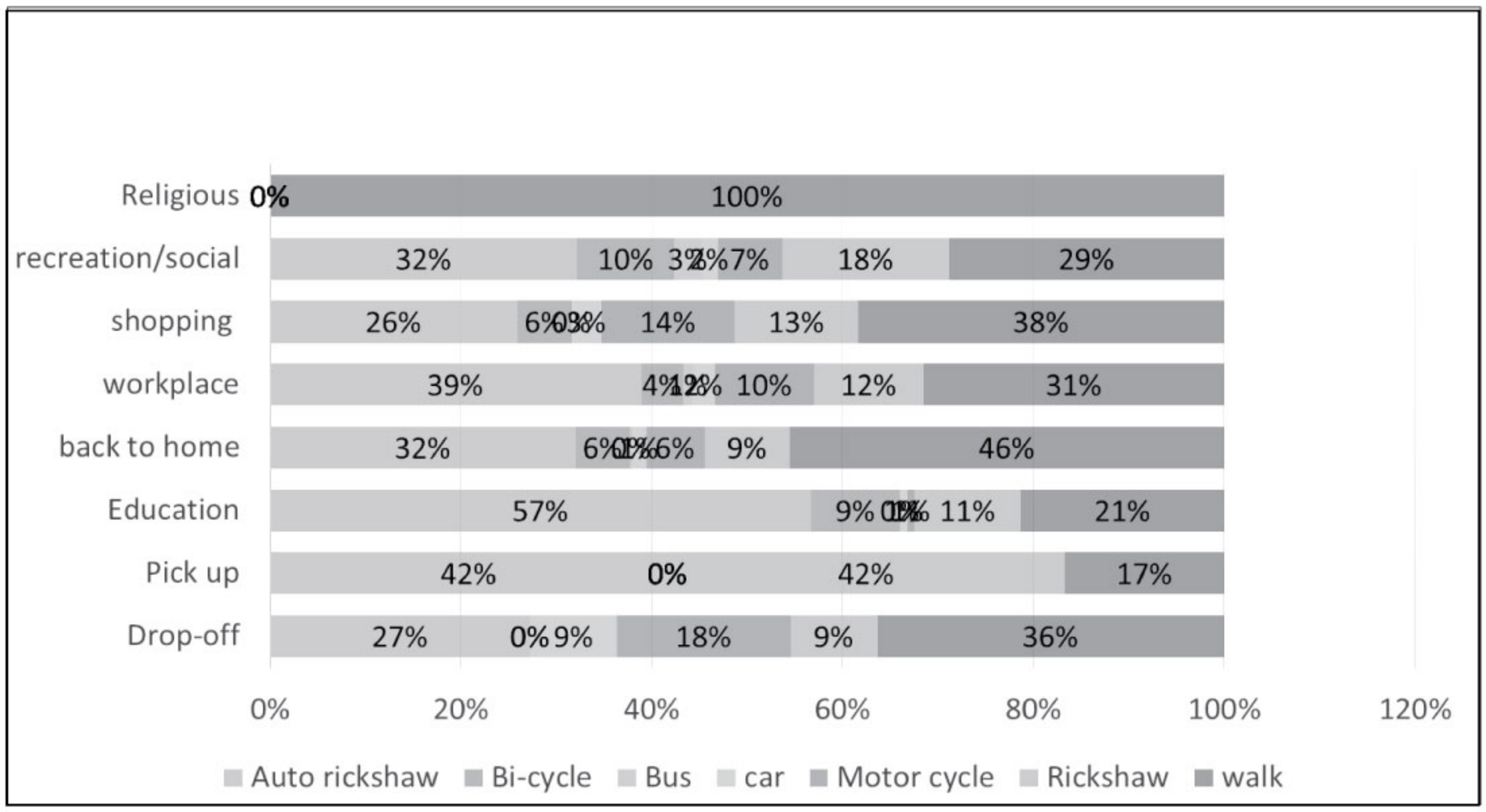
Modal Share

Walking holds the largest modal share (40%). Due to the absence of intracity bus service, autorickshaw is the dominant vehicular mode. About 33% of the total daily trip is made by auto rickshaw. The second dominant mode is rickshaw followed by motorcycle and bicycle (Figure 7).



