

TRIP GENERATION IN KHULNA CITY: A HOUSEHOLD BASED ANALYSIS

Mehedee Hassan ^{*1}, Showmitra K. Sarkar ², Muhammad Salaha Uddin ³ and M. Mokhlesur Rahman ⁴

¹ Student, Dept. of URP, KUET, Bangladesh, e-mail: mehedee.hassan41@gmail.com

² Student, Dept. of URP, KUET, Bangladesh, e-mail: dhrubo008@hotmail.com

³ Assistant Professor, Dept. of URP, KUET, Bangladesh, e-mail: msupavel@yahoo.com

⁴ Lecturer, Dept. of URP, KUET, Bangladesh, e-mail: mrahman.buet03@gmail.com

ABSTRACT

Trip generation and trip characteristics are essential in transportation planning process. A very small change in trip generation or trip characteristics can induce the necessity of new transportation infrastructure or the redevelopment of the existing infrastructure. Understanding and analyzing the trip characteristics and generation are pivotal concern in transportation planning process. Failure to do so can cause obsolescence the functionality of newly developed infrastructure and produce traffic congestion and road accident, engendering loss of valuable life, time and money. Considering this situation this study was conducted to determine the total number of trips generated in ward 19, 20 and 21 within Khulna City Corporation (KCC) area using cross-classification method. Moreover, this study also analyzed the trip characteristics based on socio economic factors of households. The study was carried out based on primary data that were collected from household based questionnaire survey. It is found that in the study area 7, 8369 trips were generated and Home Based Work (HBW) trips had the highest contribution in the total trip production. The study also found that with the increase of auto ownership the number of trip production reduced, however long distance trip increased. It is also observed that many people use rickshaw as their mode of transport despite of having higher number of auto ownership for short distance travel. The maximum numbers of trips are generated by the middle income people earning BDT 15000 to BDT 35000 per month. On the other hand, the high income people with earning more than BDT 35000 per month produced the least number of trips. Finally, this study suggested further investigation, in this field to understand the trip characteristics at city scale.

Keywords: *Transportation planning, trip generation, cross classification*

1. INTRODUCTION

Estimation of total number of trips and finding their characteristics (e.g. trip type, trip length, cost of trip, trip in peak and off peak period, relation between occupation and trip number) are very important for the transportation planning in urban areas of Bangladesh. Considering this importance the study is conducted to find out the trip generation in some selected areas of Khulna city and to predict the travel behavior of residents. Khulna is the third largest metropolitan city of Bangladesh. The population of the city is increasing gradually (Chowdhury, 2013; Dhaka Mirror, 2013). As a result, the number of trip is also increasing. Due to the economic development the number of vehicle ownership increases which boost up the vehicular trips. If the transportation system is not properly planned the road network will easily lose its capacity to serve the continuously growing number of trips. This will result in traffic congestion and road accident. Bangladesh is a densely populated country with a very small geographic area and every inch of land is precious so once road infrastructure is developed their further modification and extension is difficult since it is related with lot of sophisticated issue like land acquisition, resettlement and sufferings to the traveler. So unplanned transportation system will cause loss of property, life and time in future. Hence, it is clear that for designing a better transportation system of a city, the knowledge of present number of generated trips and their characteristics is very important.

2. LITERATURE REVIEW

Transportation planning is the total process of design, assessment and evolution of the transportation facilities (e.g. roads, railways, terminal, depots, parking area) for increasing accessibility and mobility of people, better connectivity between different regions and ultimately contributing in productivity and economic growth. In the process the user of the facilities (e.g. community people, businessmen, financial organizations and other necessary organizations) should be involved by the metropolitan planning organization (Mehub, 2004). For designing the transport facilities it is required to determine the present and expected future volume of trips of an area. For estimating total number of trips in a particular area authorities mainly use the four step urban transport

