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ANALYSING THE FACTOR INFLUENCING TRAVEL PATTERN AND MODE CHOICE BASED ON HOUSEHOLD INTERVIEW SURVEY DATA: A CASE STUDY OF DHAKA CITY, BANGLADESH

Summary. For transport planning and policy-making, visualising the relationship among attributes; gender, education, occupation, age with travel pattern and mode choice is important. Household Interview Survey (HIS) is one of the major inputs in transport study which contains information about travel and demographic characteristics. From the analysis of 28,235 households in Dhaka city, this study represents the social demographic characteristic of Dhaka city based on the household survey. It was found that 89.79% of dwellers make double trips in a day and the trip rate per trip maker is 2.16, where 14% of total trips are generated at morning peak time between 7 to 8 am. The bus is the most preferable mode share and its contribution is about 35%. The scenario changed in a multimodal trip case and walking was the domination mode share with about 45% of total trips. Vehicle ownership had a vital rule in particular mode choice, especially in car and motorcycle household ownership case. Significant impact on travel patterns and mode choice criteria was found with gender, education, occupation, age, household income, trip purpose and time and vehicle ownership, which can help to formulate the strategic plan to solve the transport-related problem in Dhaka.

Keywords: attribute, mode choice, travel pattern

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1. INTRODUCTION

Investigation of the travel pattern mode choice is a vital research topic in transportation research and urban planning, irrespective of developed and developing countries. It offers the background information required to better understand the complex relationship among urban structure, transportation system and people's activity participation [1,2]. The demand for travel is derived from the demand for spatially separated activities of people. Travel behaviour largely depends on a number of factors such as travellers personal/household attributes, socioeconomic characteristics, the purpose of trips, the place of origin-destination, pace of economic growth, local culture and the medium of transport under the constraints of time, cost, comfort, availability, etc. It is very important to analyse the relationships among these factors to be able to grasp current and future travel patterns as well as travel demand. The growing volume and complexity of urban travel in developing countries have become a major concern to transportation planners, service sponsors in urban area and policy makers [3-6]. People travel because they get benefits from it, or more precisely, they get benefits from the things they do or buy at the end of the trip [7]. One of the key issues of travel behaviour is the travel mode choice decision. Mode choice plays a vital role in transportation planning and policy making in any city. Past research has clearly shown that individual and household socio-economic characteristics have a strong influence on mode choice decisions. They identified income, gender, vehicle ownership, and employment status as the most influencing variables in mode choice decisions [8,9]. In most cases, a large-scale Household Interview Survey (HIS) is conducted to understand passenger movement or build the four-step travel demand forecasting model. This type of household survey has played a significant rule in addressing the urban transportation problem of cities and provide a valuable source of information for transportation planning.

With over 18 million population, Dhaka is one of the world's largest and most densely populated cities, which faces acute transportation-related problems due to unplanned urbanisation and inadequate road network with an increasing number of private and public transport. Travel activity has a deep connection with personal attributes such as age, income, sex, occupation and household car ownership. Household interview survey on Dhaka city which was conducted by the Bangladesh Bridge Authority in 2019 is used in this study to understand the travel pattern of Dhaka city dwellers and make relationships among travel-related parameters to personal/household attributes. This study can help in policy-making and traffic management to reduce traffic jams as well as to take a new transport-related project.

Although Dhaka is a very old city, few detailed household interview surveys have ever been conducted for transport planning studies, however, none have effectively achieved the basic objective of the transportation system. The first household survey was conducted for the Greater Dhaka Metropolitan Area Integrated Transport Study [10]. For the Strategic Transport Plan for Dhaka [11] and Revision and updating of the strategic transportation plan for Dhaka [12] project, a household survey was also conducted. But all of those studies cannot visualise detailed travel behaviour and mode choice factors of Dhaka city dwellers which are related to personal or household attributes. There were some limitations of these studies. As such these studies only consider single-mode trip for mode choice analysis and do not consider a multimodal trip in mode choice analysis. Household car/motorcycle/bicycle ownership were not considered in mode choice analysis. Trip frequency per person along with the number of mode interchange during a single trip was analysed. Subsequently, this study was done to overcome the previous studies and capture detailed information about the travel behaviour of city dwellers.

2. OBJECTIVES

The objective of this study is to compute the basic features of the surveys-question items. This will help in conducting similar HIS in the future, along with the purpose to clarify the relationship of the city's economic performance, transportation situations, cultural background and mode share using travel behaviour analysis or statistical models.

3. DATA

Household interview survey is a major input to transport planning studies that gather information on travel and socio-economic characteristic of the population. This survey was conducted across the Dhaka Metropolitan Region to gather data on travel patterns, mode choice origin-destination and other characteristics of trip makers in the first half of 2019. The survey was conducted on 28,235 households, which consists of 111,662 household members considering 146 Traffic Analysis Zone (TAZ). The TAZ area helps to capture accurate travel behaviour throughout the city. Fig. 1 shows the TAZ area of Dhaka city.
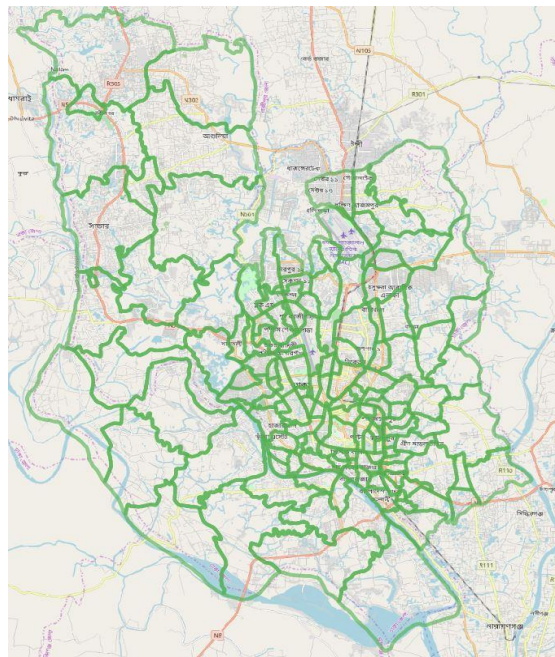

Fig. 1. Traffic Analysis Zone (TAZ) in Dhaka city

4. SOCIAL DEMOGRAPHIC INFORMATION OF DHAKA CITY

The scenario of social demographic information of Dhaka city can be observed from the household interview survey. There is a significant relationship between social-demographic attributes with travel behaviour attributes. For an understanding of the travel behaviour of city dwellers, it is important to visualise the social demographic information of the city. The survey was conducted on 28,235 households, which consists of 111,662 household members. Among them, 58,090 (52.02%) household members were male and 53,572 (47.98%) household

members were female. From the analysis, it was found that 3.95 people live together per household. Fig. 2 represents the percentage of the male and female number of the survey as well as the present scenario of Dhaka city male and female population ratio.
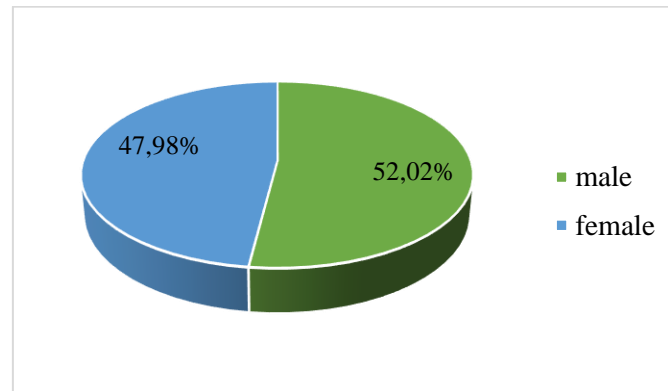

Fig. 2. Percentage of the male and female population of Dhaka city

The Occupation of Dhaka city dwellers was included in this survey. Ten criteria of occupation: student, public employee, private employee, business, agriculture, housewife, unemployed, retired, not applicable and others. People below the age of 6 years were considered under the not applicable criteria. Fig. 3 represents the percentage of occupation of Dhaka city dwellers. Student and housewife occupations capture a large percentage, 26.66 and 25.46%, respectively. It is indicated that 2.80, 16.10 and 12.76% of the people are public employees, private employees, and business people. It is remarkable to note that only 1.56% of the people are unemployed.
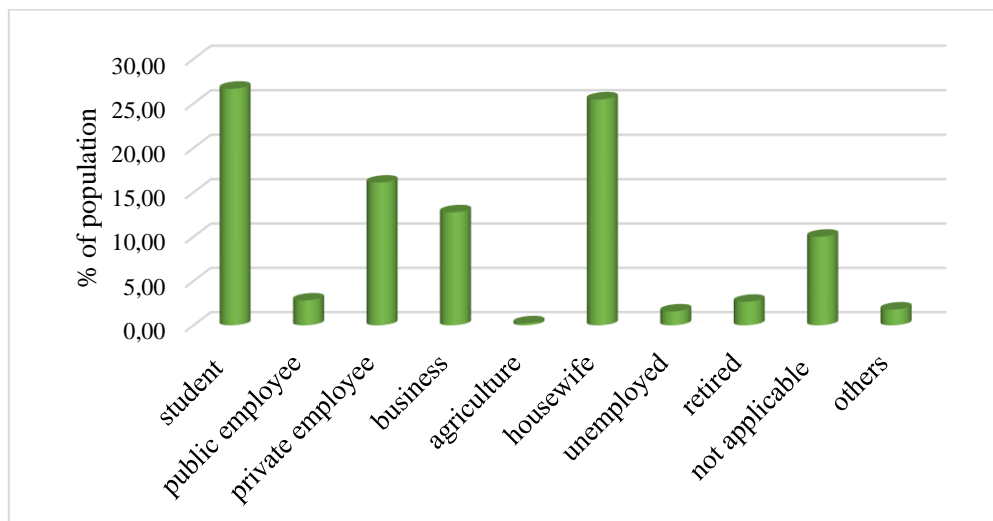