Source: Field Survey, 2016

Figure 7: Modal Share

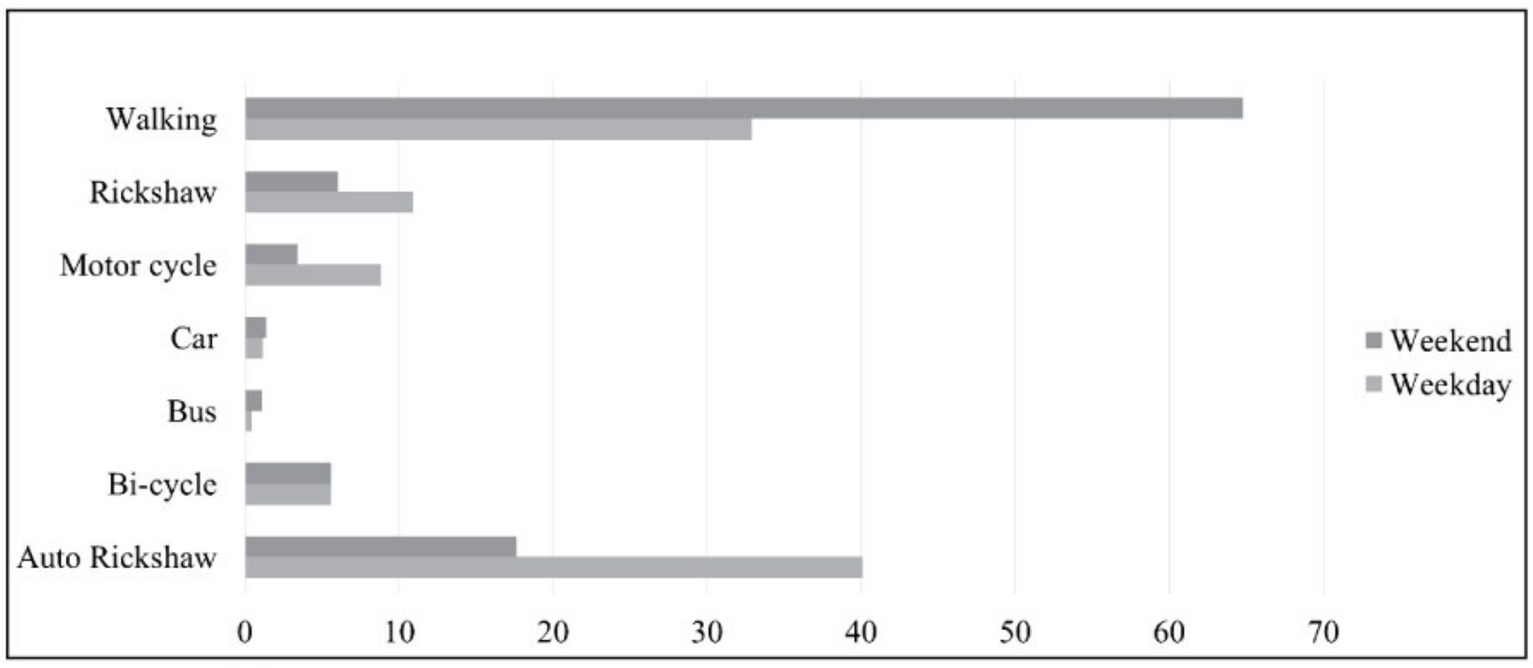


Source: Field Survey, 20016

Figure 8: Modal Composition by Trip Purpose

Auto rickshaw is predominantly used mode for social (32%) and recreational, work trip and educational purpose. About 57% of the educational trip is made by auto rickshaw (Figure 8). Due to the availability of religious institutions within walking distance, all religious trips are walk trips.

Figure 9 represents the variation in mode choice during weekday and weekend. It has been found that auto rickshaw is mostly used in weekday as this mode is time and cost efficient. But at the weekend, its use is reduced and people prefer a rickshaw or walking. The reason is that 73% respondents think rickshaw journey is more relaxing and comfortable than auto-rickshaw. Again, walking is preferred by 43% respondents due to health benefit (Field Survey, 2016).

