

**STUDY ON TRIP GENERATION CHARACTERISTICS
OF NEW APARTMENT BUILDINGS
IN THE COLOMBO CITY**

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Degree of Master of Science in Transportation

Department of Civil Engineering

University of Moratuwa

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Thesis/Dissertation submitted in partial fulfillment of the requirements for
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DECLARATION OF THE CANDIDATE AND SUPERVISOR

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Abstract

Colombo city as the economic hub of Sri Lanka is attracting more and more people day by day and most of them wanted to settle nearby Colombo city. Therefore, many high-rise apartment buildings have been constructed and many more projects are planned in and around Colombo.

Currently, an apartment building can be classified as low, middle or high-income based on the prize of the unit and the facilities provided for the housing unit. The impact of traffic generated by each category varies with the frequency, time and mode of vehicle travel. In general, generalizing the travel patterns of apartment buildings is quite difficult as it has highly distributed traffic flow throughout the day. There are many land use activities that can affect the flow of neighbourhood traffic, but this research is limited to study the impact on traffic flow by residential developments in operational phases.

The impact of different types of apartment buildings on traffic flow and trip generation rates is very important and useful in making decisions. However, when consider the Sri Lankan context there is no comprehensive study to measure those details. As per the existing practice, the parking demand of the apartment building is estimated based on the unit floor area and no standards have been developed to estimate the trip generation of different type of apartments. Therefore, this study aims to study the trip generation rates for each apartment type and the most suitable parking requirements for different apartment types.

During this study, apartments were selected under three main categories as Low, middle and high income category based on the available facilities and unit price. For this study, 15 apartments as 5 from each category spread over the Colombo Municipal Council area, were selected. The number of occupied housing units, vehicle ownership rate, number of visitors and visitor's vehicle composition were collected by an on-site observation survey, while traffic counts and vehicle composition were collected by a traffic survey. Satisfaction level of the unit owner on the parking facilities provided was collected via questionnaire survey.

Trip generation rate per apartment unit and mode of the vehicle were analyzed individually and compared with each apartment type. Correlation analysis was conducted to study the relationship between trip generations against average unit floor area, average number of bedrooms in occupied units and unit price were analyzed to identify suitable parameter to determine parking requirement of a housing unit. A unit owner's perception was analyzed to check visitor's parking requirements.

During the analysis, it was found that middle income apartments have reported overall highest trip share percentage in morning and evening peak while high income and low income apartments are taking 2nd & 3rd place respectively. Low income apartments have reported high trip share in the day time while high income reported lowest trip share Middle income apartment has the highest per unit trip generation rate. When consider the vehicle composition, car has reported the highest percentage in each apartment category with the highest percentage in the middle income category.

The only unit floor area was found as a suitable criteria for determining traffic generation or parking requirement of an apartment unit, but the average unit price and number of bedrooms per unit are found not significant. Visitor's parking space requirement for cars is between five to ten percent of the total parking requirements while less than five percent is enough for motorcycles and three wheels

Keywords: *Trip generation, Parking requirement*

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LIST OF ABBRIVIATIONS

CMC	Colombo Municipal Council
CCDP	City of Colombo Development Plan
HI	High Income
IHT	Institution of Highways and Transportation
ITE	Institute of Transportation Engineers
LI	Low Income
MC	Municipal Council
MI	Middle Income
TIA	Traffic Impact Assessment
UDA	Urban Development Authority
USA	United State of America

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CHAPTER ONE

1. INTRODUCTION

1.1. Background

An apartment building is a multi-storied building which contains a number of apartment units on different floors. The apartment developments based on its height can be categorized such as low rise, intermediate rise, middle rise & high rise building (UDA, 2008). Also apartments are called as low income, middle income and high income based on the unit prices. But there is no proper definition or demarcation for such categorization.

The generated traffic from each category above will vary in term of the vehicle count, time and vehicle mode, and it directly affect on the existing vehicle flow of the nearby road network.

“Trip generation is the first step in the conventional four-step transportation forecasting process commonly used in the impact analysis. A trip is defined as a one-way person movement by one or more modes of travel and having an origin and a destination” (Regidor, 2006). “Trip generation studies have been conducted since the 1960s in the USA and Canada and from that time vehicular trip generation data was collected and analysed until the Institute of Transportation Engineers (ITE) published the first edition of Trip Generation Manual in 1976” (Khaled Al-Sahili, Sameer Abu Eisheh and Fawz Kobari, 2018)

1.2. Problem Statement

Basically, people who are daily travelling for their works into any urban area is concerning about their travel time. The majority of them wanted to settle within the urban area or at least closer to the periphery of the urban area due to the factors such as short distance to the reputed school and easy access to working place & other amenities. Therefore, more demand is created for residential uses within the urban areas in Sri Lanka and predominantly low rise & middle rise apartment developments can be seen in the general urban areas to serve for such housing demand.

Colombo city as the economic hub of Sri Lanka is attracting more and more people every day as compared to other urban areas. Due to the land scarcity in Colombo City & the immediate surrounding area, more demand is created for the high rise apartment buildings.

Apartment buildings at present categorized as low, middle & higher income based on the price of a housing unit and available facilities within the apartment building. The impact of traffic generated by each category varies with the frequency, time, mode of vehicle travel, and it directly affect on the existing vehicle flow of the nearby road networks. Generally, traffic flow generated from office building can be predicted easily since there is peak in the morning and evening. But when considers the traffic pattern of apartments it is somewhat difficult to generalize as it has a highly distributed traffic flow throughout the day.

Obviously, there is an impact to traffic flow change due to the traffic generated from each type of apartments and investigations of trip patterns from apartment buildings & traffic generation rate are very important and useful in making decisions.

However, when consider the Sri Lankan context there is no comprehensive study to quantify the trip generation rates for different type of apartment buildings. As per the existing practice, the parking demand of the apartment building is calculated based on the unit floor area and there is no manual focuses on prediction of trip generations in Sri Lanka. However, in other countries the number of bedrooms is used as criteria for deciding minimum legal parking requirements for apartment buildings. Therefore, this research aims to study the trip generation rates and the travel patterns of the residents of apartment buildings to identify **“Study on trip Characteristics of Apartment Buildings in the Colombo City”**

1.3. Objectives of the study

The specific objectives of this study are,

- i. Estimate trip generation patterns due to different types of apartment buildings
- ii. To identify the relationship between trip generation and other variables such as unit price, unit floor area and number of bedrooms
- iii. To identify the actual parking requirements for the apartment category including visitor parking
- iv. To identify the user's satisfaction on provided parking facilities

1.4. Scope and Limitations

- This research considered three types of apartment buildings based on the unit price and available facilities within the Colombo Municipal Council area
- Trip generation during the operational stage were considered for this study

1.5. Study Approach

The below approach has been followed throughout the research process in order to achieve the research objectives.

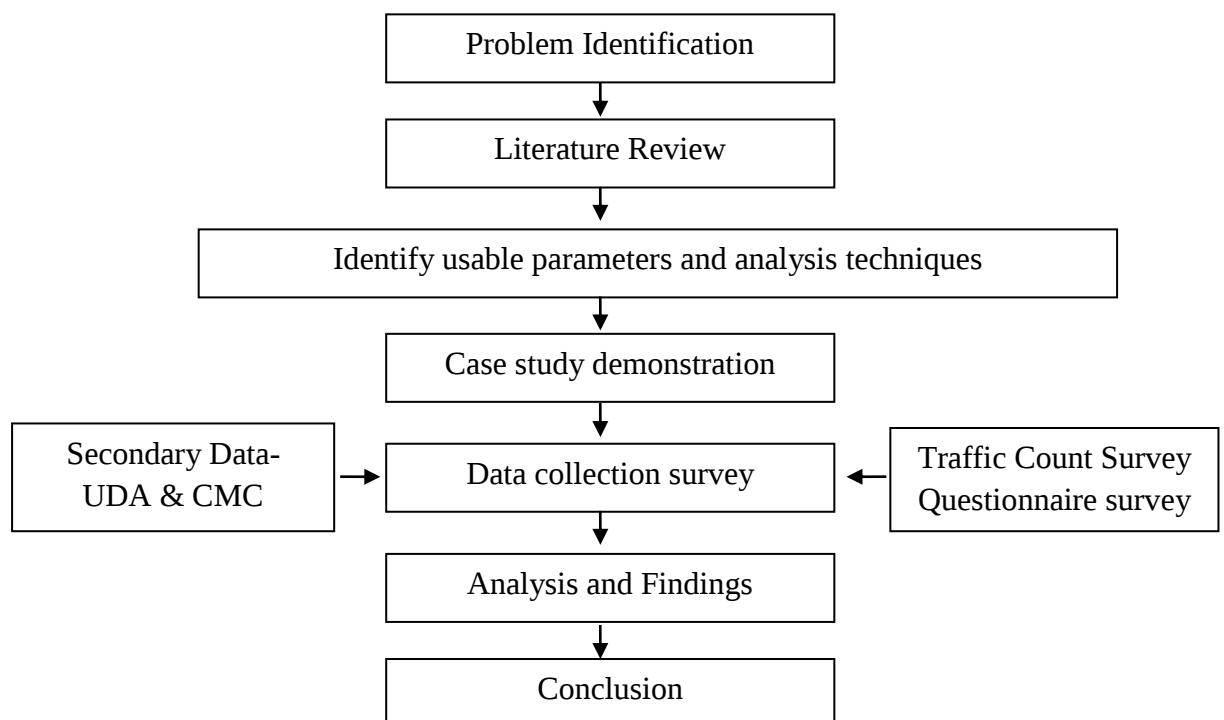


Figure 1-1 Study approach

CHAPTER TWO

2. LITERATURE REVIEW

This chapter focuses on the review of literature related to the previous studies to evaluate the relationship between land use & traffic flow and Traffic Impact Assessment (TIA) conducted by the different countries. The main focus here is to identify the suitable indicators to estimate traffic generation and analytical methods which used for the same kind analysis. A considerable amount of researches has been conducted by the Institute of Transportation Engineers (ITE), US and Institution of Highways and Transportation (IHT), Europe while only a few studies in Asian cities.

2.1 Apartments

An apartment building is a tall building which contains different apartments on different floors (wikipedia, 2022). Apartment building can be categorized as;

Table 2-1 Apartment categorization

Category by	Category levels	Category
Levels	Low rise	0 – 4 floors
	Inter Mediate rise	5- 8 floors
	Middle Rise	9 – 12 floors
	High Rise	Above 12 floors
Unit Price	Low income	Less than Rs.10mn
	Middle income	Rs. 10- 25mn
	High Income	More than Rs.25mn

Source: (UDA, 2008)&, (Perera, 2015)

In this study, fifteen apartments were selected under three main categories as Low, middle and high income category based on the available facilities and unit price as per the above breakdowns. This research is totally based on the traffic flow generated by the residential apartments which located in the Colombo Municipal Council Area.

2.1.1 Independent parameters in apartment units

One objective of this study is to check the relationship between trip generation and the independent variables in the apartment in order to identify which variable is more affected for traffic generation in each apartment. Accordingly, the number of occupied units, unit floor area, number of bedrooms & unit price were selected as independent variables for this study.

a. Size of the developments in number of units

“It is hypothesized that the higher the income of household or individual the greater the tendency to live in smaller developments at lower densities with large residential units: as opposed to households with lower income living in large high density developments with small residential units such as flats” (P Peska and C Venter, 2009)

b. Density development/ Unit floor area

“It is hypothesized that the higher the income of a household or individual, the greater the tendency to live in a larger unit with more private space in a lower density development; as opposed to a household or individual with a lower income living in a smaller unit, with less private space, in a higher density development” (P Peska and C Venter, 2009)

c. Number of bedrooms

“The number bedrooms are directly linked to the size of the unit and can be logically linked to the income of the residents. The greater the number of bedrooms in a unit; the greater the size of the unit; the greater the size of the unit, the higher the bond repayment or the rent; the higher the bond repayment or rent, the higher the income of the household” (P Peska and C Venter, 2009)

2.2 Traffic Flow

“Traffic flow is the study of interactions between travelers (including pedestrians, cyclists, drivers, and their vehicles) and infrastructure (including highways, signage, and traffic control devices), with the aim of understanding and developing an optimal transport network with efficient movement of traffic and minimal traffic congestion problems” (wikipedia, 2022)

2.2.1 Traffic Flow Parameters

Few traffic study reports done for the apartment developments by other countries were reviewed and observed that following parameters were used commonly in every assessment. (Beaton, 2019) (Ewing, 2017)

- a. Trip generation (In & out)
- b. Parking generation
- c. Traffic distribution by mode / Vehicle composition
- d. Traffic distribution by direction
- e. External traffic growth
- f. Intersection turning movement volumes

The objective of this study is to examine the trip generation rates and the travel patterns of the residents of apartment buildings in order to identify how the new apartments contribute to traffic flow increase in the surrounding area. Therefore, Trip generation (In & Out), traffic distribution by mode and parking generation were selected as suitable parameters for this study.

a. Trip Generation

Trip generation is “the first step in the conventional four-step travel forecasting process commonly used in impact analysis. A trip is defined as a one-way person movement by one or more modes of travel and having an origin and a destination” (Regidor, 2006). “Trip generation studies have been conducted since the 1960s in the USA and Canada and from that time vehicular trip generation data was collected and analyzed until the Institute of Transportation Engineers (ITE) published the first edition of Trip Generation Manual in 1976” (Khaled Al-Sahili, Sameer Abu Eishah and Fawz Kobari, 2018)

The South Africa Trip Generation Rates document recommends peak our trip rates of 0.5 trips per dwelling unit for low income areas, 1.1 trips per dwelling unit for middle income area, 1.5 trips for high income areas” (Transportation, 1995)

b. Parking Generation

Parking is “a derivative of trip generation, wherein the term parking generation is used to refer as the parking spaces required as a result of trip attraction” (Regidor, 2006). “The practice of transportation engineering and planning has employed trip and parking generation rates to determine the number of trips generated by developments, as well as the required number of parking spaces for facilities” (Regidor, 2006)

c. Traffic distribution by mode / Vehicle composition

Type of vehicle that used by unit owners and vehicle composition by percentage have been discussed in most of the research and bicycle, motor bicycle, three wheel, car, bus & lorry were identified as basic mode of vehicles (Beaton, 2019) (Ewing, 2017)

2.3 Parking requirement standards

Parking requirement standard is a regulation or a code that use to regulate providing of minimum requirement of parking spaces to operate a particular activity while maintaining smooth vehicle movements in and around the site. Arrangement of such parking lots and access for the parking lots are also guided under the parking standards. The main intention of the imposing parking standards is to ensure the accommodation of vehicles which attracted to the premises with assessing development proposals. Further, followings two paragraphs are discussed more about the parking requirement standards in Sri Lankan context and other countries.

2.3.1. Sri Lankan context

In the Sri Lankan context, the Urban Development Authority (UDA) holds the power to formulate and published planning and building regulations related to the construction developments. Parking requirement standards are one of the main set of regulation published and implemented under each Development Plan prepared by the UDA. Basically, the legal parking requirement is guided based on the unit floor area and number of units, but it may change from the Development Plan to plan. However, in 2021 UDA has published common parking standards including visitor’s parking requirements which apply for each local authority area.

2.3.1.1. Parking standards for residential buildings

Table 2.2 shows the existing and past regulations practice in the Sri Lanka to calculate parking requirements for residential buildings.

Table 2-2: Parking standards for residential buildings in Sri Lanka

Document	Criteria	Regulation
Planning & Development Regulation 2021, UDA	Single housing unit (less than or equal 400m ²)	1 space + additional 1 space area exceeds 400m ²
	Apartment – Category 1 (with or without pool, gym, supermarkets)	1 space per unit + additional 1 space area exceeds 200m ² + 1 visitor parking for every 10 units
	Apartment – Category 2 (with luxury facilities (club, Penthouse) other than category 1	2 space per unit + 1 visitor parking for every 10 units
City of Colombo Development Plan) - 2022	Less than 200m ² of unit floor area	1 for 1 unit
	Over 200m ² of unit floor area	2 for 1 unit
	Visitors parking	one space for 10 units up to first 20 units and after that one space for every 20 units
City of Colombo Development Plan (Amendment) - 2008	Less than 75m ² of unit floor area	1 for 2 units
	75 - 200m ² of unit floor area	1 for 1 unit
	Over 200m ² of unit floor area	3 for 2 units
Development Plan prepared for Maharagama, Kaduwela, Kotte & Homagama - 2008	Dwelling houses	1 for 1 unit
	Flats	1 for 1 unit
Development Plan prepared for Dehiwala MC area - 2008	Less than 75m ² of unit floor area	1 for 2 units
	Over 75m ² of unit floor area	1 for 1 units
Gazette notification number 392/9 dated 10/03/1986	Dwelling houses exceeding 200m ² of unit floor area	1 for 1 unit
	Flats exceeding 100m ² of unit floor area	1 for 1 unit
	Flats less than 100m ² of unit floor area	1 for 5 unit or 1 for 200m ² whichever is high

Source: Urban Development Authority

2.3.1.2. Parking standards for parking space

Table 2.3 shows the standard dimensions for parking stall for each vehicle type.

Table 2-3: Parking Standard for parking space

Vehicle Type	Stall width (Angled or Parallel Parking)	Stall width (Angled or Parallel Parking)	Stall Length (Parallel Parking)
Cycles	0.6m	2.25m	2.25m
Two & Three wheels	2.1m	2.4m	2.5m
Standards	2.4m	4.8m	5.5m
Commercial (Two Axle)	3.6m	10m	12m
Commercial (Multi Axle)	3.6m	18m	20m

Source: Urban Development Authority

2.3.1.3. Parking standards for driveway

Table 2.4 shows the standard dimensions for vehicle driveway with different parking angles.

