"SAFER ROADS FOR SAFER CHILDHOOD"

A Detailed Report

On

School related mobility pattern in Jorhat, Assam, India

Submitted by

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Preface

The trip characteristics of school going children depend on the household characteristics and school zone laws of a particular region. It is evolving out to be an important area of concern for the development-planning bodies in identifying the behavioural pattern of students towards the travel mode choice to schools; and collectively developing model recommendations to the decision makers for its useful application. This study provides the basic understanding of student's travel pattern and mode choice to school in Jorhat, Assam. A multinomial logit model has been estimated that models the impact of socio-economic and demographic characteristics, trip characteristics and built environment factors of the study area on school related mobility.

Table of Contents

List of Figures

List of Tables

1 Introduction

Children's travel pattern to school has long been a subject of research in the western countries. However, the studies and understanding on this subject is very much limited in developing countries such as India. Adults make their own travel decisions and thus, travel patterns of adults and school going children are very much different from each other (McMillan, 2005). Although, most teenagers take decisions regarding their school travel on their own, school trip decisions of younger children are entirely decided by their parents (Singh, N. and Vasudevan, V., 2018). Thus, students should be considered as major stakeholders in transportation as well as road safety policy recommendations. Moreover, studying the travel pattern and impact of various socioeconomic, demographic, trip characteristics and built environment factors is very much necessary in understanding the mode choice decisions of school students.

As today's children step into adulthood to become responsible citizens of tomorrow, school education is of primary emphasis, which contribute vastly to the development of young adolescents. India, ranked second among all the countries in terms of overall population also has the highest population of students in the world with approximately over 315 million students at various levels of school. The school education of such a massive number of student is also a major subject of interest for a developing nation like India. The opening hour timings of majority of the schools and offices in India are identical and thus school trips contribute a major portion of the peak hour traffic. The increased urbanization, increasing number of traffic, unskilled or semiskilled drivers, ignorance and intentional violation of traffic rules, lack of proper lane discipline and the woefully inadequate road infrastructure system make Indian roads very much hazardous. Most of the lower-middle income group people in India primarily dependent on motorized two-wheelers for everyday commute. Thus, two wheelers, motorized as well as non-motorized vehicles are the primary components of Indian traffic (Gururaj, 2008; Mohan, 2004; Kanchan and Menezes, 2008) and consequently pedestrians, two wheeler users, and bicyclists are considered as the most vulnerable road users (Gururaj, 2008). All these elements contribute to high road traffic injuries among adolescents. Although In India, age group 25-35 years has the highest RTA deaths in 2017, 2018 and 2019, age group of less than 18 has seen the highest percentage increase in road accident deaths in 2018 over 2017 and 2019 over 2018 compared to other age groups (Table 1) (Road Accidents in India-2019, MoRTH). This is a very concerning situation as the road accident related death rate is continuously

declining for age groups more than 18 years of age, whereas this rate is growing continuously for age group of less than 18 years.

Table 1: Age profile of accident related deaths in India 2017, 2018 and 2019

Age group	No. of persons killed			% change in 2018 over 2017	% change in 2019 over 2018
	2017	**2018**	**2019**		
Less than 18	9,408	9,977	11,168	**6.05**	**11.94**
18-25	31,775	32,777	33,206	-4.28	1.31
25-35	38,076	39,960	39,023	1.04	-2.34
35-45	33,558	32,788	32,509	-0.35	-0.50
45-60	22,174	22,462	22,612	1.50	-0.82
Above 60	8814	9,384	9,004	-3.29	-0.78

A vast amount of research have been done to understand the student's mode choice behaviour in western countries with recent development in these studies being understanding of built environment factors, effect of parental attitude and perceptions and decline tendency of use of active modes to schools. However, in a lower-middle-income economy country like India (according to World Bank), student's mode choice behaviour in school trips is still vogue. Furthermore, the basic understanding of the issues related to this subject is yet inadequate in the context of a small sized Indian city.

This study conducted in a small Indian city of Jorhat, Assam provides basic insight of different modes available for school trips in the area and the factors affecting the choice decisions of student's mode to school. The primary modes used for school trips in Jorhat are identified as walking, two-wheeler (accompanied by parents), intermediate public transport (IPT) (Auto/Tempo) and van-share, which comprises of more than 80% of the total trips. A multinomial logit model has been estimated from the data collected during household survey, which provides the understanding of various influencing factors and it effects in mode choice decisions in school trips in Jorhat.

2 Objective of the Study

The primary objective of this study was to assess the student's mobility pattern and to develop a reasonable understanding of the mode choice behaviour in school trips in a small sized Indian city based on the data collected from a representative sample of students in the small Indian city of Jorhat, Assam. The aim of this study is to identify the various modes available for school trips and the significant variables affecting in choosing these modes for children's trip to school. A multinomial logit (MNL) model is to be estimated from the collected data, which would give an insight to the effects of various influencing factors on school related mobility behaviour in the study area. The major variable categories primarily focusing to estimate the model are

- Student Characteristics
- Household Characteristics
- Trip characteristics
- Built Environment.

The estimated MNL model will help understand the important built environment factors as well as trip characteristics such as the location of the home and school, the distance between the school and home, existing transport infrastructure etc. These understanding will eventually help the line authorities and policy makers to provide adequate road infrastructure near the schools, new school establishing policy as well as other suitable road safety measures.

3 Study Area Description

Jorhat city, also known as the cultural capital of Assam state, is one of the major cities of Assam. It acts as a gateway to upper Assam and to the state of Nagaland. It was the last capital of the Ahom Kingdom and home to many historical monuments of Assamese culture. Jorhat city is located on the south bank of the Mighty Brahmaputra with geographical coordinates of 26.75°N and 94.22°E (Figure: 1). Jorhat Municipal Corporation (JMC) is the only municipal corporation in the district with an area of 109 Km^2 having total 19 wards and a total population of 1.85 lakhs (2011 census).
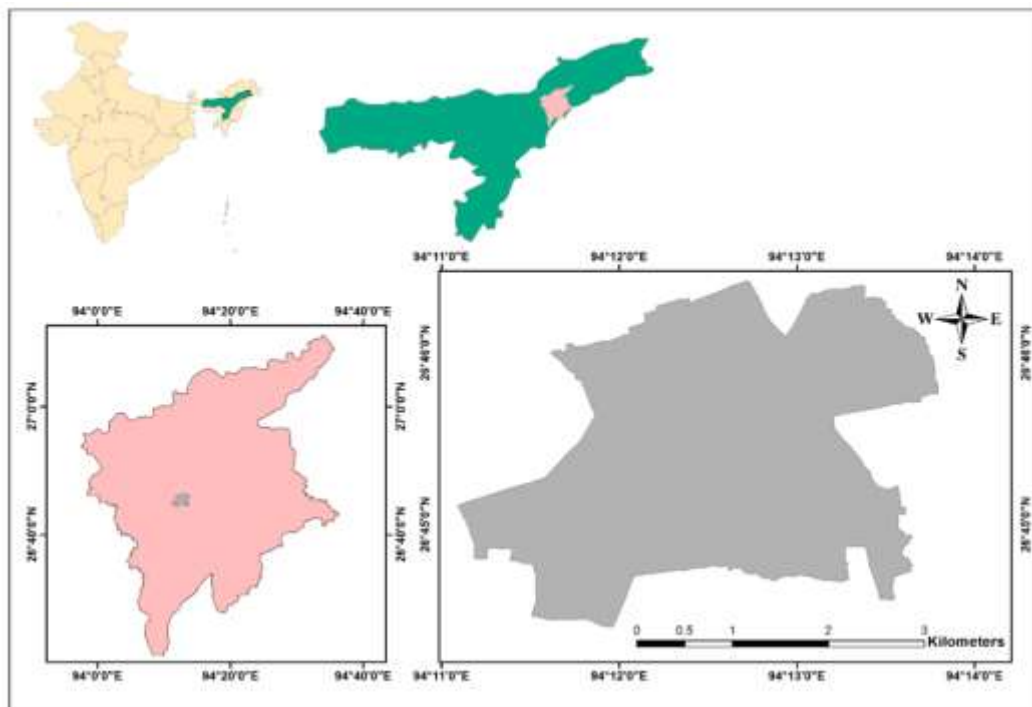
Figure 1: Study area

Jorhat city is well connected with the rest of the country by Air, Rail and Road network. The Jorhat Airport (JRH), commonly known as Rowriah Airport, is located at Rowriah, which is within the city itself, and approximately 7 Km from the city Centre. Jorhat falls under the Tinsukia railway division of Northeast Frontier Railway zone. The Inter State Bus Terminus (ISBT) of Jorhat is located at Tarajan, Kotokipukhuri, on the western part of the city, provides connectivity to other parts of the state as well as the Northeast of India with regular buses operated by Assam State Transport Corporation (ASTC) and private operators.

4 Survey Design and Data Collection

The household survey, being one of the primary activities of the project has been conducted with both questionnaire developments after repeated consultation and content alterations as well as executions in the field in an efficient manner. The survey was conducted through Pen-and-Paper Interview (PAPI) based technique, one of the effective and competent method of household survey, where the interviewer visited individual household and narrate the scope and objective of the survey and recorded necessary information in the questionnaire provided by the respondents (Households owner). The overview of the activities and methodology adopted for the appropriate execution of the survey are following.

4.1 Preparation of Questionnaire

The questionnaire plays a key role in the survey process in which information is transferred from the respondents (Households) to the surveyor. It is considered to be the key instrument through which the required information by the respondents is expressed in operational terms as well as the main basis of input for the data processing in a particular survey.

The questionnaire for the household survey has been prepared after repeated consultation, information from previous research and content modification in the structural configuration. Initially it was drafted for a preliminary sample survey for further modification and subsequently finalizing the questionnaire covering the most influential aspects of mode choice and other associated parameters essential for aggregate model development.

The drafted questionnaire includes parameters associated with the children's mode preference to and from school, student characteristics household socio-economic characteristic, trip characteristics, parental attitude and perception on various statements laid down for the specific behavioural analysis. The primary target of the questionnaire was to collect data from the randomly selected households for various modes such as walking, bicycling, two-wheeler escorted by parents, intermediate public transport (IPT) and hired private vanpool etc.
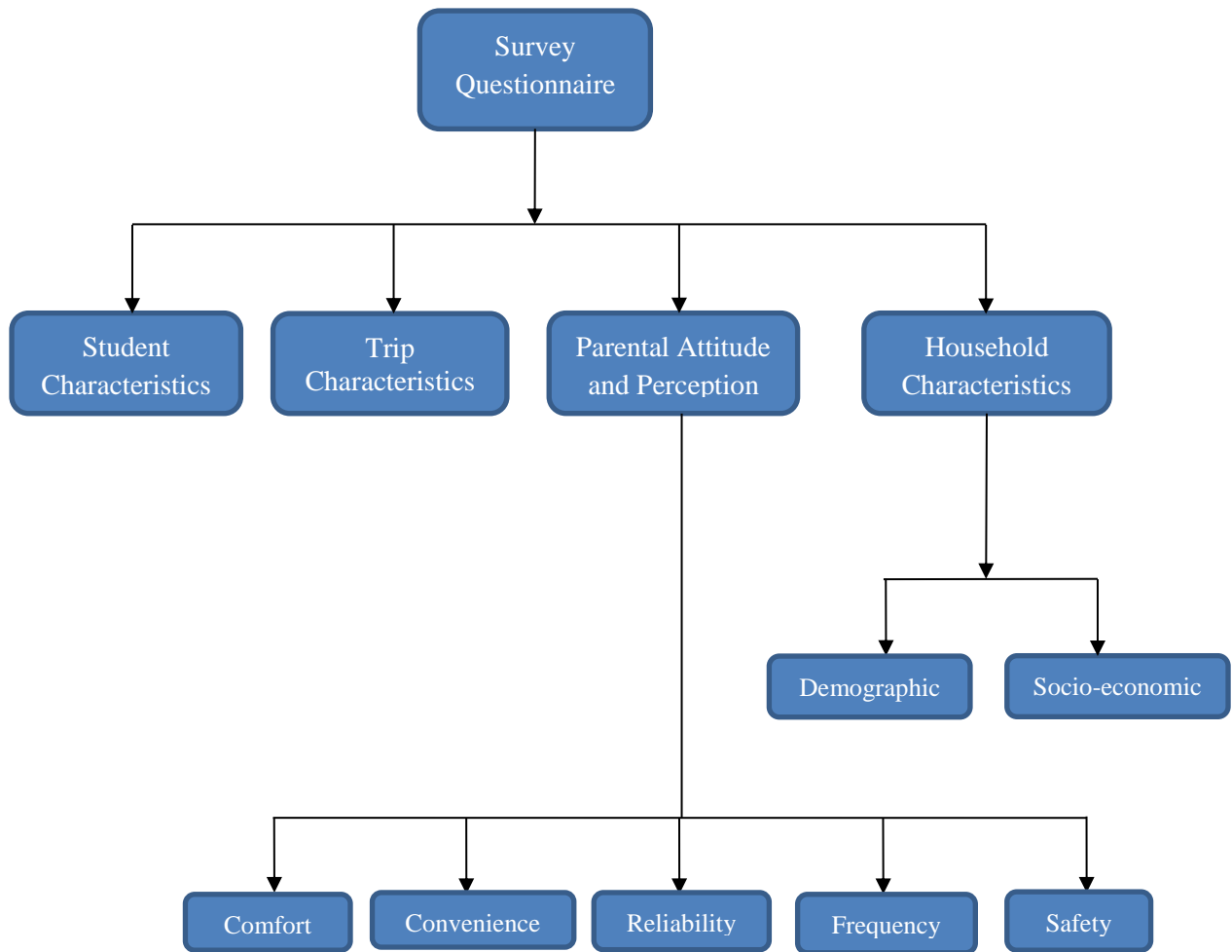
Figure 2: Flowchart of survey questionnaire

