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Trips Generated by Rickshaw Pullers and Trip Rate for Cycle Rickshaws: A Case Study of Delhi

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Abstract

With rapid growth in urbanization, the demand of infrastructural services has boosted up. High economic opportunities in metropolitan cities lead to increased movement of people which ultimately results in very large demand of transportation services. As transportation sector has very large impact on the social, economic and environmental growth of a country it is imperative to make it greener and more sustainable. For a country to have a better growth, transportation sector should be inclusive and provide equity. Cycle Rickshaws are a green mode of transport that has to the potential to provide last-mile-connectivity, act as feeder mode, as well as supplant motorized trips for shorter distances. The usage of cycle rickshaw is seen in many parts of India and it forms a popular mode of transport for shorter trips made in small towns. Since NCT of Delhi, which has tremendous number of motorized vehicles plying on its roads, the promotion and improvement in cycle-rickshaw services may provide a respite to the environment from the carbon load. With this motivation, this study aims to study the trip generation pattern for cycle rickshaw for selected locations of Delhi. The results reveal that age, status and duration of ownership, income, perception of difficulty governs the number of trips generated by pullers. Occupancy and the trip rates are also analyzed in the article. This study aims to provide an initiative towards the development of sustainable transportation by taking a step forward in the direction of organized structure of Non-motorized vehicles.

Peer-review under responsibility of WORLD CONFERENCE ON TRANSPORT RESEARCH SOCIETY.

Keywords: Non-motorized transportation; Cycle rickshaw; Sustainability; Trip generation; Trip Rate; Occupancy factor

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1. Introduction

Excessive growth of motorized vehicles in Delhi has led to the rise of traffic congestion, safety issues and environmental hazards. Since mass transit is viewed as a greener alternative (Minal & Ravi Sekhar, 2016) planners are trying to improve them to attract the people towards public transportation system. Efficiency of public transportation demands an effective feeder system to attract the commuters.

Huge investments in provision of rapid transit and metro rail services are not justified when these services are underused. Thus, an efficient feeder service that is seamless and provides last mile connectivity to transit users will improve the usage of mass transit services. In this scenario, NMT services prove to be economic, equitable and sustainable (Sagaris & Arora, 2016). The step towards the organized structure of NMT is necessary to shift the people from using motorized vehicles to non-motorized ones. Germany, Denmark, Japan and the Netherlands have experienced considerable growth of NMT due to various policies involved. Asian cities have more than 25% to 80% of NMT which proportion is greater than anywhere else in the world (Replogle, 1992). Figure 1 shows the willingness of people to shift to another mode in Asian cities if no improvements is done in NMT. NMT sector is the most sustainable as they are non-polluting, cheap and labor intensive. It helps in generating employment which is very much needed especially in the developing countries where poverty is the major issue. About 1000,000 people earn their livelihood by cycle rickshaw all over India (Saini, 2015).

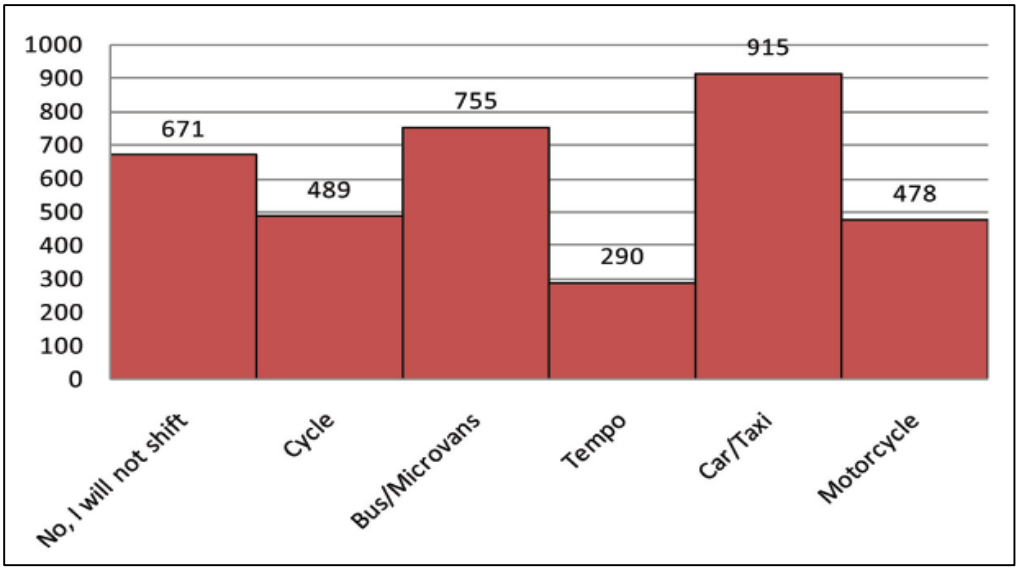

Figure 1 Shift to other modes if no improvement (Source: Clean Air Asia,2012)

Urban population in Indian cities is increasing day by day which demand more transportation services. Study show that urban population in India was 17.3% of total in 1951, 31.2% of total in 2011 and expected to reach 37% of total by 2021 (Jain, 2015). Demand for transportation sector is also growing rapidly with the growth in urban population. The population growth rate in Delhi is 1.4% and surprisingly, that of motorized vehicle is 7% (Parida & Parida, 2008). Figure 2 shows the motorized vehicular growth in Delhi. In Delhi, the number of cycle rickshaws is more than 500,000 which generate near about 1.5 million trips per day (Saini, 2015). In the city like Delhi, where the traffic congestion and pollution are major problems, the cycle rickshaw proved to be a green mode of transportation. It has efficient use of road space as almost half of the space is required by cycle rickshaw than that of required by a passenger car. The cycle rickshaws provide employment opportunities to the unskilled workers who have migrated from rural to urban areas of the country. According to (Anon., 2018) the growth of motorized vehicle is tremendous but that of Non-motorized vehicles such as cycle rickshaw does not show a considerable increase. The reason may be

the hardship, safety and security issue and less income earned by pulling rickshaw. The study is aimed to analyse the influence of various parameters that motivates or demotivates the pullers from pulling rickshaw. The findings of the study help to improve the Non-Motorised Transport modes, especially the Cycle Rickshaws.

