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# Study on willingness to use Non-motorized modes in a tier 3 city: A case study in India

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**Abstract**

Urbanization and population growth escalated Motorized Vehicles (MVs) use and caused serious environmental, health and traffic issues. These can be tackled by increasing Non-Motorized Vehicles (NMVs, walk and Bicycle) share and decreasing the MV usage. The purpose of this paper is to study the potential of NMV usage in Rewa city (Tier 3), India. Many studies have been conducted in Tier 1 and 2 cities of India to get an insight on willingness to use NMVs, but Tier 3 cities are seldom studied. This study is an attempt to explore the factors that influence NMV usage. Are these factors different from those of Tier 1 and 2 cities? Revealed Preference (RP) and Stated Preference (SP) data were collected using a paper questionnaire and both mandatory and non-mandatory trips were studied and certain MV restrictive and NMV oriented policies were asked. It was found that 27 and 11 percent of the respondents of mandatory and non-mandatory trips were currently using NMVs. It was also observed that as the age, occupation level, income level, vehicle occupancy increases the willingness to use NMVs increases and it decreases rapidly after 3kms in both types of trips. Logistic regression models were developed, to estimate the probability of willingness to use NMVs which showed an accuracy of 80 percent in the prediction of willingness level. The study gives an insight on factors influencing the NMV usage, it also helps in understanding various infrastructural and policy provisions that can encourage NMV usage.


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*Keywords:* Non-motorized vehicle (NMV); willingness; logisic regression; tier 3 city; India;

## 1. Introduction

Today the world is facing many transportation-related problems like- increased pollution, congestion, travel cost, travel distance, travel time, accidents and country's dependence on imported oil. All these problems combined

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together can potentially make the planet inhabitable to many species. With the increase in global population, the demand for personal vehicles is growing simultaneously (Schafer et al. 2000). This effect is more profoundly visible in fast-developing countries, especially in India and China. This in turn also affects the economy of the nation as the vehicle demand consequentially increases the demand for oil and causes pollution and congestion. Due to this, new problems are emerging like- lack of parking spaces, accidental casualties, health issues etc.

Many solutions have been proposed by prominent scholars to fight these problems (Black 2010, Khisty 1993 and Loeper 2009). One such solution is increasing the share of Non-Motorized (NM) trips. These are those trips that are conducted by Non-Motorized Vehicles (NMVs) and are driven by human or animal power, which reduces the dependency on oil. NM trips are quite useful for short to medium distances and include the trips by- walk, bicycle, bullock cart, handcart, pedicabs etc. Some other modes of non-motorized trips are inline skates, kick scooters, electric bicycles, tandems bicycle, segway, manual wheelchair, assistive power scooter, adult tricycle, hand cycle, stroller, recumbent bicycle, bicycle trailer, power wheelchair, and skateboards.

These have the capability to generate employment and alleviate poverty. Additionally, they utilize a sustainable power source, and stress on the utilization of labour rather than capital for mobility, thus they offer easy private transport at low cost. Apart from these benefits there are some demerits of non-motorized commute like their use causes perspiration in hot weather, they have restricted speeds, and the absence of strict rules makes NMT vulnerable, etc. The unruliness of Indian traffic makes NMT susceptible to accidents.

Hook (2003) found in most of the developing countries more than 6 of every 10 trips are under 3 km and in some well-planned German cities this figure goes up to 8 per 10 trips. These small distance trips can be made by walking or bicycling. Rastogi (2011) reported that adequate cycling distances as accepted by commuters for Delhi, Trichy and Mumbai are 5100m., 5200m and 2724m. This distance was observed to be 3300m and 6000m for Indonesia and China. With the expanding populace and simultaneously increasing trips, we must consider the requirement of designing facilities for NM modes.

In most of the countries, the contribution of NMT in terms of total km travelled is small; however, it is significant in terms of the total number of trips. These trips are for the most parts conducted by school and college going students and also used for transporting goods and services by economically weaker section for short to medium distances of 3 to 10 km. The study conducted by Pai (2007) suggests that the share of bicycling and walking is not influenced by average trip length. Furthermore, Rietveld and Daniel (2004) reported that in major Asian cities the share of NMT was 40-60 percent and in African cities, this share is much higher.

According to Gwilliam (2003), Indian cities have significant trips on bicycles. Its utilization fluctuates from 7-15 percent in big cities to 13-21 percent in medium and small cities. Its high ownership, low cost and simple utilizationmake it an alluring method of transport for students and low-income workers. Approximately 30 percent and 65 percent of the families in medium and large-sized cities owns one or more bicycle, though in the smaller cities its share varies between 33 percent and 48 percent.

Tiwari (2011) reported that in Indian megacities (populace of more than 8 million) trip share of NMT (bicycling and walking combined) is 30 percent. A large number of people in urban cities live in slums, e.g. Mumbai 54.1 percent, Kolkata 32.5 percent, and Delhi 18.7 percent (census 2011). These individuals can't manage the cost of private vehicles or buses for their everyday travel. The primary mode of movement for them is either walking or cycling. A study led by Khadaiya (2014) revealed that NMV share varied between 33 percent-51 percent in Roorkee, in India. Share of cycle-rikshaw fluctuated between 6 and 21 percent and that of cycle varied between 27 to 30 percent. This was affected by the type of infrastructure on roadside and type of neighbourhood. The area which has 33 percent share of NMVs has almost all categories of traffic, and the area which has 51 percent of share is the old Roorkee which is densely populated. Another study conducted by Bhargav (2009) in Roorkee at various locations reported that share of NMVs varied between 15.47 to 72.5 percent and that of bicycles ranged between 10.56 and 59.14 percent. At a few locations, the share of bicycle was found to be nearly 50 percent during peak hours.

The population is exploding and the transport needs are also increasing. Petrol and other non-renewable resources are limited in the world. So, we should emphasize on sustainable transportation trips especially for short to medium distances. The transportation sector is responsible for approximately 15 percent of the manmade Carbon-di-oxide emission this is projected to increase (Center for Biological Diversity).

A comprehensive study on NMT is required to comprehend the significance and design requirements for such trips. With the goal to design facilities for these trips to make them safer, more efficient and time effective, engineers and planners can attain great help from the study. The literature on non-motorized trips is being discussed with emphasis given on understanding the importance of NMT before looking at other aspects.

According to Guintink et al. (1994), NMT offers exceptionally adaptable solutions to accessibility, particularly where the resources are rare. They concluded that flexibility and affordability are the two imperative components related to NMT. Flexibility is a multipurpose tool that can be utilized for door-to-door transport of people and goods with enhanced travel time and route alternatives. Affordability is a component of price factor in relation to income and it is certain that NMT is affordable for all users. For the economically weaker section, NMT gives access to employment, social services, educational activities, and household chores (Bamney and Rastogi, 2017). From the economic study of Servaas (2000), it can be concluded that investing on bicycle infrastructure rather than motorized traffic lanes gives a total saving on infrastructure and trip expenses of around 35 percent of the total yearly cost of bicycle infrastructure. The aggregate cost (infrastructure and working expenses) for motorized traffic is 4 to 8 times higher than bicycles. Rietveld (2001) deduced that the share of NMT in total distance travelled is small, however, it is substantial as far as the total number of trips. It is valid for both developed as well as less developed countries with high and low-income households respectively. The door to door transport facility is the reason for this substantial number of trips apart from that their infrastructure has high spatial infiltration, they don't prompt high waiting times contrasted to public transport stops. Moreover, they have a favourable natural execution, these are economic transport modes, and are fundamental components in the multimodal transport chain. Furthermore, Hook (2003) reported that NMT generate no air pollutant and no ozone-depleting or greenhouse gases. Bicycle users and pedestrians are the most efficient users of scarce street space than private motor vehicles, which helps in fighting congestion and are friendlier to the environment. NMT is economically vital essential and lessen the nation's reliance on imported oil and enhance accessibility for poor and social attachment. These are equipped for lessening more than 5,00,000 unexpected deaths from traffic accidents each year. A study cited by Rietveld shows in Bogota, in 1997 the death rate was 2 to 3 individuals every day however after the upgrades in bicycle and walking infrastructure this rate has reduced to 1 to 2 per day.

