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Urban Density Influence on Travel and Mode choice Behavior of Savar Municipality: Household Survey Study

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ABSTRACT

Urban density influences on travel behavior. In Savar Pourashava, travel behavior varies based on household's demographic and socio-economic characteristics. It also varies based on the services provided by the mixed modes in the research area. The land use feature has an impact on the research area's travel behavior pattern. Passenger's attitudes and preferences can have an impact on mode selection. This paper aims to explore these factors by researching into commuters' preferred method of transportation and the reasons for their choice. Aside from that, it investigates the link between land use, density, and travel behavior, wherein land use characteristics influence travel patterns. A field survey as well as passenger's opinion survey about their modal choice has been conducted to identify these factors. 250 samples were considered for household survey. From the field survey and analysis, it is found that there is a gap between the trip maker's demand and the existing facilities. The existing facilities have not met the actual demand of the trip makers. In the result we see the ward wise weightage index and trip ratio have a correlation of 0.92, indicating that density and land use are substantially positively connected with generated trips in the studied area. The findings of these surveys can help municipality authority to balance the transportation system with the land use and density of the municipality.

Keywords:-*Urban density, Land use, Modal Choice, Travel Behavior, Household Survey.*

INTRODUCTION

Population growth and rapid unplanned urbanization in municipalities in developing countries increases mobility demand and [1] creates different problems in transportation system [2]. Savar Municipality, near the capital city Dhaka, the population in 2020 is roughly 0.45 million with density of 31,960 people per square kilometer [3]. One of the key reasons of traffic-related problems is high population density with limited road networks [4], and different transportation problems, such as traffic congestion and conflicts, can be seen [5] in major cities of Bangladesh. With the shortage of road network and other facilities the city's traffic problems increasing day by day [6] and creating different road management system [7] and different health related problems in major cities in Bangladesh [8]. About 3.2 million working hours wastes by congestion every day and costs the economy billions of dollars every year [9].

A large number of offices, business centers as well as schools and other commercial activities are located in the Savar Municipality which attracts huge traffic and generate lots of trips within the municipality. However, different factors generated huge number of trips. Besides the modal transport, peoples now preferring walking for their daily activities

[10]. Walking is considered as the most comfortable and equitable means of transportation [11] and the footpath user has less than moderate satisfaction level [12].

In Bangladesh, passengers can't choose their preferential modes of transport due to lack of convenience, affordability etc. For passengers, mode choice behavior is critical in transportation planning choices. Time, cost of travel, income, costs, household type, gender, and ethnicity all had a role in mode selection [13]. The major influencing factors of transportation on land is find such as built-up area, road network, income, age, driving license, occupation, trip interchanges [14]. The mode choice of travelers is also influenced by their socioeconomic status [15]. As a result, land use planning and transportation planning are inextricably linked [16]. Passenger journey duration and total number of person trips can be reduced by urban planning that ensures the balance of uses of areas where a person may satisfy their need from the closest distance [17].

Urbanization and rapid population growth have severe effects on natural settings [18, 19]. Unplanned land use development, particularly unplanned road network, has severe effects on natural arrangements [20, 21]. Satellite data and remote sensing GIS are becoming common methods for detecting land use change, particularly the influence of the road network on land use [22, 23, 24]. With rising population housing and road demand, open spaces/playgrounds and wetland regions are being converted to buildup areas [25, 26], and narrow roads are increasing risk susceptibility such as earthquake and fire [27, 28, 29]. All of these changes in land use and road networks provide job opportunities [30] and shift mode preferences with land use dynamics in each city [31], as well as affecting certain essential services [32] and in revenue earnings of a city [33, 34].

Savar is located on the Dhaka-Arica highway and about 29 kilometers north-west of Dhaka City [35]. Dhaka is one of the world's least motorized cities, with the world's worst traffic congestion. As the closest satellite city, Savar Municipality has experienced significant growth in population and increase in housing [36], as well as increasing and diverse urban land use patterns, resulting in significant travel demand, mode choice modeling [37] and severe transportation issues. This study therefore conducts surveys on trip behavior and household data is evaluated using questionnaire survey. The findings of these surveys can help municipality authority and transport authorities to take more attractive strategic actions to improve household trips in comfort level. This paper studies the urban density influence on travel and mode choice behavior of Savar Municipality, Bangladesh. There is also make an evaluation of municipality people's perception regarding the travel pattern and influencing factors for modal choice in Savar municipality area.

METHODOLOGY

Savar Upazila covers an area of 280.13 square kilometers, with the Savar municipality covering 17.15 square kilometers. The municipality of Savar is composed primarily of about 9 wards and 55 mahallas, with a total population of over 286008 [38]. Single person was chosen as the sampling unit in this study. Only 250 samples were chosen for further investigation. Despite the fact that the sample was limited, it was representative.

Formula:

Sample size= $z^{\wedge}2pq/d^{\wedge}2$

here, at 90% confidence level and 5% error

Sample size= 250.06 (250)

Objective Variable matrix

Objectives	Variable	Data type and Sources
Mode choice	❖ Amount of walking, Amount of rickshaw user, Amount of auto-rickshaw user, Amount of bike user, and Amount of bi-cycle user, ❖ Travel time, Travel cost, and Travel distance.	❖ Primary data (Questionnaire survey)
Factors that influence the modal choice.	Socio economic characteristics ❖ Age and Sex ❖ Vehicle ownership ❖ Occupation and Educational level ❖ Household size and Family income ❖ Member of earning members	❖ Primary data (Questionnaire survey)
	Trip Information ❖ Travel time and Travel cost ❖ Trip purpose, Mode, Trip distance and frequency ❖ Waiting time, walking time, starting time, ending time, and Existing time ❖ Origin and Destination	❖ Primary Data (Questionnaire survey)
Explore the relationship between land use system and travel behavior	❖ An overall land use scenario, ❖ Trip ratio, Trip purpose and Trip mode ❖ Trip time and Trip distance ❖ Cost of trip, Trip distribution and Trip frequency	❖ Primary data (Field survey & Questionnaire survey) ❖ Secondary data (Local Government Engineering Department & Savar pourashava,)

Source: Developed by authors, 2020

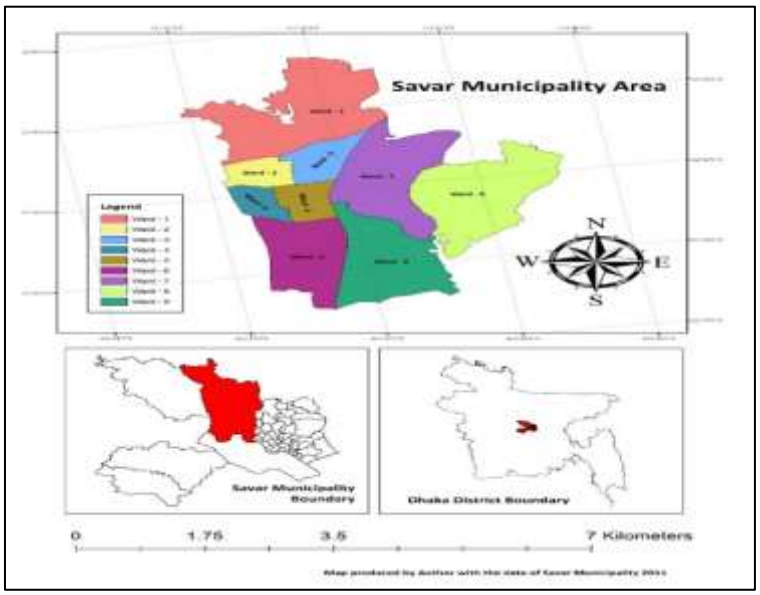


Fig.1:-*Study Area Map*
Source: Developed by authors, 2020

RESULT AND DISCUSSION

Operating Modes of the Study Area

In the Savar Pourashava both motorized and non-motorized vehicles are used, and it serves as a vital link between Dhaka and its suburbs. Non-powered vehicles include walk and rickshaws, bicycles, and human haulers, buses, and auto-rickshaws, whereas motorized vehicles include human haulers, buses, and auto-rickshaws. Table 1 shows a list of motorized and non-motorized vehicles that are used in the study region.