As far as author's knowledge goes trip generation analysis based on the above mentioned factors for cycle rickshaw

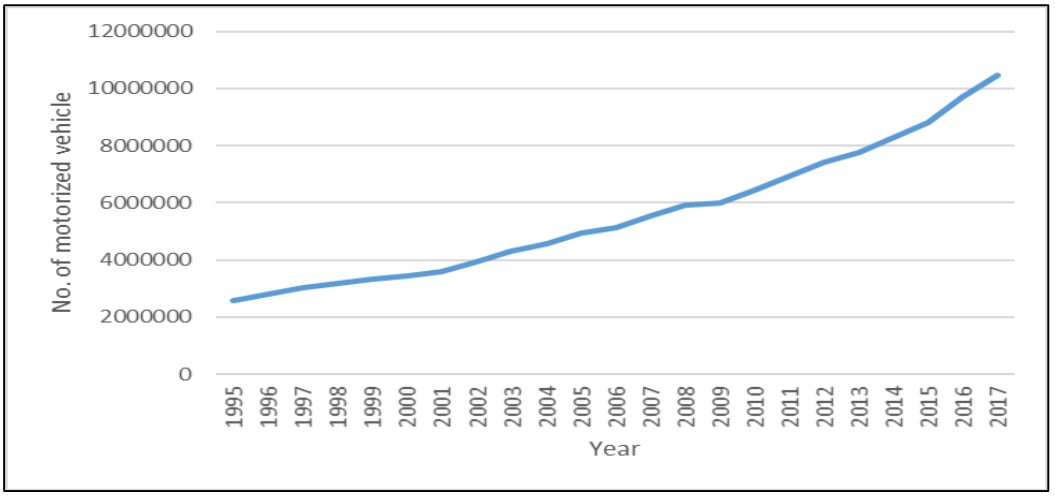

Figure 2Growth of motorized vehicle (Source: Delhi statistical handbook,2018)

has not been done and thus this paper covers a gap in the literature. Also, the study analyses the occupancy trends with respect to time-of-day and gender of the cycle rickshaws plying on the road of Delhi. The study also estimates the tip rate of cycle rickshaw at the selected locations in the city of Delhi. This paper is further organized with a state of art of the literature on NMT and cycle rickshaw. Further, the description of study area and data collection methods are discussed. The paper proceeds with a discussion on the parameters used along with the trip generation analysis. The occupancy pattern and trip rates for cycle rickshaw are discussed further in paper. The paper concludes with a discussion on the results.

2. Literature review

Importance of NMT for urban infrastructure became a topic of debate since late 90s (Replogle, 1992; Gupta, 1992). Replogle (1992) discussed about the impact of cycle rickshaws and bicycles on the urban infrastructure in Asian cities. Various issues and barriers such as taxes and import duties hinder the growth of NMT in developing cities of Asia. It shows that land use and transportation investment have major impact on NMT. The various strategies which can be implemented to enhance the growth of NMT sector depends on the parameters such as income of household, trip length, cost of trip, etc. Usage of NMT is also affected by favourable climate, good terrain, and space availability (Lukomona, 2017). Sustainability is an important factor to be considered for the development of smart cities (Roy & Sharma, 2016). Authors have considered the comparative study of codes & guidelines and case study of various locations in Delhi. Parameters such as pedestrian conflicts, availability of footpath and obstructions in the available footpaths, appropriate crossing, motorist behaviour, space available for medians are considered to retrofit the NMT sector in the city. It is concluded that retrofitting of NMT is very much essential for the smart city development. The only mode for the sustainable transportation is NMT (Gupta, 1992). The author developed various models representing the relation between emission rate of pollutants and trip length. As the city size increases, the consumption of fuel also increases and hence policy should be developed to control the size of the city to a population of 0.3 million. It is demonstrated that land use pattern in emerging cities are suitable for NMT growth. (Khan, et al., 2014) have developed model to explain the behaviour of NMT in terms of built environment factors. Results shows that street structure has the greatest impact on the behaviour of NMT. NMT has strong sensitivity to age and gender parameters. 'Fazilka model' is a successful example for developing organized structure of cycle-rickshaws which is based on dial-up-

rickshaw service (Saini, 2015) in Punjab, India.

The role of cycle rickshaw is discussed in detail by (Tiwari, 2014). Study states that cycle rickshaw continue to play vital road for meeting transportation demand for short distances in South Asian cities. Author discussed about the restriction on the number of cycle rickshaw by the municipal authority of Delhi. Author argues against this restriction as 24 % of the metro trips are dependent on cycle rickshaw. The demand of separate lanes for slow moving traffic is very much essential because the PCU value for the same are very high especially when their composition is less than 5%.Author (Tiwari, 2014)concluded that the separate lanes for slow moving traffic such as cycle rickshaw increases safety and highway capacity, reduces traffic congestion and improves operation characteristics of vehicles. Cycle rickshaws also play an important role in goods movement in the commercial markets of Delhi and have unique features of last –mile delivery and ability to negotiate narrow roads (Gupta, 2016). Studies have been carried out to analyse the impact of urbanization on trip rate in Surat, India (Joshi & Katti, 2006). The analysis revealed that household characteristics, trip purpose, mode choice and spatial distribution of home and activity ends have great influence on the trip rate. LIG (Low Income Group) of people have high trip rate by non-motorized transportation. It is stated that work and school trip rate is directly proportional to the income of household.

From the review of literature on cycle rickshaw and NMT, we find that there is a gap in the study of trip generation of cycle rickshaws. This paper tries to fill this gap in literature by analysing the trip generation patterns along with estimation of trip rate, occupancy and occupancy factors of cycle rickshaws. Based on the results obtained from the trip generation regression analysis, a policy intervention scenario is also evaluated. This scenario is based upon the ownership level of rickshaw amongst the rickshaw pullers. The results give insights into the factors that can be intervening with help of proper policy formulation. Through the understanding of factors that affect trip generation of cycle rickshaws a proper policy can be formulated to promote usage of Cycle rickshaws in the city.

3. Study Area

Delhi, officially The National Capital Territory of Delhi (NCT) is the capital of India. It is located at 28º36’36” N and 77º13’48” E. It has been continuously inhabited since 6th century and now it is classed as a global city as it is one of the most productive sector in India. It is surrounded by Haryana on three sides and Uttar Pradesh to the east. The urban area of Delhi is extending to the NCT boundary and include Faridabad, Gurgaon, Noida and Ghaziabad. The population of NCT is 16.8 million according to (Census, 2011).

Delhi has the highest road density in India which is 2103 km per 100 km^2. The city has wide road network where

Figure 3 Boundary of NCT-Delhi (Source: Google Maps)

City buses and State transportation buses ply. Buses are an important mode of transportation in the city. Delhi also has a metro service plying which serves as a modern transportation system and is fast, comfortable, safe and reliable. According to (Anon., 2014) report Delhi is one of the most polluted city in the world. With the fast growth of urbanization and motorized vehicles the pollution is increasing rapidly. The problem of pollution is very severe and demands sustainable transportation system.