The volume of NMVs can be enhanced by employing NMV oriented policies accompanied by some MV restricting policies. In this direction researchers (Servaas 2000, Hook 2003, Rastogi 2011, Litman 2010, Yazid et al. 2011, Olio et al. 2014 and VTPI 2010) have suggested provisions of separate cycle track, bicycle slips, prevention of bicycle stealing, policy of making bicycle accessible to poor, public bicycle system, separated pedestrian signals for crossing the road, traffic calming methods, reduced detour factor, satisfactory facility width, illumination level on a facility, travel mode combinations (walk or bicycle with transit) and minimising the requirement of the pedestrians to cross the road to improve share and safety of NMV commuters. Law enforcement, congestion pricing, vehicle parking policies, subsidy support to bicycle companies, flexible reporting hours, financial aids on using NM modes, NMV priority rules in traffic stream and storage, and increased fuel taxes are thought to encourage the use of MVs.

Appropriate provision of facilities for NMVs is necessary but encouraging shift to them is a big challenge. The key cause behind it is the comfort and ease linked with the use of MVs. Factors like age, gender, socio-economic level and ethnicity of individuals, trip distance, rainfall and topographic features, road laying pattern, social awareness and driving cost (Bhat et al. 2005, Rastogi 2010, Litman 2015) are also found to influence the decisions.

With the above understanding, a study on willingness to shift to NMVs was carried out in the Rewa city, Madhya Pradesh, India. This paper presents the results related to mandatory (work and education trips) and non-mandatory (shopping and recreation trips) trips, factors that play an important role in the willingness to use NMVs. It also shows the socio-economic and travel characteristics of the respondents of the study area. In addition to this, it shows the responses to certain policy measures like preferred lane choice, maximum acceptable parking distance and parking cost were also examined. Moreover, binary logistic models were developed for both mandatory and non-mandatory trips. This paper can be helpful in developing certain policies that can increase the share of NMTs in the study area.

## 2. Data Collection

Lots of research has been done (Singh et al. 2008, Munshi and Talat 2016, Taylor et al. 2012) to study the travel characteristics and passenger behaviour in the tier 1 cities but tier 2 but tier 3 cities are seldom investigated.

As per the census of India, 2011(Government of India 2011) there are 46 metropolitan or tier 1 cities in India. Thus, the remaining cities are either tier 2 or 3. Tier 3 city is a city which is not the capital of a state but is administrative headquarter with no metro and limited job opportunities. Their numbers are quite significant and these cities hold very high potential for the use of NMVs because the travel distances are low and the socio-economic characteristics of the people like (income, HH income etc.) supports NMV usage. Thus there is a high probability that the road users in these cities can be found to be more willing to shift to NMVs and the problems such as pollution, congestion, jams and accidents can be reduced manifolds.

All these problems discussed earlier demand stark attention for this study. Hence Rewa city (tier 3, Madhya Pradesh, India) was selected for such a study. It is the administrative centre of Rewa district and Rewa division. The city spans in a radius of 9 to 10 km in all directions from the city centre-Sirmour Chowk. Since the city is small it was very easy to collect data from all the 45 wards of the city. The share of NM modes was found to be significant.

To collect the RP and SP data a questionnaire was prepared. RP information comprised of demographic details of a household, personal and financial characteristics and data on travel-related attributes. In the SP data, the preference of respondents with respect to NVM lane either marked or segregated, acceptable parking costs and parking distances. Both RP and SP data were collected at the same time from the respondent. 6 years was the minimum age to be eligible. The trip purpose was fixed as either mandatory or non-mandatory. There were 292 valid responses for mandatory trips and 203 for non-mandatory trips. Time spent to accumulate data per family was around 25 minutes. Logical checks were applied to data before utilization. Checks were made as for the household characteristics, say income v/s vehicle ownership, and trip characteristics say travel time v/s travel distance v/s travel mode.

The analysis done to look at the variation in the willingness to shift to NVMs with respect to personal and travel characteristics is now presented in the following sections.

## 3. Willingness Analysis

The willingness analysis to use NMVs was done for both mandatory and non-mandatory trips separately. These are explained in successive sections.

### 3.1 Willingness to shift to NMVs: Analysis for mandatory trips

The ease and comfort associated with the conventional mode of transport psychologically impact the willingness to use NMVs. Figure 1 shows the share of different travel modes in mandatory trips. The share of NM mode for mandatory trips was found to be 26.37 percent, which includes both bicycle as well as walk trips. This is a better composition than observed in larger cities like Nagpur, 34 percent for bicycle and 24 percent for walk by Tiwari and Jain (2008). The share of 2-w (motorized) towered up to 45 percent and the share of IPT was high (23 percent) because the school going students generally use it for their commute. Sharing auto is the only public transport mode available in Rewa city. Interestingly 32 percent of the respondents reported to have at least 1 car in their house but the share of cars for mandatory trips was very low (below 7 percent). This small share of cars can be understood from the fact that only 32 percent households in the city (survey sample) had car. Another reason might be small trip lengths as it is a tier 3 city. As evident from the figure majority (91 percent) of the households had at least one motorized 2-w and 45 percent had 2 or more. About two-third (63.36 percent) of the households in the city had bicycles but they rely more on 2-w for their daily commute. Car, 2-w, and bicycle ownership of the city was found to be 0.37, 1.46 and 0.85 per HH respectively. Although bicycle ownership is high but the culture of the city does not promote its usage.

The willingness to shift to NMT of trip makers currently using other modes is also shown in figure 1. Nearly 40 percent of the trip makers using 2-w and more than half of the IPT commuters were willing to shift to NMVs.

Overall, around 32 percent of the mandatory trip makers were willing to use NM mode in the present scenario. Fixed destinations and short trip lengths might be the reason behind this willingness to shift.

