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SCHOOL OF CIVIL AND ENVIROMENTAL ENGINEERING

Parking Demand Analysis and Modeling for Shopping Centers:- A Case Study of Major Shopping Centers in Addis Ababa City

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The undersigned have examined the thesis entitled "Parking Demand Analysis and Modeling for Shopping Centers: - A Case Study of Major Shopping Centers in Addis Ababa City" by Asfaw Dessie, a candidate for degree of Master of Engineering and hereby certify that it is worthy of acceptance.

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DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been presented or submitted partially or in full by any other person for a degree in any other university, and that all sources of materials used for the purpose of this thesis have been duly acknowledged.

Asfaw Dessie Azanaw Sign_____ Date_____

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Abbreviation

FTA = Federal Transport Authority

AACRA = Addis Ababa City Roads Authority

TAAABO = Transport Authority Addis Ababa Branch Office

AATB = Addis Ababa Transport Bureau

ERA = Ethiopian Roads Authority

UTTMO =Urban Transport and Traffic Management Office

ORAAMP = Office for the Revision of Addis Ababa Master Plan

CSA = Central Statistical Agency

ITE = Institute of Transportation Engineers

ULI = Urban Land Institute

ICSC = International Council of Shopping Centers

CBD = Central Business District

ASCE = Society of Civil Engineers

SC = Shopping Center

TAR = Trip Attraction Rate

GFA = Gross Floor Area

GLA = Gross Leasable Floor Area

LFA = Leasable Floor Area

PA = Plinth Area

EPS = Existing Parking Space

NOS = Number of Shops

PPD = Peak Parking Demand

MLR = Multiple Linear Regression

DV = Dependent Variable

IDV = Independent Variable

E.C. = Ethiopian Colander

Definition of key words

Shopping centre: A single architectural unit of planned retail outlets and associated services and facilities, designed and managed as a fully integrated retail system.

Gross Floor Area :- Total floor area of the shopping centre including all the service and circulation spaces.

Plinth Area: - Horizontally projected area covered by shopping centre building at ground level, out to out, that is to the outside face of the walls

Inventory of Parking Spaces: - This is the existing surveyed parking facilities in shopping centers

Parking demand:- The number of drivers desiring to park in a given area during a specified time period during the peak hour of the day and parking supply or existing parking facility is the amount of legal parking spaces available in a given area.

Parking accumulation:- it is defined as the number of vehicles parked at a given instant of time. Normally this is expressed by accumulation curve.

Parking volume:- Parking volume is the total number of vehicles parked at a given duration of time. This does not account for repetition of vehicles. The actual volume of vehicles entered in the area is recorded.

Average parking duration:- It is the ratio of total vehicle hours to the number of vehicles parked.

Parking turnover :- It is the ratio of number of vehicles parked in duration to the number of parking bays available. This can be expressed as number of vehicles per bays per time duration.

Parking lots: - These are vehicle temporary storing stations and they form a main part of the overall transportation system.

Parking space : - An area adequate for parking of one vehicle including a sufficient space for opening doors; it is connected with an adjacent route and does not include a maneuvering space.

On-street parking :- These are the roadside parking spaces which may be used by vehicles for parking parallel, perpendicular, or angular to the sidewalk depending on certain factors including width of the adjacent road and volume of traffic on it. Roadside parking may be:

Off-street parking :- These are areas adjacent to roads which are designated and organized as parking lots. Entrance to or exist from them is done by gates which link them to adjacent roads.

ABSTRACT

In recent years, many commercial centers like shopping centers and malls are under construction in Addis Ababa city. These developments and the rising vehicles population in the city have resulted in growing demand for parking spaces and run into severe multidimensional transportation problems. The study assessed the demand for parking spaces in selected shopping centers through investigative parking utilization indices survey. Findings reveal inadequacy of designated parking facilities.

The present study has also made an empirical approach to develop parking demand model through case study of ten important shopping centers and malls in the city by analyzing some quantitative factors affecting the parking demand. The findings suggest that there exists a mathematical model providing linear, positive and most significant relationship between the parking demand and physical properties (explanatory variables) of the shopping centers and malls. Gross floor area, plinth area and existing parking space were identified as the direct influencing variable among the four selected explanatory variables. A verification study was conducted to test the validity of the regression model. The verification has indicated that there is a shortage of proper parking facilities in at least in most of the shopping centers.

This finding provides a basis for design consideration if the present pattern of vehicle ownership and other circumstances prevail in the near future. The model developed would help to determine adequate parking demand so that adequate parking spaces can be planned at proper location. Finally, the study recommends a method towards providing adequate parking space is an essential consideration for construction of shopping centers in Addis Ababa city.

CHAPTER ONE

INTRODUCTION

1.1 Back ground

Parking is an integral component of the transport system. It plays a crucial role in the management of traffic and congestion (Allison, 2002). Therefore, efficiency of the transportation circulation depends upon existing transportation system which parking facilities are major component.(Obot et al, 2009). Studies also show that one of the main problems of today's road networks is parking. In most of the cities in developing countries the planning of road networks lacks the provision of the entire basic infrastructure to be provided for the safe and orderly movement of the vehicles (Akhuewu, Wasiri, 2008). Addis Ababa as a developing city is also facing similar problem.

At this time Addis Ababa city is going through transformation and development. A wide range of real estate developments and commercial activities are being taking place at different corners of the city. Shopping centers, modern hotels, school and colleges, medical centers, financial institutions, housing buildings and high- rise residential apartments and commercial and office buildings are among the developments taking place in the city. These urban developments are directly related to transportation infrastructure of the city. According to the statistics obtained from Federal Transport Authority website the number of cars in the city increasing. This situation has negative aspects like congestion, air pollution and accidents. Especially in city centers serious problems were caused, not only when a car is driving but also when a car is parked. This time parking is one of the major problems people confront every day in the commercial areas of Addis Ababa city which is created by the increasing in vehicles population and absence of enough parking spaces in city. Generally, vehicle accumulation in commercial areas is becoming higher and causing congestion in Addis Ababa city. This increased parking demand for commercial trips is posing a major consequence in the total city. The city has also been experiencing development .of modern shopping areas through the establishments of new shopping malls as well as partial or total conversion of buildings for commercial purpose. These shopping malls are also being hub of commercial and retail activity, they are bound to become spots of problems such as inadequate parking spaces, traffic congestion and hawkers encroachments etc. It is therefore shopping centers and malls were selected as the potential study area for this thesis.

This study is aimed to construct parking demand model for the shopping centers in Addis Ababa city through analyzing some selected variables affecting demand and supply situations directly. In order to justify this, it is necessary to obtain a clear picture of existing patterns by some form of surveys.

1.1.1. Transportation and Land Use Interaction

Land use refers to the kinds of activities on the land or the major purposes of the occupancy of the land (Shoup, 2005, p.609). The major land use categories are residential, commercial (including both office and retail uses), industrial and institutional. Land use and transportation are mutually interconnected (Mitchell and Rapkin, 1952). Thus urban transport plan is based on land use plan and its implementation. Parking demand is also a function of land use type, size, and location. Because of this the Institute of Transportation Engineers (ITE) publishes parking demand estimates by land use type, which are often the starting point for parking demand analyses.

The main components of Addis Ababa transport system are the road network, light rail, city buses, minibuses, taxis, private vehicles and large pedestrians. The road network provides the means for travel through the city. The total length of road in the city is 1, 329.59 kms, out of which 29.7 percent or 395.27km.is asphalt road, the remaining 70.03 percent or 934.34 km is non-asphalt. Road gross density is 1.45 percent which is including asphalt and non-asphalt roads adequate to support the smooth running and development of the socio economic and physical integration of the city. Light railway is also another means of transport service.

As it is indicated in the Addis Ababa 2010 master plan, lack of adequate parking is one of the main challenges mentioned. Commercial land use is responsible for the generation of greater volume of traffic and frequency of movement. So, identifying about cities land use and its intensity is important to understand mobility within the city. The following land use distribution of the Addis Ababa city is prepared as part of the city master Plan (2002-2010).

From the following table 1.1, it can be seen that, out of the total land, the central business district takes 2.4% and 1.9% transportation. And, most of the development of the city is with defined residential, commercial and industrial areas. The main commercial and industrial complexes can be identified being concentrated in three key areas, in addition to main road corridor strip development. Merkato is the main commercial center of the city lying mostly with in Addis Ketema sub-city. The major land freight terminals are situated within this area. Most of governmental services lie in Arada and Lideta sub-cities, known as Mexico, Piazza

and Arat kilo. Industrial areas are mainly located along the North-South road corridor mainly in Akaki Kality. Central Business District areas are characterized by intense generation of traffic by all modes and capacities are limited due to high traffic volumes on street and on street parking.

Table 1.1: Major component of the land use of Addis Ababa city

Major Components of the land use Plan	**Area(ha)**	**Percentage**
Mixed use (Housing) Built up	16,274	31.3
Mixed use (Housing) Expansion Area	6,974	13.4
Existing Industry(industrial area)	1,244	2.4
Proposed Industry(industrial area)	1,777	3.4
Central business district	1,276	2.4
Existing Social Service Area	495	1.0
Proposed Social Services Area	600	1.2
Road Network coverage	1,975	3.8
Transportation	989	1.9
Forest Open Space/	12,176	23.4
Agricultural Area	7,175	13.8
Reserved Area	1,045	2.0
Total	**52,000**	**100**

Source: ***AACRA (2012)***

1.1.2. Vehicle Populations Trend in Addis Ababa city

Addis Ababa city is characterized by the largest share of road traffic flow comparative to other cities in the nation. Addis Ababa has a large concentration of motorized vehicles. According to the Urban Transport Study, 2004/2005, out of the total number of vehicles in the country about 75% was estimated to be concentrated in Addis Ababa. The annual motorization rate of the city vehicle had been 5.8 percent on the average according to the Federal Transport Authority (FTA) computer database for the year 2010/2011. The data obtained show that, total number of vehicles are 260,837 for the year 2010/2011 out of these 95,131 are private and 114,190 are business vehicles which is 36.47% and 43.78% of the total vehicles, respectively. In the fiscal year 2013/14 the registered were 340,880 vehicles and the number of vehicles registered for the year 2016 has reached 447,669 vehicles in the city. From the total 708,416 vehicles in Ethiopia, more than 63.19% are found in Addis Ababa as can be seen in the following table

taken from FTA website. From this we understood that the number of vehicles is growing at a rapid rate with the development of the socio-economic activity of the city.

Table 1.2: Vehicle populations in Addis Ababa City and Regions in 2016

Type of Vehicles and Number in the Regions (up to Sene 2008) Registration												
Description	**AA**	**AM**	**AF**	**BN**	**DD**	**SO**	**TG**	**GM**	**HA**	**SN**	**OR**	**Total**
Ambulance	15229	0	26	27	7		69	8	4	5	160	**15535**
Automobile	122637	1341	46	27	1693	478	927	21	1275	10281	6372	**145098**
Bajaj	98	1108	1776	1146				185	536	4105	5146	**14100**
Tri Cyle	0	3605	0	0	0	0	0	0	0	0	16526	**20131**
Bus(< 12 Seats)	20847	5956	417	215	952	633	2799	0	0	0		**31819**
Bus(> 11 Seats)	12636	6781	276	171	375	434	1521	143	357	1257	2067	**26018**
Combiner	16	19			1	2	8	59	357	98	6322	**6882**
Dozer	14	0	3			1	5	0	20	1	252	**296**
Dry Cargo(<=10 Quintals)	25898	1167	225	90	630	762	733	48	176	35	1063	**30827**
Dry Cargo(>10 Quintals)	81641	3584	210	87	3290	1947	4372	2	2	0	509	**95644**
Dual Purpose Vehicle	36084	2804	314	231	870	335	1665	1	36	65	131	**42536**
Field Vehicle	41684	1433	277	128	348	718	1034	45	445	67	7162	**53341**
Grader	4	2			1	1		23	3	218	17517	**17769**
Forklift	16	0	2		3		2	214	317	30276	19880	**50710**
Gotach	665	0	0	0	48	0	308	0	1699	3133	1305	7158
Liquid Cargo	4745	201	33	2	186	98	621	13	7	1315	358	**7579**
Liquid Trailer	559	10						24	336	25	2188	**3142**
Motor Bicycle	16353	17154	864	2351	5331	931	5705	2	0	1	401	**49093**
Other	12117	320	39	1	93	33	524	0	72	3207	2	**16408**
Three wheel dry load	0		0	0	0	0	65	0	1	0	263	**329**
Three wheel public load	13			2	74	2	5046	0	0	0	7	**5144**
Tractor	715	213	44	114	16	3141	184	0	0	1	238	**4666**
Trailer	17133	248	8	1	296	1	2485	0	0	0	13	**20185**
Vehicle with Machinery	149	99	12	1	103	27	62	0	0	0	164	**617**
Not Specified	38416	991	20	6	2634	1134	187	0	0	0	1	**43389**
Total	**447669**	**47036**	**4592**	**4600**	**16951**	**10678**	**28322**	**788**	**5643**	**54090**	**88047**	**708416**

Source: The Federal Transport Authority Website (http://www.transportauthority.gov.et)

1.1.3. Challenges of Car Parking in Addis Ababa

A study conducted by Korean Knowledge Sharing Program showed that the existing parking service in Addis Ababa city is inadequate and suffers from structural problems, mainly street parking. Consequently it has contributed to inefficient utilization of the road network, safety and congestion problems. Parking in Addis Ababa is critical, most parking is done on the street and it clogs major transportation arteries. Parking demands exceed available supply. Off-street parking is usually found in private and government premises, or fuel stations. In few areas small underground parking is available under high rise buildings. The Urban Plan Representation Sub-Process (August 2009), the number of paid on street parking places were 72 in 2008. These on-street vehicle parking service areas are estimated to 76,038 meters linier and 12,823 car parking lots. But opposite to parking demand spaces the number of vehicles is increasing in the central business areas, residential areas and industrial areas of the city. Thus

parking remains one of the critical issues that need to be addressed through the transport planning of the city.

Dawit Fisseha in his Master's thesis (2013) also showed that parking space is one of the big challenges of the Addis Ababa city and little attention is given for parking space with respect to international standards for commercial areas. Parking has received little consideration as compared to the growing need and development of physical and building structures in the city indicating that the issue has often been neglected and underestimated by urban planners. Furthermore, the lack of providing a sufficient number of parking spaces in commercial and business centers may create some economic impacts. The poorly functioning traffic system has resulted in high level of congestion particularly at peak hours. Besides, at some road sides, there is a facility for car wash which has a serious problem for the purpose of the road and the waste water affects the road durability. One of the proposals of the revised master plan of the city is the provision of adequate parking spaces by developing proper off-street parking facilities to reduce bottlenecks and congestion at critical road intersections and locations.

The problem of parking space is getting worst because there are also incidents where already readied parking basement lots of commercial centers are used for other purposes. From an interview with an official of the building occupancy permit documentation sub-process owner at the Addis Ababa City Administration said the building owners change their parking places located in basements in to shops, stores and nightclubs. Further, this act will upset the activity in the area forcing motorists to park in the space surrounding the building (pedestrian walk, entrance to buildings and houses). It is still common these days in the central and commercial centers of Addis Ababa, to observe huge buildings with many stories have according to their own initiative, avoided their obligation to facilitate their buildings with ample parking space. Many commercial buildings or residential units use the nearby public roads as reserve for their own parking purpose even if the plots are intended to serve as pedestrian sidewalks and other public purposes. Parking remains one of the critical issues that need to be addressed through the transport planning of the city.

In order to address problems of parking lots in the capital, Addis Ababa city administration is building smart and surface car parks. The 15-storey smart car parks being built around Megenagna, near Zefmesh grand mall are three buildings, each with the capacity to accommodate 30 cars, will be erected at the area, according to infrastructure head of the Addis Ababa City Transport Program Coordination Office. The city administration is also contemplating to build similar car parks around Churchill road and in front of Grand Anwar

Mosque. In addition to the smart car parks, the construction of surface car parks, each with the capacity to accommodate 49 vehicles, is underway at various parts of the city. The construction of a concrete parking lot, which could accommodate 500 vehicles, will be commenced soon at a place commonly known as Shola Gebeya, according to Addis Ababa City Transport Program Coordination

1.2 Problem Statement

In Addis Ababa city parking problem is becoming the most common occurence. People have habituated to park cars just on the road for a long time which degrades the efficiency of the road. As a result concentration of parked vehicles on the busy streets is reducing the normal traffic flow capacity of the roads, increase accident potentials and confuse vehicular and pedestrian movements in the city and this problem may worsen in the future as car the number owner ship increases. This is because lack of provision of adequate on street and off street parking facilities on the road ways and commercial and shopping centers while planning and designing. According to media editorials the existing parking service is inadequate. An interview of Capital Ethiopia news papers with former general manager of Addis Ababa City Administration, some four years back that his office has formed a strategy to develop parking lots throughout the city to solve the parking space shortage and Fortune news papers publication interview with the present mayor Addis Ababa city twenty multi-story parking garages are also going to be built which are some of them are under construction now for the purpose of addressing the increasing traffic congestion and parking problem in the city. According to the city administration plan, the road from Meskel Square to Megenagna and from Meskel Square to Bole International Airport were the priority areas that need immediate parking lots as there is a large concentration of vehicles in these areas that lack sufficient parking facilities compared with the traffic flow. The deputy scientific director at the Ethiopian Institute of Architecture Building Construction & City Development in his an interview with Fortune News paper Published on November 3, 2013, also said that there is no detailed study on parking has been done in Ethiopia. This shows that there is a lack of parking demand and supply studies for Addis Ababa city. These shopping centers are being a hub of commercial and retail activity in city and bound to become spots of problems such as inadequate parking spaces, traffic congestion and hawkers encroachments etc. Thus provision of ample parking spaces, service roads and appropriate space provision for vendors need to be the part and parcel of planning consideration. Choice of site for shopping centers thus also becomes critical i.e. it

should be appropriate with respect to accessibility and availability of infrastructure and services.