Table 1:-*List of motorized and non-motorized vehicles*

Broad vehicle group	**Operating modes**
Non-Motorized Vehicle (NMT)	Walk, rickshaw & bicycle
Motorized Vehicle (MT)	Bus, human hauler, auto-rickshaw, private car & motor-cycle

Role of Different Modes of the Study Area

Savar's transport system is predominantly road based. Motorized, non-motorized and mixed (motorized plus non-motorized) modes are operated in the study area. Non-motorized vehicles account for 42.8 percent of all vehicles in the research region. Non-motorized vehicles include walk, rickshaw, and walk plus rickshaw, with rickshaws accounting for around 30% of journeys in the research region.

The average rickshaw journey takes 14 minutes. The average trip distance for walk, rickshaw and walk plus rickshaw are 1.00, 2.00 and 1.50 k. m. respectively (Field survey, 2019).

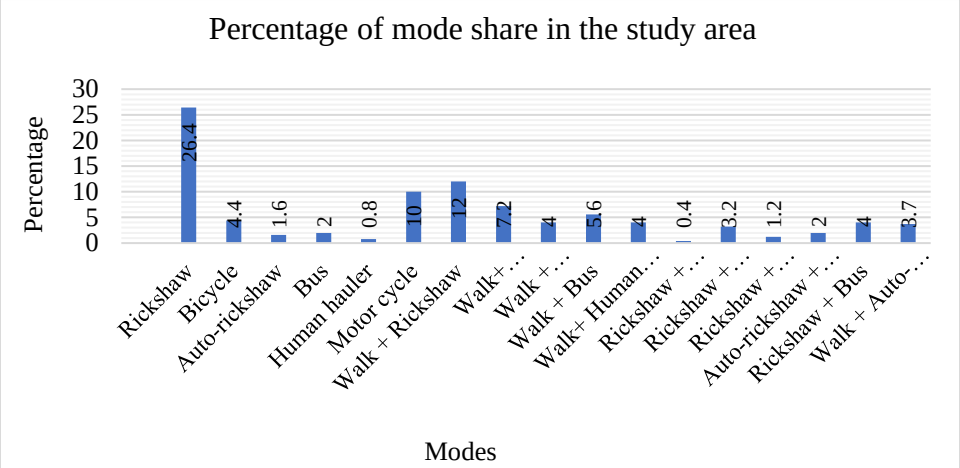


Fig.2:-*Percentage of mode share in the study area*
Source: *Field Survey, 2019*

The modes selection factors for all the modes are dependent on age. Highest number of trips generated by mode is walk then rickshaw is the second position of all mode for all age groups of respondents. The modes of auto-rickshaw, bus and human haulers are less chosen mode. Figure 3 shows that most of age group prefer walking, other prefer rickshaw and other prefer auto-rickshaw, bicycle, motor-cycle, bus, human hauler.

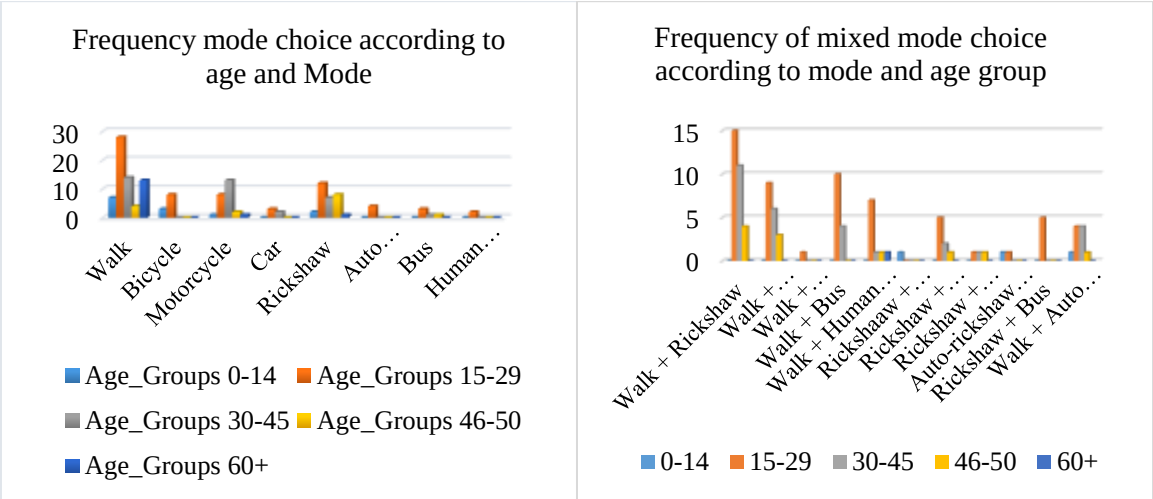


Fig.3:-*Frequency of single and mixed mode choice according to age and mode*
Source:-*Field Survey, 2019*

Sex

According to age group, male and female respondents are classified out of total 250 respondents. Figure shows that male respondents are 3.20% and female respondents are 3.20% within 0-14 age group whereas 24.80% male and 25.60% female respondents within 15-29 age group. Within the age group of 30-45, male and female respondents are 18.40% and 8.00% respectively. 5.60% and 4.80% are male and female respondents respectively within 46-60 age group. Finally, within age group 60+, male respondents are 5.20% and female respondents are 1.20%. The graphical presentation of the percentage of respondents according to age groups and sex is shown below.