Table 2-4: Parking standards for driveway

Parking angle (Degree's)	One way traffic one side bays	One way traffic two side bays	Two way traffic
00 degree - Parallel	3.6m	3.6m	6.0
30 degree -Angle	3.6m	4.2m	6.0
45 degree -Angle	4.2m	4.8m	6.0
60 degree -Angle	4.8m	4.8m	6.0
90 degree -Angle	6.0m	6.4m	7.2

Source: Urban Development Authority

2.3.1.4. Parking requirement for differently able peoples

Parking requirement standards for differently able people is guided by the Gazette notification number 1467/15 dated 17/10/2006 published by Ministry of Social Service and Social Welfare. In this Gazette notification, it was stated that “Every parking area shall have designated parking spaces for disabled drivers and passengers and such space shall be located as close as possible to main entrance and exits of buildings”. Minimum stall width and length of the parking lot of standard vehicles provided for different peoples should be 3.6m & 4.8m respectively. The minimum number of assessable space to be provided shall be as follows

Table 2-5: Minimum number of assessable space for differently able peoples

Total number of parking space in open car park or car park building	Required minimum number of accessible spaces
01 - 25	1
26 - 50	2
51 - 75	3
76 - 100	4
101 - 150	5
151 - 200	6
201 - 300	7
301 - 400	8
401 - 500	9
Over 500	2% of the total

Source: Ministry of Social Service and Social Welfare.

2.3.2. Other countries context

Even in the other countries, the legal parking requirement standards are published under the development plans prepared for the different municipally areas. However, most of the countries have used number of bedrooms as criteria for deciding minimum legal parking requirements for apartment buildings.

2.3.2.1. Parking standards for residential buildings

Table 2.6 shows some regulations or codes that are using in overseas countries to calculate parking requirements for residential buildings

Table 2-6: Parking standards for residential buildings in other countries

Document	Criteria	Regulation
National Building Code (P.D. 1096) of the Republic of the Philippines, 2004	Less than 50m ² of unit floor area	1 for 6 units
	50 - 100m ² of unit floor area	1 for 4 unit
	Over 100m ² of unit floor area	1 for 1 units
Institute of Transportation Engineers, Transportation and Land Development	Single family dwellings	2 space per 1 unit
	Multi-family dwelling with 3 or more bedrooms	2 space per 1 unit
	Multi-family dwelling unit with 1 or 2 bedrooms	1.5 space per 1 unit
	Multi-family efficiency dwelling unit	1 space per 1 unit
Vehicular Access Standards, 2 nd edition, 1999	1 Bed apartment unit	1.5 per unit
	2 Bed apartment unit	1.75 per unit
	3 Bed apartment unit	2.0 per unit
	1& 2 bed terrace house	1.75 per unit
	3 bed terrace house	2.0 per unit
(Parking Standards Design and Good Practice Supplementary Planning Document, 2010) by Rochford District Council, UK	1 Bed room	1 for 1 units
	2 & more Bed room	2 for 1 units
	Retirement developments	1 for 1 units
	Visitors	1 for 4 units
(Parking Standards, 2011) by Moray Council, UK	House – 4 or more bed rooms	3 for 1 units
	House – 3 or less bed rooms	2 for 1 units
	Flats – up to 2 bed rooms	1.5 for 1 units
	Affordable housing – 3 or more bed rooms	2 for 1 units
	Affordable housing – 2 or less bed rooms	1 for 1 units
	Sheltered housing	1 for 1 units
	Houses in multiple occupancy	1 for 1 units

2.3. Data Collection Methods

Field surveys during the morning and afternoon peak periods, Vehicle trips counts, attracted vehicle trips counts, generated vehicle trips counts, peak hour trips count, manual traffic counts surveys, personal interviews and observation surveys can be identified as data collection methods that used in the past studies which conducted to evaluate trip generation rate for hospitals (Naser, 2015), to estimate trip generation rates for retirement homes and villages in South Africa (J Roux and M Bruwer, 2017) and Estimation of new development impacts through trip generation rates for major land uses in Palestine (Khaled, 2018)

2.4. Analytical methods

Common analytical methods that used in the past studies can be identified as correlation analysis between traffic counts and the independent variables, regression analysis, multi variate analysis, bivariate analysis, bar chart and pie chart comparisons. (Chris De Gruyter, Seyed Mojib Zahraee, Nirajan Shiwakoti, 2021)

In some research, multiple linear regression analysis and weighted average trip rate analysis were used to identify the independent variable that produced the most stable relationship and the highest coefficient of determination (P Peska and C Venter, 2009)

CHAPTER THREE

3. RESEARCH METHODOLOGY

This chapter describes methods used for the data collection and the analysis and a description about the selected case study. Traffic flow indicators such as trip generation (In & Out), traffic distribution by mode and parking generation which have been identified in the literature review were taken as study parameters.

3.1. Introduction to Study Area

It is well-known that the Colombo City is the economic hub of Sri Lanka and being the commercial capital and largest city, it is attracting more and more people day by day and most of them wanted to settle nearby Colombo city. As a result, Colombo City has more attraction for the housing developments.

Therefore, Colombo Municipal Council area was selected as the case study area for this research. It has about 37km² in extent consisting 47 administrative wards under 15 postal codes and it is located in Colombo District in Western Province as shown in figure 3.1 below

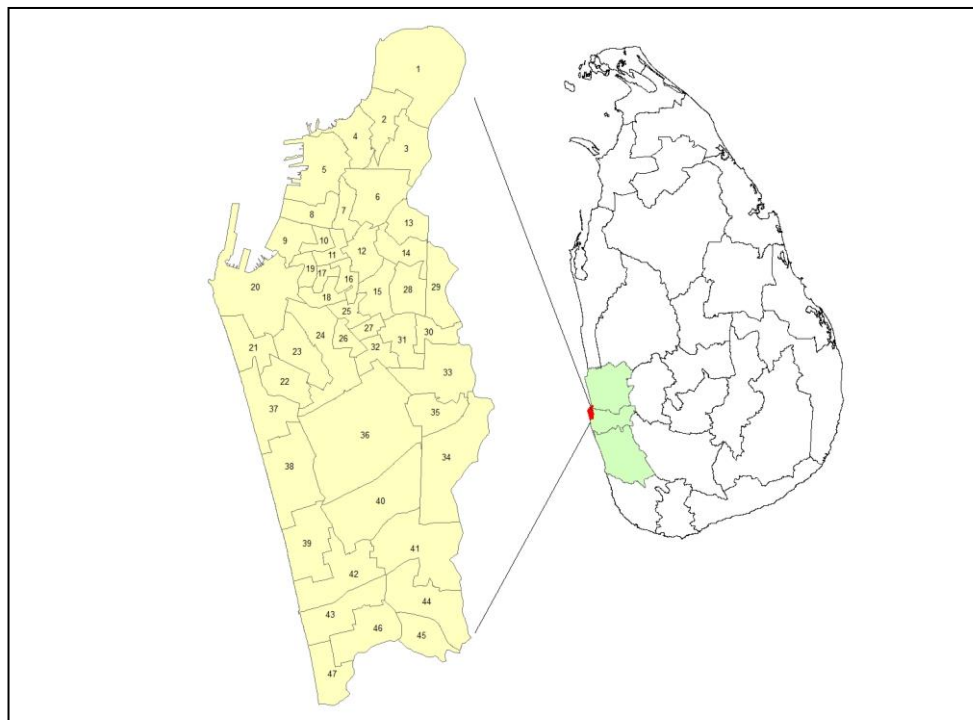


Figure 3-1: Location of Colombo Municipal Council Area

3.2. Method of study

Figure 3-2 shows the overall process of the study method from selection of case studies level up to the analysis and finding level. Details of each step are described under following paragraphs.

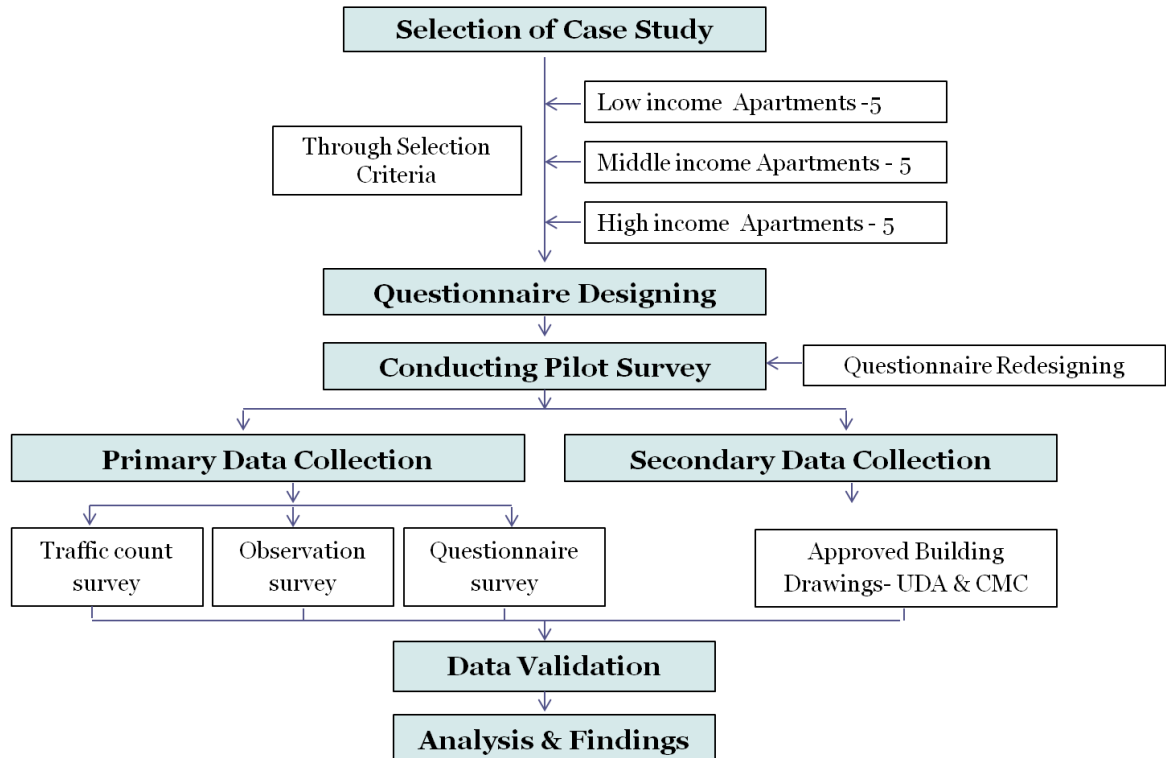


Figure 3-2: Method of study

3.3. Selecting of samples for Case Study

Fifteen apartments (Five each from low, middle & high income category) located over the Colombo Municipal Council area were selected for this study while using the following selection criteria.

- As per the Institute of Transportation Engineers manual – 2012, at least three (preferable five) site should be surveyed
- Minimum of 60% housing units should be occupied because there should be a sufficient crowd for the survey (It is not expected to have 60% of the occupancy throughout the year but at a given time)
- It should be at least one-year-old because traffic flow of the apartment should be fit out to the existing traffic flow

- Those apartments should be located and spread out within the Colombo Municipal Council since this research scope is confined to the Colombo Municipal Council area
- Data should be available for collection, especially secondary data like approved building plan
- It should be approved one in order to ensure the providing of minimum of parking requirement as per the prevailing regulations

3.4. Selected Apartments for survey

Altogether, fifteen apartments, five from each category which located over the Colombo Municipal Council area were selected for this study. Table 3-1 shows the selected apartments in each category. Hereafter high, middle & low income apartments are referred as HI, MI & LI respectively

Table 3-1: Selected apartments for survey

Apartment type	Apartment	No. of floors
High Income (HI)	HI1. Havelock City at Wellawatta	28
	HI2. Prime Residencies at Castle street	12
	HI3. Prime Residencies at Kyncy Road	8
	HI4. Capitol Seven at Rosmead Place	6
	HI5. Capitol Elite at Horton Place	6
Middle income (MI)	MI1. Prime Residencies at Edmonton Road	10
	MI2. Trillium Residencies at Torrinton Avenue	6
	MI3. Prime Residencies at Rajawatta Terrace	7
	MI4. Barnes Residencies at Barnes Place	5
	MI5. Capitol Residencies at Dharmapala Mawatha	13
Low income (LI)	LI1. Rose Bank Residency at Barnes Place	3
	LI2. Span Towers at Kalyani Road	9
	LI3. Orchard Tower at Wellawatta	7
	LI4. HR Residencies at Maya Avenue	8
	LI5. Sinsapa Road at Wellawatta	9

3.5. Location of the selected apartments

Figure 3.3 shows the locations where selected apartments are located within the Colombo Municipal Council area. Basically selected high income apartments were located in the Central area while low income & middle apartments were located in the South Colombo

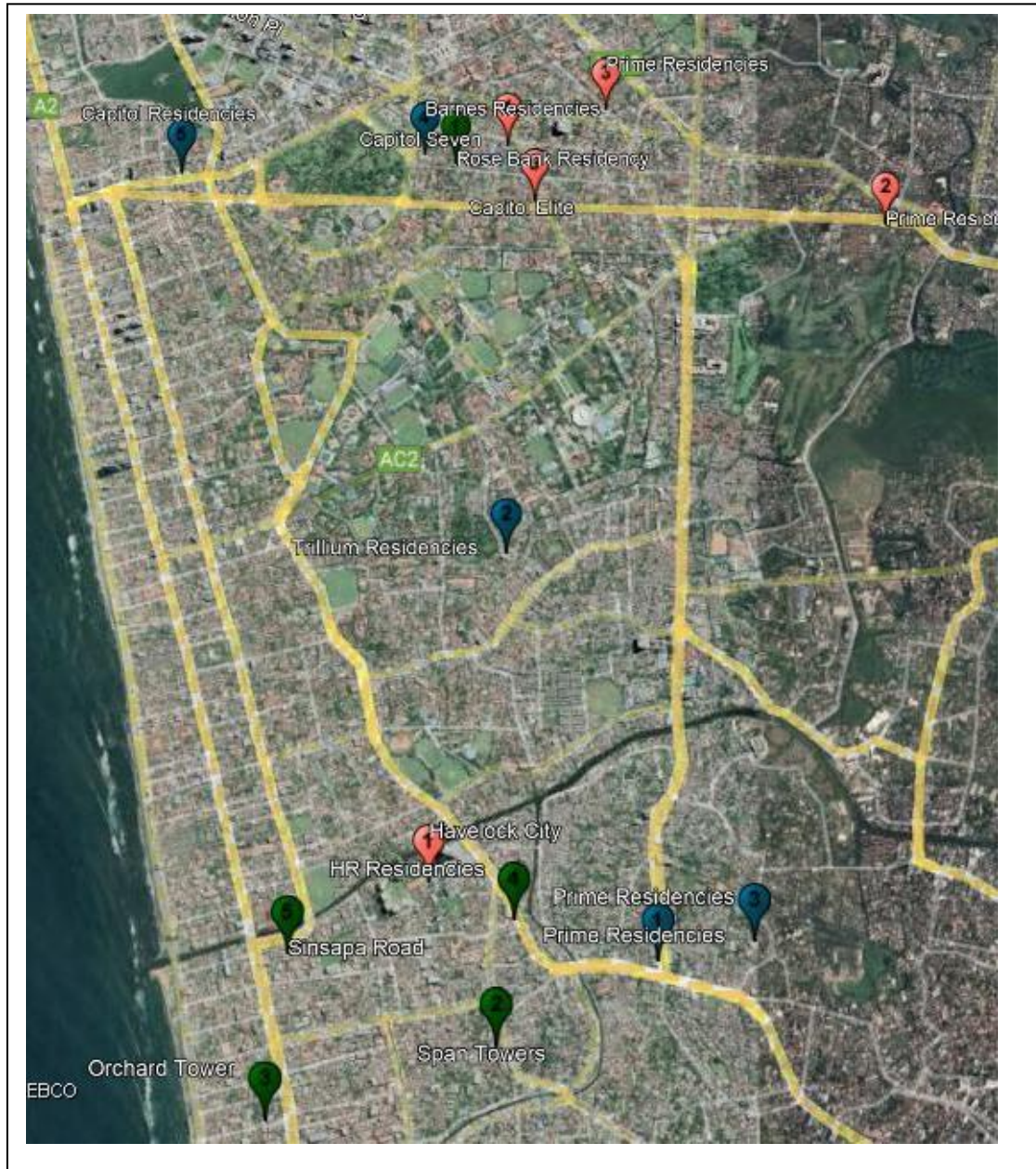


Figure 3-3: Location of the selected apartments

3.6. Method of data collection

Traffic count survey, onsite observation survey and interview survey from unit owners were carried out to collect primary data. Secondary data was collected from approved building plans through Colombo Municipal Council & Urban Development Authority.

3.6.1. Traffic count survey

Separate survey sheet (Appendix A) was prepared for the traffic count survey. A survey was conducted on a weekday during 0600 to 1800 hours in front of the main vehicle entrance & exit gates of each apartment building. Basically, apartment type, vehicle count (in & out) and vehicle type (in & out) were collected from all selected 15 apartments.

3.6.2. Interview of unit owners

Interview survey was conducted on the same day of the traffic counting. In each apartment building, randomly selected 05 unit owners (total of 75 unit owners) who were available at the premises in the survey time were interviewed using a questionnaire sheet (Appendix B). Apartment type, number & type of vehicles owned by the unit owner, number of visitors coming per day, week & month and visitor's vehicle type were collected through interview survey. Apart from that, a unit owner's satisfaction level regarding provided facilities such as the number of parking spaces provided in housing unit, the size of the parking space, vehicle driveway width, arrangement of the parking space, ramp arrangement of multi-level parking, mechanical parking and provided number of parking lots for visitors were collected.

3.6.3. Interview of premises manager

A specific survey sheet (Appendix C) was prepared for the interview with a premises manager or chief security officer. Number of total housing units, number of housing units occupied, number of total parking lots provided, number of parking lots occupied, the number of illegal parking lots and parking allocated for visitors were collected during this survey.