Parking requirements practices in Addis Ababa city seems neglected. This is because there is no consistencies in the parking space demand provisions. Parking standards and manuals from other countries can be used as a tool to understand parking demand and can provide data from their experience to determine parking need but it is cannot be used as authoritative standards. This is because parking demand differs from one area to another depending on economic conditions, land use patterns, levels of vehicle ownership, public transport service, travel behavior, and traffic management measures. Thus without studying the distinctive factors of a city that contribute to travel behavior and parking demand, copying even a successful plan from a different location may lead to undesirable results. Therefore, to address the local parking demand to carry out studies by incorporating the findings of overseas studies into local context. There is also a dearth of national literatures on parking demand for all land uses including shopping centers which require proper planning. In designing a successful shopping centre it is important to determine parking space based on reliable data to provide proper amount of parking space.

The discussion in the literature review indicates that there is a dearth of national literatures on parking demand which require proper planning. The foreign studies are more concerned to develop the conceptual framework about parking demand analysis. So, there is a need to incorporate the findings of overseas studies into our local context and design an effective survey method within the present framework.

Therefore, this study intends to fill the identified gap parking demand study of Shopping centers and malls as the potential study area. This studies the current parking demand by conducting survey counts of parking at peak hours by analyzing the parking demand and supply situation in selected shopping centers and malls in Addis Ababa City. And finally come up with mathematical model that is used to estimate the current peak parking demand of shopping centers.

1.3 Objective

The main objective of this study is to conduct parking demand survey at peak hours in some selected shopping centers (SC) or a malls and develop a relationship between the number of vehicles (parking demand) attracted to the shopping center and the features of the whole shopping

center through analyzing some quantitative variables affecting the parking demand within the framework of existing facilities and conditions.

1.3.1 Specific Objectives

The specific objectives of this thesis work are the following:

i. To assess the existing parking supply and demand situation of the selected shopping centers.
ii. To develop a parking demand model using linear regression method using basic site characteristics such as available physical properties of the shopping centers.
iii. To formulate some recommendations for the improvements of present parking situation

1.4 Scope of Study

The vehicles attracted to the shopping centers with mixed uses such as for shopping, and other services were assumed as they are for shopping purposes since the selected shopping centers are dominated with shops.

The original intention was to consider as many variables as possible; however this was impractical due to limitations of time, cost and personnel. Only the quantitative variables from the physical circumstances of the shopping centers having direct influences on the parking demand are analyzed using the statistical techniques. In the present analysis, vehicle ownership, age of the shopper and parking distance are not considered as explanatory variables because it is assumed the age of the shopper and parking distance have little effect on the choice process. From my literature review I found that that the relationship between floor area and parking requirement produced a general trend. But very few have gone, relating parking demand to anything more generalized floor area of the developments. Therefore, it is also impractical to consider all the variables due to limitations of time, cost and personnel. The following explanatory variables are selected for the final analysis:

	Variable	Unit of Measurement
i.	Gross floor area	Meter Square
ii.	Plinth area	Meter Square
iii.	Number of shop	Number
iv.	Existing parking space	Meter Square

1.5 Organization of the Thesis

The research has five Chapters. The Chapter part is the introduction, which states the back ground, problem, objective, scope and organization of the research. The second chapter deals

with literature review that is relevant to the research. The third chapter of the research discuses the research method, that explains the sources, sampling technique, and procedures of collecting data for the study. The forth chapter descries the location and characteristics of case study shopping centers and evaluation of their parking demand and supply situations. The fifth chapter focuses on the analysis and discussion of multiple regression analysis models developed based of data gathered in light of the chapter four and presents summary of the main results on the findings.. The sixth chapter focuses on discusses, draws conclusion and recommendations based on the findings of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

A number of previous research works dealt with the similar problem, helped to select the appropriate factors i.e. variables for the present study. An extensive search for academic journals, reports and prior studies relating to parking demand analysis and multiple linear regression models for shopping centers have been explored to get a clear concept about the parking demand supply analysis as part of the literature review.

2.2 Concept of Parking

Parking is defined as the act of stopping and disengaging a vehicle and leaving it unoccupied (Wikipedia, free encyclopedia). A parking space is a location that is designated for parking, either paved or unpaved. Parking spaces can be in a parking garage, in a parking lot or on a city street. It is usually a space delineated by road surface markings. The automobile fits inside the space, either by parallel parking, perpendicular parking or angled parking.

The Victoria Transport Policy Institute, TDM Encyclopedia (2012) explains that parking demand is affected by vehicle ownership, trip rates, mode split, duration (how long motorists park), geographic location (i.e., downtown, regional town centre or suburban), the quality of travel alternatives, type of trip (work, shopping, recreational), and factors such as fuel and road pricing. There are usually daily, weekly and annual demand cycles. For example, parking demand usually peaks on weekdays at office buildings and on weekend evenings at theaters and restaurants. Parking demand can change with transportation, land use and demographic patterns.

There two types of parking, on-street parking and off-street parking. On-street parking can be described as parking that is located along the edge of the road, and where maneuvering into and out of a parking space may interact with traffic flow. While, off-street parking is where the parking facility does not directly interact with the through traffic flow along a road other than at the access point between the road and the car park.

2.2.1 Parking Statistics

The parking statistics that are used to evaluate existing condition of parking facilities include:

2.2.1.1 Rate of Arrival and Departure

The rate of arrival and departure involves determining the extent of parking usage, which is includes counting of parked vehicles, at regular interval over a period of time. The beat survey method was used where the data on parking demand was obtained by recording the registration plate number of the vehicle sparked in each parking space for a period of with an interval period of 15 minutes to meet the research precision. The data on parking demand is important in understanding the parking behavior where this method was used to study the patterns of arrival and departure and parking duration of the users. However, this method was applied to collect data pertaining only to vehicle arrival at the parking areas (Mathew, 2014).

2.2.1.2 Average Parking Duration

Parking duration is the length of time a vehicle parked at a space. When the parking duration is given in average, it indicates how frequent a parking space becomes available. Besides that, the average parking duration also helps to identify whether a parking facility is used as a short-term or long-term. Duration is calculated by dividing the total vehicle-minutes parked (time period of vehicles occupying parking spaces at the facility) by the total number of vehicles parked (Mathew, 2014).

2.2.1.3 Parking Accumulation

Parking accumulation refers from total number of arriving vehicles minus total number of departing vehicles, accumulated from the start of the observation The time interval should be short for greater accuracy, maximum 15 minutes (Mathew, 2014).

2.2.1.4 Average Occupancy

Parking occupancy is the percentage of occupied parking spaces during a specific period of time. It refers to the utilization rate of the parking facility, and is expressed in percentages (%). It relates parking demand with the existing parking supply. Furthermore, the parking occupancy also indicates the peak-hour demand. From the parking occupancy method, the data is analyzed by calculating the number of available parking that actually used in the facility. The formula for parking occupancy is (Mathew, 2014).

2.2.1.5 Parking Turn-Over

Parking turnover is the number of vehicles utilizing the same stall over a given period of time. In short, it is known as the rate of usage of parking space. The parking turnover for individual parking spaces can be determined by counting the number of different cars using a particular

parking space throughout the 14 hour study period. This is to determine the utilization rate of individual parking spaces. As for the average parking turnover for the parking lots, it is computed by dividing the total number of cars parked throughout the study period with the total number of parking spaces (Mathew, 2014).

2.3 Literature Reviews Related to Parking Demand Study

The major studies of actual survey data on parking demand for shopping centers include ITE, ULI, and The Victoria Transport Policy Institute and other special studies.

The Parking Generation data are necessary for transport professionals for conducting parking requirement analysis, site impact studies, on-site circulation studies and other land use related studies. The Institute of Transportation Engineers (ITE) is an international body of transport professionals based in Washington, DC, USA, that publishes and updates the information on the parking generation for various types of land uses in USA through Parking Generation (4th Edition), 2010 that includes data on 106 land use types. Generally parking studies were conducted to collect and analyze data relationship between parking and the site characteristics for a particular land use type based on the USA local conditions. The Institute of Traffic Engineers (ITE) hand book presents different parking demand models (equations) and rates for single family residential, town homes, multi-family residential, retail, office, and industrial. The following Parking Generation equations correspond to the retail areas. ITE's *Parking Generation* Manual compiles peak parking demand rates, typically by GLA, for various land uses for weekdays and Saturdays. Using data collected from more than 140 surveys at all types of shopping centers ranging in size from 25,000 to 1,400,000 *ft2* of GLA. ITE also performed regression analyses on their data and presented best fit regression equations that can be used to estimate the parking demand for shopping centers.

The ULI's Parking Requirements for Shopping Centers study of parking demand was performed on the basis of surveys at more than 135 shopping centers in the United States and Canada *(2).* Parking surveys were conducted on the Friday after Thanksgiving and on the following three Saturdays before Christmas. Historically, this is the period when the yearly peak parking demand will occur. This study also investigated the impact of many variables including shopping center size, types of uses (retail or nonretail), and shopping center location.

The Urban Land Institute (ULI), United States (1983) carried out a linear regression analysis to study the relationship between office parking demand and office floor area. This study indicated that parking demand and floor area were highly correlated, with an average parking

ratio of approximately 2.5 parking spaces per 1,000 fleet of occupied floor area. Details of the regression result are shown in Figure 3.4.

In Britain the parking standards are based upon the recommendations of Multiple Shop Federation (MSF, 1973) and National Economic Development Office (NEDO, 1971) which are in terms of gross retail area.

Chiara and Koppelman (1969) have identified a number of factors affecting the parking demand for a shopping centre. Accordingly parking demand depends upon .the the following factors .

a) Size and type of the centre
b) Composition of the tenancy
c) Location in relation to customer traffic from public transportation
d) Character and income level of the trade area
e) Amount of walk-in-trade generated from the nearby works
f) Local parking habits; rate of turnover in the parking spaces
g) Size and shape of the property
h) Cost of the land and maintenance cost

Henry Fan, et.al. (1996) considered gross floor area, leasable floor area, occupancy rate, car park spaces variables to relate peak to parking demands in his study. The methodology of the study conducted was the number of vehicles parked in the building was counted then followed by hourly parking accumulation counts, and then the counts were summarized every 15 minutes. Vehicles parked on the vicinity or the adjacent street whether designated or prohibited areas were also counted.

In developing a downtown parking model by Ergun (1971), the author considered two types of possible explanatory variables for the analysis of choices made. The first type that represented system characteristics included parking cost, parking distance, slope of the parking cost profile and number of parking hours. The second type of explanatory variables investigated was socio-economic characteristics of the individuals. Such characteristics were income, age and sex. Nevertheless, very few studies have gone any further than relating parking provision to anything more but the retail floor area of the developments (Kamali and Crow, 1989).

A study on Trip Attraction Rates (TAR) of Shopping Centers (SC) by Shinya Kikuchi, Marian Felsen, Sharat Mangalpally and Anuj Gupta (2004) in Northern New Castle County (Delaware). From this assessment they showed that the average TAR of the SC has a positive relationship with floor area, number of stores and available parking space i.e. as the size of

shopping centre, number of stores and available parking space increases the total number of cars available to make trips to the centre also increases. From it can be stipulated that parking demand has a positive relationship with floor area, number of stores and available parking space since parking demand are positively related to trip attraction rates.

The next study was a trip attraction rate of shopping centers by M. S. Mamun, S. M. R. Rahma, M. M. Rahman, Y. B. Aziz, M. A. Raihan in Dhaka City (Bangladesh).

In this study regression models were developed to determine attractions of the shopping centers. This research was conducted to determine trip attraction rates of shopping centers in the context of Bangladesh. Two models were developed: one is function of gross floor area in 1000 sq. feet, availability of parking and availability of restaurant; and other is the function of number of stores, availability of parking and restaurant.

Other studies by department of planning and development division in Monroe County (New York, 2007), Yan and Passmore, D. J. (2010) in Singapore and Al-and Masaeid, H. R. Al-Omari, B. and Al-Harasheh, (1999) in Jordan have developed models that relates parking demand to gross floor area, type of shopping center and location for different land uses. The model developed by department of planning and development division in Monroe County is simple linear regressions (SLR) that relates parking demand and gross floor area of shopping centers while the models developed by Yan and Passmore, D. J. (2010) in Singapore and Al-and Masaeid, H. R. Al- Omari, B. and Al-Harasheh, (1999) in Jordan are multi linear regressions (MLR).

Another prominent example was the investigation at 16 shopping centers in Glasgow by Codd (1983). From the study of 16 Shopping centers in Glasgow by Codd (1983), it was revealed that car ownership rate had no straight forward effect on maximum parking accumulation. Codd's assessment was, as the size of shopping centre increases, its catchment area increases and thus the total number of cars available to make trips to the centre also increases (Codd, 1983).

Henry S. L. Fan, and Soi Hoi Lam (1997) in Journal of Transport Engineering to American Society of Civil Engineers (ASCE) mentioned that parking requirements of proposed developments in developing cities are determined using rates developed for western cities.

Saha (1979) also studied market centers in Dhaka city (Bangladesh) and attempted to use it as a planning tool. Her study analyzed the intra-urban spatial systems, type of commercial establishments (i.e. retail, wholesale etc.) and trade areas of 20 commercial nodes and markets

in Dhaka city. This was an earlier and remarkable research work providing quantitative statistical analysis of rank correlation coefficients.

2.4 Parking Demand Rates

In the developed world various techniques for estimating parking demand have been developed. Parking regulations and codes often specify the amount of parking for designated land uses. Peak period of parking demand is the hour of the day during which the highest parking demand ratio occurs (ITE parking demand generation manual). Parking generation rates can be found in a number of parking resources. This includes the Institute of Transportation Engineers (ITE), Urban Land Institute (ULI) and the International Council of Shopping Centers (ICSC) is the most comprehensive guides for parking requirements for different land use as well as shopping centers available in this field. These provide an index or parking ratio used to calculate the number of spaces to supply at a particular location.

The standard, recommended for parking provision at new shopping centre developments in different countries throughout the world, are expressed in relation to gross leasable area or gross floor area. Parking standards for off-street parking requirements adopted for use at American commercial centers are based upon the value recommended by the U.S. Urban Land Institute and Institute of Transportation Engineers. The value i.e. the amount of parking spaces varies with size and location of the shopping centre (ULI Bulletin-53, 1965).

The Institute of Transportation Engineers (ITE) Parking Generation is the standard for vehicle parking demand estimation and is used across the US by traffic engineers, transportation planners, and city/county officials to estimate the number of parking spaces to be supplied by a development. ITE compiles parking studies for various sites and land uses, groups these studies into categories, and then develops rates and equations which can be applied to similar projects. The reference guide provides parking demand characteristics for hundreds of distinct land uses. Parking Generation is one of two nationally recognized parking demand datasets, with both being used as the basis for parking studies throughout the United States of America. Parking Generation provides methodology to estimate parking demand which represents the number vehicles that desire to park at a specific location and is typically provided as the maximum number of spaces demanded in the peak hour during the day.

The Institute of Transportation Engineers (ITE) in its period report developed a guideline specifying the number of parking bays required for 1,000 square feet of each category of land use. The ITE has determined parking rates for 101 different land uses such as fast food

restaurants with drive in windows, churches, and residential condominiums. The parking generation rates are in units of number of parking spaces per 1,000 square feet of floor area of the building. The average of the peak parking occupancy of each survey at a particular land use determines the parking generation rate for that land use. For shopping centers, ITE recommend 5.0 parking spaces for 1,000 square feet area of this land use (ITE, 2010). This area includes shops and also restaurant spaces because of its significant influence on parking demand.

Other studies have also provided guidance on parking demand for shopping centers. A study titled "Parking Requirements for Shopping Centers" prepared under direction of Urban Land Institute (ULI) and the International Council of Shopping Centers (ICSC) is the most comprehensive guide for parking requirements for Shopping Centers available in this field. This study has data collection and analysis of hundreds of existing Shopping Center throughout the USA. For shopping centers, the Urban Land Institute estimates the peak parking demand based upon the gross leasable area (GLA).

The ULI's Parking Requirements for Shopping Centers study of parking demand was performed on the basis of surveys at more than 135 shopping centers in the United States and Canada. Parking surveys were conducted on the Friday after Thanksgiving and on the following three Saturdays before Christmas. Historically, this is the period when the yearly peak parking demand will occur. This study also investigated the impact of many variables including shopping center size, types of uses (retail or nonretail), and shopping center location.