4.2 Training cum preliminary Survey for Volunteers

A total of 19 technical background students preferably having the demographic knowledge about the area were selected as the volunteers to be engaged in the household survey data collection procedure for making the data acquisition process more convenient and effective. The engaged interviewer in data acquisition practice were trained about the purpose and objective of the survey along with some handful information required in the field, as well as the granted permission for conducting this huge survey from the district level administration to ensure the individual safety of the volunteers.

In the training for selected volunteers (Figure 3), they were introduced to the questionnaires soon after providing the background of the project; standard procedures and guidelines for collecting the data from the household with the prepared questionnaire were unfolded. The basic demographic information to all engaged volunteers were given and accordingly the locations to be surveyed were allotted individually for making the survey more convenient.

Figure 3: Training session for engaged volunteers

Additionally, all the interviewers were provided with all the fundamental equipment and other materials required in the survey for its smooth conduction. Volunteers were asked to fill some sample questionnaires before the main survey so that the quarries and difficulties occurred while filling up the questionnaire can be cleared. Queries related to the data collection procedures were subsequently addressed after checking the data against the standard records to ensure their correctness.

4.3 Marking the Household Locations on Google Map

The individual volunteers were given handful training to save the household locations on google map as point features on their android/IOS device to ensure the availability of digitized locations as well as latitude and longitudes of all the individual households to be entered in the questionnaire.
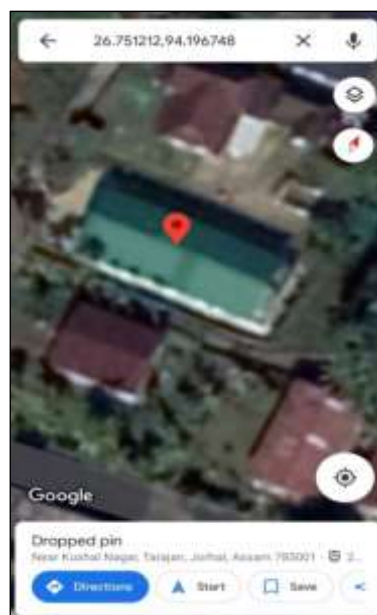
Figure 4: Household coordinates in google map

These point features in later stages has been entered into the google earth software as kml (.kml) files and subsequently exported into the GIS map in shape file (.shp) format which is one of the integral component for the accurate interpretation of trip length i.e. distance from home to school and vice versa. It is also useful for evaluating built environment parameters such as the number of intersections and junctions along with associated safety for an individual's way to school.

4.4 Collection of Household Data

The entire study area was divided into some sub regions for efficiently conducting the survey. The volunteers divided into some sub groups were assigned to visit the respected regions allotted and to collect the requisite data of those students coming to the schools that are in the Jorhat municipality area using different modes to commute to school.

The individual interviewers visited the respective households and the data collection was done by face-to-face interview method with the respondents where the interviewers read the questions, clarify it and finally transcribe the response in the appropriate field of the questionnaire. The individual households coming under this survey were presented with an attractive memento for the school children to cooperate with the requisite information.

In addition to that, the respondent was given sufficient space to reveal their feeling about the area of concern for parents related to the safety of children on the way to schools, comfort in preferred mode of journey, availability of various services and other aspect being faced by their children while coming to the respective schools. With the productive interaction between the interviewer and the respondent, the interviewer drew the attitude of the parents towards various facilities.

5 Digitization of the Data

After the collection of the filled up questionnaire from the individual volunteers, the accuracy, effectiveness, credibility and authenticity of the data was checked thoroughly to meet the certain requirement in a reasonable analysis process for the development of the mode choice models. The digitization of the collected data has been conducted in following two steps.

5.1 Household Locations on Google Earth

One of the influential parameters collected during the exercise of data acquisition is the household location in terms of latitude and longitude, which helps in finding the exact trip length of the students to and from schools. It is considered to be one of the vital elements in the perception analysis of parent's concern relating to the children's safety as well as their steep inclination towards the distant schools from the neighbourhood schools.
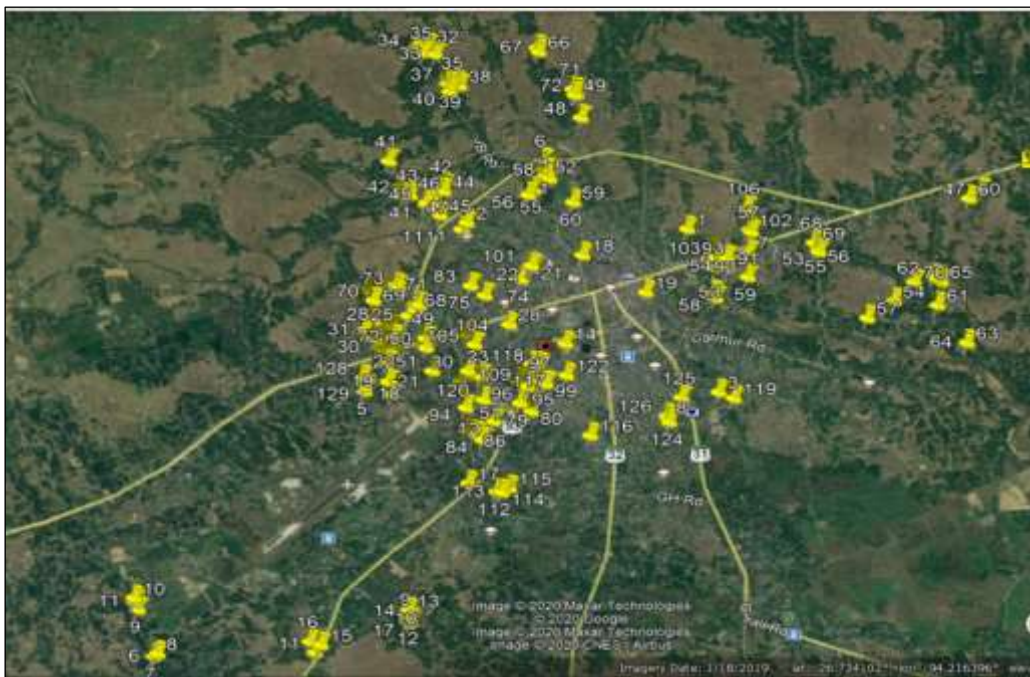
Figure 5: Household locations in Goggle Earth software

5.2 Extraction of Data in MS-Access

The accumulation of the collected data into a uniform platform to facilitate the advantageous later stage analysis and interpretations was necessary through the development of requisite platform. The collective efforts associated with the data compilation practice well executed to

ensure that the collected data meet the assured level of accuracy, precision, effectiveness and quality.

Figure 6: Template of data extraction in MS-access

The extraction task of the collected data has been performed in a prearranged format refined in MS-access, a digitized data bank for storing large-scale data through manual operation to upscale the convenience for further research analysis process. It is being one of the mammoth tasks to digitize the data without compromising with the quality and accuracy, required a broad consumption of time as well as meticulous efforts from the individual associating with the digitization process.

A total of 1000 questionnaires have been extracted out of which, 956 questionnaires comprising of different modes viz. walking, two wheelers, intermediate public transport (IPT), private vanpool, bicycle, rickshaw and personal car have qualified for further analysis and stored in MS-access database.

6 Preliminary Data Analysis and Interpretations

Different variables of primary influential variable categories viz. student characteristics, socioeconomic characteristics of the household and trip characteristics has been analysed in detail with their effects on mode share. It has been observed from the analysis that most of the important variables have similar effects as previous mode choice studies on mode share. The striking findings from the data analysis are shown in the following sections.

6.1 Trip Characteristics

Trip length is known to be among the strongest determinants of mode use, whether it is for school trips, daily commuting or any other trip. However, it is likely that trip distance does not affect mode use in a linear fashion.

6.1.1 Trip Length
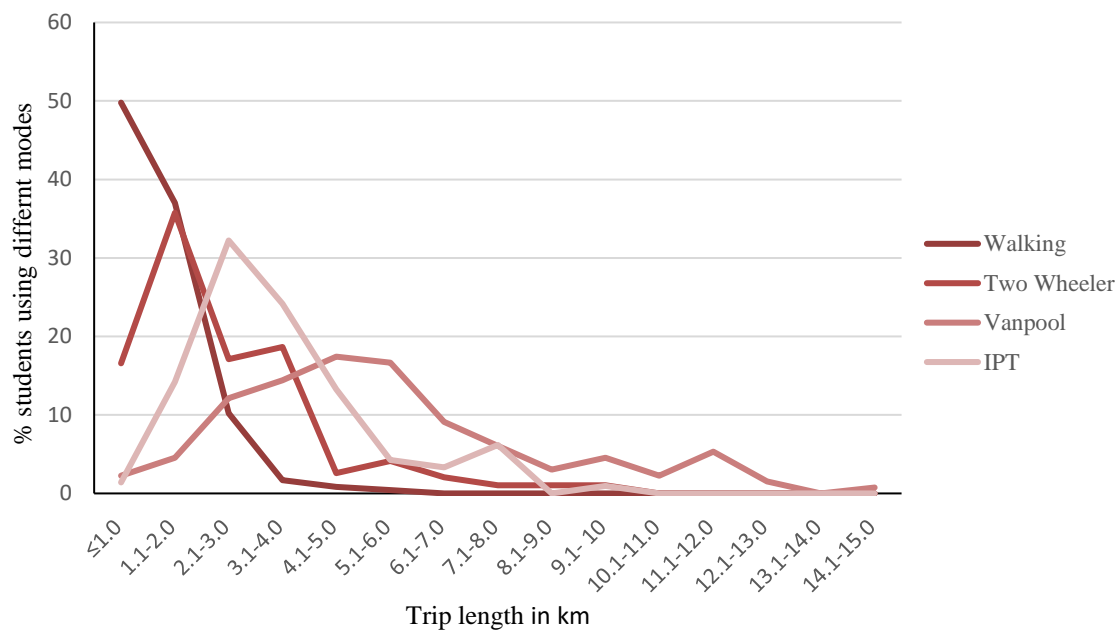
Figure 7: Trip length vs Mode usage

Studies consistently report that the distance between the students' home and school is one of the most significant trip characteristic factors affecting the use of active mode of travel. Almost all studies regarding this subject have found negative correlation between distance and active mode (non-motorized) of travel (McDonald 2008; Ewing et al. 2004; Wilson et al., 2010; Zhang et al., 2017; Easton and Ferrari, 2015; ; Stark et al., 2018 etc.). It can be seen from Figure: 7 that the student's walking percentage is decreasing with increase in the trip length.