Fig. 3. Percentage of the population belongs to different occupation criteria

Fig. 4 shows the percentage of education qualification level criteria of Dhaka city dwellers. It was observed that the number of the percentage population decreased with an inverse increase in the educational qualification level. From the analysis, it was discovered that about 15% of people have graduated level education qualification.
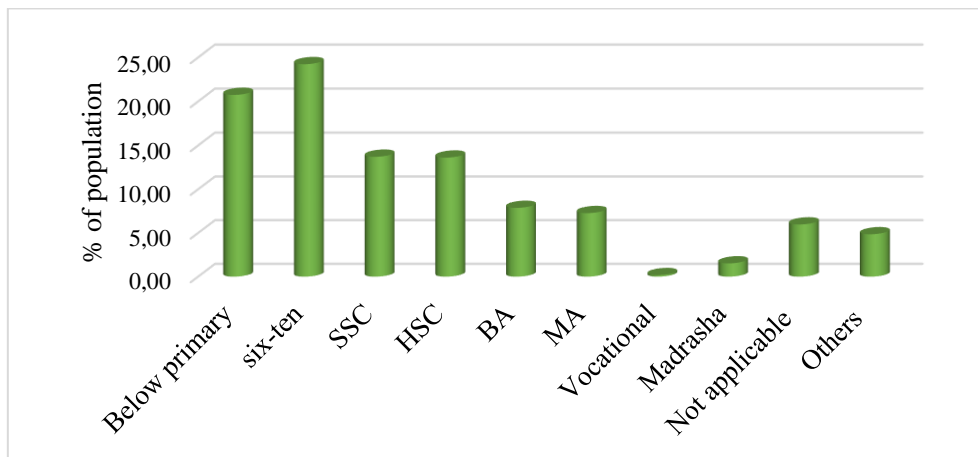
Fig. 4. Percentage of different educational qualification criteria of the population

Household income level is a vital parameter to understand the lifestyle and financial status of the city. Fig. 5 represents the percentage of different household income level criteria of the population. It was found that majority of the people belong to 20,000 to 30,000 BDT household income level criteria and 22.97% of the people belong to 30,000 to 40,000 BDT household income level criteria.
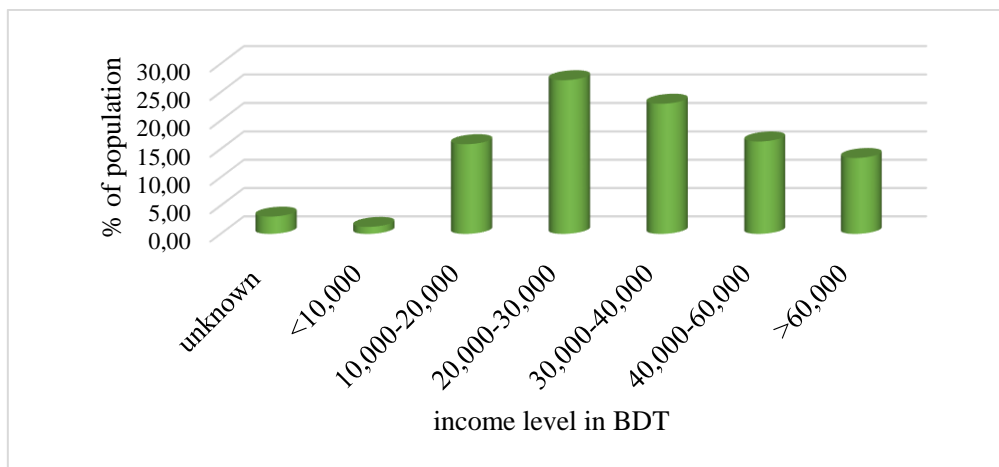

Fig. 5. Percentage of different household income level criteria of the population

The percentage of the different age level criteria in the population is shown in Fig. 6. Most of the people belong to the 21 to 30 age limit which is 22.11% of the population. Only about 3.50% of the people were above 60 years.

From this survey, it is indicated that 49.54% are trip makers on a particular survey day. And 39.85 and 10.62% are not trip makers and not applicable, respectively, in this survey. Tab. 1 shows the percentage of trip makers in this survey.
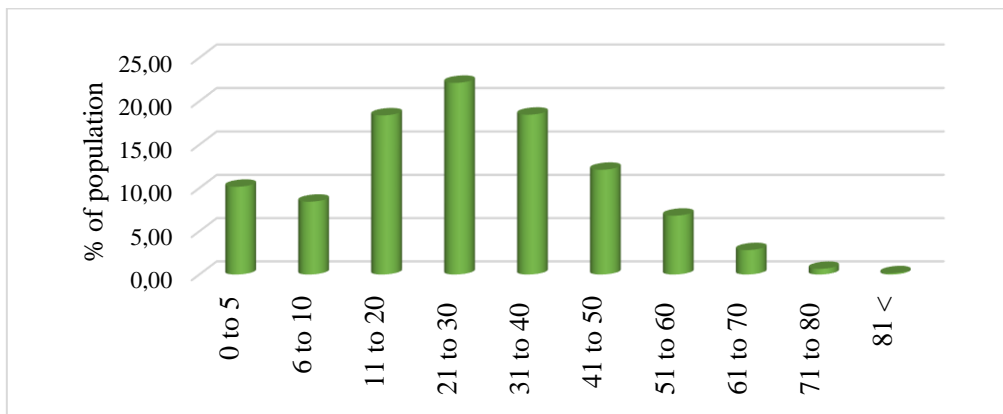
Fig. 6. Percentage of the different age level criteria of the population

Tab. 1

Percentage of trip makers in the survey

Trip maker	Number	Percentage (%)
Yes	55,315	49.54
No	44,494	39.85
Not applicable (<6 year)	11,853	10.62
Total	111,662	100.00

5. TRIP CHARACTERISTICS

Household interview survey data consists of household data, individual data, and trip data. The rate of trips per trip maker is 2.16, while the rate of trips per household is 4.20. Characteristic of trip generation is influenced by different factors such as sex, income, education, occupation, time and purpose. It is important to understand the proper transportation-related policy. This section represents the variation of trip generation attributes considering social demographic factors.
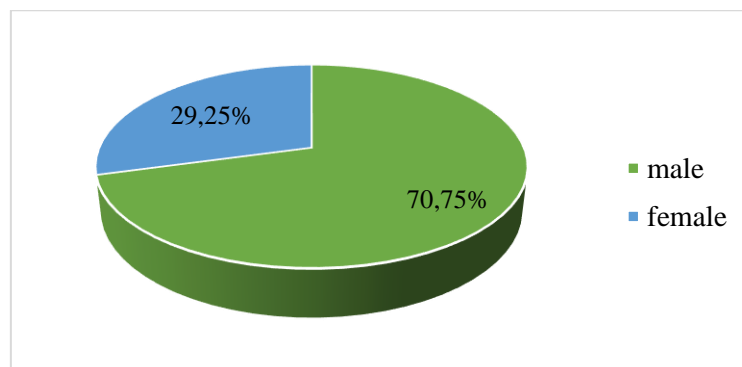

Fig. 7. Percentage of trip generation by gender

Fig. 7 represents the gender characteristics of travellers analysed against the number of trips. Males are mostly responsible for trip generation in Dhaka city. 89.78% of the people of Dhaka city make double trips per day. Trip frequency per person per day is shown in Fig. 8.
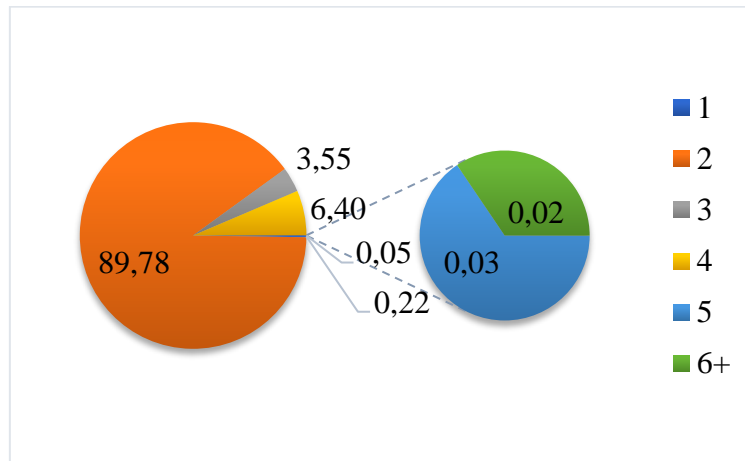

Fig. 8. Percentage of travellers according to the number of trips

Fig. 9 shows the proportion of trips and their departure times. The morning peak in Dhaka is quite pronounced, with about 14% of all trips generated around 7 to 8 AM.
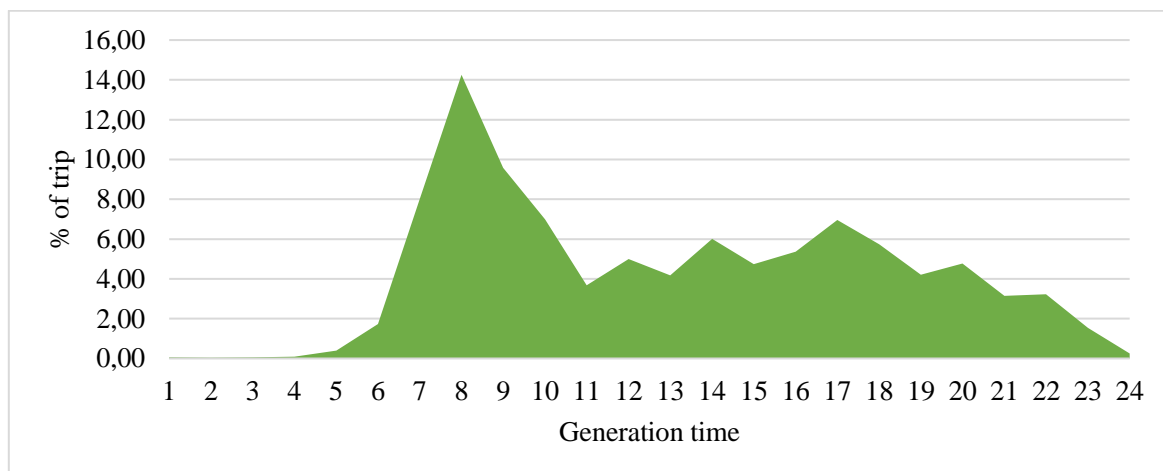
Fig. 9. Percentage of trip generation time

In the case of trip purpose, 56.05, 26.72, 7.19, 4.09 and 3.57% trips were generated for work, education, personal issues, shopping and leisure purpose from home. On the other hand, the house is the dominating trip destination place or trip purpose from trip origin excluding home place. Tab. 2 represents the trip percentage according to the trip purpose. And Tab. 3 visualised the trip categories according to home base and non-home base trip. 97% of all the trips have linkage with the home for its start end or its end and it is really high compared to other cities.