The ULI recommendations for providing adequate parking at shopping centers as follows:

• Four (4.0) spaces per 1,000 ft2 of GLA for centers having a GLA of 25,000 to 400,000 ft2.

•From 4.0 to 5.0 spaces in a linear progression, with an average of 4.5 spaces per 1,000 ft2 of GLA, for centers with 400,000 to 600,000 ft2.

•Five (5.0) spaces per 1,000 ft2 of GLA for centers with more than 600,000 ft2.

The Victoria Transportation Policy Institute set amount of parking for a given unit of something relating to the land use for which the parking will be used. Specifically, a building parking provision is calculated per square foot of retail, dwelling unit, seat in a theater, etc. The Victoria Transportation Policy Institute published typical parking standards shown here in table below

Table 2.1: Typical Parking Demand Rates

Land Use Category	Unit	Index (85th Percentile)	Peak Parking Period
Single Family Housing	Dwelling Unit	2.0	Evening
Multi-Family Housing	Dwelling Unit	1.5	Evening
Elderly Housing	Dwelling Unit	0.5	Weekday
Hotel	Guest Room	1.0	Weekday-evening
Hospital	100 sq. m./Bed	5/2.6	Weekday-day
Health Spa	100 sq. m. GLA	6.8	Weekday
Retail – Shopping Center	100 sq. m. GLA	5.0	Saturday-day
Office Building	100 sq. m. GFA/Employee	3.3/0.9	Weekday-day
Light Industry	100 sq. m. GFA/Employee	2.2/1.0	Weekday-day
Heavy Industry	100 sq. m. GFA/Employee	1.7/0.6	Weekday-day
Fast-Food Restaurant	Seat	0.85	Weekday
Church/Synagogue/Mosque	Seat	0.2	Sunday/Saturday/Friday
Movie Theater	Seat	0.25	Saturday-Evening

GLA = Gross Leasable Area GFA = Gross Floor Area

In the case of Ethiopian condition there is no specific parking ordinance enacted by the city government or municipalities. But the review of the Federal Democratic Republic of Ethiopia Addis Ababa Urban and Metropolitan Transport and Land Use Linkages Strategy Review (2014) specifies parking space requirement for the land-development process. Accordingly developers need to provide one parking space per large apartment, one parking space per 5 moderately-sized apartments, one parking space per 10 small apartments, and 1 parking spot for every 70 m^2 of commercial space provided. The urban transport and traffic management planning office (UTTMPO) also set amount of parking for a given unit of land uses as following table.

Table 2.2: Typical Parking Demand Rates from UTTMPO

Use Type	**Required parking sepals**
Dwelling	One space per housing unit.
Industry	One space per 3-20 workers
Office	One space per 2-10 workers
Theater	One space per 10-15 seats
Hotels	One per 5 bed rooms

This shows the provision of one parking spot for every 70 m^2 of commercial space in the Federal Democratic Republic of Ethiopia Addis Ababa Urban and Metropolitan Transport and Land Use Linkages Strategy Review is lower than the requirement by ITE which is 5 spaces per 1,000 square feet (304 square meters).

2.5 Parking Demand Models

Parking standards, parking manuals and other studies utilize regression analyses to estimate parking demands. These models generally use aspects like commercial floor space as independent variables. Different planning manuals use this method for estimating demand through sampling (ITE, 2004; Smith, 2005 and Urban Land Institute (ULI)).

This includes the Institute of Transportation Engineers (ITE), Urban Land Institute (ULI) and the International Council of Shopping Centers (ICSC) is the most comprehensive guides for parking requirements for different land use as well as shopping centers available in this field. Other journal publications used regression analysis as a curve-fitting tool in the establishment of parking generation rates.

2.5.1 The Institute of Transportation Engineers (ITE) Models

The ITE model uses the gross leasable area (in thousand square feet) as independent variable, and the peak parking demand to the shopping center as dependent variable. The gross leasable area (GLA) is the total floor area designed for tenant occupancy and exclusive use, including any basements, mezzanines, or upper floors, expressed in square feet. For the purpose of trip generation calculation, the floor area of any parking garages within the building should not be included within the GLA of the entire building (ITE Trip Generation Manual, 1997). The ITE Manual provides different models for weekdays (peak hours, off peak hours), Saturday, Sunday and Christmas Season. The models in the ITE Parking Generation Manual use the following model to predict the peak parking demand.

P = (3.62 *X) + 120 (ITE Code 820)……Equation 2.1

P = peak parking demand (spaces)

X = in 1,000 square feet of gross leasable area

2.5.2 The Urban Land Institute (ULI) Models

The ULI developed shared parking models for different mixed land uses in United States of America. The models for retail centers are

Retail less than 400,000 square feet (Customer)

P = 2.90 * X …….Equation 2.2

P = peak parking demand (spaces)

X = 1,000 square feet of gross leasable area

Retail less than 400,000 square feet (Employee)

P = 0.70 * X …….Equation 2.3

P = peak parking demand (spaces)

X = 1,000 square feet of gross leasable area

2.5.3 Parking Demand Model Developed in Monroe County

A project study by Department of Planning and Development Division (2007) developed a model that relates parking demand model for different land uses in Monroe County (New York). The project was intended to be a resource in evaluating existing parking demand codes and ordinances, and to be used in conjunction with other technical resources, such as the Institute of Transportation Engineers' Parking Generation manual. The equation (model) between the observed peak hour demand and the shopping center's square footage during non-holiday periods is:

P= 2.211(X) + 11.16 ……Equation 2.4

P = Peak hour parking demand

X = 1,000 square feet of gross floor area

This best fit curve equation for the data is a simple linear relationship of 11 spaces plus 2.21 spaces per every 1,000 square feet. This is a strong, positive relationship with a goodness of fit measure (R2) of 0.80. A perfect predictor would have an R2 value of 1.0.

Some states and municipalities in United States of America have performed trip generation studies to obtain local and regional data, which may more accurately estimate trip generation in their areas. The Buffalo and Ellicott studies (Desman Associates, 2008, 2009) used their own parking demand generation rates determined by local land use studies.

2.5.4 Parking Demand Model Developed in Jordan

Al-and Masaeid, H. R. Al- Omari, and Al-Harasheh, (1999) considered a number of factors affecting the parking demand and have develop models for different land uses in Jordan. Peak parking demand for shopping centers was found to be significantly influenced by the area of shopping centers and types of shopping centers whether it is private or military shopping centers. They that showed peak parking demand is found to be strongly related to the (gross or leasable) floor area of the development. This lends support to the use of floor area as a measure for determining parking rates. Results of this study indicated that the use of LFA gives slightly better estimates of parking generation rates than the use of GFA. However, for practical considerations, the use of GFA is recommended. This study assessed vehicle parking demand for different land uses which are hospitals, office buildings, hotels, apartment buildings, restaurants and shopping centers in Jordan . Peak parking demand for shopping centers was

found to be significantly influenced by the area of shopping centers. Parking demands for two types of shopping centers were investigated, including private and military shopping centers. Field observations and empirical results of this study indicated that the peak parking demand of military shopping centers is much greater than that of the private centers. In fact, military shopping centers provide services for military members or their families only, and they normally have distinct characteristics. Another reason is attributed to the diversity of goods presented by the military shopping centers. Consequently, a dummy variable was included in the modeling analysis to account for the type of shopping center.

The dummy variable was included because both types of shopping centers had approximately the same slope and variance when separate regressions were developed. Thus, it was more precise to work with one regression model containing a dummy variable since more degrees of freedom will be associated with the mean square of errors. Based on the analysis, the following linear equation was developed:

VPDSH = 18.19 + 0.008 GFA +16.76 ´ TSH ……....Equation 2.5

Where VPDSH = vehicle parking Demand of shopping centers,

GFA = Gross Floor Area of shopping center and

TSH = type of shopping center (1 for military shopping center, 0 otherwise).

2.5.5 Parking Demand Model Developed in Singapore

A journal study by Yan and Passmore, D. J. (2010) pointed out several relevant variables to develop a downtown parking model for several land uses in Singapore. The regression analysis among peak parking demand as independent variable, gross floor area and site location one hand and peak parking demand as independent variable, leasable gross floor area and site location on the other hand of commercial developments have been related. From this Yan and Passmore, D. J. (2010) showed peak parking demand is found to be strongly related to the (gross or leasable) floor area of the development. This lends support to the use of floor area as a measure for determining parking rates. Regression analysis among peak parking demand as independent variable, gross floor area and site location one hand and peak parking demand as independent variable, leasable gross floor area and site location on the other hand of commercial developments in Singapore. The regression analysis relationships obtained are shown in the following equations. Site location is used as a proxy for access to public transit and is represented in these models by the dummy variable (CBD), which has a value of one if the site is within the CBD, and a value of zero otherwise.

GFA model: PARK = 32.8 + 11.55GFA - 128.9CBD……Equation 2.6

LFA model: PARK = 31.3 + 16.93LFA - 126.ICBD…….. Equation 2.7

GFA = Gross Floor Area per 1000 m^2

LFA = Leasable Floor Area per 1000 m^2

CBD = 1 if site is within the Central Business District otherwise CBD = 0

Site location is used as a proxy for access to public transit and is represented in these models by the dummy variable (CBD), which has a value of one if the site is within the CBD, and a value of zero otherwise.

2.5.6 Trip Attraction Model Developed in Northern New Castle County

A study on Trip Attraction Rate (TAR) of Shopping Centers (SC) by Shinya Kikuchi, Marian Felsen, Sharat Mangalpally and Anuj Gupta (2004) in Northern New Castle County (Delaware), showed that the total floor area influences the number of customers visiting the shopping center (SC) and the total number of attractions for various individual stores. The trip attraction (TA) to a SC also depends on the total number of parking spaces, which, in turn depends on the total floor area, and the concentration of the customer at a particular time. In this approach there are two regression models that establish the relationship between the TAR of the SC and the factors of the SC. The first regression model considers the floor area of the SC and the number of stores in the SC. The second regression model considers the number of parking spaces in the SC.

The macroscopic model estimates the trip attraction rate (TAR) of the Shopping Center (SC) based on the physical features of the whole SC.

In the first form, TAR of the SC is estimated as a function of floor space and the number of stores. In the second from, TAR of the SC is estimated by the number of parking spaces. The reason for having two separate forms is to avoid multi collinearity. The number of parking spaces is related to both the number of stores and also the floor area of the store. Multi-collinearity is a situation where in two independent variables are highly correlated and they both convey essentially the same information Using the data given in Table 8.1, the parameters of the two forms of macroscopic model are calibrated separately. In the first form, the equation obtained is the following.

$y = 0.44x_1 + 2.30x_2$; $R^2 = 0.9199$; $R = 0.9591$……..Equation 2.8

Where x_1 and x_2 are the floor area of SC in thousand square feet and the number of stores, respectively; and y is the average TAR of a SC in terms of number of persons per 15 minutes.

Coefficients of x1 and x2 are positive. This means that. The values of R^2 and R represent the coefficient of determination and coefficient of correlation respectively. R^2 = 0.92 means 92.0% of the variation of the TAR is explained by the variation of x_1 and x_2. R = 0.95 indicates a very strong positive correlation; and as the floor area and the number of stores increase, the TAR of the SC increases.

In the second form, the result of the regression analysis is the following:

$y = 0.12x$; $R^2 = 0.9014$ $R = 0.9494$…….. 2.9

Where x is the number of parking spaces and y is the average TAR of the SC in number of persons per 15 minutes. The expression indicates that with an increasing number of parking spaces, the TAR of the SC increases. R^2 = 0.90 indicates that 90.1% of the variation of the TAR is explained by the variation in the number of parking spaces. R = 0.95 means very strong positive correlation between x and y.

From this we understood that the ITE, ULI and other studies can be used as a tool to understand parking demand and can provide the best available data that may be necessary to determine parking need but it cannot be used as authoritative standards. This is because all developments have unique characteristics that can affect their parking generation. The Parking Generation is not intended to be an authoritative standard, but provides the best available data that may be necessary to accurately determine parking need (ITE 2010). These manuals create a framework for estimating parking demand in settings like shopping centers, in which parking is naturally shared. It adapts parking generation rates from a variety of sources, including ITE, and shares its own set of recommended parking ratios for developments of different sizes and for specific land uses that might be included in a mixed use project. In the context of Addis Ababa city, I did not get many comprehensive parking studies that address local conditions.

Therefore, the review of the above literatures of parking provisions at shopping centers indicates that the relationship between floor area and parking requirement produced a general similar trend. They also showed that the parking requirements differ from one region to another. Very few also have gone, relating parking demand to anything more generalized floor area of the developments. In view of these points, it is essential to make studies and develop parking generation rates for a number of land uses to address the actual conditions of the city.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter is about the methods that used for collecting information in the field based on the literature review from previous study in order to gain the knowledge and information regarding the scope of the research. It mainly explains how the study was conducted, the applied methods and techniques in data collection and the reasons as to why they were used according to the research aims and main objectives of the study. This chapter involves discussion of the research process, the selection of the study area, sampling methods and sources of data used in the study. Analytical techniques used in analyzing the data for the study are also discussed.

3.2 Market Centers in the Study Area

Addis Ababa city is going through a development process. A wide range of real estate developments and commercial activities are being taking place at different corners of the city. Shopping centers, modern hotels, school and colleges, medical centers, financial institutions, housing buildings and high- rise residential apartments and commercial and office buildings are among the developments taking place in the city.

The main shopping districts in Addis Ababa are Merkato area, Piazza area and the stadium area Bole area, Shiromeda area, Kirkos area and Shola Gebya area. Piazza is one of the main shopping districts in Addis Ababa. In recent years, several enclosed shopping centers and malls are developing at different corners of the city to better suit their locale and meet public expectation. Shopping complex is one or more buildings for merchandising, with interconnecting walkways enabling visitors to easily walk from unit to unit, along with a parking area- a modern, indoor version of the traditional market place within visually distinct scenery.

Merkato marketplace is the largest market serves as Addis Ababa's major retail trading hub for the wholesale and retail distribution of fresh produce, clothing, home ware and various other types of general merchandise. Many small shops found close to the minibus ranks and on major arterial routes. Merkato is also known for packed shopping centers in one area.

There are many small shops and street stalls in Piazza. It is one of the favorite shopping for many people as there are many jeweler shops, boutiques, shoes stores and shops where you can buy all types goods. There are numerous small shops like Ethiopian crafts-, like statues, embroidery, and pottery, handmade and household goods on and around Addis Ababa's

Churchill Avenue. Churchill Avenue is also one of the main shopping streets in Addis Ababa. There are numerous small shops on and around Addis Ababa's Churchill Avenue.

The area around Addis Ababa stadium is also famous for its Ethiopian leather goods, like clothes and bags. Shiromeda is known for its traditional Ethiopian clothing like a Shemma Shopping centers. A large number of formal retail shopping precincts are scattered across the city. Retail shopping malls form part of the lower floors of a multi-level, mixed-use building comprising of office and sometimes residential components.

The Bole area is a home for wide range of destinations, shopping centers, school and college, medical center, a number financial institutions, mid (4-5 storey) and high- rise residential apartments (10-12 storey) and 8-12 storey commercial and office buildings line up along the bole road. The Bole area is a modern trendy district of town, packed with shopping centers, the Edna Mall cinema, condos, hotels, and plenty of both international and upscale Ethiopian restaurants. Especially, the Olympia area is known for their wide range of destinations (shopping centers, school and college, medical center, number financial institutions in Bole area.

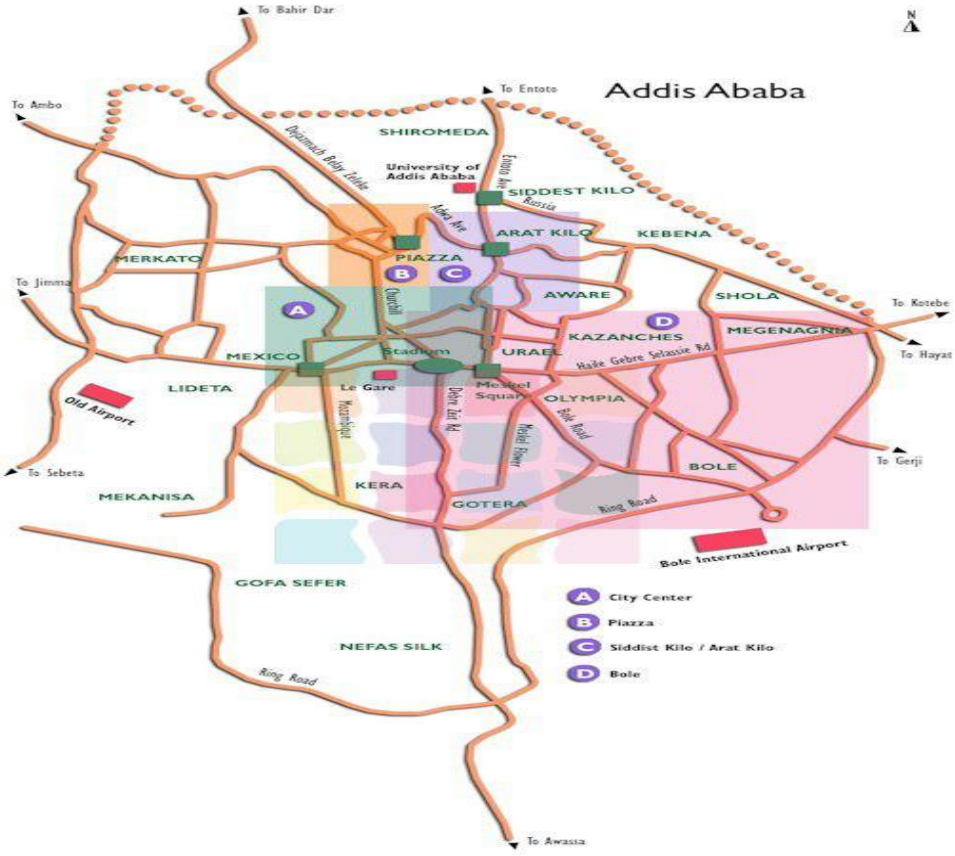

Fig. 3.1: Map of Addis Ababa City and Market Centers

3.2.1 Selected Shopping Centers for Case Study

The shopping centers and malls in this in this study ranges from large hall to multi storied building complexes. This shopping complex attracts a huge amount of traffic, a major portion of which are cars that are parked on-street and parking stalls. Moreover, the designated space for on-street parking proved to be inapt as the surrounding road is overburdened with parked cars which create traffic congestion. All these conditions made this shopping center ideal for selecting them as the study area to depict the parking demand and supply scenario of the commercial land uses in general for Addis Ababa city.