More than 85% (precisely 86.81 %) of the students use walking as a mode to school when the trip length is between 0-2 km which is in line with the previous studies of finding threshold as 1.6 km for probability of using active modes (McMillan, 2007; Schlossberg et al., 2006). Similarly more than 83% of the students use IPT (Intermediate Public Transport) as a mode to school when the distance is 1-5 km and 70% of the students use this same mode of travel when the trip length is 2-5 km. A little more than 1% of the students use this mode when trip length is 0-1 km (Figure: 7). This is obvious as majority of the students who use IPT as a mode to school in Jorhat mainly come from the outskirts of the city municipality area. More than 88% of the students prefer two-wheeler when the trip length to school is 0-4 km. This percentage noticeably drops to less than 12% ((Figure: 7) when the trip length increases to more than 4 km. The analysis shows a significant result that the use of Vanpool is almost 70% when the trip length is greater than 4 km with most of this mode (75.8%) is used between trip lengths of 2-8 km. This shows that the Vanpool is generally used as a mode to school when the distance from home to school is large.

Table 2: Distance travelled by students with respect to different transportation modes

Distance (km)	Walking		Two wheeler		Vanpool		IPT	
	%	Cum %	%	Cum %	%	Cum %	%	Cum %
≤1.0	49.79	49.79	16.58	16.58	2.27	2.27	1.42	1.42
1.1-2.0	37.02	**86.81**	35.75	52.33	4.55	6.82	14.22	15.64
2.1-3.0	10.21	97.02	17.10	69.43	12.12	18.94	32.23	47.87
3.1-4.0	1.70	98.72	18.65	**88.08**	14.39	33.33	24.17	72.04
4.1-5.0	0.85	99.57	2.59	90.67	17.42	50.76	13.27	**85.31**
5.1-6.0	0.43	100.00	4.15	94.82	16.67	67.42	4.27	89.57
6.1-7.0			2.07	96.89	9.09	76.52	3.32	92.89
7.1-8.0			1.04	97.93	6.06	**82.58**	6.16	99.05
8.1-9.0			1.04	98.96	3.03	85.61	0.00	99.05
9.1-10.0			1.04	100.00	4.55	90.15	0.95	100.00
> 10.0					9.85	100.00		

Aiming at the students of primary school in Ireland, Kelly and Fu (2014) observed that travel distance of 2 km to school is the 'splitting line' between the active travel modes and motorized modes. The graph (Figure: 7) clearly indicates that students hardly choose walking as a mode to school once the distance between home and school increases more than 2 km. This result of the current study can also be observed from Table:1 (shows the cumulative percentage of students choosing walking, two wheeler, vanpool and IPT as modes to school), which shows that nearly 87 % of the students choose to walk when the distance is lesss than 2 km.
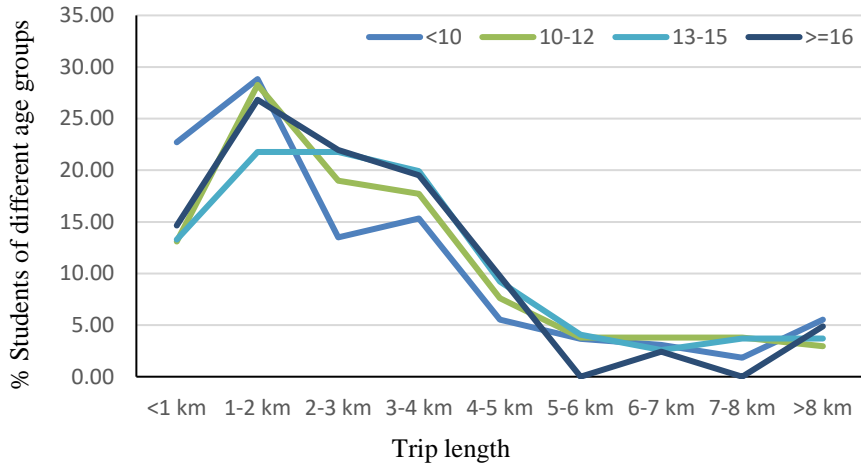
Figure 8: Trip length according to age group

An analysis has also been done to observe the effects of various age groups on trip length to school. It has been observed that more than 65% of the students (Figure: 8) which belong to the age group of <10 years, their usual trip length is 0-3 km. In comparison, the students who belong to the age group of 10-12 years the similar percentage can be seen (65%) when trip length is 1-4 km. The percentage increases to 72% (Figure: 8) for the age group of 13-15 years when the trip length to school is 1-5 km. For the age group >=16 years for the same trip length of 1-5 km the percentage again increases to 78%. The analysis reflects that, as age increases students tend to go for longer trip length to school. This may be because the parents' concerns towards their child little ease out with increase in age. It shows that the age has some effect on school trip lengths but the effect is not too significant.

6.1.2 Trip Accompany to School
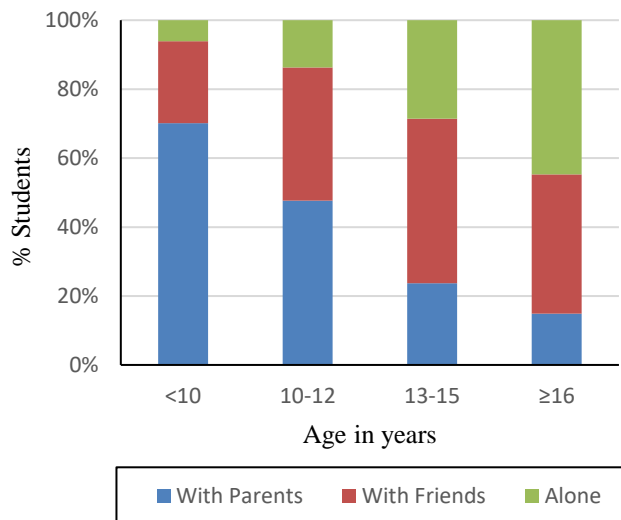
Figure 9: Accompany to school

The analysis shows that maximum number of students in Jorhat (44%) is accompanied to school by their parents, which includes walking, two wheeler and IPT as the major modes. 34% of the students go to school with their friends that include Vanpool as the primary mode that accompanies students with their friends. Only 22% of the students travel alone to school that uses walking and IPT as the major mode to school (Figure: 9).

From the figure (Figure: 10) below it can be seen that the distance has no significant effect on parental escort to school. In the trip length of 1-2 km, the parental escort is highest among all, which is 30.45% as most of the students in this trip length, either walk to school or pillion ride with their parents.
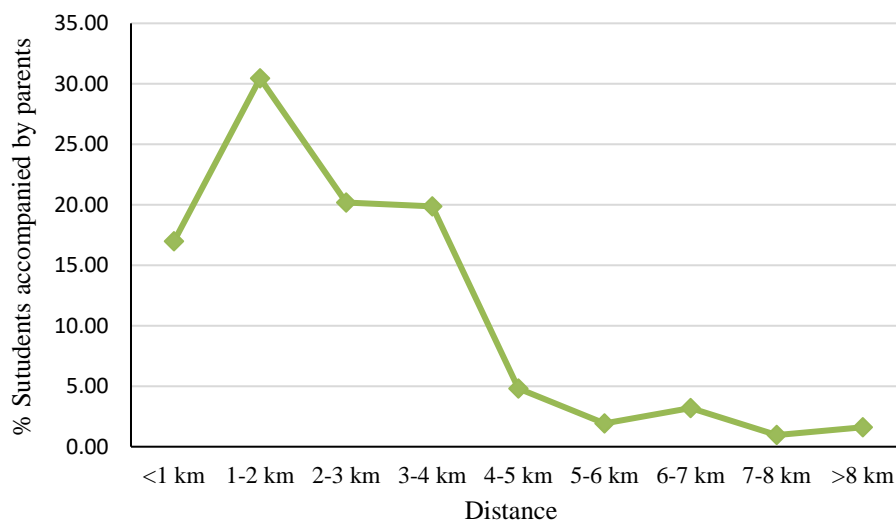
Figure 10: Distance vs Parents accompany

6.2 Student Characteristics

The Characteristics of school-going children is one of the primary categories of variables that influence the mode choice behaviour. Sociodemographic factors, referring to student characteristics, the most important attributes that are widely discussed in previous literatures are age and gender.

6.2.1 Age

Based on analysis of the data most researchers believe that there is a positive relationship between age and using active modes of travel (McDonald, 2008a, 2008b; Ermagun and Samimi, 2015; Li and Zhao, 2015; Noland et al., 2014; Sidharthan et al., 2011). The analysis below (Figure: 11) shows that the possibility of walking increases with increase in age, which is similar to the results observed in previous studies. However, it can be noticed that walking

percentage is more than 33% in the age group of <10 years, may be because parents escort most of the students to school in this age group (Figure: 12). It has been found that the likelihood of pillion ridden two-wheeler increases as the age of students reduces. This seems logical since parents of younger children prefer to accompany their child on two-wheelers, as it is perceived to be the safest mode according to parents. Similarly, there is a positive relationship between age and using IPT mode in school trips, with the exception being the highest age group of ≥ 16 years. The relationship between age and van-share mode is similar to that of two-wheeler with only exception is the age group of ≥ 16 years.
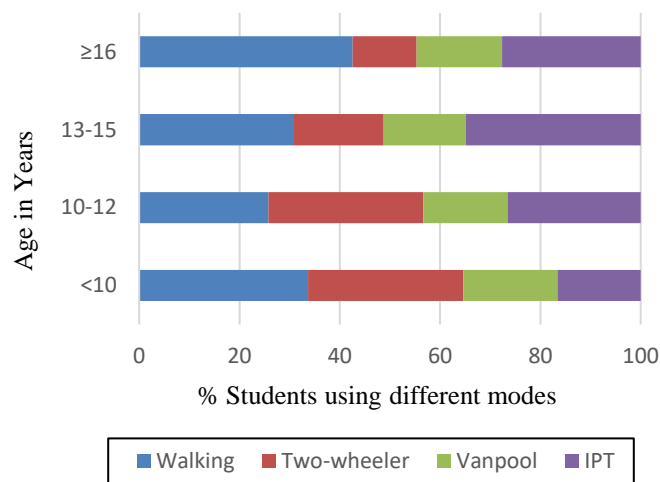
Figure 11: Mode share according to different age groups

Table 3: Percentages of student's mode of trip to school corresponding to different age groups

| | Sample size | Mode of trip to school | | | |
		Walking %	Two-wheeler %	Vanpool %	IPT %
Total	771	30.48	25.03	17.12	27.37
Age group of students					
<10	181	33.70	30.94	18.78	16.57
10-12	256	25.78	30.86	16.80	26.56
13-15	287	30.66	18.12	16.38	34.84
≥ 16	47	42.55	12.77	17.02	27.66