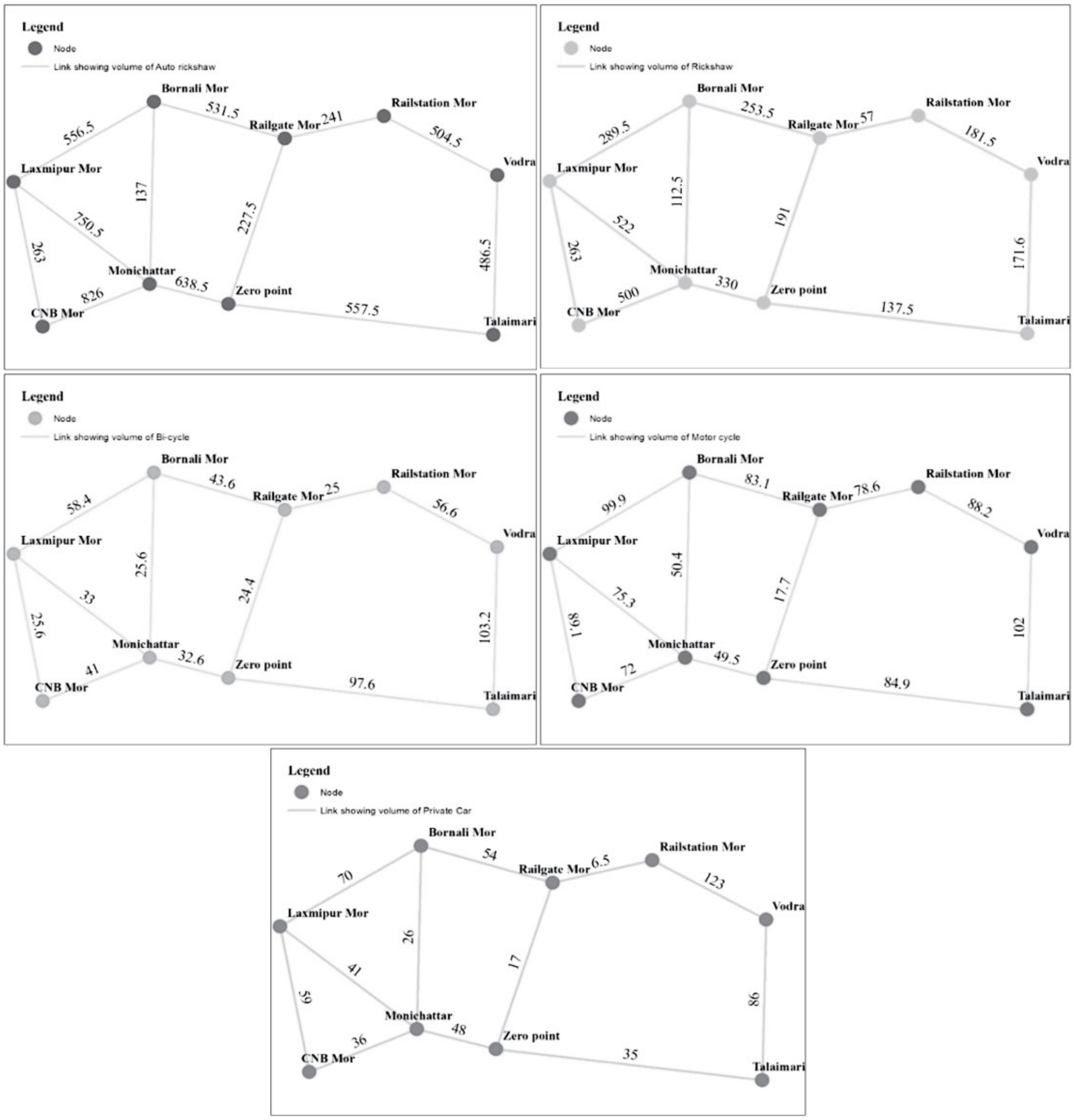


Source: Field Survey, 2016

Figure 9: Variation in mode Choice in Weekday and Weekend

5.1.3. Choice of Travel Routes

In this section, mode wise peak hour volume mapped along major links. Highest peak volume occurs covering CBD (Shahab Bazar) Sub CBD (Laxmipur) and educational area (Talaimari). Zero point to Monichattar link has the highest traffic volume in the morning peak period and Monichattar to Laxmipur link experiences the highest hourly volume of auto-rickshaw in PCU (Passenger Car Unit) during evening peak period.