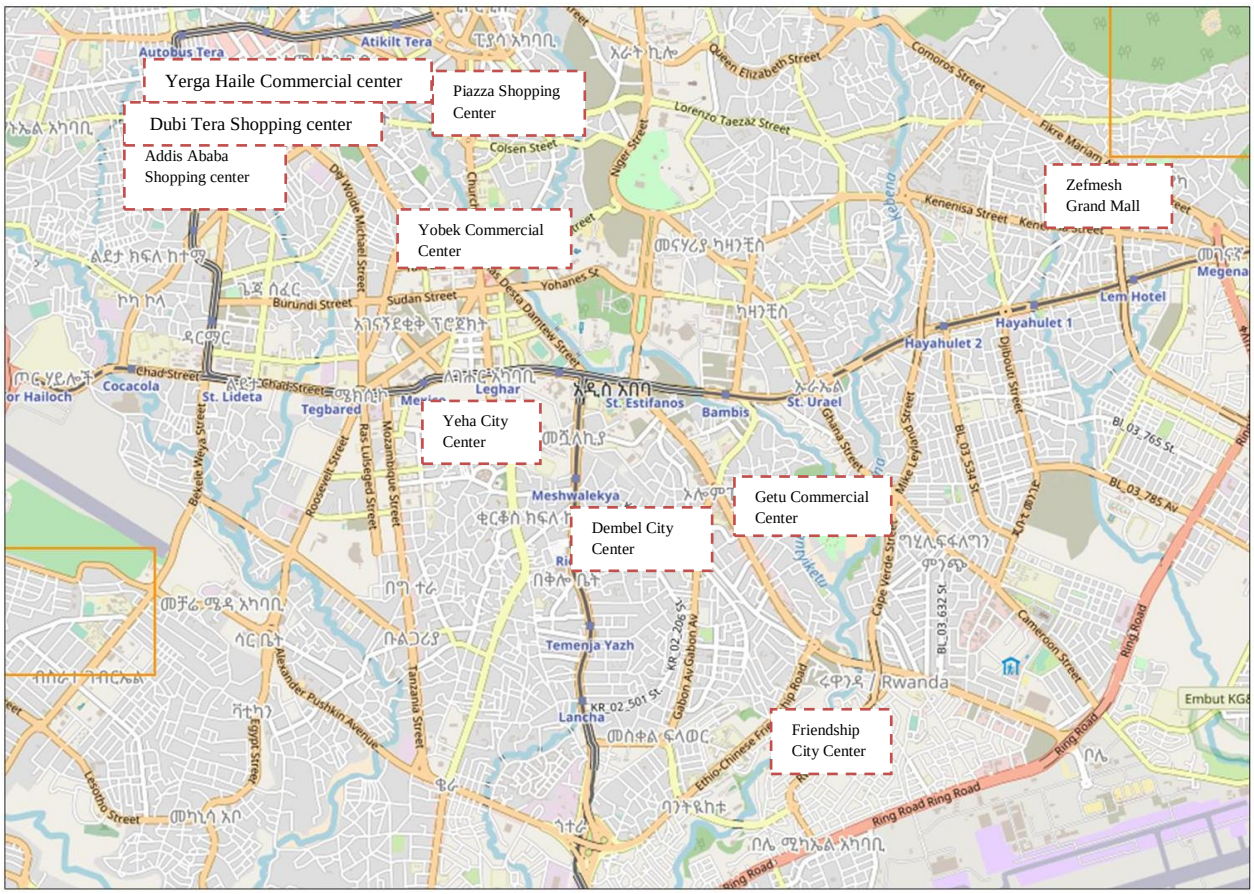

Fig. 3.3: Location map of case study shopping and commercial centers

3.2.2 Criteria for selecting Shopping Centers

This study generally interested in the large shopping center buildings with structured parking. This is in part because these buildings are proving to be the development trend for coming years. Data of the shopping centers were based on inferences and verbal information by building administrators and occupants. Thus, the major criteria to be selected in this study is the location, scale and occupancy level of the shopping centers, parking spaces and the

information of them is easy to gain are considered as criteria to selecting the survey shopping centers for this study. The location of the shopping center was a major attribute for the parking demand of the shopping centre, therefore shopping centers located in the central business district of the city were considered for this study. The size of the shopping centers is another criterion for the shopping centers as a result as much as possible relatively large shopping centers were selected. The other criteria considered is occupancy level as a result as much as possible ninety percent and above occupied shopping centers were selected. Accordingly ten shopping centers and malls found in the major central business districts (market centers) are selected based on the above set criteria as case study to be surveyed.

3.3 The Research Process

The method used when collecting, processing and analyzing the gathered information can be either quantitative or qualitative research method. Quantitative research methods: collect numerical data (data in the form of numbers) and analyze it using statistical methods. Qualitative research methods: collect qualitative data in the form of text and images drawn from observations, interviews and documentary evidence, and analyze it using qualitative data analysis method. In this study interviews with officials of the shopping centre management authority and personal field survey and observation approaches has been used to collect the data. Field survey was used to count the existing parking facilities and parking demand in and around the shopping centers.

3.4 Research Design

As stated above both qualitative and quantitative research method used for the purpose of this study which enables the research to interpret the finding adequately and accurately is summarized in flow chart as follow shown diagrammatically in the Figure 3.3.

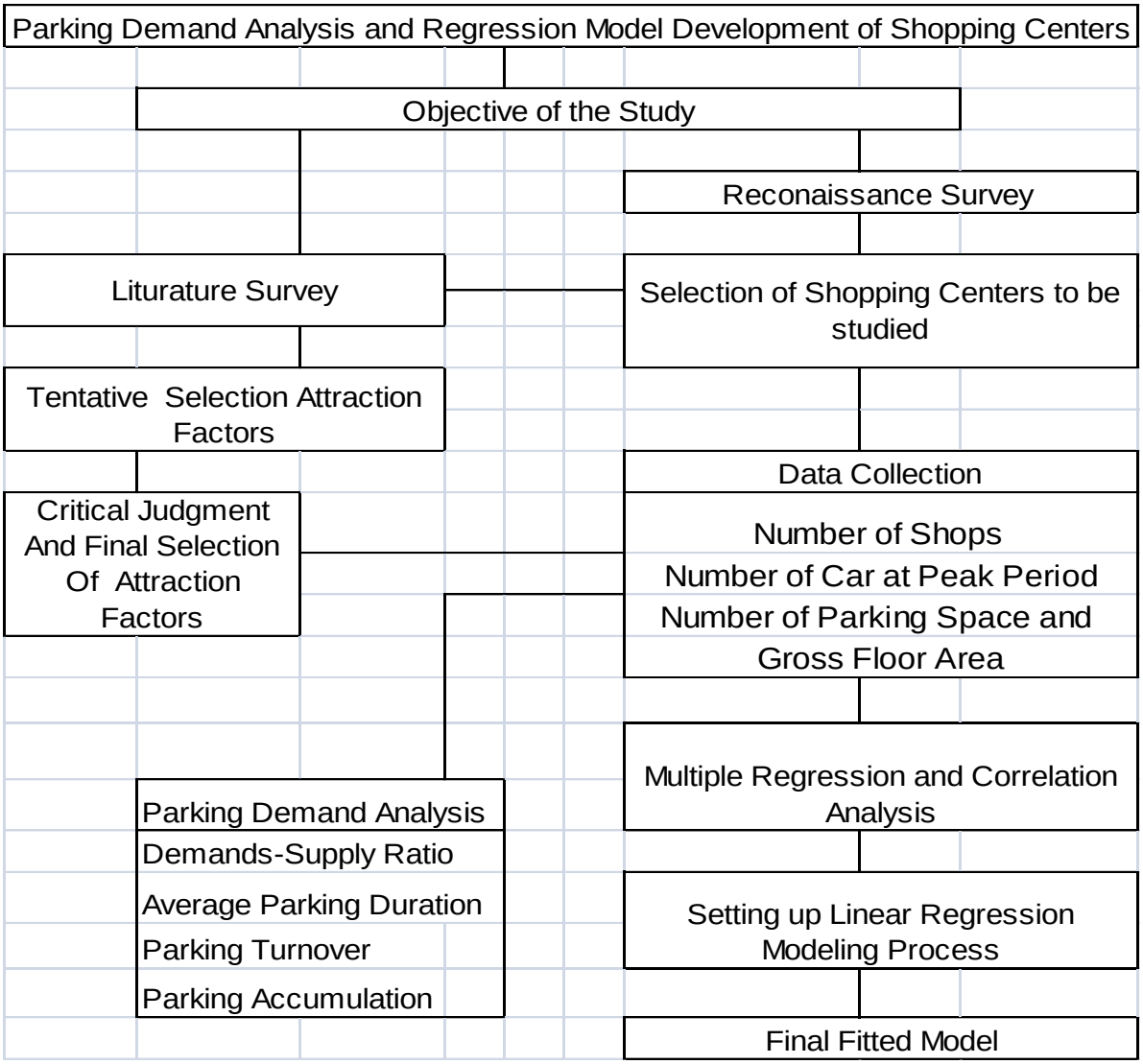

Figure 3.4 Flow Diagram of Methodology of the Study

Critical judgment is thinking and selecting attraction factors which are relevant for the study based on the surveys.

3.5 Data Type and Source

The study employed both primary and the secondary data types. Officials of the shopping centre management and field survey were considered as the primary source of information. While secondary data is collected from reports, published as well as unpublished materials from the City Administration, Addis Ababa Transport Bureau (AATB), and others which are related in the area of the study. Besides, different books, journals, research papers written on the issues and the internet are also considered for the study.

3.5.1. Attraction Factors Survey:

The relevant information required for the study and necessary data about the attraction factors of the selected shopping centers collected with the help of observations, survey and interviews with officials of the shopping centre management authority. The following attraction factors are selected for this study based on the literature review. The gross floor area (total floor area of the shopping centre including all the service and circulation spaces), plinth area (horizontally projected area covered by shopping centre building at ground level, out to out, that is to the outside face of the walls) and number of shops.

3.5.2 Parking Demand Survey

The surveys are conducted on separate working days. In the first day, parking inventory survey carried out to collect data on the amount, type and location of space actually or potentially available for parking in the study area. Parking usage survey is conducted on the following day which included counting parked vehicles at 15 minutes intervals through a period of three hours during the peak periods.

The parking supply and demand survey was investigated at the peak parking period between October of 2016 and December of 2016. Data collection occurred on Tuesdays, Wednesdays, and Thursdays to represent typical weekdays at the peak period time range of 10:00pm-1:00pm. The survey dates and time is determined such that it must cover the peak hours and peak days of parking demand. This was based on the information gathered from the experience of parking operators of the shopping centers and my reconnaissance survey conducted.

The surveyors were positioned at near the entrance(s) and exit(s) while also move around the vicinity of the building especially along on-street parking lots to record the plate number, time of arrival and time of departure of each incoming vehicle in the parking recorded at the peak periods for three hours survey period. This is ensured through counts for a number of entering and exiting vehicles for underground parking lots during the peak hour survey time.

For on-street parking the survey has been done with 15 minutes interval during the same peak hour survey time. The surveyor recorded the registration number of the cars parking in the study buildings by going from one side to other side of the parking area at 15 minutes interval until the end of the survey period. All vehicles attracted to the shopping centers with mixed use services were counted assuming that they are coming for shopping purpose since all of the shopping centers selected for this study are dominated with shops.

The parking demand data collected using the format shown in the Appendix for each shopping centre. This is to know whether occupants of vehicles parked on the road are left the parking lot or still parked on there.

The count is performed according to the following steps:

• Immediately before commencing detailed traffic counts at a given site, information of registration plates of existing vehicles recorded using the form attached in the Appendix. Those vehicles shall be considered later as entered at the start of the count.

• Gates are numbered (or blocks, in the case of on street parking) or any parking access to differentiate between them.

• Detailed traffic count is performed by using the form (shown in the appendix) by the trained counters.

• If the subject parking location is off-street, the enumerators are distributed in the parking area so that each one of them records the registration plate of all entering or exiting vehicles together with time at their specified location.

In the processes of data collection, data entry and analyses, consideration given to separate the data of each type of parking (surface, underground, on street) through the use of separate data collection form. This was done by distributing the enumerators in a manner that ensures obtaining entering/exiting vehicle data for each type of parking separately so that it becomes possible to analyze each type of parking individually and accurately to identify the utilization of each type of parking.

In the survey day, the highest number of parked vehicles counted at every fifteen minutes during the survey period is considered as the peak parking demand.

3.5.3 Parking Space Supply Survey:

This survey is carried out by counting the total parking space available in the shopping center and its surrounding streets. Manually count the number of available parking spaces in the studied site for each type of parking (on street, surface, or garages). In case there are no marking for parking spaces, then the number of parking spaces could be obtained by dividing the existing lengths / areas for parking by the minimum dimensions allowed for parking indicated in the Parking Specifications published by the Ministry (6.5 meters for parallel parking and 2.5 for perpendicular parking. This length is variable for diagonal parking according to its angle).

3.6 Data Collection Tools

Interview and field survey were considered as the major means of data gathering tools. An interview with the shopping center administrators was conducted to obtain information mainly about attraction factors of the selected shopping centers i.e. plinth Area, gross floor area, number of shop types and parking area from plans and elevation of the building complexes. These are also verified from the architectural drawings and documents obtained from the shopping center administrators. Observation and survey were conducted to determine peak parking demand and the average parking duration period, at each selected shopping centre.

3.7 Sample Size and Techniques

Purposively selected sampling technique was implemented in the study to identify the shopping centers to be studied. This is because all the population of the shopping centers are not equally important to this study interms of their location and parking space problems. Thus, the study selects the market centers (shopping centers and malls) that have high parking demand in the central business district of Addis Ababa City . According to the building occupancy permit official of the Addis Ababa municipality, there are about 62 major shopping center and mall building complexes which issued building occupancy permit and distributed throughout the city. But most of them are located in central business district. The potential commercial buildings in context of parking generation have been identified in the central business districts through reconnaissance survey. Thus, total population of the study considered all registered shopping centers and malls of the city, though the case study. Purposive sampling method was used to select central business districts and shopping centers to be a case study. Among the potential parking generator, ten commercial buildings have been selected randomly for case study. Most of these shopping centers are located in the central business districts of city along which the study was conducted and most of them are solely for mixed commercial uses while a considerable number were for shopping and office uses. The scale of the shopping centers, their location and the information of them is easy to gain is also taken under consideration.

3.8 Methods of Data Analysis and Presentation

The analysis part has two parts that is evaluation of the exiting parking pattern using charts, tables and figures and finally multiple regression model development for parking demand of the shopping centers. To do this both quantitative and qualitative methods will use in analyzing the information collected using different instruments.

Qualitative data obtain through interview, observations and document analysis will analyze qualitatively and quantitatively. Then the amount of peak parking demand, expressed in number of vehicles was computed for survey days.

In survey day, the highest number of parked vehicles was taken comparing among the different values counted at every fifteen minutes interval. Finally the highest figure was taken as the value of peak parking demand (i.e. value of dependent variable) for the respective shopping centre. A detail description of determining peak parking demand is presented in the next chapter. For quantitative data mathematical model is developed by multiple regression statistical analysis to model the relationship between observed peak parking demand and explanatory variables of the shopping centers

- Plinth area of the shopping center
- Gross Floor Area (cumulative floor area of the shopping center)
- The number of shops in the shopping center
- The existing parking spaces in the shopping center

That is multiple regression will be used to show the parking demand of the shopping malls in relation to gross floor area, number of shop and existing parking supply.

Evaluation of parking demand pattern relative to the peak hour is the other task carried out. Consequently, this paper analysis the existing parking demand conditions and develop a model for the parking demand of shopping centers.