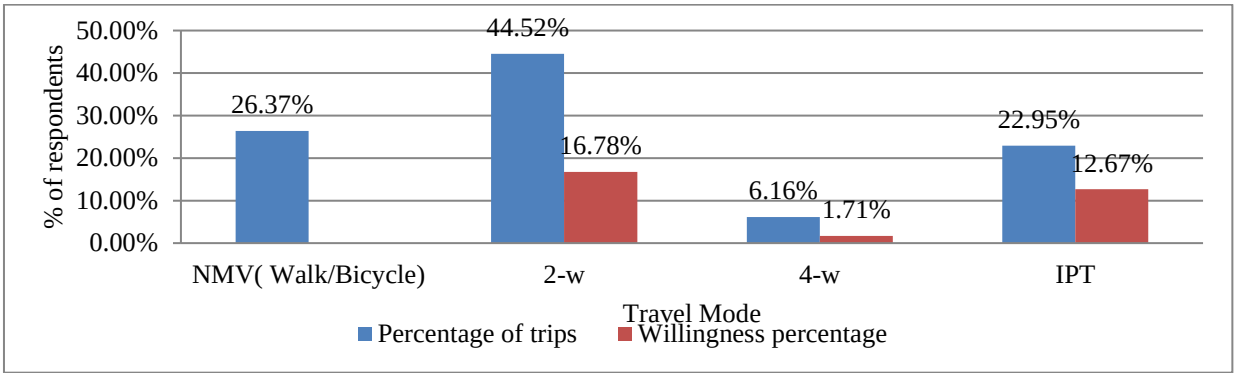


Figure 1 Willingness to use NMVs by travel mode for mandatory trip makers

Personal characteristics were also studied to determine willingness potential. These are now discussed in the following paragraphs.

Almost 50 percent of the respondents were deliberately chosen to be students thus the majority of the respondents, as seen from the graph, are under 25 years. The reason behind this was, the total share of mandatory trips should be divided equally in education and work trips. Approximately 19 percent of trip makers were from the age group 25-45 years and 45-55 years. Thus 78 percent of all the respondents fall below 45 years. Furthermore, the share of the elder age group (55-65 years) was found negligible. The respondents of age group 45-55 were least interested to shift (this finding was in concurrence with the existing literature).

As expected, the school going students up to the age of 18 years were more willing to shift to NMVs, and their inclination towards NMVs can be clearly seen in Figure 2, nearly 75 percent have shown interest (willing + already using NMVs) in using NMVs. It was contrary to the findings of Bamney and Rastogi (2016) in Bhopal city (tier 2, India). In the age group of 25-45 years, two-thirds of the respondents were interested in using NMVs. All the findings in all the age groups were in concurrence with the existing literature that increasing age has a negative effect on NMV usage. The reason might be as the age of people increases, they tend to drive more due to increment in work trips and family-related trips, which is somewhat similar to the findings of Bhat and Eluru (2009), Zhang et al. (2012).

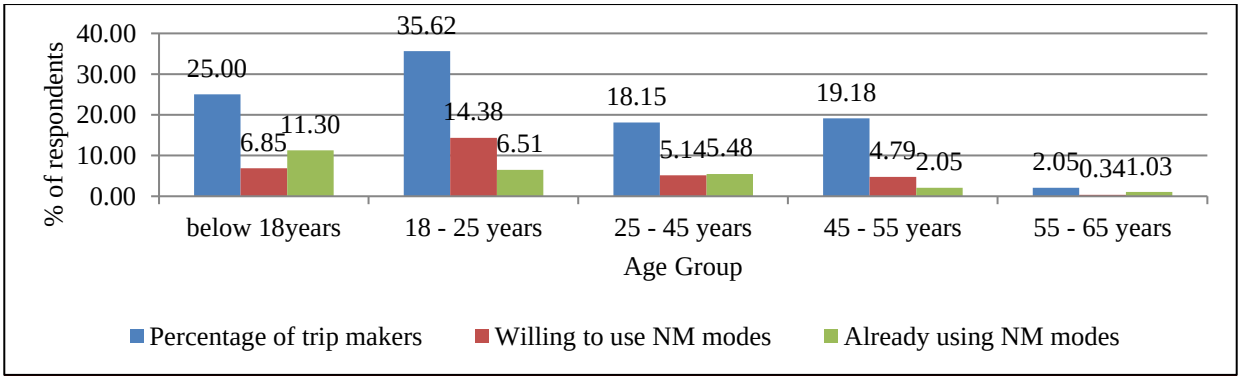


Figure 2 Willingness to use NMVs by Age distribution for mandatory trip makers

Gender wise statistics of mandatory trips and willingness response of trip makers is shown in Figure 3. The share of women making mandatory trips was found significantly less than males and was in concurrence with the study

conducted by Bamney and Rastogi (2016). It was observed that almost one-fourth of the mandatory trip makers in both male and female categories were already using NM modes. The proportion of female mandatory trip makers willing to shift was more than males. Similar results were achieved by Polk (2003) and Polk (2004) in Sweden.

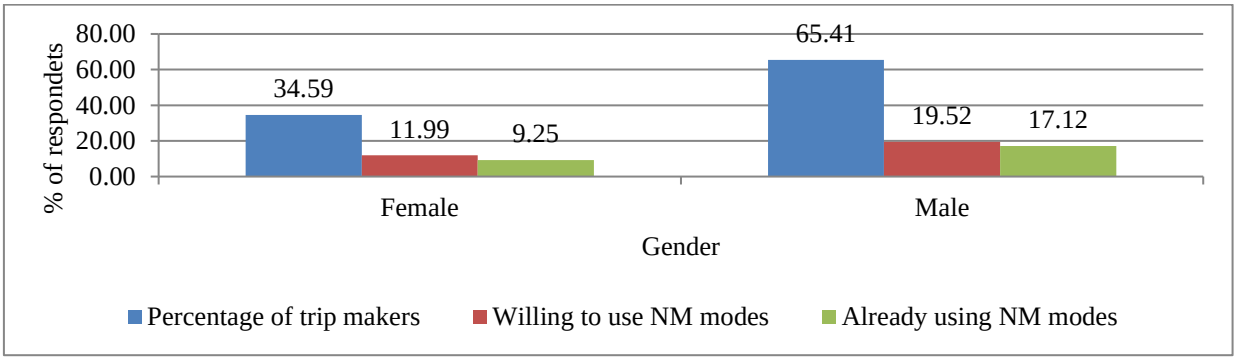


Figure 3 Willingness to use NMVs by Gender for mandatory trip makers

Figure 4 shows the willingness to use NMVs for the trip makers having different occupation levels. It was taken care during the survey that the numbers of educational and work trips are equal, and can be seen from the graph that 55 percent of the mandatory trips were made by students. Almost half of the mandatory trip makers were students. In the working class majority of the respondents were at support level followed by middle level and higher level respectively. The share of the higher level was found to be very low and it was awful to see that none of the higher level commuters was using NM mode even for short distances (between 1 and 2 km). Nearly half of the support level and one-fourth of the students were already using NMVs. Almost one in a four from both groups was willing to shift to NMV. As expected, support level commuters were found to be more willing to shift to NM mode because of the scarcity of resources and it was observed as the occupation level increases, the willingness to shift to NMVs decreases.