3.6.4. Interview of Developers

According to the nature of this research, it is very much important to identify high income, middle income & low income apartments separately. The type of apartment is decided based on the unit price and provided facilities. During the literature survey, the price range for above apartment types were found from a document prepared in 2015. However, no documents found to take latest unit price ranges for these apartment types. Therefore, it was decided to interview apartment developers (7Nos) of the selected apartments in order to collect data regarding latest price ranges, average unit floor area and type of facilities provided respective to the apartment types. Separate survey sheet (Appendix D) was prepared for this survey.

3.6.5. Secondary data collection

Basically, secondary data relevant to the apartment buildings was collected from approved building plans which were approved by the Colombo Municipal Council or Urban Development Authority. Type of the apartment, number of floors, number of housing units, unit floor area, number of bedrooms per unit (Unit type), number of parking lots (including for visitors) provided in the drawing were collected accordingly.

3.7. Method of analysis

Analysis was conducted by using SPSS & EXCEL software. Traffic generation rate per unit, daily traffic generation pattern, and compositions of vehicles were derived individually and compared with each apartment category. Scatter diagrams were built up and correlations were tested with traffic generation versus number of units occupied, number of bedrooms, average unit floor area and unit price individually and paired sample correlations were tested in order to identify which factor (occupied units, bedrooms, unit floor area & unit price) has relationship with traffic generation and how it change with apartment category.

Number of visitors coming rate per unit per day and their vehicle mode were calculated and compared against apartment category while testing paired sample correlation with number of visitors against number of units occupied, number of

parking lots, number of bedrooms and unit price to evaluate which above factor in which apartment category has a relationship with number of visitors parking.

A unit owner's satisfaction level regarding provided facilities such as number of allocated parking lots per housing unit, the size of the parking lot, arrangement of the parking, vehicle driveway width, multi-level parking and number of parking lots provided for visitors were tested using cross tabulation

CHAPTER FOUR

4. DATA COLLECTION

4.1. Secondary data

4.1.1. Detail of all selected apartments

Table 4-1 shows the details of each apartment. Number of floors, number of units, and number of bedrooms, average floor area and number of approved parking lot's details were collected from building drawings approved by Colombo Municipal Council or Urban Development Authority and other information were collected from premises managers

Table 4-1: Detail of all selected apartments

Apartment Type		Number of floors	Number of units	Number of occupied units	Number of total bed rooms	Number of total bed rooms in occupied units	Average unit price (Rs.mn)	Average unit Floor area (ft ²)	Number of approved parking lots
High Income	HI1	28	1095	800	3200	2400	62	1550	1300
	HI2	12	40	23	110	60	45	1200	40
	HI3	8	17	17	55	55	50	1600	17
	HI4	6	45	45	95	95	53	1200	49
	HI5	6	35	35	75	75	53	1250	37
Sub total		60	1232	920	3535	2685	Average 52.6	Average 1360	1443
Middle Income	MI1	10	28	13	70	35	30	1100	28
	MI2	6	25	22	65	60	30	1150	25
	MI3	7	32	32	90	90	40	1200	32
	MI4	5	50	50	135	135	35	1100	50
	MI5	13	55	55	149	149	35	1050	55
Sub total		41	190	172	509	469	Average 34	Average 1120	190
Low Income	LI1	3	10	10	25	25	27	1050	12
	LI2	9	23	15	64	42	28	1100	23
	LI3	7	9	9	30	26	25	1200	9
	LI4	8	28	28	56	56	20	1000	28
	LI5	9	64	64	128	128	20	850	51
Sub total		36	134	126	303	277	Average 24	Average 1040	123
Grand total		137	1556	1218	4347	3431	Average 37	Average 1173	1756

Source: CMC, UDA & Interview from premises manager

4.2. Traffic count data

4.2.1. Total vehicle counts for period of one week in all selected high income apartments

Table 4-2 shows the total motor bicycle, three wheel, car, bus and lorry counts for the period of week in all four high income apartments. Havelock city is not counted here because it cannot be compared with other four apartments as it has more than 1000 housing units

Table 4-2: Total vehicle count for period of week in all selected high income apartments

Time	Vehicle type & count (In & Out)					
	Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
0600h to 0700h	4	4	104	0	0	112
0700h to 0800h	25	14	217	0	7	263
0800h to 0900h	30	23	142	0	9	204
0900h to 1000h	18	15	62	0	10	105
1000h to 1100h	9	12	42	0	0	63
1100h to 1200h	5	6	32	0	0	43
1200h to 1300h	2	3	62	0	0	67
1300h to 1400h	5	3	58	0	0	66
1400h to 1500h	1	11	90	0	0	102
1500h to 1600h	7	24	103	0	0	134
1600h to 1700h	39	40	180	0	0	259
1700h to 1800h	29	32	266	0	2	329
Total	174	187	1358	0	28	1747

4.2.2. Average vehicle count per day in all selected high income apartments

Above traffic count data were collected for a continues 7 days and table 4-3 shows the average vehicle count per day in four high income apartments except Havelock City

Table 4-3: Average vehicle count per day in all selected high income apartments

Time	Vehicle type & count (In & Out)					
	Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
0600h to 0700h	0.6	0.6	14.9	0.0	0.0	16.0
0700h to 0800h	3.6	2.0	31.0	0.0	1.0	37.6
0800h to 0900h	4.3	3.3	20.3	0.0	1.3	29.1
0900h to 1000h	2.6	2.1	8.9	0.0	1.4	15.0
1000h to 1100h	1.3	1.7	6.0	0.0	0.0	9.0
1100h to 1200h	0.7	0.9	4.6	0.0	0.0	6.1

1200h to 1300h	0.3	0.4	8.9	0.0	0.0	9.6
1300h to 1400h	0.7	0.4	8.3	0.0	0.0	9.4
1400h to 1500h	0.1	1.6	12.9	0.0	0.0	14.6
1500h to 1600h	1.0	3.4	14.7	0.0	0.0	19.1
1600h to 1700h	5.6	5.7	25.7	0.0	0.0	37.0
1700h to 1800h	4.1	4.6	38.0	0.0	0.3	47.0
Total	24.9	26.7	194.0	0.0	4.0	249.6

4.2.3. Total vehicle counts for period of week in all selected middle income apartments

Total motor bicycle, three wheel, car, bus and lorry counts for period of week in all five middle income apartments are shown in table 4-4

Table 4-4: Total vehicle count for period of week in all selected middle income apartments

Time	Vehicle type & count (In & Out)					
	Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
0600h to 0700h	9	10	114	0	0	133
0700h to 0800h	26	30	383	0	11	450
0800h to 0900h	15	33	214	0	11	273
0900h to 1000h	7	4	134	0	15	160
1000h to 1100h	18	8	87	0	7	120
1100h to 1200h	14	4	91	0	2	111
1200h to 1300h	3	0	97	0	5	105
1300h to 1400h	5	1	89	0	5	100
1400h to 1500h	9	5	130	0	14	158
1500h to 1600h	2	12	124	0	2	140
1600h to 1700h	36	38	216	0	0	290
1700h to 1800h	24	15	478	0	2	519
Total	168	160	2157	0	74	2559

4.2.4. Average vehicle counts per day in all selected middle income apartments

Table 4-5 shows the average vehicle count per day in all five middle income apartments

Table 4-5: Average vehicle count per day in all selected middle income apartments

Time	Vehicle type & count (In & Out)					
	Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
0600h to 0700h	1.3	1.4	16.3	0.0	0.0	19.0
0700h to 0800h	3.7	4.3	54.7	0.0	1.6	64.3
0800h to 0900h	2.1	4.7	30.6	0.0	1.6	39.0
0900h to 1000h	1.0	0.6	19.1	0.0	2.1	22.9
1000h to 1100h	2.6	1.1	12.4	0.0	1.0	17.1
1100h to 1200h	2.0	0.6	13.0	0.0	0.3	15.9
1200h to 1300h	0.4	0.0	13.9	0.0	0.7	15.0
1300h to 1400h	0.7	0.1	12.7	0.0	0.7	14.3
1400h to 1500h	1.3	0.7	18.6	0.0	2.0	22.6
1500h to 1600h	0.3	1.7	17.7	0.0	0.3	20.0
1600h to 1700h	5.1	5.4	30.9	0.0	0.0	41.4
1700h to 1800h	3.4	2.1	68.3	0.0	0.3	74.1
Total	24.0	22.9	308.1	0.0	10.6	365.6

4.2.5. Total vehicle counts for period of week in all selected low income apartments

Total motor bicycle, three wheel, car, bus and lorry counts for period of week in all five low income apartments are shows in table 4-6

Table 4-6: Total vehicle count for period of week in all selected low income apartments

Time	Vehicle type & count					
	Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
0600h to 0700h	19	16	55	0	0	90
0700h to 0800h	21	29	95	0	3	148
0800h to 0900h	26	29	70	0	1	126
0900h to 1000h	12	10	57	0	4	83
1000h to 1100h	21	17	61	0	1	100
1100h to 1200h	12	21	46	0	0	79
1200h to 1300h	12	10	39	0	0	61
1300h to 1400h	22	7	60	0	0	89
1400h to 1500h	13	8	32	0	2	55
1500h to 1600h	25	13	41	0	0	79
1600h to 1700h	25	35	131	0	0	191
1700h to 1800h	14	20	153	0	1	188
Total	222	215	840	0	12	1289

4.2.6. Average vehicle counts per day in all selected low income apartments

Table 4-7 shows the average vehicle count per day in all five low income apartments

Table 4-7: Average vehicle count per day in all selected low income apartments

Time	Vehicle type & count					
	Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
0600h to 0700h	2.7	2.3	7.9	0.0	0.0	12.9
0700h to 0800h	3.0	4.1	13.6	0.0	0.4	21.1
0800h to 0900h	3.7	4.1	10.0	0.0	0.1	18.0
0900h to 1000h	1.7	1.4	8.1	0.0	0.6	11.9
1000h to 1100h	3.0	2.4	8.7	0.0	0.1	14.3
1100h to 1200h	1.7	3.0	6.6	0.0	0.0	11.3
1200h to 1300h	1.7	1.4	5.6	0.0	0.0	8.7
1300h to 1400h	3.1	1.0	8.6	0.0	0.0	12.7
1400h to 1500h	1.9	1.1	4.6	0.0	0.3	7.9
1500h to 1600h	3.6	1.9	5.9	0.0	0.0	11.3
1600h to 1700h	3.6	5.0	18.7	0.0	0.0	27.3
1700h to 1800h	2.0	2.9	21.9	0.0	0.1	26.9
Total	31.7	30.7	120.0	0.0	1.7	184.1

4.2.7. Total vehicle counts for period of week in each apartments

Summary of motor bicycle, three wheel, car, bus and lorry counts for period of week in all fifteen apartments are shows in table 4-8

Table 4-8: Total vehicle count for period of week in each apartment

Apartment Type		Vehicle type & count (In & Out)					
		Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
High Income	HI1	3355	3327	7276	41	197	14196
	HI2	25	29	232	0	10	296
	HI3	46	38	263	0	4	351
	HI4	53	62	444	0	10	569
	HI5	50	58	419	0	4	531
Sub Total		3529	3514	8634	41	225	15943
Middle Income	MI1	11	4	168	0	12	195
	MI2	25	29	273	0	8	335
	MI3	24	42	475	0	12	553
	MI4	59	14	583	0	30	686
	MI5	49	71	658	0	12	790
Sub Total		168	160	2157	0	74	2559
Low Income	LI1	16	16	114	0	0	146
	LI2	37	33	200	0	0	270
	LI3	54	51	85	0	0	190
	LI4	51	53	193	0	0	297
	LI5	64	62	248	0	12	386
Sub Total		222	215	840	0	12	1289
Grand Total		3919	3889	11631	41	311	19791

4.2.8. Average vehicle counts per day (6am to 6pm) in each apartments

Table 4-9 shows the average motor bicycle, three wheel, car, bus and lorry count per day in all fifteen apartments

Table 4-9: Average vehicle count per day in each apartment

Apartment Type		Vehicle type & count (In & Out)					
		Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
High Income	HI1	479	475	1039	6	28	2028
	HI2	4	4	33	0	1	42
	HI3	7	5	38	0	1	50
	HI4	8	9	63	0	1	81
	HI5	7	8	60	0	1	76
Sub Total		505	501	1233	6	32	2277
Middle Income	MI1	2	1	24	0	2	28
	MI2	4	4	39	0	1	48
	MI3	3	6	68	0	2	79
	MI4	8	2	83	0	4	98
	MI5	7	10	94	0	2	113
Sub Total		24	23	308	0	11	366
Low Income	LI1	2	2	16	0	0	21
	LI2	5	5	29	0	0	39
	LI3	8	7	12	0	0	27
	LI4	7	8	28	0	0	42
	LI5	9	9	35	0	2	55
Sub Total		31	31	120	0	2	184
Grand Total		560	555	1661	6	45	2827

4.2.9. Average visitor vehicle counts per day (6am to 6pm) in each apartments

Table 4-10 shows the average visitors vehicle count as motor bicycle, three wheel, car, bus and lorry per day in all fifteen apartments

Table 4-10: Average visitors vehicle counts per day in each apartment

Apartment Type		Vehicle type & count					
		Motor Bicycle	Three wheel	Car/ Van	Buss	Lorry	Total
High Income	HI1	40	40	100	0	0	180
	HI2	4	4	3	0	0	11
	HI3	6	5	5	0	0	16
	HI4	5	8	6	0	0	19
	HI5	6	7	5	0	0	18
Sub Total		61	64	119	0	0	244
Middle Income	MI1	2	1	3	0	0	6
	MI2	4	4	3	0	0	11
	MI3	3	6	6	0	0	15
	MI4	3	2	6	0	0	11
	MI5	4	8	2	0	0	14
Sub Total		16	21	20	0	0	57
Low Income	LI1	2	2	2	0	0	6
	LI2	2	4	2	0	0	8
	LI3	2	1	2	0	0	5
	LI4	3	3	3	0	0	9
	LI5	3	4	4	0	0	11
Sub Total		12	14	13	0	0	39
Grand Total		89	99	152	0	0	340

4.3. Interview of premises managers and security officers

Table 4-11 shows the number of units, number of occupied units, number of approved parking lots, number of occupied parking lots, number of illegal parking lots details of the all apartments which taken form interview of premises managers

Table 4-11: Interview of premises managers and security officers

Apartment Type		Number of units	Number of occupied housing units	Number of approved parking slots	Number of occupied parking slots	Number of informal parking slots	Number of visitors parking slots
High Income	HI1	1095	800	1300	800	0	100
	HI2	40	23	40	23	0	0
	HI3	17	17	17	17	1	0
	HI4	45	45	49	45	0	4
	HI5	35	35	37	35	0	2
Sub total		1232	920	1443	920	1	106

Middle Income	MI1	28	13	28	8	0	0
	MI2	25	22	25	11	0	0
	MI3	32	32	32	32	2	0
	MI4	50	50	50	50	0	0
	MI5	55	55	55	55	2	0
Sub total		190	172	190	156	4	0
Low Income	LI1	10	10	12	10	0	2
	LI2	23	15	23	15	0	0
	LI3	9	9	9	8	0	0
	LI4	28	28	28	28	2	0
	LI5	64	64	51	51	0	0
Sub total		134	125	123	112	2	2
Grand total		1556	1218	1756	1188	7	108

4.4. Interview of unit owners

4.4.1. Unit owner's satisfaction levels

Unit owner's satisfaction level regarding provided facilities such as number of provided parking space per housing unit, size of the parking lot, arrangement of the parking, vehicle drive way width, access for parking and number of parking lots provided for visitors are shows in table 4-12

Table 4-12: Unit owner's satisfaction levels

Satisfaction level of parking facilities		Number of Responses in each Apartments															Overall Responses			
		High Income					Middle Income					Low Income					High Income	Middle Income	Low Income	Total
		H 1	H 2	H 3	H 4	H 5	M 1	M 2	M 3	M 4	M 5	L 1	L 2	L 3	L 4	L 5				
No of parking lots allocated for a unit	SS	2	0	0	0	0	0	0	0	0	2	3	4	5	5	1	2	2	18	22
	S	3	5	5	5	5	5	5	5	4	3	2	1	0	0	4	23	22	7	52
	N	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1
	DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Size of the parking	SS	2	0	0	0	0	0	0	0	0	2	3	3	5	5	5	2	2	21	25
	S	3	5	5	5	5	5	5	5	5	3	2	2	0	0	0	23	23	4	50
	N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Arrangement of the parking	SS	0	0	0	0	0	0	0	0	0	1	1	2	2	2	0	0	1	7	8
	S	5	5	5	3	5	5	5	5	5	2	3	1	3	2	5	23	22	14	59
	N	0	0	0	2	0	0	0	0	0	2	1	2	0	1	1	2	2	5	9
	DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Width of the driveway	SS	1	0	0	0	0	0	0	0	0	2	2	2	0	1	1	1	2	6	9
	S	4	5	5	4	5	5	5	5	5	2	3	3	2	2	3	23	22	13	58
	N	0	0	0	1	0	0	0	0	0	1	0	0	3	2	1	1	1	6	8
	DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Access for parking	SS	1	0	0	0	0	0	0	0	0	1	1	2	1	1	0	1	1	5	7
	S	4	5	5	4	5	5	5	5	4	4	4	3	3	3	5	23	23	18	64
	N	0	0	0	1	0	0	0	0	1	0	0	0	1	1	0	1	1	2	4
	DS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	SD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Allocated parking for Visitors	SS	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4
	S	1	3	2	2	5	2	2	2	0	4	1	1	2	1	0	13	10	5	28
	N	0	2	3	2	0	3	3	3	2	1	3	2	1	3	1	7	12	10	29
	DS	0	0	0	1	0	0	0	0	3	0	1	1	1	1	2	1	3	6	10
	SD	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	0	4	4
SS- Strongly satisfied, S- satisfied, N – Neutral, DS – Dissatisfied, SD- Strongly Dissatisfied																				

4.4.2. Visitor's parking requirement

Unit owner's perspective regarding visitors parking requirements were collected through interview survey and those details are shown in table 4-13.