3.9 Regression Model Building Approaches

The linearity assumption has been checked prior to the model building, while the other assumptions have been checked after building the model. Scatter plots were used to visualize the relationship that exists between each the independent variable and the dependent variable. Then

3.9.1. Step-wise regression

To select the best regression models were the widely used 'stepwise' regression methods employed. Stepwise regression is an automated tool in SPSS that is usually used in the exploratory stages of regression model building to identify a useful subset of predictors. The process systematically adds the most significant variable or removes the least significant variable during each step. Standard step wise was used to identify the most important factors in the model. The independent variables to be included in this step are only the factors that have been proven to have a strong linear relationship with the dependent factor. The step wise

regression usually provides an understanding about the degree of importance of each independent factor.

3.9.2. Multicollinearity Check

The Multicollinearity can be checked by examining the collinearity statistics. As a rule of thumb, variable with Variance Inflation Factor (VIF) that exceeds 10 are said to be highly collinear and will pose a problem to regression analysis (Hair et al., 2013).

3.9.3. Model Test

Using the recommended independent factors by the step wise regression test, a general regression test was conducted to evaluate the model and its components. The two Hypotheses that have been tested in the ANOVA analysis for each independent variable at this step are:

H0: the independent variable has no effect on the dependent variable.

H1: the independent variable has an effect on the dependent variable.

The significance level of the test was 95%, The P- Value of (0.05) was used to accept or reject the null Hypothesis.

Table 3.1: P-Value to accept or reject the null hypothesis

P- Value	Null Hypothesis
P- Value ≤ 0.05	Reject the H0
P- Value ≥ 0.05	Accept the H0

Other test statistics were evaluated to understand the output of the regression test. These elements have been covered thoroughly in the literature review. Here is a quick reminder about their meaning and interpretation.

F- Value

This evaluates the overall significance of the model by comparing the model to the intercept model. This Value is usually used to compare between different models, the greater this value, the better the model.

T-Value

As this value represent the value of the estimated coefficient for each independent variables divided by its own standard, and it measures how many standard deviations the estimated coefficient is from zero, then the bigger the t- value the more significant the coefficient. This value is used in an association to P-Value to accept or reject the null hypothesis. An absolute t-value less than two leads to reject the null hypothesis. The t-test for:

$H_0 : \beta_k = 0$

$H_1: \beta_k \neq 0$

Actually tests whether the variable X_k should be included in the model. If one rejects H_0, then the decision is to keep X_t in the model, whereas if one does not reject H_0 the decision is to eliminate X_t from the model. Since rejecting H_0 is usually done when either absolute value of t is ≤ 2.0 . Likewise, if a variable has a corresponding t-value, which is equal to or less than 2 in absolute terms, it should be eliminated from the model.

3.9.4. Equal variance or homoscedasticity checking

The assumptions of the linear regression were checked through the residual plot.

. A random patter should be noticed in the plot to fulfill this assumption.

3.9.5. Normality Checking

An individual normality test through SPSS has been conducted to verify that the residuals of the regression are normally distributed. The normality test generates a normality plot and provides information about the mean value, the standard deviation, the Anderson value, the P-value.

The two hypotheses to be tested at this step are:

H_0: the data are normally distributed.

H_1: the data are not normally distributed.

The P-value was used to reject or accept the null hypothesis. Please refer to table 3.1.

CHAPTER FOUR

DESCRIPTIONS OF CASE STUDY SHOPPING CENTERS AND PARKING DEMAND ASSESSMENT

4.1 Introduction

A reconnaissance survey is conducted for the selection of shopping centers and ultimately on the basis of having larger size, higher car accumulation and having tentatively well defined parking area ten shopping centers and malls selected this case study. The model developed is applied to study the parking demand at various locations within the major commercial areas of Addis Ababa City. These shopping centers and malls are located on the major commercial area of Addis Ababa City. As stated earlier in the methods of data collection, 10 out of the 62 shopping centers and malls on the central business districts were studied into greater detail. As much as possible those shopping centers having similar character in their commodity composition have been selected. Accordingly, the following are the shopping centers selected for the present parking demand analysis. The location of the sites located in the business district commercial area of Addis Ababa City. Mintaf Tera (Addis Ababa Shopping Center), Dubi Tera Shopping Center and Yerga Haile Commercial Center in Merkato area, Edna Mall and Frendship Commercial center in Bole area, Dembel City Center and Getu Commercial around Olympia area, Dubi Tera (Meseretawi Hiwet) Shopping Center and Yobek Commercial Center around Stadium area, Piazza Shopping Center on Churchill Ave in Piazza area and Zefmesh Grand Mall around Megenagna are selected.

4.2 Description of The Shopping centers

The following sections give descriptions regarding the location of the shopping center, size of the shopping center, size of parking space in the shopping center and the number of available rooms for shopping.

4.2.1 Edna Mall

Edna mall is located in Bole area in front of Bole Medihanealem Church. It is 2B+G+6 building structure consisting of *1,940.00* square meters plinth area, *14166.00* square meters gross floor area and *10,532.80* square meters gross leasable area. Edna mall is a three purpose built mall for cinema, game and shopping complex. This mall hosts shops, indoor multi-screen cinema, cafes, restaurants and children play ground, offices and other services. There are

children and adult clothing, computer, mobile and electronic accessories, photo and video studios, beauty salons and cosmetics for men and women, café and restaurants, jeweler shops, in addition insurances and private offices. Currently it has eighty two shops.

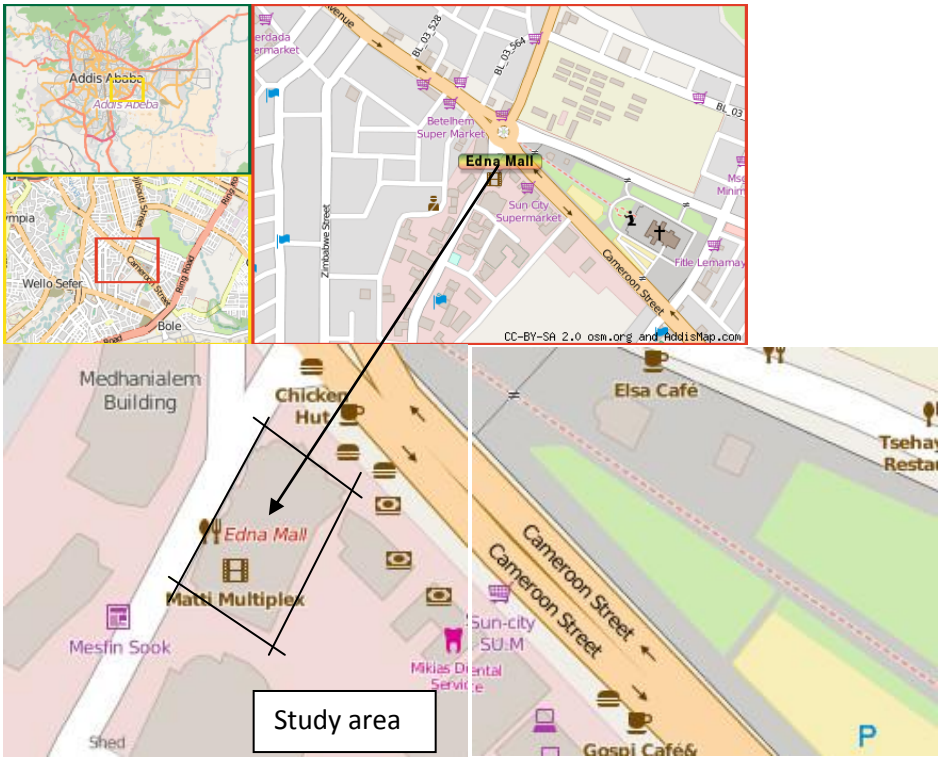

Fig. 4.1 Location Map of Edna Mall Study Area

4.2.1.1 Parking Supply and Demand in Edna Mall

A parking inventory was conducted during study to identify all existing parking spaces and parking demand survey within the study shopping centers and malls, both on-street and off-street locations. Edna mall has two level basement floors with the upper basement floor partially and the lower fully dedicated for parking with total parking area *2,200.00* sq. meters. Total capacity of this basement parking is *52* vehicles at a time. Parking lots are arranged in two lanes separated by driveway. Parking supply of this shopping center can be seen from two perspectives as illegal on street parking practices and the designated building basement provisions. The illegal on street parking space not treated as supply and the designated off street parking spaces counted as supply in this study. There is no designated on street parking provisions for this commercial complex. Vehicles are parked on two sides of the building. At one side vehicles are parked parallel to the road and at the other side vehicles are parked both angular (90^{o}) and parallel to the road. Vehicles are parked on the foot paths and blocked pedestrian movements.

The existing on street parking conditions is enlightened in the appendix with the help of pictures**.** Parking demand surveys were also conducted for the subject shopping centre for the off street (basement floor) of the shopping center and on the streets around the shopping center. The number of vehicles arrived in the survey time at peak hours added to find the parking demand for this commercial center. The peak parking volume is 52 vehicles in off street and 16 vehicles. Combine parking demand for this commercial center is 68 vehicles at the peak time.

4.2.2 Friendship Shopping Center

`Friendship City Center is located around bole area. It is a B+G+9 building structure having 2,000 square meters plinth area, 15,400 square meters gross floor area. This shopping center has 154 rooms designated for use as shops, offices & service providers consisting of a super market, fashion boutiques, shoes, accessories, home interior design offices, furnishings, restaurants, cafes, health & beauty salons, gift shops, telephones, bank and insurances, a dental office, pharmacy, photo studio. There are also places to recreate for the youngsters, children and adults as well including big restaurants with different specializations of local and international meals.

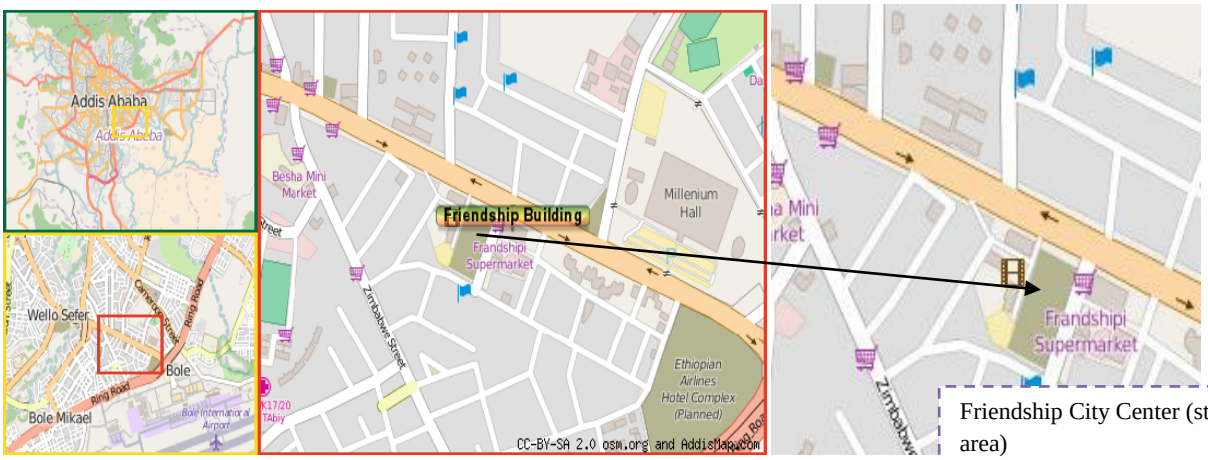

Fig. 4.2 Location Map of Friendship Shopping Center Study Area

4.2.2.1 Parking Supply and Demand in Friendship

Basement floors are dedicated for parking with estimated total parking area of 1,800.00 sq. meters. Total capacity of this underground parking is 65 vehicles at a time. These parking lots are arranged in two lanes separated by driveway. There is no designated on street parking

provisions for this commercial complex. Vehicles are parked on two sides of the building. At front and rare side of the shopping center vehicles are parked parallel to the road.

Parking demand surveys were also conducted for the subject shopping centre for the off street (basement floor) of the shopping center and on streets parking lots around the shopping center. The number of vehicles at peak hours added to find the parking demand for this commercial center. Parking volume is 61 vehicles in off street and 10 vehicles on street. Combine parking demand for this commercial center is 72 vehicles at peak time.

4.2.3 Dembel City Centre

Dembel City Center, also known as Dembel Mall is a shopping center in Addis Ababa, located in the center of the city on the Airport Road or Africa Avenue. Dembel City Center is one of the first western-style shopping malls to open in Ethiopia. It is a twelve floor structure designated for use as shops and other business offices. Dembel City Center is among the largest shopping center in Addis Ababa located laying on 3,500 square meters plinth area and 24,300 square meters gross floor area. It is one of the first shopping malls to open in Ethiopia. It is a twelve floor structure built in 2007 with 205 rooms designated for use as shops and other business offices. It currently has about 182 shops, offices, galleries, banks with ATM, Insurance, clinic, VIP cinema, special Ethiopian and Italian café and restaurants and other stores open for business.

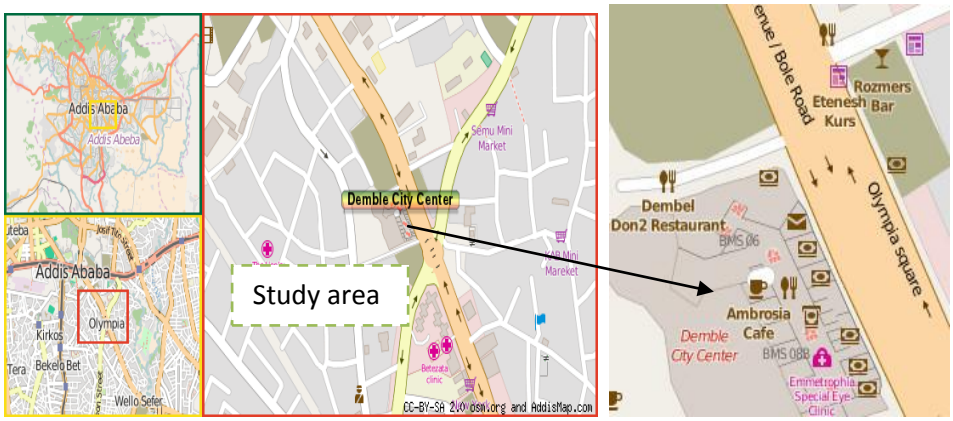

Fig. 4.3 Location Map of Dembel City Center Study Area

4.2.3.1 Parking Supply and Demand in Dembel City Center

Dembel City Center has an open air and three down stairs parking lots. The three level basement floors 4,800.00 sq. meters total parking area that can accommodate 180 vehicles at a time.. The upper basement floor is partially dedicated for parking. Parking charge is applicable here. The open air parking lot can accommodates 60 vehicles at a time. There is no designated

on street parking provisions for this commercial complex. Vehicles are allowed to park on sides of the building.

Parking demand surveys were also conducted for the shopping centre for basement floors and open air parking of the shopping center and on the streets around the shopping center. The number of vehicles arrived at peak hours added to find the parking demand for this commercial center. Parking volume is 47 vehicles in open air and 85 vehicles in basement floors over the period of the survey time. Combine peak parking demand for this commercial center is 132 vehicles at peak hours.

4.2.4 Getu Commercial centre

Getu commercial center is a large multi story mixed use building shopping mall located on bole road. It is a B+G+6 building complex having 1600.00 square meters plinth area, 12,060.00 square meters gross floor area. It is surrounded by several other shopping malls. It has good brand and souvenirs shops, café and restaurants. Starting from the ground floor to the fifth floor, there are several categories of local and international brand shops, non-branded shops, cosmetics shops. The sixth and seventh floors space is dedicated for office use. There are 112 children and adult clothing boutiques, computer, mobile and electronic accessories, photo and video studios, beauty salons and cosmetics for men and women, jeweler shops, café and restaurants, in addition banks, insurances and private offices.

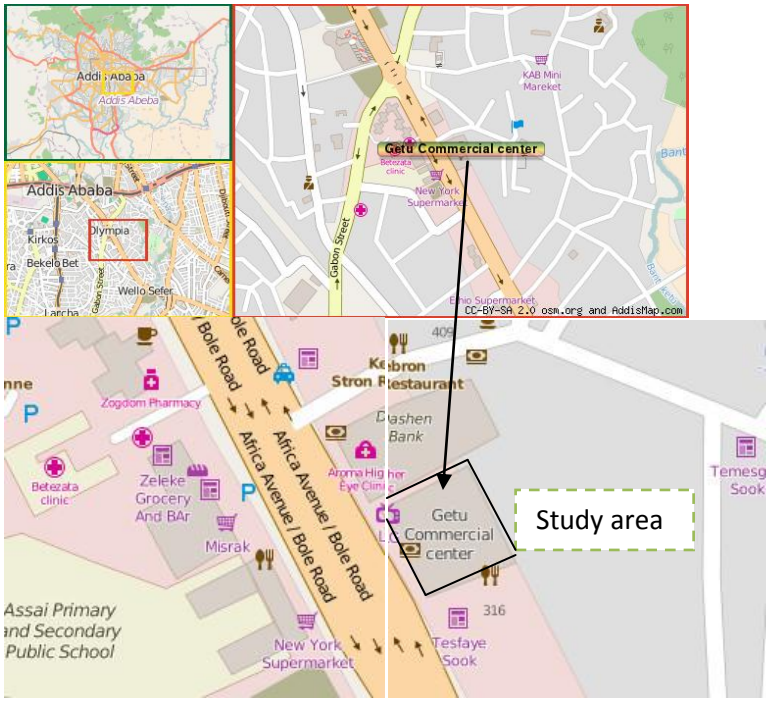

Fig. 4.4 Location Map of Getu Commercial Center Study Area

4.2.4.1 Parking Supply and Demand in Getu Commercial Center

Basement floor is dedicated for parking with total parking area 1,450.00 sq. meters. Total capacity of this underground parking is 46 vehicles at a time. Parking charge is applicable here. Parking demand surveys were conducted for basement floor and on the streets around the shopping center. The number of vehicles arrived at peak hours added to find the parking demand for this commercial center. The peak parking volume is 46 vehicles in basement floor and 22 vehicles on street at the peak period of the survey time. Combine parking demand for this commercial center is 68 vehicles at the peak period.

