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Development of Trip Generation Model of Bharatpur Metropolitan City

by

Santosh Khadka

A THESIS

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The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis report entitled **"Development of Trip Generation Model of Bharatpur Metropolitan City"** submitted by Santosh Khadka in partial fulfillment of the requirements for the degree of Master in Science in Transportation Engineering.

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ABSTRACT

Trip generation model, first step of four stage travel modelling in transportation system, is useful in predicting total number of trips generated and attracted to each zone based on household data and socio-economic attributes. Main objective of this study is to develop home based trip production model for Bharatpur Metropolitan City (BMC). Multiple linear regression analysis was used with the help of SPSS (Statistical Package of Social Science) to develop a trip production models for different trip purposes. Trip based approach was used in which household interview surveys were done to collect socio-economic as well as other home based trip related data. In this study, different trip generation models such as work trip model, shopping trip model, business trip model, educational trip model and leisure trip model were developed and their validation was checked by using chi-square test. The major conclusions obtained from this study are:

Work trip is dominantly affected by number of employees in the house along with other parameters such as number of bicycles, number of four wheelers and low income. House having more number of females, more four wheelers and high income produces more shopping trips whereas greater distance to central business district from house have tendency to reduce shopping trips. Business trip production is influenced by number of own account workers, high income and occupation of main member as own account worker whereas educational trip is largely dependent on the number of students present in the house. Increase in number of family members results more leisure trip from the house. House having greater number of members of age 18 to 60 and greater than 60 year results more leisure trip.

Total trip generation is affected by number of family members, number of bicycles, number of two wheelers, number of four wheelers, distance to central business district, number of members of age 18 to 60, number of employees, number of students, number of own account workers and high monthly family income.

Outcome of this study is useful for making various decision in planning level of BMC for systematic and planned development of transport related infrastructure in near future.

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LIST OF ABBREVIATION

BMC	:	Bharatpur Metropolitan City
CBD	:	Central Business District
HH	:	Household
HB	:	Home Based
NHB	:	Non Home Based
FSTM	:	Four Stage Travel Modelling
TGM	:	Trip Generation Model
MLRA	:	Multiple Linear Regression Analysis
SPSS	:	Statistical Package of Social Science
DoTM	:	Department of Transport Management

CHAPTER 1. INTRODUCTION

1.1 Background

Transportation is considered as the vein and arterial for the flow of the economy of the nation (Abdullah, et al. 2013). Systematic transportation infrastructure development is one of basic and important need for the general development of the country as well as for the economic development of the country. In our country, the goal of industrial development can be achieved through an efficient transportation system. So, there is necessity of better and improved planning in the transport sector.

There are many cities in Nepal which are in developing phase. But these developing cities lack proper systematic rigid basis or model for transport sector in planning phase as well as in development phase. So, their development is proceeding in haphazard way which may cause serious problem in near future to accommodate increasing traffic and transport infrastructure related development. Among various cities, Bharatpur Metropolitan City (BMC) is the one which is the major city having large economic activities as well as rapidly developing city on vehicle number increment and traffic flow scenario basis.

The average growth rate of vehicle registered in the Narayani zone is 22.72% per year in the last five years record from B.S. 2070/71 to B.S. 2074/75 (Department of Transport Management 2019). Total population of Bharatpur Metropolitan City (BMC) is 2, 80,502 and population growth rate of Chitwan is 2.06 % per annum according to last census 2011 (Bharatpur Metropolitan City 2015). With this data, population of BMC in coming future will be too large for existing transportation system and the increasing trend of vehicle registered data for last 5 years in Narayani Zone shows that in near future number of vehicles use in BMC is too high for the existing transportation infrastructure facility. With this rapid increase in population and vehicle numbers, in near future, existing transport system is not effective and it becomes insufficient to accommodate future traffic flow demand. Development in transport sector is in primitive phase in BMC, so it is possible to develop transport sector of Bharatpur in a systematic and improved pattern.

For systematic development according to traffic demand and requirement, Four Stage Travel Modelling (FSTM) is necessary. Trip Generation Model (TGM) is the first stage of classical transport demand model i.e. FSTM (Hensher and Button 2007) and it is the tool that suggest planner about the present and future traffic flow demand. It also provides the clear vision on the traffic flow direction and pattern based on various household characteristics. TGM gives the clear idea on which method and strategy is effective and economical in transport sector planning and development.

Trip generation involves the estimation of the total number of trips entering or leaving a certain area per time period as a function of the socioeconomic, locational, and land-use characteristics of that area (Sarsam 2011). Trip generation is determined based on the vehicle ownership, employment, income, household characteristics etc. of the zone (Mathew and Rao 2007).

Trip generation is affected by various factors. The main factors affecting personal trip production include income, vehicle ownership, Household (HH) structure and family size while the factors like residential density, value of land and accessibility are also considered for modelling at zonal levels (Mathew and Rao 2007)

Study related to trip generation is major component for developing transport sector. Result or outcome of such study gives the planner idea about the tool or strategies to adopt for the better development of the transport sector. Despite being various studies conducted on international level, results are not directly suitable or useful for our context due to the fact that this study gives different results for different socioeconomic criteria, different geographic criteria, different human activities criteria etc. Studies related to trip generation are conducted in very few numbers in our country and cities. Bharatpur Metropolitan city (BMC) also lack this type of study which directly impact on making difficulty in developing rigid model and plan for transport sector development. Thus this research study is necessary for BMC.

1.2 Statement of Problem

Study on trip generation is one of the important study for developing the present and future transport infrastructure to accommodate present and future traffic flow demands. Various studies related to this field was carried out in an international level. Different results are obtained at different countries and different study areas. So these results are

not directly suitable and applicable for our country and cities due to the socio-economic differences, cultural differences, geographic differences, differences in human nature and habits, differences in life standards etc. Bharatpur Metropolitan City (BMC) is one of the major city of Nepal which is rapidly developing. BMC has many potential to develop as a most advanced and facilitated city of Nepal. But proper planning and clear vision is required. Population growth rate and number of vehicle growth is increasing rapidly. Without proper planning this increment may create havoc in the development process of city in near future. So, to address this problem, sufficient and necessary study is required to develop the basic tool or model which guide the transport infrastructure development in the present and in near future also. It is necessary to develop various transportation infrastructure in systematic and planned way to make the proper development of the city. But this city also lack study on trip generation model which is the first and major step of Four Stage Travel Modelling (FSTM). Due to this lacking there are no any proper and rigid model or tool that direct how and in which strategies transport infrastructures would be planned and developed in the city. Travel demand forecasting is the major and primary task for transport infrastructure development which is the major lacking in the BMC. City does not have rigid model to develop transport infrastructure. This lacking suggest that city does not have proper transport planning to serve the future increasing transport demand. Hence, FSTM must be done in BMC which starts with trip generation modelling.

1.3 Objective of Study

This trip generation study has the following objectives:

- To determine the parameters that significantly influence on the household trip generation for different trip purposes, i.e. for work, shopping, business, education and leisure, of the study area of Bharatpur Metropolitan City (BMC).
- To develop total trip model and to determine the significant parameters that affect the total trip production from the house.
- To develop the various home based trip production models, i.e. work trip model, shopping trip model, business trip model, educational trip model and leisure trip model, for the study area of Bharatpur metropolitan city on trip based approach using household interview survey data by multiple linear regression analysis (MLRA) technique.

1.4 Limitation of Study

For achieving the objective of developing the trip generation model for this research study, required tasks were performed carefully and stepwise within the requirement of this research study. Even getting the satisfactory results from this study, certain limitation are associated with this study as follows:

- In this research, for trip generation study only 14 wards out of 29 wards of the Bharatpur Metropolitan City comprises as the study zone due to the fact that these wards forms the core populated area around the central business district (Chaubiskoti) within Bharatpur Metropolitan City (BMC) and data obtained from this zone provides the better realistic trip model for BMC.
- This research study mainly focuses on home based trip production from selected study zone.
- In this research, impact of public transport availability on home based trip generation is not studied in depth.

1.5 Thesis Organization

This thesis study is organized into five main chapters. First chapter provides introduction on the study subject matter which includes background, statement of the problem, objective of the study and its limitation. Second chapter summarizes the literature review related with trip generation study. Third chapter discusses about the adopted methodology for the conduction of this research study. Fourth chapter includes the analysis of collected data and discusses the results obtained from the analysis and their statistical verification. Chapter five gives the conclusions on this research study and also provides the recommendations for future works.

CHAPTER 2. LITERATURE REVIEW

2.1 Trip generation

Transport infrastructure development is major parameter to suggest the development level of the city. To achieve the goal of development of city or country, systematic and planned development of the transport infrastructure of the city or country is required. Before this transportation demand forecasting is necessary for better transport planning of the city. Hensher and Button suggested in his publication about the four step travel demand modelling which includes trip generation, trip distribution, mode choice and network assignment (Hensher and Button 2007). This type of study or modelling is not in proper level for transport planning in our context.

Trip generation is the first stage of the classical first generation aggregate demand models which provides the idea about the total number of trips produced and attracted to each zone of the study area i.e. this stage answers the questions to "How many trips" originate at each zone, from the data on household (HH) and socio-economic attributes (Mathew and Rao 2007)

The objective of trip generation is to estimate the number of trips originated in each zone within the study area, which it is usually correlated to the socioeconomic characteristics of the resident population in that zone (Ortuzar and Willumsen 2011)

Generally trips are home based trips and non-home based trips. Therefore the trip generation is the sum of the home based trips and non-home based trips. Since, 95% of the resident trips are home based, the socio-economic variables used to adjust generation models are closely related to the population in the transport zones and the characteristics of the households (Amavi, et al. 2014)

Trip generation is represented by the question "How many person trips?" and generally the output that would be obtained from trip generation is used to predict the number of trips originating in or destined for a given traffic analysis zone (Aloc and Amar 2013)

2.2 Some Definitions

Definition of some useful terminologies for this research study are as follows:

Trip or Journey:-One-way movement from a point of origin to a point of destination is known as trip or journey (Ortuzar and Willumsen 2011).

Home Based Trips:-This is the trip where home of the trip maker is either origin or destination of the trip (Ortuzar and Willumsen 2011).

Non Home Based Trips:-Trips where neither end of the trip is the home of the trip maker, is known as non-home based trips (Ortuzar and Willumsen 2011).

Trip Production:-Trip production is defined as the home end of a HB trip or as the origin of an NHB trip (Ortuzar and Willumsen 2011).

Trip Attraction:-Trip attraction is defined as non-home end of an HB trip or the destination of NHB trip (Ortuzar and Willumsen 2011).

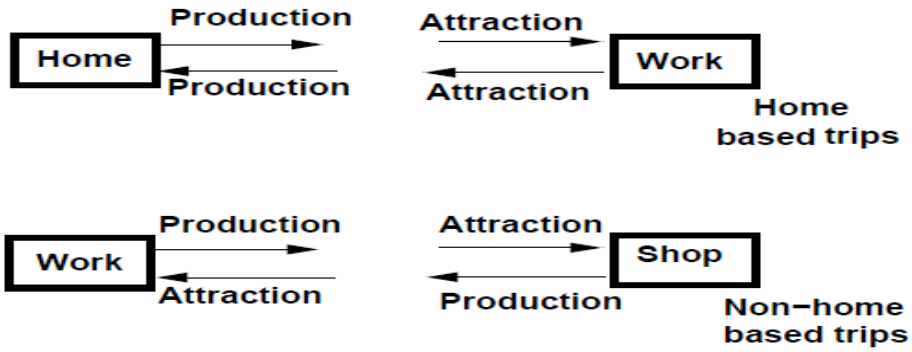

Figure 2.1 Home-based and Non-home based Trip Production and Attraction

Trip Generation:-Trip generation is defined as total number of trips generated by HHs in a zone be they HB or NHB (Ortuzar and Willumsen 2011).

Sojourn:-It is a short period of stay in a particular location (Ortuzar and Willumsen 2011).

Activity:-It is an endeavor or interest often associated with a purpose as work, study, shopping, leisure etc. but not necessarily linked to a fixed location (Ortuzar and Willumsen 2011).

Tour or Trip Chain:-It is a set of linked sojourns and trips (Ortuzar and Willumsen 2011).

2.3 Trip Classification

Trip purpose, person type, trip time of the day are some basis for the trip classification. If separate models are developed based on the trip purpose then Trip Generation Models give the better Results. The trips can be classified based on the trip purpose as trips for work, trips for education, trips for shopping, trips for recreation and other trips. Work and education trips as mentioned above are often referred as mandatory trips and the rest as discretionary trips (Mathew and Rao 2007).

According to Ortuzar and Willumsen, generally trips are categorized based on the following three basis:

a) By Purpose

It has been found that a better understanding can be achieved if trip generation models are developed separately for different purposes of trip. In case of HB trips, trips may be categorized as work trip, education trip, shopping trip, social and recreational trip, escort trip and other trip. NHB trips are sometimes separated into 'on business' and 'other' but are often kept as a single category because they only amount to 15-20% of all total travel.

b) By Time of Day

On this basis, trips are sometimes classified into peak and off-peak period trips.

c) By Person Type

By person type classification is important classification as individual travel behavior is largely dependent on socioeconomic attributes. Based on by person type, following categories are generally employed;

- Income level (e.g.:- 3 strata: low, middle, high income)
- Car Ownership (typically 3 strata: 0,1 and 2 or more cars)
- HH size and structure (e.g.:- six strata in the classical British studies)

(Ortuzar and Willumsen 2011).