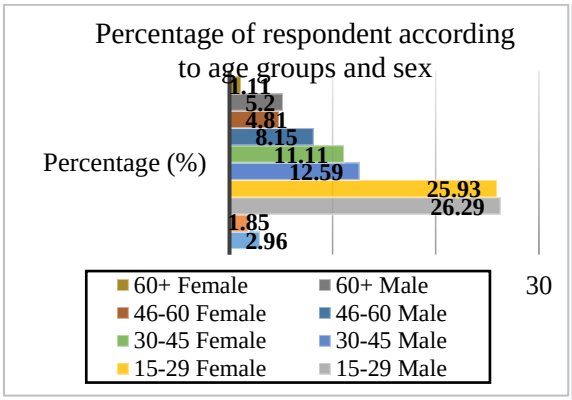


Fig.4:*-Respondents age groups and sex*

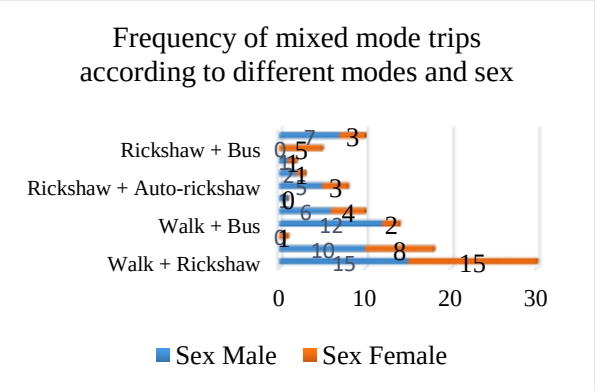


Fig.5:*-Mixed trips with different modes and sex*

Source: *Field Survey, 2019*

Figure 5 shows that walk and rickshaw is the highest use of mode considering sex that is 29.69% out of 100% from which 52.87% trips are generated by male respondents and 47.13% trips are generated by female respondents. In case of walk and auto-rickshaw in mixed mode, 53.45% trips are generated by male and 46.55% trips are generated by female. Male and female both generate 42.22% trips. In walk and human haulers trips, 60.78% trips are generated by male and 39.22% trips are generated by female. 53.28% and 46.72% trips are made by auto-rickshaw and bus by the male and female respondents respectively in mixed mode choice. Numbers of trips are varied with sex that is made by different modes. The number of mixed mode trips according to different modes and sex is presented in the above Figure 4 and 5.

In the study area, out of 66 walk trips, 38 trips are generated by male respondents and 28 trips are generated by female respondents. Out of 5 bus trips, male and female respondents are generated by 3 and 2 trips in single mode choice. Out of 30 rickshaw trips, male is generated 12 trips and female is generated is 18 trips in single mode choice. Bicycle, Motorcycle and private cars are generated 11, 25 and 5 trips respectively by male.

Income

Income is profound to be the most influencing factor in one's travel decision. It is found that there are also significant variations in demand, according to income group. After identifying three broad income groups, the samples included individuals from all the three income groups. Table 2 shows the frequency of mixed mode trips according to income and different mode. Table shows that 20000-30000 income group people make more trips in walk in single mode choice. In Savar pourashava most people make their trip by walk and rickshaw. Higher income group such as 40000-50000 income group people make their trip by their own vehicle

such as motorcycle and private car. But In savar pourashava, most of the people belongs in 20000-30000 income group. This is generally call middle income groups.

Table 2:-*Frequency of mixed mode trips according to income and different modes*

Mode	Monthly income						Total
	Below 10000	10000-20000	20000-30000	30000-40000	40000-50000	Above 50000	
Walk	1	8	34	5	17	2	66
Bicycle	1	0	7	0	4	0	11
Motorcycle	0	2	10	1	11	1	25
Car	0	0	1	0	4	0	5
Rickshaw	0	5	13	4	8	0	30
Auto rickshaw	0	2	0	0	2	0	4
Bus	0	1	2	0	2	0	5
Human hauler	0	0	0	1	0	0	2

Source: Field Survey, 2019

Vehicle Ownership

Vehicle ownership of the respondents determines his accessibility and hence, it is a very strong influencing factor in mode choice behavior. Out of 250 samples, only 50 respondents have owned a car (6) or motor cycle (30) or cycle (14) and 200 respondents have no ownership of vehicle.

Occupation

In the study area, the largest trip makers are student and worker, business which is 30.80% and 24.4%, 23.20% respectively. The fourth position is housewife which is 12%. Service and retired person are 5.60% and 3.60% respectively. Other's respondents (daily labor, hawker) are .40% out of total 250 respondents.

The relative level of service (LOS) of the various forms of transportation

The relative level of services is made up of journey duration, travel cost, mode accessibility, and mode travel features. These factors, which were discovered as a consequence of the survey, are explained in the following section.

Travel time

Travel time vary with different age group traveling by different modes. Figure 6 shows that spending time in transportation by different age groups of respondents Most of the age groups of respondents spend 20 minutes in transportation. Then 30 and 15 minutes is second and third highest spending time in transportation of all age groups of transportation

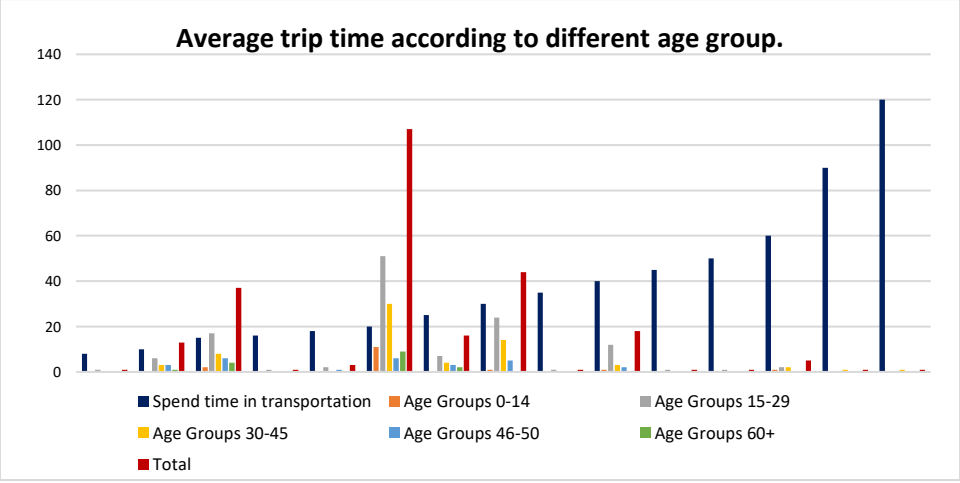


Fig.6:-*Average trip time according to different age group*
Source: *Field Survey, 2019*

Figure 7 shows trip time in minute according to income groups. Figure shows income between 20000-30000 travel more than those of higher income group. The graphical presentation of maximum, minimum and average trip cost according to different modes operating in the study area is shown in Figure 8