6.2.1.1 Trip Accompany (According to Age)

<10 Years

- With Parents
- With Friends
- Alone

75%
18%
7%

10-12 Years

- With Parents
- With Friends
- Alone

15%
52%
33%

13-15 Years

- With Parents
- With Friends
- Alone

23%
32%
45%

>=16 Years

- With Parents
- With Friends
- Alone

12%
51%
37%
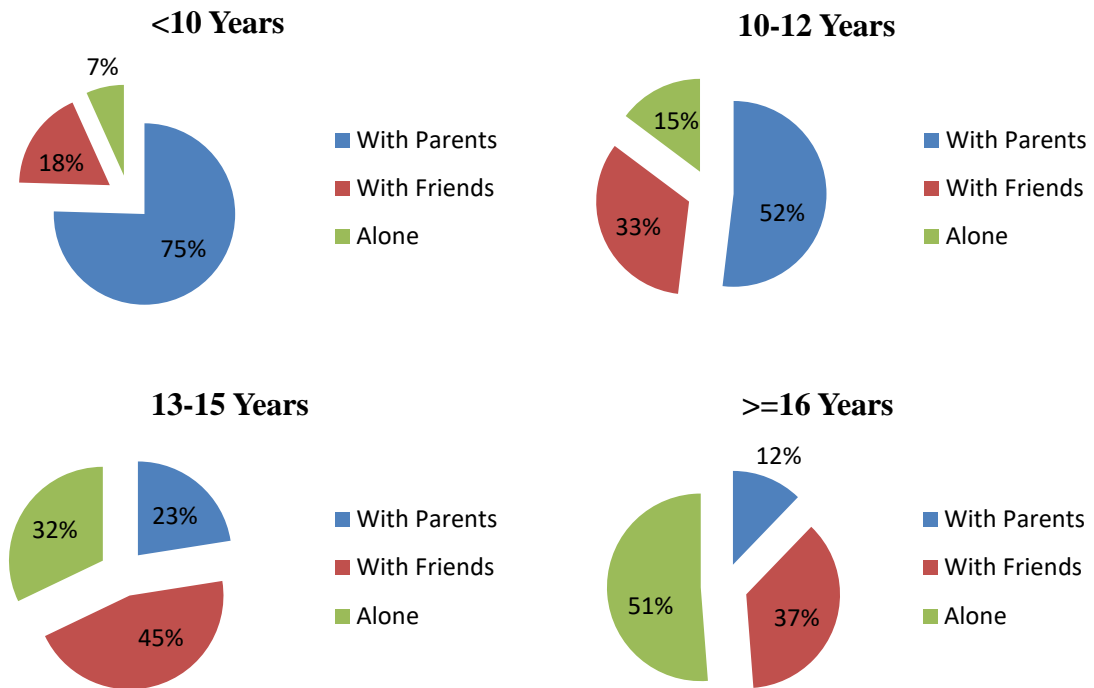
Figure 12: Different age group showing accompany to school
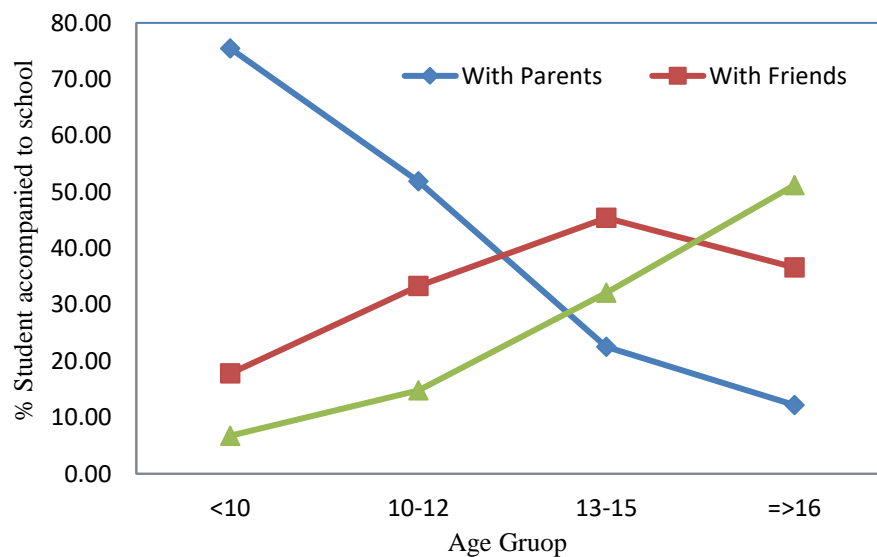
Figure 13: Age vs Accompany to school

The analysis shows (Figure: 12) that 75% of the students who belong the age group of <=10 years are accompanied by parents and this percentage decreases to only 12 % for the age group of =>16 years. Similarly travelling alone to school is the highest for the age group of =>16 years and lowest for <=10 years (Figure: 12). This shows that as age increases parental escort decreases while independent travel of students increases (Figure: 13).

6.2.2 Gender
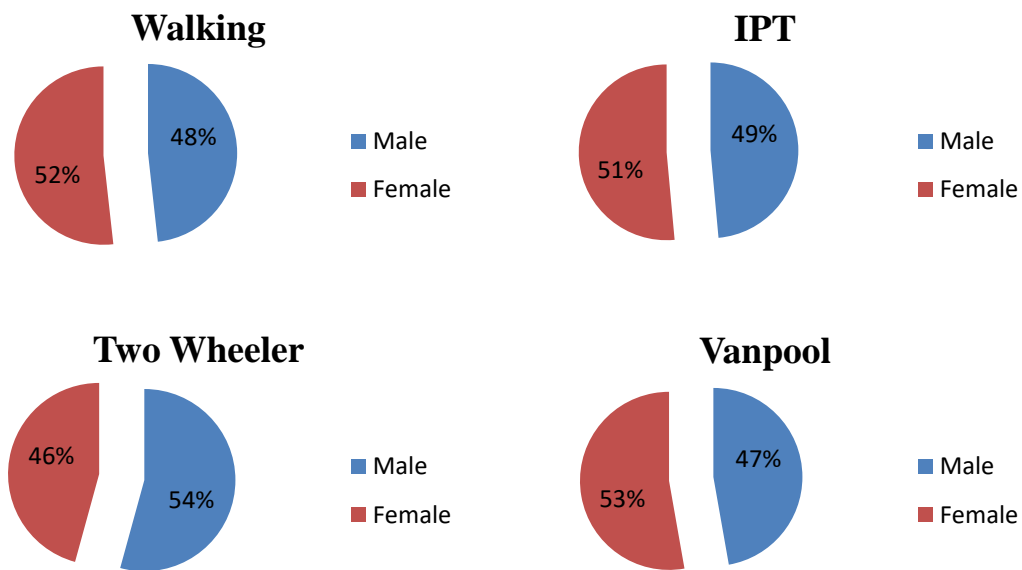
Figure 14: Mode share according to gender

Gender is another attribute which has considerable influence on student's mode choice behaviour, although the results of different studies are varied. From the figure above it can be observed that walking and IPT are the modes more preferred by female students than male students, although the difference is very small. The results are similar for vanpool as well. Only two-wheeler is more used by male students (Figure: 14).

6.2.2.1 Trip Accompany to School (According to Gender)
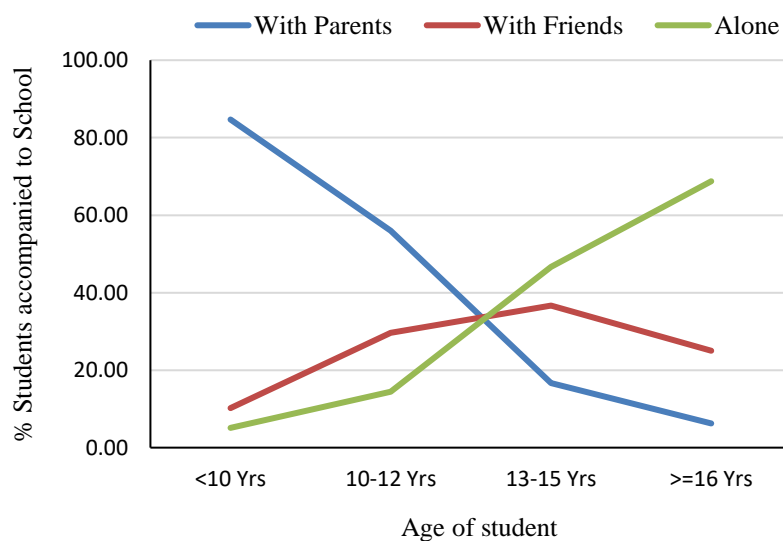
Figure 15: Male students accompany to school for different age groups
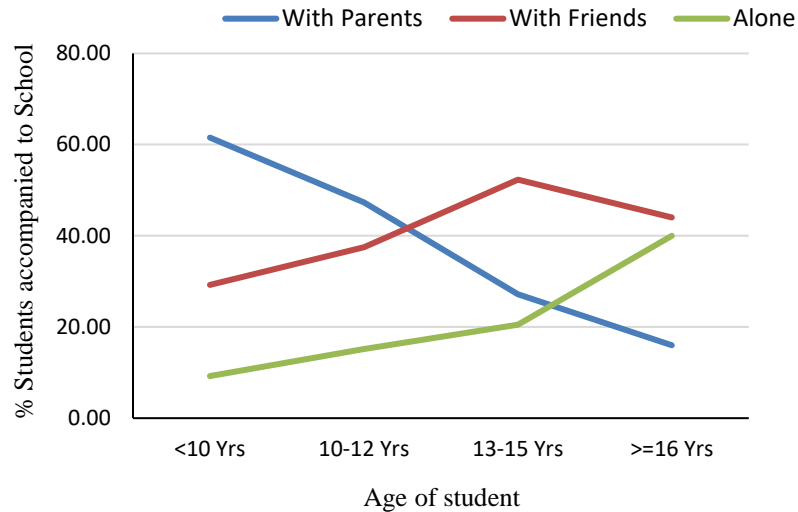
Figure 16: Female students accompany to school for different age groups

The above figures (Figure: 15 & Figure: 16) show the student's accompany to school according to their gender for different age groups. It can be seen from both the figures that parent's escort to school for both male and female student decreases with increase in their age, while school trips alone increase with increase in age. This may be because the parents of younger children are likely to be more skeptical about safety of their children when they travel alone.
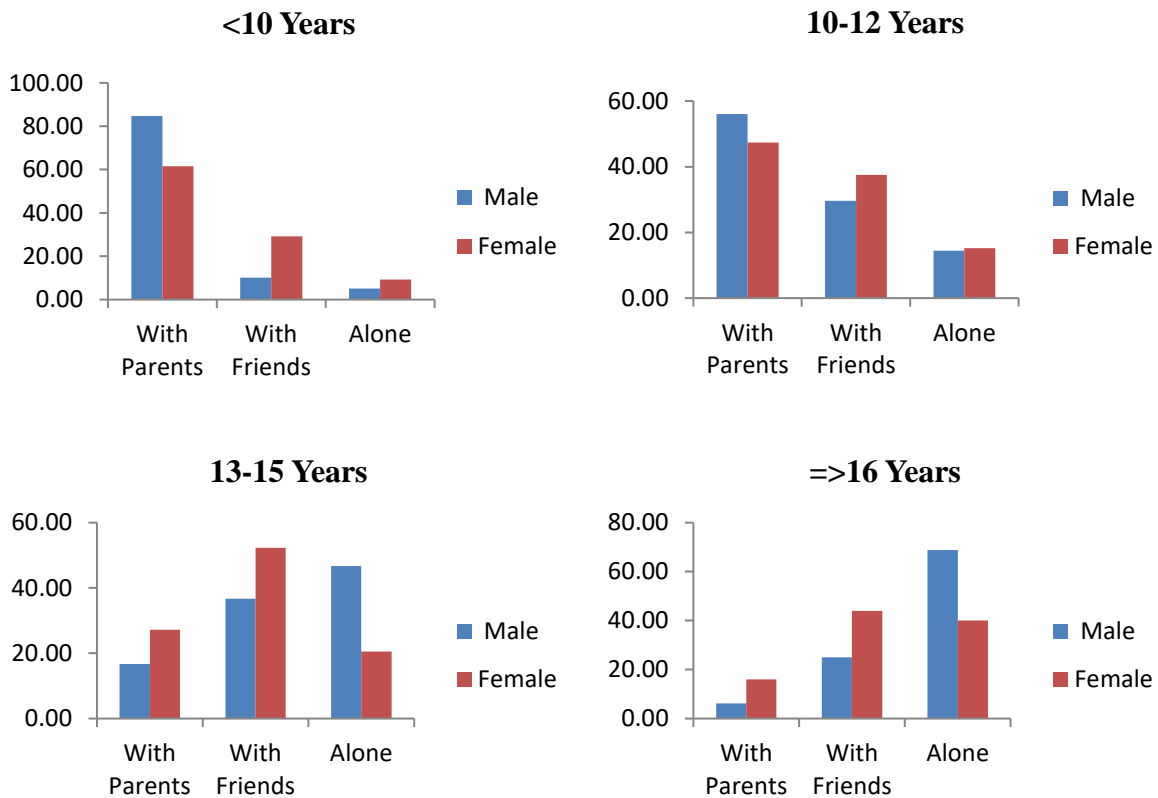
Figure 17: Different age groups showing school accompany according to gender

From the analysis above (Figure: 17) it can be interpreted that in the age group of <=12 years, male students are more likely to be escorted by their parents than their female counterparts. On the other hand, female students have more tendencies to be accompanied by their parents to school in the age group of =>13 years. Although in both the cases, the difference is not too huge. The male students have more probability of travelling alone to school than female students in the age group of =>13 years and the difference is noticeably large (Figure: 17). This means that as the age increases male students prefer to travel alone while female students are not too keen to travel alone may be due to parental concerns about harassment and the vulnerability of girls. Another noticeable observation is that in all the age groups female students tend to travel more with their friends than male students do.