Source: Traffic Volume Survey, 2016

Figure 10: Number of Trips along Various Routes

5.2. Analysis of Mobility Pattern

Mobility results from demand for activity (Salomon & Mokhtarian, 1998:139-140). It depends on the location of origin and destination (Cervero, 2009:12). Mapping human movement from origin to destination, a pattern emerges. This mobility pattern aides in visualizing which ward attracts most trip from which ward. It also helps in understanding which routes are most used, by which mode, how long it takes to travel on this route and how much it costs. To map the mobility pattern, data has been collected using a travel diary. It logged data on the origin and destination, cost, travel time, travel mode, etc. of each trip. These data have been processed to produce mobility maps.

5.2.1. Volume of trips

The map (Figure 11) shows the volume or number of trips per route. It has been produced by plotting the routes from origin to destination, then a number of trips per route were assigned.
It can be seen that most routes end at Shaheb Bazar, confirming that it attracts the highest number of daily traffic. The second and third most traffic attracting points are Laxmipur and Talaimari, respectively. Land use data show that Shaheb Bazar, the CBD, is both a hub of educational (Collegiate School, Government P. N. School, Rajshahi College, etc.) and commercial infrastructures which attract traffic. Laxmipur is a sub-CBD, known for its abundance of health facilities. Also, two important high schools are located here. Resulting traffic for both educational and health purposes. Talaimari is renowned for Rajshahi University of Engineering and Technology which attract education trips. Also, the location of BRTC bus stand and several commercial facilities causes traffic attraction. Most used routes are from ward 16 to 12, from Wards 5 and 9 to 6, Ward 26 to 27 and Ward 24 to 25.