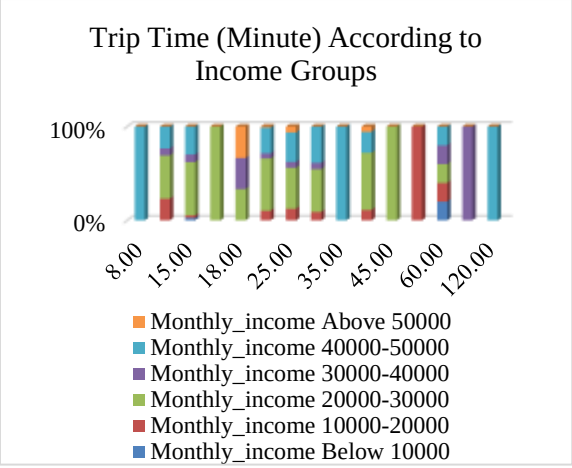


Fig.7:-*Trip time according to income groups*

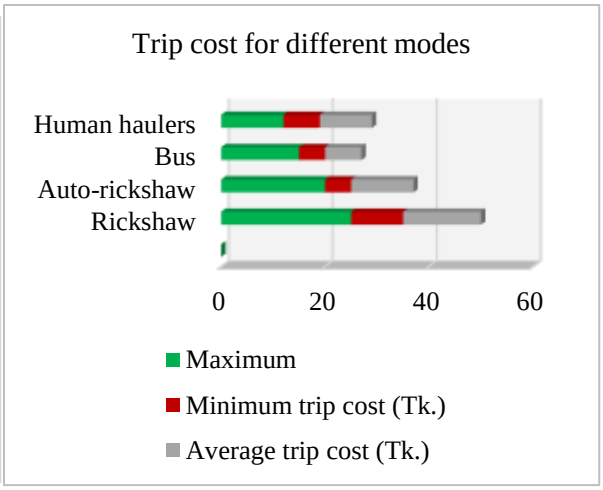


Fig.8:-*Trip cost of different modes*

Source: *Field Survey, 2019*

Travel Cost

Study shows that the average trip cost for rickshaw is highest in the study area that is 15 taka. The second position is auto rickshaw for which average travel cost is 12 taka. The average cost for bus and human haulers is 07, 10 taka respectively. The maximum and minimum cost for rickshaw is 25 and 10 taka respectively. The cost for auto-rickshaw is 20 and 5. The maximum cost is 15 and minimum cost is 5 taka for bus. The maximum and minimum cost for human haulers is 12 and 7 taka respectively.

Availability of the modes and waiting time

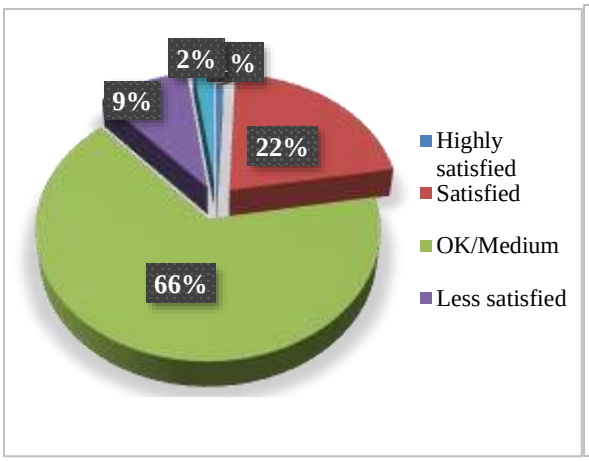
The respondents were asked if they were available to participate in a mode. The following Table 3 reveals this. The maximum availability of rickshaw is 39.27 percent, with the shortest waiting time. Buses are available in 37.64 percent of cases, auto-rickshaws in 23.64 percent of cases, and human carriers in 17.27 percent of cases.

Table 3:-*Opinion about availability of different modes.*

Modes	Attributes		
	Available near home	**More waiting time**	**Less waiting time**
Rickshaw	**86.36%**	19.10%	12.00%
Bus	**37.64%**	21.82%	13.27%
Human haulers	17.27%	15.82%	**19.45%**
Auto rickshaw	**23.00%**	10.35%	17.64%

Source: Field Survey, 2019

According to Figure 9 shows satisfaction level in respect to availability and waiting time for different mode. 66% people in the study area said that level of factor is medium, 22% are satisfied and 9% are less satisfied. The trip distance of different modes according to the male and female respondents is shown in the following Figure 10.



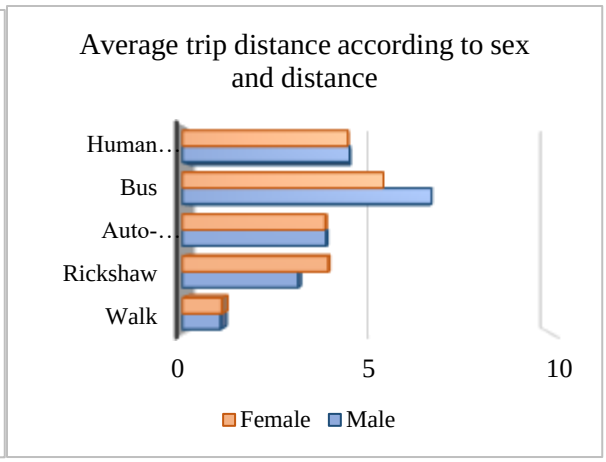


Fig.9:-*Satisfaction level for modes* ***Fig.10:-****Trip distance according to modes and sex*
Source: *Field Survey, 2019*

Travel attributes of different modes

Respondents are asked about some of the travel attributes/factors (convenience, comfort, privacy, reliability, safety and security) for different modes of travel in the Savar urban area. In the study area, bus and rickshaw are the preferable modes by the respondents considering the above factors. Table 4 shows the choice factors for different modes by the respondents.

Table 4:-*Respondent's opinion about mode choice factors.*

Modes	**Choice factor**					
	Convenience	**Comfort**	**Privacy**	**Reliability**	**Safety**	**Security**
Rickshaw	**39.18%**	18.57%	**38.67%**	24.15%	11.21%	10.00%
Bus	24.20%	14.33%	11.35%	**39.53%**	23.15%	24.20%
Human haulers	15.27%	22.20%	20.32%	18.31%	**37.53%**	**38.18%**
Auto rickshaw	10.14%	**38.18%**	25.05%	5.80%	17.31%	12.35%

Source: Field Survey, 2019

Trip purpose

Trip purposes are related to business, service, school and work purposes. Business trips include trips from home to various business centers and business center to business center. Services both government and private include trip from home to various government and private service institutions; and office to another office. School trips include trips from home to various educational institutions such as schools, colleges, technical institutes, coaching centers and universities for educational purposes. Work trips include trips that are made by the industrial workers; hawkers from home to work place; and work place to work place for special purposes. In the study area most of the trips are generated for work purpose that is 40.70% trips. Trips that are generated in the Savar Pourashava for service, school and business purposes are 8.60%, 34.30% and 15.00% trips respectively and rest of trip purposes are recreational and medical treatment.

Trip distance

Trip distances are varied according to various modes. Figure 11 shows that the average trip distance for different modes that are walk, rickshaw, walk and rickshaw; walk and bus; rickshaw and bus; bus; human haulers; auto-rickshaw. Trip distance is also varied with different modes and sex. The average trip distance for male by using different modes such as walk, rickshaw, auto-rickshaw, bus and human haulers are 1.04, 3.13, 3.88, 6.73, 4.52 k. m. respectively. While in case of female the average trip distance for walk,

rickshaw auto-rickshaw, bus and human haulers are 1.07, 3.94, 3.86, 5.43, 4.47 k. m. respectively. Average trip distance for business and service purposes are 2.50 and 2 k. m. respectively. The average trip distance for school and work purposes are also 1.50 and 3 k. m. respectively.