2.4 Factors Affecting Trip Generation

Factors like income, vehicle ownership, household (HH) structure and family size affects mainly on the personal trip production. In addition factors like value of land,

residential density and accessibility are also considered for modeling at zonal levels. Whereas factors like roofed space available for industrial, commercial and other services influenced on the personal trip attraction. In addition zonal employment and accessibility are also used at the zonal level (Mathew and Rao 2007).

Income, car ownership, family size, HH structure, value of land, residential density and accessibility are the factors that have been proposed for consideration in many practical studies while predicting personal trip production. Income, car ownership, HH structure and family size have been considered in several household trip generation studies, whereas for zonal level studies value of land and residential density have also been considered. Accessibility has rarely been used, the reason is that it offers a way to make trip generation elastic to changes in the transport system. For personal trip attraction, the most widely used factor has been roofed space available for industrial, commercial and other services (Ortuzar and Willumsen 2011).

Trip generation models are concerned with the estimation of the number of trips into and out of various traffic zones. This is based on the principle that land use generate trips, and that the number and type of "from home" trip is influenced by socioeconomic variables such as car ownership or availability, house-hold income and size, occupational status, household composition e.g. no of workers per household (Hobbs 1973).

2.5 Modelling Techniques

2.5.1 Growth Factor Modelling

In this modelling, models tries to predict the number of trips produced or attracted by a HH or zone as a linear function of explanatory variables. The basic equation of models:

$$T_i = f_i \, t_i \qquad (2.1)$$

Where, T_i and t_i is the number of future and current trips in that zone respectively and f_i is a growth factor.

The growth factor f_i depends on the explanatory variable such as population (P) of the zone, average HH income (I), average vehicle ownership (V). Then simplest form of f_i as follows:

$$f_i = (P_i^d * I_i^d * V_i^d) / (P_i^c * I_i^c * V_i^c) \qquad (2.2)$$

Where‘d’ denotes the design year, and 'c' denotes the current year (Mathew and Rao 2007).

2.5.2 Regression Modelling

General form of trip generation model is:

$$T_i = f(x_1, x_2, x_3 \ldots\ldots\ldots, x_i \ldots\ldots\ldots, x_k) \quad (2.3)$$

Where x_i s are prediction factor or explanatory variable.

The most common form of trip generation model is a linear function of the form

$$T_i = a_0 + a_1x_1 + a_2x_2 + \ldots\ldots\ldots + a_ix_i + \ldots\ldots\ldots + a_kx_k \quad (2.4)$$

Where, a_i s are the coefficient of the regression equation and can be obtained by doing regression analysis (Mathew and Rao 2007).

2.6 Previous Studies

Sufficient studies about the trip generations are lacking in our country and cities but various studies were done at various level regarding the trip generation around the world. Some of the previous studies about the trip generation are summarized below:

A study carried out in Kathmandu, Nepal , developed a trip generation model for each study zone for 22 zones inside the ring road, and concluded that study area trip generation is highly influenced by household size, numbers of students, income, numbers of vehicle ownership, numbers of employers, numbers of females, number of employees in household. From this study it was also concluded that mobility of medium class family is high as compared with low class and high class family, and mobility of family with vehicle ownership is higher than family having no vehicle. This study also resulted that average household trip rate of ring road area is 5.72 and average person trip rate is 2.10. He also suggested that trip generation model developed in his research study is appropriate for urban area like Kathmandu (Dhakal 2015).

A study carried out in Lipa City, Philippines, concluded that for regression analysis, population per zone, number of households per zone, workers per zone, students per zone and household head monthly income per zone are significant parameters for a particular zone to produce and attract trips (Aloc and Amar 2013).

A study on Bangladesh in 2017, suggested that among the different land use on Kaptai road, trip generated from commercial land use is predominant. This study also determined the trip rates of commercial land uses as weighted average rates of the shopping centers are 9.32 trips/1000 sq.ft./hr and banks are 14 trips/1000 sq.ft./hr (Rahaman, Hashi and Azom 2017).

A study carried out in Ciputat Baru and Graha Permai residential area, Researcher developed the best model that describe about the trip generation from this area. The developed best model is:

$$Y = 0.371 + 0.803 * X_1 + 0.818 * X_3 \quad (2.5)$$

With X_1 is the number of population in household (person), X_3 is vehicle ownership (unit) and R^2 value is 0.71. So, this study concluded that total of trip generation is influenced by the number of population in HH and vehicle ownership (Ayuningtyas n.d.).

A study carried out, in India, by Desai and Vala discussed about the characteristics of special generators that identify the trip generation from specific locations. This study discussed that standard trip generation module consisting sequential four step procedure (trip generation. trip distribution, route choice and route assignment) only cannot be capable to capture fully the trip generation of certain types of facilities such as military bases, universities, hospitals and major shopping centers, large industries etc. This study suggested that the special generators have very different characteristics and cannot be treated as regular employers. This study concluded that special trip generators clearly identified the number of trips generated from specific location and which may not be clearly notified by the ordinary four step traffic forecasting model used by the municipal corporation and any other agencies for the forecasting. This study also resulted that in population of approx. 1,96,000 of Morbi city, there is 9992 trips per a single day of Heavy Vehicles are enough to disturbed the easy flow of traffic in urban area which is designed by the ordinary four step traffic forecasting model (Desai and Vala 2017).

A study carried out in Budapest, Hungary shows that people of one-person households make more shopping trips and go out more often, and students have more trips to visit their friends or go out. This study also shows that among the non-active population

shopping trips are of prime importance, two third of their daily trips is devoted to that purpose (Berki and Monigl 2017).

Sarsam carried out a study to develop the model of household trip generation for selected zones at Al-Karkh side of Baghdad City. This study resulted that total persons trips/household are related to family size and structure variables such as number of person more than 6 year age, number of male, total number of workers, total number of students in the household, number of private vehicles. Also the results of this study shows that the home-based work trips are related to number of worker in the household, number of male workers in the household, number of female workers in the household and number of persons of (25-60) year age and Home-based education trips are strongly related to number of students in the household (Sarsam 2011).

A study carried out by Soni and Sughandhi, in India, concluded that urban areas in Indian cities are facing continuous high traffic growth and it is already known that it will grow with higher percentage in coming decades. There is urgent requirement of transport system study for future transport planning and forecasting specially at urban areas. There is an urgent need for significant improvements in the transport system including mass transport system keeping in view the long term requirements of the City. There is absence of scientific planning and implementation of scientific methods to forecast urban city traffic and transportation plans (Soni and Sughandhi 2017).

A research study carried by Sillaparcharn, in Thailand, proposed a series of vehicle ownership models for different vehicles category together with trip generation model. And he suggested that these models are important for decision making in trip frequency, trip distribution, modal choice and route choice (Sillaparcharn 2007).

A study was carried out in Seoul metropolitan area, South Korea, for comparative analysis of trip generation models. This study used home based work trips in the Seoul metropolitan area for comparative analysis of models. This study compares the performance of trip generation models. Mainly two approaches; regression analysis and category analysis have been considered in this study. In this study household travel daily data and Korea Regional Development Total Information System (REDIS) were used for modelling and six kinds of models were estimated and validated. The results of this study concluded that the category-type models are superior in overall performance (Chang, et al. 2014).

A study carried out in Maiduguri Metropolis researchers developed each regression models for vehicular trip generation for two study zones. The model developed for first zone was:

$$Y1 = 5.34 + 0.237NP1 – 0.0741\ AA1 – 0.000001\ IN1 – 0.0504\ AT1 \quad (2.6)$$

The R^2 value for the model was 0.583 that suggest the relationship is just a little high than the average.

The model developed for the second zone was:

$$Y2 = 3.64 + 0.138\ NP2 - 0.0482\ AA2 - 0.000001\ IN2 + 0.0088\ AT2 \quad (2.7)$$

R^2 value for this model was 0.241 that suggest the relationship is very low.

In above equation:
Y1 and Y2 = Total trips generated at a house in a day for first zone and second zone respectively
NP1 and NP2 = Number of person in the household for first and second zone respectively
AA1 and AA2 = Average Age for first and second zone respectively
IN1 and IN2 = Total income of the household for first and second zone respectively
AT1 and AT2 = Total time in minute for first and second zone respectively (Abdullah, et al. 2013).

A study carried out in Metropolitan Shiraz, Iran, in 2011 discussed about that socio-economic characteristics are most positive determinants of intra-zone trip generation. This study also revealed that distance from central business district (CBD) and distance from public transport facilities have negative relation with trip generation. However, this study concluded that physical factors like land use mix and network connectivity were found not important in affecting intra-zone trip generation, but suggested that exclusionary zoning and market forces have tended to segregate activities and lengthen trips, bringing origin and destinations closer together decreases daily travel activities. This study also suggested that better urban form would locate workplaces and activities linked as trip productions and attractions are as close together as possible (Soltani and Ivaki 2011).

A study carried out on four urban districts in Shiraz Metropolitan area, Iran, in 2012, concluded that there is a functional relationship between land use diversity and the volume of urban travel as either intra-zonal or extra-zonal. This study also suggested that an appropriate distribution of urban services can be useful in reducing extra-zonal trips leading to a considerable decline in traffic volume and provision of local facility may encourage residents to travel more. This study further discussed on association of trip generation with household type as households with adults make more external trips than those comprising children. In addition, owning a car increases the probability of making trips (Soltani, et al. 2012).

Masaeid and Fayyad conducted a study about trip generation from residential area of Ibrid city, Jordan, in 2018. This study concluded that number of residential trip generation was largely dependent on socio-economic variables like household size, household income and car ownership (R.Al-Masaeid and S.Fayyad 2018).

In a study that was carried out on capital of Alsharkia Government, Egypt, in 2019, the researcher developed a model for trip generation of resident persons for a study zone by making regression analysis. The developed model from this study was

$$T_R = 1.870*POP-2.957 \quad (2.8)$$

This model has R^2 value as 0.987.
This study shows that trip generation of resident persons of study zone is dependent only on population of the zone. This study also resulted that trip rates as 8.57 person trips per household and 1.86 person trip per person (Altaher, et al. 2019).

A study conducted on Akure Metropolis Ondo State, Nigeria, in 2012, reveals that the type of trips made by commuters in the area is significantly related to their socio economic characteristics including sex, income, education and occupation, most especially their occupation; as it principally accounts for most of the trips made by road users in the area (Awoyemi, et al. 2012).

Pettersson and Schmocker carried out a study about impact of older age in trip generation and tour complexity in Metro Manila. This study analyses the travel pattern by those aged 60 or over. Trip frequency and tour complexity are analyzed with ordered probit regression, separating the effects of sociodemographic characteristics as well as

land-use patterns. The results are compared to observations made for cities in developed countries, in particular London. This study showed that there is a more pronounced decrease in total trips made with increasing age in Manila. This study also resulted that after analyzing for specific trip purposes, the number of recreational trips is fairly constant in all age groups. This study also concluded that as people get older they will make shorter and less complex tours in general but more and longer recreational trips and as income increases, more trips will be made by car in Manila (Pettersson and Schmocker 2010).

CHAPTER 3. METHODOLOGY

This chapter described the methodology adopted to achieve the required objectives of the study. Figure 3.1 clearly shows the research methodology followed in this research study.