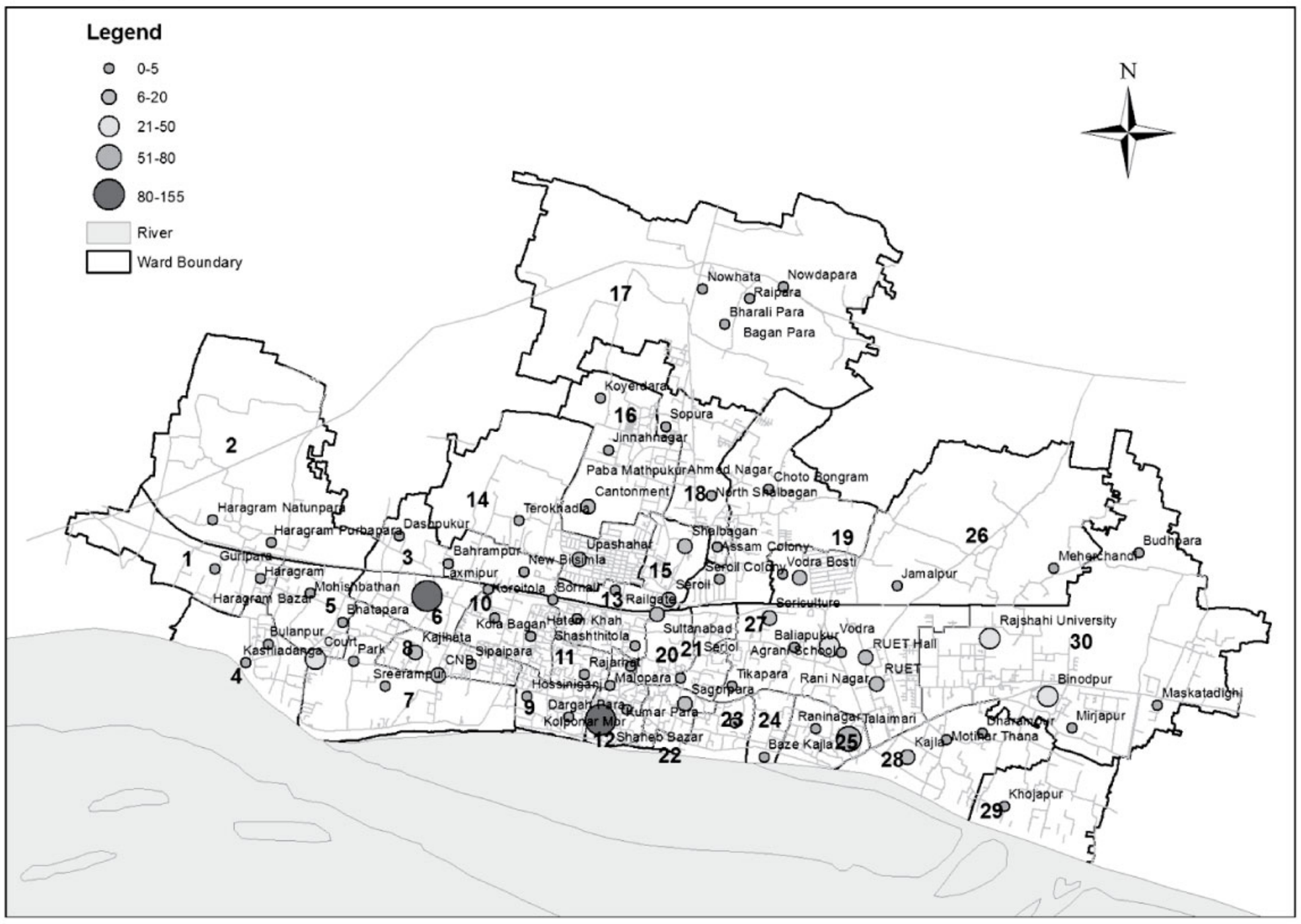


Source: Field Survey, 2016

Figure 11: Mobility Pattern Showing the Volume of Trips

5.2.2. Traffic Attraction Points

By analyzing origin and destination of the trips, the major attraction points have been derived. The following map (Figure 12) illustrates these attraction points. Most traffic attracting area is Shaheb Bazaar where resides several prominent educational institutes, such as Collegiate School, Government P. N. School, Loknath School and Rajshahi College. Also, Shaheb Bazaar is the CBD and most of the major markets and commercial institutions are located here. The second most traffic attracting area is Laxmipur where Rajshahi Medical College, RMC Hospital and several other clinics and diagnostic centers are located. Lastly, Talaimari, where Rajshahi University of Engineering and Technology, Varendra University, Agrani School and college, BRTC Bus Counter and various commercial facilities are located, is the third most traffic attracting area.