modeling (Mwakalonge & Badoe, 2012). The very first step of this model is trip generation. Trip generation estimates total number of trips that originate and end in each zone for a given jurisdiction. The zone that contains the origin end of trip is considered to have produced the trip and destination is said to have attracted the trip (Sekhar, et al., 1997). All the trips that begin or end at home is known as Home-Based Trip (HBT) and the trips that neither begin nor end at home are known as Non-Home Based Trip (NHBT). Various empirical studies mainly used linear regression and cross-classification methods to estimate total number of trips (Montealegre, et al., 2010; Rahman, 2011; Ahmed, et al., 2014; Chang, et al., 2014; and Al-Taei & Taher, 2006). Cross-classification method is often known as category analysis. Cross-classification using disaggregated approach divides people into some homogenous groups for determining trip rate based on household characteristics (e.g. population, income level, auto ownership, number of worker) considering different strata of population. The technique is non-parametric because it does not consider any probabilistic distribution between the dependent and explanatory variables. This method uses raw data obtained from household questionnaire survey. Many researchers use these methods due to its simplicity (i.e. simple method of analysis, not required to assume any prior information on shape of curve) (Montealegre, et al., 2010; Al-Taei & Taher, 2006; Mwakalonge & Badoe, 2012). The method, however, has some shortcomings. This method requires large number of samples which is both costly and time consuming to collect (Ortuzar and Willumsen, 2011). Cross-classification does not allow extrapolation and statistical goodness of fit measurement (Chang, et al., 2014).

In Dohuk a city of Iraq the standard of living of residents has grown up and many people were obtaining private car. In the last four years considerable amount of car and trips increased but transportation facilities (e.g. road width, road lane, parking facilities) remained same as a result causing traffic jam, road accident and increasing demand of parking facilities. In this context, Al-Taei & Taher (2006) used 2437 household survey data for cross classification method to predict the trip rate production and travel pattern of Dohuk city's residential area. The research found that maximum numbers of trip were Home Based work (68%) and only 7% of total trip were None Home Based (NBH) in nature. The study predicted that, trip rate would increase with the increase in family size and car ownership by each family but the private trips per household were predicted to increase even if the families not having any vehicle. In future the trip rate of family with zero and one car will increase on the other hand trip rate of family having two or more than two cars will decrease. The contribution of workers to the total trip production will be the highest. Finally author concluded though trip production depends on many factors (e.g. family size, income level, number workers, and car ownership) the main factor influencing trip production is car ownership.