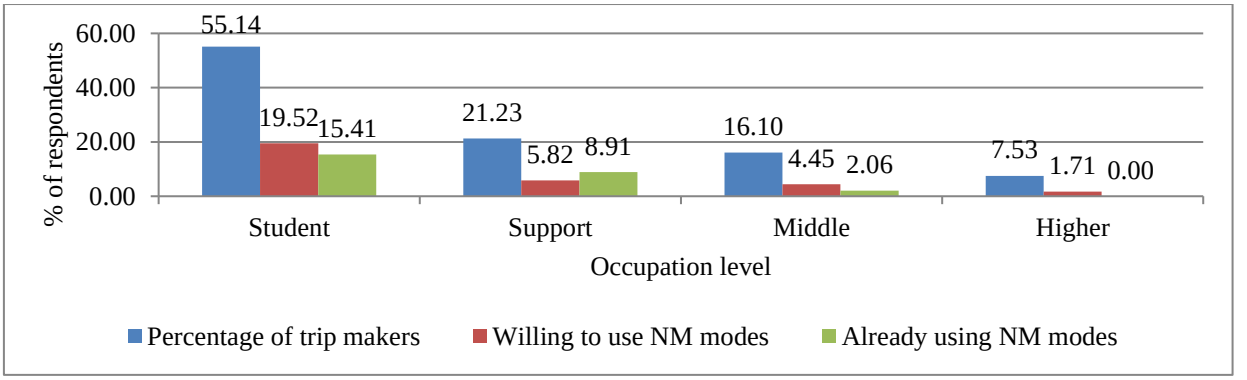


Figure 4 Willingness to use NMVs by occupation level for mandatory trip makers

Figure 5 indicates that 82 percent of the NMV users earn less than equal to 50,000 rupees per month. Nearly 72 percent of the respondents earning below 15,000 INR per month were interested (willing and already using) in using NMVs, which is quite high. Nearly half of the respondents in this age group were already using NMVs. Nearly one-third of the trip makers earning 15000-30000 INR showed a willingness to use NMVs. This share gradually goes down for higher income groups. Half of the trip makers in the income group below 15000 rupees per month and one-fifth in the income group between 15000 and 30000 rupees per month were already found using NMVs. It was observed and was similar with other researchers, Bamney and Rastogi (2016), and Joewono and Kubota (2005) that as the income level increases the willingness to shift to NMVs decreases and the trip makers become less interested

in using NMVs. Apart from modal share and willingness vehicle ownership was also affected by income, With the increase in HH income, the bicycle ownership was observed to decrease and 2-w and car ownership rapidly increased.

It is interesting to note that no one earning more than 50,000 INR was using NM mode but during the survey, they showed willingness to shift. Higher income group's respondents were willing to shift for very short distances under 0.5 to 1.0 km.

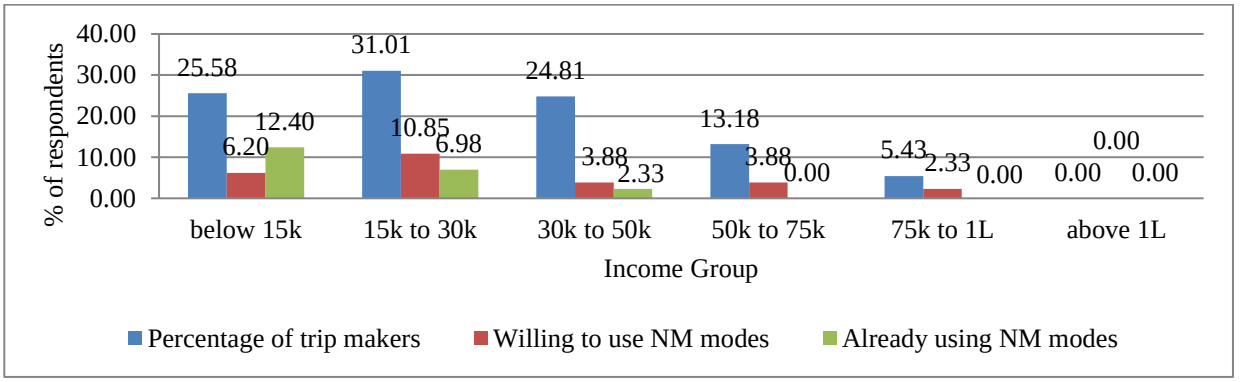


Figure 5 Willingness to use NMVs by Income level for mandatory trip makers

Education level was another criterion of study (Figure 6). Around three in five of the mandatory trip makers were either graduates or post-graduates but negligible post-graduates were currently using NMVs. This is in accordance with the finding of Hong et al. (2014) and Zhang et al. (2012) that respondents with education level of graduation or more tend to have longer commuting Vehicle Miles Travelled (VMT) compared to those who graduated only high school since jobs requiring high levels of education tend to require more spatially dispersed business activities. This was probably because they might not be getting a suitable job in a nearby location. One-third of the graduates were willing to use NMVs and 60 percent of the illiterate mandatory trip makers were found using NMVs. It can be noted that of all the NMV users, the majority were either illiterate or had only studied up to school.

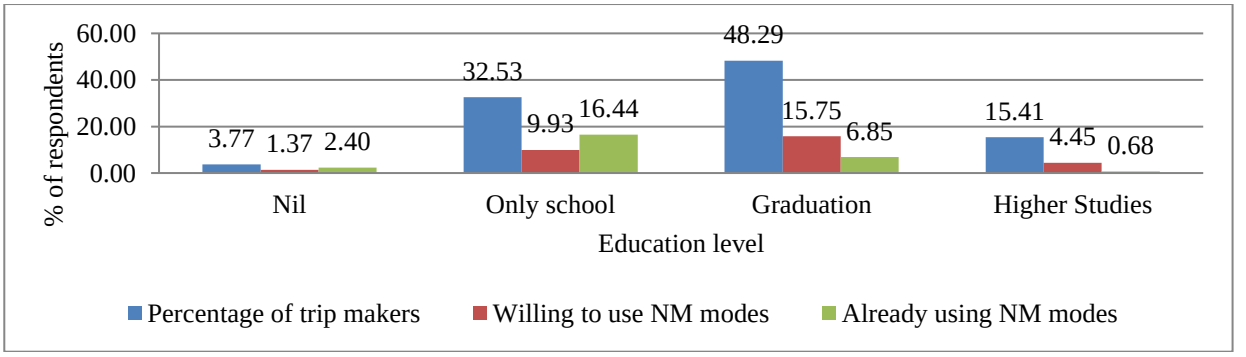


Figure 6 Willingness of mandatory trip makers with varying Education level to use NMVs

Distance plays a pivotal role on whether a person is willing to use NMV. This is due to the inherent shortcomings of NMVs with respect to the distance. Distance up to 3km can be covered by NMVs especially by bicycle. Table 1 shows that 58 percent of the trips were within 3kms and two-thirds (38.23 percent) of these are already being done by using NMVs. It can be noted that as the trip distance increases beyond 2kms, the percentage of NMV trips drops exponentially. With 42 percent of all trips being farther than 3km, only 10 percent were NMV trips. It was encouraging to see that substantial trip makers travelling up to 4km showed their willingness to shift to NMVs for their mandatory trips. Educational trip makers were more willing to use NMV beyond 4km as compared to work trip makers.

Table 1. Willingness to use non-motorized vehicles with varying distances

| Distance | Total Trips | | Willing to shift to NMV | | Already using NMV | |
|---|---|---|---|---|---|---|
| (in kms) | No. of trips | percent of trips | No. of trips | percent of trips* | No. of trips | percent of trips* |
| <1 | 51 | 17.47 | 14 | 27.45 | 35 | 68.63 |
| 1-2 | 55 | 18.84 | 22 | 40.00 | 20 | 36.36 |
| 2-3 | 64 | 21.92 | 26 | 40.63 | 10 | 15.63 |
| 3-4 | 32 | 10.96 | 8 | 25.00 | 3 | 9.38 |
| 4-5 | 53 | 18.15 | 12 | 22.64 | 3 | 5.66 |
| More than 5 | 37 | 12.67 | 10 | 27.03 | 6 | 16.22 |

*this is the percentage of trips in that distance range.