4. Data Collection and Survey locations

The data for the study was collected through two surveys. The first survey was conducted through a questionnaire-based interview method. Rickshaw pullers were interviewed regarding various aspects of trip making. Questionnaire based interview surveys were undertaken at selected locations and conducted personal interviews of rickshaw pullers. The surveys incorporated aspect of cycle rickshaw travel like number of daily trips. Also, socio-economic information of rickshaw pullers like age, ownership status, duration of ownership, hardship in rickshaw pulling, daily income, daily rent was included. The second survey was conducted to record the 'occupancy' of cycle rickshaws. The occupancy survey was conducted at morning and evening peak hours and recorded gender-based occupancy along with the single or shared usage of cycle rickshaws. Surveys were conducted at the following three locations:

a) Maharani Bagh

Maharani Bagh: It is a posh residential area located in South Delhi. The area comprises of several markets, a community centre and religious places in the vicinity which leads to very high number of trip generation. In the city of Delhi, markets are very congested which demands the very efficient use of road space by vehicles. Cycle rickshaw

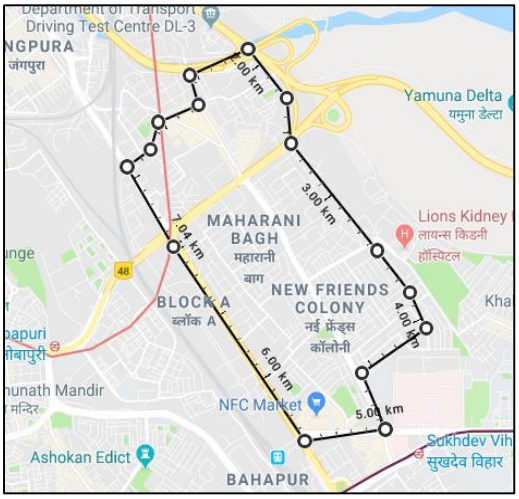

Figure 4 Location of Maharani Bagh (Source: Google Map)

being a compact vehicle and ability to negotiate narrow roads is suitable for the area. Moreover, trip generation rate is likely to be increased because of the construction of Ashram metro station. Provision of metro station would demand more short distance trips. For this purpose, also, cycle rickshaw is the best mode of transportation.

b) Botanical Garden

It is located at captain Vijyant, Thapar Marg in NCT of Delhi. The area surrounding Botanical garden is congested residential area having markets, Gurudwara and Temples in the vicinity. The main reason behind selecting this location is that it is a major recreational spot and attracts commuters for leisure activities. Also, it has a metro station in its vicinity which is the junction of two metro lines. Due to junction of metro lines, the metro station has a heavy inflow and outflow of passengers and thus it is imperative to study the usage of cycle rickshaw in this region.

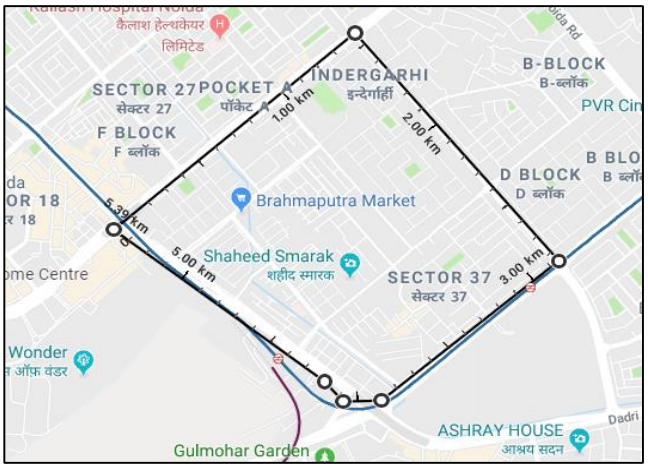

Figure 5 Location of Botanical Garden (Source: Google maps

c) Paharganj

The area is known as Shahganj or King's ganj is located in Central Delhi. New Delhi railway station is situated at to just east of Paharganj. It is one of the three administrative subdivision of Central Delhi district. It is a hub of hotels, lodges, dhabas, restaurants and international cuisine catering to both domestic travellers and foreign tourists. The area is heavily congested residential area containing narrow streets which is unsuitable for motorized para transit. The area consists of majority of low income group and hence cycle rickshaw proves to be most economic mode of transportation.

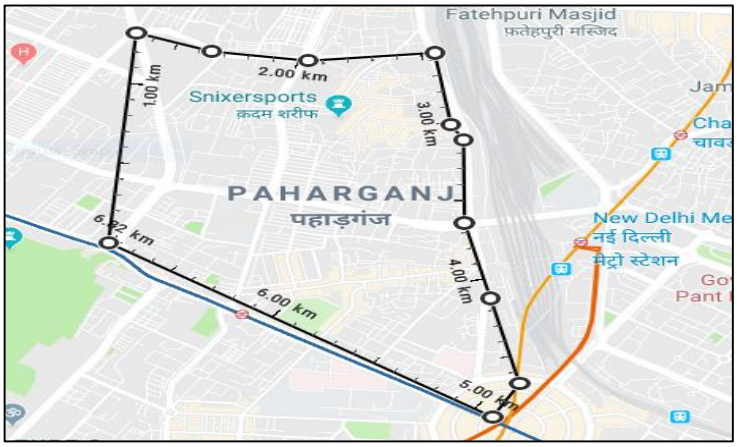

Figure 6 Location of Paharganj (Source: Google maps)

Survey was carried out at the above three locations during peak hours to determine the influence of various characteristics of rickshaw pullers on the number of trips they generate. Here, trip is defined in the context of rickshaw pullers. A trip by rickshaw puller is referred as "A rickshaw puller travelling with minimum one passenger from the origin to destination". For example, if a passenger wants to go from home to metro station by a cycle rickshaw, his home is considered as origin and metro station is considered as destination for a rickshaw puller to complete one trip.

Around 280 rickshaw pullers were interviewed and data was collected by personal interviews, which include the below mentioned parameters (Table 1). To avoid the biasness in the data collection, the questionnaire was prepared in local language for their better understanding. Moreover, the responses were also cross checked by the interviewers. The average daily number of trips by pullers are reported instead of trip made on a day to avoid daily variation in the trip. Incomplete sample were eliminated and 224 samples were considered for further analysis.

Except daily trips, variables are listed out in Table 1 have been taken as independent variables. Age, Experience, Duration of ownership, daily rent and daily income are considered as continuous variables whereas for ownership status and perception of difficulty, dummy variables have been created as shown in Table 1.

The visual observations for 'occupancy' counts have also been taken during peak hours at Maharani Bagh and Paharganj to determine the occupancy factors. Descriptive statistics of the input variables were performed and summarized in Table 2.

Table 1 Variables considered for the study

Parameter	Quantity/Unit
Age	Years
Experience	Years
Duration of ownership	Years
Daily rent	INR
Daily income	INR
Ownership status	Categorized (Owned :1, Rented: 0)
Perception of difficulty	Categorized (Extremely difficult: 1, 2. Difficult 3. Not so difficult 4. Easy 5. Very easy)
Daily trips	Number

Table 2 Parameter - Descriptive Statistics

Parameter	Mean	Standard deviation
Age	38.59	11.22
Experience	10.25	7.93
Duration of ownership	0.59	2.32
Daily rent	41.28	18.26
Daily income	363.34	97.74
Daily trips	18.57	8.57

As people involved in the occupation of rickshaw pulling have large variation in their age, and so in the experience, the values of standard deviation are quite high. Number of trips generated by pullers may vary with their age and other aspects and hence this parameter shows high deviation. As income is proportional to number of trips, the income also shows large deviation.