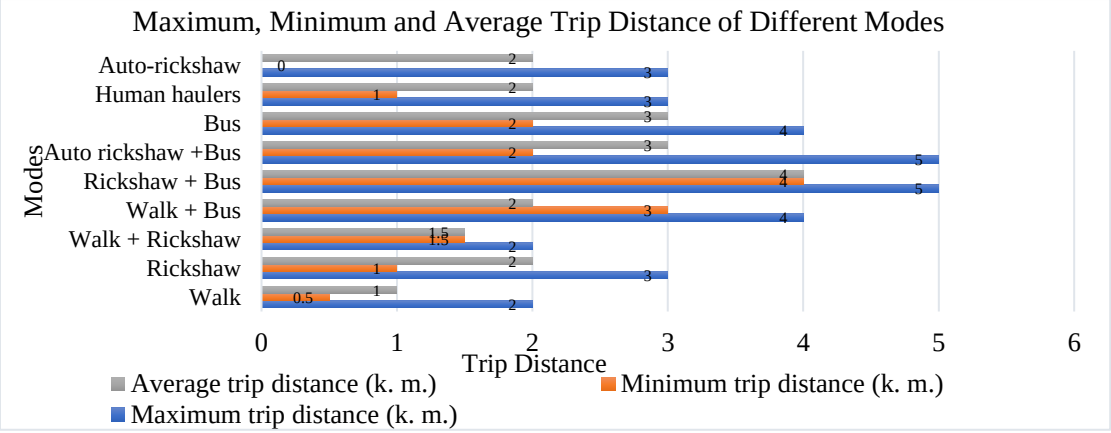


Fig.11:-*Maximum, minimum and average trip distance of different modes*
Source:-*Field Survey, 2019*

Trip generation

There are both motorized and non-motorized means of transportation functioning in the studied area, including rickshaws, auto-rickshaws, buses, and human transporters. These modalities are used to travel in this area. Mixed journeys include journeys taken in motorized and non-motorized vehicles, as well as trips taken on foot and vehicles such as walk + bus and rickshaw + bus. The motorized trips are made by bus, human hauler, and auto-rickshaw. All these are shown in the Table 5.

Table 5:-*Different modes in the study area*

Broad vehicle group	Modes
Non-Motorized vehicle (NMT)	Walk, Rickshaw, Bicycle, Walk + Rickshaw
Mixed (NMT+ MT)	Walk +Bus, Walk + Rickshaw + Bus, Walk + Human hauler, Rickshaw + Bus, Auto rickshaw + Bus
Motorized vehicle (MT)	Bus, Motorcycle, Private car, Human hauler, Auto rickshaw

Source: Field Survey, 2019

Travel cost

Travel cost plays a significant role at the time of selecting a mode by the respondents because in the study area, there are various people who engage in different occupation and their income is also different. The respondents choose these modes whose travel costs are within their income. The maximum acceptable travel costs for different modes that are operating in the study area are discussed below. Figure 12 shows the maximum acceptable travel cost for rickshaw, auto-rickshaw, bus and human hauler. It is found that out of 250 respondents, 65.9% respondents think that the maximum travel cost for rickshaw should be 20 taka, 2.3% respondents think the cost should be 22 taka, 5% respondents think the cost should be 25 taka, 26.1% respondents think the cost should be 30 taka. Out of 250 respondents, 57.10% respondents think that the travel cost for auto-rickshaw should be 12 taka, while 20% and 14.3% respondent's opinion about the cost are 15 and 20 taka respectively. 8.6% respondents think, the cost should be 25 taka.

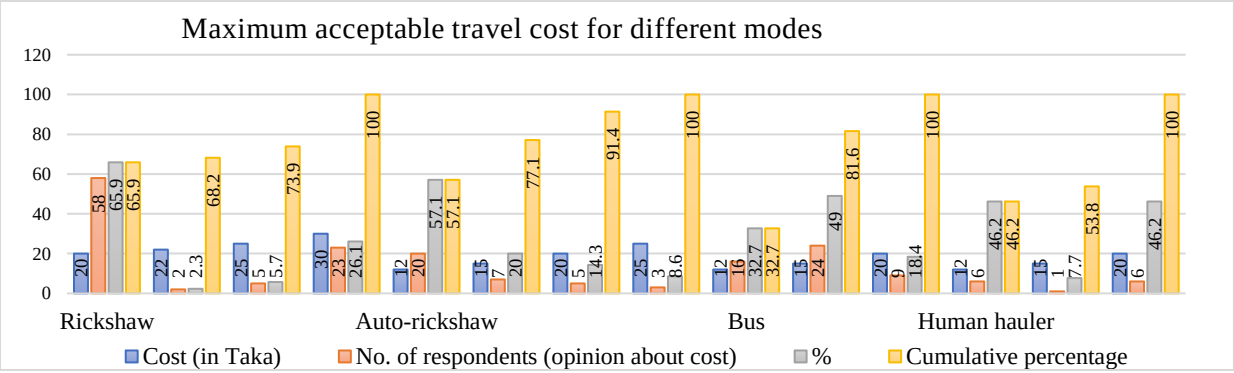


Fig.12:-*Maximum acceptable travel cost for rickshaw, auto-rickshaw, bus and human hauler*
Source:-*Field Survey, 2019*

From this Figure, it is found that 32.59% respondents think that the travel cost for bus should be 12 taka, 49% respondents think that the cost should be 15 taka. 17.78% respondents think, the cost should be 20. The percentage of respondents is represented in cumulative form in the figure 12. Figure 12 also shows that 46.2% respondents out of total 250 respondents' opinion about the travel cost for human hauler is 12 taka. 7.7% and 46.2% respondents think that the cost should be 15 and 20 taka respectively.

Travel distance

At the time of survey, respondents are asked about the minimum and maximum acceptable travel distance for different modes operating in the study area such as rickshaw, auto-rickshaw, bus and human haulers. The results that are obtained from the survey are discussed in the following section. Figure 13 shows the minimum travel distance for rickshaw, auto-rickshaw, bus and human hauler. It is found that 51.10% respondents acceptable travel distance for rickshaw is 0.5 k. m. while 28.40% and 20.50% respondents think that the distance should be 0.75 and 1 k. m. respectively. Figure 13 shows that 55.90% respondent's opinion about the minimum travel distance for auto-rickshaw is .5 k. m. 26.50% and 17.60% respondents think that the distance should be .75 and 1.0 k. m. respectively. Figure 13 shows that 40.80% respondents' opinion about the minimum travel distance for bus is .50 k. m. 24.50% and 12.20% respondents think that the distance should be 1.0 and 1.50 k. m. respectively. 22.40% respondents think that the distance should be 2.0 k. m. Figure 13 also shows that 15.40% respondents' opinion about the minimum travel distance for human hauler is .50 k. m. 7.70% and 30.80% respondents think that the distance should be .75 and 1 k. m. respectively. 46.20% respondents think that the distance should be 1.5 k. m.