Tab. 2

Percentage of trip generation from origin according to purpose

Origin/ Destination	Home	Work	Education	Shopping	Medical	Personal issues	Leisure	Other	Total
Home	0.02	56.05	26.72	4.09	1.91	7.19	3.57	0.44	100
Workplace	92.34	5.75	0.07	0.50	0.09	1.10	0.07	0.09	100
Education	98.61	0.38	0.14	0.21	0.01	0.49	0.10	0.05	100
Shopping	96.77	0.76	0.04	0.65	0.15	1.26	0.27	0.11	100
Medical	95.89	0.86	0.00	0.94	0.34	1.63	0.09	0.26	100
Personal issues	94.35	1.41	0.17	0.86	0.34	2.26	0.30	0.32	100
Leisure	96.99	1.70	0.00	0.28	0.14	0.52	0.28	0.09	100
Others	90.68	5.14	0.64	0.32	0.32	1.61	0.32	0.96	100

Tab. 3

Percentage of trip base on home base and non-home base trips

Type of trip	Percentage of trip (%)
Home base trip	97.188
Non-home base trip	2.8112

Although student and housewife occupations capture the large percentage of the population in the city, the private employee is the major occupation responsible for 29.45% of trips. Fig. 10 shows the distribution (in percentage) of trips by occupation. The relationship between trip and education is shown in Fig. 11.
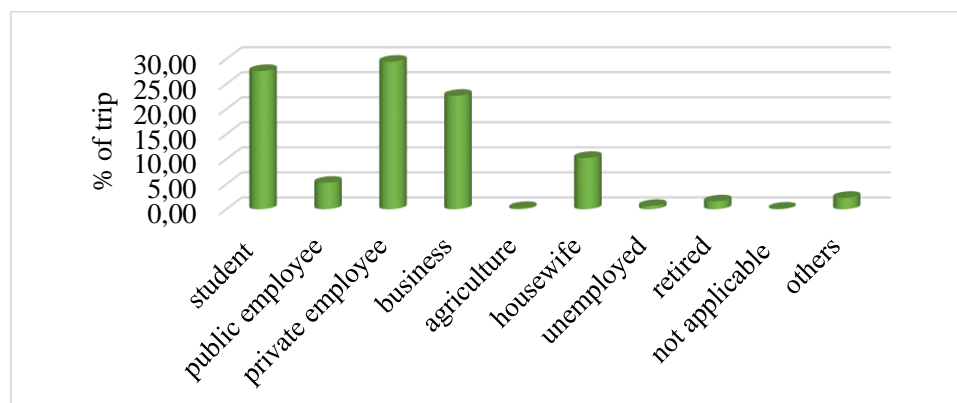

Fig. 10. Percentage of trip generation by occupation level

Household income represents its ability to pay for a trip and the number of trips generated by a household. A general trend is that the higher the income, the higher the trip generation rate. Figs. 12 and 13 visualise the distribution of trips according to household income level and age level, respectively. Household income level directly represents the personal income level. From the analysis, it was discovered that household income levels 20,000 to 30,000 and 30,000

to 40,000 are most responsible for trip production. With the increase in household income, trips per person increased along with the majority of the trips generated by 21 to 30 and 31 to 40 age level people.
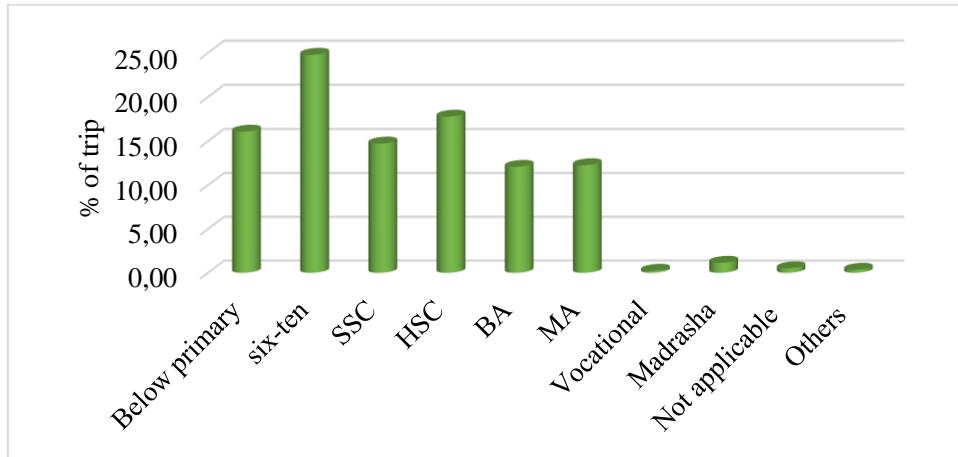
Fig. 11. Percentage of trip generation by education qualification
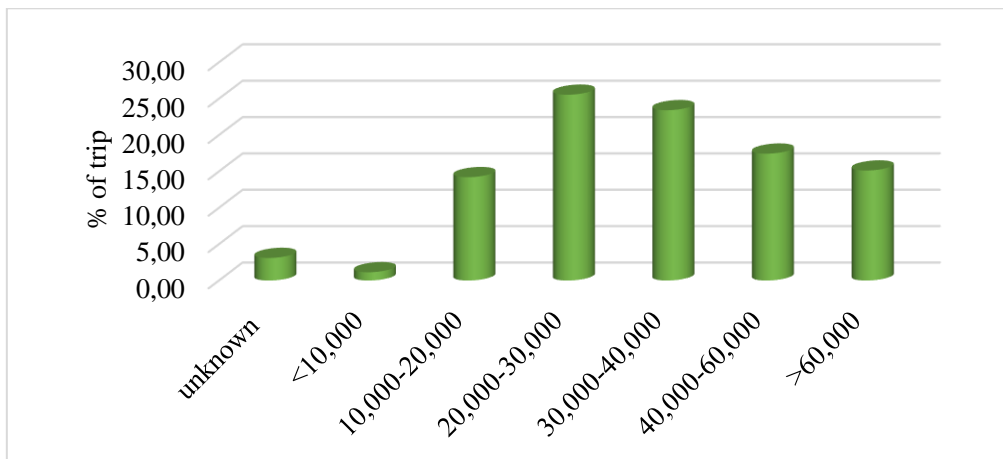
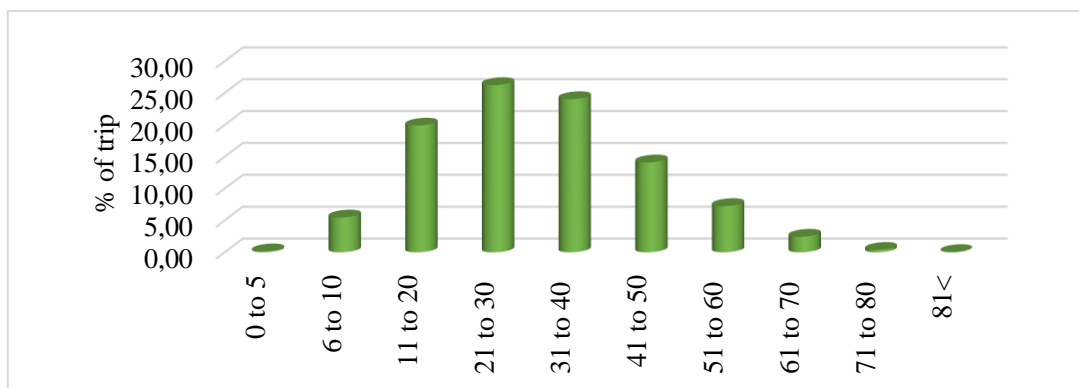Fig. 12. Percentage of trip generation by household income level

Fig. 13. Percentage of trip generation by age

6. MODE CHOICE ANALYSIS

The issue of mode choice, therefore, is probably the single most important element in transport planning and policy making. It affects the general efficiency with which city dwellers can travel in urban areas. Therefore, it is important to develop and use a model that is sensitive to the attributes of travel that influence the individual choice of mode. Characteristics of the trip maker, characteristics of travel and characteristics of transport facility are the three major components to influence mode choice. This section will represent the relationship between the trip maker and the mode. All available ten types of mode are considered in the household survey. In Dhaka, train and water vehicles are not available as modes of transport.
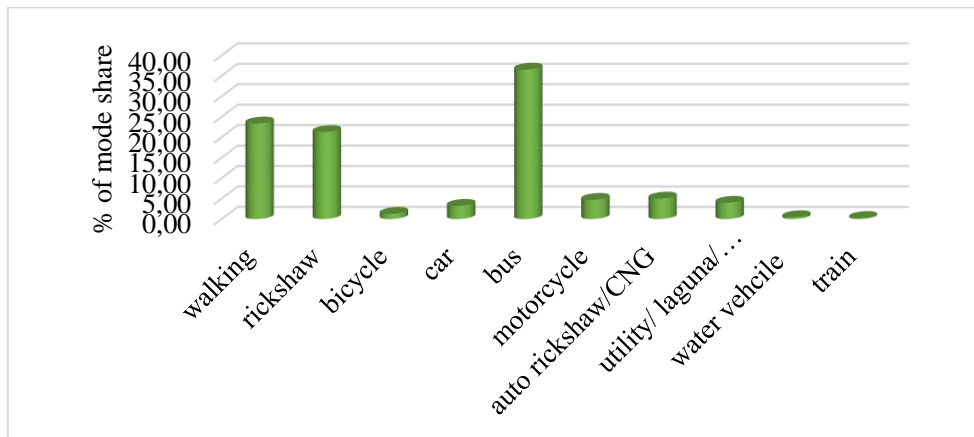
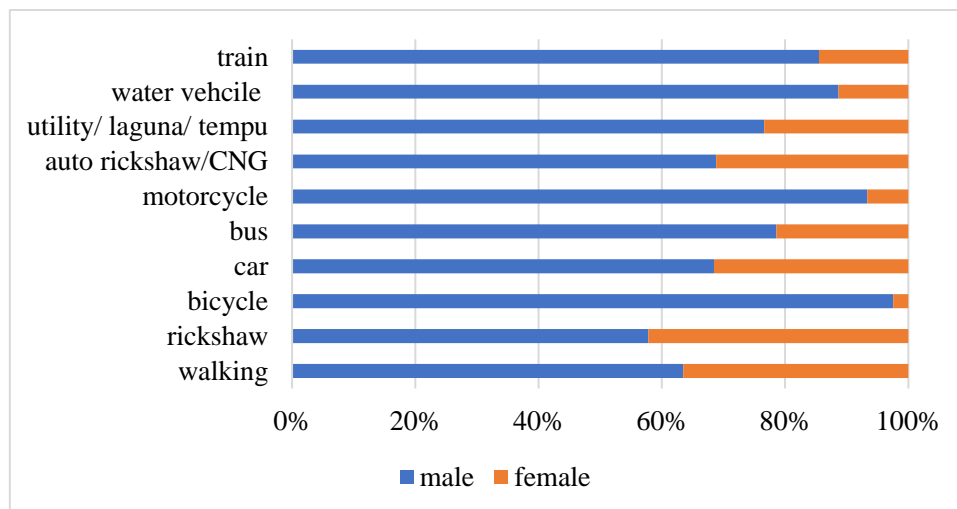Fig. 14. Percentage of mode share considering the trip number