The mean distance up to which the respondents were willing to shift to NMV was found to be 3.252 kms. It was interesting to see that the trip makers were willing to shift for a higher distance as compared to those currently using NMVs. It was also observed that the current average travel distance for mandatory trips for NMVs was 2 km, and that of the moped was 3 kms. This much distance can be easily covered with bicycle. Nearly one-third of the driving respondents for mandatory trips do not possess a driving license.

Table 2. Mean TT and travel distance of willingness to shift

| Trip makers willing to shift | | Trips actually using NMVs | |
|---|---|---|---|
| Mean TT | Mean Distance | Mean TT | Mean Distance |
| 15.32 min | 3.252 kms | 15.01 min | 2.075kms |

### 3.1.1 Model Estimation for mandatory trips.

Binary logistic regression model was developed for mandatory trips. Driving License (DL) holding, distance, speed, travel mode, access cost to IPT and access distance to IPT were found statistically significant in defining the willingness to use NMVs. All these attributes negatively affected the willingness except access distance to IPT. Hook (2003) and Rastogi (2010) and Bamney and Rastogi (2016) had also inferred that as the distance increases the willingness to use NMVs for trips decreases. Table 3 presents the model estimates for mandatory trips in Rewa city. The overall accuracy of prediction of willingness to use NMVs was observed to be 80 percent.

P-value of the attributes was found within the acceptable limits. The Chi-square value was also found statistically significant at 95 percent confidence level (Chi-sq = 124.56). This indicates the goodness of fit of the model. The Hosmer Lemeshow test showed that there was no significant difference between the predicted values and the observed values. In addition to this, the value of Log-linear, Cox-Snell, and Nagelkerke's R square were found to be satisfactory. Table 3 and 4 shows the statistics for Hosmer-Lemeshow and chi-square index, and classification table for mandatory trips, respectively.

Table 3. Statistics for the estimated model for Rewa mandatory trips

| Parameter | Coefficient | S.E. | p-value | exp(coeff.) |
|---|---|---|---|---|
| Intercept | 5.567 | 0.747 | 0.000 | 261.577 |
| DL possession | -2.084 | 0.360 | 0.000 | 0.124 |
| Dist. in Kms | -0.200 | 0.107 | 0.062 | 0.818 |
| Speed (km/hr) | -0.049 | 0.021 | 0.017 | 0.952 |

| | | | | |
|---|---|---|---|---|
| Travel mode | -0.506 | 0.122 | 0.000 | 0.603 |
| Access cost of IPT | -0.074 | 0.024 | 0.002 | 0.929 |

The categorical values of the DL possession are: 1 if yes, 0 if no. And the categorical values for Travel Mode were: 1 if NMV, 2 if motorcycle, 3 if moped, 4 if 4-w, 5 if IPT. Distance in Kms, Speed in km/hr, Access cost of IPT in INR were continuous variables

It was observed that coefficients of all the dependent variables were found to be negatively associated with willingness to shift to NMVs. The model indicates that if the person is having DL, then the probability of using NMVs decreases by 88%. This indicates, if a person is capable to drive then he/she is less likely to use NMVs. Furthermore, as the distance travelled distance and speed increases the respondents become less likely to use NMVs. This was expected because the higher the travel distance the more tiring the journey would be for NMV users, hence people were less likely to use NMVs for longer distances. In addition, persons using higher occupancy vehicles are also less likely to shift to NMVs. The reason might be the higher occupancy vehicles (e.g. 4-w) are associated with greater comfort as compared to lower occupancy vehicle (2-w). The access cost of IPT is the amount a person must spend for a trip if he/she has to complete the trip by IPT, it was negatively associated with willingness to shift, which was expected.

The probability of an observation in the above model is given by:

$$p(y) = \frac{1}{1 + e^{-uk}} \quad (1)$$

Where, uk = b0+b1*x1+b2*x2+b3……., e = natural log, $b_\circ$ = intercept, b1 = slope of line or coefficient of that attribute, x1 = the categorical or continuous value of attribute, b2 = coefficient of second attribute x2 = value of second attribute and so on.

Table 4. Hosmer Lemeshow and Chiq-sq. statistics for mandatory trip model

| Attribute | Value | Nomenclature |
|---|---|---|
| Hosmer | 271.5501 | |
| Df | 259 | Df = degree of freedom, (number of distinct observations used for |
| p-value | 0.29 | model development |
| Alpha | 0.05 | df = degree of freedom (number of independent attributes used for |
| Sig | No | model development |
| LL0 | -198.76 | alpha = confidence interval |
| LL1 | -136.48 | sig = significant difference between the less restrictive and more |
| Chi-Sq | 124.56 | restrictive model |
| Df | 5 | LL1= log likelihood of the less restrictive model (predicted values) |
| p-value | 3.39E-25 | LL0 = log likelihood of more restrictive model (with intercept only) |
| Alpha | 0.05 | Chi-sq. = 2* (LL1 – LL0) |
| Sig | Yes | |

Table 5. Classification table for the mandatory trip model

| Willingness category | Observed willingness | Observed non-willingness | Total |
|---|---|---|---|
| Predicted willingness | 137 | 27 | 164 |
| Predicted non-willingness | 32 | 96 | 128 |
| Total | 169 | 123 | 292 |
| Accuracy | 0.81 | 0.78 | 0.80 |
| Cutoff | 0.5 | | |

### 3.2 Willingness to shift: Analysis of non-mandatory trips

In the categorization of non-mandatory trips according to travel mode (refer Figure 7), NMVs made up only 11.33 percent of the trips, which is less than half of the mandatory trips (26.37 percent), which is quite worrisome. Around 48 percent trips were made by using motorized 2-w. Share of IPT mode was 27 percent which was almost equal to mandatory trips. The average trip length for Non-mandatory trips by NM mode was found 2.39 kms and that of moped was 3.25km, which can be easily covered by bicycle.

Non-mandatory trip makers showed a greater propensity to shift to NMVs with almost half of 2-w users, and one-third of IPT users willing to shift to NMVs respectively. Only in the case of car, just one-fifth of the trip makers showed their interest to shift to NMVs. On the whole, it can be said that around 34 percent of the non-mandatory trip makers using motorized travel modes can be expected to shift to NMVs for their respective trips.

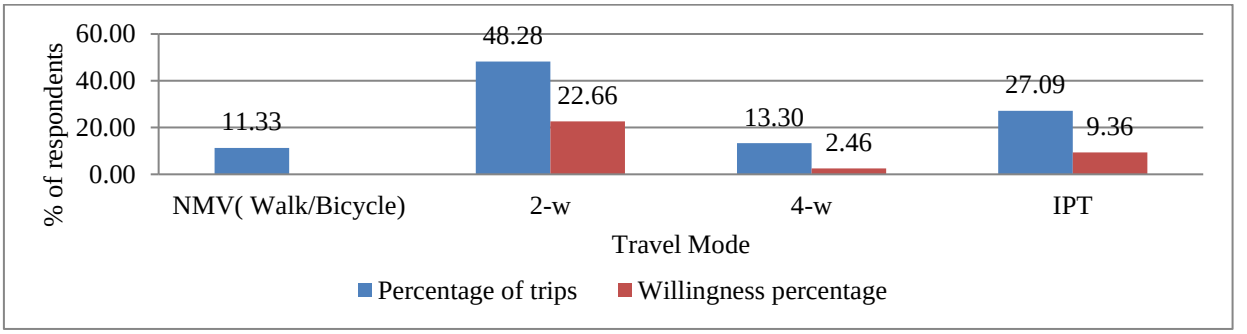


Figure 7 Willingness to use NMVs for travel modes for Non mandatory trip makers

Figure 8 gives the distribution of Non-mandatory trip makers by age group. Majority of the non-mandatory trip makers belong to the age group of 45-55 years and nearly 30 percent of them were willing to use NMVs. Moreover, 75 percent of the respondents of the age group below 18 years were interested in using NMVs and this share reduced to half in the age group of 18-25 years and 25-45 years respectively, furthermore this share reduced to one-third in the age group of 45-55 years.