4.2.5 Mintaf Tera (Addis Ababa)Shopping Center

Addis Ababa Shopping Center is B+G+4 multistory complex shopping center located in Merkato area in front of Saint Raquel Church. This shopping center is among the largest shopping centre in Merkato area in the intense commercial activity area. The shopping centre has 3320 square meters of plinth area, 13,820 square meters of gross floor area. It is a home for many types of shops and other services. This shopping centre has 214 shops, offices & service providers consisting of mainly garment and curtain shops, fashion boutiques, shoes, accessories, furnishings, health & beauty salons, gift shops, mobile and electronic accessories, banking and ATMs, photo studio, cafes and re restaurants, and much more.

Fig. 4.5 Location Map of Mintaf Tera/Addis Ababa Shopping Center Study Area

4.2.5.1 Parking Supply and Demand in Mintaf Tera Shopping Center

Basement floor is dedicated for parking with total parking area 3,320.00 sq. meters. Total capacity of this underground parking is 84 vehicles at a time. Parking charge is applicable here. Parking demand surveys were conducted for basement floor and on the streets around the shopping center. The number of vehicles arrived at peak hours added to find the parking demand for this commercial center. Thus the peak parking volume is 79 vehicles in basement floor and 19 vehicles on streets around the shopping complex at the peak period of the survey time. Combine parking demand for this commercial center is 98 vehicles.

4.2.6 Dubi Tera (Meseretawi Hiwot) Shopping Center

This shopping center is found in Merkato market center. This shopping center is B+G+4 Building complex having 3,320 square meters plinth area and 13,240.0 square meters gross floor area. This shopping center is also located in the largest market center called Merkato where commercial activities are intense. It is a larger enclosed shopping center in terms of retail space. This shopping center is surrounded by other shopping centre buildings. It has 206 mainly garment and curtain shops, fashion boutiques, shoes, accessories, furnishings, health & beauty salons, gift shops, mobile and electronic accessories, banking and ATMs, photo studio, cafes and re restaurants, and much more.

Fig. 4.6 Location Map of Dubi Tera Shopping Center Study Area

4.2.6.1 Parking Supply and Demand in Dubi Tera Shopping Center

Basement floor is dedicated for parking with total parking area 3,100.00 sq. meters. Total capacity of this underground parking is 82 vehicles at a time. Parking charge is applicable here. Parking demand surveys were conducted for basement floor and on the streets around the shopping center. The number of vehicles arrived at peak hours added to find the parking demand for this commercial center. As a result the peak parking volume is 81 vehicles in basement floor and 14 vehicles in on street over the period of the survey time. The combine parking demand for this commercial center is found to be 95 vehicles at the time

4.2.7 Yerga Haile Shopping Center

Yerga Haile Shopping Center is located in Merkato area around Gojam Berenda. It is a B+G+5 building complex having 2,160.00 square meters plinth area and 10,650.00 square meters gross floor area. It has 152 different shops, offices & service providers consisting of fashion boutiques, shoes, mobile and electronic accessories, home interior design offices, furnishings, health & beauty salons, gift shops, telephones, banking, cafes and restaurants,, photo studio and others.

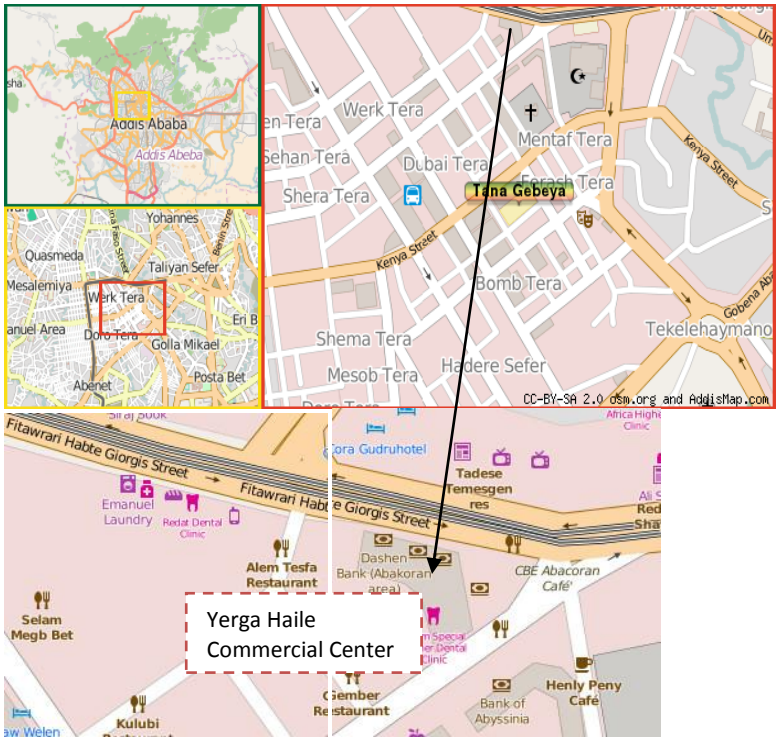

Fig. 4.7 Location Map of Yerga Haile Commercial Center Study Area

4.2.7.1 Parking Supply and Demand in Yerga Haile Center

Basement floor is dedicated for parking with total parking area 2, 056.00 sq. meters. Total capacity of this underground parking is 61 vehicles at a time. Parking charge is applicable here. The parking demand surveys for this shopping center sows that the number of vehicles arrived at peak hour is 60 vehicles in basement floor and 5 vehicles on street at peak period of the survey time. Combine parking demand for this commercial center is 66 vehicles at peak hour of the survey time

4.2.8 Piazza Shopping Center

Piazza Shopping Center is located in the main shopping districts in Addis Ababa called Piazza area which is a home for many small shops and street stalls in the area. It is a modern built multi story building shopping laying on 1,200 sq. meters plinth area and 10,360.0 square meters gross floor area serving for boutiques, furniture, shoes stores, bank and offices. The remaining floors are used for a garments industry. The upper most floors are partly constructed. It is a relatively small shopping centre but with a special attraction factor of having a sweetmeat shop. Piazza shopping center offers shops, offices & service providers consisting of garment and curtain shops, fashion boutiques, shoes, accessories, furnishings, health & beauty salons, gift shops, mobile and electronic accessories, photo studio, cafes and re restaurants, and much more. There are over 66 shops and office rooms.

Fig. 4.8 Location Map of Piazza Shopping Center Study Area

4.2.8.1 Parking Supply and Demand in Piazza Shopping Center

Basement floor is dedicated for parking with total parking area 1,050.00 sq. meters. Total capacity of this underground parking is 32 vehicles at a time.

The parking demand surveys for this shopping center sows that the number of vehicles arrived at the peak hours is 29 vehicles in basement floor and 14 vehicles on street over the period of the survey time. Combine parking demand for this commercial center is 43 vehicles at the peak hour.

4.2.9 Zefmesh Grand Mall

Zefmesh Grand Mall is sixth floors mixed use building shopping mall accommodating shopping, entertainment and refreshment, supermarkets to cinema houses. Zefmesh Grand mall lies on four thousand square meters of plinth area. It is made up of 144 different shops, offices & service providers consisting of garment shops, fashion boutiques, shoes, accessories, home interior design offices, furnishings, health & beauty salons, gift shops, telephones, banking and ATMs, cafes and restaurants,, photo studio, children's entertainment and much more. The ground floors accommodated small to medium sized shops. It has three elevators, eight escalators and stairways for pedestrians. The building from ground floor up to the third floor has assorted shops. The basement supermarket which lied on 3200sqm Shoa supermarket is the biggest stores there. The ground floor accommodated small to medium sized shops and Kaldi's café.

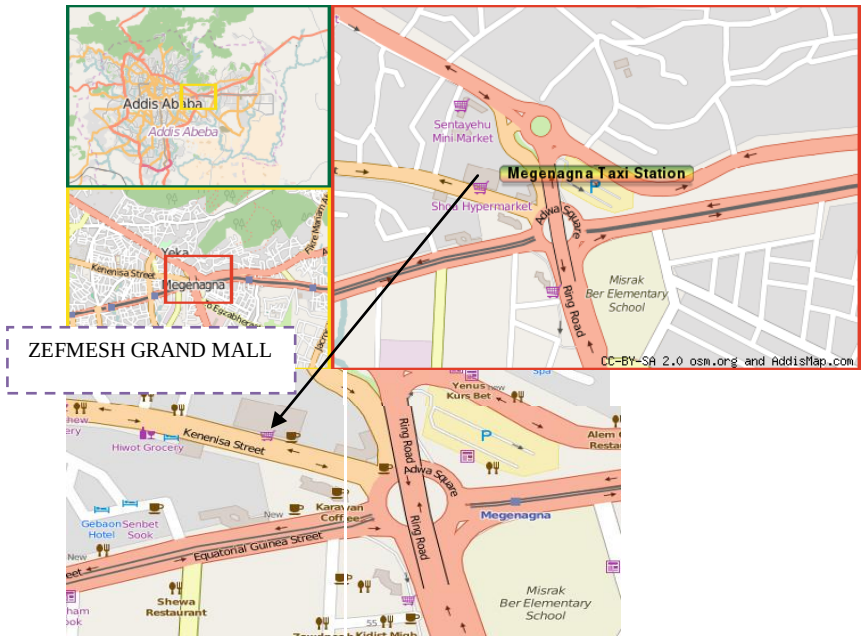

Fig. 3.9 Local Map of Zefmesh Grand Mall Study Area

4.2.9.1 Parking Supply and Demand in Zefmesh Grand Mall

This Shopping center has open air and basement floor (partially used) for parking with total estimated parking area 3,200.00 sq. meters. The total capacity of this basement and open air parking is 120 vehicles at a time. The parking demand surveys for this shopping center sows that the number of vehicles arrived at peak hours is 38 vehicles in basement floor and 86 vehicles on open air and on street parking spaces over the period of the survey time. Combine parking demand for this commercial center is 124 vehicles in the survey time

4.2.10 Yobek Commericial Center

Yobek commercial is located in Lideta Sub city known as Senga Tera with 1,800 sq. meters plinth area and total groos floor area of 15,350 square meters. This commercial center is twin buildings with 14 and 10 story buildings. There are 142 boutique shops, building material and electrical shops, offices, restaurants and three bank branches. The buildings are also equipped with state materials, including heavy carrier lifts that can accommodate 60 people at the same time

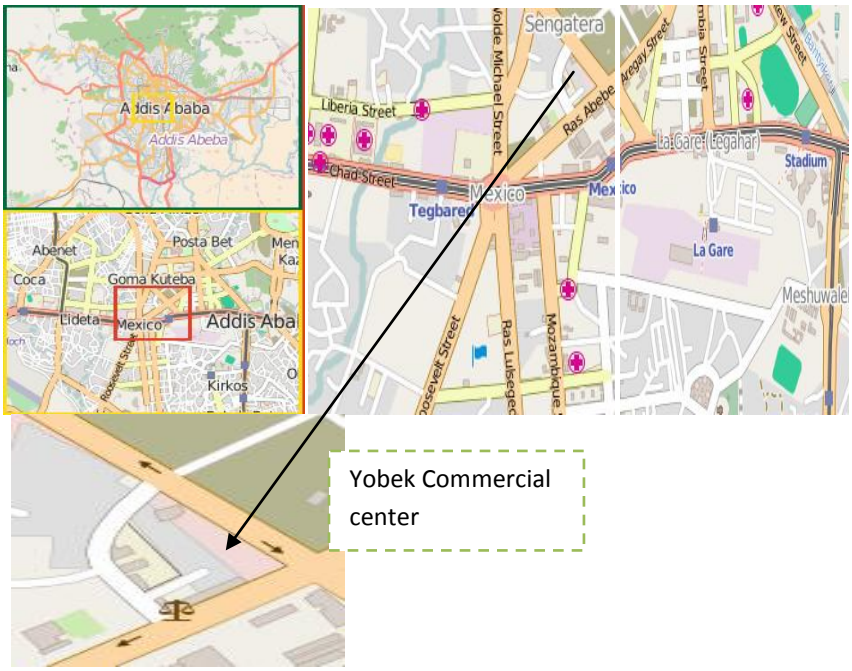

Fig. 3.10 Local Map of Yobek Commercial Center Study Area

4.2.10.1 Parking Supply and Demand in Yobek Commercial Cenjter

.Basement floor is dedicated for parking with total parking area 1,260.00 sq. meters. Total capacity of this underground parking is 42 vehicles at a time. Parking charge is applicable here. Restriction on parking at certain parking bays/lots is imposed for maneuvering purpose. This reduced the capacity of this parking provision.

The parking demand surveys for this shopping center shows that the number of vehicles arrived at the peak hours survey is 40 vehicles in basement floor and 22 vehicles on street parking spaces. Combine parking demand for this commercial center is 62 vehicles at the peak survey time

4.3 Over View of Parking Demand and Supply Assessment in the Shopping Centers

Currently parking within the study area consists of off-street (underground) private parking lots. No legally designated on-street parking is available on most major streets around the shopping centers. In most of the shopping center's parking spaces were inadequate to accommodate the vehicles who come and desire to park. Therefore, the following evaluation of parking supply and demand in the study centers showed that parking demand was met along most of the major corridors in the study area. However, in some instances, particularly in Dembel city center the parking supply was greater than demand.

4.3.1 Parking Supply

A parking space inventory was conducted, which include the capacity and type of facility of both on-street (if exits) and off-street (basement) parking in the selected shopping centers. The summary of parking spaces available in these study sites is presented in table 4.1.

Table 4.1: Parking supply summary in the shopping centers

Shopping center/mall	Available Designated parking space (No.)
Edna Mall	52
Friendship City Center	65
Dembel City Center	150
Getu Commercial Center	46
Addis Ababa Shopping Center	92
Dubi Tera Shopping Center	92
Yerga Haile Commercial Center	61
Zefmesh Grand Mall	120
Piazza Shopping Center	32
Yobek Commercial Center	42

4.3.2 Parking Demand

Parking demand refers to the number of vehicles whose driver desired to park at specific location of the study area. It is usually expressed in the number of vehicles. There are two

types of parking demands; the latent demand, and revealed demand. Revealed demand refers to the actual observation of vehicles in the parking facilities during the study period. While latent demand considers even those vehicles intending to park but due to limited spaces have to be turned away. The latent demand case was selected for this survey. That means parkers who didn't get space but desired to park is counted in the course of survey time. To assess the total parking demand and supply of the shopping centers center, parking usage survey has been conducted both on the on street and off street parking spaces. The number of vehicles arrived in the survey time at peak hours added to find the parking demand for this commercial center. The parking demand is clarified with various parking terms as follows.

4.3.3 Parking Accumulation

The peak parking demand (PPD) that will be used for the multiple linear regressions in the next chapter was obtained from the parking accumulation study during the time period of 10:00 am – 1:00 pm. This time interval is selected because based on the information gained from the parking operators the peak parking demand is occurred in this time interval. Thus the pattern and timing of vehicle on how they utilized the space during this survey time analyzed as follows.

Table 4.2a: Parking accumulation summary (10:00a.m-10:45a.m)

Shopping center/mall	Observed parked vehicles			
	10:00a.m	10:15a.m	10:30am	10:45a.m
Edna Mall	31	36	42	49
Friendship-City Center	38	43	47	54
Dembel City Center	74	85	96	101
Getu-Commercial Center	22	28	36	45
Mintaf-Tera Shopping Center	38	46	57	68
Dubi-Tera Shopping Center	34	45	57	63
Yerga-Haile Commercial Center	28	35	42	47
Zefmesh-Grand Mall	49	58	66	75
Piazza Shopping Center	17	22	26	31
Yobek-Commercial Center	18	24	31	37

Table 4.2b: Parking accumulation summary continued (11:00a.m-11:45a.m)

Shopping center/mall	Observed parked vehicles			
	11:00a.m	11:15a.m	11:30am	11:45a.m
Edna Mall	56	59	63	*68*
Friendship-City Center	61	66	*72*	70
Dembel City Center	114	123	*132*	128
Getu-Commercial Center	52	56	60	*64*
Mintaf-Tera Shopping Center	75	81	85	92
Dubi-Tera Shopping Center	71	78	86	92
Yerga-Haile Commercial Center	54	57	60	63
Zefmesh-Grand Mall	83	94	105	*108*
Piazza Shopping Center	38	43	*43*	42
Yobek-Commercial Center	43	45	52	59

Table 4.2c: Parking accumulation summary continued (12:00a.m-1:00p.m)

Shopping center/mall	Observed parked vehicles				
	12:00	12:15 pm	12:30 pm	12:45 pm	1:00 pm
Edna Mall	66	65	61	63	59
Friendship-City Center	69	70	68	67	68
Dembel City Center	129	127	128	127	125
Getu-Commercial Center	63	61	61	60	60
Mintaf-Tera Shopping Center	97	*98*	93	94	93
Dubi-Tera Shopping Center	*95*	93	94	92	88
Yerga-Haile Commercial Center	65	*66*	65	63	63
Zefmesh-Grand Mall	106	106	105	106	105
Piazza Shopping Center	*42*	40	41	42	40
Yobek-Commercial Center	59	62	*62*	59	58

The parking accumulation estimated by assessing the arrivals and departures at peak periods of the day. These are conducted to obtain data on the number of vehicles parked in a shopping center during the survey time at every 15 minutes interval. This interval is chosen because Highway Capacity Manual uses this interval as the base unit for capacity calculation, and it is also practical from the standpoint of the person collecting the data. The typical duration of a survey selected for this study was three hours.