Table 4-13: Visitor's parking requirement

Type of vehicle		Number of Responses in each Apartments															Overall Responses			
		High Income					Middle Income					Low Income					High Income	Middle Income	Low Income	Total
		H 1	H 2	H 3	H 4	H 5	M 1	M 2	M 3	M 4	M 5	L 1	L 2	L 3	L 4	L 5				
Motor Cycle	<5%	5	5	5	5	5	5	5	5	5	5	3	5	4	5	1	25	25	18	68
	5%-10%	0	0	0	0	0	0	0	0	0	0	2	0	1	0	4	0	0	7	7
	>10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Three wheel	<5%	5	4	2	4	5	3	4	3	5	5	3	5	3	4	1	20	20	16	56
	5%-10%	0	1	3	1	0	2	1	2	0	0	2	0	2	1	4	5	5	9	19
	>10%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Car/ Van	<5%	0	2	0	0	0	1	0	0	2	0	0	0	0	0	2	2	3	2	7
	5%-10%	5	3	2	5	5	2	4	3	3	4	4	3	2	3	3	20	16	15	51
	>10%	0	0	3	1	0	2	1	2	0	1	1	2	3	2	0	4	6	8	18

4.5. Interview of developers

4.5.1. Average unit price in each apartment category

According to each developer's perspective, the average unit prices of main three apartment categories are shown in table 4-14

Table 4-14: Average unit price in each apartment category

No	Developer	Average Unit Price (Rs.mn)					
		High Income		Middle Income		Low Income	
		From	To	From	To	From	To
1	Developer 1	26	50	16	25	10	15
2	Developer 2	50	75	31	50	20	30
3	Developer 3	45	76	25	40	15	25
4	Developer 4	25	35	25	30	10	15
5	Developer 5	30	35	25	30	10	20
6	Developer 6	25	35	20	25	10	15
7	Developer 7	25	30	15	25	9	12

4.5.2. Average unit floor area in each apartment category

Table 4-15 shows the average unit floor area of main three apartment categories as per the information received during the interview of developers

Table 4-15: Average unit floor area in each apartment category

No	Developer	Average unit floor area (ft ²)					
		High Income		Middle Income		Low Income	
		From	To	From	To	From	To
1	Developer 1	1500	3000	1200	1500	850	1250
2	Developer 2	1300	3000	1000	1300	900	1200
3	Developer 3	1300	2000	1000	1300	750	1000
4	Developer 4	1200	1500	1000	1500	1000	1200
5	Developer 5	1000	2000	1000	1500	900	1100
6	Developer 6	1000	1500	900	1200	750	900
7	Developer 7	1000	1500	1000	1200	900	1000

4.5.3. Facilities allocated for each type apartment units

The overall facilities allocated for main three apartment categories are shows in table 4-16 as per the information received during the interview of developers

Table 4-16: Facilities allocated for each type apartment units

No	Developer	Apartment category	Type of Facilities							
			Swimming pool	Kids pool	Fitness center	Restaurants	Mechanical ventilations	Club House	Additional parking spaces	Backup Generator
1	Developer 1	High Income	Yes	Yes	Yes	Yes	Yes	No	Yes	Common
		Middle Income	Yes	No	Yes	No	Yes	No	No	Common
		Low Income	No	No	No	No	No	No	No	Common
2	Developer 2	High Income	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
		Middle Income	Yes	No	Yes	No	Yes	No	Yes	Common
		Low Income	No	No	No	No	No	No	No	Common
3	Developer 3	High Income	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
		Middle Income	Yes	No	Yes	No	Yes	No	Yes	Common
		Low Income	No	No	No	No	No	No	No	Common
4	Developer 4	High Income	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
		Middle Income	Yes	No	Yes	No	Yes	No	No	Common
		Low Income	No	No	No	No	No	No	No	Common
5	Developer 5	High Income	Yes	Yes	Yes	Yes	Yes	No	Yes	Common
		Middle Income	Yes	No	Yes	No	Yes	No	No	Common
		Low Income	No	No	No	No	No	No	No	Common
6	Developer 6	High Income	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
		Middle Income	Yes	No	Yes	No	Yes	No	No	Common
		Low Income	No	No	No	No	No	No	No	Common
7	Developer 7	High Income	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
		Middle Income	Yes	No	Yes	No	Yes	No	No	Common
		Low Income	No	No	No	No	No	No	No	Common

CHAPTER FIVE

5. ANALYSIS AND FINDING

5.1. Trip generation patterns Vs Apartment types

Daily traffic generation pattern counted over a 12 hour period (0600 to 1800) is compared here with the type of apartment to identify the how vary the traffic pattern against type of the apartment.

5.1.1. Trip Generation Pattern in High Income Apartments

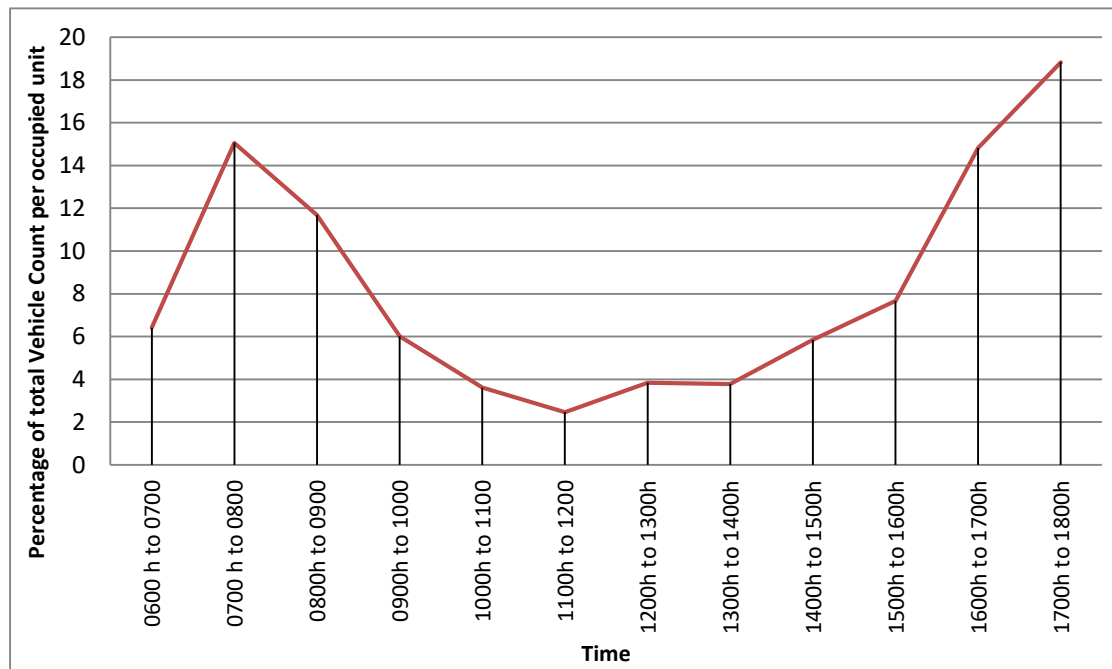


Figure 5-1: Trip Generation Pattern in High Income Apartments

Hourly breakdown of traffic counts of motor bicycle, three wheels, car/van, buss and lorry in high income apartments is presented in Table 4-3. Figure 5-1 shows how percentage share of total vehicle count per occupied unit for each hour is varied from 00600 to 1800 hours in all high income apartments.

Accordingly, it shows that morning peak was reported by 15% of vehicle share around 0700 to 0800 hours because of trips for working places and other services. But school trips were not observed here because this traffic count survey was conducted after the COVID 19 lock down period and at that time schools were operated virtually not physically and it was confirmed further since there was no

significant traffic within the school leaving time around 1200 to 1400 hours as it is just 4% vehicle share of total count. Office leaving time around 1630 to 1800 hours was reported as an evening peak with 19% of vehicle share. Comparatively, there was 4% additional traffic flow reported in the evening peak rather than morning peak because peoples were going out for dinner and other night functions

5.1.2. Trip Generation Pattern in Middle Income Apartments

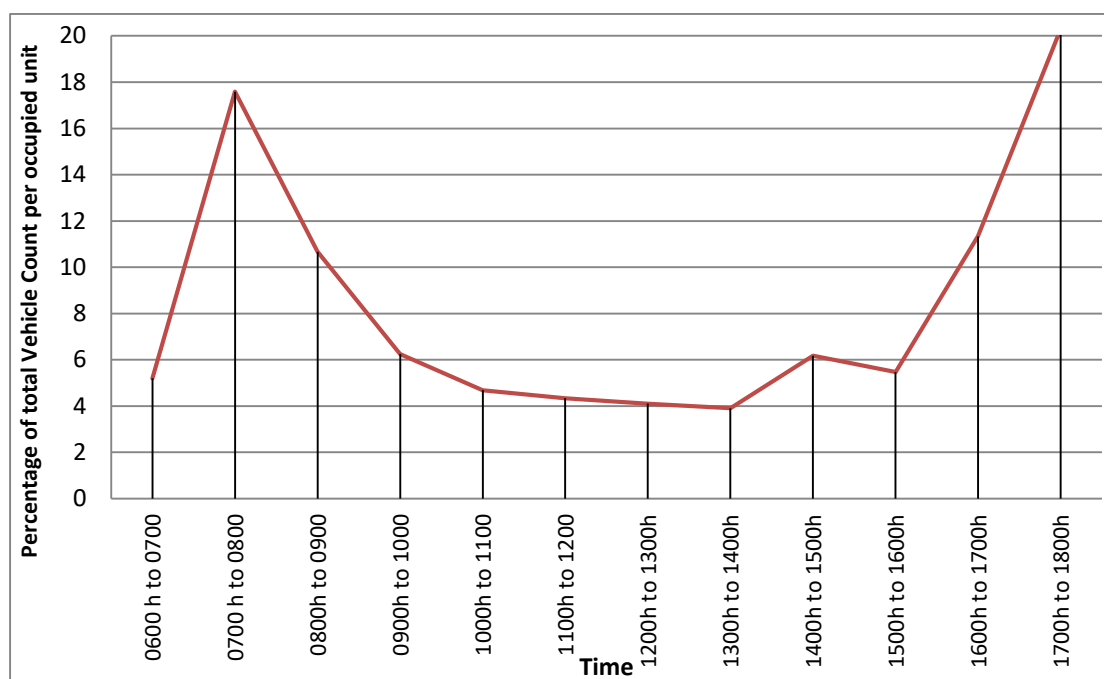


Figure 5-2: Trip Generation Pattern in Middle Income Apartments

Hourly breakdown of traffic counts of motor bicycle, three wheels, car/van, buss and lorry in middle income apartments is presented in table 4-5. Figure 5-2 shows how percentage share of total vehicle count per occupied unit for each hour is varied from 0600 to 1800 hours in all middle income apartments.

It is illustrated that morning peak was reported around 0700 to 0800 hours with 17% of vehicle shares due to the vehicle trips for working places and other services. Evening peak was reported around 1700 to 1800 hours with a 20% vehicle share.

Here also no significant traffic was reported within the school leaving time around 1200 to 1400 hours and it was just 4%, same as in the high income apartments. Only 3% additional traffic flow was reported in the evening peak rather than morning peak

5.1.3. Trip Generation Pattern in Low Income Apartments

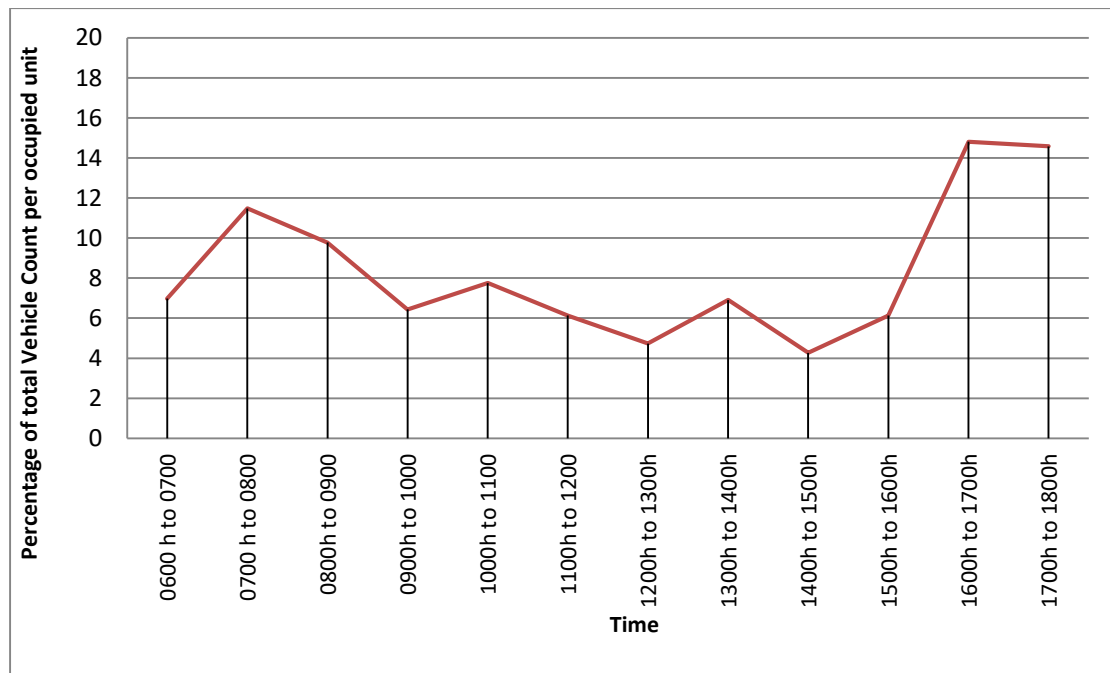


Figure 5-3: Trip Generation Pattern in Low Income Apartments

Average vehicle count per day in all selected low income apartments are presented in Table 4-7. Figure 5-3 shows how percentage share of total vehicle count per occupied unit for each hour is varied from 00600 to 1800 hours in all low income apartments.

It shows that, here also morning peak was reported around 0700 to 0800 hours with a 11% trip share. Evening peak was reported between 1600 to 1700 hours and it is 4% more than morning peak traffic flow. Between 0800 to 1500 hours trip share was varying from 10% to 4%, and it is significant difference comparatively trip share in high-income and middle income apartments.

5.1.4. Trip Generation Pattern in All Type Apartments

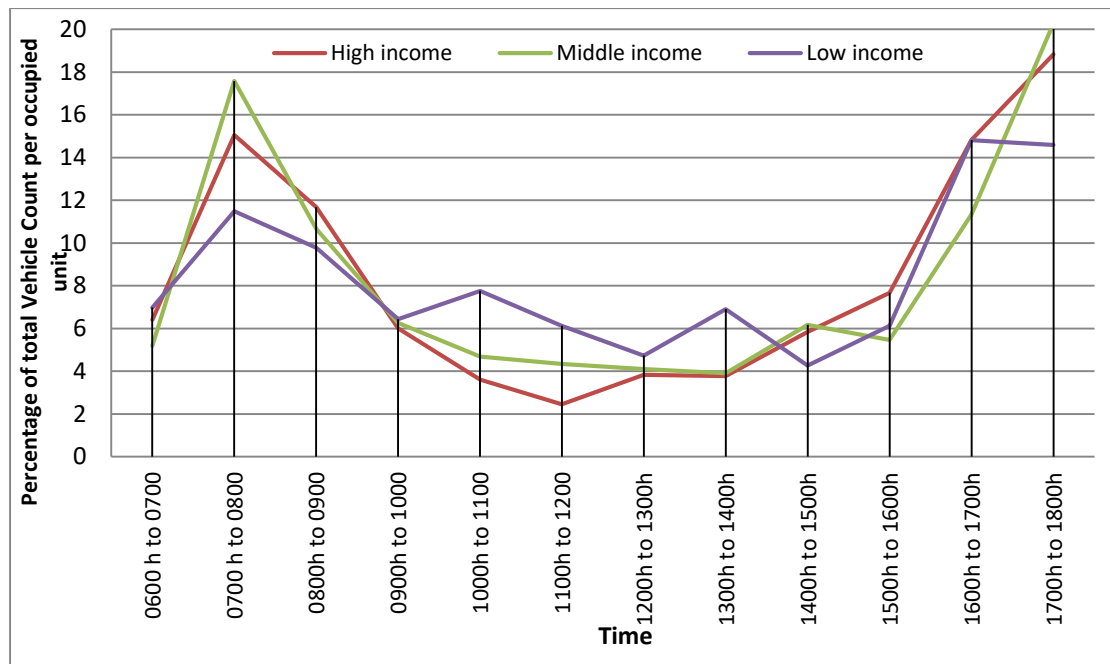


Figure 5-4: Trip Generation Pattern in All type Apartments

Average vehicle count per day in all selected high, middle & low income apartments are presented in Table 4-9. Figure 5-4 illustrates a comparison of hourly percentage of trip share in each hour in each apartment type. Comparatively, the morning peak period was reported in same time (0700 to 0800 hours) for all apartments. Low income apartments reported lowest trip share of 11% in the morning peak while middle income apartments reach highest trip share of 17%, which is 6% more than low income apartments and 2% more than high income apartments.

Evening peak period for all apartments was also reported in same time, around 1600 to 1800 hours. During the evening traffic, lowest trip share of 15% was reported by low income apartments and middle income apartments recorded highest trip share of 20%, which is 1% more than high income apartments. The rest of the day (0800 to 1500 hours) no peak hours were reported because this traffic count survey was conducted after the COVID 19 lock down period and at that time schools were operated virtually not physically. Comparatively, middle income apartments have reported overall highest trip share percentage in morning and evening peak. Especially, it was observed that low income apartments have reported high trip share in the day time while high income reported lowest trip share.