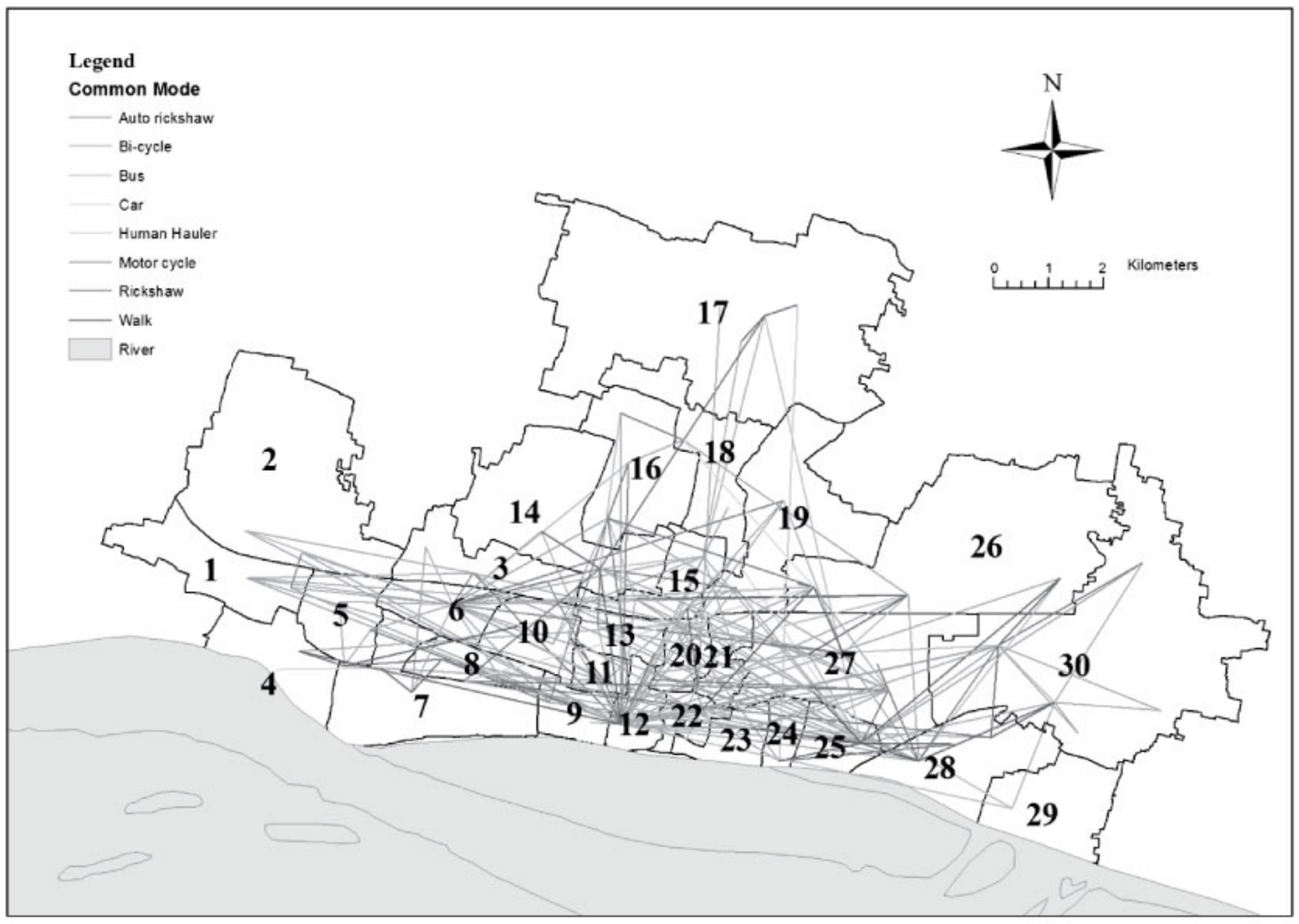


Source: Field Survey, 2016

Figure 12: Mobility Pattern Showing Major Trip Attraction Point

5.2.3. Common Travel Mode

The following (Figure 13) is a depiction showing common mode per route. It is evident from the map that the most common mode on the maximum route is either auto rickshaw or rickshaw. It may be due to their availability and affordability and also the lack of intra-city bus service. The least used mode are a car, bus, and a human hauler. Bi-cycle is fairly common, especially among students.