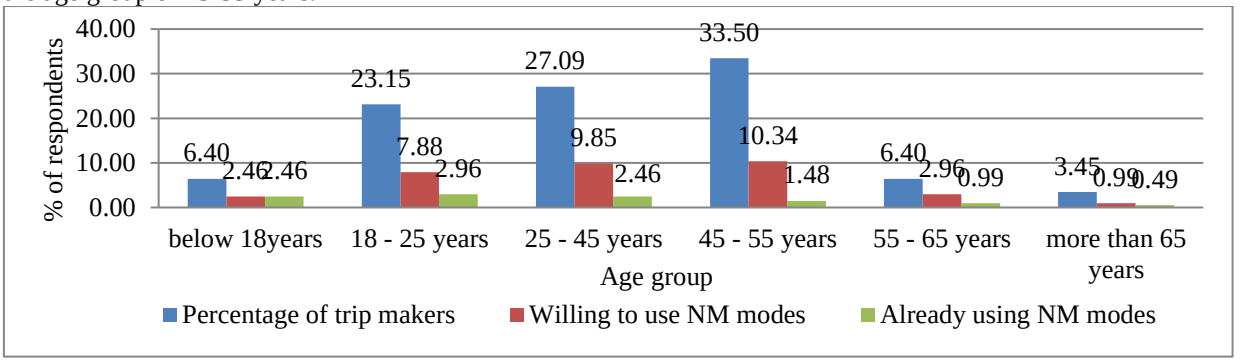


Figure 8 Willingness to use NMVs for by age for Non-mandatory trip makers

As evident from figure 9 a higher number of female trip makers can be seen which is converse to the mandatory trips. It was observed that many women were home-makers and thus made shopping and recreational trips, more often than men. High willingness to shift to NMV was seen in women but the number of trip makers already using in NMV in case of women was found to be significantly low. Male trip makers in for non-mandatory were teenagers and older people with age of more than 60 years were also seen here.

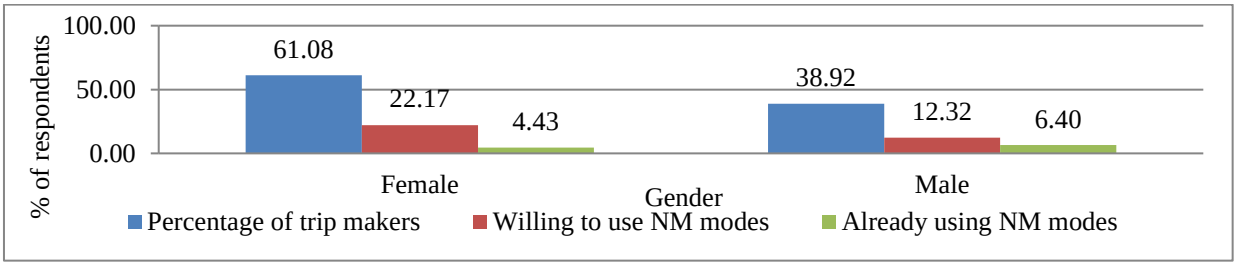


Figure 9 Willingness to use NMVs by gender for Non-mandatory trip makers

The willingness to use NMVs for non-mandatory trips is presented with respect to the trip distance in Table 6. It is clear from the distribution that 43 percent of the trips are within 3km distance. High willingness to shift to NMVs can be seen here. All of the trip makers within 1 km and almost 96 percent of the trip makers in the distance range 1-2 kms are either using or are willing to shift to NMVs. It was found that as the distance increases the willingness to shift to NMVs decreases, which is in concurrence with the literature and was expected. Moreover, 93 percent of the trips are within 5 km. Rastogi (2011) reported in the majority of Indian cities this distance of 5 kilometres is an acceptable bicycling distance. This fact probably defines the higher willingness to shift to NM modes for Non-mandatory trips in Rewa city.

Table 6. Distribution of Non-mandatory trips by distance

| Distance | Total trips | | Willing to shift to NMV | | Already using NMV | |
|---|---|---|---|---|---|---|
| (in kms) | No. of trips | percent of trips | No. of trips | percent of trips* | No. of trips | percent of trips* |
| <1 | 14 | 6.90 | 6 | 42.86 | 8 | 57.14 |
| 1-2 | 22 | 10.84 | 15 | 68.18 | 6 | 27.27 |
| 2-3 | 53 | 26.11 | 21 | 39.62 | 2 | 3.77 |
| 3-4 | 51 | 25.12 | 18 | 35.29 | 2 | 3.92 |
| 4-5 | 50 | 24.63 | 10 | 20.00 | 4 | 8.00 |
| More than 5 | 13 | 6.40 | 0 | 0.00 | 0 | 0.00 |

*percentage of trips in that distance range

### 3.2.1 Model Estimation for non-mandatory trips.

Binary logistic regression model was developed for non-mandatory trips also. The statistically significant attributes used in this model were, Household (HH) income, Driving License possession, travel distance and travel mode. Table 7 presents the model estimated for Non mandatory trips.

Table 7. Statistics for model estimated for Non-mandatory trips

| Parameter | Coefficient | S.E. | p-value | exp(coeff.) |
|---|---|---|---|---|
| Intercept | 4.381 | 0.822 | 0.000 | 79.895 |
| HH- income | -0.398 | 0.117 | 0.001 | 0.672 |
| DL possession | -0.828 | 0.365 | 0.023 | 0.437 |
| Distance in Kms | -0.285 | 0.120 | 0.018 | 0.752 |
| Travel Mode | -0.579 | 0.140 | 0.000 | 0.561 |

The probability of an observation can be founded by equation 1. In the above model, the continuous variable is distance in Kms, and the rest are categorical. The categorical values for HH-income (household income) are: 1 if below Rs.15000, 2 if Rs.15000-30000, 3 if Rs.30000-50000, 4 if Rs.50000 to 75000, 5 if Rs.75000-100000, 6 if Rs.100000 or more. The categorical values for Travel mode were: 1 if NMV, 2 if motorcycle, 3 if moped, 4 if 4-w, 5 if IPT and for Driving License (DL), 1 if possesses DL and 0 if no DL.