5.1 Input Variables

Each of the input variable are studied in detail to give an insight into the effect they have on the trip generation pattern of cycle rickshaw. Normal distribution curves of all the parameters are derived and depicted in the following section. Independent axis (X-axis) of the curve represents various parameters and depend axis (Y-axis) represents Probability Density Function (PDF). In case of finding the probability of range of a parameter, the value of probability density function at the mean of the range is multiplied by that range.

I. Age

Normal distribution curve of the parameter age (fig.7) shows that the probability of rickshaw puller's age lying between 50 and 60 years is only 12.5% which indicates that a smaller number of people having this age group involved in rickshaw pulling. The curve (fig.7) clearly shows that very few rickshaw pullers interviewed, has age below 18 years. This is due to hardship in pulling rickshaw by children and senior citizens. There are about 70% of rickshaw pullers in Delhi whose age falls within the range of 30 to 50 years.

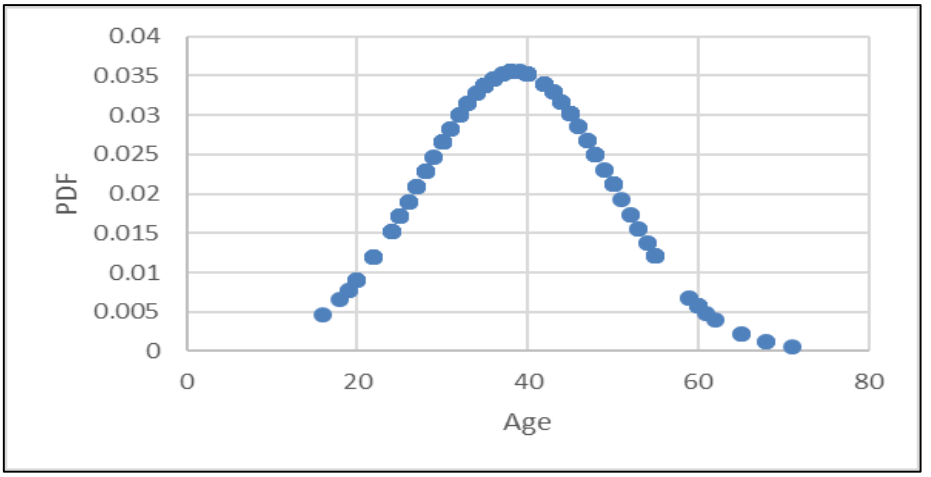

Figure 7 Age distribution

II. Experience (In Years)

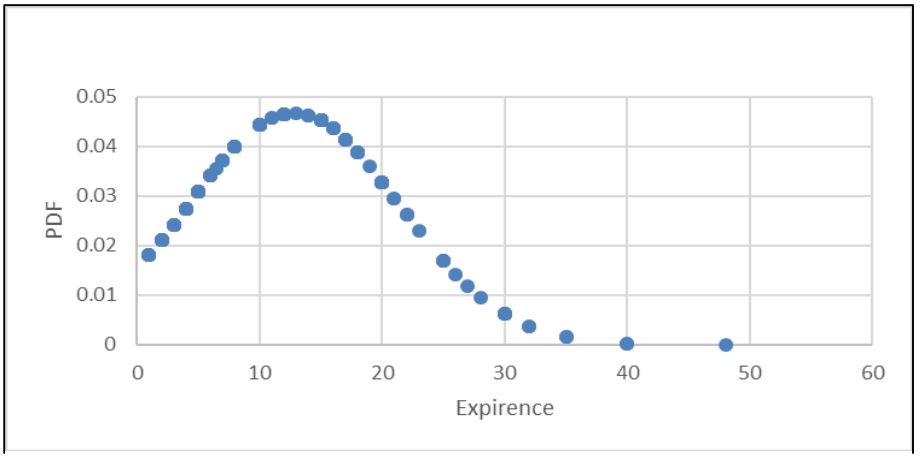

Figure 8 Experience Distribution

Experience refers to since how many years a person is plying a rickshaw on the roads of Delhi. The curve as shown in fig 8 indicates that the number of rickshaw pullers having the experience of 20 years or more is about 80%. As experience directly relates to the age of the puller, the number of people having higher age pulling the rickshaw is very large and people who pull rickshaw since 20 years or more is negligible. It is also observed from the curve that the number of pullers just involved (experience less than one year) in this profession is negligible

III. Duration of Ownership (in Years)

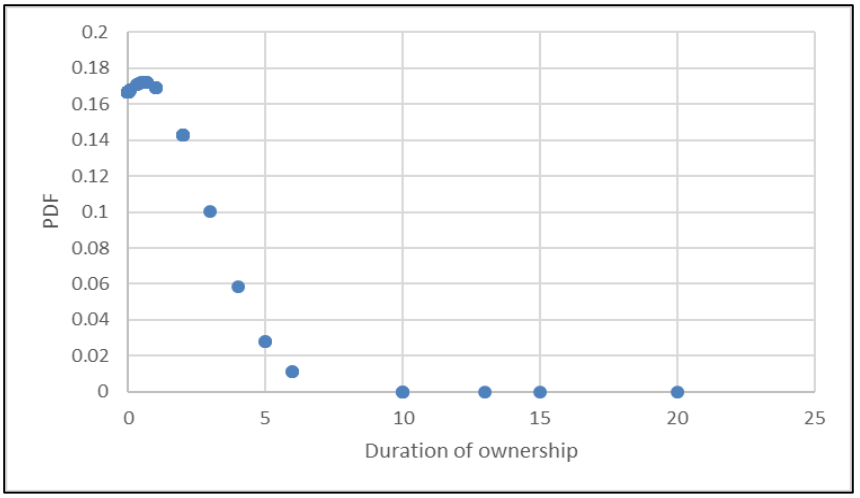

Figure 9 Ownership Duration Distribution

If earlier a puller has rickshaw on the rent, then since how many years he has his own rickshaw is indicated by the parameter "duration of ownership". The distribution of this parameter is highly scattered (fig 9) which signifies that the ownership of the rickshaws by the puller is an uncommon pattern. Most of the rickshaws are rented by the rickshaw pullers and they pay a rent to the owners on a daily/ monthly basis. The rent paid has been discussed further in the next sub-section.