3. STUDY AREA PROFILE

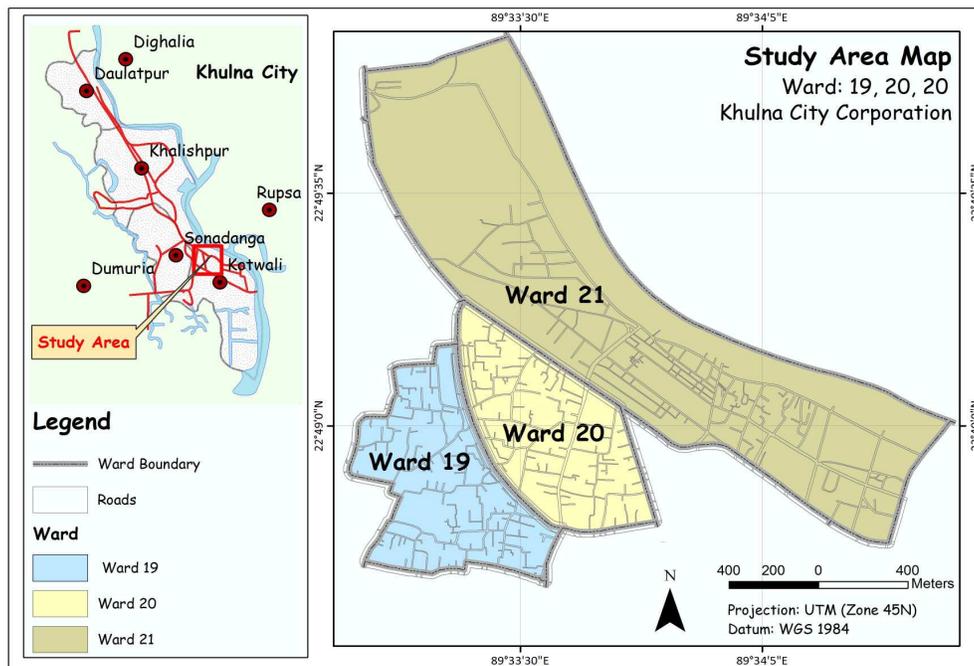


Figure 1: Map of ward 19, ward 20 and ward 21 of Khulna City Corporation

The study area selected for this study is one of the busiest places in Khulna city and considered as the heart of the Khulna city. The study area covers ward 19, ward 20 and ward 21 of Khulna City Corporation (KCC). Ward 21 is mostly covered by railway station, a railway colony and a local market known as Boro Bazar. The inhabitants of this ward are mostly low income people. Among the three wards, the households in ward 20 seemed very much wealthy compared to the other two wards. Both, medium and high income group people live in ward 19. The study area is connected by some major routes: *Moynapota to Dakbangla*, *Moynapota to Rupsha*, *Moynapota to Shib Bari*, and *Moynapota to Nirala* which have made the area more accessible from other parts of KCC.

4. DATA COLLECTION AND METHODOLOGY

A reconnaissance survey was conducted in the study area to get overall picture and rough primary data of the wards. This survey helped the study to observe the existing physical and overall conditions of the wards. Then questionnaire for household survey was prepared to collect necessary information. The questionnaire was finalized after pre-testing through pilot survey. Information on various independent variables such as age, gender, education and employment status, household size, household income, vehicle ownership, number of worker or student in the family, driving license, trip purpose, trip length, trip cost etc. and only dependent variable that is number of trips were collected through questionnaire survey. Relevant information was collected both from primary and secondary sources. Random sampling was applied to collect the primary data from the household. 120 Households were surveyed to collect household level primary data which is around 1% of total households in ward 19, ward 20 and ward 21. Secondary data in the format of maps from Google Earth image were used for identifying the study area. Population and socio-economic analysis reports were collected from different sources namely Bangladesh Bureau of Statistics (BBS) and Khulna City Corporation (KCC) which were used for classifying regional income level. The collected data were analysed accordingly after editing, coding, classification and tabulation by using MS Excel, SPSS and Arc GIS. Descriptive statistics such as frequency distribution, cross tabulation, bar-charts, pie-charts, graph etc. were used for data analysis.

5. ESTIMATION OF TRIPS

To determine the total number of trips on daily basis through cross classification method three sub model were formulated which are income sub model, auto ownership sub model and trip production sub model. In the following the formulation processes of these sub models as well as the estimation of total number of trips are described.

5.1 Income Sub Model

At first the total Khulna city was classified into 7 zones on the basis of average income level. In the entire zone the income of the household was reclassified in to three ranges. Then the percentage of household belonging to the low (below BDT 15000), medium (BDT 15000- BDT 35000) and high (above BDT 35000) income range was determined for each zone. The total percentage of household in high, medium and low income range of total seven zones were then used to generate three lines in a graph. The generated graph is shown in Figure 2.

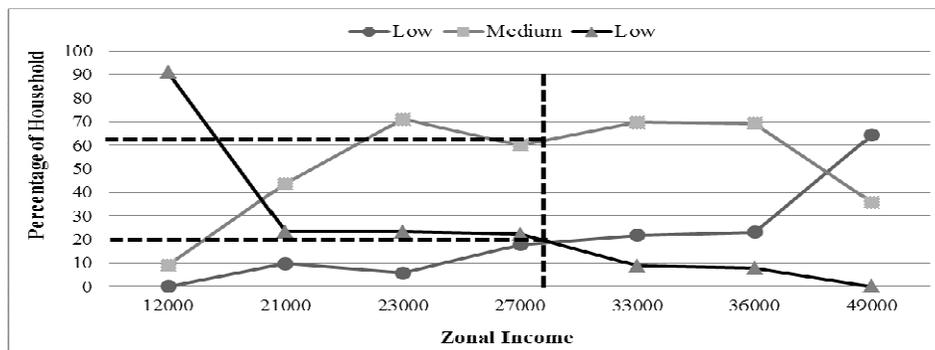


Figure 2: Percentage household in average zonal income

Then in the graph through the average regional income level of BDT 28000 a line was drawn which intersect all the three obtained line in the graph and finally from the intersection point the value of household for low,

medium and high income class were obtained by multiplying the total household in ward 19, ward 20, ward 21 and the percentage of household in each income class. The output of the sub model is given in Table 1.