First, the number of vehicles already in areas was counted and then the number of vehicles entering and exiting during that specified period are noted, and added or subtracted from the accumulated number of vehicles. From the table we observe that that peak parking demand was occurred in the period between 11:30 am - 12:00 pm. Thus the observed peak parking demands are highlighted in table 4.2a and table 4.2b.

Therefore, these observed peak parking demand figures were summarized in the table 5.1 that were used as the dependent variable in the regression analysis.

4.3.4 Occupancy Ratio

Occupancy ratio or vehicle-capacity ratio is another measure of parking utilization. It determines the degree of utilization and indicates the existing illegal parking. The occupancy calculated by dividing the accumulation of vehicles to the total parking spaces available. A percentage of greater than one hundred implies demand exceeds the available space supplied. The results and findings are tabulated as shown in Table 4.3 below. The Table shows the ratios of peak parking accumulation to the parking capacities of the study shopping centers. In each survey day, the highest number of parked vehicles was taken comparing among the different values counted at every fifteen minutes interval. Table: 4.3 shows that most occupancy ratios in the shopping centers was greater than 100% indicating many illegal parking around the shopping centers and pedestrian walk ways due to inadequate parking spaces in the shopping centers. It can be observed that there is a large gap between the supply and demand for parking for most of the shopping centers.

Table 4.3: Parking occupancy level summary of the shopping centers

Shopping center/mall	parking capacity (No.)	Peak parking accumulation (No.) /3:00 hrs	Peak Occupancy (acc/cap) (%)
Edna Mall	52	68.0	130.8
Friendship City Center	65	72.0	110.8
Dembel City Center	180	132.0	73.33
Getu Commercial Center	46	64.0	139.1
Addis Ababa Shopping Center	84	98.0	116.67
Dubi Tera Shopping Center	82	95.0	115.85
Yerga Haile Commercial Center	61	66.0	108.2
Zefmesh Grand Mall	115	124	107.82
Piazza Shopping Center	32	43.0	134.4
Yobek Commercial Center	50	62	124.6

Therefore, the peak parking demand for nine shopping centers has exceeded the supply all through the peak activity period of the market. Only Dembel city center has been under utilized. The average overall occupancy rate of parking facilities was 116.16% and the average spill-over during the survey period of (3 hours) in a day has been 16.16% considering that all the available parking bays have been occupied. This reveals that most of the cars attracted by this land use occupy road space.

4.3.5 Average Duration of Parked Vehicles

Parking duration is the time spent in the parking space. The average duration of the vehicles surveyed at basement parking during a survey period of three hours is summarized in table 4.3. From this table the average duration was found to be 1.10 hours.

Table 4.4 Average duration periods of parked vehicles at the shopping centers

Shopping Center	Average Duration Period (Hr) in 3 hrs
Edna Mall	1:10
Friendship City Center	1:05
Dembel City Center	1:45
Getu Commercial Center	0:45
Zefmesh Grand Mall	1:30
Addis Ababa Shopping Center	1:35
Meseretawi Hiwet Shopping Center	1:20
Yerga Haile Commercial Center	1:45
Yobek Commercial Center	0:50
Piazza Shopping Center	1:15

4.3.6 Parking Turnover

Another measurement of parking facilities utilization is the parking turnover rate. This measurement reveals the number of vehicles utilizing the same stall over a given time period.

Table 4.5: Parking turnover summary of the shopping centers

Shopping center/mall	parking space (No.)	Total Vehicle Parked (No.)/3:00 hrs	Turn Over (No. of veh. parked/ parking space)
Edna Mall	52	183	3.52
Friendship City Center	65	216	3.32
Dembel City Center	180	413	2.29
Getu Commercial Center	46	141	3.06
Addis Ababa Shopping Center	84	284	3.38
Dubi Tera Shopping Center	82	272	3.31
Yerga Haile Shopping Center	61	218	3.57
Zefmesh Grand Mall	120	416	3.46
Piazza Shopping Center	32	113	3.53
Yobek Commercial Center	50	128	2.56

In this case the period of time is the three hours survey period is considered. Parking turnover rate has been examined separately for each shopping center. Parking turnover in the shopping centers over a survey time period of 3.00 hours is summarized as follows in table 4.5 and shows an average turnover rate of 1.10 veh./stall/hr.

The above tabular analysis of parking supply and demand in the study area showed that parking demand was not met in most of the shopping centers. However, in some instances, particularly in Dembel city center the parking demand was less than supply.

CHAPTER FIVE

DATA ANALYSIS AND PRESENTATION

5.1 Introduction

The goal of this chapter was to develop a regression model that predicts parking demand of shopping centers relating to some quantitative attraction factors of the shopping centers. The study began with identifying the possible quantitative attraction features that may affect the parking demand. The quantitative data obtained from previous chapter was analyzed to determine the most important attraction factors to be included in the model and regression analysis was carried out to obtain the parking demand model of the shopping centers. The conceptual base for parking demand forecasting is to determine the peak time demand that fulfill design requirements.

5.2 Data Analysis

In multivariate analysis, linear regression technique is one of the most useful techniques. Among the many methods suggested for obtaining estimates of parameters in a regression model, the most commonly used method has been that of least-square estimation, in which parameter estimates are chosen to minimize a quantity called the residual sum of squares (Weisberg, 1980). The proposed regression model for this study was based on the hypothesis of linear relationship between dependent and explanatory variables i.e. parking requirement for a shopping centre was predicted on the assumption that the parking demand is a function of various attraction factors of that shopping centre and these factors affecting the parking demand situation have a linear and positive relationship with the parking requirement. Peak parking demand (PPD) is considered as the dependent variable and the quantitative attraction factors as explanatory variables in order to develop parking demand models for the shopping centers in Addis Ababa city. The quantitative factors (independent variables) that will be considered for analysis in this study are gross floor area (GFA), number of shops (NOS), plinth area (PA) and existing parking supply (EPS). Thus, the mathematical model which was postulated in the present multivariate analysis for peak parking demand is as follows. These physical features of the shopping center are easy to measure and analyze incorporated in the estimation of the parking demand.

$$PPD = b_0 + b_1\,GFA + b_2\,NOS + b_3\,PA + b_4\,EPS \quad \text{.....Eq. 5.1}$$

Where:-

PPD = predicted peak parking demand i.e. the derived dependent variable

b_o = intercept of the regression line

b_1 to b_4 = are the model parameters and the explanatory variables:

GFA = gross floor area

NOS = total number of shops

PA = plinth area i.e. only ground floor area

EPS = existing parking supply

The following explanatory variables data were collected from the conceptual (descriptive) section of chapter four for each selected shopping centers which will be used as an input in the regression analysis by software program for social sciences (SPSS).

Table 5.1: summary of peak parking demand and attraction factors of the shopping centers

Shopping Center	PPD /15 min	PA /15 min	GFA /15 min	EPS /15 min	NOS /15 min
Edna Mall	68.0	1940.0	14166.0	2200.0	82.0
Friendship city center	72.0	2000.0	15400.0	1800.0	154.0
Dembel city center	132.0	3500.0	24300.0	4800.0	182.0
Getu commercial center	64.0	1600.0	12060.0	1450.0	112.0
Mintaf Tera shopping center	98.0	3320.0	13820.0	3200.0	214.0
Dubi Tera shopping center	95.0	3320.0	13240.0	3100.0	206.0
Yerga Haile shopping center	66.0	2160.0	10650.0	2056.0	152.0
Yobek commercial center	62.0	1800.0	15350.0	1260.0	142.0
Piazza shopping center	43.0	1200.0	10360.0	1050.0	66.0
Zefmesh Grand Mall	124.0	4000.0	21540.0	3200.0	144.0

5.3 Multiple Linear Regression Assumptions

The following basic assumptions were made in the multiple linear regressions for the purpose of analysis of the data analysis.

5.3.1. Linearity assumption

It was checked by examining scatter plots of the dependent and independent variables. The Pearson correlation coefficients also used to examine relationships between the DV and the IVs measured at the interval/ratio-levels to check an indication of the magnitude of the relationship between variable pairs.

The hypotheses have been set up to check this assumption as the following for each independent variable.

H_0: There is no correlation (linear relationship) between the independent factor the dependent factor.

H1: Hypotheses there is a correlation (linear relationship) between the independent variable and the dependent variable

5.3.1.1. Peak Parking Demand (PPD) Vs Gross Floor Area (GFA).

The assumption here is that there is a positive relationship between the size in **gross floor area** in m^2 and the peak parking demand of the shopping center. The relationship between the amount of **gross floor space** of shopping centers and the peak parking demand is showed in figure . The following scatter plot, Pearson Value, P- value was generated through using correlation analysis between PPD Vs GFA. The scatter plot indicates that there is linear relationship between the PPD and GFA.

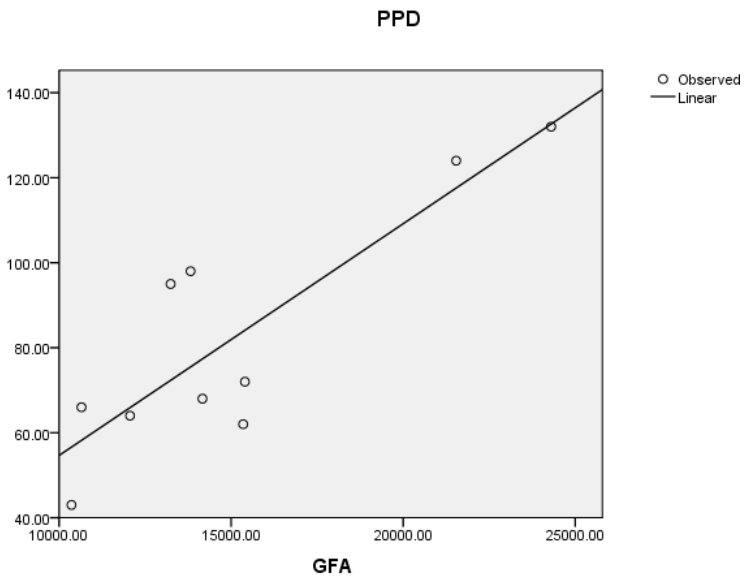

Fig. 5.1: Scatter plot and predicted regression line between PPD and GFA

Table 5.2: Model Summary and Parameter Estimates

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.730	21.592	1	8	.002	.142	.005

As the results of the regression analysis shows here is a positive and significant relationship with a p-value of 0.002 between the amount of gross floor space of shops and the peak parking demand. The relationship is also strong with an R square value of 0.730. Therefore, 73.00 percent of the variation in the peak parking demand is explained by the model. The Pearson value (R squared) indicates a strong positive relationship between the PPD and the dependent variable. The F value in the table gives an *F*-test to determine whether the model is a good fit for the data. We can see from the "Sig." column that is the P-Value is less than 0.05.

The df1 and df2 are the degrees of freedom associated with the sources of variance. The Regression degrees of freedom (df1) correspond to the number of coefficients estimated minus 1. Including the intercept, there are 2 predictors, so the Regression has 2-1=1 degrees of freedom. The total variance has 10-1 = 9 degrees of freedom (DF). The Residual degrees of freedom (df2) is the total DF minus the Model df1 which is 9 – 1 = 8.

Thus, the predicted peak parking demand model for is:

Peak parking demand = 0.005 * GFA + 0.142…… ……..….Eq. 5.2

The conclusion of this part is that there exist a positive, strong and significant relationship between the amount of floor space of shops and the peak parking demand and GFA is considered as an independent variable to be included in the next stepwise regression analysis.

5.3.1.2. Peak Parking Demand (PPD) Vs Plinth Area (PA)

The assumption here is that there is a positive relationship between plinth area in m^2 and the peak parking demand of the shopping center. The results of the regression analysis are presented in figure and table. The following scatter plots, Pearson Value, P- value were generated through using correlation analysis between Peak Parking Demand (PPD) Vs Plinth Area (PA). The scatter plot indicates linear relationship between the PPD and PA.

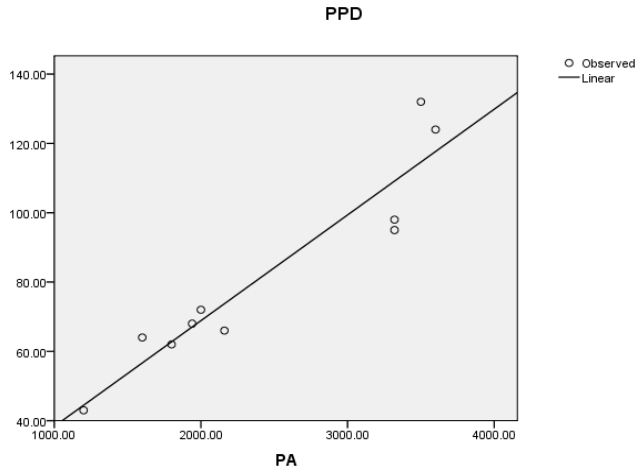

Fig. 5.2: Scatter plot and predicted regression line between PPD and PA

Table 5.3: Model summary and parameter estimates of PPD and PA

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.901	72.765	1	8	.000	11.434	.029

The Pearson value (R squared) indicates a strong positive relationship between the PPD and plinth area with a p-value of 0,000 between the amount of plinth area of the shopping center and the peak parking demand. The value of R square is 0.901 which means 90,1 percent of the variation in the peak parking demand is explained by the model. The predicted peak parking demand by the model is:

Peak parking demand = 0.029 * PA + 11.43…… ……..Eq. 5.3

The conclusion of this part is that there exist a positive and significant relationship between the amount of plinth area of shopping center and the peak parking demand and plinth area can be considered as an independent variable in the further regression analysis.

5.3.1.3. Peak Parking Demand (PPD) Vs Existing Parking Space (EPS)

The assumption here is similar to the above that there is a positive relationship between **existing parking space** and the peak parking demand of the shopping center. The following scatter plots, Pearson Value, P- value were generated through using correlation analysis between PPD and EPS. The scatter plot indicates that there is a positive linear relationship between the PPD and the EPS.

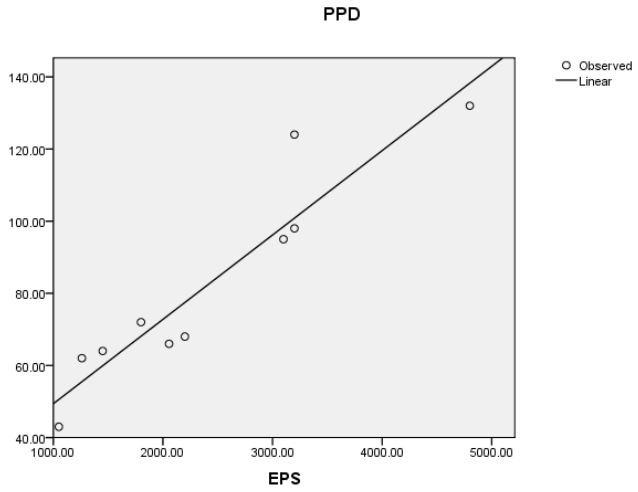

Fig.5.3: Scatter plot and predicted regression line between PPD and EPS

Table 5.4: Model summary and parameter estimates of PPD and EPS

Equation	Model Summary					Parameter Estimates	
	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.882	59.861	1	8	.000	26.002	.023

The Pearson value (R squared) also indicates strong positive relationship between the PPD and the dependent variable. The results of the regression analysis are presented in figure and table below. The relationship shows an R square value of 0.882. So 88.2 percent of the variation in the peak parking demand is explained by the model. The predicted peak parking demand by the model is:

Peak parking demand = 0.023 * EPS + 26.00…….Eq. 5.4

The conclusion of this part is that there exist a positive relationship between the amount of existing parking space in the shopping centers and the peak parking demand and EPS can be considered as an independent variable to be included in the next stepwise regression analysis.

5.3.1.4. Peak Parking Demand (PPD) Vs Number of Shops (NOS)

The assumption is there is a positive relationship between the peaking parking demand and the number of shops. The argument in favor of this is that more shops will attract more people/cars. The following scatter plot, Pearson Value, P- value was generated through using correlation analysis between PPD Vs NOS and the scatter plot indicates possible linear

relationship between the PPD and EPS. The scatter plot indicates that there was a weak positive relationship between the NOS and the PPD.