Fig. 15. Percentage of gender category considering different modes

Fig. 14 shows the main mode share during the trips of Dhaka city dwellers. Bus trips are the biggest in Dhaka, about 35% of trips are governed by bus. Walking and rickshaw are second and third dominating mode choice. For short travel distance, the rickshaw is used by dwellers. Although most of the road space is blocked by cars, they occupied less than 5% of the total trip to Dhaka city. With the increase of the ridesharing system and for the avoidance of traffic congestion, people are interested in using the motorcycle and the mode share of the motorcycle

has had increasing complains in the last few years. Mode choice of auto-rickshaw/CNG and utility/laguna/tempu is lower than the bus and those modes are preferred for short to medium travel distance. Dhaka is not designed for a dedicated lane for bicycles, hence, the percentage of mode share of the bicycle is comparatively low. Dhaka has only one rail line for intercity service with the absence of an urban rail service. In this case, the opportunity for using the train is approximately low for city people. And water vehicle is only available in the old Dhaka area. Moreover, mode share is not so high considering the urban area of Dhaka.

Gender is one of the key factors for mode choice. Figs.15 and 16 show the mode choice by gender. Females prefer walking and rickshaw rather than other modes. The bus is the domination mode preference for males along with bicycles, motorcycles are only preferable by males.
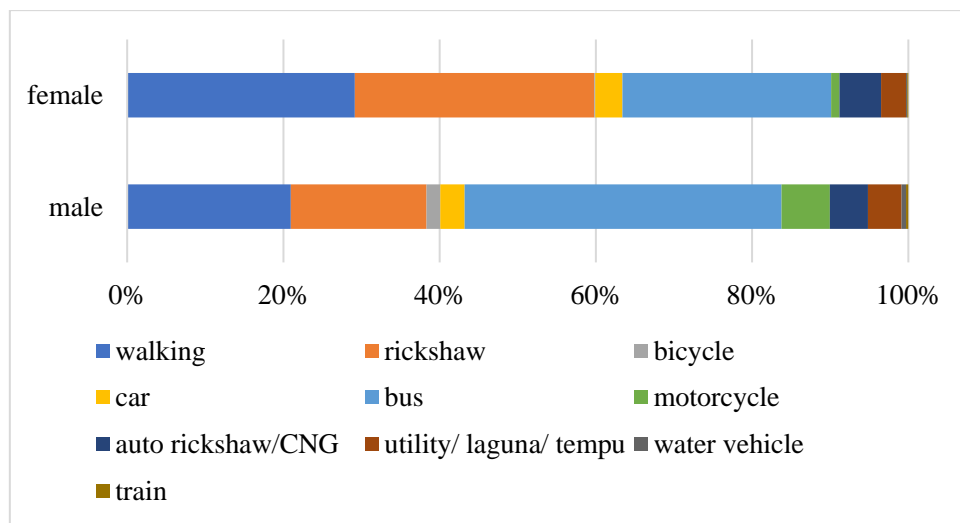

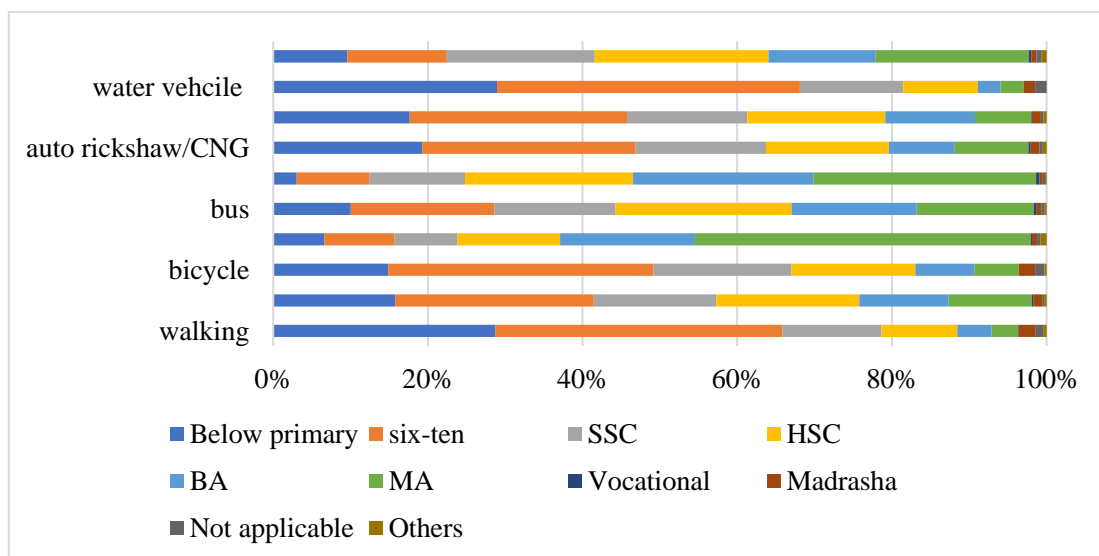Fig. 16. Percentage of mode share considering gender

Fig. 17. Percentage of education level considering different modes

Figs. 17 and 18 represents the mode choice by education level. Mode preference for walking and rickshaw is gradually decreased with the increase of education qualification level. The major share of car and motorcycle trips are performed by the graduation qualification (BA and MA) people. But the car is more shared by MA than BA education level. The bus is the major mode share for all education qualification people. Walking is the most dominant mode share for below primary level and six to ten class people. Furthermore, it is also noted that walking is also a major share for the madrasha student people.
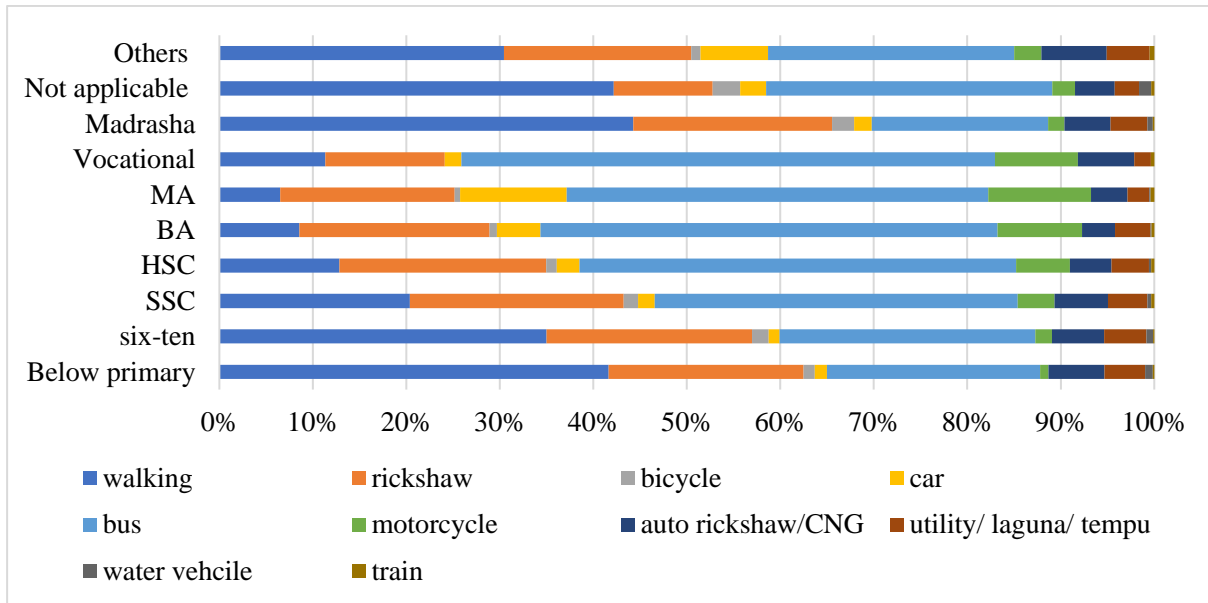
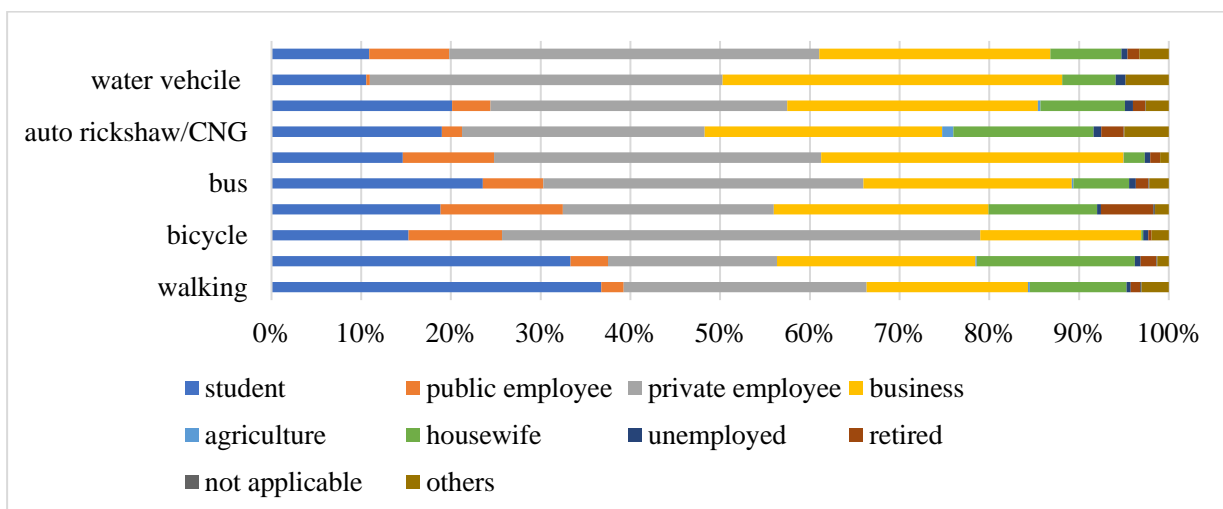Fig. 18. Percentage of mode share considering education levels