Table 1: Household percentage in average income level

Income	Household %	HH in (Ward 19,20, 21)	Total HH
Low: below 15000	19	12269	2331
Medium: 15000-35000	62	12269	7607
High: above 35000	19	12269	2331

Source: Derived from field survey, February-2015 and author’s analysis

5.2 Auto Ownership Sub Model

At this stage for determining the number of trip rate of people belonging to the high, medium and low income range people having zero, one, two, three or more than three auto, at first trip rate per vehicle in the entire seven zones was determined through cross classification. By plotting the trip rate of people possessing zero, one, two and three auto of the seven zone total four line were generated.

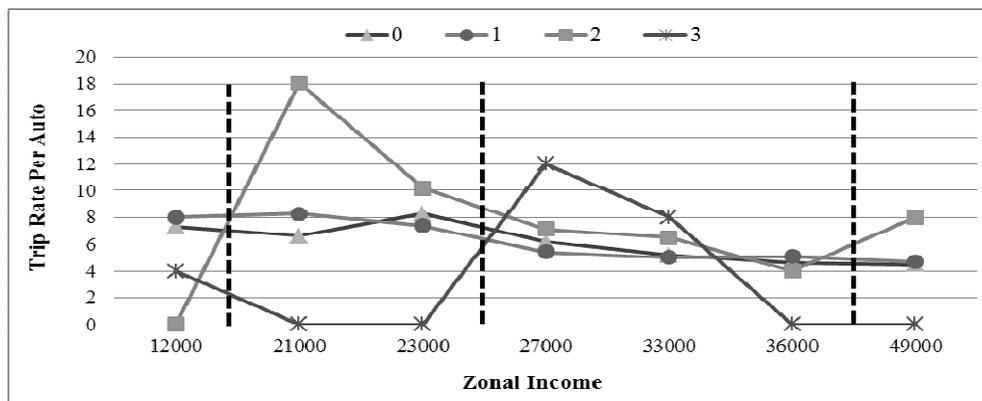


Figure 3: Trip rate per vehicle with different income level.

In this graph also, like previous graph three line were drawn which intersect the four line representing zero, one, two and three auto. Then the percentage of trip rate for low, medium and high class of people having zero to three vehicles were determined.

Table 2: Trip rate in income level and auto ownership

Auto ownership	Income Level		
	Low	Medium	High
No auto	7	7	4
One auto	8	6	5
Two autos	9	8	6
Three autos	2	6	0

Source: Derived from field survey, February-2015 and author’s analysis

Hereafter to determine the percentage of auto ownership on the basis of household income level at first in all the seven zone, percentage of people having zero, one, two and three auto were determined. By plotting the percentage of people having zero to three autos a graph was produced having four line each representing percentage of zero, one, two and three auto ownership in Figure 4. At this stage three lines were drawn similarly like the previous graph representing low, medium and high income class. Simultaneously, the percentage of people having zero to three vehicles belonging to the different income class was estimated.

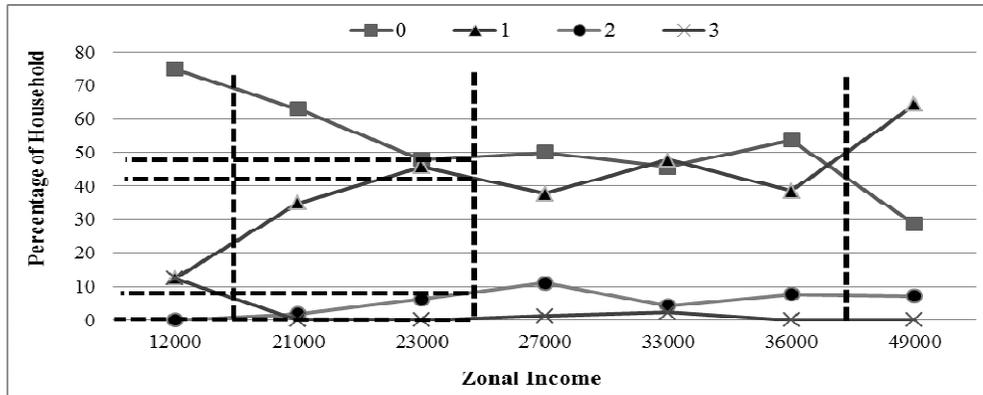


Figure 4: Percentage of household by auto ownership and income

Table 3: Percentage of vehicle ownership in different income level

Vehicle ownership	Income Level		
	Low	Medium	High
No vehicle	71	48	40
One vehicle	22	42	54
Two vehicles	6	8	6
Three vehicles	1	2	0