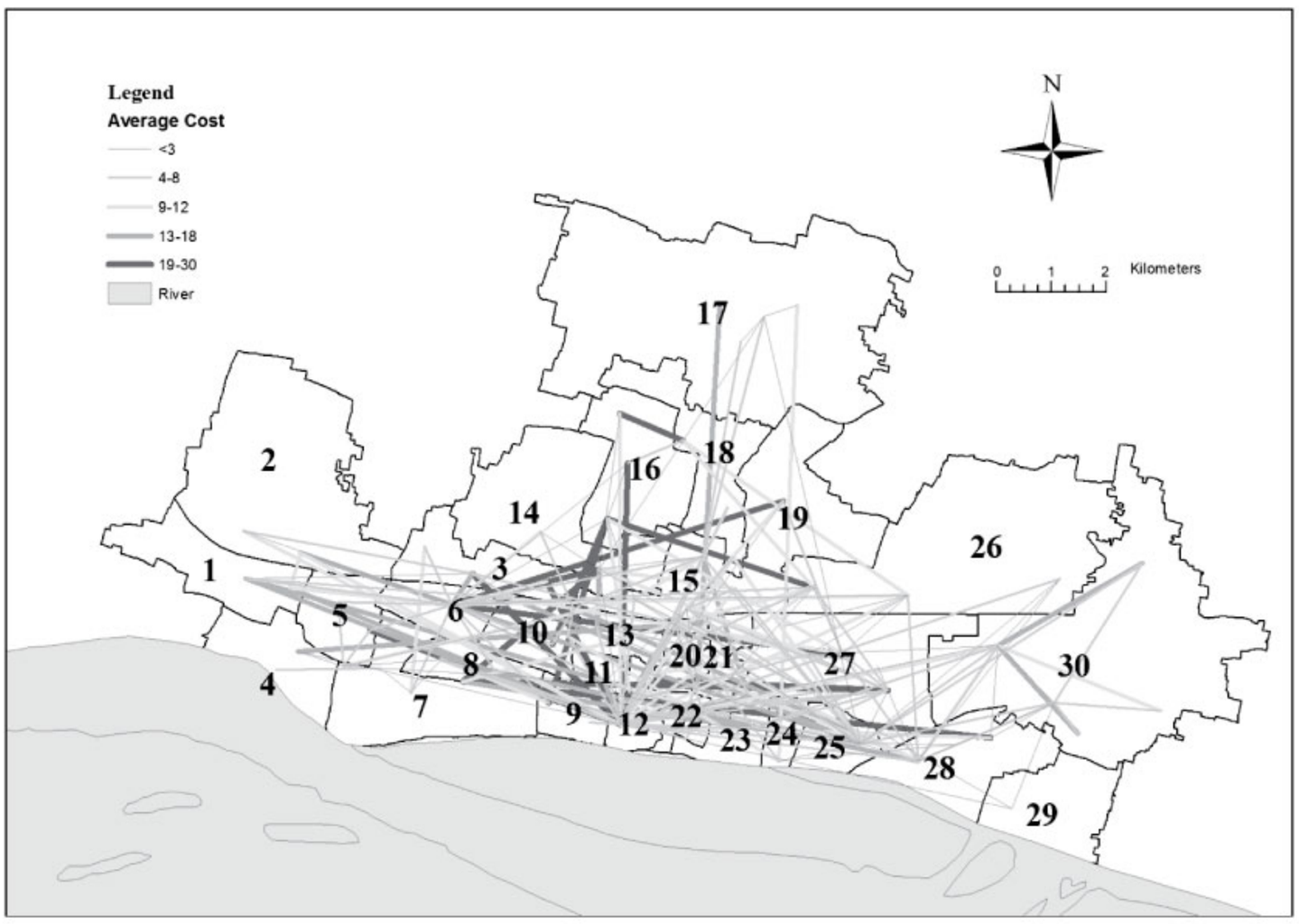


Source: Field Survey, 2016

Figure 13: Mobility Pattern Showing Common Modes

5.2.4. Travel Cost

Figure 14 shows average cost per route on the most common mode for that route. Comparing Figure 14 and 15, it is apparent that the most costly routes and those that use rickshaw as a common mode, costing up to BDT 30. Most routes have cost between BDT 5 to 12 and these routes mostly use Autorickshaw.