Fig. 19. Percentage of occupation considering different modes

The choice of mode diversifies with the variation of occupation. Figs. 19 and 20 represent the mode choice by occupation. The majority of mode share is captured by private employees and the bus is the main mode for the private employee. Walking and rickshaw are the domination mode for students because the majority of trips were performed within short

distance. 50% mode share of bicycle is occupied by private employee people. Not applicable part was only captured by the less than six-year age people and out of the list which is not so common are included in others.
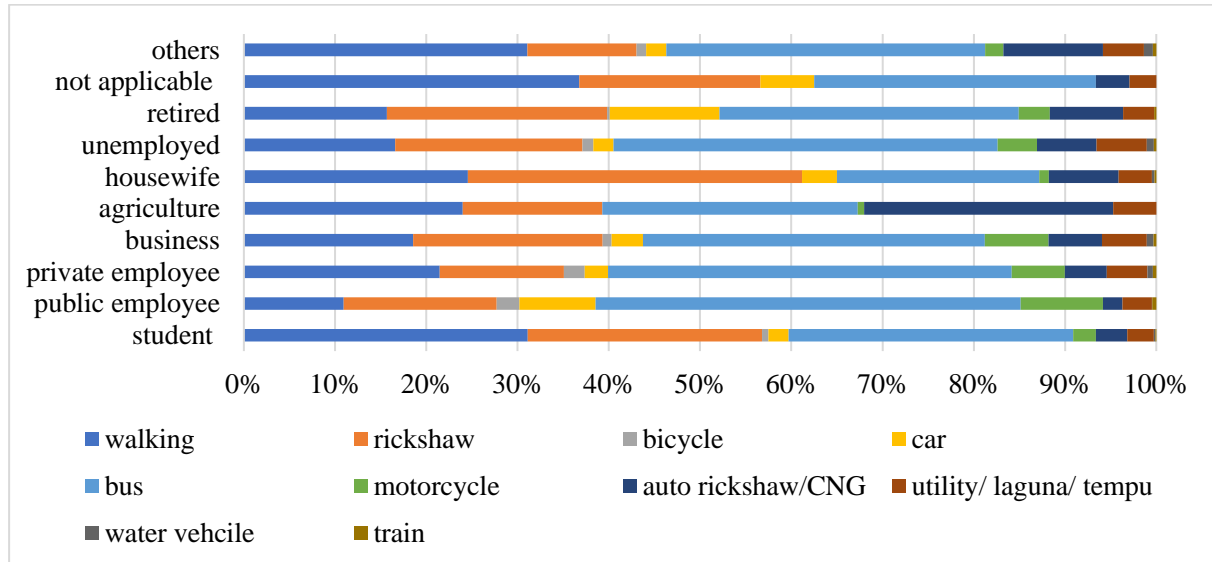

Fig. 20. Percentage of mode share considering by occupation

Household income has a strong impact on mode choice. Higher-income households and persons are thought to place a higher value on the comfort and convenience associated with private auto. Figs. 21 and 22 indicate the mode choice by household income level. With the increase in household income, the percentage of mode share of walking gradually decreased. On the other hand, the percentage of car and motorcycle mode share gradually rose with the increase in household income. About 65% of users of car belongs to greater than 60,000 BDT household income.
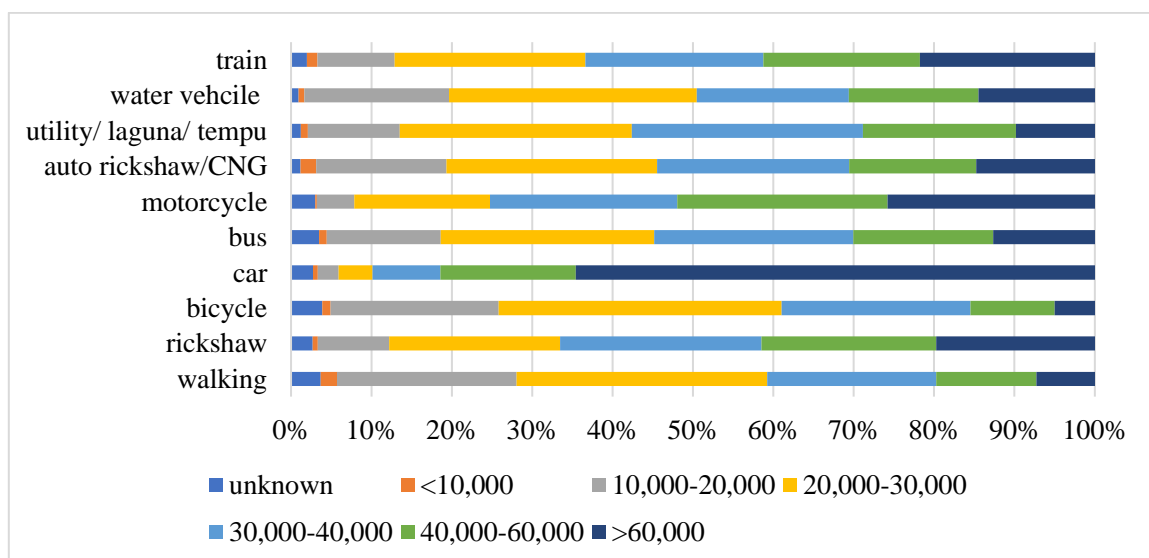

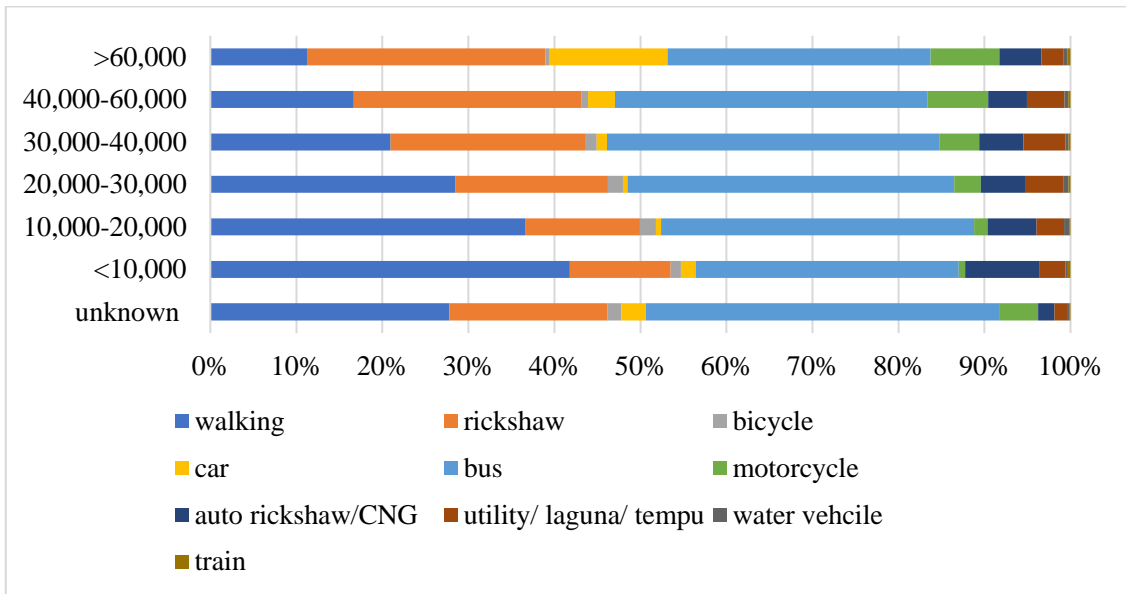Fig. 21. Percentage of household income level considering different modes

Fig. 22. Percentage of mode share considering household income levels

Figs. 23 and 24 represents the mode share scenario by age. Car is a preference for the oldest people and preference gradually increases with the increase of age for safety. Middle-aged people usually prefer the bus, rickshaw, and walking mostly for their trips.
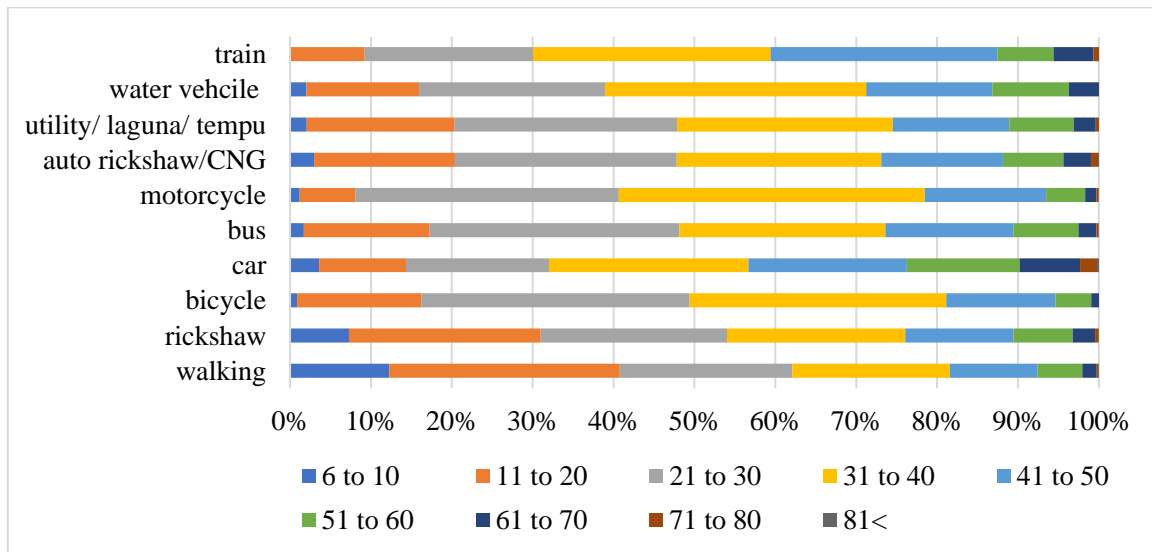