Source: Derived from field survey, February-2015 and author's analysis

5.3 Trip Production Sub Model

For determining the percentage of Home Based Work (HBW), Home Based Other (HBO) and None Home Based (NHB) trip at first the total HBW, HBO and NHB trips were determined for the total seven zone. The HBW, HBO and NHB trips were then plotted in the graph and three lines were obtained then three lines were drawn based on the average of low, medium and high income range that is BDT 17000, BDT 25000, BDT 43000 respectively.

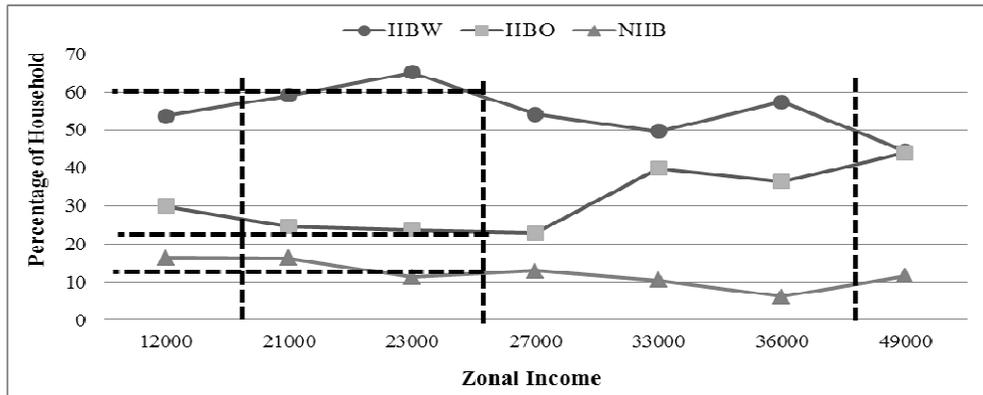


Figure 5: Purpose wise trip in different income zone

Each line intersected the three generated lines at each point and finally the percentage of HBW, HBO and NHB trips of household belonging to the low, medium and high income range were determined in Table 4. Most of the Home Based Work (HBW) trips were generated by the people of medium income range but most of the Home Based Other (HBO) trips were generated by the people belonging to the high income class and maximum of the None Home Based (NHB) trips were generated by the low income class people.

Table 4: Trip by trip purpose in different income zones

Trip Types	Income Level		
	Low	Medium	High
Home Based Work (HBW)	55	60	50
Home Based Other (HBO)	28	26	40
None Home Based (NHB)	17	14	10

Source: Derived from field survey, February-2015 and author's analysis

5.4 Estimation of Trips

By multiplying the auto ownership income percentage (Table 3) with the total respective income class household number (Table 1) the total number of household owned various no. of auto was determined. Then the result was multiplied by trip rate in income level and auto ownership (Table 2) to determine the trips made by different income class household (Table 5).

Table 5: Trips made by different income level in ward 19, ward 20 and ward 21

Auto ownership	Income Level		
	Low	Medium	High
No vehicle	11585	25557	3728
One vehicle	4104	19170	6295
Two vehicles	1260	4872	840
Three vehicles	46	912	0
Total	16995	50511	10863

Source: Derived from field survey, February-2015 and author's analysis

Table 5 shows that the people of medium income range give maximum number of trips in the study area. Among all the trips, different purposes of trips percentage was predetermined by the primary field observation data. Then the total number of trips made by different purposes was determined by using trip purpose sub model. Finally (Table 4) is multiplied with the sum of the (Table 5) to obtain Table 6 which represents the number of each type of trips belonging to the different income level