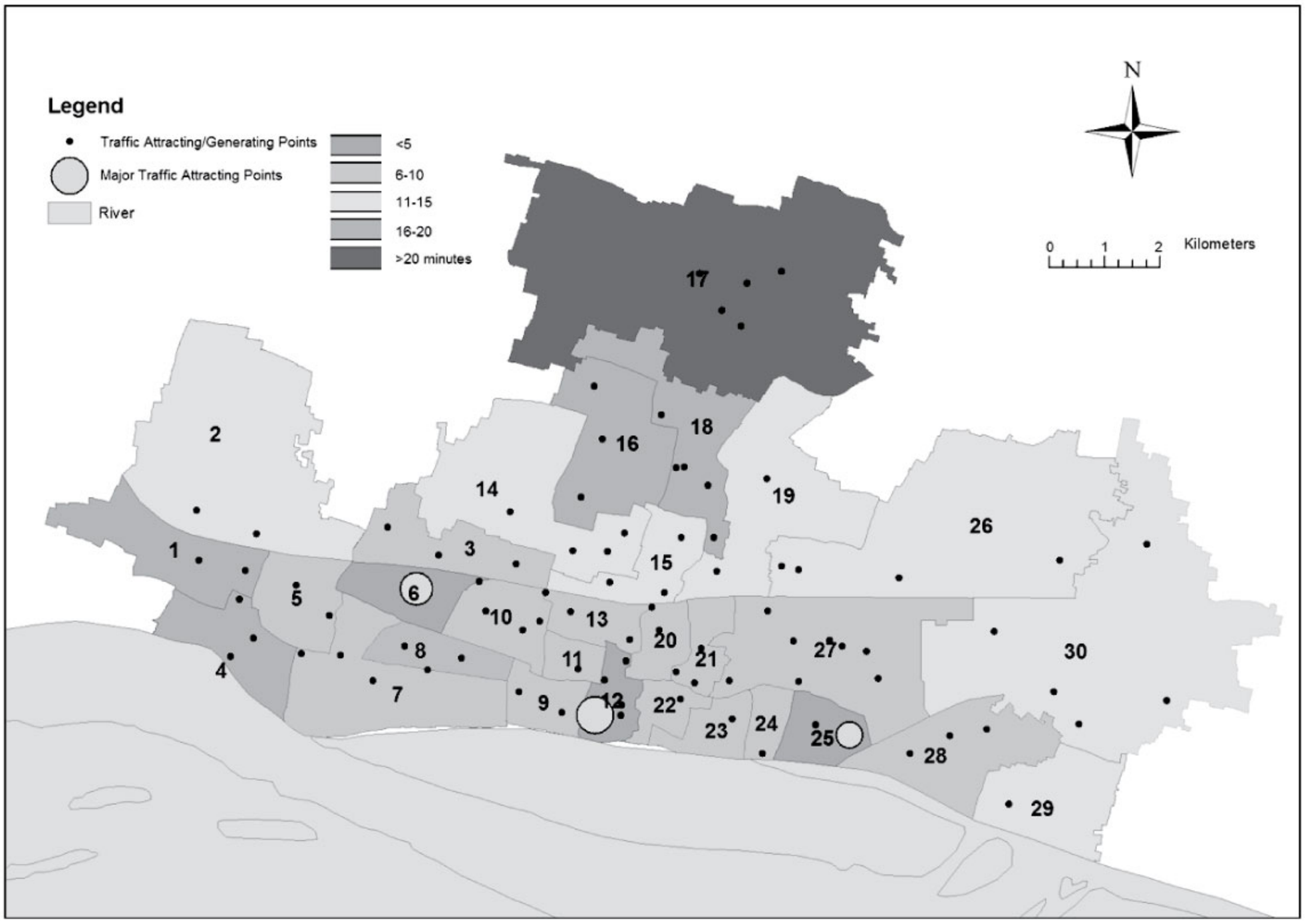


Source: Field Survey, 2016

Figure 14: Mobility Pattern Showing Average Travel Cost

5.2.5. Travel Time

Following map (Figure 15) shows the average travel time from the major attracting points. The most location has a travel time of 5-10 minutes. Some wards take up almost 15 minutes to reach. Few outlying wards (Wards 1, 4, 16 and 18) take near 20 minutes to reach the CBD and Sub-CBDs. Ward 17 has exceptionally high travel time which can be attributed to its greater physical distance from the city centers.



Source: Field Survey, 2016

Figure 15: Mobility Map Showing Travel Time from Major Trip Attraction Point

6. CONCLUSION

This research focused on investigating the human travel behavior and mobility pattern in urban areas. The results indicate that trips of the study area are influenced by age, gender, time, mode choice and other socio-economic and demographic variable. It has also been found that either or destination of the most of the trips are concentrated in some specific area like Shaheb Bazar, Laxmipur, and Talaimari where presiding transport modes are Auto rickshaw and Rickshaw. Looking to the future, continuing economic growth and increasing urbanization will put further pressures on urban transport systems. This research may provide a valuable insight to the policymakers and relevant bodies on various aspects of future transport planning of Rajshahi City.

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