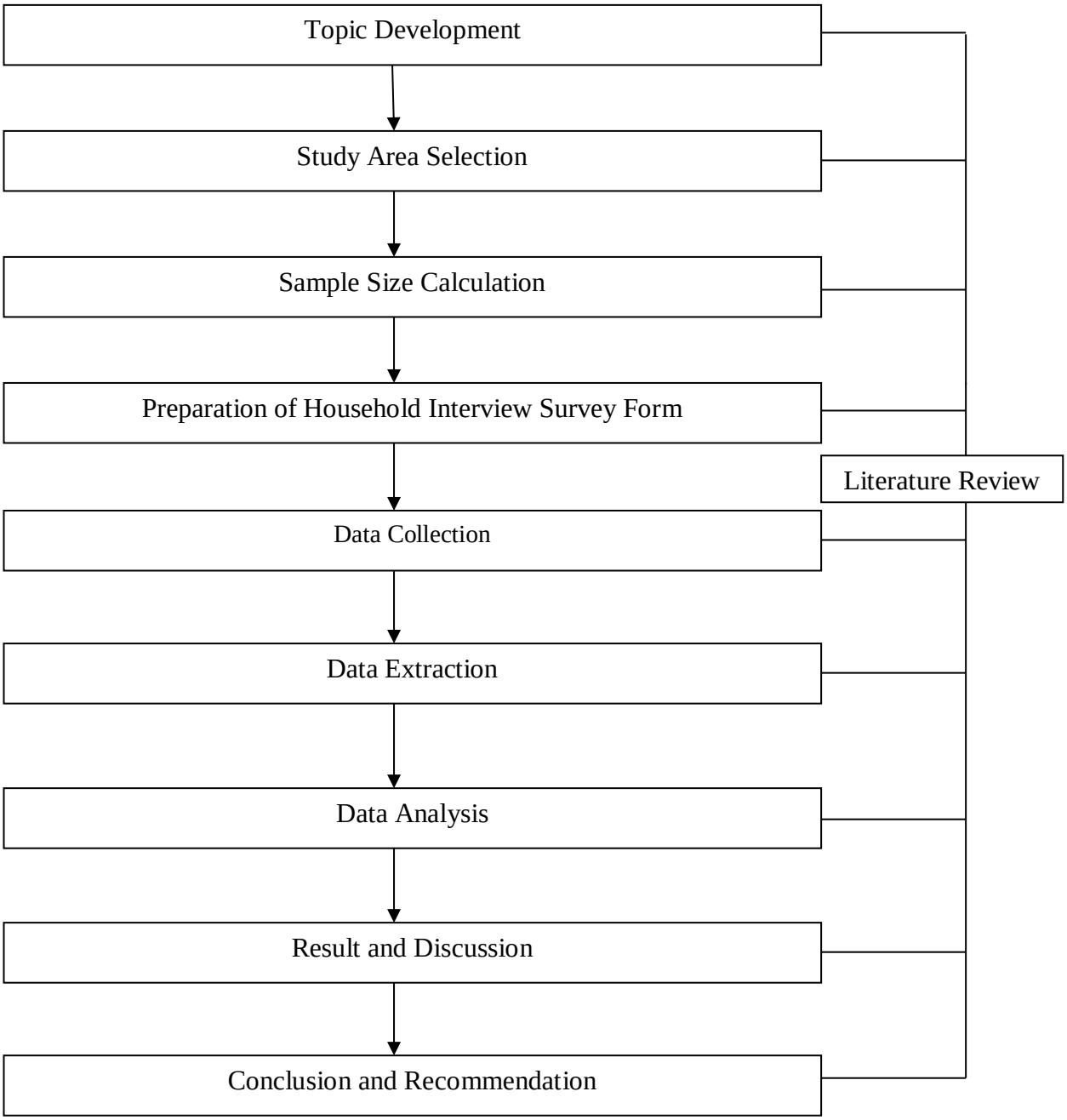

Figure 3.1 Flow Diagram of Methodology

Methodology includes the various steps or tasks which needs to carry out sequentially to meet the required objectives of the study. Methodology for this research study included the topic development, study area selection, sample size calculation, preparation of household interview survey form, data collection, data extraction, data analysis, result and discussion and finally conclusion and recommendation. Literature review is the important task in methodology which is carried throughout the entire research study.

3.1 Study Area Selection

Trip Generation Model (TGM) is one of the major study and step for the systematic and accurate travel demand forecasting. Bharatpur Metropolitan City (BMC) is the one which needs this type of research studies for systematic development of its transport sector.

BMC is one of the major and rapidly developing city of Nepal. BMC is located on the bank of Narayani River and it is the head quarter as well as commercial center of the Chitwan district. Bharatpur is established in 2035 B.S. which has been declared municipality in 2048 B.S. and later upgraded to Metropolitan City on March 10, 2017. East-West Highway is passes through this BMC and Central Business District (CBD) of this Metropolitan City is 146 km from Kathmandu, Capital City of Nepal. The Population of Bharatpur Metropolitan City according to last population census in 2011, is 2, 80,502; Women 1, 46,501 and Men 1, 34,001; Population Growth Rate is 2.06% per annum; Total household (HH) 69035; Literacy Rate 85.63% (Bharatpur Metropolitan City 2015)

BMC consists of 29 wards. Among these, only 14 wards (2,3,4,5,6,7,9,10,11,12,13,14,15 and 16) were selected as study area based on residential density and, distance and access time consideration to Central Business District (Chaubiskoti) because the regular daily trip from the wards to CBD is significant. This selected study area consists of total of about 1, 72,108 population and about 43,796 household according to the last census data of 2011. Study area for this research is clearly marked in the map given in Figure 3.2 (Bharatpur Metroploitan City 2015).

3.2 Sample Size Calculation

In this research study, data were collected by household (HH) interview survey. Determining the suitable sample size for household survey is the major task for the study as it is crucial for getting reasonable conclusions and reliable models without allocating excessive resources on data collection. The sample size for HH interview survey was computed using the equation (3.1).

$$n = \frac{CV^2 Z_\alpha{}^2}{E^2} \quad (3.1)$$

Where CV is the coefficient of variation, E is the level of accuracy (expressed as a proportion) and Z_α is the standard normal value for the confidence level (α) required (Smith 1979).

For this study CV was taken as a 1.0, sample size was calculated for 90 % confidence interval. So, value of Z_α was taken as 1.645 and E was taken as 0.10; hence the minimum required sample size for the study was calculated as near about 270.

The proportion of HH in each ward with respect to total number of HH in 14 wards was calculated. This proportion for each ward was multiplied with total sample size to calculate the sample size for each ward. After this, sample HH in a ward was selected on the basis of simple random sampling in which every 10^{th} house was selected as sample HH.

3.3 Preparation of Household Interview Survey Form

After sample size calculation, Household (HH) interview survey form was prepared to collect the required information to develop the Trip Generation Model of the selected study area. HH interview survey form consist three sections shown in Table 3.1.

HH interview survey form was typed in Nepali format for easy co-ordination with HH member during survey time in order to get required information from all category members. This form was developed in such a way that required information from the respondent extracted within the minimum possible time without getting bored. HH interview survey form accommodated all questionnaires in two pages which was printed in single paper in both sides. This results in reduction of numbers of papers handling as well as minimize the printing cost.

Table 3.1 Variables Selected For HH Interview Survey Form

Household Information	Individual Member Information of HH	Individual Member Trip Information
Number of member in HH, Number of Male, Number of Female, Vehicle ownership status, Family monthly income, Distance to CBD from HH, Type of road	Gender, Age, Occupation, Monthly income, Driving license status, Address of work place/school	Trip origin, Trip destination, Time, Trip purpose, Trip mode, Estimated cost of travel

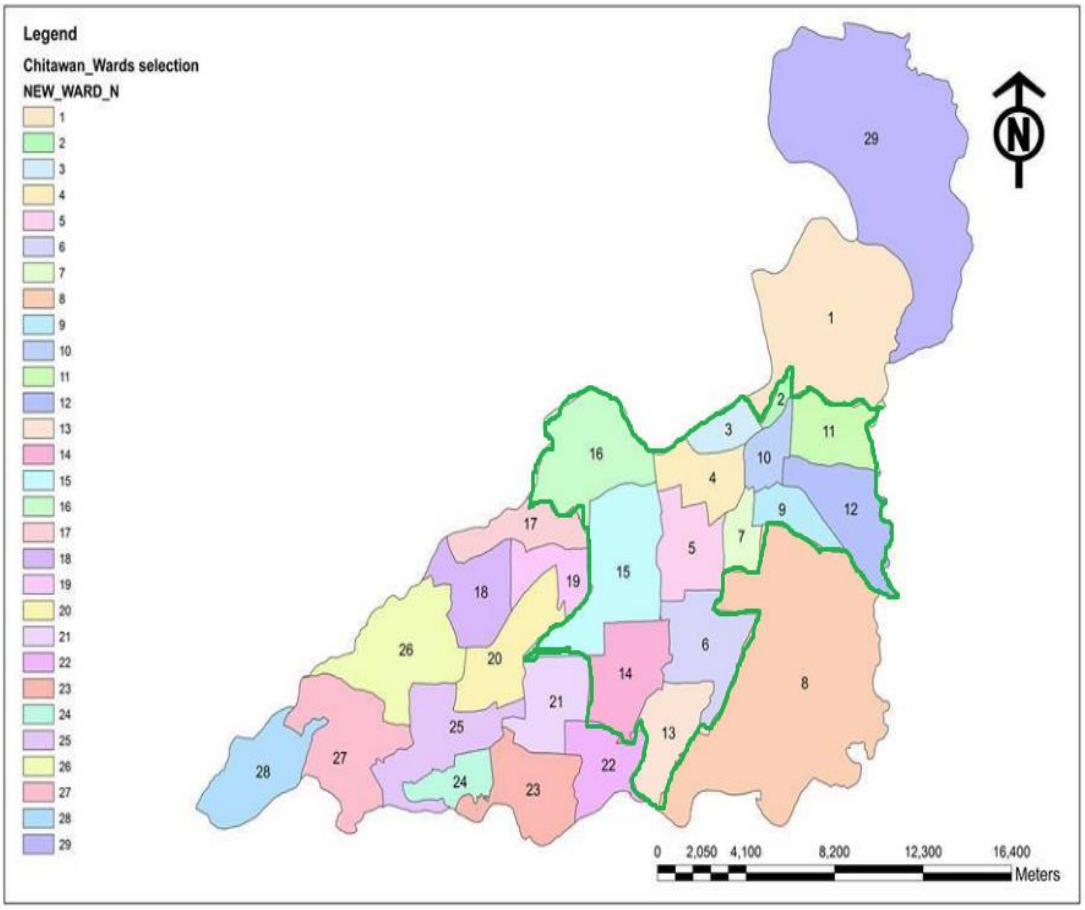

Figure 3.2 Map Showing the Boundary of BMC and Boundary of Selected Study Zone

3.4 Data Collection and Extraction

Household (HH) interview surveys were performed on the selected sample household to collect the data for the study. First boundary for the selected study area was clearly identified and sample houses were selected. Data were collected by visiting house to house for the selected sample house and the HH interview survey form was filled for each sample house in the presence of HH members. Data collection process for this study was lengthy for single person, so some diploma level students were informed about the study field and study purpose and then trained to collect data. With the help of these students 271 data were collected from 6 wards (2, 7, 9, 10, 11 and 12). Further 264 data were collected from remaining wards in the study area with active involvement of three persons. Normally HH surveys were conducted at morning time and evening time in order to contact all the members of the HH if possible. Total of 535 data were collected in selected study area which takes nearly a one and half month. The ward-wise collected numbers of data in the study area of Bharatpur Metropolitan City are presented in the Table 3.2.

Table 3.2 Number of Ward-wise Collected HH Survey Data

Ward Number	Number of collected data	Ward Number	Number of collected data
2	48	10	74
3	40	11	60
4	42	12	36
5	22	13	20
6	30	14	24
7	46	15	32
9	39	16	22

Here each individual HH was the each unit of data. These collected data then extracted on the excel sheet from the HH interview survey form which were later used for the analysis by SPSS for model development. Extraction of data on the Excel sheet nearly takes about two week for a person.

3.5 Data Analysis

Multilinear regression Analysis (MLRA) was adopted for development of trip production models. The resulting models, whose coefficient estimates were calibrated using method of least squares, present a linear relationship among dependent variables

and independent variables. Different category of variables selected for analysis is presented in following section:

- **Dependent Variable:** It included Home Based (HB) Trip Production. In this research study five dependent variables were used for developing different models based on the five different trip purposes i.e. Work Trip, Shopping Trip, Business Trip, Education Trip and Leisure Trip. Also total trip production from the household is calculated where Total Trip is Dependent variable.

- **Independent Variable:** It included 17 variables viz. Number of family members, Number of males, Numbers of females, Number of non-motorized vehicles, Number of two wheelers, Number of four wheelers, family monthly income (as low, middle and high), Distance to CBD from Home, Number of members having age less than 18, Number of members having age between 18 to 60, Number of members having age more than 60, Number of license holder members, Occupation of main member of household (as service, own account worker and unemployed), Number of employees, Number of students, Number of own account workers and Number of unemployed.

CHAPTER 4. ANALYSIS AND RESULT DISCUSSION

4.1 Variables Definition

4.1.1 Dependent Variables

Total_Trip: It includes the total number of travel generated from the individual house for any specific task or purpose, either by foot or by using vehicles, involving the family members residing on the house.

Work_Trip: It refers the total work trip generated from the individual house. Work trip includes trip generated only by regular commuters (workers) reaching their work place. Generally commuters have fixed schedule for their work trip. Trip to industry, private office, government office, grocery stores, hotels and restaurants, banks, workshop etc. by a person for completing their daily works constitutes work trips. Trip to schools, colleges and tuition centers by teacher also included in this trip heading. Trips, both by foot and using vehicles are included.

Shop_Trip: It refers the total shopping trip generated from the individual house. Shopping trip includes all short and long trips which involves trip maker buy something for their daily life purpose. This includes trip to buy something from nearest shop, hat bazar, nearest market, central business district, big market, super market etc. Trip by both foot and using vehicles included.

Business_Trip: It refers the total business trip generated from the individual house. Business trip involves all trip makes by businessman or business related person. This includes trip for business meeting, trip to own shop, trip to own office, trip related to benefit of own shop, own office/firm, trip related to business purpose, trip to market to sell the home made products and agricultural products, trip to buy the materials or goods for the development of business/local business, trip to buy the required materials for agricultural production work, trip to buy materials/goods for own shop, trip to dairy for selling milk products etc. Trip by both foot and using vehicles included.

Educational_Trip: It refers the total educational trip generated from individual house. Educational trip only includes trip to educational institutions for the academic study purpose by students like the trip to schools, tuition-centers and colleges by students. It

also includes trip to training centers by trainee. Trip by both foot and using vehicles included.