IV. Daily Rent (INR)

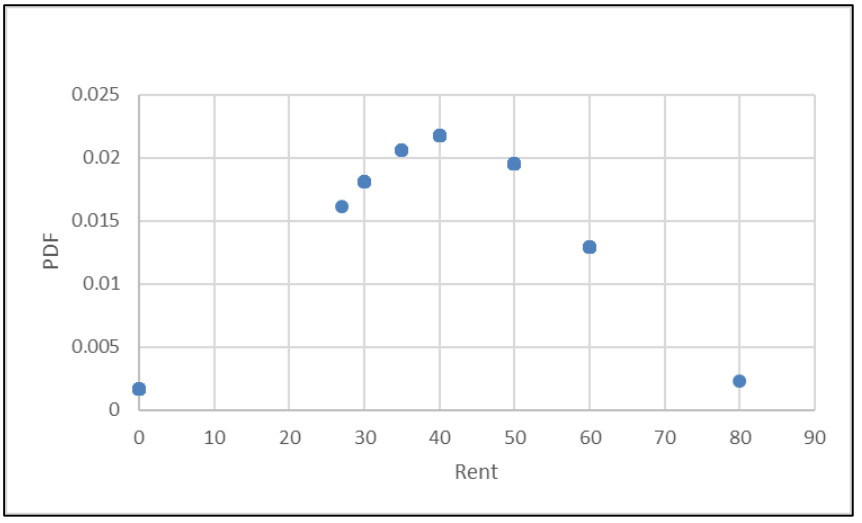

Figure 10 Daily Rent Distribution

The trend in payment of daily rent seems to be clustered around fixed rates. About 90% of the rickshaw pullers pay INR 40 to their owner on daily basis. In very few cases, the amount varies to INR 30 and INR 60. The curve (fig 10) shows that the rent paid to owner remains more or less constant irrespective of area in which rickshaw is being pulled. Monthly rent paid to owner is about INR 1200 which is a very high amount for a rickshaw puller to pay as it is more than 15% of their total income.

V. Daily Income

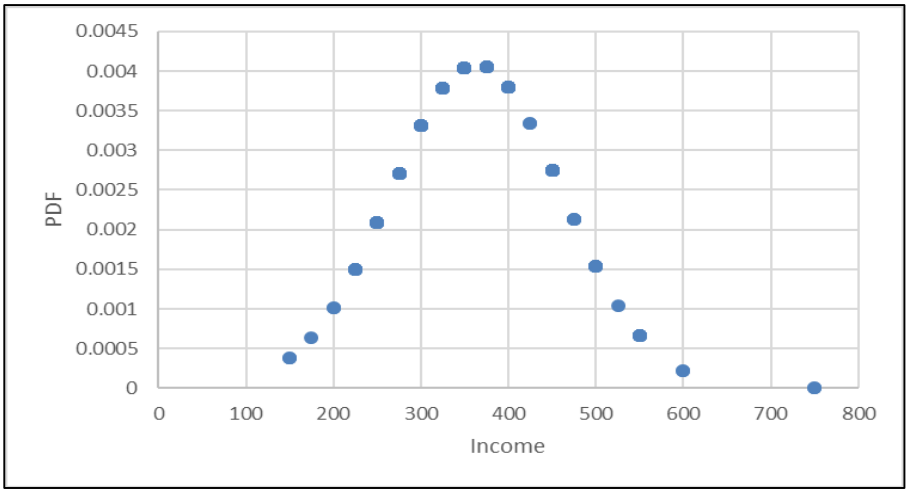

Figure 11 Income Distribution

Average daily income of a rickshaw puller is approximately INR 363. About 80 % of the pullers earn between INR 300 and INR 500 per day. The probability of earning between INR 150 and INR 200 is 2.5%. The curve shows (fig 11) that the earning pattern of rickshaw puller remain almost same as most of the pullers have daily income between INR 300 and INR 500.

VI. Number of Daily Trips

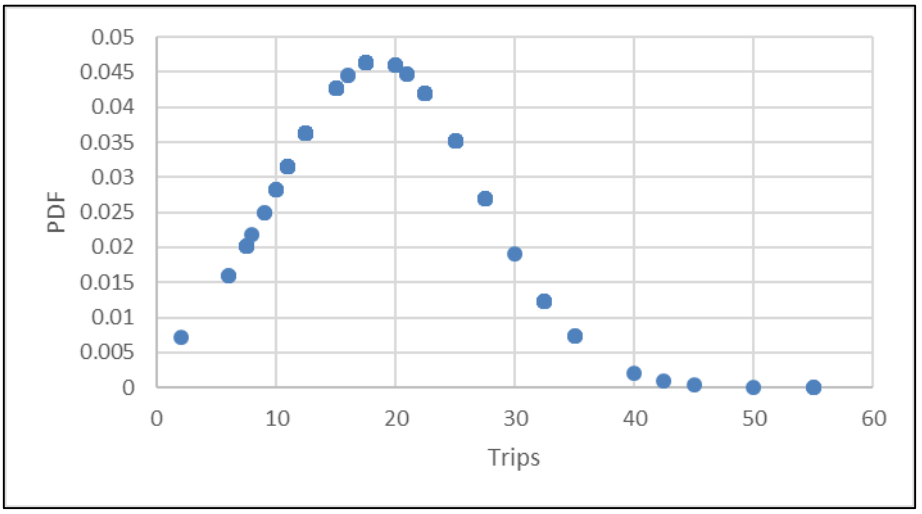

Figure 12 Trips Distribution

Number of trips produced by rickshaw pullers depend on various factors. The model is developed to establish the relationship between above discussed parameters and daily number of trips. The curve shows (fig 12) that half of the

rickshaw pullers produce 15 to 35 number of trips per day. It is observed that the probability of producing daily 20 to 30 is 25%. Each interviewed rickshaw pullers said that they make at-least 5 trips every day. However, number of trip generated is highly dependent on the distance covered by each trip. For example, the distance travelled by a person generating 50 trips and another person generating 30 trips may be same.

5. Data analysis

As discussed previously in this paper, cycle rickshaw-based service is a highly sustainable mode of transportation and very much needed in the city like Delhi where pollution is a major issue. The organized structure of NMT will help in shifting the motorized trips to the non-motorized ones as they provide door-to-door last mile connectivity. The step has been taken to determine the trip making behavior of cycle rickshaw pullers in this study. The paper shows how the various parameters like age, experience, ownership status, duration of ownership, daily income, daily rent and perception of difficulty of rickshaw pullers affect the number of trips generated per day.

For establishing the relationship among dependent and independent variables, regression analysis is used widely. Predictions are made based on the obtained regression function. Regression analysis being a popular method for determining the trip generation has been carried out to investigate the impact of parameters on trip generation of cycle rickshaws by using SPSS. The results are estimated with 95% level of confidence to establish the model of trip making behavior. The generalized equation for the daily number of trips (Y) is given by eq. (1). Before performing regression analysis, it is necessary to check correlation between the variables. Table 3 shows the correlation coefficients of parameters. Correlation between age and experience is quite high and hence experience has been removed from regression analysis.