6.3 Household Characteristics

The socioeconomic variables of a household that predominantly influence student's mode choice behaviour as stated by previous studies are household and parental resources, needs, activity patterns, the existence, gender and age of siblings, and their school trips, as well as subjective parental attitudes and perceptions.

6.3.1 Monthly Household Income

The household income is one of the major variables that have huge impact while making decisions on school trips (Pont et al., 2009; Roya et al., 2012; Ermagun and Samimi, 2015).
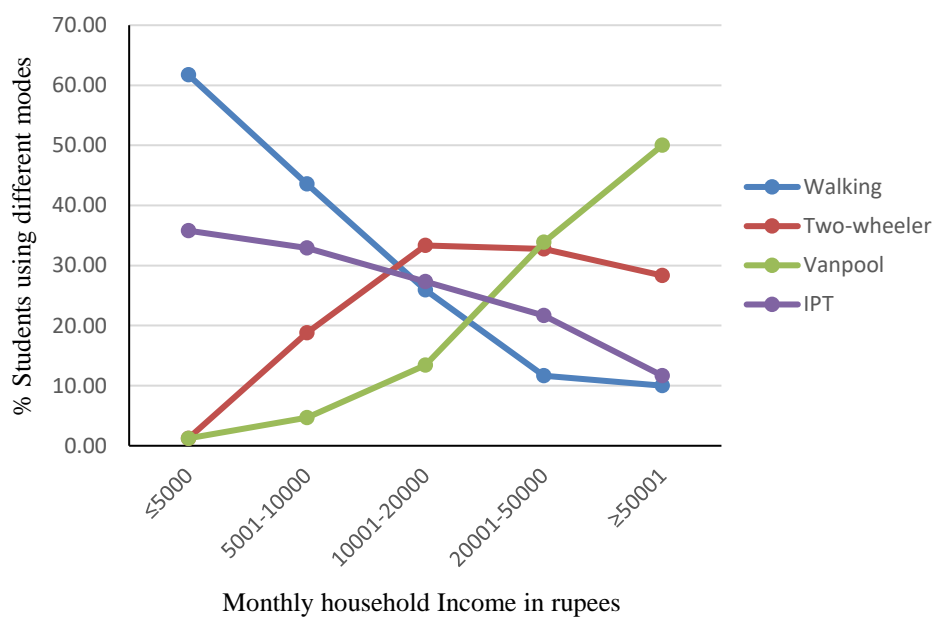
Figure 18: Monthly household income vs Mode share

Table 4: Percentage of students using different modes according to household income

	Sample Size	Mode of trip to school			
		Walking %	Two-wheeler %	Vanpool %	IPT %
Total	771	30.48	25.03	17.12	27.37
Monthly Household Income					
≤5000	81	61.73	1.23	1.23	35.80
5001-10000	234	43.59	18.80	4.70	32.91
10001-20000	216	25.93	33.33	13.43	27.31
20001-50000	180	11.67	32.78	33.89	21.67
≥50001	60	10.00	28.33	50.00	11.67

Studies in different regions of the world reported that low household income could increase the probability of students commuting actively to school (Ewing et al., 2004; McMillan, 2007; Wilson et al., 2010; Sidharthan et al., 2011). The above analysis (Figure: 18) also shows that with increase in monthly household income students likelihood of walking to their schools decreases. Conversely, 62% of the students who belongs to the families whose monthly income is ≤ 5000 INR prefer to walk. Similarly, 36% of students whose monthly household income range is 0-5000 INR prefer to use IPT as travel modes and the percentage declines as the household income increases. Most of the students who belong to the families of income range 5000-50000 INR use two wheeler as a mode to school with highest being 33% in the income range of 10000-20000 INR. However, the scenario is completely different in case of vanpool. As the household income of students increases the percentage of vanpool as mode to school increases. The effect is more significant in the income ranges of 20001-50000 INR and >50000 INR. From these observations it can be interpreted students belonging to higher income group households generally prefer vanpool, while middle-income group households are preferring two-wheeler. Contrary to the above observations, walking and IPT are the modes that normally prefer by students of lower-income group households.

Another interesting finding is the effect of income in choosing the type of school by parents. Figure: 19 shows that almost 75% of the students prefer to go to government schools when the monthly household income range is 0-15000 INR, with highest being 38% when the income is 5000-10000. Contrary to this result, 56% of the students who belong to the income range of >15000, prefers private schools. This is due to the fact that in Assam, parents with high monthly income prefers private schools as facilities and quality of education is better in comparison to government schools.
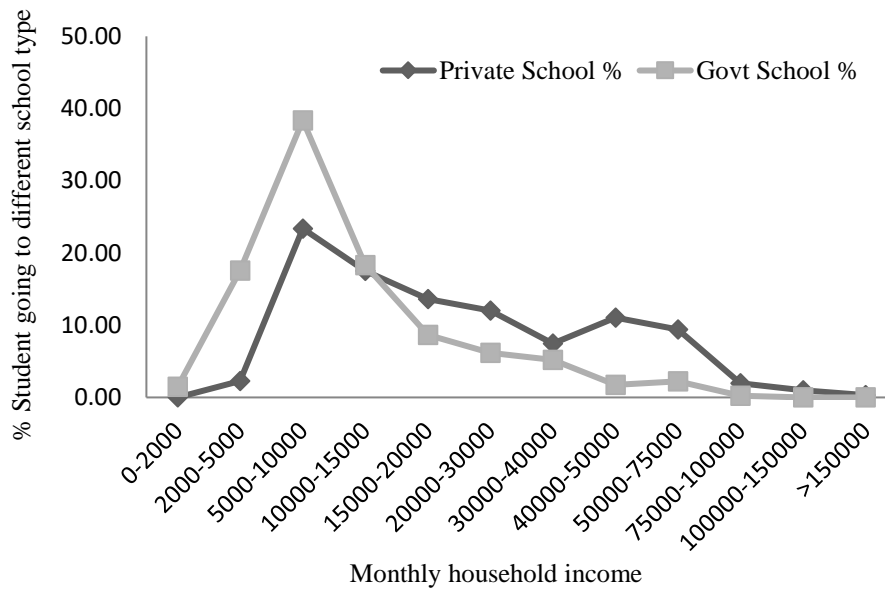
Figure 19: Monthly household income vs School type

6.3.2 Father's Employment
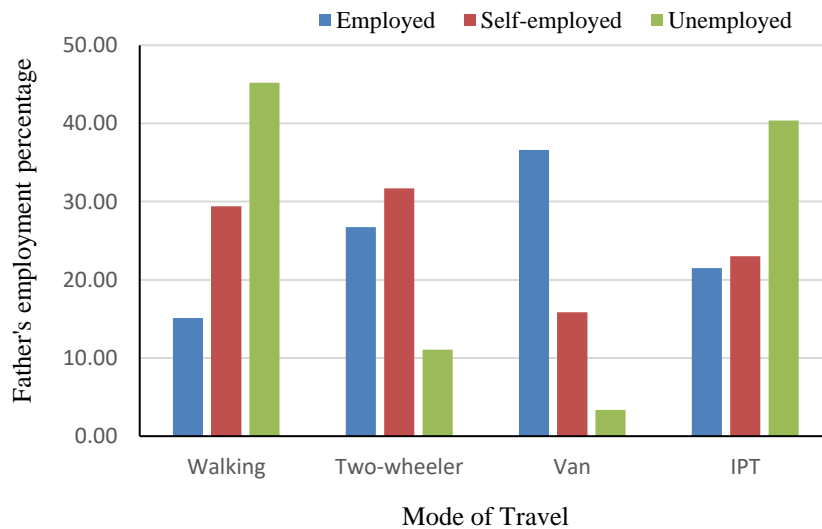
Figure 20: **Percentage of students using different modes based on father's employment**

As parents take most of the decisions on student's school trip, another vital socioeconomic covariate is the employment status of parents. Father's employment is the most dominant variable that effects the choice behaviour. The graph in Figure: 20 shows that students whose father is unemployed prefers walking followed by IPT as modes to school. Contrary to this if the father is employed the odds of choosing van-share rises. The overall scenario reveals that the likelihood of choosing expensive modes increases if the father is employed. In addition, if a father is self-employed the chances of choosing two-wheeler is the highest.

6.4 Built Environment

In recent years, a portion of the research on student's mode choice behaviour has been shifted towards built environment factors. The built environment factors plays a vital role in student's active mode of travel. The following sections describes the preliminary analysis of important built environment factors on student's mode choice.

6.4.1 Presence of Major Road

The presence of a major road in the vicinity of a school indicated the presence of state highway or a major arterial road within 300 meter of the school, effects the active mode of travel. The following figure (Figure: 21) shows that if there is no major road present within 300 meter of a school the probability of walking to school increases.
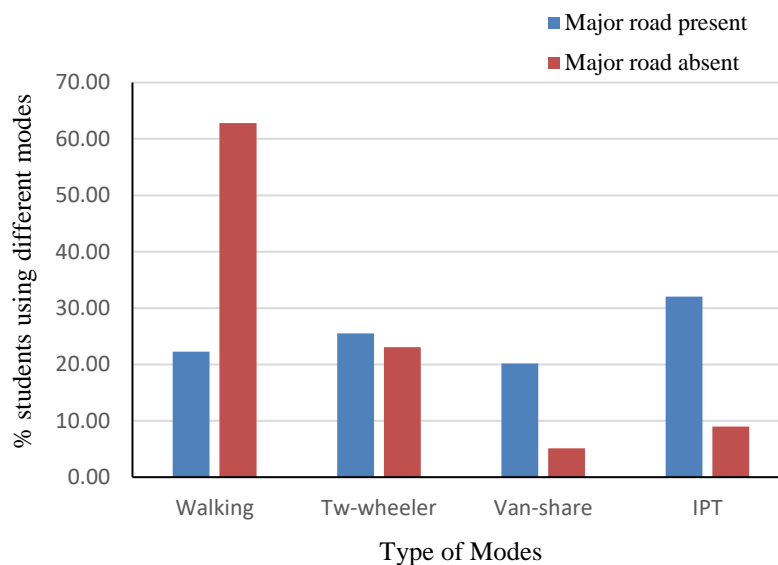
Figure 21: Percentage of students using different modes with respect to the presence of a major road

6.4.2 Presence of Sidewalk
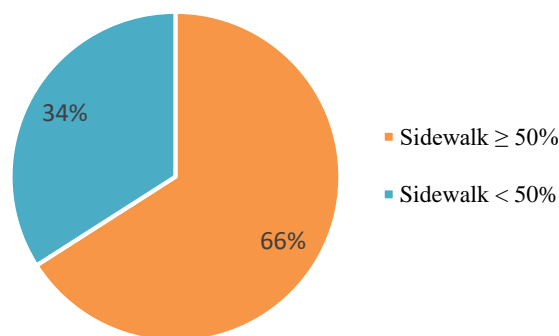
Figure 22: Percentage of students walking to school based on presence of sidewalk on the way to school

It has been found that presence of proper road infrastructure like presence of quality sidewalk on the way to school increases the likelihood of walking to school. Although the findings in the above figure (Figure: 22) justifies this finding, sidewalks are absent and most of them have less than 1 meter width as well as very poor maintenance in the majority of sections on the routes considered in this study and on streets of Jorhat city in general. Therefore, the results do not qualify for serious discussion.