Fig. 23. Percentage of age considering different modes

Figs. 25 and 26 show the mode share by purpose. The purpose is a significant issue for mode choice. Home and work are the two major purpose of all trips. Work and home purpose capture about 80 to 90% trip share for all modes. People prefer cars for personal issues and leisure rather than for work trips. Walking is not preferable for medical purpose.
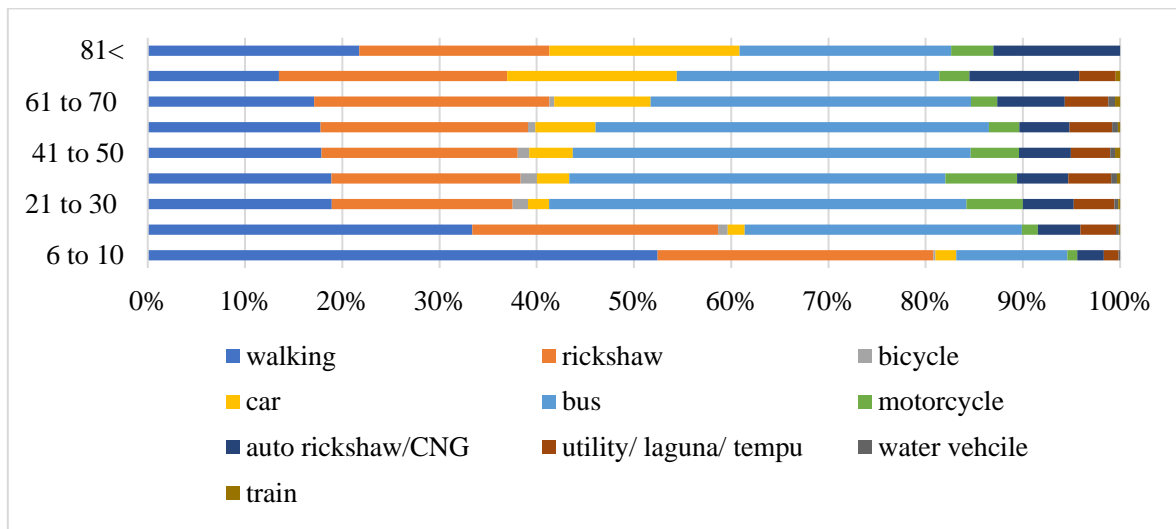
Fig. 24. Percentage of mode share considering age
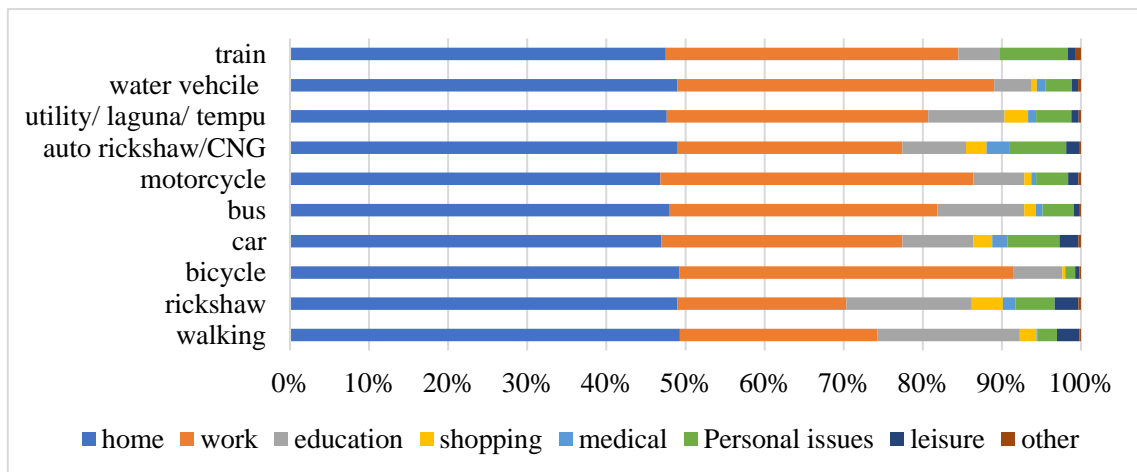

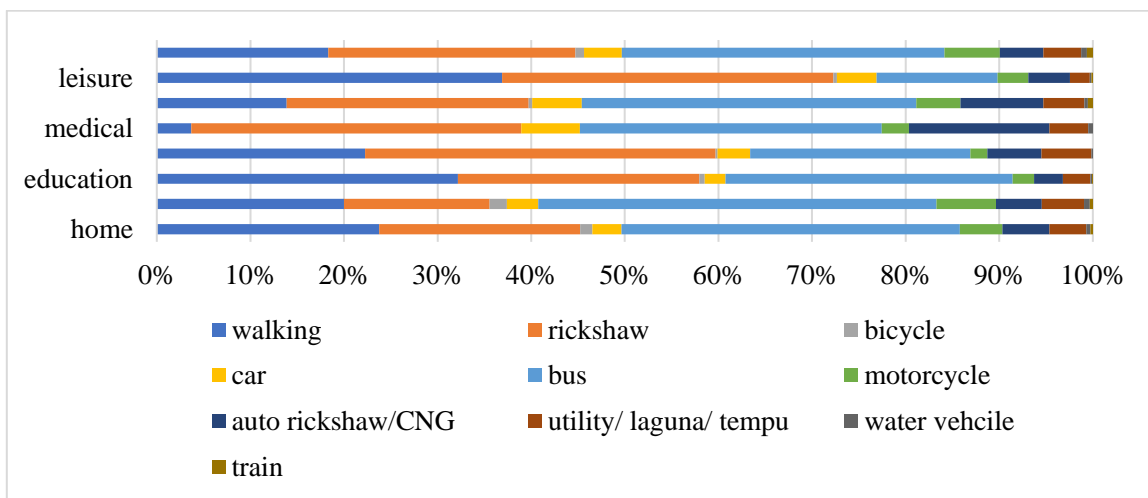Fig. 25. Percentage of purpose considering different modes

Fig. 26. Percentage of mode share considering purposes

Figs. 27 and 28 show the mode share by trip generation time. Most of the trips for all modes were generated during the morning peak between 7 to 9 AM. There is another peak time found in the evening peak at 5 PM for all modes. But the percentage of share of the evening peak is almost half of the morning peak for all modes.
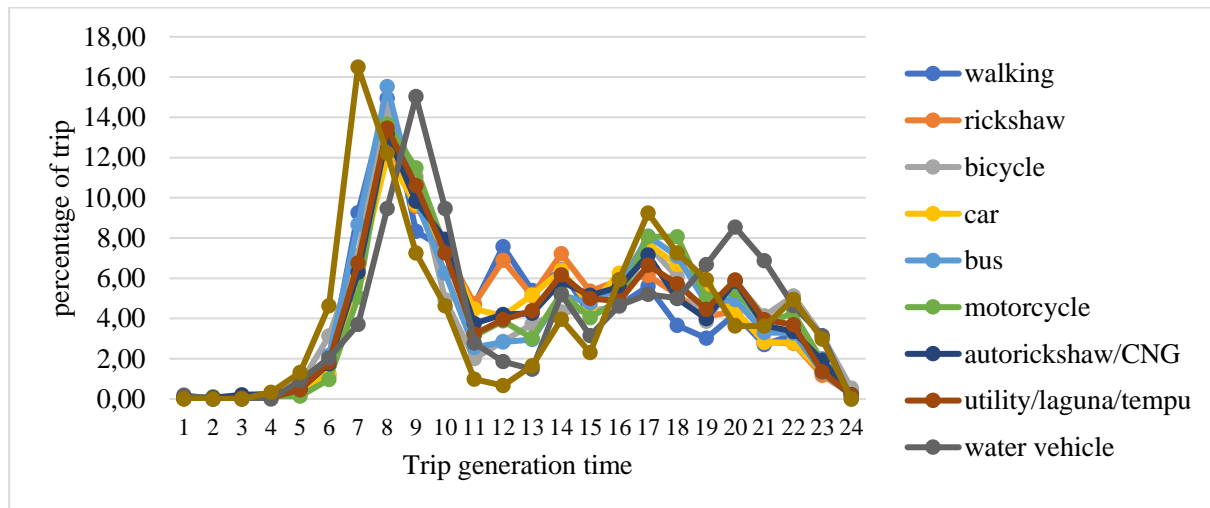

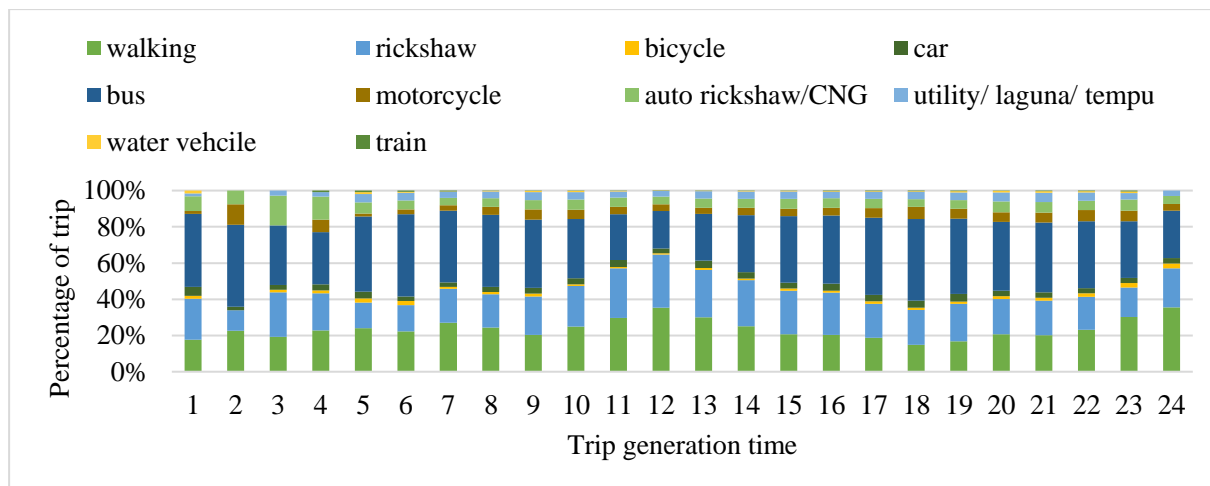Fig. 27. Percentage of departure time considering different modes