Table 3 Correlation Coefficients

	Experience	Ownership status	Daily Income	Perception of difficulty	Duration of ownership in years	Age	Daily rent
Experience	1.000	0.047	-0.037	-0.069	-0.021	-0.607	0.052
Ownership status	0.047	1.000	-0.070	0.069	-0.347	-0.019	0.349
Daily Income	-0.037	-0.070	1.000	0.002	0.063	0.157	-0.015
Perception of difficulty	-0.069	0.069	0.002	1.000	-0.082	0.241	0.139
Duration of ownership	-0.021	-0.347	0.063	-0.082	1.000	-0.078	0.018
Age	-0.607	-0.019	0.157	0.241	-0.078	1.000	0.010
Daily rent	0.052	0.349	-0.015	0.139	0.018	0.010	1.000

$$Y = a + b1x1 + b2x2 + b3x3 + b4x4 + b5x5 + b6x6 + b7x7 + \cdots \qquad eq.(1)$$

Where intercept “a” is the intercept and the “b_i” in the equation shows the co-efficient of the corresponding parameter “x_i”.

Table 4 Input parameters and results from regression analysis

Parameter	Nomenclature	Regression co-efficient	t-stats
Age	X1	-.028	-2.02
Duration of ownership	X2	-0.64	-2.50
Daily rent	X3	-0.04	-1.87
Daily income	X4	0.04	6.47
Ownership status	X5	4.32	3.23
Perception of difficulty	X6	-0.892	-5.032

The result from regression analysis reveal that 'ownership status' of rickshaw has the greatest impact on the number of trips generated daily rather than other parameters considered. Rickshaw pullers having their own rickshaw have more flexibility in terms of time, area of pulling and the way of handling the rickshaw etc. The rickshaw pullers who have their own rickshaw tend to generate more trips as there is an increased onus of responsibility and ownership.

Duration of ownership (since how many years they owned the rickshaw) has negative influence on the number of daily trips generated. Large duration of ownership indicates that the puller and rickshaw are old. The old aged puller may not be able to pull rickshaw for long distances. Also, the repair and maintenance requirement of rickshaw also goes on increasing with time so the number of trips generated are tend to decrease.
Daily rent is not significant at 95 % level of confidence. The reason behind it may be the negligible variation for rent paid to owner among rickshaw pullers.
From the model estimates, we find that level of difficulty has significant impact on trip generation. Perception of difficulty in rickshaw pulling indicates that the pullers who find hardship in rickshaw pulling tend to generate less number of trips. Daily income has a proportional relationship with trip generation. With an increased number of trips, income of pullers likely to be raised which is clearly seen by the positive relationship between trips and daily income.

The goodness of fit measures of the model are summarized in Table 5. It is observed that correlation coefficient denoted by "r" has value equal to 0.79 which indicates good degree of association between dependant and independent parameters. 'R^2", also called as Co-efficient of determination has the value of 0.631 indicates that the data are close to the fitted regression line and there is less deviation between the actual and fitted model data. From the measures of various goodness of fit, the developed model seems sound and can be used for further analysis in developing different scenarios

Table 5 Model Statistics

Correlation co-efficient	R-squared
0.62	0.79

6.1 Scenario: Policy Intervention

According to the collected data, out of total 223 number of samples only 38 number of rickshaw pullers (17.48%) have their own cycle rickshaw. The rest of the pullers ply the rickshaws on rent. Result of regression analysis shows that ownership status has very strong influence on the daily trips. Thus a scenario of policy intervention is developed to study the effects of varying levels of 'ownership-status' on the trip generation pattern of cycle rickshaws. Analysis has been carried out to determine how the daily number of trips are influenced by the variation in ownership status keeping all other parameters constant. The percentage of ownership is varied from 5% to 100% to get the total daily trips generated by using the regression equation developed in previous section. Table 6 presents the results from the policy intervention scenario. There is a constant increase in generated trips with increasing level of ownership of rickshaws. Figure 13 plots the trend line for the change. The trips generated at base case is 13 which increases to 18 at 80% ownership level. A higher sense of ownership is a motivation for the pullers to put in effort and take up more

trips by rickshaw. Since, it is clearly seen that the rickshaw pullers having their own rickshaw tend to generate more number of trips as compared to the ones who ply rickshaw on rent. To enhance the growth of NMT the strategy which helps rickshaw pullers to buy their own rickshaw may be formulated and implemented. Such facilitation of provision of own rickshaw might give a boost to the cycle rickshaw based NMT in Delhi and improve its usage.

Table 6 Variation in trips with ownership

Percentage of ownership	Average Daily Trips
5	13.72
17.48 (Base case)	14.27
25	14.60
35	15.025
50	15.68
60	16.11
70	16.76
80	17.83

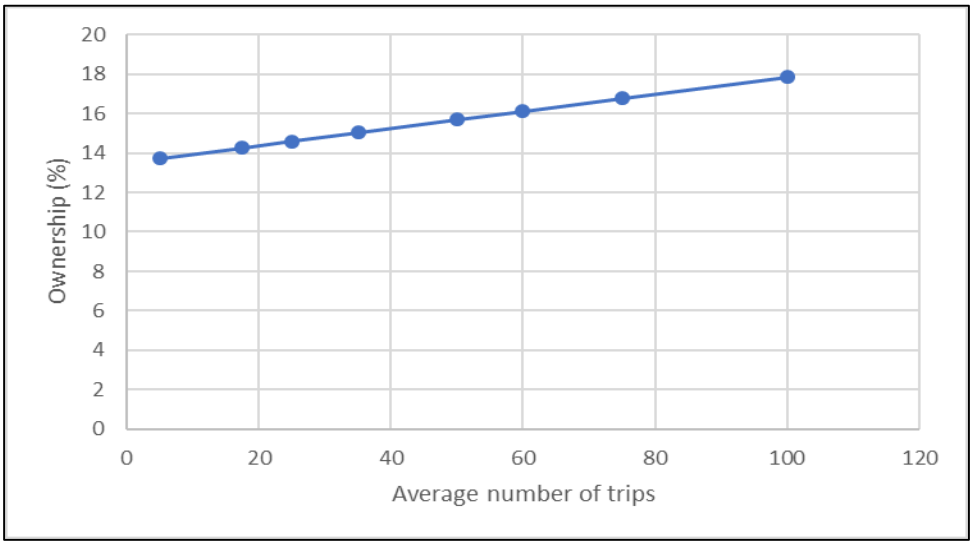

Figure 13 Variation in Number of Trips

6.2 Trip rate

Trip rates refer to the intensity of travel due to the land use development and is defined in terms of: the number of trips in comparison to the size of the development for a time period as shown in eq. (2). Estimated trip rate for an area is useful in reflecting the land use and travel pattern characteristics.