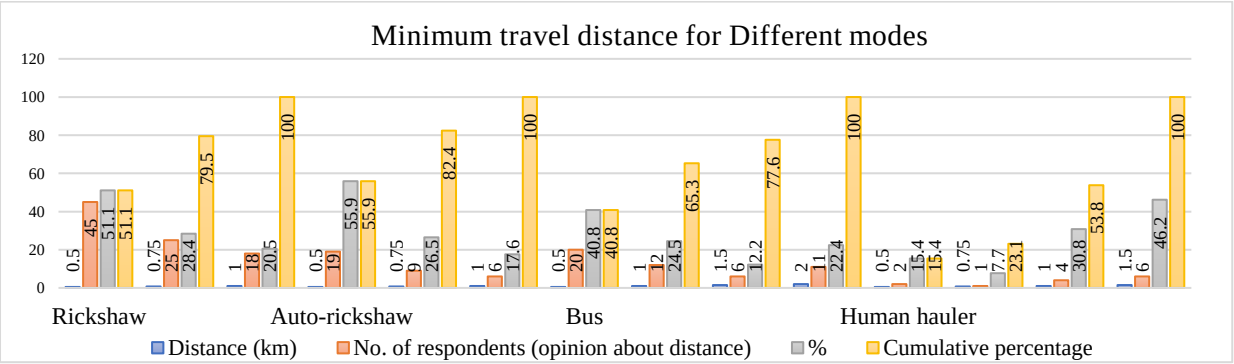


Fig.13:-*Minimum travel distance for rickshaw, auto-rickshaw, bus and human hauler*
Source: Developed by authors, 2020

Figure 14 shows that 68 respondents think about the maximum acceptable travel distance for rickshaw should be 1.5 k. m. while number of 15 and 2 respondents thinks that the distance should be 2.0 and 2.50 k. m. respectively. 2 respondents give opinion about the maximum distance that should be 3.0 k. m. Figure 14 also shows that 71.40% respondents' opinion about the maximum travel distance for auto-rickshaw is 2 k. m. 5.70% and 22.90% respondents think that the distance should be 2.5 and 3 k. m. respectively. Figure 14 shows that 35 respondents think about the maximum acceptable travel distance for bus should be 2.5 k. m. while number of 5 and 9 respondents think that the distance should be 3 and 3.5 k. m. respectively. Figure 14 also shows that 46.20 % respondent's opinion about the maximum travel distance for human hauler is 2 k. m. 15.40% and 38.50% respondents think that the distance should be 2.50 and 3 k. m. respectively. Figure 14 shows that 129 respondents think about the maximum travel distance for walk should be 1.5 k. m. while number of 11 and 1 respondents thinks that the distance should be 2.0 and 2.5 k. m. respectively. 13 respondents give opinion about the maximum distance that should be 3.0 k. m.

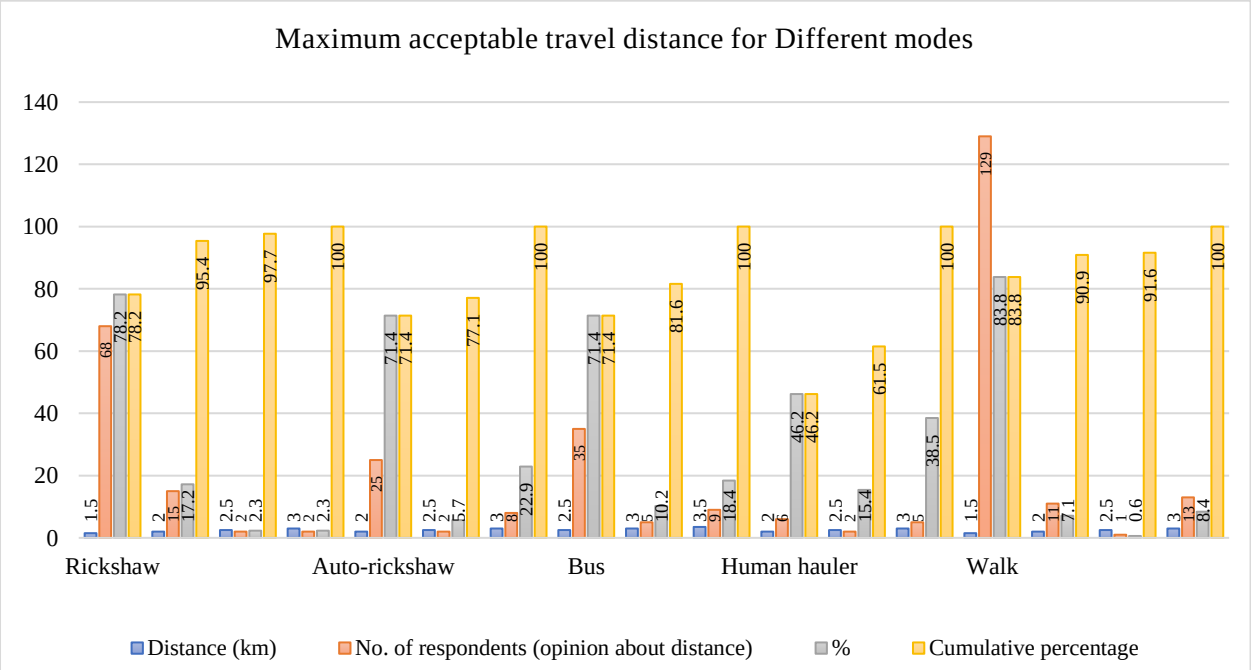


Fig.14:-*Maximum acceptable travel distance for different modes*
Source:-*Field Survey, 2019*

Travel time

In terms of modal choice, travel time is also significant. The study area's residents were asked about the shortest and longest acceptable journey times for various types of transportation. Figure 15 reveals that the minimum rickshaw journey duration is 3 minutes for 1.10 percent of respondents. The time should be 5 and 7 minutes, according to 25 percent and 17 percent of respondents. 56.80% respondents think that the time should be 10 minutes. Figure 15 also shows that 22.90% respondents' opinion about the minimum travel time for auto-rickshaw is 5 minutes. 45.70% and 25.70% respondents think that the time should be 7 and 10 minutes respectively. 5.70% respondents think that the time should be 12 minutes.

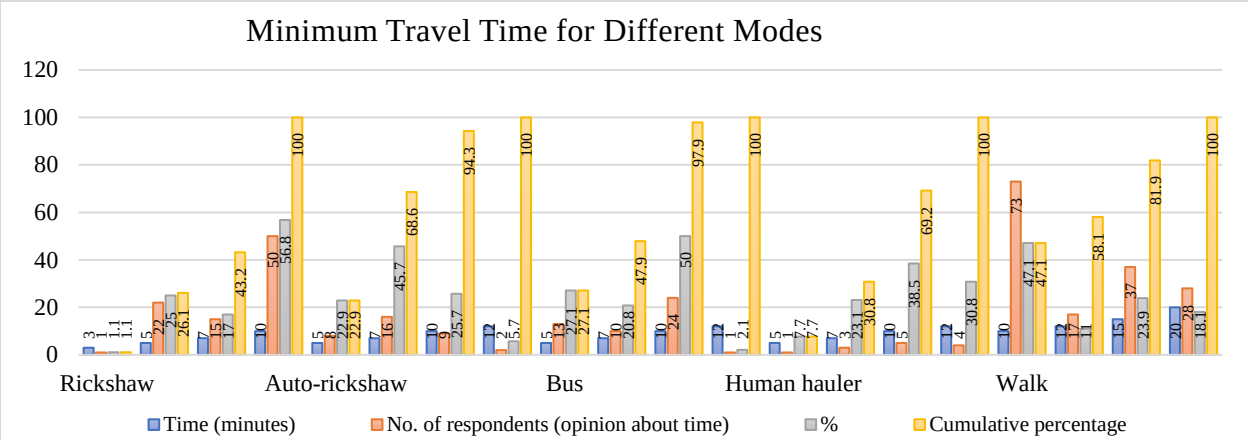


Fig.15:-*Minimum travel time for rickshaw, auto-rickshaw, bus, human hauler and walk*
Source: *Field Survey, 2019*

Figure 15 also shows that 27.01% respondents' opinion about the minimum travel time for bus is 5 minutes. 20.80% and 50.00% respondents think that the time is 7 & 10 minutes respectively. 2.10% respondents think that the time is 12 minutes. Figure 15 shows that 7.70% respondents' opinion about the minimum travel time for human hauler is 5 minutes. 23.10% and 38.50% respondents think that the time should be 7 and 10 minutes respectively. 30.80 respondents think that the time should be 12 minutes. Figure 15 also shows that 47.10% respondent's opinion about the maximum travel time for walk is 10 minutes. 11.00% and 23.90% respondents think that the time should be 12 and15 minutes respectively. 18.10% respondents think that the time should be 20 minutes.