6.4.3 Major Junction Crossing

Another finding from this study is the effect of major junction (3-way junctions or more) crossing on the way to school on walking to school. It can be noticed from the figure (Figure: 23) that among the walking sample of students, 80% of students walk to school when they have to cross one or no junction.
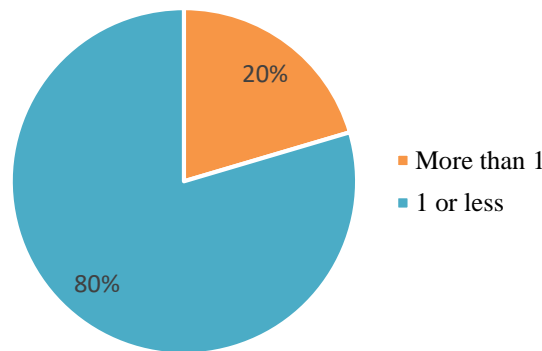
Figure 23: Percentage of students walking to school based on the number of junction crossing

6.5 School Type and Mode Share
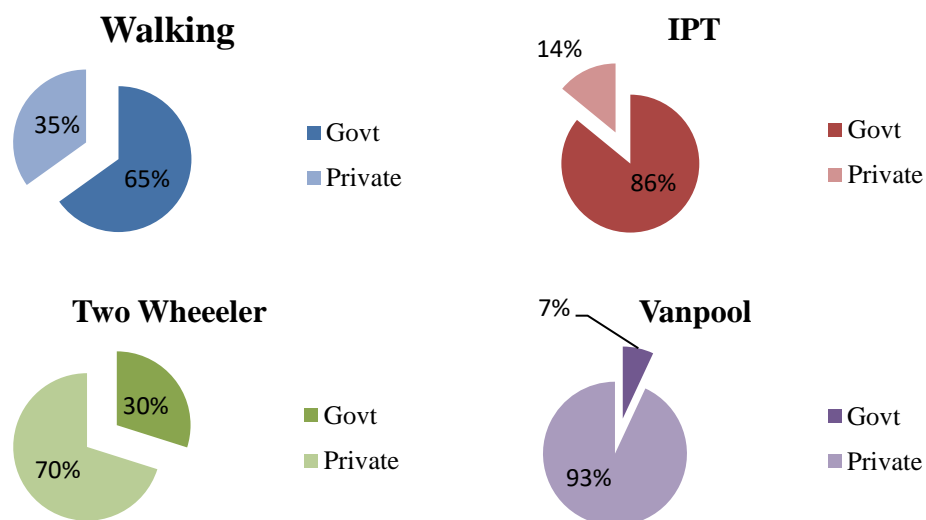
Figure 24: School type and Different mode share

Figure: 24 and Figure: 25 reveal that most of the students from government schools in Jorhat uses walking (65%) and IPT (86%) as mode to school in comparison to two wheeler and vanpool (30% and 7% respectively). Students from the private schools primarily prefer vanpool (93%), and two-wheeler (70%). This is because the higher income group of parents generally prefers private schools and prefer vanpool as the mode for their child to school as shown in the previous analysis (Figure: 18 and Figure: 19).
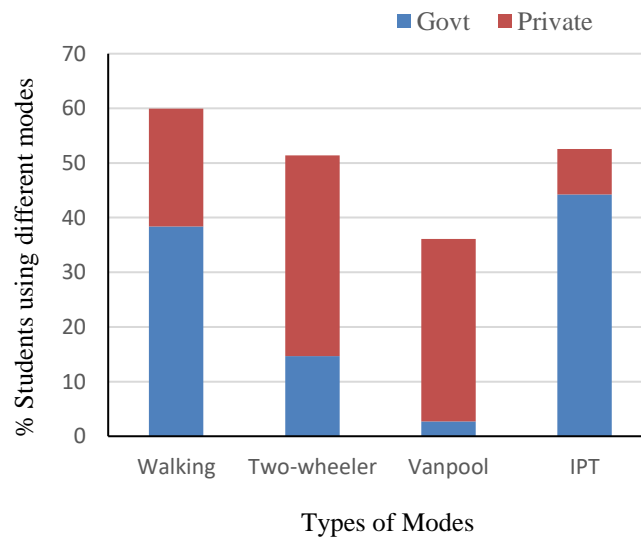
Figure 25: Mode share according to school type

7 Model Estimation and Elasticity Analysis

7.1 Disaggregate Modelling

Discrete choice models can be used to analyse and predict a decision maker's choice of one alternative from a finite set of mutually exclusive and collectively exhaustive alternatives. The theoretical basis of disaggregate model is a hypothesis that an individual will select the alternative from his/her set of available alternatives that maximizes his or her utility. To overcome many shortages of aggregate model, disaggregate model and its derivatives are widely used. The assumption of disaggregate model is that travellers would choose the travel mode for the greatest utility under certain conditions, and the utility function of it is composed by fixed term and random term. In a logit model, the random component of utility is assumed to be independent and identically distributed (IID) across the individual choice-makers and the alternatives. The formulas are as follows:

$$U_{in} = V_{in} + \varepsilon_{in}$$
$$V_{in} = \sum_{k=1}^{k} \beta_k X_{ink}$$

Where U_{in} is utility value of the ith travel mode chosen by the nth traveller; V_{in} is the fixed term of utility value U_{in}; ε_{in} is the random term of utility value U_{in}; K is the number of factors (which is also called characteristic variables) affected on the mode choice of travellers; β_k is the undetermined coefficient; X_{ink} is the kth factor of the ith travel mode chosen by the nth traveller.

7.1.1 Establishing of Multinomial Logit Model (MNL Model)

If the random term ε_{in} obeys Gumbel distribution and all variables are independent from each other, the probability P_{in} of the ith travel mode chosen by the nth traveller is given by the following formula:

$$P_{in} = \frac{e^{V_{in}}}{\sum_{j=1}^{J} e^{V_{jn}}}$$

Where J is the total number of available alternative travel modes for travellers.

At this time, the model evolves to multinomial logit (MNL) model, which is the common form in disaggregate theory. MNL model is characterized by having simple mathematical form, easy to be understand and so on, therefore, it is one of the most widely used and most mature model in the disaggregate theory.

7.2 Descriptive Statistics

Table 5: Summary of Sample Characteristics

Characteristics	% Respondents	Mode of commute (percentage of sub population)			
		Walking	Two wheeler	IPT	Van share
Age					
<10	23.5	33.7	30.9	16.6	18.8
10-12	33.2	25.8	30.9	26.6	16.8
13-15	37.2	30.7	18.1	34.8	16.4
≥16	6.1	42.6	12.8	27.7	17.0
Travel Time (in minutes)					
≤10	15.2	51.3	44.4	3.4	0.9
10-15	21.8	31.5	38.7	20.8	8.9
15-20	21.4	29.7	26.1	27.9	16.4
> 20	41.6	22.7	10.3	39.3	27.7
Gender					
Male	49.0	32.3	23.4	26.7	15.6
Female	51.0	28.7	27.8	28.0	18.6
Monthly Household Income (₹)					
≤5000	10.5	61.7	1.2	35.8	1.2
5001-10000	30.3	43.6	18.8	32.9	4.7
10001-20000	28.0	25.9	33.3	27.3	13.4
20001-50000	23.3	11.7	32.7	21.6	33.9
≥50001	7.8	10.0	28.3	11.7	50.0
Employment					
Father is unemployed	27.0	45.2	26.8	21.5	3.4
Father is self-employed	50.7	29.4	31.7	23.0	15.9
Father is employed	22.3	15.1	11.0	40.4	36.6
Mother is unemployed	81.3	31.9	23.6	15.8	28.7
Mother is self-employed	8.6	37.9	22.7	13.6	25.8
Mother is employed	10.1	12.8	38.5	30.8	17.9
Built Environment					
Major road present (absent)	79.8 (20.2)	22.3 (62.8)	25.5 (23.1)	32.0 (9.0)	20.2 (5.1)
Likelihood of choosing IPT					
Changing of IPT or total walking distance > 0.8 km or distance by actual mode < distance by IPT or IPT is not available (Not Applicable)	55.6 (44.4)	35.4 (24.3)	28.9 (20.2)	11.7 (47.1)	24.0 (8.5)

7.3 Estimated Multinomial Logit Model and Results of Estimation

Table 6: Estimated beta values of the MNL model

Variable	IPT	Two Wheeler	Van share
Alternative specific constant	-6.861*** (1.067)	-5.144*** (1.297)	-10.684***(1.528)
Distance in km	2.300 *** (0.214)	2.110 *** (0.213)	2.495*** (0.219)
Travel Time (in minutes)			
1. ≤10 minutes	Base category	-	-
2. 10-15 minutes	0.941 (0.677)	-0.629 (0.387)	1.969[a] (1.116)
3. 15-20 minutes	0.256 (0.697)	-1.998*** (0.463)	0.639 (1.131)
4. > 20 minutes	-0.143 (0.717)	-3.526*** (0.529)	0.544 (1.148)
Demographic			
Age in years	-0.001 (0.053)	-0.201*** (0.048)	-0.194** (0.064)
Gender			
1. Male	Base category	-	-
2. Female	0.395 (0.292)	0.305 (0.275)	0.088 (0.352)
Socioeconomic			
Household income group (in ₹ per month)			
1. ≤5000	Base category	-	-
2. 5001-10000	0.813[a] (0.463)	3.087** (1.099)	1.681(1.147)
3. 10001-20000	1.252* (0.499)	3.940*** (1.103)	2.777* (1.146)
4. 20001-50000	1.579**(0.578)	4.337***(1.132)	4.178***(1.167)
5. ≥50001	1.271(0.907)	4.609***(1.270)	4.232**(1.338)
Employment			
Father is unemployed	Base category	-	-
Father is self-employed	0.165 (0.335)	1.129** (0.354)	1.616** (0.563)
Father is employed	0.360 (0.459)	0.912* (0.464)	2.157*** (0.645)
Mother is unemployed	Base category	-	-
Mother is self-employed	0.500 (0.480)	0.289 (0.446)	0.530 (0.623)
Mother is employed	0.008 (0.594)	0.895[a] (0.530)	0.882 (0.624)
Built Environment			
Major road present (No=0, Yes=1)	1.559***(0.418)	0.795*(0.325)	1.633**(0.583)
Likelihood of choosing IPT			
Changing of IPT or total walking distance > 0.8 km or distance by actual mode < distance by IPT or IPT is not available	-2.304***(0.324)	-0.124 (0.288)	-0.364 (0.383)

Note: Walking is reference alternative; Standard error in parenthesis.

    1USD = 74.14 ₹ (as of June, 2021)

    Major road present within 300 m of a school

'***' $p < 0.001$

'**' $p < 0.01$

'*' $p < 0.05$

'a' $P < 0.1$

The MNL Model is estimated for four alternatives viz. walking, intermediate public transport (IPT), two-wheeler (accompanied by parents) and van-share (accompanied by a familiar driver). Walking was taken as the reference alternative. Coefficients for distance are positive and significant for IPT, two-wheeler and van-share at 99.9% significance level. The results, as expected, indicated that increase in distance between home and school, increases the odds of traveling by faster modes. Notably, the odds of choosing van-share is the highest, followed by IPT, which is higher in comparison to two-wheeler for longer home to school distances. This could also be interpreted as students from areas outside the Jorhat municipality area typically choose schools in the municipality area if they have access to IPT or van-share. Because, IPT and Van-share are the most common modes of school trips available for students from distant places in Jorhat, this result is logical.

The perceived travel time from home to school revealed by the students show strong association with two-wheeler. The lowest travel time i.e. ≤ 10 minutes has been taken as the base category. The coefficients of two higher time categories for two-wheeler mode are negative and can be interpreted that as the time taken from home to school is more than 15 minutes likelihood of using two-wheeler decreases. Time did not show any significant association with other two modes.

Demographic variables are important attributes for travel mode choice. The results of the model shows that coefficient of age is negative for both two wheeler and van-share. This can be interpreted as, when the age of student decreases odds of choosing two-wheeler and van-share increases. This result seems to be logical because the parents of younger students are likely to be more skeptical to send their students independently and more comfortable when parents accompany their child to school on two wheelers or send them in van-share along with other children. Age did not show any significant association with IPT, potentially students of all age groups use IPT.

Interestingly, the other demographic variable gender did not show any significant association with any of the modes.

The most significant socioeconomic attribute is the household income. Here, the reference category was taken as the lowest income groups with monthly household income less than ₹5000. The results show that as the monthly household income increases the odds of using two-wheeler and van-share increases. However, the coefficients of IPT mode is not significant for the higher income group (≥50001 rupees). The effects are more prominent for two wheeler and

van share modes. The coefficient of van share mode is not significant for lower income groups. It can be interpreted that for students belonging to higher income group households the odds of choosing van share and two-wheeler as the mode to school is higher. These results signifies that parents those who can afford and have higher income usually prefers two-wheeler accompanied by parents or van-share accompanied by a familiar driver for their children's school trips as these two modes are believed to be the safest and most reliable modes among all.