In this study, trip rates were calculated for each of the three location mentioned above. The area for the location was calculated using Google Map and its feature of ‘Distance-measurement’ through creation of buffer zones. The number of trips for an area has been calculated as average daily trips by puller in area multiplied by the number of cycle rickshaws in that area. Number of cycle rickshaws was observed during the survey. The results for trip rate estimation are presented in table 7.

$$Trip\ rate = \frac{Number\ of\ trips\ in\ given\ duration\ of\ time}{Area\ of\ development\ in\ terms\ of\ 1000\ sq.feet} \qquad eq.(2)$$

Table 7 Estimated trip rate

Location	Number of daily trips	Area (in terms of 1000 ft^2)	Trip rate
Maharani Bagh	525	25856.78	0.020
Botanical garden	240	19979.88	0.012
Paharganj	1500	26788.91	0.056

It can be observed from table 7 that Paharganj has a very trip rate of 0.056 for the cycle rickshaws followed by Maharani Bagh. Botanical garden has a trip rate of 0.012 for cycle rickshaws. Paharganj being an area having majority of LIG of people has the highest among all three areas under consideration. This result is in line with the findings of the study (Joshi & Katti, 2006) that people from LIG have high trip rate using NMT. Also, presence of old markets regions with constricted roads make the usage of cycle rickshaw more feasible than motorized modes as suggested by other studies (Gupta, 2016). Maharani bagh is majorly a residential area with reasonable wider roads and better income levels. Thus we see that the trip rate for cycle rickshaw in this area is lesser than that of Pharaganj. But the even though the income levels are high there is still a scope of promotion of cycle rickshaws in this region as well. The last mile connectivity provided by cycle rickshaw is a unique and strong feature that attract people to it. Trip rate for recreational purpose tend to increase with increase in income of household (Joshi & Katti, 2006).Botanical garden being a recreation area has very less trip rate by NMT because HIG of people rarely use NMT.

6.3 Occupancy

Occupancy of cycle rickshaw refers to the number of people travelling in the rickshaw during a trip. An estimation of occupancy gives an idea of demand of a particular travel mode. Surveys were conducted at Maharani Bagh and Botanical Garden to determine the occupancy of Cycle Rickshaws. These surveys were conducted during morning and evening peak hours at the locations as depicted in figure 14,15,16& 17. A brief discussion regarding the occupancy at these locations is given below.

6.3.1 Maharani Bagh:

Fig 15 depict the number of male and female passengers travelling in cycle rickshaw during peak hour periods. It is observed from the charts that the number of people travelling during evening is quite higher than that of morning. The number of both male and female passengers is almost same while travelling single sharing basis but it can be said that female passengers generally avoid rickshaw pooling.

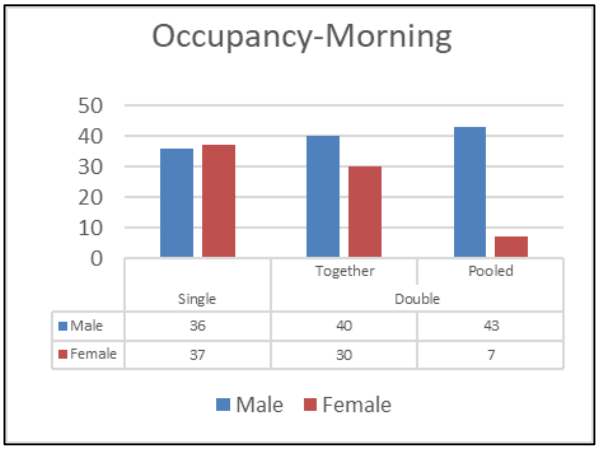

Figure 14 Maharani Bagh-1

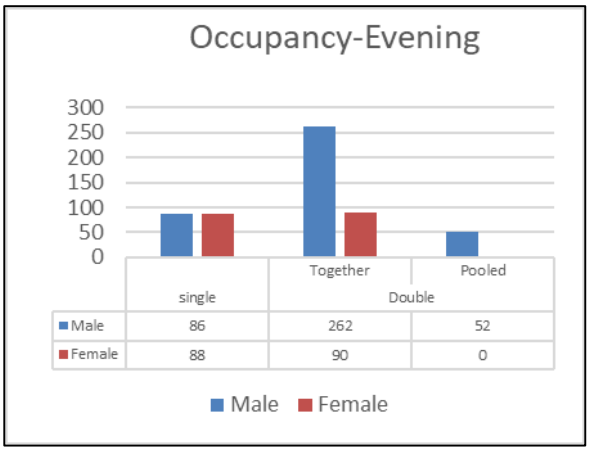

Figure 15 Maharani Bagh- II

6.3.2 Botanical garden:

Both number of male and female passengers travelling during evening is quite higher than that during morning like in case of Maharani Bagh. More number of people travel during evening on double sharing. As in case of Maharani Bagh, very less number of female passengers travel by rickshaw pooling.

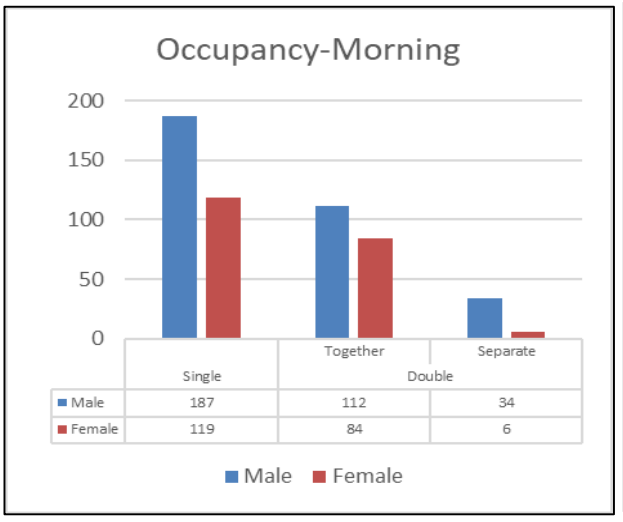

Figure 16 Botanical Garden- I

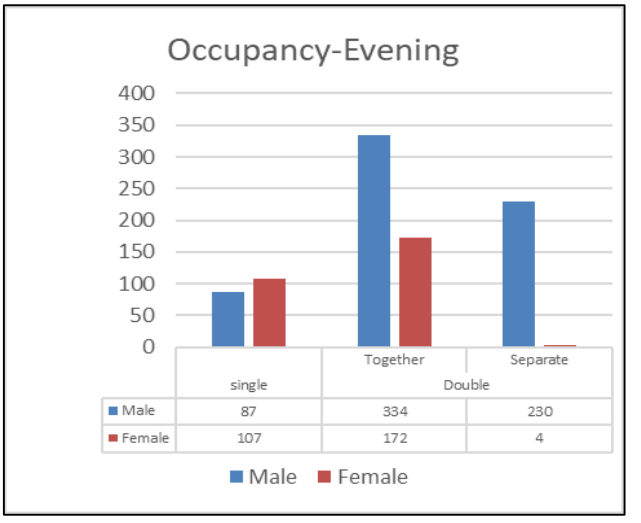

Figure 17 Botanical Garden- II

6.4 Occupancy factor

Occupancy factor is called as average vehicle occupancy and it is the ratio of total number of passenger travelling at an instantaneous time to the total number of vehicles. It reflects the demand of transportation service at a given time period. Higher value of the occupancy factor indicates that high demand of service. The estimated values of occupancy factor help in determining the number of rickshaw required at a given duration of time.