Leisure_Trip: It refers the total leisure trip generated from individual house. Leisure trip includes the trip making for refreshment. This includes the trip to watch movies, trip to spend time with family, trip to friend's house, trip to meet relatives, trip to having the dinner at hotel with family, trip to attend party, trip to temple, trip to religious place, trip to picnic trip to attend marriages or any other auspicious occasions etc. Trip by both foot and using vehicles included.

4.1.2 Independent Variables

Family_Members: It represents the total number of family members having age equal to more than 5 years currently present in the house. When number of family members increases, generally activities related to work, shopping, business, education and leisure increases. Thus work trip, shopping trip, business trip, educational trip and leisure trip produced from the house may increases. Thus the explanatory variable Family_Members may have the positive coefficient estimate on work trip model, shopping trip model, business trip model, education trip model and leisure trip model.

No_Male: It includes the total number of male members having age equal to or more than 5 years currently present in the house. Generally when number of male increases in the house, then more number of outings related to work, shopping, business, education and leisure may happen from the house. So, all the above trip i.e. work trip, shopping trip, business trip, educational trip and leisure trip production from house may increases. So, the variable No_Male may have the positive coefficient estimate on work trip model, shopping trip model, business trip model, education trip model and leisure trip model.

No_Female: It includes the total number of female members having age equal to or more than 5 years currently present in the house. Normally when number of female increases, then there may have more chances of increasing work, shopping, business, education and leisure related activities from the house. So, any of the above trip i.e. work trip, shopping trip, business trip, educational trip and leisure trip from the house may increases. Thus, the independent variable No_Female may have the positive coefficient estimate on work trip model, shopping trip model, business trip model, educational trip model and leisure trip model.

Non_Motorized: It includes total number of non-motorized vehicles i.e. bicycles available in the house which may be owned by a present members of house or provided by private/government office/firm or both. Generally, most of the houses in the study zone have the bicycles and they uses bicycles in their most of the short trips. Thus more the number of non-motorized vehicles i.e. bicycles available in the house, possibility of more will be the work trip, shopping trip, business trip, educational trip and leisure trip from houses. So, the variable Non_Motorized may have the positive coefficient estimate on work trip model, shopping trip model, business trip model, educational trip model and leisure trip model.

Two_Wheeler: It includes the total number of two wheeler i.e. motorcycles available in the house which may be owned by a present members of house or provided by private/government office/firm or both. More the number of two wheelers in the houses of study area people prefer to make more trips which may increases the number of work trip, shopping trip, business trip, educational trip and leisure trip. So, the variable Two_Wheeler may have the positive coefficient estimate on work trip model, shopping trip model, business trip model, education trip model and leisure trip model.

Four_Wheeler: It includes the total number of four wheeler i.e. taxi, van, car, jeep etc available in the house which may be owned by a present members of house or provided by private/government office/firm. Mostly the family or houses having strong economic status afford the four wheeler in the study area. And more the number of four wheeler available in the house, more will be the tendency to generate work trip, shopping trip, business trip, educational trip and leisure trip from the house so, the variable Four_Wheeler may have the positive coefficient estimate on work trip model, shopping trip model, business trip model, educational trip model and leisure trip model.

Distance_CBD: It includes the rough distance to central business district i.e. Chaubiskoti from the house in kilometer. Generally if CBD is near then people preferred to travel more, this will may increase the trip generation from the house and vice-versa. Thus, more the distances to CBD from house, people prefer to travel less towards the CBD which may results the less number of work trip, shopping trip, business trip and leisure trip from the house. So, variable Distance_CBD may have negative coefficient estimate on these trip models.

License_Holder_No: It includes the total number of members having driving license currently present in the house. More the driving license holder member numbers in the family, members may prefer to make more travel with their vehicles. This may results the more number of work trip, business trip, shopping trip, education trip and leisure trips. So, the variable License_Holder_No may the positive coefficient estimate on work trip model, business trip model, shopping trip model, education trip model and leisure trip model.

Age<18: It includes the total number of members having age less than 18 years currently present in the house. In this study this variable is considered for the model development of shopping trip, education trip and leisure trip. More the number of members having age less than 18 in the family, more will be the shopping trip, educational trip and leisure trip. So, variable Age<18 may have the positive coefficient estimate on shopping trip model, educational trip model and leisure trip model.

Age18 – 60: It includes the total number of members having age between 18 years and 60 years currently present in the house. This variable is considered for the work trip model, shopping trip model, business trip model, education trip model and leisure trip model development in this research study. When the number of member in the house having the age 18 to 60 years is more, then work trip, shopping trip, business trip and leisure trip may also increases from house but the educational trip may decreases because people of this age group is normally preferred to work or business than study. So, variable Age 18-60 may have positive coefficient estimate on work trip model, shopping trip model, business trip model and leisure trip model but may have negative coefficient estimate on educational trip model.

Age>60: It includes the total number of members having age more than 60 years currently present in the house. In this research work this variable is considered for the model development of work trip, shopping trip, business trip and leisure trip. More the number of member in the family having age more than 60 years, then there will be less number of work trip because people after 60 wants to spend retired life; less number of shopping trip because old age people does not want to travel more for shopping activities; less number of business trip because after 60 people does not want to involve actively in business; and more number of leisure trips because after 60 people attracted

to religious work, they frequently travel to temple, auspicious occasions, they frequently travel to meet relatives, they will make short refreshment trip frequently. So, the variable Age>60 may have negative coefficient estimate on work trip model, business trip model and shopping trip model but may have positive coefficient estimate on leisure trip model.

Employee_No: It includes the total number of members currently present in the house who were employed to any private office/firm, government office/firm, industry/factory or any other specific work. They do their trip on a regular basis to reach their work place by foot or by using vehicles available. This variable is considered for the model development of work trip, shopping trip and leisure trip in this thesis study. More the number of employee in the house, more will be the work trip production from the house. So, the variable Employee_No may have positive coefficient estimate on work trip model. If the people engaged in the work then their economic status will improved which ultimately forced them to trip more for shopping. That's why if more the number of employee in the house more will be the shopping trip. So, the variable Employee_No may have the positive coefficient estimate on the shopping trip model. More the number of employee in the house then these people have less time to make leisure trip more so, this may result less leisure trip. Thus the variable Employee_No may have the negative coefficient estimate on leisure trip model.

Student_No: It includes total number of students currently present in the house who were generating trip on regular basis while travelling to their educational institutions. Student_No is considered for shopping trip, educational trip and leisure trip model development. More the number of students in the house more will be the shopping activities from the house, more will be the education related trip from the house and more will be the trip for refreshment. Thus the variable Student_No may have the positive coefficient estimate on shopping trip model, educational trip model and leisure trip model.

OAW_No: It includes the total number of members currently present in the house who were involved in the business like managing own shop, handling own office/firm, handling own industry/factory, engaging in agriculture, handling own construction business etc. This variable is considered for the model development of shopping trip, business trip and leisure trip. More the people involved in the own account work then

their economic status and their family's economic status will improved that will ultimately results the more shopping activities and business related activities. Thus this will increase the shopping trip and business trip. Thus the variable OAW_No may have the positive coefficient estimate on the shopping trip model. But more the number of own account worker in the house then these people have less time to make leisure trip more so, this may result less leisure trip So, the variable OAW_No may have the negative coefficient estimate on the leisure trip model.

Unemployed_No: It includes the total number of members currently present in the house who were not involved in any of above three profession but may engaged in the house related work. This variable is considered for the development of shopping trip model and leisure trip model. Unemployed members in the house have more time to involve in the shopping so they may largely involve in the house related goods shopping. More the unemployed number in the house more will be the shopping related trip from the house. So, this variable may have positive coefficient estimate on the shopping trip model. More the number of unemployed member in the house then there will be probability of being more leisure trip from the house because unemployed members have more free time. And generally they may spend their free time on leisure activities which may ultimately increase the leisure trip. Thus the variable Unemployed_No may have the positive coefficient estimate on the leisure trip model.

Low_Income: It is a dummy variable and attains value of 1 for families with total monthly income below Rs.20, 000 and 0 for all the other cases. This variable is considered for the model development of work trip, shopping trip, business trip, educational trip and leisure trip. Low income of the family represents the minimum involvement of the family members in the work or business which results the weak economic status of the family. This ultimately impact negatively on the shopping activities, educational activities and leisure activities of the family member thus reducing the work trip, shopping trip, business trip, education trip and leisure trip produced from the house. So, the variable Low_Income is expected to have the negative coefficient estimate on the work trip model, shopping trip model, business trip model, educational trip model and leisure trip model.

Middle_Income: It is a dummy variable and accomplishes value of 1 for families with total monthly income ranges from Rs.20, 000 to Rs.1, 00,000 and 0 for all the other

cases. It included the families with total monthly income between Rs.20, 000 and Rs.60, 000.

High_Income: It is a dummy variable and takes value of 1 for families with total monthly income above Rs.1, 00,000 and 0 for all the other cases. It includes the families with total monthly income more than Rs.1, 00,000. This variable is considered for the development of work trip model, shopping trip model, business trip model, educational trip model and leisure trip model. High income of the family represents the more involvement of the family members in the work or business which results the improved economic status of the family. This ultimately impact positively on the shopping activities, educational activities and leisure activities of the family member thus increasing the work trip, shopping trip, business trip, educational trip and leisure trip produced from the house. So, the variable High_Income may have the positive coefficient estimate on the work trip model, shopping trip model, business trip model, educational trip model and leisure trip model.

Service: It is a dummy variable and takes value of 1 for the families having currently present main member's occupation is service and 0 for all other cases. It represents the occupation of the currently present main member of the family as a service i.e. employed. This variable is considered for the model development of work trip, educational trip and leisure trip. If the occupation of main member of the family is service then this will suggest the family may have improved economic status and may lead the more production of work trip, education trip and leisure trip. So, the variable Service may have the positive coefficient estimate on the work trip model, educational trip model and leisure trip model.

OAW: It is a dummy variable and attains value of 1 for the families for which currently present main member's occupation is own account work and 0 for all other cases. It represents the occupation of the currently present main member of the family as own account work i.e. business. This variable is considered for the model development of shopping trip, business trip and education trip. If the occupation of the main member of the family is own account worker then this represents that this family may have financially favorable condition for increasing shopping trip, business trip and education trip. Thus, the independent variable OAW may have the positive coefficient estimate on the shopping trip model, business trip model and education trip model.

Unemployed: It is a dummy variable and takes value of 1 for the families for which currently present main member is unemployed and 0 for all other cases. It indicates the currently present main member of the family is unemployed i.e. not involved in any profession. The independent variable unemployed is considered for the model development of shopping trip and leisure trip in this thesis study. If the main member of the family is unemployed then shopping trip and leisure trip may produce more from the house due to the availability of more time to make shopping and leisure activities for main member of the house. Thus, the independent variable Unemployed may have the positive coefficient estimate on the shopping trip model and leisure trip model.

4.2 Correlation Matrix

After selecting the dependent and independent variables, correlation between the variables needs to be checked. Before starting any analysis task on Statistical Package of Social Science (SPSS), variable type and their measures are checked and corrected. Correlation matrix is generated from correlation between each set of variables. For a pair of variables having correlation coefficient above 0.8, only one of the variables is taken for the analysis to avoid multi-collinearity of coefficients. None of the variable pairs under consideration exhibit correlation coefficient exceeding the set limit and hence any regressor can be included in a model irrespective of its correlation with others. Correlation matrix is shown in the Appendix-2.

4.3 Model Calibration

Model is developed for each trip purpose as each independent variable by multilinear regression analysis with the help of Statistical Package of Social Science (SPSS). Number of trips for different purposes are dependent variables and other variables that are likely to have effect on the model are taken as independent variables. Following notations are given to the each variables to represent them in the model:

TT : Total Trip

WT : Work Trip

BT : Business Trip

ST : Shopping Trip

ET : Educational Trip

LT	:	Leisure Trip
NFM	:	Number of family members
NM	:	Number of males
NF	:	Number of females
NonM	:	Number of non-motorized vehicles
TW	:	Number of two wheeler
FW	:	Number of four wheeler
LI	:	Low Income
MI	:	Middle Income
HI	:	High Income
D	:	Distance to CBD
A18	:	Number of members having age less than 18
A1860	:	Number of members having age from 18 to 60
A60	:	Number of members having age more than 60
O	:	Own Account Worker
S	:	Service
U	:	Unemployed
NE	:	Number of employees
NS	:	Number of students
NOAW	:	Number of own account workers
NU	:	Number of unemployed

4.3.1 Model Development for Work Trip

For the development of work trip model by Multilinear Regression Analysis, Work_Trip is considered as dependent variable and independent variables considered are No_Male, No_Female, Non_Motorized, Two_Wheeler, Four_Wheeler, High_Income, Low_Income, Distance_CBD, Age18-60, Age> 60, License_Holder_Number, Service and Employee_No. Initially, model developed for work trip when considering all these variables in the analysis is shown in Table 4.1.