The p-values of the attributes and Chi-square value were found within the limits (at 95 percent confidence level), showing that these attributes are statistically significant, and the model is a good fit. The Hosmer Lemeshow test showed that there was no significant difference between the predicted values and the observed values. Moreover, the classification table revealed 69 percent prediction accuracy of the model, which was mediocre. Table 8 and 9 shows the statistics for Hosmer-Lemeshow and chi-square statistics, and prediction classification table for Non mandatory trips, respectively. The model shows that with an increase in household income and travel distance the likelihood of shifting to NMVs decreases drastically. With the increase in HH income, the purchase power increases and the people may become insensitive towards fuel and vehicle cost, this might be the probable reason for the negative sign of HH-income. Furthermore, the possession of DL and use of higher occupancy vehicle is also negatively associated with willingness to use NMVs. The reason for this might be the same as explained for mandatory trips.

Table 8. Hosmer-Lemeshow and Chi-sq. test statistics

| Attribute | Value | Attribute | Value |
|---|---|---|---|
| Hosmer | 133.900 | Chi-Sq | 46.537 |
| Df | 127 | df | 4 |
| p-value | 0.320 | p-value | 1.9E-09 |
| alpha | 0.05 | alpha | 0.05 |
| sig | No | sig | Yes |
| LL0 | -139.403 | | |
| LL1 | -116.135 | | |

Table 9. Classification table for Non-mandatory trips

| Willingness category | Observed willingness | Observed non-willingness | Total |
|---|---|---|---|
| Predicted willingness | 55 | 28 | 83 |
| Predicted non-willingness | 35 | 85 | 120 |
| Total | 90 | 113 | 203 |
| Accuracy | 0.61 | 0.75 | 0.69 |
| Cutoff | 0.5 | | |

## 4. Analysis of stated preference data and miscellaneous findings

The trip makers were asked the reasons for not using NMVs. The majority (40 percent) of them responded found NMV usage to be time-consuming. Nearly one-fifth reported it as laborious. This may be an important factor as Rewa city has extreme temperatures in different seasons. Around 16 percent trip makers found that use of NMV is not suiting to their status. Some cited other reasons like they never considered NMVs and security issues. Furthermore, nearly 75% of the respondents want a segregated NMV lane in the city.

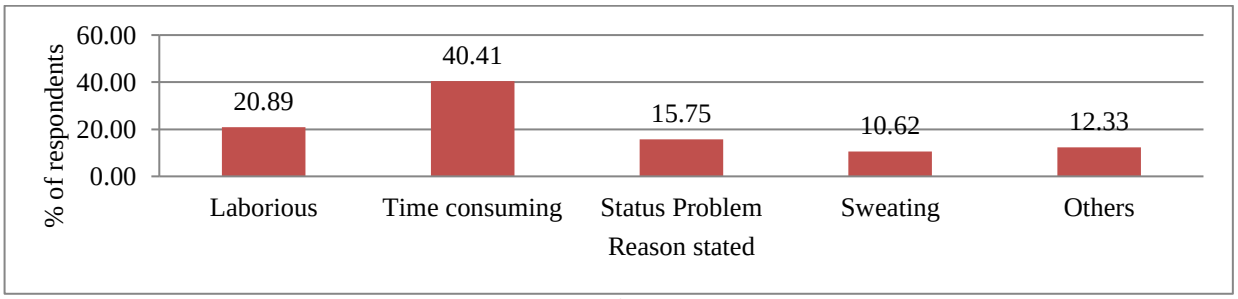


Figure 10 Reasons for not using NMVs

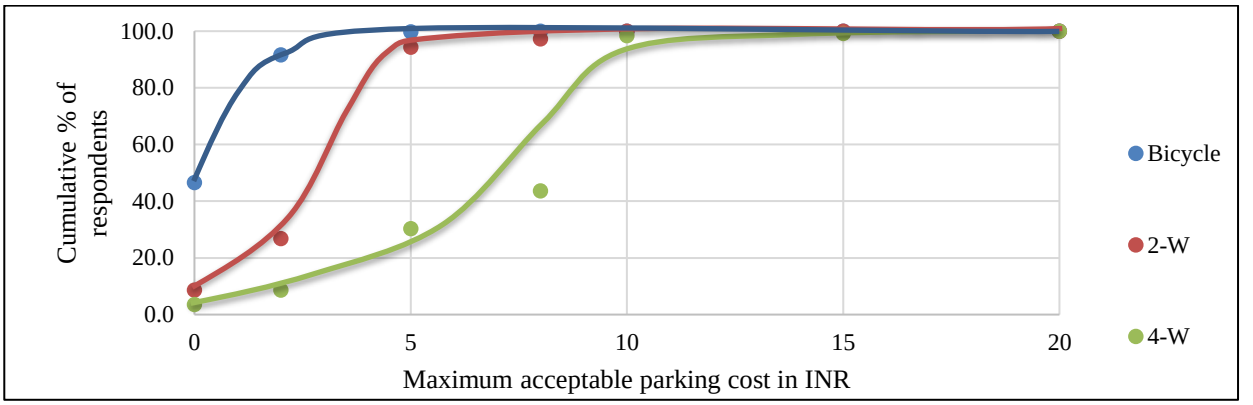


Figure 11. Maximum acceptable parking cost per 2 hr

In the stated preference analysis, the trip makers were asked about the maximum acceptable parking costs (refer figure 11) for various travel modes. And an S-curve was plotted from the data. The s-curve suggests that 85th percentile value of parking (per 2 hrs) for Bicycle, 2-w and 4-w was Rs. 2, 4 and 10 respectively. These are the maximum values, which mean that if the fee exceeds this value then it can become a vehicle restrictive policy for motorized vehicles.

Along with maximum acceptable parking cost, maximum acceptable parking distance was also asked, and the respondents were given four options. The options were up to 150m, up to 250m, up to 500m and more than 500m. More than half (53 percent) of the people accepted maximum parking distance as 150m and a constant declination afterwards is observed in acceptable parking distance. This may be due to the reason that the parking facility is close to the destination in the city and people do not want to walk more distances for parking.

## 5. Conclusions

### 5.1 Mandatory trips.

It was observed that more than one-fourth of the mandatory trip makers were currently using NMVs and approximately one-third of these trips makers have shown willingness in using NM mode, which can bring a remarkable environmental change on the roads of Rewa city. It can also be stated that more than half of the mandatory trip makers of the city were either willing or currently using NM mode. It was also observed and was in concurrence with the existing literature that as the age, occupation level, income level and vehicular ownership increases the willingness to use NMVs decreases. It was interesting to see that female mandatory trip makers were more willing to shift to NM mode as compared to males. It was expected that the respondents earning below 15,000 INR and those at the support level might be more interested in using NMVs. They showed a great interest in using NMVs, which was more than expected. The reason might be high affordability of bicycles and less travel distance (average distance 2.5 kms). It was also found that nearly 82 percent of the NMV users were earning less than equal to 50,000 INR per month, which indicates that it is a favourite mode of lower-middle society. In addition to this, none of the respondents who earned more than 50,000 INR was found using NM mode for their work trips. The school going respondents below 18 years of age were highly interested (75 percent) in using NMVs, which if cultivated properly, the whole picture of the city may change and a huge environmental change towards sustainable transportation can be seen. Approximately 58 percent of the trips are within 3 kms range which can be easily covered by walk or bicycle. It was observed that the average travel time of the NMV users was 15 minutes, and if consider the speed of bicycle be 15 km/hr, then in 15 minutes a person can cover a distance of 3.75 km, which is quite acceptable bicycling distance. But the willingness to shift to NMVs decrease just after 3kms and the respondents become reluctant in using NMVs. The model estimates of the mandatory trips suggest- distance, speed, occupancy of vehicle, possession of DL and access cost of using IPT is negatively associated with probability of using NMVs.