Table 6: Total numbers of trips by purpose in ward 19, ward 20 and ward 21

Trip Purpose	Income Level			Total
	Low	Medium	High	
Home Based Work (HBW)	9347	30307	5432	45086
Home Based Other (HBO)	4759	13133	4345	22237
None Home Based (NHB)	2889	7071	1086	11046
Total	16995	50511	10863	78369

Source: Derived from field survey, February-2015 and author's analysis

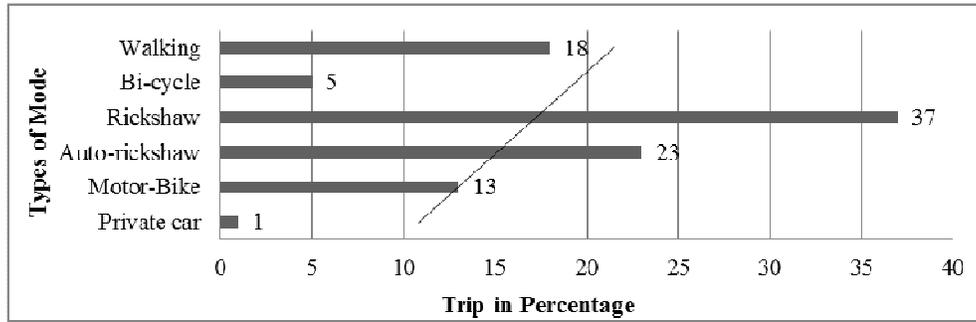
The generated Table 6 depicts the total number of trip of which HBW trip is 45086, HBO is 22237 and NHB is 11046 made by low, medium and high income people of the wards.

6. ANALYSIS OF TRIP CHARACTERISTIC

Total HBW trips, HBO trips and NHB trips have some specific characteristics. The calculated trips have different relationship with different socio-economic factors of the study area.

6.1 Mode Choice

Figure 6 represents mode choice behavior of the people in the study area. The study found that Rickshaw is used mainly as a transport mode in Khulna City. Middle and low class people use this mode mostly for traveling within the city. Now-a-days, Auto-rickshaw is becoming a popular mode of transport due to the easily availability and very economic compared to other moods of transport (Rahman & Kabir, 2004). Significant number of people walk and use bi-cycle usually for short distance travel to avail daily necessities. In contrast, private car for travelling in the study area due to high fuel cost, small traveling distance and lack of proper parking area.

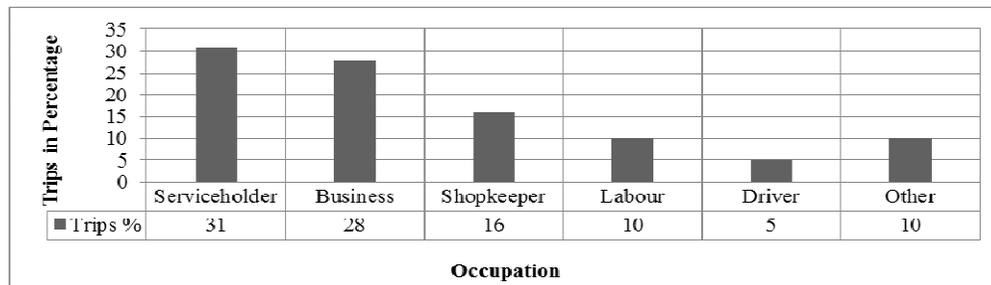


Source: Derived from field survey, February-2015 and author's analysis

Figure 6: Trip percentage by different types of mode

6.2 Relation between Occupation and Trip Production

Analyzing survey data this study found that service holders compare to other occupations generate more trips. Residential land use is dominant in the study area. Therefore, people live in this area and make home based work trips every day to go to their work places located outside of the study area. Similarly, a significant number of trips are generated by the businessmen particularly small businessmen and shopkeepers because they frequently travel between homes and work places in a day. Khulna Rail Way Station and Khulna Ferry Ghat are located in Ward 21 adjacent to the *Rupsha* River. Therefore, most labors of Ward 21 work at the station, Ferry Ghat and *Boro Bazar*, consequently generate a significant number of trips.