Fig. 28. Percentage of mode share considering departure times

7. MULTIMODAL TRIP CHARACTERISTIC

Multimodal trip making, that is, trips using a combination of several modes between origin and destination, is expected to be beneficial to the society and might offer advantages to the traveller as well. This may consist of different vehicles, such as a car, bicycle, bus or different services, such as stop or express services. A multimodal trip, thus, always consists of two or more legs with different modes between which a transfer by foot is necessary. Typical examples of multimodal trips are chains such as walk-bus-bicycle-walk. From the analysis, it was pointed out that 46.80% of trips of Dhaka city are unimodal trips, which consist of single-leg on a trip

and other trips are multimodal. Walking is the major mode for single leg trip. Fig. 29 shows the percentage of unimodal and multimodal trips. 22.78% trips consist of two legs on a single trip and 25.81% trips consisted of three legs on a single trip.
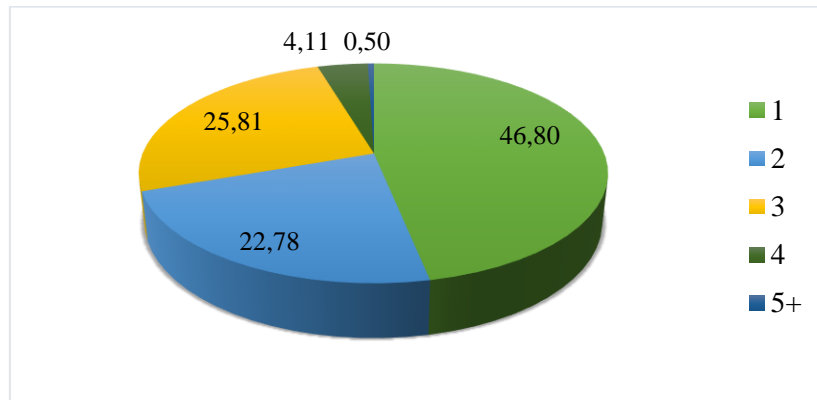

Fig. 29. Percentage of multimodal trip

Previous studies have neglected the complete mode share in the multimodal trip, only analysing the mode share for the main mode on a trip. Without considering the multimodal trip analysis, it is difficult to understand the complete transport system. Fig. 30 shows the mode share considering a multimodal trip. It was found that more than 45% of trips were made by walking, which is one of the major dominating modal shares in Dhaka. Because the first and last leg of the trip is performed by walking mode in the majority of multimodal trips.
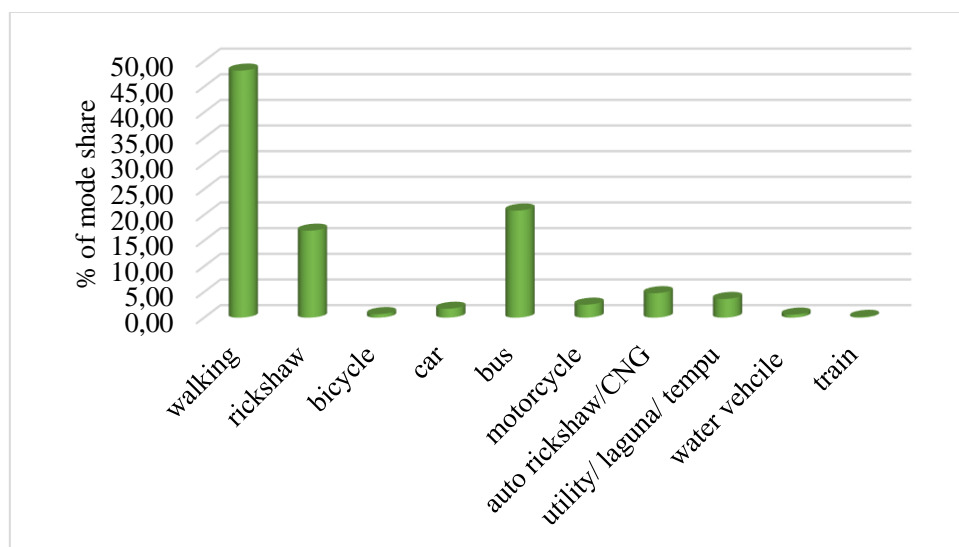

Fig. 30. Mode share considering multimodal trip

Fig. 31 shows the comparison of mode share between the main mode and all mode in the multimodal trip. Except for the mode share of walking, other modes share were comparatively lower for mode share of multimodal trips than mode share of main mode in trips.
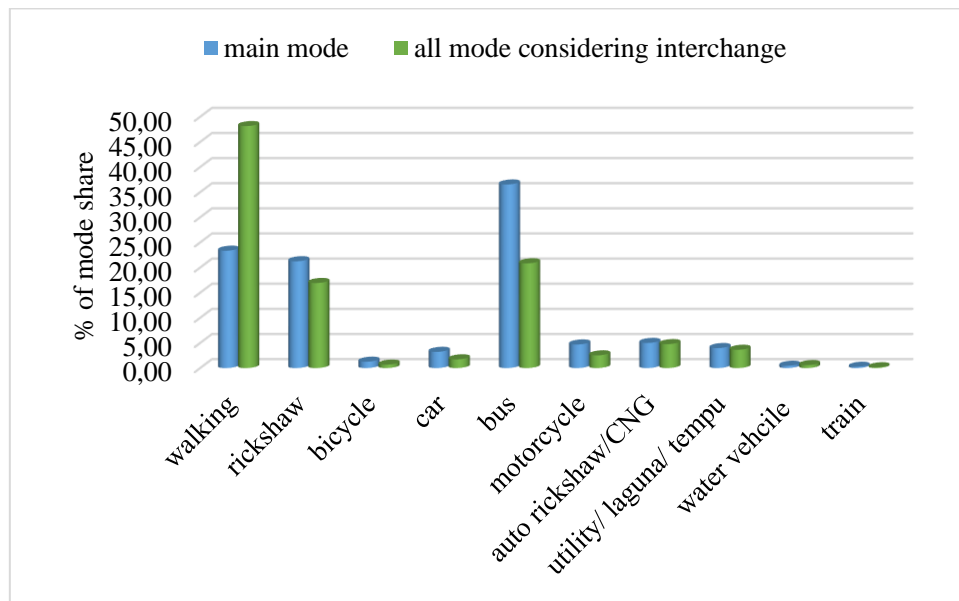
Fig. 31. Comparison of mode share between main mode and all modes in multimodal trip

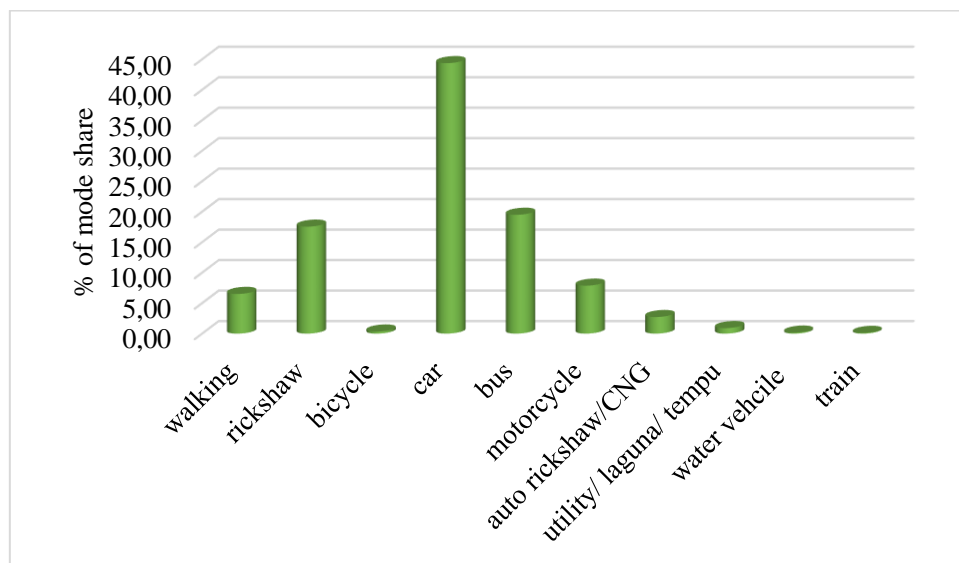## 8. MODE SHARE CHARACTERISTIC OF VEHICLE OWNERSHIP

Fig. 32. Mode share for only household car ownership

Researchers have identified that vehicle ownership is a fundamental element in travel-related decision-making processes in Asian cities [13,14]. This section will identify mode share for the car/motorcycle or bicycle household ownership. Dhaka is not well furnished with public transport such as a bus. Recently, vehicle household ownership significantly increased in the bid to avoid trouble in public buses.