Table 4.1 Regression Coefficients for Initial Work Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.106	.069		-1.526	.128
	No_Male	.027	.033	.025	.839	.402
	No_Female	.007	.029	.006	.223	.824
	Non_Motorized	.098	.033	.068	2.954	.003
	Two_Wheeler	.004	.046	.003	.088	.930
	Four_Wheeler	.094	.062	.036	1.510	.132
	Distance_CBD	-.001	.005	-.002	-.122	.903
	Age18-60	-.037	.031	-.041	-1.179	.239
	Age>60	-.037	.038	-.025	-.959	.338
	Lisence_Holder_No	.023	.040	.020	.579	.563
	Employee_No	1.135	.035	.892	32.127	.000
	Low_Income	.291	.118	.047	2.476	.014
	High_Income	.077	.046	.038	1.685	.093
	Service	.081	.051	.040	1.585	.114

a. Dependent Variable: Work_Trip

The analysis results from Statistical Package of Social Science (SPSS) shows that the independent variables Non_Motorized, Employee_No and Low_Income have the t-values 2.954, 32.127 and 2.476 respectively which are greater than 1.964. This means initially when taking all the above considered variables in the analysis, only these three variables are seen to have significant impact on work trip production.

Model summary obtained for the work trip model while taking all the considered independent variables in the analysis is shown in Table 4.2.

Table 4.2 Model Summary for Initial Work Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.928[a]	.860	.856	.383

a. Predictors: (Constant), Service, Lisence_Holder_No, Non_Motorized, Age>60, Distance_CBD, Low_Income, Four_Wheeler, No_Female, High_Income, No_Male, Employee_No, Two_Wheeler, Age18-60

This developed work trip model has R square value of 0.86. That means initially when taking all the considered variables in the analysis there is 86 % relationship between dependent variable and independent variables in the model.

After eliminating some of non-significant independent variables serially and running the analysis several times, finally the model having only significant independent variables is obtained in the Table 4.3.

Table 4.3 Regression Coefficients for Final Work Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.075	.036		-2.066	.039
	Non_Motorized	.084	.027	.058	3.080	.002
	Four_Wheeler	.122	.049	.047	2.468	.014
	Employee_No	1.171	.023	.921	50.206	.000
	Low_Income	.260	.112	.042	2.312	.021

a. Dependent Variable: Work_Trip

Here four independent variables i.e. Non_Motorized, Four_Wheeler, Employee_No and Low_Income are seen as significant variables for work trip model. As expected the variables Non_Motorized, Four_Wheeler and Employee_No has the positive coefficient estimate on the work trip model as they increases the number of work trip production from the house if their number increases. Above model shows the unit value increment in the variable Non_Motorized by keeping other variables in the model constant then the work trip increased by 0.084 times. Similarly, work trip increases for Four_Wheeler and Employee_No are 0.122 and 1.171 times respectively.

But the independent variable Low_Income has also the positive coefficient estimate on the work trip model which is counter-intuitive with the general expectation of Low_Income may have negative coefficient estimate on the work trip model. This result is due to the reason that the families having low income have the more numbers of workers making trip for work but their work payment is less. And the another reason is members of low income families mostly engaged in part time work in two or more places or short distance work from their house so they frequently make trip to their work place two or more times from house in a day which ultimately increases the work trips. From the result it can be concluded that the unit increment in the variable Low_Income by keeping other variables constant in the model then the work trip increased by 0.260 times. The final work trip model formulation having only significant variables is given by equation (4.1).

WT = - 0.075 + 1.171 (NE) + 0.122 (FW) + 0.260 (LI) + 0.084 (NonM) (4.1)

Model Summary obtained for work trip model when taking only significant independent variables is given in Table 4.4.

Table 4.4 Model Summary for Final Work Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.926[a]	.858	.857	.382

a. Predictors: (Constant), Low_Income, Non_Motorized, Employee_No, Four_Wheeler

The final work trip model developed has the R square value of 0.858. That means the relationship between dependent variable and independent variables in the model is 85.8% when considering only significant independent variables.

4.3.2 Model Development for Shopping Trip

For the development of shopping trip model by Multilinear Regression Analysis, Shop_Trip is input as explained variable in SPSS and No_Male, No_Female, Non_Motorized, Two_Wheeler, Four_Wheeler, High_Income, Low_Income, Distance_CBD, Age<18, Age 18-60, Age> 60, License_Holder_Number, OAW, Unemployed, Employee_No, Student_No, OAW_No and Unemployed_No are inputs as explanatory variables. Initially, shopping trip model developed when taking all the considered variables in the analysis is shown in Table 4.5.

The above table displays that the explanatory variables like Non_Motorized, Four_Wheeler, Distance_CBD and High_Income have t-values as 2.311, 2.516, -5.457, and 2.023 respectively which are either greater than 1.964 or less than -1.964. This means initially only above four explanatory variables are seen as significant in shopping trip model.

Model summary for the shopping trip model while taking all the considered explanatory variables in the analysis is shown in Table 4.6.

Table 4.5 Regression Coefficients for Initial Shopping Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.905	.137		6.621	.000
	No_Male	.381	.429	.381	.889	.375
	No_Female	.460	.421	.455	1.092	.275
	Non_Motorized	.150	.065	.112	2.311	.021
	Two_Wheeler	.108	.090	.077	1.205	.229
	Four_Wheeler	.305	.121	.127	2.516	.012
	Distance_CBD	-.051	.009	-.227	-5.457	.000
	Age<18	-.265	.432	-.224	-.613	.540
	Age18-60	-.144	.433	-.175	-.333	.739
	Age>60	-.247	.434	-.184	-.569	.569
	Lisence_Holder_No	-.092	.078	-.087	-1.180	.239
	Employee_No	.107	.387	.091	.277	.782
	Student_No	.132	.390	.134	.338	.736
	OAW_No	-.020	.386	-.014	-.051	.959
	Unemployed_No	-.033	.382	-.025	-.086	.931
	Low_Income	-.313	.230	-.055	-1.360	.175
	High_Income	.181	.089	.097	2.023	.044
	OAW	.226	.121	.121	1.862	.063
	Unemployed	.091	.206	.019	.442	.659

a. Dependent Variable: Shop_Trip

Table 4.6 Model summary for Initial Shopping Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.626[a]	.392	.365	.742

a. Predictors: (Constant), Unemployed, Distance_CBD, Age>60, Low_Income, Age<18, Four_Wheeler, OAW, Age18-60, Two_Wheeler, High_Income, Non_Motorized, Unemployed_No, No_Female, Employee_No, OAW_No, Lisence_Holder_No, Student_No, No_Male

This developed shopping trip model has R square value of 0.392. That means there is 39.2 % relationship between explained variable and explanatory variables in the developed shopping trip model when taking all the explanatory variables considered for shopping activities.

After eliminating some of the non-significant variables among the considered explanatory variables and again running the analysis several times, the shopping trip model developed is shown in Table 4.7.

Table 4.7 Regression Coefficients for Final Shopping Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.942	.118		7.974	.000
	No_Female	.146	.052	.144	2.821	.005
	Non_Motorized	.157	.059	.118	2.675	.008
	Four_Wheeler	.247	.107	.103	2.307	.022
	Distance_CBD	-.047	.009	-.211	-5.197	.000
	Employee_No	.161	.063	.137	2.556	.011
	Student_No	.204	.050	.208	4.108	.000
	High_Income	.216	.083	.116	2.606	.009
	OAW	.247	.093	.133	2.644	.008
	Age18-60	.136	.042	.164	3.240	.001

a. Dependent Variable: Shop_Trip

After running several analysis and eliminating non-significant explanatory variables from the model, finally only nine explanatory variables are seen as significant in the shopping trip model. These significant explanatory variables are No_Female Non_Motorized, Four_Wheeler, Distance_CBD, Employee_No, Student_No, High_Income, OAW and Age18-60. Generally as per expectation the explanatory variables No_Female, Non_Motorized, Four_Wheeler, Employee_No, Student_No, High_Income, OAW and Age18-60 has the positive coefficient estimate on the shopping trip model with coefficient 0.146, 0.157, 0.247, 0.161, 0.204, 0.216, 0.247 and 0.136 respectively. And as expected the explanatory variable Distance_CBD has negative coefficient estimate on shopping trip model with coefficient - 0.047, indicating the reduction in number of trips by 0.047 for unit increment in distance from CBD. The final Shopping trip model formulation with significant explanatory variables only is given by equation (4.2).

$$ST = 0.942 + 0.146\,(NF) + 0.157\,(NonM) + 0.247\,(FW) - 0.047\,(D) + 0.161\,(NE) + 0.204(NS) + 0.216\,(HI) + 0.247\,(O) + 0.136\,(A1860) \quad (4.2)$$

Model Summary when taking significant explanatory variables only in the model for shopping trip is given in Table 4.8.

This developed final shopping trip model has the R square value of 0.381 which suggests that there is only 38.10% relationship between explained variable and explanatory variables in the model.

Table 4.8 Model Summary for Final Shopping Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.617[a]	.381	.368	.741

a. Predictors: (Constant), Age18-60, Distance_CBD, OAW, Four_Wheeler, Non_Motorized, High_Income, Student_No, No_Female, Employee_No

4.3.3 Model Development for Business Trip

Business trip model is developed by using the Business_Trip as regressand and No_Male, No_Female, Non_Motorized, Two_Wheeler, Four_Wheeler, High_Income, Low_Income, Distance_CBD, Age18-60, Age> 60, License_Holder_Number, OAW, and OAW_No as regressors in the analysis. These regressors are considered in the analysis based on their probable relationship or impact (positive or negative) on the increment or decrement of the business activities. Initially, the business trip model for business related travel starting from home in the study area is developed by taking all of the above mentioned regressors which is shown in Table 4.9.

Table 4.9 Regression Coefficient for Initial Business trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.237	.116		-2.036	.042
	No_Male	.127	.058	.087	2.185	.029
	No_Female	.108	.052	.073	2.060	.040
	Non_Motorized	.008	.059	.004	.128	.898
	Two_Wheeler	.210	.082	.102	2.557	.011
	Four_Wheeler	.463	.112	.132	4.152	.000
	Distance_CBD	-.011	.008	-.032	-1.245	.214
	Age18-60	-.098	.056	-.081	-1.758	.079
	Age>60	-.134	.068	-.068	-1.965	.050
	Lisence_Holder_No	-.056	.070	-.036	-.803	.423
	OAW_No	1.396	.081	.684	17.227	.000
	Low_Income	-.095	.211	-.011	-.453	.651
	High_Income	.214	.081	.078	2.628	.009
	OAW	.397	.104	.145	3.797	.000

a. Dependent Variable: Business_Trip

The above outcome clearly shows that the regressors No_Male, No_Female, Two_Wheeler, Four_Wheeler, Age>60, OAW_No, High_Income and OAW have the t-values required for them to be a significant in the model as 2.185, 2.060, 2.557, 4.152, -1.965, 17.227, 2.628 and 3.797 respectively which were either greater than

1.946 or less than - 1.946. So, this analysis result gives the idea that only above eight regressors are significant in the business trip if we develop the model by considering all the regressors that might have certain probable direct or indirect impact in the business related activities.

Model summary for the business trip model while taking all the above considered regressors in the analysis is given in Table 4.10.

Table 4.10 Model Summary for Initial Business Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.870[a]	.757	.749	.685

a. Predictors: (Constant), OAW, Low_Income, Non_Motorized, Age>60, Distance_CBD, Age18-60, Four_Wheeler, High_Income, Two_Wheeler, No_Female, No_Male, OAW_No, Lisence_Holder_No

This developed business trip model has the R square value of 0.757. That means the model shows there is 75.70% relationship between regressand and regressors.

The final business trip model developed after eliminating some of the non-significant regressors and running the analysis several times is shown in Table 4.11.

Table 4.11 Regression coefficient for Final Business Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.199	.069		-2.871	.004
	Two_Wheeler	.181	.054	.088	3.362	.001
	Four_Wheeler	.420	.096	.119	4.374	.000
	OAW_No	1.402	.079	.687	17.810	.000
	High_Income	.187	.080	.068	2.344	.020
	OAW	.382	.104	.140	3.692	.000

a. Dependent Variable: Business_Trip

Here five regressors i.e. Two_Wheeler, Four_Wheeler, OAW_No, High_Income and OAW became significant for business trip model. The regressors Two_Wheeler, Four_Wheeler, OAW_No, High_Income, and OAW has the positive impact on the business related activities and has the positive coefficient estimate on the business trip model as supporting the general expectation with the coefficients of 0.181, 0.420,

1.402, 0.187 and 0.382 respectively. The final business trip model formulation having only significant regressors is given by equation (4.3).

BT = - 0.199 + 0.181 (TW) + 0.420 (FW) + 1.402 (NOAW) + 0.187 (HI) + 0.382 (O) (4.3)

The developed business trip model when taking only significant regressors in the analysis has the model summary shown in Table 4.12.

Table 4.12 Model Summary for Final Business Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.866[a]	.751	.748	.687

a. Predictors: (Constant), OAW, Two_Wheeler, Four_Wheeler, High_Income, OAW_No

This developed business trip model has the R square value of 0.751. Thus the relationship between regressand and regressors in the business trip model is 75.10%.