### 5.2 Non-mandatory trips.

The share of NMVs in non-mandatory trips was less than half of the mandatory trips i.e. 11 percent only, it is quite different from the expectation. It was also observed that nearly half of the 2-w users and one-third of the IPT users in this category of trips were willing to use NMVs. If by some means these respondents can be shifted to NMVs then a remarkable change can be observed in Rewa city. As expected, 4-w users were least willing to shift to NMVs the reason might be the comfort associated with that mode. It was observed that as the age increases the respondents loose interest (both willingness and current share of NMVs decrease) in using NMVs. 75 percent of the school going students were either willing or currently using NM mode for non-mandatory trips. In addition to this, it was found that beyond 2 kms the respondents become reluctant in using NMVs and the willingness and current share of NMVs decreased rapidly. It was witnessed that two-thirds of the non-mandatory trip makers were women, and more than one-third of them were willing to shift to NMVs, but only 7 percent of the females were currently using NMVs. The model estimate suggests that the possession of DL, higher HH-income, higher distance travelled, and higher occupancy vehicles were negatively associated with the willingness to shift to NMVs.

### 5.3 Stated preference analysis.

In addition to this, it was also observed that nearly three-fourths of the respondents of the city want a segregated NMV lane. It was also found that keeping motorized parking station above 150m can become an MV restrictive policy and can help in increasing the share of NMVs. The 85th percentile value of 2-w and 4-w was Rs. 4 and Rs. 10 respectively, keeping parking cost beyond this range can help in reducing the number of MVs.

## References

Bamney, A., and Rastogi, R., 2016. Willingness to use non-motorized vehicle for trips in urban areas. Transportation Planning and Implementation Methodologies for Developing countries, peer review conference.

Bamney, A., and Rastogi, R., 2017. Studies on Importance and Design Needs for Non-motorized Trips – A Review. Conference of Transportation Research Group of India, peer review conference.

Bhargav, R., 2009. Bicycle movements in a class-I city. Unpublished M Tech project, submitted to Department of Civil Engineering, Indian Institute of Technology Roorkee.

Bhat, C.R. and Eluru, N., 2009. A copula-based approach to accommodate residential self-selection effects in travel behavior modeling. Transportation Research Part B: Methodological, 43(7), pp.749-765.

Bhat, C.R., Guo, J.Y. and Sardesai, R., 2005. Non-Motorized Travel in the San Francisco Bay Area. University of Texas, Austin, pp.17-27.

Black, W.R., 2010. Sustainable transportation: problems and solutions. Guilford Press.

Census of India. 2011. Provisional Population Totals. New Delhi, India.

Center for Biological Diversity. Transportation and Global Warming. https://www.biologicaldiversity.org/programs/climate_law_institute/transportation_and_global_warming/. Last Accessed 29 April 2019.

Guitink, P., Holste, S. and Lebo, J., 1994. Non-motorized transport: confronting poverty through affordable mobility (No. Transport No. UT-4).

Gwilliam, K., 2003. Urban transport in developing countries. Transport Reviews, 23(2), pp.197-216.

Hong, J., Shen, Q. and Zhang, L., 2014. How do built-environment factors affect travel behavior? A spatial analysis at different geographic scales. Transportation, 41(3), pp.419-440.

Hook, W., 2003. Sustainable Transport: A Sourcebook for Policy-makers in Developing Cities. Module 3d: Preserving and Expanding the Role of Non-motorized Transport.

Joewono, T.B. and Kubota, H., 2005. The characteristics of paratransit and non-motorized transport in Bandung, Indonesia. Journal of the Eastern Asia Society for Transportation Studies, 6, pp.262-277.

Khadaiya P., 2014. Flow characteristics of Non-motorized traffic, MTech Thesis submitted to Department of Civil Engineering, IIT Roorkee.

Khisty, C.J., 1993. Transportation in developing countries: Obvious problems, possible solutions. Transportation research record, 1396, pp.44-49.

Litman, T., 2010. Quantifying the benefits of nonmotorized transportation for achieving mobility management objectives. Victoria Transport Policy Institute, 28.

Litman, T., 2015. Evaluating active transport benefits and costs (pp. 134-140). Victoria Transport Policy Institute.

Loeper, G., 2009. On the regularity of solutions of optimal transportation problems. Acta mathematica, 202(2), pp.241-283.

Munshi, T., 2016. Built environment and mode choice relationship for commute travel in the city of Rajkot, India. Transportation research part D: transport and environment, 44, pp.239-253.

Olio, D. L., Ibeas, A., Bordagaray, M. and Ortúzar, J.D.D., 2013. Modeling the effects of pro bicycle infrastructure and policies toward sustainable urban mobility. Journal of Urban Planning and Development, 140(2), p.04014001.

Pai M., 2007. Transport in cities- India Indicators, Embarq, Washington DC.

Polk, M., 2003. Are women potentially more accommodating than men to a sustainable transportation system in Sweden?. Transportation Research Part D: Transport and Environment, 8(2), pp.75-95.

Polk, M., 2004. The influence of gender on daily car use and on willingness to reduce car use in Sweden. Journal of Transport Geography, 12(3), pp.185-195.

Rastogi, R., 2010. Willingness to shift to walking or bicycling to access suburban rail: Case study of Mumbai, India. Journal of urban planning and development, 136(1), pp.3-10.

Rastogi, R., 2011. Promotion of non-motorized modes as a sustainable transportation option: policy and planning issues. Current Science, 100(9), pp.1340-1348.

Rietveld, P. and Daniel, V., 2004. Determinants of bicycle use: do municipal policies matter? Transportation Research Part A: Policy and Practice, 38(7), pp.531-550.

Rietveld, P., 2001. Biking and walking: the position of non-motorised transport modes in transport systems.

Schafer, A. and Victor, D.G., 2000. The future mobility of the world population. Transportation Research Part A: Policy and Practice, 34(3), pp.171-205.

Servaas, M., 2000. The significance of non-motorised transport for developing countries: Strategies for policy development.

Singh, A., Gangopadhyay, S., Nanda, P.K., Bhattacharya, S., Sharma, C. and Bhan, C., 2008. Trends of greenhouse gas emissions from the road transport sector in India. Science of the total environment, 390(1), pp.124-131.

Taylor, P.J., Ni, P., Derudder, B., Hoyler, M., Huang, J. and Witlox, F., 2012. Global urban analysis: A survey of cities in globalization. Routledge.

Tiwari, G. and Jain, H., 2008. Bicycles in urban India. Bicycling in Asia, pp.9-25.

Tiwari, G., 2011. Key mobility challenges in Indian cities. International Transport Forum Discussion Paper.

VTPI 2010. Nonmotorized Transportation Planning, Identifying Ways to Improve Pedestrian and Bicycle Transport. TDM Encyclopedia, Victoria Transport Policy Institute, http://www.vtpi.org/tdm/tdm25.htm, Victoria, Canada.

Yazid, M.M., Ismail, R. and Atiq, R., 2011. The use of non-motorized for sustainable transportation in Malaysia. Procedia Engineering, 20, pp.125-134.

Zhang, L., Hong, J., Nasri, A. and Shen, Q., 2012. How built environment affects travel behavior: A comparative analysis of the connections between land use and vehicle miles traveled in US cities.