Modal Share in the study area

In the study area, there are several types of modes are operating. For a variety of reasons, people are making trips via these modes. Respondents are questioned about the forms of transportation they use to travel for their specific objectives throughout the survey period. The survey results, which are depicted in the accompanying image, provide a genuine picture of the study area's modal share. Figure 16 depicts the proportion of people who use various modes of transportation in the study area. From this figure, it is found that the highest share of mode in the study area is walk that is 26.40%. The second highest mode is rickshaw that is 12.00%. The respondents who are made trips by bus are 2.00%, while 10.00% trips are made by motorcycle. The modal share of human hauler in the study area are .80%.

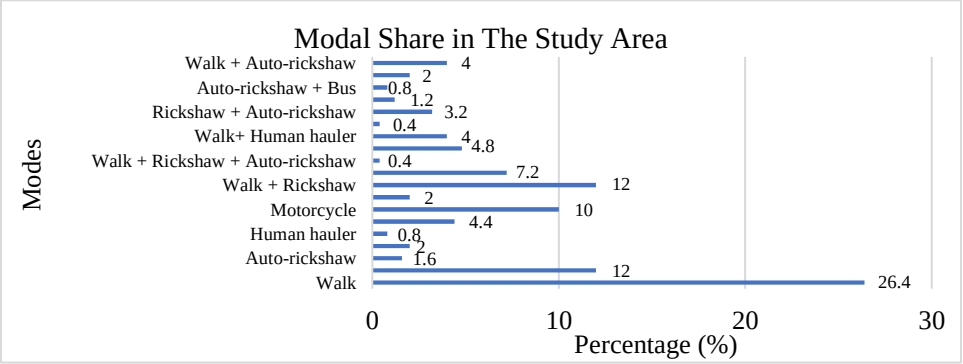


Fig.16:-*Modal share in the study area*
Source:-*Field Survey, 2019*

According to the survey results, the majority of participants in the research region walked to their destination. On the other hand, rickshaws and buses are also popular modes of transportation that respondents utilize on a regular basis for various purposes such as business, service, school, and job. Only a few trips are generated by human hauler from Ondho market road to Rajashan village. As a result, there is no option for the people to choose another mode for their particular journey purpose within the study area. Rickshaws are the most frequent means of transportation in the studied area, and individuals of all income levels use them. The goal of this part is to characterize the land use and transportation systems, as well as to explain the land use factors that impact the study area's travel behavior.

Land use characteristics affect travel behavior

The volume of travel, travel demand, relative attractiveness, and mode choice are all influenced by land use features. One of the three key categories of variables that influence travel behavior and demand is land use. The land use features that influence the study area's travel behavior are now explored in the following sub-sections.

Development density

Population density, employment, dwelling units, floor area etc. are considered as parameters to measured development density [42]. Population density is used as a primary criterion in this study to determine the association between the proportion of trips and the research area's population density. Table 6 shows that the percentage of trip increases according to density and ward three has higher density that is 62112/sq. km. and for this, higher trips are generated from this ward that is 16.40% of total trips. Because of their higher population density, wards two, three, five, six, and seven have a larger percentage of trips. Table 6 also shows the population density and travels by ward.

Table 6:-*Ward wise population density and trips.*

Ward No.	Density/sq.km.	Percentage of Trips
01	9626	4.00
02	34733	14.00
03	62112	16.40
04	18559	10.80
05	43978	14.40
06	21790	13.20
07	15822	12.80
08	11590	6.0
09	12993	8.40

Source: [38] and DAP 2010

Mix land use

Mix land use refers to the combination of residential, commercial, industrial, institutional, and agricultural land uses. The land use in the study region is mixed. There are no land uses that are solely residential, commercial, or industrial. The pattern of travel behavior is influenced by these various land uses. Residential land use dominates all nine wards in the studied area, whereas agricultural land use is in second place and has a low trip rate. However, in areas where commercial, industrial, and institutional land uses coexist with residential land uses, the trip rate is significantly higher. Table 7 shows the percentages of various land uses in the research region by ward.

Table 7:-*Percentage of different land use of the study area.*

Ward No.	Percentage of land uses						Percentage of trips
	Residential	Commercial	Industrial	Institutional	Agricultural	Accessibility (Road network)	
01	44.18	--	--	1.39	32.76	0.49	4.00
02	81.44	14.78	0.29	2.32	--	1.17	14.00
03	82.98	6.39	0.41	2.30	7.39	0.53	16.40
04	65.40	28.46	--	4.80	--	1.34	10.80
05	83.07	7.82	--	7.56	--	1.55	14.40
06	61.12	0.47	10.39	8.25	15.73	0.62	13.20
07	59.53	8.11	0.24	3.09	17.47	0.67	12.80
08	40.66	5.97	0.92	1.92	41.22	0.58	6.0
09	49.24	--	4.38	1.13	30.96	0.70	8.40

Source: [39, [40] and [41]

Table 7 shows that highest amount of commercial, industrial and institutional land use (33.26%) besides the residential land use (65.40%) exists in ward four. The accessibility of ward four is comparatively better that is 1.34%. Therefore, the percentage of trips is comparatively high in this ward that is 17.83%. In respect of percentage of generating trips, ward five is in the second position that is 16.80% and ward two is in the third position that is 15.30%. The share of commercial, industrial and institutional land use is high (17.39%) in ward two compare to ward five that is (15.38%) but the trip is high in ward five because of higher population density of this ward and its accessibility. But there is a variation in respect of density and trips compare to ward one, eight and nine. In ward one, the density is high compare to ward eight and nine but the generating trips of this region is low (4.60%) than ward eight (7.28%) and ward nine (5.50%). The main reason here, there is no industrial and commercial land use and agricultural land use (32.76%) dominate besides the residential land use (44.18%) and accessibility is low other than these wards. As a result, the people of ward one basically travels long distance and they also generate few trips compare to ward eight and nine. They like to use bus, auto-rickshaw and human haulers for their trip making purposes.