5.2.Trip generation Vs apartment's characters

5.2.1. Average all trip rates per day per occupied unit Vs Average number of bed rooms per occupied unit in each apartment types

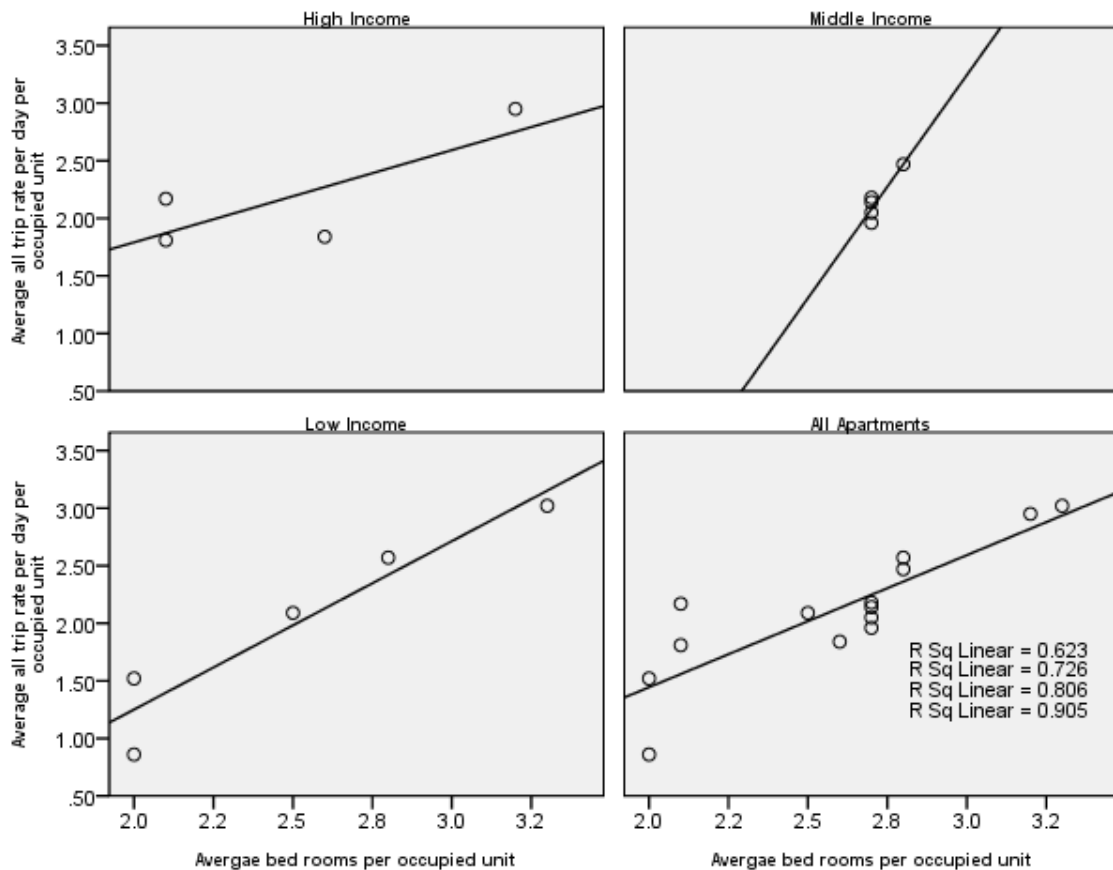


Figure 5-5: Average all trip rate per day per occupied unit Vs Average number of bed rooms per occupied unit in each apartment types

Figure 5-5 shows the results of the analysis of average all trip rates per day per occupied unit against the average number of bedrooms in the occupied apartment unit as presented in Table 4-1 & 4-9. High income apartments & middle income apartments have reported a positive correlation with the R-squared value of 0.623 & 0.726 respectively. Low income apartments have a positive strong relationship with R-squared value is 0.905.. When compare the all apartments together, number of bedrooms can be considered as a criteria for determining trip generation or parking requirement of an apartment unit since there was a strong positive relationship between trip rates per occupied unit per day and the average number of bedrooms per occupied unit with R-squared value of 0.806

5.2.2. Average all trip rates per day per occupied unit Vs Average Unit Floor Area in each apartment types

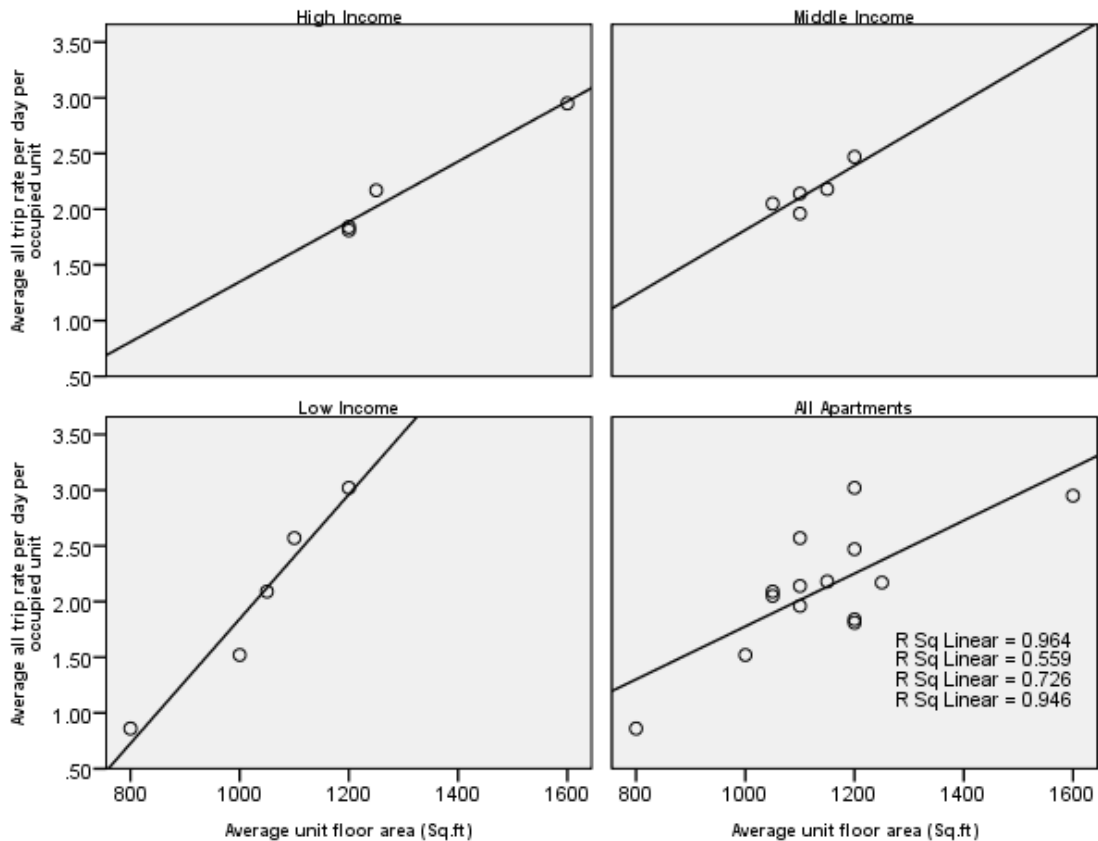


Figure 5-6: Average all trip rate per day per occupied unit Vs Average Unit Floor Area in each apartment types

Figure 5-6 shows the results of the analysis of average car count per day per unit against an average unit floor area of an apartment unit as presented in Table 4-1 & 4-9. It was illustrated that high income & low income apartments have reported a positive strong correlation with the R-squared value of 0.964 & 0.946 respectively. Middle income apartments also have reported a positive relationship but it is not strong enough as R-squared value is 0.559. When compare the all apartments together, it is shown that there is a strong positive relationship between average trip rates per day per occupied unit and average unit floor area with R-squared value of 0.726. Accordingly, unit floor area can be considered as a criteria for determining trip generation or parking requirement of an apartment unit. As per the prevailing regulation imposed by the UDA, the parking requirement also calculating based on the unit floor area.

5.2.3. Average all trip rates per day per occupied unit Vs Unit price in each apartment types

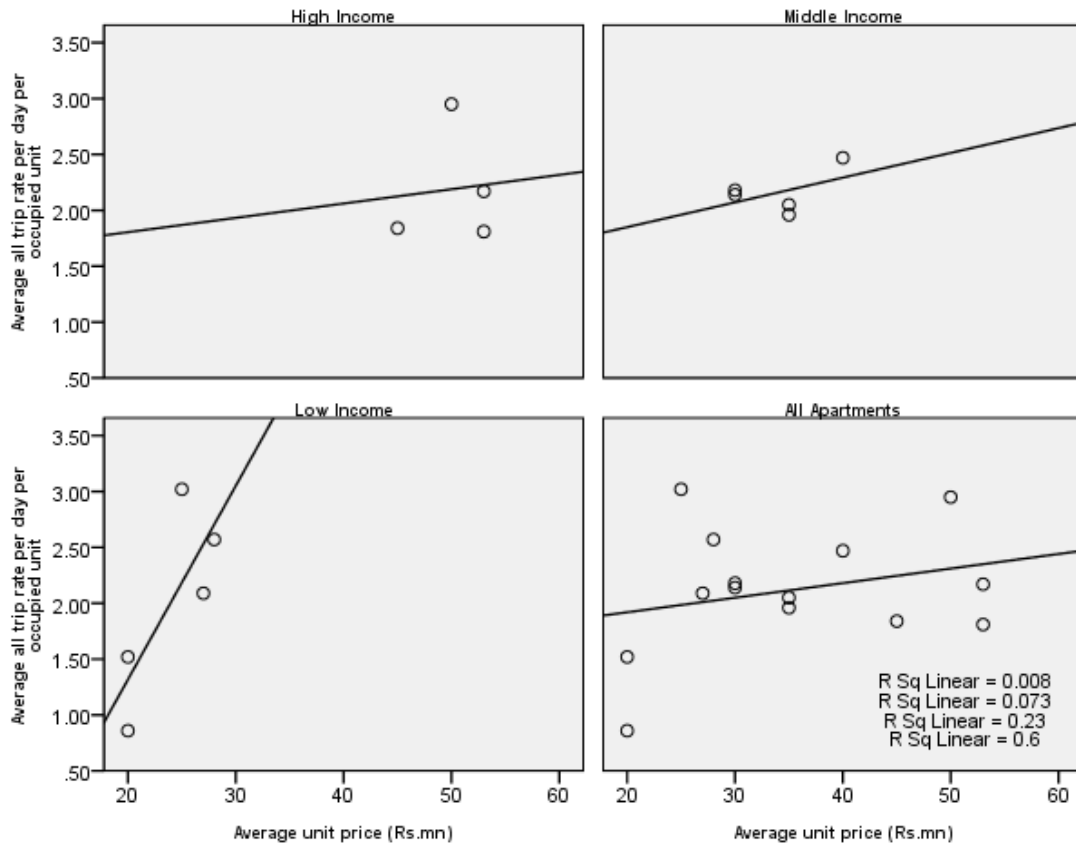


Figure 5-7: Average all trip rates per day per occupied unit Vs Unit price in each apartment types

Figure 5-7 shows the results of the analysis of average car count per day per unit against the average unit price of an apartment unit. Data were collected from a traffic count survey & interview of premises managers as presented in Table 4-1 & 4-9. High income & middle income apartments have reported a positive very weak relationship between average trip rate & average unit price with R-squared value of 0.008 & 0.073 respectively. Low income apartments have reported positive correlated relationship with R-squared value of 0.6. When compare the all apartments together, it is illustrate that there is weak positive relationship between average trip rates per day per occupied unit and average unit price with R-squared value of 0.23. Accordingly, it is shown that average unit price cannot be considered as a criteria for determining traffic generation or parking requirement of an apartment unit.

5.2.4. Average all trip rates per day Vs number of occupied housing units in each apartment types

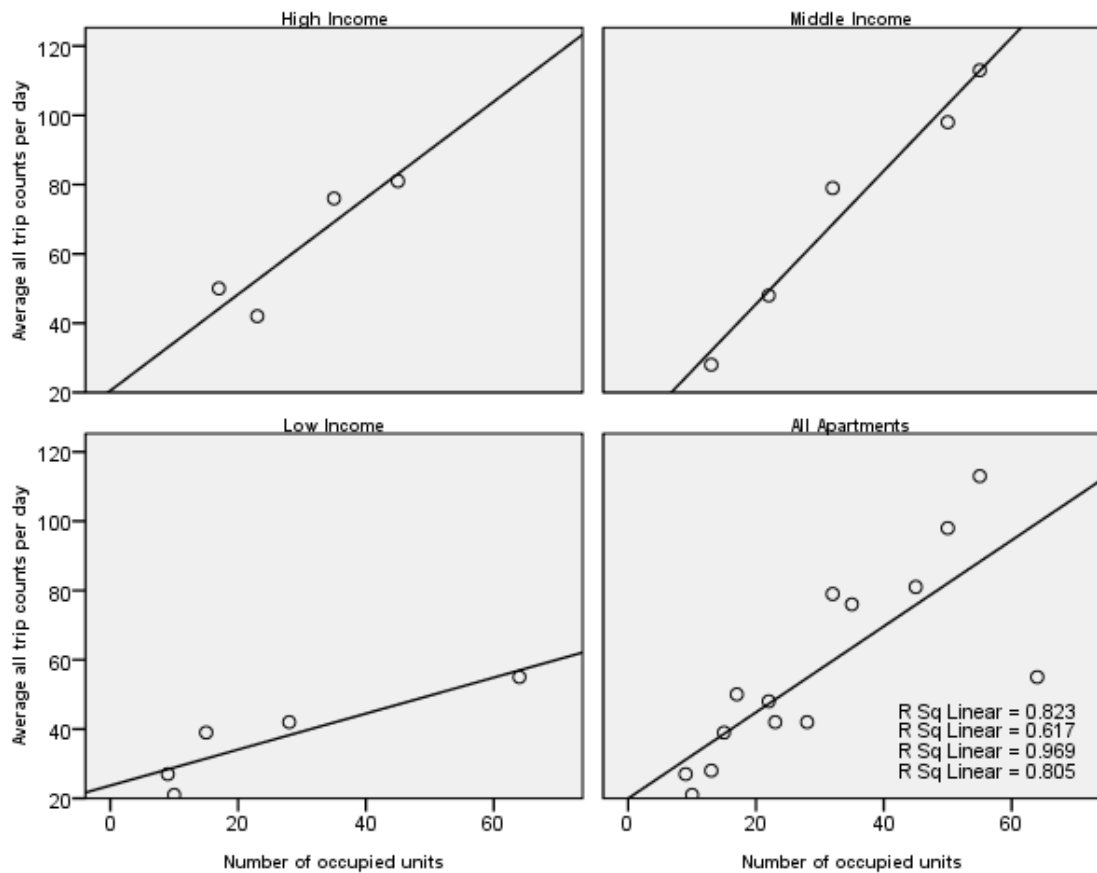


Figure 5-8: Average all trip rate per day Vs number of occupied housing units in each apartment types

Figure 5-8 shows the results of the analysis of average car count per day per unit against the number of occupied apartment units. Data were collected from a traffic count survey & interview of premises managers as presented in Table 4-1 & 4-9. It was illustrated that high income has reported a positive strong correlation with the R-squared value of 0.823. Middle income apartments also have a positive relationship with R-squared value of 0.617. low income apartments also have a positive strong correlation with R-squared value of 0.805 but it has a lower gradient rather than other apartments. It means that trip generation of the low income apartments is lower than high & middle income apartments. When compare the all apartments together, it is shown that there is a strong positive relationship between average trip rate per day and number occupied apartment units with R-squared value of 0.969.

5.3. Vehicle composition

5.3.1. Trip generation per occupied unit Vs apartment type

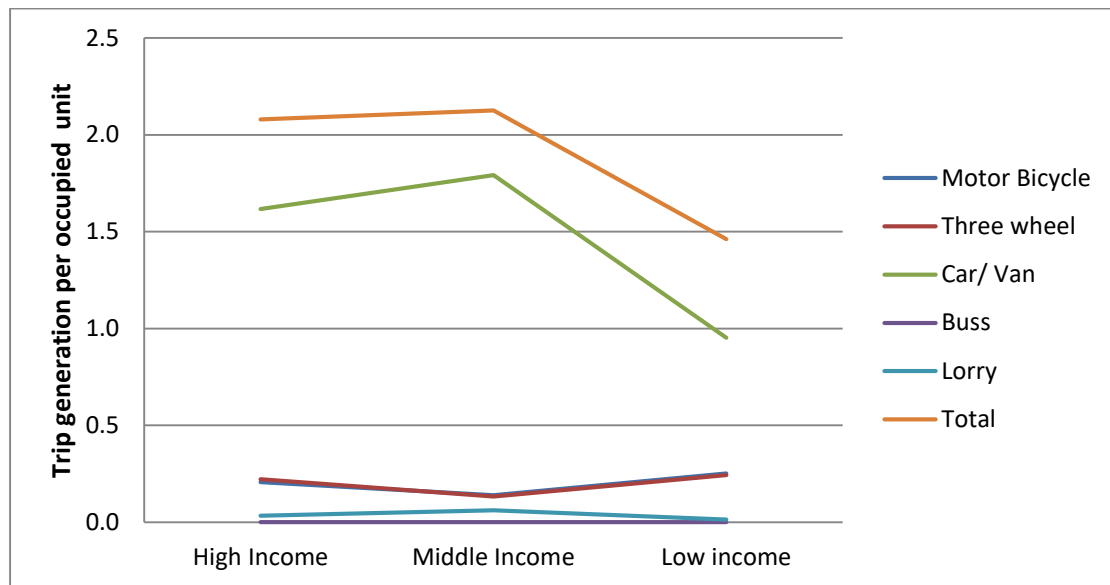


Figure 5-9: Trip generation per occupied unit Vs apartment type

Figure 5-9 shows the result of the analysis of trip generation rate per occupied unit in each apartment. Data were collected from traffic count survey as presented in Table 4-9. When consider the car trip generation, middle income apartments have reported highest generation rate of 1.8 per unit while low income apartments reported lowest generation rate of 0.9. Reason for this situation can be elaborated as majority of the peoples who are living in the middle income apartments are usually going for working places and other services out of the home. But the majority of the people who are living in the highest income apartments are representing top management levels of their institutions and most of them are working on the house basis or some peoples are going to works but not attending to day to day other works like middle income apartments people doing.