It is clearly observed from the graph that occupancy factors at Maharani Bagh do not show a large difference during morning and evening which shows that demand for cycle rickshaw remains almost same during morning and evening. At botanical garden, the occupancy factor is high during morning when compared to evening. It can be observed that cycle rickshaws are fully occupied during morning at Botanical garden and demands more cycle rickshaw service.

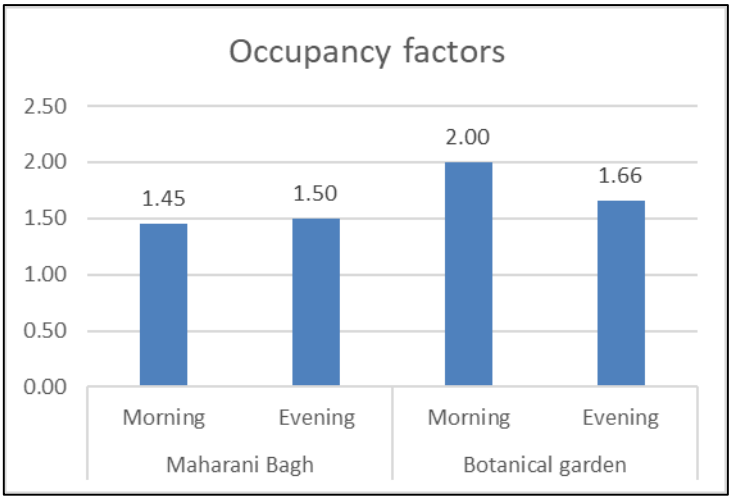

Figure 18 Occupancy Factors

6. Conclusion

This study is aimed to determine the travel characteristics of cycle rickshaws plying in Delhi. Cycle rickshaws are a traditional mode of transport in India, that provide last mile connectivity and even cater to movement of goods over shorter trips (Gupta, 2016). Data was collected by use of interview- questionnaire of the rickshaw pullers. Also, a survey to assess the occupancy of cycle rickshaw was carried out. The detailed discussion about the socio-economic characteristics of rickshaw pullers assist in determining the influence it has on trip making behavior. Linear regression was used to analyze the trip generation based upon the parameters considered for the study.

The developed regression model shows how the trip generation fluctuate with the variation in various socio-economic characteristics of rickshaw pullers such as age, experience, duration of ownership, ownership status, daily rent and daily income and perception of difficulty. Result shows that ownership status has the highest influence on the trip making behavior of rickshaw pullers. To analyze this result further, a sensitivity analysis was carried out in which the trend in the variation of trips with respect to the various combination of ownership status was investigated. It was observed that with the rise in the proportion of ownership amongst the rickshaw pullers, the total trip generation is also increasing. According to bye-laws constructed for cycle rickshaws, it is an offence to own more than one cycle rickshaw. The strategy of municipal authority is like “owner must be a puller” (Anon., 1957) but instead of that the strategy “Puller must be an owner” would assist to raise the number of trips. Thus, provision of financial aid for purchase and ownership of the rickshaws will be a motivating factor to improve the trips undertaken by the cycle rickshaw pullers. It would also subsequently provide social security and financial inclusion to rickshaw pullers.

Further, Trip rate calculation for the three locations clearly reflect the effects of land use characteristics of the development area, income levels and trip purpose have on number of trips generated for cycle rickshaw. Trip rates are very useful for the formation of transport planning scheme. Area with higher residential densities and lower income group tend to have larger trips rates by cycle rickshaws. For area with higher income levels the trip rates are lesser and the least trip rate is observed for the recreational land use type. Another parameter analyzed in this study is occupancy factor of cycle rickshaws plying on the roads of Delhi at different locations and during different period of time. The study shows that female passengers avoid to travel on rickshaw pooling basis. Also, the occupancy of cycle rickshaws is higher during the evening peak hours as compared to morning peak hours.

Researches so far have not investigated the occupancy and trip rate analysis of cycle- rickshaws for urban areas and hence this study aims to full-fill this gap. It provides an insight for the development of organized infrastructure for cycle rickshaws and ultimately take a step towards sustainable, inclusive and equitable transportation.

References

Anon., 1957. *Delhi municipal corporation Act of 1957,* s.l.: Delhi Municipal corporation.
Anon., 2014. *Report on Ambient Air Pollution,* s.l.: World Health Organization.
Anon., 2018. *Road Accidents in Delhi-2017,* New Delhi: Delhi Traffic Police .
Census, 2011. *Census of India,* s.l.: Government of India.
Gupta, J. D., 1992. Nonmotorized Urban Transportation for Emerging Cities in India. *Transportation Research Record,* Issue 1372, pp. 85-89.
Gupta, S., 2016. *Role of Non -Motorized Transport in Distribution of Goods in the Metropolitan City of Delhi.* Shanghai., s.n., pp. 978-984.
Jain, D. R. K., 2015. Non-motorized Transport and Sustainable Urban Planning: A Case Study of Pune Metropolitan Region. *International Journal of Civil Engineering and Technology (IJCIET),* VI(7), pp. 69-79.
Joshi, G. J. & Katti, B., 2006. Trip Rate Analysis for a Metrpolitan City in Indian Context. *ASCE,* pp. 689-694.
Khan, M., Kockelman, K. M. & Xiong, X., 2014. Models for Anticipating Non-motorized Travel Choices,and the Role of Built Envionment. *Tranport Policy,* pp. 117-126.
Lukomona, R., 2017. *Non-Mototised Transport (NMT) Infrastructure along selected Roads in The City of Lusaka: Status, Experiences and Policy,* LUSAKA: THE UNIVERSITY OF ZAMBIA.
Minal, S. & Ravi Sekhar, C., 2016. Commuter's sensitivity in mode choice: An empirical study of New Delhi. *Journal of Transport Geography,* Volume 57, pp. 207-217.
Parida, D. P. & Parida, D. M., 2008. *Environmental Concerns of Urban Transport and NMT as a Sustainable Transport Initiative in India.* Ho Chi Minh City, s.n.
Replogle, M., 1992. BIcycles and Cycle-Rickshaws in Asian Cities: Issues and Statagies. *Transportation Research Record,* Volume 1372.
Roy, U. K. & Sharma, A., 2016. *Retrofitting Options for NMT Movements in a Residential Neighbourhood in the context of Smart Mobility for India.* s.l., Procedia Environmental Sciences.
Sagaris, L. & Arora, A., 2016. Evaluating How Cycle-Bus Integration could Contribute to "Sustainable" Transport. *Research in Transportation Economics.*
Saini, A., 2015. Case Studt of Cycle Rickshaw on Ergonomic Basis. *International Journal of Advanced Research in Engineering and Applied Sciences,* Volume IV, pp. 55-66.
Tiwari, G., 2014. The Role of Cycle Rickshaws Today and Tomorrow. *Spring,* pp. 83-96.