Correlation between density, land use and trip ratio

A link between density and land use is developed in order to justify the requirement that "if the density of any ward grows and the land use is intense, the generating trips from that ward likewise increase." First, the general land use scenario of the studied area is presented in order to create a relationship between density, land use, and trip ratio. Second, the population density of each ward is weighted. Finally, we calculated total weightage for several wards and drew a correlation line to see if the link between density, land use, and trip ratio is favorably or negatively connected.

Overall land use of the study area

The overall area of the Savar urban area, also known as Savar Pourashava is 17.15 square kilometers [22.] Out of a total area of 17.15 square kilometers, residential accounts for 54.85 percent, commercial for 4.56 percent, industrial for 2.08 percent, institutional for 2.93 percent, agricultural

for 24.55 percent and road network for 0.67 percent.

The weightage for wards wise population density

$$= \frac{Highest\ value - Lowest\ value}{1 + 3.322 \log 9}$$

$$= \frac{62112 - 9626}{4.169994}$$

$$= \frac{52486}{4.169994}$$

$$= 12586.58$$

Determining the maximum and minimum value of the density of wards and convert it to 1 point Likert scale.

Class interval

Now, the weightage for density of different wards is shown in the following way according to 1 point Likert scale.

Table 8:-*Weightage of density for different wards.*

Density/sq.km.	Weightage
9626-22213	0.2
22213-34800	0.4
34800-47387	0.6
47387-59974	0.8
59974-72561	1.0

Therefore, the obtained weightage forward wise population density is shown below in the tabular form.

Table 9:-*Weightage of density for different wards.*

Ward No.	Density/sq.km.	Weightage
01	9626	0.2
02	34733	0.4
03	62112	1.0
04	18559	0.2
05	43978	0.6
06	21790	0.2
07	15822	0.2
08	11590	0.2
09	12993	0.2

Source: [38] and LGED 2018

Estimation of total weightage for different wards

$$WW_j = \text{Weightage of density} + \sum_i^w (\%\ \text{of ward wise land use} \times \%\ \text{of study area land use})$$

Where,

$i = \text{Residential, Commercial, Industrial, Institutional, Agricultural, Accessibility.}$

$WW_j = \text{Total weightage for ward } j$

The total weightage of each ward according to density and land uses is calculated by the following formula.

$$WW_j = \text{Weightage of density} + \left\{\begin{array}{l}(\%\text{ of residentia l area of ward } j \times \%\text{ of total residentia l area})+\\(\%\text{ of commercial area of ward } j \times \%\text{ of total commercial area})+\\(\%\text{ of industrial area of ward } j \times \%\text{ of total industrial area})+\\(\%\text{ of institutio nal area of ward } j \times \%\text{ of total institutio nal area})+\\(\%\text{ of agricultur al area of ward } j \times \%\text{ of total agricultur al area})+\\(\%\text{ of accessibility of ward } j \times \%\text{ of total accessibility})\end{array}\right\}$$

Therefore,

$$= 0.2 + \left\{\begin{array}{l}(0.4418 \times 0.5485) + (0 \times 0.0456) + (0 \times 0.0208) + (0.0139 \times 0.0293) + \\ (0.3276 \times 0.2455) + (0.0049 \times 0.0067)\end{array}\right\}$$

$$= 0.2 + \{0.242 + 0 + 0 + 0.0004 + 0.080 + 0.00003\}$$

$$= 0.2 + 0.32$$

$$= 0.52$$

By using the above formula, the total weightage for the one ward is estimated and the result is given below.

By using the above formula, the total weightage forward one is estimated and the result is given below.

WW_{one} = .52

WW_{Two} = .85 WW_{Three} = 1.47

WW_{Four} = 1.37 WW_{Five} = 1.06

WW_{Six} = 0.58 WW_{Seven} = .57

WW_{Eight} = 0.56 WW_{Nine} = 0.55

Correlation between weightage index and trip ratio

The ward wise weightage index and trip ratio data that were utilized to determine a correlation between these two variables are tabulated below.

Table 10:*-Ward wise weightage index and trips.*

Ward No.	Weightage index (x_i)	Trip ratio (y_i)
01	0.52	0.046
02	0.85	0.1400
03	1.47	0.1640
04	1.37	0.1080
05	1.06	0.1440
06	0.58	0.1320
07	0.57	0.1280
08	0.56	0.060
09	0.55	0.0840
	$\bar{x}$ = 0.75	$\bar{y}$ = 0.19

Source: [38] and LGED 2018

The correlation between weightage index and trip ratio of different wards is established by using the following formula.

$$r = \frac{(x_1 - \bar{x})(y_1 - \bar{y}) + (x_2 - \bar{x})(y_2 - \bar{y}) + \text{--------} (x_n - \bar{x})(y_n - \bar{y})}{\sqrt{(x_1 - \bar{x})^2 (x_2 - \bar{x})^2 + \text{---} + (x_n - \bar{x})^2}\sqrt{(y_1 - \bar{y})^2 (y_2 - \bar{y})^2 + \text{---} + (y_n - \bar{y})^2}}$$

$$r = \frac{0.07682}{0.758 \times 0.110}$$

$$= \frac{0.07682}{0.08338}$$

$$= 0.9213$$

$$= 0.92$$

The correlation result $r = 0.92$ shows that the trip ratio, density and land use are strongly positively correlated.

CONCLUSION

Savar is well connected by road to its inner and outside areas, but commuters have a significant challenge in deciding on forms of transportation because residents come from a variety of socioeconomic backgrounds. The transportation system includes both motorized and non-powered modes. People in the studied area use various modes for a variety of trips, including commerce, service, school, work, showing, medical, recreational, religious and medical purposes. Residents in the studied area have a wide range of modal preferences. In light of this, the research was done with the goal of identifying the factors that influence commuter modal choice and determining which mode is favored by commuters. Aside from that, the research uncovers a link between travel behavior and the study area's land use system, since land use has an impact on travel behavior patterns. It was attempted to determine the contribution of various modes of communication inside and outside of the research region in terms of trip planning, travel cost, duration and distance, accessibility of various modes such as rickshaw, auto-rickshaw, bus, and human hauler, respondents' views on modal choice characteristics such as convenience, comfort, safety, privacy, dependability, and security, as well as travel hours of the day and frequency. It was also attempted to determine the overall number of trips generated in the research region, the distribution of these trips, the selection criteria for different modes, and the reasons for commuter preference.

For their various trip-making reasons, the residents in the studied area favored bus transportation to communicate both within and beyond the research region. However, commuters in the study area stated that current bus services are unable to fulfill travel demand, and that the fares are prohibitively expensive for people of all income levels and ages. The trip makers choose rickshaws for short distance transport inside the study area. In the studied area, auto-rickshaws are not present in every ward. However, commuters have no choice in terms of these modesTravellers will profit in terms of saving time and money, as well as being able to reach their destinations on time, if these modes are developed in the studied area. Transportation mode preferences are also impacted by lifestyle and vocational considerations. Some commuters choose to employ means of transportation that are pleasant for them rather than considering the cost of travel, as some prefer to save money over comfort. The bus and auto rickshaw are the favored modes of transportation for commuters due to cheaper travel costs. Apart from that, the link between land use and travel behavior is investigated. When land use is a mix of residential, commercial, and industrial, the number of short-distance trips generated is high; however, as density rises and land use becomes more intense, the number of trips generated rises as well.

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