Motor cycle & Three wheels have reported equal generation rate among the same apartment type and low income apartments have reported highest generation rate for Motor cycle & Three wheels rather than high & middle income apartments. When consider the overall trip generation per occupied unit, high income & middle income

has reported similar rates around 2.1 to 2.2. Low income apartments reported quite low trip rate of 1.4 per occupied unit

5.3.2. Vehicle composition in all apartments

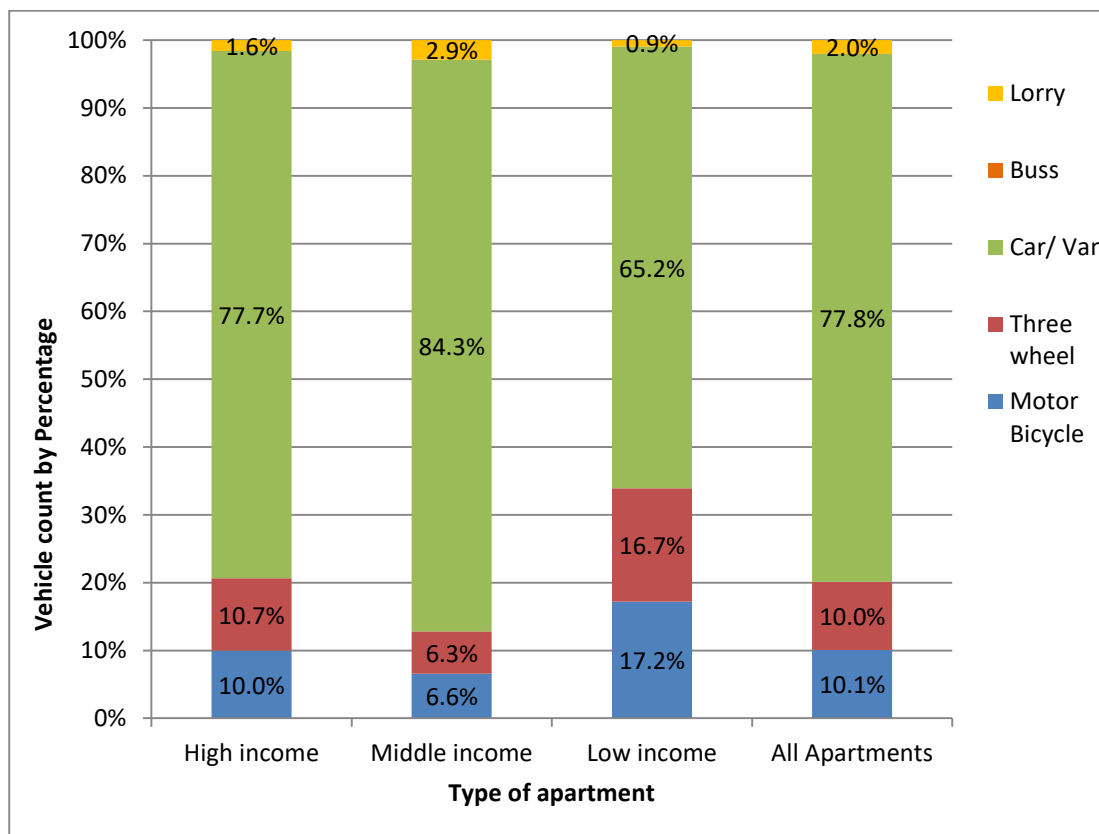


Figure 5-10: Vehicle composition in all apartments

Figure 5-10 shows the vehicle composition in all apartments. Data were collected from the traffic count survey as presented in Table 4-9. It can be seen that car has reported the highest percentage (77.8%) of vehicle composition in each apartment category while reporting the highest percentage of 84.3% in middle income apartments. Low income apartments have reported the highest percentage of motorcycle (17.2%) & Three wheels (16.7%) because those vehicle modes are used by the peoples in low income apartments. Middle income apartments recorded the lowest percentage of motorcycle (6.6%) & three wheels (6.3%). Compare to the middle income apartments high percentage of three wheels & motor bike percentage can be seen in high income apartments because of some delivery service facilities.

5.4. Vehicle ownership Vs apartment character

5.4.1. Number of owned vehicles per unit Vs Average Number of bed rooms per unit in each apartment types

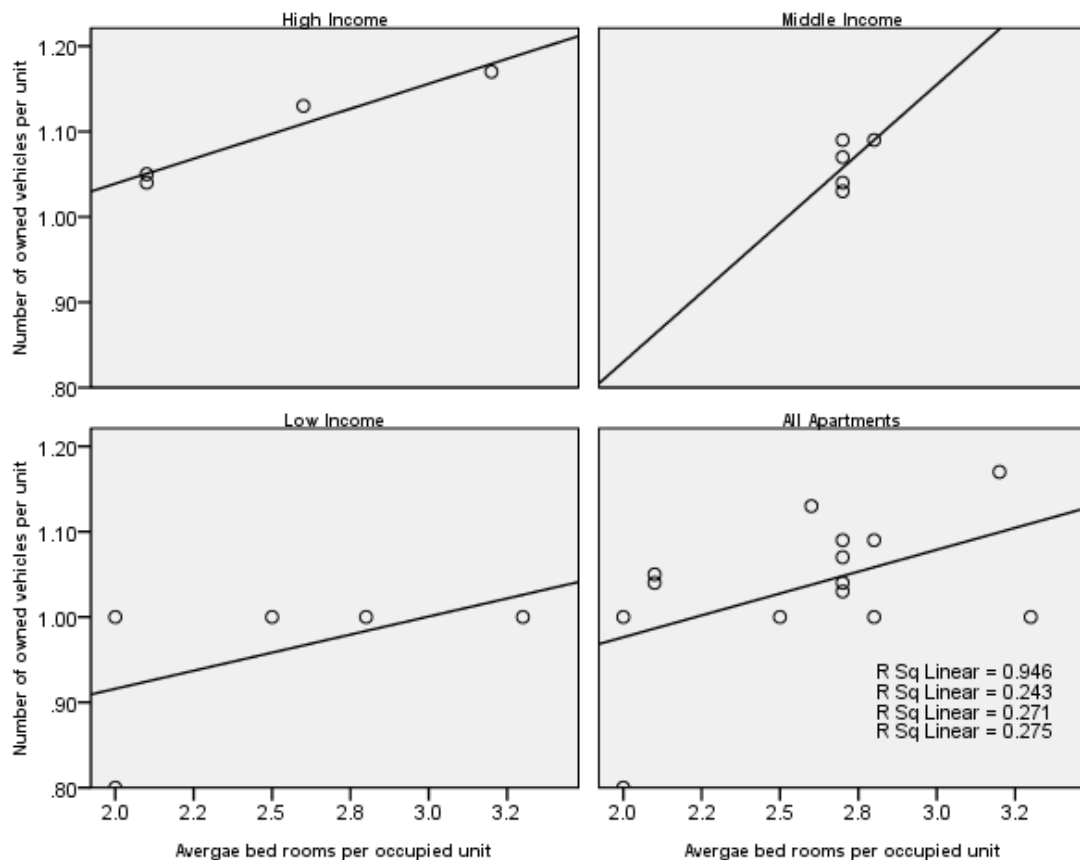


Figure 5-11: Number of owned vehicles per unit Vs Average Number of bed rooms per unit in each apartment types

Figure 5-11 shows the results of the analysis of number of owned vehicles per unit against number of average bedroom per occupied apartment units. Data were collected from the traffic count survey & interview of premises managers as presented in Table 4-1 & 4-11.

High income apartments have reported a positive strong correlation with the R-squared value of 0.946. Middle & low income apartments also have positive relationship, but it is not strong enough as R-squared value is 0.243 & 0.275 respectively. When compare the all apartments together, it is illiterate that there is weak positive relationship between number of occupied vehicles per occupied unit and average number of bedrooms per occupied unit with R-squared value of 0.271. Accordingly, it can say that that number of bedrooms cannot be considered as a criteria for determining parking requirement of an apartment.

5.4.2. Number of owned vehicles per unit Vs Average Unit Floor Area in each apartment types

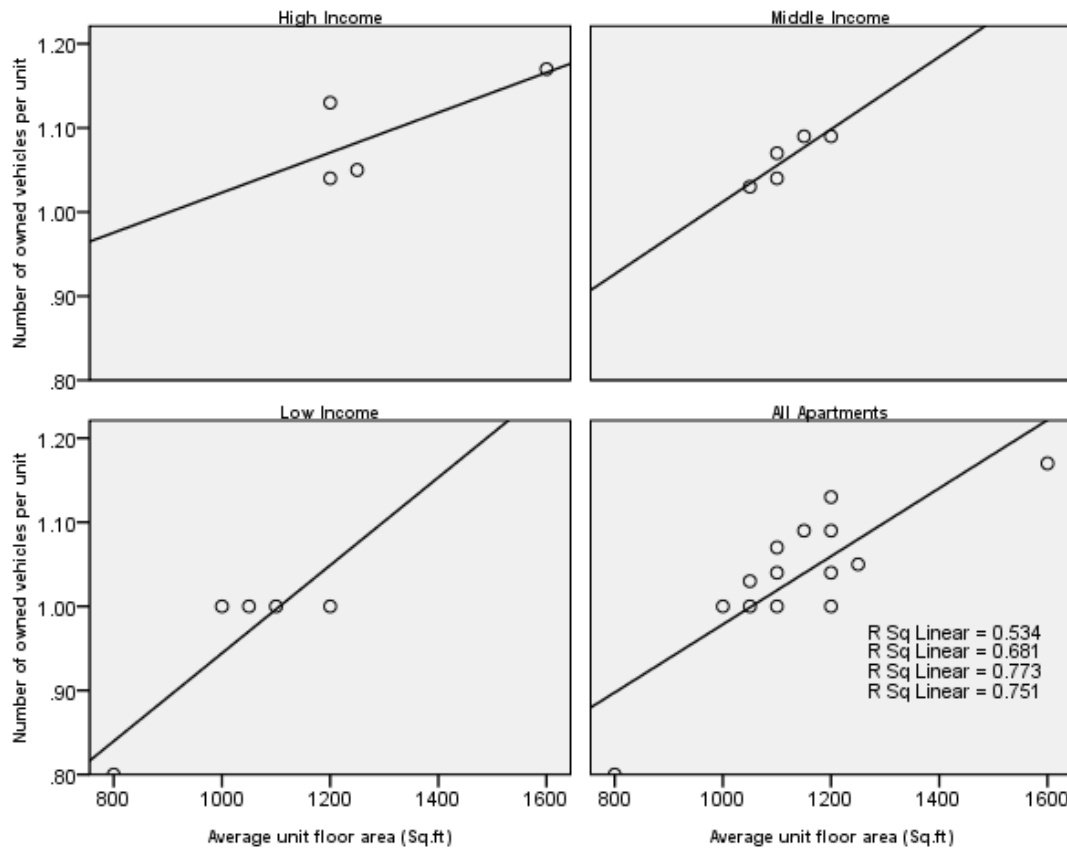


Figure 5-12: Number of owned vehicles per unit Vs Average Unit Floor Area in each apartment types

Figure 5-12 shows the results of the analysis number of owned vehicles per unit per day against average unit floor area of an apartment unit. Data were collected from the traffic count survey & interview of premises managers as presented in Table 4-1 & 4-11. It was illustrated that high income apartments have reported a positive correlation with R-squared value of 0.534. Middle & low income apartments have reported strong positive relationship with R-squared value is 0.681 and 0.751 respectively. When compare the all apartments together, it is shown that there is a positive strong relationship between the number of owned vehicles per unit and average unit floor area with R-squared value of 0.773. Accordingly, it can say that average unit floor area can be considered as a criteria for determining parking requirements of an apartment.

5.4.3. Number of owned vehicles per unit Vs Unit price in each apartment types

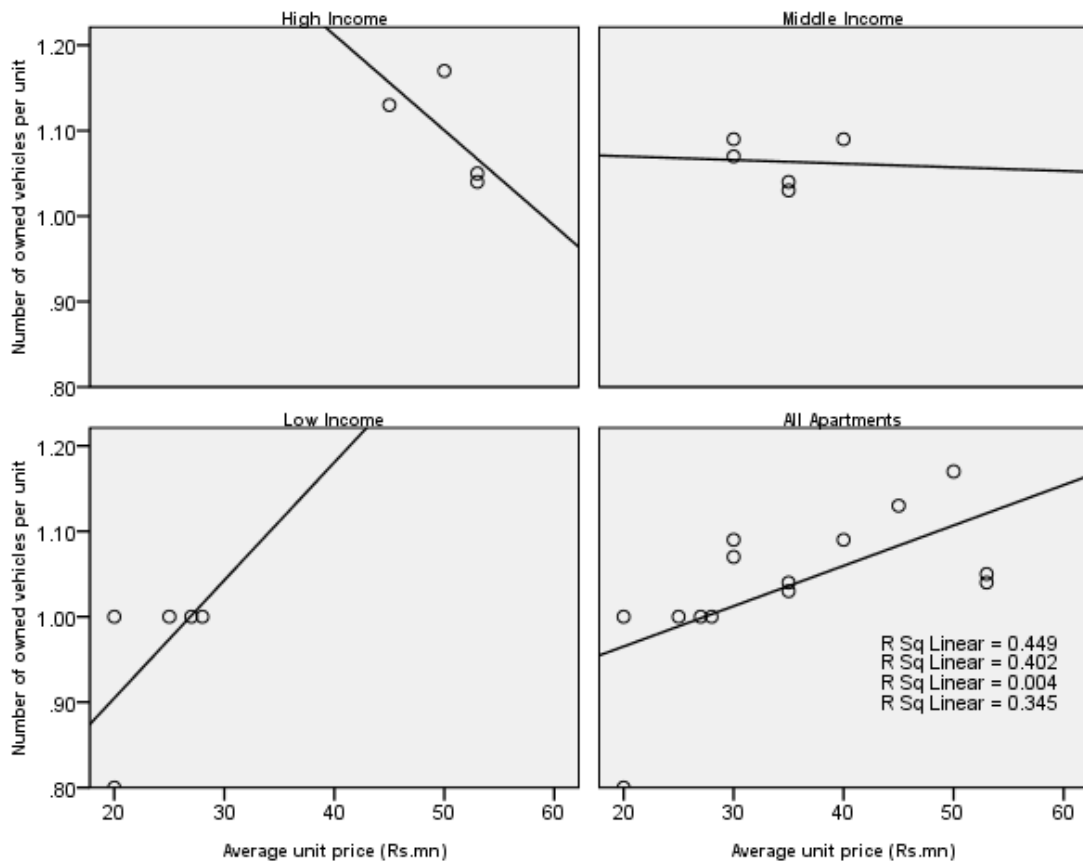


Figure 5-13: Number of owned vehicles per unit Vs Unit price in each apartment types

Figure 5-13 shows the results of the analysis of number of owned vehicles per unit against the average unit price of an apartment unit. Data were collected from the traffic count survey & interview of premises managers as presented in Table 4-1 & 4-11. High income & middle income apartments have reported a negative weak relationship between the number of available vehicles per unit & average unit price with R-squared value of 0.449 & 0.402 respectively. Low income apartments have reported positively correlated weak relationship with R-squared value of 0.345. When compare the all apartments together, it is illiterate that there is a very weak positive relationship between the number of available vehicles per unit and average unit price. Accordingly, it was shown that average unit price cannot be considered as a criteria for determining traffic generation or parking requirement of an apartment unit.