4.3.4 Model Development for Educational Trip

Educational_Trip is considered as predictand and predictors considered in the analysis are No_Male, No_Female, Non_Motorized, Two_Wheeler, Four_Wheeler, License_Holder_No, High_Income, Low_Income, Age<18, Age18-60, Student_No, Service and OAW for the development of the educational trip. Initial educational trip model developed for educational activities when taking all these considered predictors in the analysis is shown in Table 4.13.

This consequence shows that the only two predictors as Four_Wheeler, and Student_No are seen as significant in the initial model according to their t-values and significance values.

Initial educational trip model has the summary as shown in Table 4.14.

This educational trip model developed has the R square value of 0.990. That means relationship between predictand and predictors is 99.00% in the developed educational trip model.

After eliminating some of the non-significant predictors and running the analysis several times, the final educational trip model developed is shown in Table 4.15.

Table 4.13 Regression Coefficient for Initial Educational Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.009	.024		.356	.722
	No_Male	.013	.008	.013	1.542	.124
	No_Female	-.003	.008	-.003	-.378	.706
	Non_Motorized	-.013	.008	-.010	-1.659	.098
	Two_Wheeler	-.017	.011	-.012	-1.533	.126
	Four_Wheeler	-.054	.015	-.022	-3.504	.001
	Age<18	.012	.011	.010	1.010	.313
	Age18-60	.004	.008	.004	.460	.646
	Lisence_Holder_No	.009	.009	.009	.970	.333
	Student_No	.986	.009	.984	115.653	.000
	Low_Income	.002	.029	.000	.068	.946
	High_Income	.007	.011	.004	.603	.547
	Service	-.009	.025	-.005	-.354	.723
	OAW	-.025	.025	-.013	-1.014	.311

a. Dependent Variable: Educational_Trip

Table 4.14 Model Summary for Initial Educational Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.995[a]	.990	.990	.095

a. Predictors: (Constant), OAW, Low_Income, Age<18, Four_Wheeler, Two_Wheeler, Age18-60, Non_Motorized, High_Income, No_Female, No_Male, Student_No, Lisence_Holder_No, Service

Table 4.15 Regression Coefficient for Final Educational Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-.013	.010		-1.258	.209
	No_Male	.011	.006	.011	2.003	.046
	Student_No	.990	.006	.989	179.065	.000
	Four_Wheeler	-.040	.012	-.016	-3.372	.001

a. Dependent Variable: Educational_Trip

Here three predictors i.e. No_Male, Student_No and Four_Wheeler become significant for educational trip model. As expected the predictors No_Male and Student_No has the positive coefficient estimate on the educational trip model. But the predictor Four_Wheeler has the negative coefficient estimate on educational trip which is counter-intuitive with the initial general assumption of Four_Wheeler may have

positive coefficient estimate on educational trip model. This result is obtained due to the most of the settled and economically strong family i.e. family having four wheeler keep their students away from the home for providing them a better education. This means the well settled families having four wheeler in the house have less number of students present in the house. Thus the variable Four_Wheeler has negative coefficient estimate on the educational trip model. The final educational trip model formulation with only significant predictors is given by equation (4.4).

$$ET = 0.011\ (NM) + 0.990\ (NS) - 0.040\ (FW) \quad (4.4)$$

Final educational trip model Summary obtained with only significant predictors is given in Table 4.16.

Table 4.16 Model Summary for Final Educational Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.995[a]	.990	.990	.094

a. Predictors: (Constant), Four_Wheeler, Student_No, No_Male

This educational trip model developed has the R square value of 0.990. That gives the idea that the relationship between predictand and predictors is 99.00% in the developed final educational trip model.

4.3.5 Model Development for Leisure Trip

For the development of leisure trip model, Leisure Trip is considered as response in the analysis and No_Male, No_Female, Non_Motorized, Two_Wheeler, Four_Wheeler, High_Income, Low_Income, Distance_CBD Age<18, Age18-60, Age>60, Student_No, Employee_No, OAW_No, Unemployed_No, Service and Unemployed are taken as stimulus in the analysis. So, initial model developed for leisure trip when taking all considered stimulus in the analysis is shown in Table 4.17.

This outcome from analysis indicates that only one stimulus i.e. High_Income is seen significant in the initial leisure trip model which has the t-values as 2.806 which is greater than 1.946.

Model summary obtained for the initial leisure trip model is shown in Table 4.18.

This leisure trip model developed has the R square value of 0.354. This suggests relationship between response and stimulus in the initial leisure trip model is 35.4%.

Table 4.17 Regression Coefficient for Initial Leisure Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.166	.180		.925	.355
	No_Male	.803	.491	.723	1.635	.103
	No_Female	.824	.483	.734	1.707	.089
	Non_Motorized	.096	.074	.064	1.288	.199
	Two_Wheeler	.200	.103	.128	1.948	.052
	Four_Wheeler	-.045	.139	-.017	-.320	.749
	Distance_CBD	-.018	.011	-.073	-1.707	.089
	Age<18	-.350	.496	-.266	-.707	.480
	Age18-60	-.103	.497	-.113	-.208	.835
	Age>60	-.023	.498	-.015	-.045	.964
	Lisence_Holder_No	-.026	.089	-.022	-.293	.770
	Employee_No	-.397	.444	-.304	-.895	.371
	Student_No	-.363	.447	-.334	-.813	.417
	OAW_No	-.497	.443	-.322	-1.123	.262
	Unemployed_No	-.238	.438	-.166	-.544	.587
	Low_Income	-.311	.263	-.049	-1.179	.239
	High_Income	.287	.102	.139	2.806	.005
	Service	.130	.139	.062	.932	.352
	Unemployed	.032	.245	.006	.132	.895

a. Dependent Variable: Leisure_Trip

Table 4.18 Model Summary for Initial Leisure Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.595[a]	.354	.326	.851

a. Predictors: (Constant), Unemployed, Distance_CBD, Age>60, Low_Income, Age<18, Four_Wheeler, Service, Age18-60, Two_Wheeler, High_Income, Non_Motorized, Unemployed_No, No_Female, Employee_No, OAW_No, Lisence_Holder_No, Student_No, No_Male

After eliminating some of the non-significant stimulus and running the analysis several times, the final leisure trip model developed is shown in Table 4.19.

Seven stimulus i.e. No_Male, No_Female, Two_Wheeler, Age>60, OAW_No, High_Income and Age18-60 are seen as significant stimulus for final leisure trip model. As per general expectation the stimulus No_Male, No_Female, Two_Wheeler,

Age>60, Age18-60, OAW_No and High_Income has the positive coefficient estimate on the leisure trip model.

Table 4.19 Regression Coefficient for Final Leisure Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.191	.124		1.537	.125
	No_Male	.132	.067	.119	1.969	.050
	No_Female	.167	.060	.149	2.763	.006
	Two_Wheeler	.156	.072	.100	2.177	.030
	Age>60	.367	.083	.246	4.405	.000
	OAW_No	-.200	.065	-.130	-3.067	.002
	High_Income	.251	.090	.121	2.784	.006
	Age18-60	.239	.066	.260	3.639	.000

a. Dependent Variable: Leisure_Trip

The final leisure trip model formulation having only significant variables is given by equation (4.5).

LT = 0.132 (NM) + 0.167 (NF) + 0.156 (TW) + 0.367 (A60) + 0.239 (A1860) - 0.200(NOAW) + 0.251 (HI) (4.5)

Model Summary obtained for final leisure trip model with only significant stimulus is shown in the Table 4.20.

Table 4.20 Model Summary for Final Leisure Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.581[a]	.338	.327	.850

a. Predictors: (Constant), Age18-60, Age>60, OAW_No, High_Income, Two_Wheeler, No_Female, No_Male

This developed final leisure trip model has the R square value of 0.338. This indicates that relationship between response and stimulus in the final leisure trip model is 33.80%.

But in the leisure trip model developed above, both No_Male and No_Female are seen as significant in the model. So, these two stimulus can be replaced by a single stimulus as Family_No in the analysis because total members in the family is the sum of number

of male and female present in the family. After replacement, the final leisure trip model developed is shown in Table 4.21.

Table 4.21 Regression Coefficient for Final Leisure Trip Model with Family Members

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.196	.124		1.579	.115
	Two_Wheeler	.151	.071	.097	2.134	.033
	Age>60	.367	.083	.246	4.435	.000
	OAW_No	-.200	.065	-.130	-3.072	.002
	High_Income	.250	.090	.121	2.774	.006
	Age18-60	.239	.065	.260	3.671	.000
	Family_Members	.149	.053	.205	2.829	.005

a. Dependent Variable: Leisure_Trip

Then final leisure trip model formulation with significant variables, shown in the Table 4.21, is given by equation (4.6).

LT = 0.149 (NFM) + 0.151 (TW) + 0.367 (A60) + 0.239 (A1860) - 0.200 (NOAW) + 0.250 (HI) (4.6)

Model summary for this developed model is given in Table 4.22.

Table 4.22 Model Summary for Final Leisure Trip Model with Family Members

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.581[a]	.337	.328	.850

a. Predictors: (Constant), Family_Members, High_Income, OAW_No, Age>60, Two_Wheeler, Age18-60

This developed final leisure trip model has the R square value of 0.337 which suggests the relationship between response and stimulus is 33.70% in the above developed final leisure trip model.

4.3.6 Model Development for Total Trip

Total trip model is developed by taking Total_Trip as controlled variable and No_Male, No_Female, Non_Motorized, Two_Wheeler, Four_Wheeler, High_Income, Low_Income, Distance_CBD Age<18, Age18-60, Age>60, Student_No, Employee_No, OAW_No, Unemployed_No, Service and OAW as control variables in

the multilinear regression analysis. Initially, model developed for total trip when taking all the considered control variables in the analysis is shown in Table 4.23.

Table 4.23 Regression Coefficients for Initial Total Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.796	.330		2.412	.016
	No_Male	1.581	.686	.507	2.305	.022
	No_Female	1.684	.674	.534	2.498	.013
	Non_Motorized	.436	.104	.104	4.208	.000
	Two_Wheeler	.546	.143	.125	3.808	.000
	Four_Wheeler	.852	.194	.114	4.384	.000
	Distance_CBD	-.080	.015	-.114	-5.370	.000
	Age<18	.113	.692	.030	.163	.871
	Age18-60	.402	.694	.156	.580	.562
	Age>60	.293	.695	.070	.422	.673
	Lisence_Holder_No	-.093	.124	-.028	-.749	.454
	Employee_No	-.290	.620	-.079	-.467	.640
	Student_No	-.253	.624	-.083	-.406	.685
	OAW_No	-.210	.618	-.048	-.339	.734
	Unemployed_No	-1.104	.611	-.274	-1.806	.072
	Low_Income	-.495	.368	-.028	-1.344	.180
	High_Income	.707	.143	.122	4.951	.000
	Service	.069	.329	.012	.210	.834
	OAW	.379	.342	.065	1.107	.269

a. Dependent Variable: Total_Trips

This table shows that only the control variables No_Male, No_Female, Non_Motorized, Two_Wheeler, Four Wheeler, Distance_CBD, High_Income has significant impact on the initial total trip model based on their t-values and significance values which are either greater than 1.964 or less than - 1.964. This means initially when taking all the considered control variables in the analysis, only seven control variables are seen as significant variables for initial total trip model.

Initial total trip model has the summary as shown in Table 4.24.

Table 4.24 Model Summary for Initial Total Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.917[a]	.840	.833	1.188

a. Predictors: (Constant), OAW, Low_Income, Age<18, Unemployed_No, Distance_CBD, Four_Wheeler, Two_Wheeler, Age18-60, High_Income, Non_Motorized, Employee_No, No_Female, Age>60, OAW_No, Lisence_Holder_No, Service, Student_No, No_Male

The developed initial total trip model has the R square value of 0.840 that means relationship between controlled variable and control variables is 84.00% for the initial total trip model developed.

After eliminating some of the non-significant control variables and running the analysis several times, the final total trip model developed is given in Table 4.25.

Table 4.25 Regression Coefficient for Final Total Trip Model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.844	.194		4.351	.000
	No_Male	.720	.103	.231	7.016	.000
	No_Female	.838	.099	.266	8.470	.000
	Non_Motorized	.440	.103	.105	4.263	.000
	Two_Wheeler	.511	.114	.117	4.483	.000
	Four_Wheeler	.856	.181	.114	4.725	.000
	Distance_CBD	-.077	.015	-.110	-5.216	.000
	Age18-60	.198	.074	.077	2.672	.008
	Employee_No	.690	.120	.188	5.770	.000
	Student_No	.752	.102	.246	7.381	.000
	OAW_No	.973	.133	.224	7.302	.000
	High_Income	.751	.140	.129	5.382	.000

a. Dependent Variable: Total_Trips

Here eleven control variables i.e. No_Male, No_Female, Two_Wheeler, Four_Wheeler, High_Income, Age18-60, Employee_No, Student_No, OAW_No and Distance_CBD are seen as significant for final total trip model developed. As expected the control variables No_Male, No_Female, Non_Motorized, Two_Wheeler, Four_Wheeler, Age18-60, Employee_No, Student_No, OAW_No and High_Income has the positive coefficient estimate on the total trip model developed. And as expected the variable Distance_CBD has the negative coefficient estimate on the total trip model

developed. The final total trip model formulation with only significant control variables is given by equation (4.7).