Source: Derived from field survey, February-2015 and author's analysis

Figure 7: Trip percentage by different types of mode

6.3 Trips Percentage in Peak and Off-Peak Period

Table 7: Trips by the Peak and Off-peak Period in Ward 19, Ward 20 and Ward 21

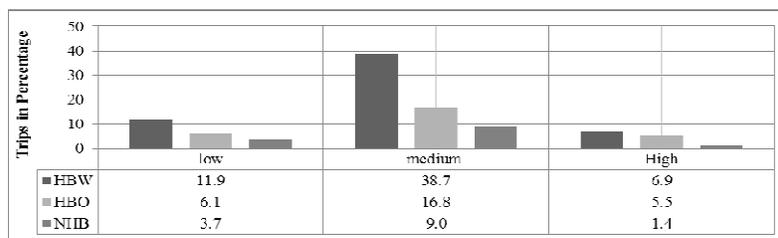
Household Composition Work trips	Income (5000-20000)		Income (20001-40000)		Income (40001-60000)	
	Peak (8am-10am, 6 pm-8pm)	Off-peak	Peak (8am-10am, 6 pm-8pm)	Off-peak	Peak (8am-10am, 6 pm-8pm)	Off-peak
No worker	0	0	0	0	0	0
One worker	7	5	11	7	2	2
Two worker	6	4	2	2	2	1
Three worker	0	0	1	1	0	0
Education trips	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
One students	3	5	4	6	1	2
Two students	1	1	2	2	1	1
Others trips	Peak	Off-peak	Peak	Off-peak	Peak	Off-peak
One member	0	3	0	3	0	1
Two members	0	5	0	5	0	2
Three members	0	0	0	1	0	0

Source: Derived from field survey, February-2015 and author's analysis

Table 7 represent that most of the trips are work trips and more trips are generated during the peak period compare to the off-peak period. About 53% of the total trips are work trips and 31% of them are generated during peak hour and other 22% during off-peak hour. Moreover, in the study area 57% of the total trips are generated during the peak period and 43% during the off-peak period. Most families in the city are nuclear family having at least one worker, thus generate work trips. Among the work trips, the people with income between BDT 20001 and BDT 40000 generated highest number of trips (about 24%). Moreover, they are responsible for 45% of the total trips. Education purpose generates 28% of the total trips and 17% of the trip is generated during off-peak period.

6.4 Trip Purpose with Respect to Income Level

In the study area medium income people generated maximum numbers of trips In contrast, higher income people generated the lowest number of trips. The main reason behind this scenario is the lack of adequate and standard recreational space in the study area. Moreover, the number of high income people is very low in the study area compare to the medium and low income people. This study also found that people generated highest number of Home Based Work (HBW) (about 58%) trip compare to Non Home Based trips (14%), which is shown in figure 8.

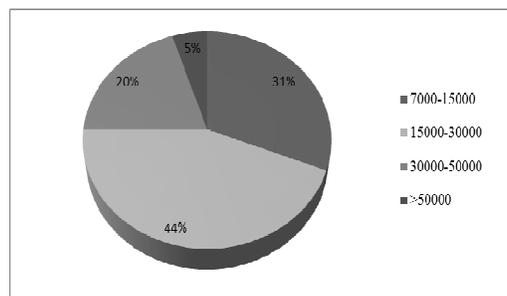


Source: Derived from field survey, February-2015 and author's analysis

Figure 8: Trip percentage by different trip purpose

6.5 Family Trip and Monthly expenditure of Family

Figure 9 depicts that in the study area the people who expend more than BDT 50000 per month produced only 5% of the total trips, which the lowest percentage of trip produced by any group based on expenditure. The household expending between BDT 15000 and BDT 30000 per month produced maximum amount of trips (e.g. 44% of total trips)



Source: Derived from field survey, February-2015 and author's analysis

Figure 9: Trip percentage by different expenditure level per month

6.6 Trip Percentage with Vehicle Ownership

Table 8 shows that more trips are generated by the people with no vehicle ownership. Many lower and lower middle income people in the study area do not have any vehicle because they usually do short distance travel and public transport is available. Similarly, some middle income people having one vehicle, work outside the study area and generated a large portion of total trips. In contrast, people having two vehicles and three vehicles generated lower number of trips because the city is small and owner of vehicles have a tendency to save fuel cost. It is observed from Table 9 that trip length increase with increasing vehicle ownership. The family having one vehicle made short distance (0-3 km) travel because they use vehicle for work trips in the city. In contrast, people having three vehicles made longer distance (3-10 km) travel because vehicle owners use their vehicles only for traveling outside the city mostly for recreation.