The effect of another socioeconomic variable parent's employment on student's mode choice is also checked. The results shows that effect of a self-employed as opposed to being unemployed is significant at 99% significance level for two-wheeler and van-share choices. The results seem logical because a self-employed father can manage time to accompany their children to schools on two-wheelers. The results also shows that for an employed father as opposed to being unemployed van share is significant at 99.99% significance level. This is because an employed father who can afford van-share prefers this mode for their child as this is time saving, efficient and reliable. If a mother is employed, as opposed to being unemployed the likelihood of a child walking to school decreases and choice of two-wheeler increases. Mother's employment did not show any significant association with other modes.

A significant result found by this study is the likelihood of choosing IPT in school trips. The results shows that the coefficient of the logic mentioned is negative and significant at 99.99% significance level for IPT. This means that the probability of selecting IPT by a student to school decreases if the student has to change IPT between the trips or if the combined access and egress distance is more than 800 meters or distance by IPT compared to other modes is more or there is no availability of IPT en route to school.

The binary variable presence of "major road" appears significant. Here presence of a major road indicated the presence of state highway or a major district or arterial road within 300 m of the school. Coefficients of this variable are significant for IPT, two-wheeler and van-share at 99.99%, 95% and 99% confidence levels respectively. A major road passing by the neighbourhood of schools decreases the likelihood of walking against use of IPT, two-wheeler or van-share for the school trips.

7.4 Elasticity Analysis

Sensitivity analysis refers to the degree of change of the final predicted result, while an influencing factor has changed in the model, which can be used not only to understand the interaction between travel mode choices and influencing factors, but also can evaluate qualitatively and quantitatively the impact on the model result when variables change in the model.

7.4.1 Variation of choice probability with respect to distance
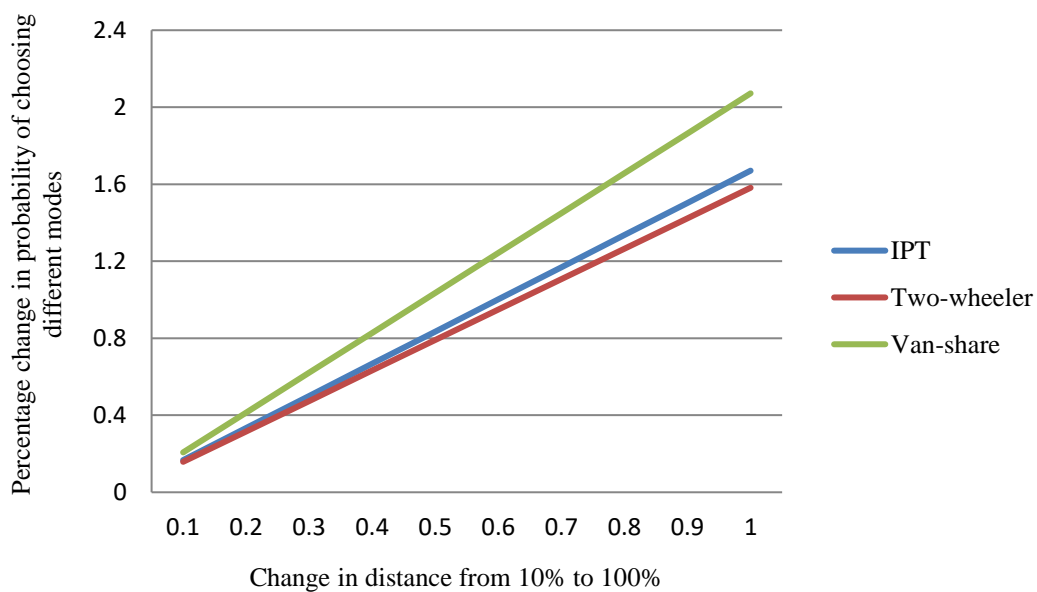

Figure 26: Variation in choice probability corresponding to various modes with distance

From the figure (Figure: 26) it can be seen that the probability of all the modes viz. IPT, Two-wheeler, Van-share increases with increase in distance. So, it can be interpreted that as the distance from home to school increases the probability of using motorized modes increases. The figure shows that the slope of the line for Two-wheeler is lesser as compared to the other modes. This indicates that as the distance increases student more preferred to use the modes such as IPT and Van-share as compared to Two-wheeler. The probability of choosing Van-share is more compared to other two modes indicating that with higher trip length to school student more tend to use Van-share as a mode. This interpretation is true because the parents preferred the safer mode for their child for longer distances of travel.

7.4.2 Variation of choice probability with respect to travel time

The variation of choice probability of two-wheeler with respect to total travel time from home to school has been shown in Figure: 27. It can be observed from the results that the slope of the

two lines are decreasing for both the time groups i.e. 15-20 minutes and >20 minutes. Thus, the results reveal that as the time from home to school increases the likelihood of using two-wheeler in school trips reduces.
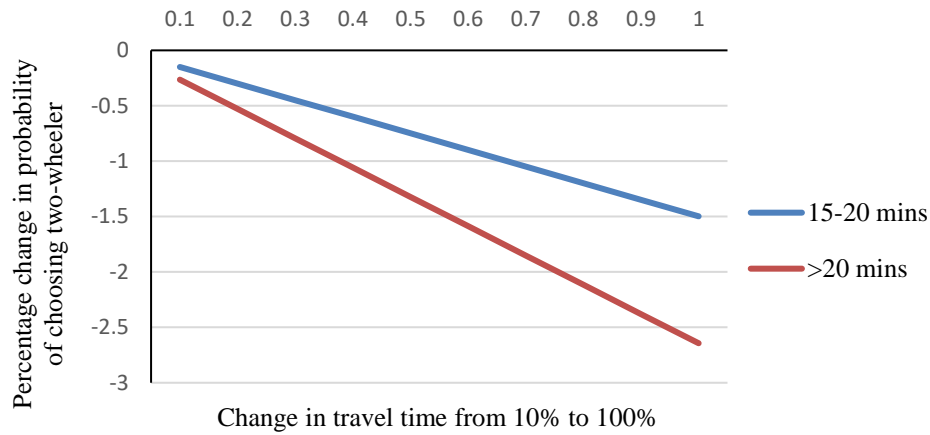
Figure 27: Variation in choice probability corresponding to two-wheeler with travel time

7.4.3 Variation of choice probability with respect to age

The choice probability variation with respect to age of student (Figure: 28) indicates that the odds of choosing two-wheeler and van-share decreases as the age of student increases. This interpretation is logical because parents of younger children are more skeptical about the safety of their child compared to teenagers. Thus, it is obvious for parents to choose safer modes like two-wheeler or van-share in school trips for students of lower age groups.

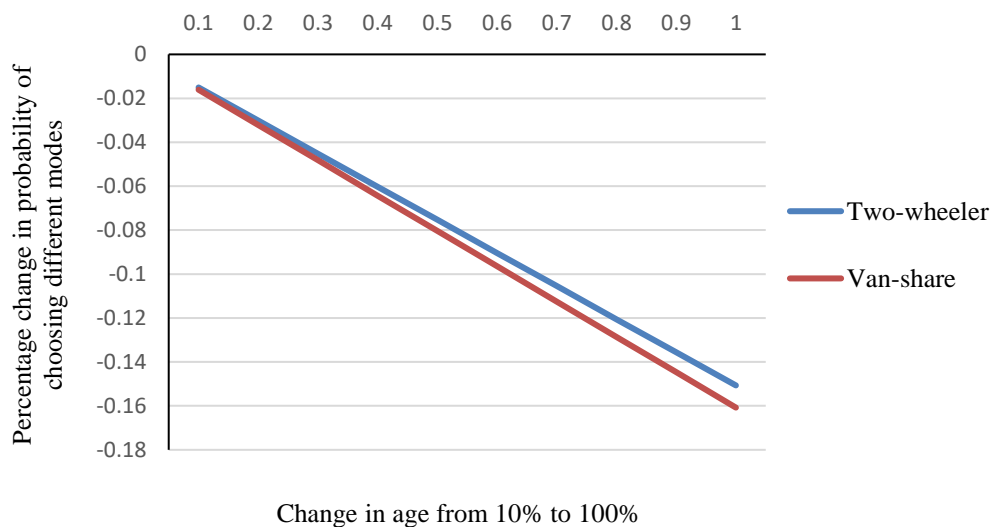**Figure 28: Variation in choice probability corresponding to various modes with distance**

31

7.4.4 Variation of choice probability with respect to Income

Income Range ₹ 5001-10000

Income Range ₹ 10001-20000

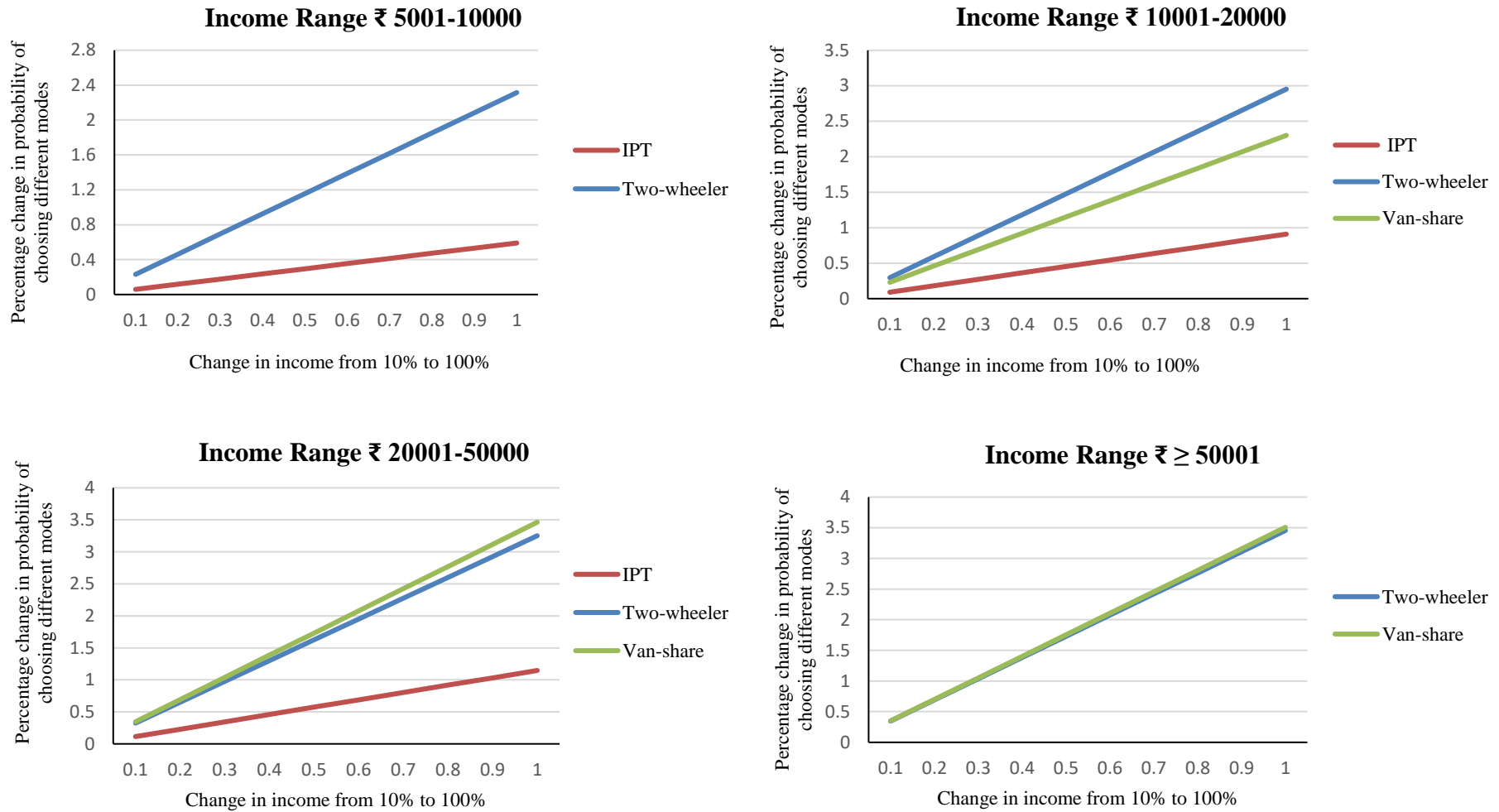### Income Range ₹ 20001-50000

Income Range ₹ ≥ 50001

Figure 29: Variation in choice probability corresponding to various modes with different income groups