TT = 0.844 + 0.720 (NM) + 0.838 (NF) + 0.440 (NonM) + 0.511 (TW) + 0.856 (FW) - 0.077 (D) + 0.198 (A1860) + 0.690 (NE) + 0.752 (NS) + 0.973 (NOAW) + 0.751(HI) (4.7)

Model Summary obtained for final total trip model developed with only significant control variables is shown in Table 4.26.

Table 4.26 Model Summary for Final Total Trip Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.914[a]	.836	.832	1.192

a. Predictors: (Constant), High_Income, Student_No, Distance_CBD, Employee_No, Non_Motorized, Four_Wheeler, OAW_No, Two_Wheeler, No_Female, Age18-60, No_Male

The developed final total trip model has the R square value of 0.836, which means relationship between controlled variable and control variables is 83.60%.

But in above developed total trip model, both No_Male and No_Female are seen as significant control variables in the model. So, these two control variables can be replaced by a single control variable as Family_No in the analysis because total number of member in the family is the sum of number of male and number of female present in the family. After replacement, the final total trip model developed is shown in Table 4.27.

Then final total trip model formulation with significant control variables, shown in the Table 4.27, is given by equation (4.8).

TT = 0.858 + 0.776 (NFM) + 0.435 (NonM) + 0.490 (TW) + 0.827 (FW) - 0.076 (D) + 0.199 (A1860) + 0.698 (NE) + 0.758 (NS) + 0.982 (NOAW) + 0.755 (HI) (4.8)

Model summary for the final developed model is as given in Table 4.28.

Table 4.27 Regression Coefficients for Final Total Trip Model with Family Members

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.858	.194		4.413	.000
	Non_Motorized	.435	.103	.104	4.209	.000
	Two_Wheeler	.490	.113	.112	4.349	.000
	Four_Wheeler	.827	.179	.111	4.613	.000
	Distance_CBD	-.076	.015	-.109	-5.156	.000
	Age18-60	.199	.074	.077	2.676	.008
	Employee_No	.698	.120	.190	5.823	.000
	Student_No	.758	.102	.248	7.405	.000
	OAW_No	.982	.134	.226	7.348	.000
	High_Income	.755	.140	.130	5.404	.000
	Family_Members	.776	.088	.378	8.787	.000

a. Dependent Variable: Total_Trips

Table 4.28 Model Summary for Final Total Trip Model with Family Members

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.914[a]	.835	.831	1.196

a. Predictors: (Constant), Family_Members, Distance_CBD, Four_Wheeler, OAW_No, Two_Wheeler, High_Income, Non_Motorized, Employee_No, Age18-60, Student_No

This developed final total trip model has the R square value of 0.835. This indicates the relationship between controlled variable and control variables in the developed total trip model is 83.50%.

4.4 Model Validation

The different trip models developed for Bharatpur Metropolitan City (BMC) in this research study are validated by using Chi-Square test.

A chi-square test is the statistical hypothesis test where the sampling distribution of the test statistic is a chi-square distribution when the null hypothesis is true. This test is used for determining whether there is a significant difference between the expected frequencies and observed frequencies. In the standard applications of this test, the observations are classified into mutually exclusive classes, and there is some theory, or say null hypothesis, which gives the probability that any observation falls into the corresponding class. The purpose of the test is to evaluate how likely the observations that are made would be, assuming the null hypothesis is true. Chi-squared tests are often

constructed from a sum of squared errors, or through the sample variance. Test statistics that follow a chi-squared distribution arise from an assumption of independent normally distributed data, which is valid in many cases due to the central limit theorem. A chi-squared test can be used to attempt rejection of the null hypothesis that the data are independent.

The chi-square distribution is an asymmetric distribution that has a minimum value of 0, but no maximum value. For each degree of freedom there is a different chi-square distribution. The mean of the chi-square distribution is the degree of freedom and the standard deviation of the chi-square distribution is twice the degree of freedom. For any given level of significance, the critical chi-square value is greater for greater degree of significance. Figure 4.1 shows the shape of chi-square distribution.

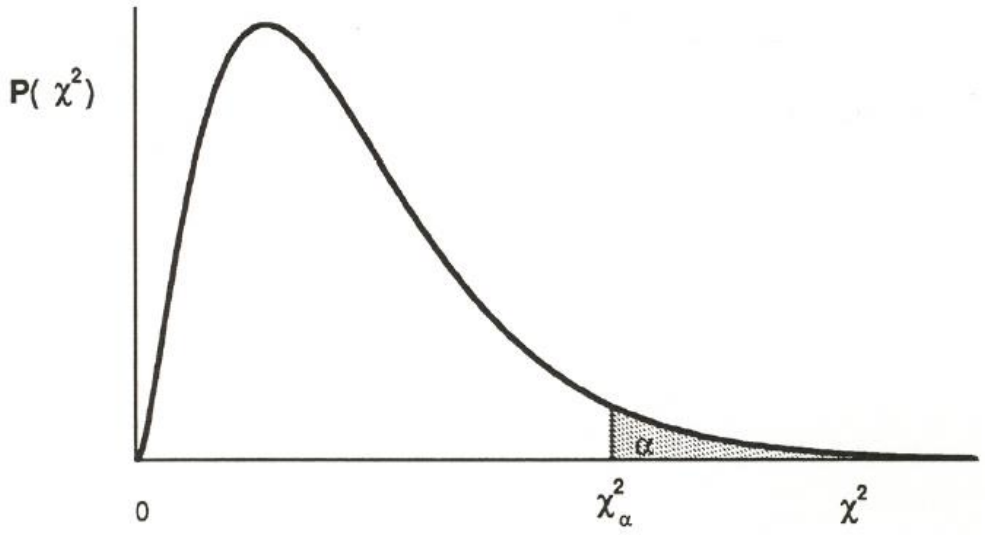

Figure 4.1 Shape of Chi-square distribution

Here the chi-square value is on the horizontal axis and probability for each chi-square value is represented in the vertical axis. The level of significance is represented by shaded area in the above diagram. The critical value for chi-square is obtained from the chi-square table.

For validating the each trip model developed, first null hypothesis and alternative hypothesis is set for each trip model for the goodness of fit with observations where null hypothesis is set as model has good fit with observations and alternative hypothesis

is set as model does not have good fit with observations. After then chi-square value is calculated for each trip model with the help of observed trip values and expected trip values for each specific trip purpose. And then critical chi-square value is obtained from the chi-square table with the help of level of significance and degree of freedom. Calculated chi-square value and critical chi-square value is then compared for the acceptance or rejection of the null hypothesis. If the calculated chi-square value for any trip model is less than the critical chi-square value then accept the null hypothesis of model has the good fit with observations and vice-versa.

In this research study, among the total of 535 data set, 101 data set is randomly selected for the validation of the developed trip model of the BMC. Hence, the degree of freedom is 100, which is less by one than the total validation data set. And the level of significance is 5% i.e. $\alpha = 0.05$. For this value of degree of freedom and level of significance, the critical chi-square value from the table is 124.342.

For the work trip model, the calculated value of chi-square from the observed and expected work trips is 10.348. This calculated value is less than the critical chi-square value 124.342, thus the work trip model developed has good fit with the observations taken. Although the work trip model developed has R-square value of 0.858 which is on the higher side.

The chi-square value calculated from experimental and estimated trip values for shopping trip model is 33.906 which is lower than the critical chi-square value. Thus the shopping trip model has good fit with observed trip data even the developed model has low R-square value of 0.381.

The business trip model has the calculated chi-square value of 26.693 which is smaller than the 124.342. So, the model developed has good fit with business trip observations. And the model developed has R-square value 0.751 which also suggests model performance accuracy on higher side.

In this research study, the calculated chi-square value with help of observed and expected values for the educational trip model developed is 3.394 which is much lower than the critical chi-square value. Thus the model developed has good fit with educational trip observations also with high model R-square value of 0.99.

Leisure trip model developed has model R-square value of 0.337 and the chi-square value calculated for this model is 49.666. Here even the model has low R-square value, the calculated chi-Square value for the model is lower than the critical chi-square value that suggests even with low R-square value, the model has good fit with the leisure trip observations based on chi-square test.

For validating total trip model, chi-square value is calculated as 24.787 for the developed model. This value is lower than the tabulated critical chi-square value of 124.342. Thus it is hard to reject the null hypothesis of model has good fit with observations. Also, the total trip model developed has the model R-square value as 0.835 which is also suggests that the model accuracy is on the higher side.

CHAPTER 5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Various trip models i.e. work trip model, shopping trip model, business trip model, educational trip model and leisure trip model for respective trip purposes and total trip model are developed after multi-linear regression analysis of the collected data by using SPPS and these models are validated using chi-square test. Results of the analysis is already discussed in the above chapter. And from the results obtained, some major conclusions are established which are discussed here:

- Home based work trip production from a house is affected by the household characteristics like number of non-motorized vehicles available in the house, number of four wheelers available in the house, number of employees in the house that make regular outings for work and socio-economic characteristics like low monthly income of the family. From the result, it is concluded that more the number of non-motorized vehicles i.e. bicycles, four wheeler i.e. car/jeep/van available in the house and number of employees in the house more be the work trip production from the house. It is also seen from the result that families having low income also produces more work trips.
- Factors like number of females present in the house, number of bicycles available in the house, number of four wheelers available in the house, number of employees present in the house, number of students present in the house, number of members having age from 18 years to 60 years increases the shopping trip from the house if their numbers increases in the house. It is also concluded from the result that the high income and main member has occupation as own account worker in the family also helps to increase the shopping trips from the house. And another major factor that affect the shopping trip is distance to central business district from the house as the distance increases trip production rate from the house decreases.
- Business trip generation from house is influenced by the characteristics like number of two wheelers i.e. motorcycles/Scooters available in the house, number of four wheelers i.e. car/jeep/van available in the house and number of own account workers, i.e. businessman or person involved in own business activities, present in the house as increment in their number increases the

business related trip from the house. Also the families having high income and occupation of main member as own account worker generates more number of business trips i.e. they have positive impact on business trip generation.

- The parameters that have impact on the educational trip production from home are number of male members in the house, number of students in the house and the number of four wheelers available in the house. These significant parameters increases the educational trip if their numbers in the house increases except number of four wheelers which has tendency to reduce educational trip if its number increase.
- Leisure trip generation from the house is determined by the factors like total number of family members present in the house, number of two wheelers available in the house, number of persons in the house having age greater than 60, number of persons in the house having age from 18 to 60 years, number of own account workers in the house and monthly family income as high income. Except number of own account workers in the house, which has tendency to reduce trip as their number in the house increases, all other significant factors have tendency to increase the leisure trip generation as they have positive relation with leisure trip.
- Total trips generated from the house is dependent on the constraints like number of family members present in the house, number of bicycles available in the house, number of two wheelers available in house, number of four wheelers available in the house, distance to central business district (CBD) from the house, number of members in the house having age from 18 to 60 years, number of employees in the house, number of students present in the house, number of own account workers present in the house and income status of the family as high income. Among these constraints, only distance to CBD has negative impact on total trip generation as its increment reduces the total trip generation, and remaining constraints has the positive impact on total trip generation.

5.2 Recommendation

The outcome of this research study provides the various idea on the home based trip production. This study creates the platform for further research studies in the field of trip generation and transportation planning related field. Although the outcomes of this study is satisfactory, some recommendations for future studies are as follows:

- This study can be extended to the whole 29 wards of the Bharatpur Metropolitan City and other cities of Nepal.
- Study on impact of public transport availability on home based trip generation is recommended for future study.
- This research study was carried out on trip based approach. So, this study can be carried out on activity based approach.
- Impact of seasonal variation, i.e. rainy season and non-rainy season, on trip generation can be studied for better trip generation model development.