Car ownership is regarded as a vital variable in travel pattern and mode choice. Car ownership has a direct linkage with the income level of a household. Fig. 32 revealed that more than 40% of all trips for car ownership households was generated by car and Fig. 33 compares

the mode share for all household and car household ownership. It was noted that high-income families have household cars. Hence, bicycles and other public modes for comfort and safety were not preferred. It is also indicated that modal share of motorcycle and of car ownership household is comparatively higher than the general household because of high income. Percentage of those using walking and rickshaw as a mode is approximately lower for car ownership household people than other people.
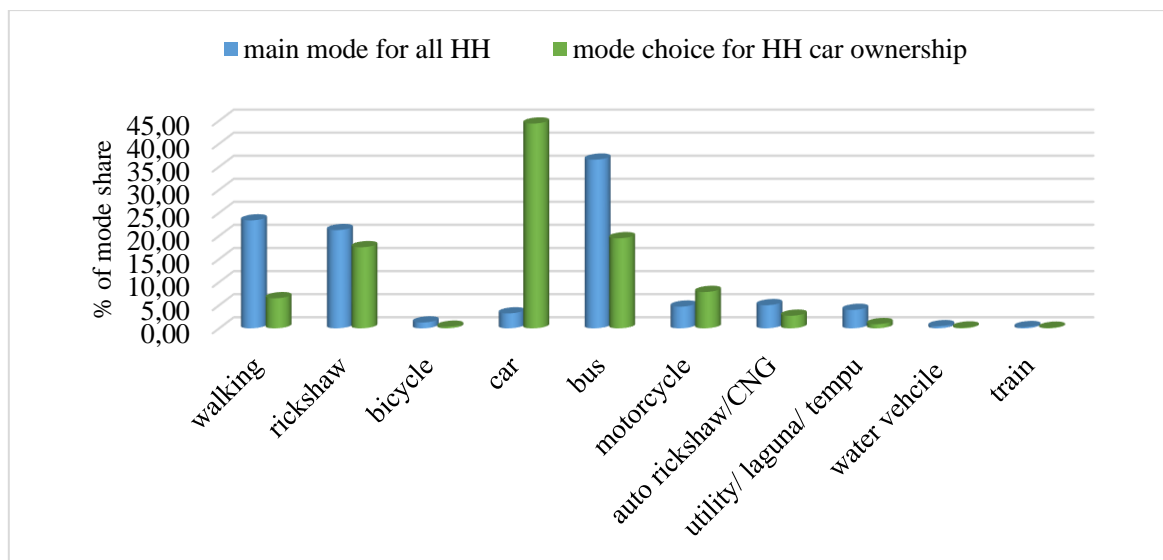

Fig. 33. Comparison of mode share between all household and car ownership household

Fig. 34 points out that about 35% of all trips for motorcycle ownership households was generated by the motorcycle and Fig. 35 compares the mode share for all household and motorcycle household ownership. The mode share of the motorcycle is higher for those people who belong to the motorcycle ownership household. Moreover, it was found that the private mode; car and motorcycle is higher than in other public modes. Mode share of walking and rickshaw are comparatively low for motorcycle household ownership people.
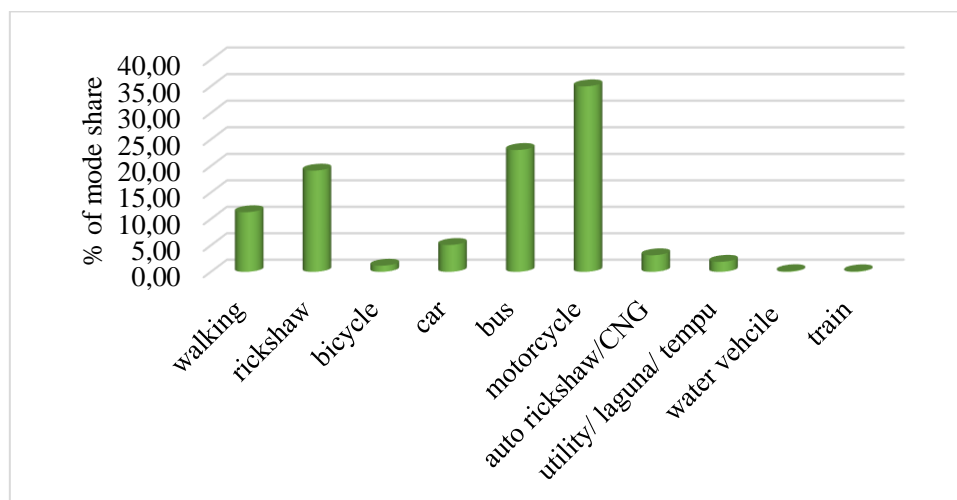

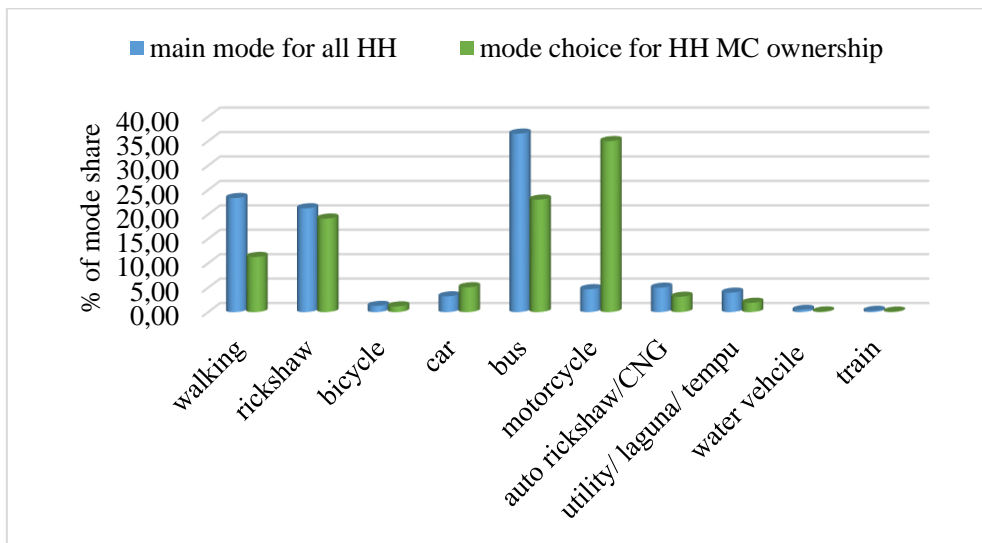Fig. 34. Mode share for only household motorcycle ownership

Fig. 35. Comparison of mode share between all household and motorcycle (MC) ownership household

Except for the mode share of the bicycle, other modes share are comparatively lower for bicycle ownership than other people. Fig. 36 shows that more than 15% of all trips for bicycle ownership households was generated by the bicycle and Fig. 37 compares the mode share for all household and bicycle household ownership.
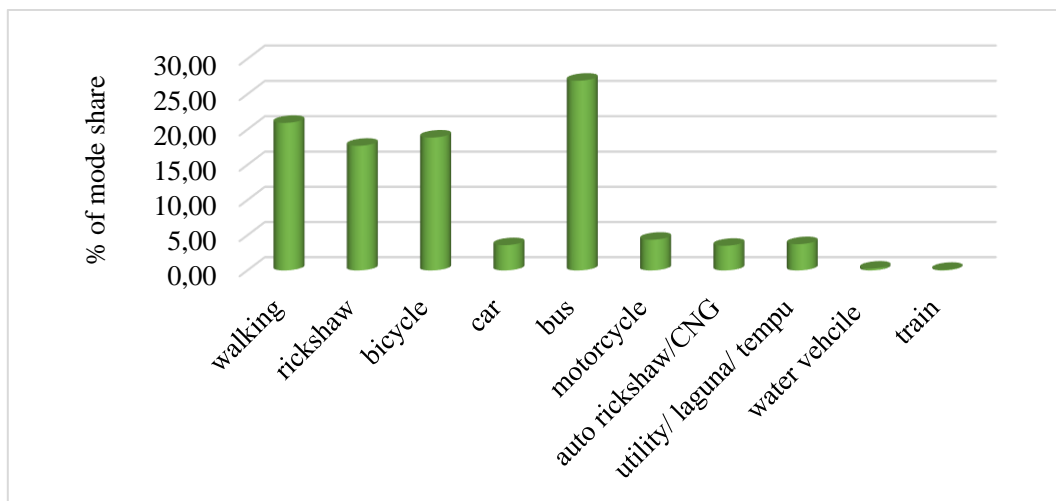

Fig. 36. Mode share for only household bicycle ownership

Household vehicle ownership represents a significant factor for mode choice for a household member. Preference for walking, rickshaw and other public transport modes are approximately low for vehicle household ownership. Given that Dhaka is not well designed for bicycles, in this case, the number of bicycle ownership is insignificant. To reduce both traffic jams and the number of car ownership, policy makers can take a step to increase bicycle ownership. Additionally, it is necessary for the eco-transportation system.
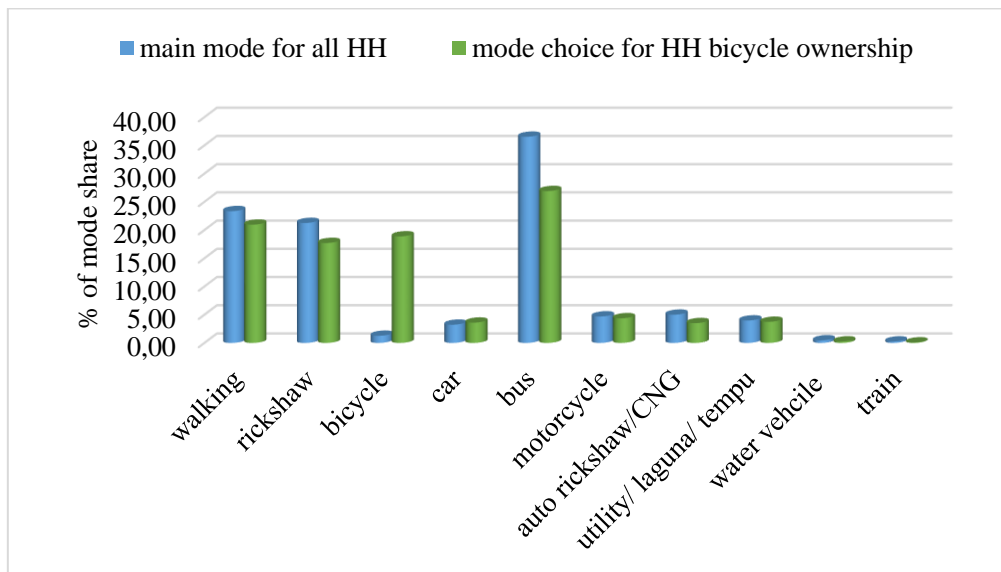
Fig. 37. Comparison of mode share between all household and bicycle ownership household

9. DISCUSSIONAND CONCLUSION

This paper analysed the travel and social-demographic characteristics of trip makers of Dhaka city dwellers using a household interview survey which opens a new avenue for researchers involved in transportation planning for Dhaka city. Demonstrating the relationship trip characteristics with age, gender, occupation, education as well as modal share analysis considering attributes; gender, age, occupation, education, multimodal and vehicle ownership. This study found out that walking is the domination mode share for multimodal trips. And the bus is the main mode share for Dhaka. Walkway in Dhaka is not well established along with a public bus that fails to provide better service. Policy makers need to be concerned about providing a better facility in walking and bus priority related project. This will help in reducing traffic jams, which is one of the major problems in Dhaka city. Furthermore, this paper described the travel pattern of Dhaka, which will help in any development project related to transport. However, this analysed data does not include precise Level of Service (LOS) and trip distance, thus, the close relationship between travel behaviour with LOS and trip distance should be examined by future analyses.

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