5.4.4. Number of owned vehicles Vs number of occupied housing units in each apartment types

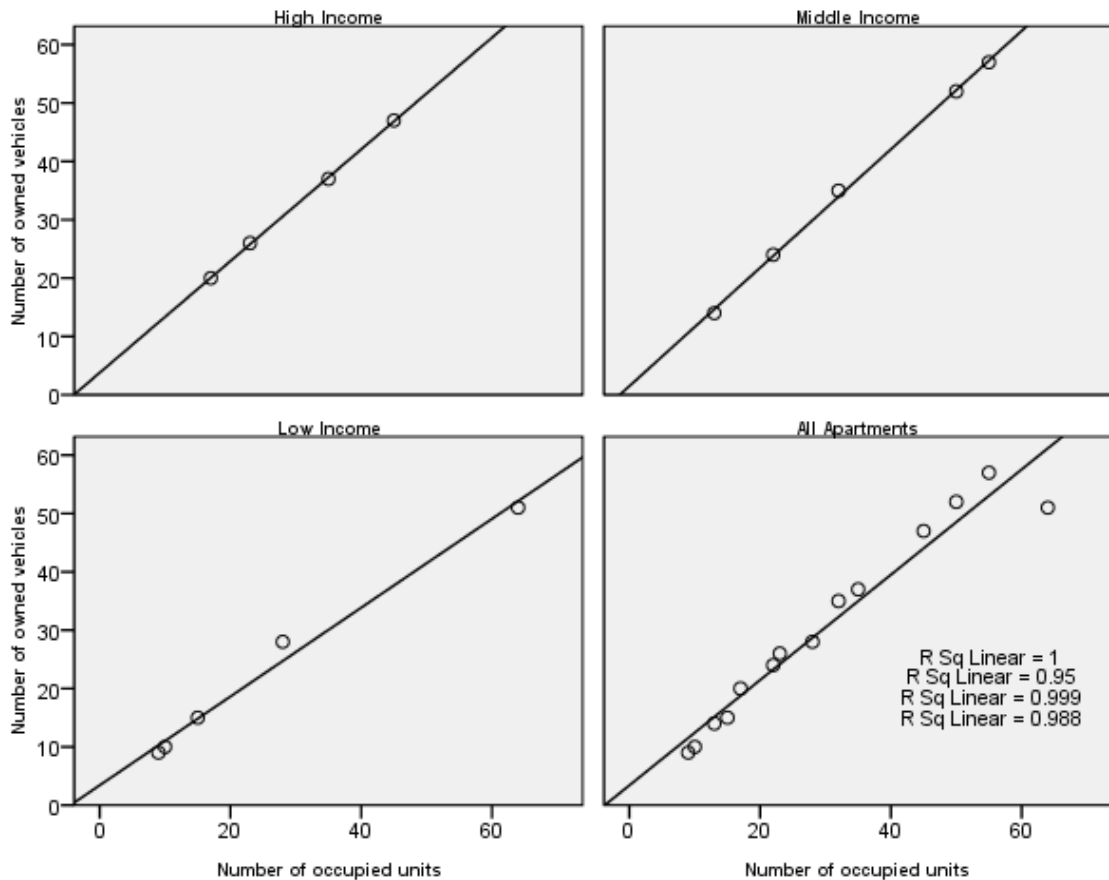


Figure 5-14: Number of owned vehicles Vs number of occupied housing units in each apartment types

Figure 5-14 shows the results of the analysis of number of owned vehicles per unit against the number of occupied apartment units. Data were collected from the traffic count survey & interview of premises managers as presented in Table 4-1 & 4-11. It was illustrated that high income apartments have reported a positive strong correlation with R-squared value of 1 and a gradient of 450. It means that each apartment unit in the high income apartment has one vehicle. Middle income and low income apartments also have reported a positive strong correlation with R-squared value of 0.95 & 0.988 respectively.

When compare the all apartments together, it is shown that there is a strong positive relationship between the number of owned vehicles per unit and number occupied apartment units with an R-squared value of 0.999. Accordingly, the number of units

can be considered as a criteria for determining traffic generation or parking requirement of an apartment unit.

5.5.Visitor's Vehicle composition

5.5.1. Visitor's trip generation per occupied unit Vs apartment type

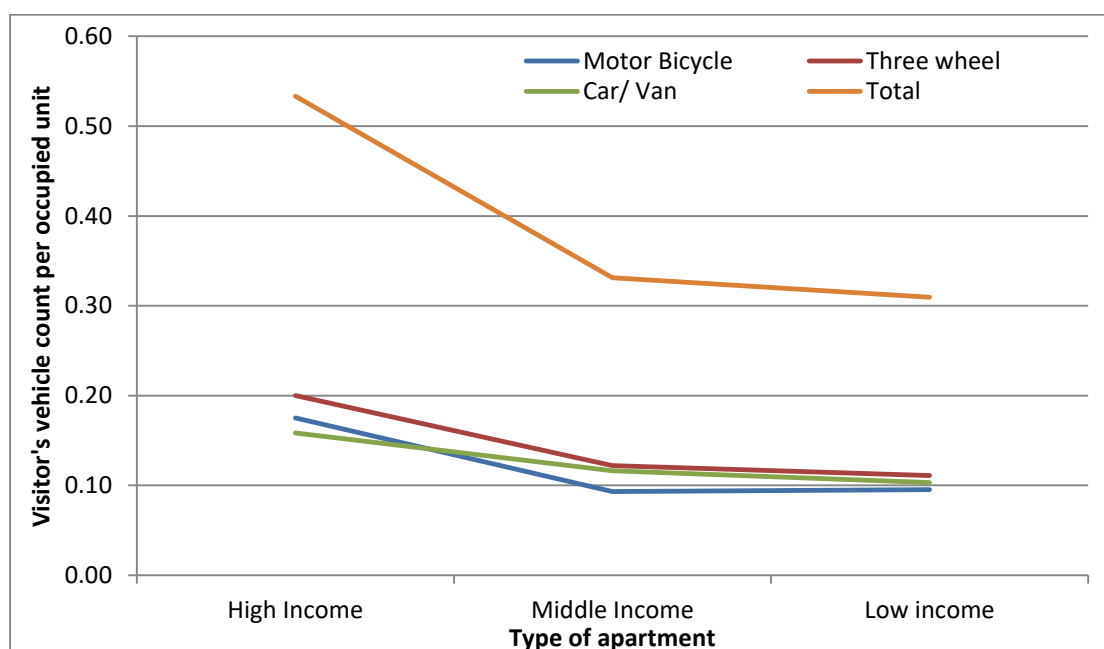


Figure 5-15: Visitor's trip generation per occupied unit Vs apartment type

Figure 5-15 shows the result of the analysis of visitors trip rate per occupied unit in each apartment. Data were collected from the traffic count survey as presented in Table 4-10. When considered the three wheels as a mode of visitor, high income apartments have been reported highest generation rate of 0.20 per occupied unit while low income apartments reported lowest generation rate of 0.11 per occupied unit.

When considered the car as a mode of visitor, high income apartments have been reported highest trip rate of 0.15 per occupied unit while low income apartments reported lowest generation rate of 0.10 per unit. For motor bicycle, high income has reported highest generation rate of 0.18 and middle & low income apartments have reported lowest generation of 0.10

When consider overall visitor's trip rate analysis, high income apartments have reported the highest rate and low income apartment has reported lower rates because

of more delivery service vehicles & hiring vehicles can be seen in the high income apartments rather than the other two categories.

5.5.2. Visitor's vehicle composition in all apartments

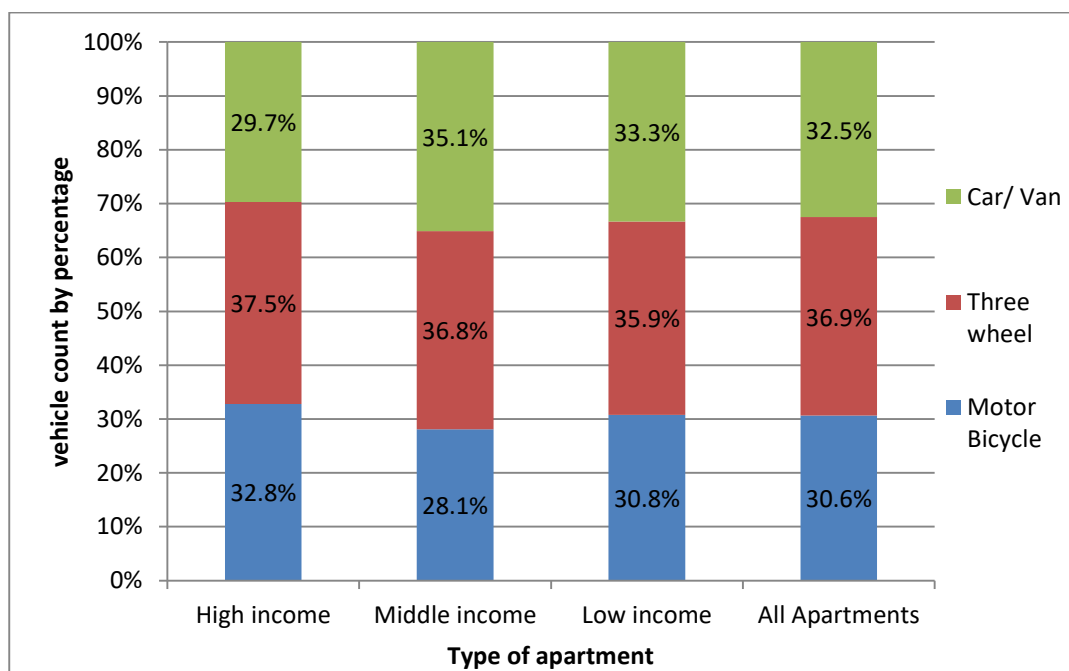


Figure 5-16: Visitor's vehicle composition in all apartments

Figure 5-16 shows the vehicle composition in all apartments. Data were collected from the traffic count survey as presented in Table 4-10. It can be seen that three wheels have reported the highest percentage (36.9%) of vehicle composition in each apartment category while reporting the highest percentage of 37.5% in high income apartments. Accordingly, three wheels can be considered as the main mode of visitors in each apartments category. Compare to the middle & low income apartments high percentage of motor bicycle composition (32.8%) can be seen in high income apartments because of some delivery service facilities.

When consider overall visitor's vehicle composition analysis, 36.9% visitors were used three wheels, 32.5% visitors were used cars and rest of the visitors (30.6%) was used motor bicycles. Buss & lorry were not reported as a mode for visitors. Accordingly, it was shown that, there are requirement for giving parking facilities for any visitors in any apartment category.

5.6. Summary of analysis between trip generation and apartment character

Table 5-1: Correlation analysis (Bivariate) between trip generation and apartment characters

		No. of Occupied Units	Average Bed Rooms per Occupied Unit	Average Unit Floor Area (Sq.ft)	Average Unit Price	No of owned vehicles per unit	Average All vehicles count per day per unit	Average All Visitor's vehicles count per day per unit
No. of Occupied Units	Pearson Correlation	1	-.532	-.434	.085	-.467	-.667**	-.738**
	Sig. (2-tailed)		.050	.121	.772	.093	.009	.003
Average Bed Rooms per Occupied Unit	Pearson Correlation	-.532	1	.557*	.023	.493	.852**	.556*
	Sig. (2-tailed)	.050		.038	.938	.073	.000	.039
Average Unit Floor Area (Sq.ft)	Pearson Correlation	-.434	.557*	1	.716**	.825**	.747**	.840**
	Sig. (2-tailed)	.121	.038		.004	.000	.002	.000
Average Unit Price	Pearson Correlation	.085	.023	.716**	1	.634*	.270	.398
	Sig. (2-tailed)	.772	.938	.004		.015	.350	.158
No of owned vehicles per unit	Pearson Correlation	-.467	.493	.825**	.634*	1	.615*	.620*
	Sig. (2-tailed)	.093	.073	.000	.015		.019	.018
Average All vehicles count per day per unit	Pearson Correlation	-.667**	.852**	.747**	.270	.615*	1	.750**
	Sig. (2-tailed)	.009	.000	.002	.350	.019		.002
Average All visitor's vehicles count per day per unit	Pearson Correlation	-.738**	.556*	.840**	.398	.620*	.750**	1
	Sig. (2-tailed)	.003	.039	.000	.158	.018	.002	

** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

Correlation (bivariate technique) analysis was conducted to identify which factors are correlated each other as shown in table 5-1. Accordingly, it is illustrated that unit floor area has recorded more significance correlation with the no of owned vehicles, average all vehicle count per day and average visitor's vehicle count per day as shown in green color in above table. Average unit price and number of bedrooms in an occupied unit as shown in blue and brown color have recorded less correlation when compared with the average unit floor area. Accordingly, it can be concluded that unit floor area can be considered as a criterio for determining trip generation or parking requirement of an apartment unit.

5.7. Unit owner's satisfaction levels

Table 5-2 shows the result of the analysis of the unit owner's satisfaction level on the provided number of parking slots per unit, the size of the parking space, arrangement of parking space, the width of the driveway, access to parking space and allocated parking space for visitors in each apartment category. Data were collected from an interview survey of unit owners as presented in Table 4-12.

Table 5-2: Unit Owner's satisfaction level

		Apartment Type							
		High Income		Low Income		Middle Income		Total	
		Count	%	Count	%	Count	%	Count	%
1. Number of parking slots allocated per unit	Strongly Satisfied	2	8.0%	18	72.0%	2	8.0%	22	29.3%
	Satisfied	23	92.0%	7	28.0%	22	88.0%	52	69.3%
	Neutral	0	.0%	0	.0%	1	4.0%	1	1.3%
	Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
	Strongly Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
2. Size of the parking space	Strongly Satisfied	2	8.0%	21	84.0%	2	8.0%	25	33.3%
	Satisfied	23	92.0%	4	16.0%	23	92.0%	50	66.7%
	Neutral	0	.0%	0	.0%	0	.0%	0	.0%
	Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
	Strongly Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
3. Arrangement of parking space	Strongly Satisfied	0	.0%	7	28.0%	1	4.0%	8	10.7%
	Satisfied	23	92.0%	14	56.0%	22	88.0%	59	78.7%
	Neutral	2	8.0%	4	16.0%	2	8.0%	8	10.7%
	Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
	Strongly Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
4. Width of driveway	Strongly Satisfied	1	4.0%	7	28.0%	2	8.0%	10	13.3%
	Satisfied	23	92.0%	12	48.0%	22	88.0%	57	76.0%
	Neutral	1	4.0%	6	24.0%	1	4.0%	8	10.7%
	Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
	Strongly Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
5. Access for parking space	Strongly Satisfied	1	4.0%	5	20.0%	1	4.0%	7	9.3%
	Satisfied	23	92.0%	18	72.0%	23	92.0%	64	85.3%
	Neutral	1	4.0%	2	8.0%	1	4.0%	4	5.3%
	Dissatisfied	0	.0%	0	.0%	0	.0%	0	.0%
6. Allocated parking space for visitors	Strongly Satisfied	4	16.0%	0	.0%	0	.0%	4	5.3%
	Satisfied	13	52.0%	5	20.0%	10	40.0%	28	37.3%
	Neutral	7	28.0%	10	40.0%	12	48.0%	29	38.7%
	Dissatisfied	1	4.0%	6	24.0%	3	12.0%	10	13.3%
	Strongly Dissatisfied	0	.0%	4	16.0%	0	.0%	4	5.3%

When consider the number of parking lots allocated to a unit, it was illustrated that, 98.6% of unit owners were satisfied about the number of parking slots allocated for a unit. Out of that 29.3% unit owners were strongly satisfied and most of them (82%) were living in the low income apartments. Accordingly, it was shown that there was no issue regarding the number of parking slots allocated for each unit since there is nobody unsatisfied over provided parking lots.

Also, it was found that 100% of unit owners were satisfied about the size of the parking slot. Out of total 33.3% unit owners were strongly satisfied and most of them (84%) were living in the low income apartments. Finally, it was shown that there was no issue regarding the size of the parking slots allocated in each apartment since there is nobody unsatisfied over the size of the parking slots.

Further, it was illustrated that, 89.4% of unit owners were satisfied about the provided arrangement of the parking facility.. Out of total 10.7 unit owners were strongly satisfied and most of them (87%) were living in the low income apartments. 10.7% of the unit owners were neutral. Accordingly, it was shown that there was no issue regarding the arrangement of the parking facility allocated in each apartment.

It was found that 89.3% of unit owners were satisfied about the width of the driveway. Out of the total 13.3% unit owners were strongly satisfied and most of them (70%) were living in the low income apartments. 10.7% of the unit owners were neutral. Accordingly, it is also shown that there was no issue regarding width of driveway allocated in each apartment

When consider the access provided for parking slots, it was observed that, 94.6% of unit owners were satisfied about the access provided for parking slots. Out of total 9.3 unit owners were strongly satisfied and most of them (71.4%) were living in the low income apartments. 5.3% of the unit owners were neutral. Accordingly, it was shown that there was no issue regarding access provided for parking slots in each apartment.

Finally, it was illustrated that, only 42.6% of unit owners were satisfied about the parking space allocated for visitors. Only 5.3% of unit owners were strongly satisfied and all of them are in high income apartments. 18.6% of unit owners were not

satisfied and out of that 71.4% of the unit owners were living in the low income apartments. 38.7% of the unit owners were neutral. Accordingly, it was shown that there is a requirement for further attention on parking space to be allocated for visitors in each apartment category.

5.8. Parking space requirement for visitors

Table 5-3 shows the result of the analysis of the unit owner's perspective regarding sufficient space to be allocated for Motor Bicycles, freewheel and cars for visitors. Data were collected from an interview survey of unit owners as presented in Table 4-13.

Table 5-3: Parking space requirement for visitors

		Apartment Type							
		High Income		Low Income		Middle Income		Total	
		Count	%	Count	%	Count	%	Count	%
1. Motor bicycle space for visitors	Less than 5%	25	100.0%	18	72.0%	25	100.0%	68	90.7%
	Between 5-10%	0	.0%	7	28.0%	0	.0%	7	9.3%
	More than 10%	0	.0%	0	.0%	0	.0%	0	.0%
2. Three-wheel space for visitors	Less than 5%	20	80.0%	16	64.0%	20	80.0%	56	74.7%
	Between 5-10%	5	20.0%	9	36.0%	5	20.0%	19	25.3%
	More than 10%	0	.0%	0	.0%	0	.0%	0	.0%
3. Car space for visitors	Less than 5%	2	8.0%	2	8.0%	3	12.0%	7	9.3%
	Between 5-10%	20	80.0%	15	60.0%	16	64.0%	51	68.0%
	More than 10%	3	12.0%	8	32.0%	6	24.0%	17	22.7%

When consider the motorcycle space requirement for visitors, it was observed that 90.7% of unit owners including all in high income & middle income apartments were believed that less than 5% of the total parking space is sufficient for visitors for motor bicycles and only 9.33% unit owners who living in low income apartments were believed that between 5-10% of the total parking space is sufficient for visitors. Accordingly, it can be summarized as 5% of the total parking space is sufficient for visitors for motor bicycles

Further, it was observed that 74.7% of unit owners were believed that less than 5% of the total parking space is sufficient for visitors for three wheels and only 25.3% unit owners were believed that between 5-10% of the total parking space is sufficient for visitors. Accordingly, it can be summarized as 5% of the total parking space is sufficient for visitors for three wheels

Finally, it was found that only 9.3% of unit owners were believed that less than 5% of the total parking space is sufficient for visitors for cars. 68% unit owners were believed that between 5-10% of the total parking space is sufficient for visitors. 22.7% unit owners were believed that more than 10% of the total parking space to be allocated for car for visitors. Accordingly, it can be summarized as between 5-10% of the total parking space to be allocated for visitors for cars.