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APPENDICES

Appendix-1

ट्रिप जेनेरेसन मोडेल विकासका लागि घरधुरी सर्वेक्षण प्रश्नावली फाराम

"यो सर्वेक्षण प्रश्नावली फाराम ट्रान्सपोर्टेशन इन्जिनियरिङको स्नातकोत्तर तहको थेसिसको लागि तयार पारिएको हो । यसबाट आउने कुनैपनि व्यक्तिगत विवरणहरुको कुनै पनि माध्यमबाट खुलासा हुने छैन र अध्ययन अनुसन्धान हेतु मात्र प्रयोग गरिनेछन् ।"

१. घरधुरी सम्बन्धी

(क) ठेगाना :

(ख) घरमा भएका सदस्यहरुको संख्या : ☐

(ग) पुरुषहरुको जम्मा संख्या : ☐

(घ) महिलाहरुको जम्मा संख्या : ☐

(ङ) घरमा भएका सवारीसाधनहरुको किसिम र संख्या

सि.नं.	सवारी साधनको किसिम	सवारी साधनको संख्या			कैफियत
		निजी	कार्यालय/संस्थाबाट प्राप्त	भाडामा लिइएको	
१	साईकल				
२	मोटरसाईकल				
३	कार/भ्यान				
४	म्याजिक/टेम्पो/अटोरेक्सा				
५	बस				
६	अन्य (विवरण)				

(च) परिवारको मासिक आम्दानी रु. (विदेशी रेमिट्यान्स, भाडा, लगानी, पेन्सन इत्यादी)

(अ) २०,००० भन्दा कम (आ) २०,००० देखि ४०,००० (इ) ४०,००० देखि ६०,००० (ई) ६०,००० देखि ८०,००० (उ) ८०,००० देखि १,००,००० (ऊ) १,००,००० देखि माथी

(छ) घरदेखि मुख्य बजार (चौविसकोटी) सम्मको दुरी (कि.मि.) : ☐

(ज) यात्रा गर्ने सडकको प्रकार

(अ) कालोपत्रे गरिएको सडक (आ) ग्राभेल गरिएको सडक (इ) कच्ची सडक

२. घरका सदस्यहरुको व्यक्तिगत विवरण

सि.नं.	लिङ्ग		उमेर	पेशा	मासिक आम्दानी	सवारी चालक अनुमति पत्र		कार्यालय/विद्यालय/कलेजको ठेगाना	कै.
	पुरुष	महिला				छ	छैन		

३. **<u>यात्रा सम्बन्धी विवरण</u>** (सर्वेक्षण गरिएको दिन भन्दा अघिल्लो दिनको)

सि.नं.	ट्रिप नं.	यात्रा				यात्रा		यात्राको उदेश्य	यात्राको साधन	यात्राको अनुमानित खर्च	कै.
		शुरु गरिएको स्थान		पुग्ने स्थान		छुट्ने समय	पुग्ने समय				
		स्थान वर्गिकरण	ठेगाना	स्थान वर्गिकरण	ठेगाना						

साधन

१. पैदल
२. साईकल
३. मोटरसाईकल
४. कार/भ्यान
५. म्याजिक/टेम्पो/अटोरेक्सा
६. बस
७. अन्य (विवरण)

स्थान वर्गिकरण

1. Home
2. School/University/Education Place
3. Office
4. Factory/Ware House
5. Shop/Shopping Center/Market
6. Restaurant/Other entertainment
7. Hospital
8. Religious Places
9. Other (Specify)

यात्राको उदेश्य

1. To Work
2. To School
3. To Home
4. Business
5. To Shopping
6. Leisure/Recreation
7. Medical/Treatment
8. Other (Specify)

पेशा

1. Employer
2. Employee
3. Unemployed
4. Own Account Worker
5. Unpaid Family Worker
6. Housekeeper
7. Student
8. Others (Specify)

Appendix-2

	Total_Trips	Work_Trip	Shop_Trip	Business_Trip	Leisure_Trip	Educational_Trip	Family_Members	No_Male	No_Female	Non_Motorized	Two_Wheeler	Four_Wheeler	Distance_CBD	Age<18	Age18-60	Age>60	Lisence_Holder_No	Employee_No	Student_No	OAW_No	Unemployed_No	Low_Income	Middle_Income	High_Income	Service	OAW	Unemployed
Total_Trips	1.00	0.38	0.70	0.44	0.62	0.60	0.85	0.66	0.63	0.27	0.47	0.24	-0.14	0.35	0.67	0.24	0.57	0.36	0.60	0.33	0.17	-0.18	-0.32	0.37	-0.09	0.17	-0.22
Work_Trip	0.38	1.00	0.18	-0.32	0.23	0.10	0.34	0.29	0.23	0.07	0.33	0.11	-0.10	0.06	0.34	0.06	0.39	0.92	0.10	-0.38	-0.11	-0.03	-0.13	0.14	0.55	-0.46	-0.21
Shop_Trip	0.70	0.18	1.00	0.18	0.27	0.40	0.53	0.38	0.43	0.18	0.25	0.19	-0.22	0.23	0.44	0.11	0.34	0.23	0.41	0.16	0.09	-0.14	-0.21	0.25	-0.07	0.11	-0.11
Business_Trip	0.44	-0.32	0.18	1.00	0.05	0.03	0.29	0.26	0.18	0.06	0.21	0.27	0.02	0.03	0.25	0.14	0.29	-0.32	0.04	0.84	0.08	-0.07	-0.34	0.36	-0.61	0.69	-0.20
Leisure_Trip	0.62	0.23	0.27	0.05	1.00	0.24	0.50	0.40	0.37	0.14	0.35	0.08	-0.05	0.06	0.40	0.31	0.35	0.26	0.24	0.07	0.32	-0.15	-0.21	0.26	0.05	-0.02	-0.08
Educational_Trip	0.60	0.10	0.40	0.03	0.24	1.00	0.68	0.50	0.54	0.28	0.16	-0.04	-0.10	0.67	0.41	-0.03	0.19	0.07	1.00	-0.02	-0.03	-0.08	0.06	-0.03	0.05	-0.05	-0.01
Family_Members	0.85	0.34	0.53	0.29	0.50	0.68	1.00	0.77	0.76	0.36	0.41	0.08	-0.02	0.49	0.68	0.38	0.48	0.35	0.68	0.26	0.44	-0.12	-0.15	0.19	-0.03	0.10	-0.19
No_Male	0.66	0.29	0.38	0.26	0.40	0.50	0.77	1.00	0.17	0.24	0.41	0.15	-0.02	0.31	0.55	0.32	0.51	0.29	0.50	0.23	0.33	-0.10	-0.14	0.18	0.01	0.08	-0.24
No_Female	0.63	0.23	0.43	0.18	0.37	0.54	0.76	0.17	1.00	0.31	0.23	-0.02	0.00	0.44	0.49	0.26	0.22	0.25	0.55	0.17	0.34	-0.08	-0.08	0.11	-0.06	0.08	-0.05
Non_Motorized	0.27	0.07	0.18	0.06	0.14	0.28	0.36	0.24	0.31	1.00	-0.12	-0.26	0.23	0.34	0.16	0.10	-0.13	0.03	0.28	0.12	0.20	-0.01	0.11	-0.11	-0.08	0.09	-0.02
Two_Wheeler	0.47	0.33	0.25	0.21	0.35	0.16	0.41	0.41	0.23	-0.12	1.00	0.00	-0.01	0.01	0.39	0.20	0.71	0.37	0.16	0.15	0.06	-0.23	-0.23	0.30	0.07	0.00	-0.17
Four_Wheeler	0.24	0.11	0.19	0.27	0.08	-0.04	0.08	0.15	-0.02	-0.26	0.00	1.00	-0.09	-0.14	0.16	0.08	0.37	0.09	-0.02	0.14	-0.04	-0.07	-0.42	0.44	-0.09	0.13	-0.09
Distance_CBD	-0.14	-0.10	-0.22	0.02	-0.05	-0.10	-0.02	-0.02	0.00	0.23	-0.01	-0.09	1.00	-0.09	0.04	0.01	-0.13	-0.11	-0.11	0.09	0.15	-0.05	0.07	-0.06	-0.09	0.09	0.00
Age<18	0.35	0.06	0.23	0.03	0.06	0.67	0.49	0.31	0.44	0.34	0.01	-0.14	-0.09	1.00	-0.09	0.02	-0.06	0.03	0.67	-0.01	0.06	0.01	0.14	-0.15	0.01	-0.01	0.00
Age18-60	0.67	0.34	0.44	0.25	0.40	0.41	0.68	0.55	0.49	0.16	0.39	0.16	0.04	-0.09	1.00	-0.15	0.53	0.37	0.41	0.25	0.16	-0.18	-0.18	0.24	0.02	0.08	-0.25
Age>60	0.24	0.06	0.11	0.14	0.31	-0.03	0.38	0.32	0.26	0.10	0.20	0.08	0.01	0.02	-0.15	1.00	0.17	0.06	-0.03	0.15	0.58	0.04	-0.17	0.16	-0.12	0.11	0.02
Lisence_Holder_No	0.57	0.39	0.34	0.29	0.35	0.19	0.48	0.51	0.22	-0.13	0.71	0.37	-0.13	-0.06	0.53	0.17	1.00	0.41	0.19	0.22	0.04	-0.24	-0.36	0.44	0.00	0.09	-0.23
Employee_No	0.36	0.92	0.23	-0.32	0.26	0.07	0.35	0.29	0.25	0.03	0.37	0.09	-0.11	0.03	0.37	0.06	0.41	1.00	0.06	-0.40	-0.11	-0.07	-0.09	0.11	0.58	-0.49	-0.22
Student_No	0.60	0.10	0.41	0.04	0.24	1.00	0.68	0.50	0.55	0.28	0.16	-0.02	-0.11	0.67	0.41	-0.03	0.19	0.06	1.00	-0.02	-0.04	-0.08	0.05	-0.03	0.04	-0.04	-0.01
OAW_No	0.33	-0.38	0.16	0.84	0.07	-0.02	0.26	0.23	0.17	0.12	0.15	0.14	0.09	-0.01	0.25	0.15	0.22	-0.40	-0.02	1.00	0.04	-0.03	-0.26	0.27	-0.68	0.76	-0.22
Unemployed_No	0.17	-0.11	0.09	0.08	0.32	-0.03	0.44	0.33	0.34	0.20	0.06	-0.04	0.15	0.06	0.16	0.58	0.04	-0.11	-0.04	0.04	1.00	-0.01	-0.02	0.02	-0.11	0.08	0.08
Low_Income	-0.18	-0.03	-0.14	-0.07	-0.15	-0.08	-0.12	-0.10	-0.08	-0.01	-0.23	-0.07	-0.05	0.01	-0.18	0.04	-0.24	-0.07	-0.08	-0.03	-0.01	1.00	-0.16	-0.17	0.01	0.00	-0.04
Middle_Income	-0.32	-0.13	-0.21	-0.34	-0.21	0.06	-0.15	-0.14	-0.08	0.11	-0.23	-0.42	0.07	0.14	-0.18	-0.17	-0.36	-0.09	0.05	-0.26	-0.02	-0.16	1.00	-0.95	0.18	-0.20	0.06
High_Income	0.37	0.14	0.25	0.36	0.26	-0.03	0.19	0.18	0.11	-0.11	0.30	0.44	-0.06	-0.15	0.24	0.16	0.44	0.11	-0.03	0.27	0.02	-0.17	-0.95	1.00	-0.18	0.20	-0.04
Service	-0.09	0.55	-0.07	-0.61	0.05	0.05	-0.03	0.01	-0.06	-0.08	0.07	-0.09	-0.09	0.01	0.02	-0.12	0.00	0.58	0.04	-0.68	-0.11	0.01	0.18	-0.18	1.00	-0.92	-0.19
OAW	0.17	-0.46	0.11	0.69	-0.02	-0.05	0.10	0.08	0.08	0.09	0.00	0.13	0.09	-0.01	0.08	0.11	0.09	-0.49	-0.04	0.76	0.08	0.00	-0.20	0.20	-0.92	1.00	-0.21
Unemployed	-0.22	-0.21	-0.11	-0.20	-0.08	-0.01	-0.19	-0.24	-0.05	-0.02	-0.17	-0.09	0.00	0.00	-0.25	0.02	-0.23	-0.22	-0.01	-0.22	0.08	-0.04	0.06	-0.04	-0.19	-0.21	1.00

Appendix-3: Descriptive Statistics of Data used for Analysis

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Family_Members	434	8	1	9	1659	3.82	.068	1.419	2.012
No_Male	434	6	0	6	818	1.88	.045	.932	.869
No_Female	434	5	1	6	840	1.94	.044	.922	.850
Non_Motorized	434	4	0	4	349	.80	.033	.697	.486
Two_Wheeler	434	4	0	4	433	1.00	.032	.664	.441
Four_Wheeler	434	2	0	2	74	.17	.019	.389	.151
Distance_CBD	434	19.0	1.0	20.0	2491.5	5.741	.2000	4.1669	17.363
Age<18	434	4	0	4	263	.61	.038	.786	.618
Age18-60	434	8	0	8	1205	2.78	.054	1.128	1.273
Age>60	434	5	0	5	188	.43	.033	.694	.482
Lisence_Holder_No	434	5	0	5	589	1.36	.042	.883	.780
Employee_No	434	5	0	5	364	.84	.038	.794	.630
Student_No	434	5	0	5	497	1.15	.046	.951	.905
OAW_No	434	3	0	3	305	.70	.032	.670	.450
Unemployed_No	434	4	0	4	489	1.13	.035	.723	.522
Valid N (listwise)	434								

Descriptive Statistics

	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Total_Trips	434	16	2	18	3228	7.44	.140	2.909	8.464
Work_Trip	434	5	0	5	435	1.00	.048	1.009	1.018
Shop_Trip	434	5	0	5	910	2.10	.045	.932	.868
Business_Trip	434	7	0	7	574	1.32	.066	1.368	1.873
Leisure_Trip	434	5	0	5	748	1.72	.050	1.036	1.073
Educational_Trip	434	5	0	5	493	1.14	.046	.953	.908
Valid N (listwise)	434								

Frequencies

Statistics

		Income	Occupation_ Main
N	Valid	434	434
	Missing	0	0

Frequency Table

Income

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	High_Income	82	18.9	18.9	18.9
	Low_Income	12	2.8	2.8	21.7
	Middle_Income	340	78.3	78.3	100.0
	Total	434	100.0	100.0	

Occupation_Main

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	OAW	217	50.0	50.0	50.0
	Service	199	45.9	45.9	95.9
	Unemployed	18	4.1	4.1	100.0
	Total	434	100.0	100.0	