Table 8: Trips Percentage by the Vehicle Ownership Type in Ward 19, Ward 20 and Ward 21

Vehicle Ownership Types	Trip in Percentage with Income Level			Total
	Low	Medium	High	
No vehicle	15	33	5	52
One vehicle	5	24	8	38
Two vehicles	2	6	1	9
Three vehicles	0	1	0	1

Source: Derived from field survey, February-2015 and author's analysis

Table 9: Percentage of trip distance by the vehicle ownership type in ward 19, ward 20 and ward 21

Auto ownership	Trip Distance(Percentage)		
	Short (0-1km)	Medium (1-3) km	Long (3-10) km
1	15	10	2
2	3	18	16
3	1	9	26
Total	19	37	44

Source: Derived from field survey, February-2015 and author's analysis

7. CONCLUSIONS

The total number of generated trip was estimated in the study area of ward no. 19, 20 and 21 by using cross classification method. It was found that the number of Home Based Work (HBW) trip was the maximum and the people belonging to the medium income range generated maximum of the total trips. People of high income range produced the lowest percentage of total trips even though they owned personal vehicle and reason behind this unwillingness to trip is the lack of attraction point in the city. To reduce the amount of congestion during the peak hour it is recommended to encourage the use of more public transport instead of private vehicle. Mixed land use planning should be introduced which will help to reduce the total number of trip generated in the study area. Though with the increase of income and vehicle ownership trip production of the respective families are not increasing proportionally due to the lack of recreational facilities and open space so developing more recreational facilities and open space within the easy access from the study area must be ensured.

REFERENCES

- Ahmed, I., Hasan, T., Ramli, I. and Pua, O. C. (2014). Trip Generation Characteristics of Kindergartens in Johor Bahru, Malaysia. *Jurnal Teknologi*, 71(3), 23-26.
- Al-Taei, D. K. and Taher, M. A. (2006). Prediction Analysis of Trip Production". *Al-Rafidain Engineering*, 14(4), 51-63.
- Chang, J. . S., Jung, D., Kim, J. & Kang, T. (2014). Comparative analysis of trip generation models: results using home-based work trips in the Seoul metropolitan area. *The International Journal of Transportation Research*, 6(2), 78-88.
- Chowdhury, M. A. Sayem. (2013). An Assessment of Water Quality And Quantity For Khulna City Water Supply System". Masters Of Engineering Thesis. Bangladesh University of Engineering and Technology. Dhaka Mirror. (2013). 3 new police stations likely in Khulna city. *Dhaka Mirror*
- Mehbub, A. . A. (2004). *Trip generation models for Khulna City of Bangladesh: a transport planning guidelines perspective*. Hong Kong.
- Montealegre, L. U., Mosquera, D. J., Molina, C. J. & Hoyos, J. M. (2010). *Trip Generation Model Based On Household through Crossed Classification Technique in the Municipality of Palmira, Colombia*. Lisbon.
- Mwakalonge, J. L. & Badoe, D. A. (2012). Comparison of Alternative Methods for Estimating Household Trip Rates of Cross-Classification Cells with Inadequate Data. *Transportation Research Forum*, 51(2), 5-24.
- Ortuzar, J. d. D. & Willumsen, L. G. (2011). *Modelling Transport*. 4th ed., John Wiley & Sons Ltd.
- Rahman, A. F. & Kabir, M. A. (2004). *Towards A Sustainable Public Transport System for Khulna City, Bangladesh*. 671-686.
- Rahman, M. L. (2011). Analysis of Traffic Generation in an Urban Area: A Case Study of Savar Pourashava. *Journal of Bangladesh Institute of Planners*, 4, 33-43.
- Sekhar, S., Ananda, S., and Karim, M.R. (1997). Comparison of regression model and category analysis: A case study. *Journal of Eastern Asia Society for Transportation Studies*, 2(3), 917-930.