Figure: 29 shows the variation of choice probabilities of different modes viz. intermediate public transport (IPT), two-wheeler (accompanied by parents) and van-share with respect different income groups. The analysis shows that the choice probability of two-wheeler as a mode to school increases with increase in income for all the households belonging to different income groups i.e. ₹ 5001-10000, ₹ 10001-20000, ₹ 20001-50000 and ₹ ≥50001. Similarly the probability of students choosing van-share as a mode increases with increase in income for the three income groups, ₹ 10001-20000, ₹ 20001-50000 and ₹ ≥50001. This result is logical because the van-share is mostly available to students from private schools rather than the government schools in Jorhat and thus only the students belonging to middle to higher income households can afford to choose van-share as a mode to school. On the other hand, the choice probability of IPT increases as the monthly household income increases for the three lower to middle-income groups. It can be observed from the figure that the choice probability of van-share is higher with respect to increase in household income as compared to the other modes for two higher income groups' viz. ₹ 20001-50000 and ₹ ≥50001. Likewise, the probability of choosing IPT with respect to increase in household income as compared to the other modes for three lower to middle-income groups' is the lowest. This may be because of the fact the in the study area, the students who choose IPT as a mode to school are mostly from lower to middle income group households and prefers government schools for their education.

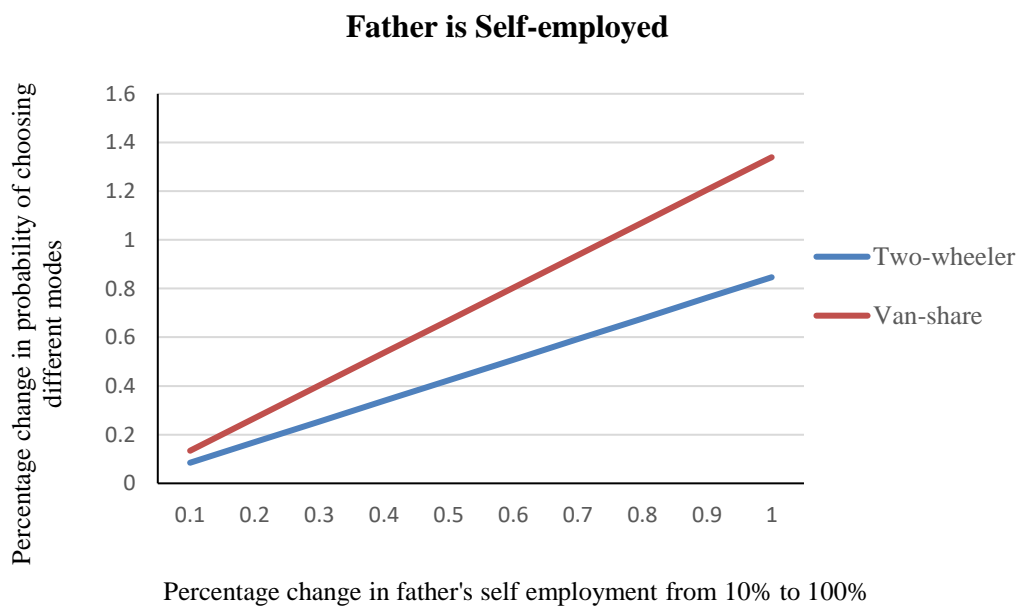## 7.4.5 Variation of choice probability with respect to Father's Employment

Father is Self-employed

Figure 30: Variation in choice probability corresponding to various modes with father's self-employment
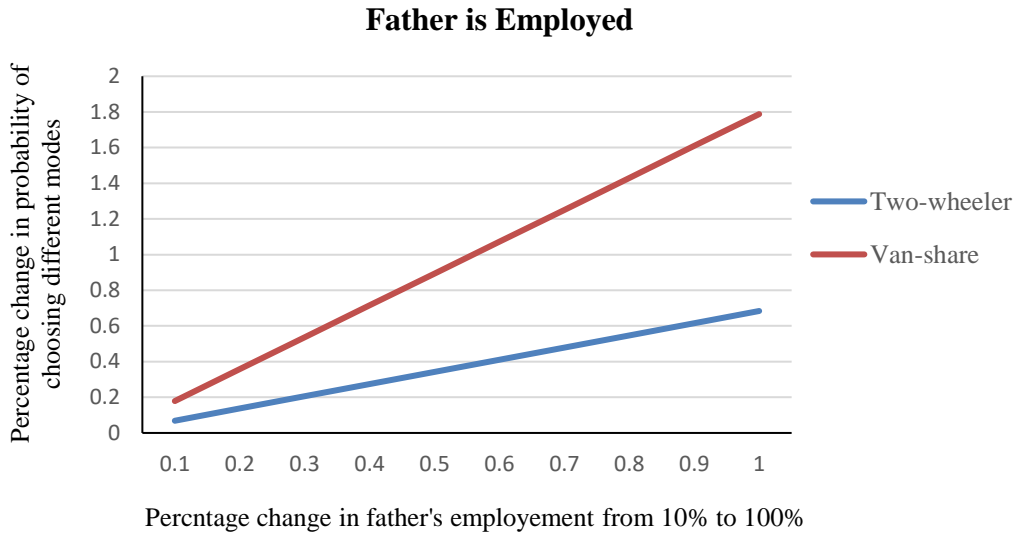
Father is Employed

Figure 31: Variation in choice probability corresponding to various modes with father's employment

The Employment of father is another variable that affects the choice probability of student's mode to school. If the chances of father being self-employed increases as opposed to being unemployed the odds of using two-wheeler and van-share both increases (Figure: 30). Correspondingly, the choice probability of both two-wheeler and van-share also increases as the chances of father being employed increases (Figure: 31). It can be noted that, in case of an employed father the effect is more in van-share as compared to two-wheeler. This may be because of the fact that, as van-share is more affordable to an employed father, the effect is more prominent.

7.4.6 Variation of choice probability with respect to presence of a major road

Figure 32: Variation in choice probability corresponding to various modes with presence of major road
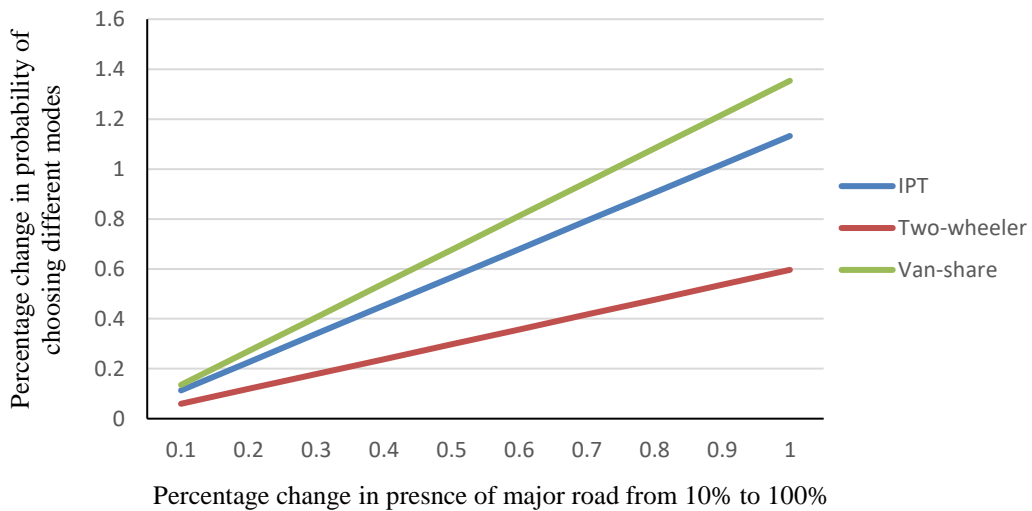
Figure: 32 shows the variation of choice probability of different modes with respect to presence of a major road (presence of state highway or a major district or arterial road) within 300 meter of a school. For all the modes, the slope is positive and thus it can be interpreted that the odds of choosing other modes increases as compared to walking for school trips if the chances of presence of a major road increases. In addition, the change is highest for van share and thus it reveals that likelihood of choosing safer and reliable mode is more in contrast of walking.

The results from the above analyses shows that with increase in distance as well as monthly household income increases the probability of choosing IPT, two-wheeler and van-share as a mode in school trips. Because of a verity factors, including lack of proper road infrastructure, poor law enforcement and lack of lane discipline, roads in India pose serious traffic risk, especially for children. In addition, people belonging to middle and low-income groups are hugely dependent on motorized two-wheelers (also shown in the analysis) for everyday commuting, which escalates the situation more and increase the overall traffic risks of road users and more specifically school going students. These poor conditions contribute to high road traffic injuries among adolescents (Debata et al., 2014; Hyder et al., 2006). Thus, the improvement of road infrastructure is utmost necessary to prevent traffic risk for school students in developing countries like India now a day. Moreover, the presence of a major road within 300 meter of a school decreases the odds of walking to school. Thus, the proper pedestrian infrastructure is utmost necessary in the vicinity of a school to increase the use of active modes between students in school trips.

8 Conclusions

From the preliminary data analysis and estimated MNL model shown in the above sections, it can be observed that there are different variables that affect the overall mode choice behaviour of students. These effects are different for different variables. In the trip characteristics variable category, the analysis shows that trip length is the most significant variable as reported by almost all the previous studies. It has a negative correlation with walking i.e. as the trip length increases the percentage of walking decreases. On the other hand, the vanpool is preferred generally when the trip length is large. Two-wheeler is a preferred mode of trip when the trip length is intermediate.

Student characteristics like age and gender are the most significant variables as observed in the previous literatures. The previous studies found that there is a positive relationship between age and active mode of travel and the same has been found true for public transport by some studies. The analysis of the data collected in Jorhat shows that the possibility of walking increases with increase in age. Similarly, there is a positive relationship between age and using IPT as travel mode. Conversely, two-wheeler has a negative relationship with age. It can also be interpreted that as the age increases parental escort decreases and student's independent travel increases. Gender is also an important variable, although the results of different studies are varied. However, the analysis in this study has not found any significant association of gender with any of the modes. Preliminary analysis reflects that female students have higher mode share in walking, IPT and vanpool but the difference is very little. Also, it can be observed that even in the age group of =>13 years, female students tend to be more escorted by parents than male students and male students have higher tendency of travelling independently.

Another primary variable category is household characteristics and household income is one of the most significant factors that have huge impact while making mode choice decisions. Various studies have revealed that children from status household have lesser tendency to use public transport and less likely to use active modes. The analysis shows that as the income increases the possibility of using vanpool increases when students belong to high-income households. Middle-income group households generally prefer two-wheeler in school trips. Father's employment is also an important covariate of household characteristics. This study found that if father is self-employed or employed, the odds of walking to school decreases. In

addition, two-wheeler is mostly preferred by a student if father self-employed. Another useful result is that, private schools are mostly preferred by middle to high-income households, while government schools are preferred by middle to low income households.

Among the built environment characteristics, it has been observed that presence of a major road within 300 meter of a school decreases tendency of walking and increases the use of other modes. The preliminary analysis reveals that if sidewalk is present on the way to school student preferably walks. However, this result is vague as most of the roads considered in this study does not have sidewalk or in very poor condition.

This study primarily focused on collecting data of various attributes of influential variable categories such as student characteristics, socio-economic and demographic characteristics of household, trip characteristics and to analyse the effects of these variables on mode choice of school children. The primary influential attributes found by past researches usually seen to have a similar and significant effect on mode choice pattern of a student apart from a few variables. The mode choice analysis of this study will aid in policy recommendations to improve the use of active modes and road safety of students in school trips.

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