CHAPTER SIX

6. RECOMMENDATION AND CONCLUSIONS

Main objectives of this research were to estimate trip generation patterns due to different types of apartment buildings, to identify the relationship between trip generation and other variables such as unit price, unit floor area and number of bedrooms, to identify the actual parking requirements for the apartment category including visitors parking and to identify user's satisfaction on provided parking facilities

When consider the observations found at the analysis of average vehicle count per day in all apartments under the first objective, the morning peak period and evening peak period for all apartments were reported in same time from 0700 to 8000 hours and 1630 to 1800 hours respectively. Comparatively, low income apartments reported lowest trip share (11% & 15%) in both peak times while middle income apartments reach highest trip share (17% & 20%) and high income apartments reported medium trip share (15% & 19%). During the day time, no significant peak hours were reported for any apartments because this traffic count survey was conducted after the COVID 19 lock down period and at that time schools were operated virtually and not physically. Finally, it can be concluded as middle income apartments have reported overall highest average trip share (40%) while high income (35%) and low income (25%) apartments are taking 2nd & 3rd place respectively. Per unit trip generation of low, middle & high income apartments can be reported as 1.4, 2.2 & 2.1 respectively.

During the analysis of the vehicle composition of all apartment categories, it was found that the car has reported the highest percentage (77.8%) of vehicle composition in each apartment category while reporting highest individual percentage (84.3%) in the middle income category. Overall highest percentage (17.2%) of vehicle motorcycle count is reported in the low income category.

When consider the observations found at the first analysis serious of relationship between trip generation with other variables such as unit price, unit floor area and number of bedrooms under the second objective, it was illustrated that there is strong

positive relationship between average all trip rates per day per occupied unit with average number of bedrooms per occupied unit and average unit floor area with R-squared value of 0.806 and 0.726 respectively. And the weak positive relationship could be seen between all trip rates per day per occupied unit and average unit price. Accordingly, it is shown that the average number of bedrooms per unit and unit floor area can be considered as a criteria for determining traffic generation or parking requirement of an apartment unit but the average unit price is not suitable.

Further, result of the second analysis serious of relationship between number of owned vehicles per unit with other variables such as unit price, unit floor area and number of bedrooms founded that there is positive relationship between number of owned vehicles per unit and average unit floor area with R-squared value of 0.773. and there is weak positive relationship between number of owned vehicle per unit with average unit price and average number of bedrooms per occupied unit.

As per the third anyalsis (correlation anyalsis), it was founded that unit floor area has recorded more significance correlation with the no of owned vehicles, average all vehicle count per day and average visitor's vehicle count per day. Average unit price and number of bedrooms in an occupied unit have recorded less correlation when compared with the average unit floor area.

Accordinly, it can be concluded as only unit floor area can be considered as a suitable criteria for determining traffic generation or parking requirement of an apartment unit but the average unit price and of bedrooms per unit are not suitable.

When consider the observations founded at the number of owned vehicles, analysis of visitor's vehicle counts and the visitor's vehicle composition under the third objective of this research, it was founded that for any apartment category, the parking requirement can be considered as one space for one unit. Further, it was founded that high income apartments have reported highest visitor's trip rate (0.55) per unit and low income apartment have reported lowest rate (0.3) per unit because of more

delivery service vehicles & hiring vehicles can be seen in the high income apartments rather than other two categories.

As per the visitor's vehicle composition analysis, 36.9% visitors were used three wheels, 30.6% visitors were used motor bicycles and the rest of the visitors (32.5%) were used cars. Buss & lorry were not reported as a mode for visitors. Accordingly, it was shown that, there are requirement for giving parking facilities for visitors in any apartment category.

As per the unit owners perspection it founded that 90.7% and 74.7% of unit owners in each apartment have reported as visior's parking space requirement for motor bicycle & freewheel is less than 5% of the total parking slots, 68% of unit owners have reported as visitor's parking space requirement for the car is between 5-10% of the total parking requirements

Finally, the overall result can be concluded as follows;

- i. Average trip share percentage of low income, middle income & high income apartments are 25%, 40% & 35% respectively
- ii. Trip generation rate of low income, middle income & high income apartments are 1.4, 2.2 & 2.1 per unit respectively
- iii. Car is the most used mode in any apartment category
- iv. Only unit floor area can be considered as a suitable criteria for determining traffic generation or parking requirement of an apartment unit but the average unit price and of bedrooms per unit are cannot be considered
- v. For any apartment category, the parking requirement can be considered as one space for one unit
- vi. Average trip share percentage of low income, middle income & high income apartments are 25%, 40% & 35% respectively
- vii. As per the unit owners perspection it founded that 90.7% and 74.7% of unit owners in each apartment have reported as
- viii. Visitor's parking space requirement for motor bicycle & three wheel is less than 5% of the total parking slots. For the car visitors it is between 5-10% of the total parking requirements

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Appendix A: Traffic Count Survey sheet

A. TRAFFIC COUNT SURVEY SHEET																							
Purpose of this survey is collecting information for the academic research doing by the Post Graduate Student of University of Moratuwa in order to examine "How the new Apartments are Affects for Traffic Flow?"																							
Sheet No:		Enumerator										Contact											
Date		D	M	Y	Sun	Mon	Tue	Wed	Thu	Fri	Sat												
1. Apartment Type:		Middle Income					Low income					High Income											
2. Location																							
3. Vehicle Count																							
In - (Tally Count)																							
Time	Motor Bicycle				Three wheel				Car/Van				Buss				Lorry						
	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts			
0600 to 0700																							
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1700 to 1800																							
Out - (Tally Count)																							
Time	Motor Bicycle				Three wheel				Car/Van				Buss				Lorry						
	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts	00-15 mnts	15-30 mnts	30-45 mnts	45-60 mnts			
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4. Special Observations																							

Appendix B: Interview survey sheet for apartment unit owners

B. INTERVIEW SURVEY SHEET (For Apartment Unit Owners)									
Purpose of this survey is collecting information for the academic research doing by the Post Graduate Student of University of Moratuwa in order to examine "How the new Apartments are Affects for Traffic Flow?"									
Sheet No:		Enumerator		Contact					
Apartment Name				Date	D	M	Y		
1. Apartment Type:	Midlle Income		Low income		High Income				
2. Location									
3. Price of your housing unit (Rs)									
4. How many vehicle you own? - Please fill count of each vehilce									
a.	Motor Bicycle		c.	Car/ van					
b.	Three wheel		d.	Lorry/ Buss					
5. Number of visitors coming for you and type of vehicle					Per Day	Per Week	Per Month		
a.	No vehicle								
b.	Motor Bicycle								
c.	Three wheel								
d.	Car/ van								
6. As per your perspective how much percentage to be allocated for the visitor's parking space					Less than 5%	5% - 10%	More than 10%		
a.	Motor Bicycle								
b.	Three wheel								
c.	Car/ van								
7. What is your Satisfaction level regarding following facilities?									
Facility		1. Strongly Satisfied	2. Satisfied	3. Nutral	4. Disatisfied	5. Strongly Disatisfied	If you are dissatisfied or strongly dissatisfied, what are the your suggestions for improvements of each facility		
a.	Number of parking lots allocated for a unit								
b.	Size of the parking								
c.	Arrangement of the parking								
d.	Width of the driveway								
e.	Level of parking (Ramps/ Car lift/ Mechanical Parking)								
f.	Access for parking								
g.	Allocated parking for Visitors								
8. Additional Comments/ Observations									

Appendix C: Interview survey sheet for premises manager

C. INTERVIEW SURVEY SHEET (For premises manager)							
Purpose of this survey is collecting information for the academic research doing by the Post Graduate Student of University of Moratuwa in order to examine "How the new Apartments are Affects for Traffic Flow?"							
Sheet No:		Enumerator		Contact			
Apartment Name				Date	D	M	Y
1. Apartment Type:							
Midlle Income			Low income			High Income	
2. Location							
3. Number of occupied housing units in the apartment building							
4. Number of parking lots;							
Type of Vehicle		Provided Physically		Occupied Physically		Additional/ informal	
		For unit owner	For visitors	By unit owner	By visitors	By unit owner	By visitors
a.	Motor Bicycle						
b.	Three wheel						
c.	Car/ van						
5. Number of visitors coming for apartment building and type of vehicle					Per Day	Per Week	Per month
a.	No vehicle						
b.	Motor Bicycle						
c.	Three wheel						
d.	Car/ van						
6. As per your perspective how much percentage to be allocated for the visitor's parking space					Less than 5%	5% - 10%	More than 10%
a.	Motor Bicycle						
b.	Three wheel						
c.	Car/ van						
7. Additional Comments/ Observations							

Appendix D: Interview survey sheet for developers

D. INTERVIEW SURVEY SHEET (For developers)																																																																																																																																																														
Purpose of this survey is collecting information for the academic research doing by the Post Graduate Student of University of Moratuwa in order to examine "How the new Apartments are Affects for Traffic Flow?"																																																																																																																																																														
Sheet No:		Enumerator		Date	D	M Y																																																																																																																																																								
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Appendix E: Traffic survey result in high income apartments

Apartment Number	Vehicle Mode	Time												
		0600 h to 0700	0700 h to 0800	0800h to 0900	0900h to 1000	1000h to 1100	1100h to 1200	1200h to 1300h	1300h to 1400h	1400h to 1500h	1500h to 1600h	1600h to 1700h	1700h to 1800h	Total
High income 1	Motor Bicycle	22	57	44	33	36	41	52	42	37	34	39	44	479
	Three wheel	25	36	36	43	39	44	45	42	40	36	44	44	475
	Car/ Van	32	54	94	77	76	83	110	98	88	95	105	126	1039
	Buss	3	1	0	0	0	0	0	0	0	0	0	1	6
	Lorry	0	1	1	3	4	3	4	4	2	3	2	1	28
	Total	81	149	175	157	154	171	212	186	167	167	191	217	2028
High income 2	Motor Bicycle	0	1	0	0	0	0	0	0	0	0	1	1	4
	Three wheel	0	0	1	0	0	0	0	0	0	1	1	1	4
	Car/ Van	3	7	3	1	1	1	1	1	4	1	4	7	33
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	1	1	0	0	0	0	0	0	0	0	0	1
	Total	4	9	4	2	1	1	1	1	4	2	5	9	42
High income 3	Motor Bicycle	0	1	1	1	1	0	0	0	0	0	1	1	7
	Three wheel	0	0	0	1	0	0	0	0	1	0	1	1	5
	Car/ Van	3	5	4	2	2	1	2	2	1	4	5	7	38
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	0	0	1	0	0	0	0	0	0	0	0	1
	Total	3	6	6	4	3	2	3	3	2	4	7	9	50
High income 4	Motor Bicycle	0	1	1	1	0	0	0	0	0	0	2	1	8
	Three wheel	0	1	1	1	1	1	0	0	0	1	2	1	9
	Car/ Van	6	11	6	3	1	1	2	1	7	3	8	14	63
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	0	1	0	0	0	0	0	0	0	0	0	1
	Total	6	13	10	4	2	2	2	1	7	5	12	16	81
High income 5	Motor Bicycle	0	1	2	1	0	0	0	0	0	1	1	1	7
	Three wheel	0	1	1	1	0	0	0	0	1	1	2	2	8
	Car/ Van	3	8	7	3	3	1	3	4	2	6	9	10	60
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	0	0	1	0	0	0	0	0	0	0	0	1
	Total	3	9	10	5	3	2	4	5	2	8	12	13	76
Total	Motor Bicycle	22	61	48	35	37	41	53	42	37	35	44	48	504
	Three wheel	26	38	39	45	40	45	46	43	42	40	50	49	502
	Car/ Van	46	85	114	86	82	88	119	107	101	109	131	164	1233
	Buss	3	1	0	0	0	0	0	0	0	0	0	1	6
	Lorry	0	2	2	5	4	3	4	4	2	3	2	1	32
Grand Total		97	187	204	172	163	177	222	196	182	186	228	264	2278

Appendix F: Traffic survey result in middle income apartments

Apartment Number	Vehicle Mode	Time												
		0600 h to 0700	0700 h to 0800	0800h to 0900	0900h to 1000	1000h to 1100	1100h to 1200	1200h to 1300h	1300h to 1400h	1400h to 1500h	1500h to 1600h	1600h to 1700h	1700h to 1800h	Total
Middle income 1	Motor Bicycle	0	0	0	0	0	0	0	0	0	0	0	0	2
	Three wheel	0	0	0	0	0	0	0	0	0	0	0	0	1
	Car/ Van	1	5	3	1	1	0	0	1	0	2	2	8	24
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	0	1	0	0	0	0	0	0	0	0	0	2
	Total	1	6	3	1	1	1	1	1	0	2	2	8	28
Middle income 2	Motor Bicycle	0	1	0	0	0	0	0	0	0	0	1	1	4
	Three wheel	0	0	1	0	0	0	0	0	0	1	1	1	4
	Car/ Van	4	9	4	2	1	0	2	1	3	2	4	7	39
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	0	0	0	0	0	0	0	0	0	0	0	1
	Total	4	11	6	3	1	0	2	1	3	2	5	8	48
Middle income 3	Motor Bicycle	0	1	0	0	1	0	0	0	0	0	2	0	3
	Three wheel	0	1	1	0	0	0	0	0	0	0	2	0	6
	Car/ Van	4	17	8	2	1	3	2	1	2	2	7	20	68
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	0	0	1	0	0	0	0	0	0	0	0	2
	Total	4	19	10	3	1	3	2	1	3	2	10	20	79
Middle income 4	Motor Bicycle	1	1	1	1	1	1	0	0	1	0	1	0	8
	Three wheel	0	1	0	0	0	0	0	0	0	0	0	0	2
	Car/ Van	1	3	8	10	9	7	5	6	9	8	8	9	83
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	0	0	1	0	0	0	1	2	0	0	0	4
	Total	2	4	9	11	11	8	6	8	11	9	9	10	98
Middle income 5	Motor Bicycle	0	1	1	0	1	0	0	0	0	0	2	2	7
	Three wheel	1	2	2	0	0	0	0	0	0	1	3	1	10
	Car/ Van	7	21	8	4	1	3	4	3	5	4	11	24	94
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	1	1	0	0	0	0	0	0	0	0	0	2
	Total	8	25	11	5	3	4	4	3	5	5	15	27	113
Total	Motor Bicycle	1	4	2	1	3	2	0	1	1	0	5	3	24
	Three wheel	1	4	5	1	1	1	0	0	1	2	5	2	23
	Car/ Van	16	55	31	19	12	13	14	13	19	18	31	68	308
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lorry	0	2	2	2	1	0	1	1	2	0	0	0	11
Grand Total		19	64	39	23	17	16	15	14	23	20	41	74	366

Appendix G: Traffic survey result in low income apartments

Apartment Number	Vehicle Mode	Time													
		0600 h to 0700	0700 h to 0800	0800h to 0900	0900h to 1000	1000h to 1100	1100h to 1200	1200h to 1300h	1300h to 1400h	1400h to 1500h	1500h to 1600h	1600h to 1700h	1700h to 1800h	Total	
Low income 1	Motor Bicycle	0	0	0	0	0	0	1	0	0	0	0	0	2	
	Three wheel	0	0	0	1	0	0	0	0	0	0	0	0	2	
	Car/ Van	0	2	2	1	2	1	1	1	1	1	1	3	16	
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Lorry	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total	0	2	2	2	2	1	2	1	1	2	2	3	21	
Low income 2	Motor Bicycle	1	0	0	0	1	0	0	0	0	0	1	0	5	
	Three wheel	0	1	0	0	1	1	0	0	0	0	1	0	5	
	Car/ Van	3	1	1	2	2	2	1	3	1	1	7	4	29	
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Lorry	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total	5	1	1	3	3	3	1	4	2	1	9	5	39	
Low income 3	Motor Bicycle	0	0	1	1	1	0	0	2	0	2	0	0	8	
	Three wheel	0	1	2	1	1	1	1	0	0	0	0	0	7	
	Car/ Van	0	1	1	1	2	1	1	1	0	1	1	1	12	
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Lorry	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total	0	2	4	3	4	2	3	3	1	3	1	1	27	
Low income 4	Motor Bicycle	1	1	1	0	1	0	0	0	0	1	1	1	7	
	Three wheel	1	1	1	0	1	1	0	0	0	1	1	1	8	
	Car/ Van	2	2	1	2	2	2	1	3	1	1	6	5	28	
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Lorry	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Total	4	4	2	3	3	3	1	3	2	2	8	7	42	
Low income 5	Motor Bicycle	1	2	1	0	1	0	0	1	0	1	2	1	9	
	Three wheel	1	1	2	0	0	0	0	0	0	1	2	1	9	
	Car/ Van	2	8	4	1	1	1	1	1	1	2	4	9	35	
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Lorry	0	0	0	1	0	0	0	0	0	0	0	0	2	
	Total	4	12	8	2	2	2	1	1	2	3	7	11	55	
Total	Motor Bicycle	3	3	4	2	3	2	2	3	2	4	4	2	32	
	Three wheel	2	4	4	1	2	3	1	1	1	2	5	3	31	
	Car/ Van	8	14	10	8	9	7	6	9	5	6	19	22	120	
	Buss	0	0	0	0	0	0	0	0	0	0	0	0	0	
	Lorry	0	0	0	1	0	0	0	0	0	0	0	0	2	
Grand Total		13	21	18	12	14	11	9	13	8	11	27	27	184	