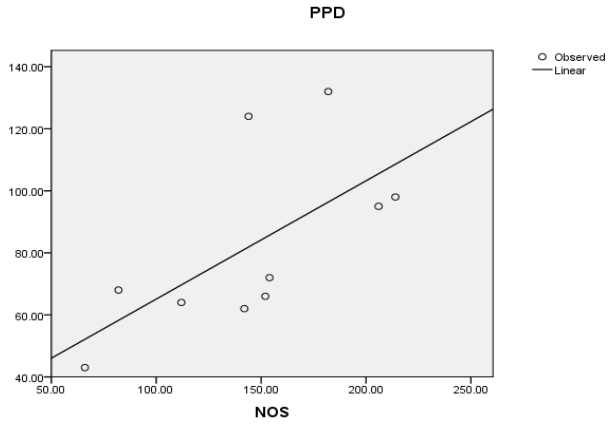

Fig.5.4: Scatter plot and predicted regression line between PPD and NOS

Table 5.5: Model summary and parameter estimates of PPD and NOS

	Model Summary					Parameter Estimates	
Equation	R Square	F	df1	df2	Sig.	Constant	b1
Linear	.414	5.644	1	8	.045	26.951	.381

The Pearson value (R squared) also indicates strong positive relationship between the PPD and the dependent variable (EPS). The R square value is 0.414. So, only 41.4 percent of the variation in the peak parking demand is explained by the model. This means that there is no strong relationship between peak parking demand and number of shops. The predicted peak parking demand model resulted from the above regression analysis is:

Peak parking demand = 0.381*NOS +26.95…….……Eq. 5.5

As we can see coefficient/slope of the equation is 0.381. These shows there is a positive relationship between the total number of shops and the peak parking demand of the shopping centers.

5.4 Multiple Regression Analysis

The multiple linear regression analysis here started with all the four explanatory variables and the following in the next step wise regression some of the explanatory variables may be dropped out due to their low significance to the model. Thus, after

checking the multicollinearity, multiple linear regression was carried out using all the independent variables having linear relationship with the independent variable.

5.4.1 Testing for multicollinearity

As can be seen from table below the VIF values in the table are all less than ten. Therefore, there is no multicollinearity among the explanatory variables and assumption has been fulfilled.

Table 5.6: summary of collinearity statistics and confidence interval

Model	Collinearity Statistics	
	Tolerance	VIF
GFA	.352	2.838
PA	.174	5.758
EPS	.177	5.648
NOS	.385	2.597

The next table shows the multiple linear regression model summary and overall fit statistics with all predictors in the regression analysis. We find that the adjusted R^2 of our model is 0.982 with the R^2 = 0 .990 that means that the linear regression explains 98.2% of the variance in the data.

Table 5.7: MLR with all variables model summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.995[a]	.990	.982	3.87512

The next ANOVA table shows the F-test that is the linear regression's F-test has the null hypothesis that there is no linear relationship between the variables (in other words R^2=0). The F-test is highly significant, thus we can assume that there is a linear relationship between the variables in our model.

Table 5.8: Analysis of Variance (ANOVA) for MLR with all variables

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7409.317	4	1852.329	123.353	.000[a]
	Residual	75.083	5	15.017		
	Total	7484.400	9			

Table 5.9: shows the linear regression equation coefficients for the model variables. Here we use the unstandardized coefficients in the equation, because the constant [beta zero] is included. Based on this table, the equation for the regression equation is as follows.

Table 5.9: model coefficients for MLR with all variables in the model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-1.213	6.234		-.195	.853	-17.238	14.812
	GFA	.002	.000	.310	4.103	.009	.001	.003
	PA	.015	.003	.498	4.634	.006	.007	.023
	EPS	.007	.003	.263	2.471	.056	.000	.013
	NOS	.005	.043	.009	.123	.907	-.105	.115

Predicted PPD = -1.21+0.002*GFA+0.015*PA+0.007*EPS+0.005*NOS…….Eq. 5.6

The resulting equation had a multiple correlation coefficient of 0.951 and a standard error of estimate of 4.068. This means that 95.1 percent of the variation in mean peak parking demand was explained by the equation. The input and rejection of variables into and out of equations was controlled by the t-value of each regression coefficient.

5.4.2 Stepwise Regression

The next step was to select a subset of explanatory variables terms which appeared most relevant or significant to specify or the model finally. In the process of stepwise regression a

level of significance of 0.05 was used for a variable to enter the model and 0.10 for a variable to be removed from the model.

The selection of final parking demand model was on the basis of the following stipulations:

a) The selected equation had to have a multiple correlation coefficient, R, which was significant at the 95 percent level of confidence.

b) All the explanatory variables in the regression equation had to have regression coefficients which were significantly different from 0 at 95 percent level of confidence.

c) The value of the coefficient of multiple determinations, R^2 had to be sufficiently high to yield a reasonably low standard error of estimate. To define the most important variables in the model, a step wise analysis has been conducted in SPSS to automatically identify the useful subset of predictors to be included in the model. At each step, the SPSS enters one independent variable at a time and performs the following calculations: for each variable currently in the model, it computes "F-to-remove" statistic; for each variable not in the model, it computes "F-to-enter" statistic. At the next step, the program automatically enters the variable with the highest F-to-enter statistic, or removes the variable with the lowest F-to-remove statistic. Each predictor is constantly assessed. As can be seen from the table the automated step wise regression and based on the given criteria NOS is excluded from the regression analysis due to statistical insignificance and recommended a model that includes only PA, GFA and EPS as independent variables in the model.

Table 5.10: Summary showing the significant variables for step wise regression

Model	Variables Entered	Variables Removed	Method
1	PA	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
2	GFA	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).
3	EPS	.	Stepwise (Criteria: Probability-of-F-to-enter <= .050, Probability-of-F-to-remove >= .100).

Table 5.10: tells which variables were included in the model at each step: PA was the single best predictor (step 1), GFA was the next best predictor (step 2), EPS was third best predictor (added the most) after PA and GFA were included in the model (step 3).

Table 5.11: model summary for step wise regressions

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.949[a]	.901	.889	9.62644
2	.988[b]	.977	.970	5.00009
3	.995[c]	.990	.985	3.54287

Table 5.11 shows the multiple linear regression model summary and overall fit statistics. We find that the adjusted R^2 of our model is 0.985 with the R^2 = 0.990 that means that the linear regression explains 99.0% of the variance in the data. The adjusted R-Square value indicates that the model explains 98.50 % of the variation of the dependent value of the model. The regression analyses that have been analyzed by the step wise regression in SPSS are the dependent variable PPD and the independent variables PA, GFA and EPS. NOS was exclude by SPSS from the regression analysis after significance test set in SPSS due to its low significance to the model. As a result the following regression analysis results were generated.

Table 5.12: Summary of ANOVA after step wise regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6743.053	1	6743.053	72.765	.000[a]
	Residual	741.347	8	92.668		
	Total	7484.400	9			
2	Regression	7309.394	2	3654.697	146.182	.000[b]
	Residual	175.006	7	25.001		
	Total	7484.400	9			
3	Regression	7409.089	3	2469.696	196.759	.000[c]
	Residual	75.311	6	12.552		
	Total	7484.400	9			

Analysis of Variance (ANOVA) calculations and other relevant findings are summarized in this Table 5.12. This ANOVA table shows the model has three predictors which are significant at $p < 0.05$ and F values for each model. The significant F value, $F(3, 6) = 196.76$, $p < 0.000$, indicates that there is a significant relationships between PPD and the three predictors. That is the variables that were considered significant predictors in the final model were PA, GFA and EPS.

Table 5.13: Summary of model Coefficients after step wise regression

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	11.434	8.859		1.291	.233	-8.995	31.862
	PA	.029	.003	.949	8.530	.000	.021	.036
2	(Constant)	-5.557	5.824		-.954	.372	-19.328	8.214
	PA	.021	.002	.687	8.598	.000	.015	.026
	GFA	.002	.001	.380	4.759	.002	.001	.004
3	(Constant)	-.735	4.467		-.165	.875	-11.666	10.196
	PA	.015	.003	.504	5.869	.001	.009	.022
	GFA	.002	.000	.306	4.893	.003	.001	.003
	EPS	.007	.002	.266	2.818	.030	.001	.012

Table 5.13 shows the linear regression equation coefficients for the model variables as follows. Therefore, gross floor area, plinth area and existing parking space proved to be sufficient at 95.0% significant level to account for a very large percentage of variation in mean peak parking demand. This was accomplished by the previously discussed stepwise algorithms. After the elimination of variables the following equation was resulted:

PPD = -0.735 + 0.002 x GFA + 0.015 x PA + 0.007EPS……Eq. 5.7

The equation produced a correlation coefficient of 0.942 and a standard error of 4.068, indicating is about 94.20 percent' of variation in mean peak parking demand has been explained. The regression coefficients were highly significant at 95 percent confidence level.

The F -value, computed from the shopping centre data was 196.76, providing strong evidence against null hypothesis. Positive relationship was established between parking demand and gross floor area, plinth area and existing parking space. Finally inference can be drawn that the model was fitted by data very well.

5.4.3 Residuals vs predicted values

This is measured by the vertical distance from the prediction to the actual observation and is called the residual. Regression coefficients are calculated so that the resulting line has the lowest possible accumulation of residuals, minimizing the overall distance between the observations and the predictions.

5.4.4 Equal variance or homoscedasticity

This assumption refers to an equal variance of errors across all levels of the independent variables. This assumption is maintained when the variance around the regression line is the same for all values of the predictor variable.

As can be seen in the figure standardized residuals are scatter randomly around a horizontal line of zero. Therefore, the constant variance assumption is not violated.

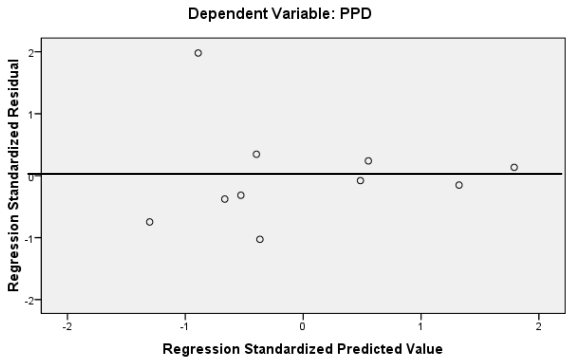

Figure 5.5: Scatter plot showing equal variance

5.4.5 Normality

As Figure 7.6 shows, the residuals form a reasonably normal distribution, which is a good indication that the regression is working well. The residual plots show a normal distribution, with a mean of zero. Since a residual of zero means a point is right on the line, a mean of zero indicates the line is in the middle of the points. And the bell shape means that most are close to the line, and there are fewer points farther from the line.

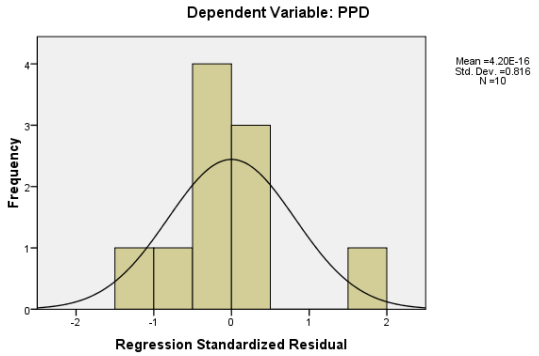

Figure 5.6 Histogram of normally distributed residual

5.4.6 Residuals vs normal probability scale

As can be seen in the figure the points cluster around a straight line indicating the selected variable matches the test distribution.

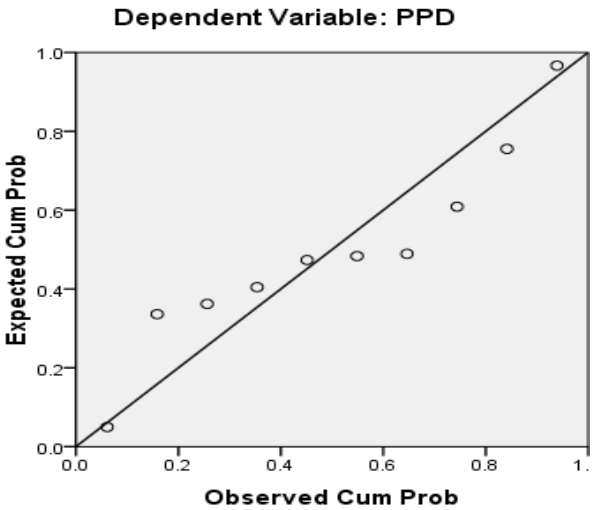

Figure 5.7 P-P plot of regression standardized residuals

5.4.7 Hypothesis testing

Defining and evaluating hypotheses is a very critical part of statistical inference. In order to perform this task, some theory should be setup put forward, either because that theory is believed to be true or because it is to be used as a basis for argument, but has not been proved (Easton, & McColl). Each problem leads simply into two competing hypotheses; the null hypothesis, denoted H0, against the alternative hypothesis, denoted H1 (Easton, & McColl).

i. Test Statistic

A test statistic is a standardized value that is calculated from sample data during a hypothesis test. Test statistics can use to determine whether to reject the null hypothesis.

ii. F- Value:

The F-statistics tests the hypothesis that all the slope coefficients of the multiple regression model are zero, that is all independent variables jointly have no impact on the dependent variable. As the ANOVA table shows, the F-statistics for parking demand model is 196.759. Since this is a high significant value, the hypothesis all independent variables (PA GFA and EPS) have no impact on the dependent variable (PPD) is rejected at the 95.0% level of significance and the alternative hypothesis that all these variables jointly affect the dependent variable is accepted

iii. T-Value:

The input and rejection of variables into and out of equations was controlled by the t-value of each regression coefficient. But none of the regression coefficients of that equation was significant at 95 percent confidence level (Table 5.13).

The t -tests the null hypothesis that the partial slopes are zero.

H_0: $B_0 = 0$: The constant coefficient has no impact on the dependent variable (PPD). As the coefficient table 5.13, shows the t-statistics for constant coefficient is -0.165. Since this value is insignificant, that indicates that we accept the null hypotheses that states that the constant coefficient has no impact on the predicted value of PPD and the alternative hypothesis the dependent variable has impact on the dependent variable is rejected.

H_0: B1 = 0: The dependent variable (GFA) has no impact on the dependent variable (PPD). As the coefficient table shows, the t-statistics for GFA is 5.869. Since this value is highly significant the hypothesis the dependent variable (GFA) has no impact on the dependent variable (PPD) is rejected and the alternative hypothesis the dependent variable has impact on the dependent variable is accepted.

Similarly, H0: B2 = 0: The dependent variable (PA) has no impact on the dependent variable (PPD) .As the coefficient table shows, the t-statistics for PA is 4.893. Since this value is highly significant the hypothesis the dependent variable (PA) has no impact on the dependent variable (PPD) is rejected and the alternative hypothesis the dependent variable has impact on the dependent variable is accepted.

Finally, H0: B3 = 0: The dependent variable (EPS) has no impact on the dependent variable (PPD) .As the coefficient table 5.13 shows, the t-statistics for EPS is 2.818. Since this value is significant the hypothesis the dependent variable (EPS) has no impact on the dependent variable (PPD) is rejected and the alternative hypothesis the dependent variable has impact on the dependent variable is accepted.

In summary it can be concluded that PA, GFA and EPS do explain the variation in the peak parking demand model. The resulting equation had a multiple correlation coefficient of 0.990 and a standard error of estimate of 3.54287. This means that 99.00 percent of the variation in mean peak parking demand was explained by the equation. Thus, the final model obtained was as follows.

PPD = 0.002 x GFA + 0.015 x PA + 0.007EPS……Eq. 5.8. (R^2 = 0.990)

5.5 Discussion of the multiple linear regression results

The outcomes or results from the MLR were interpreted as follows

5.5.1 Coefficient interpretation

The unstandardized coefficient of an independent variable (also called **B** or **slope**) measures the strength of its relationship with the dependent variable. It is interpreted as the size of the average difference in the dependent variable that corresponds with a one-unit difference in the independent variable. In this model, the coefficient for GFA is 0.002. For every one unit increase in the GFA, there is a predicted increase in the PPD of 0.002. The coefficient for PA is 0.015. For every one unit increase in the PA, there is a predicted increase in the PPD of 0.015. The coefficient for EPS is 0.007 and for every one unit increase in the EPS, there is a predicted increase in the PPD of 0.007.

5.5.2 P-Value interpretation

The P-value helps in rejecting or accepting the null hypothesis. It tests the independent factor has no effect on the dependent factor. And explains how significant each variable in the model is. The p-value (significance) for each term tests the null hypothesis that the coefficient is equal to zero (no effect). A low p-value (< 0.05) indicates that you can reject the null hypothesis. In other words, a predictor that has a low p-value is likely to be a meaningful addition to the model because changes in the predictor's value are related to changes in the response variable. Conversely, a larger (insignificant) p-value suggests that changes in the predictor are not associated with changes in the response. SPSS gives a *p*-value for the *F*-test of $p = 0.000$. So we can reject H0 at level 0.05, and also at level 0.01. The model does have predictive power.

5.5.3 T - Value interpretation

Except the constant coefficient the absolute value of all of T-Values for all the independent factors is greater than two. That's indicates that these factors are significant in the model. Therefore, we can conclude that the model does have predictive power.

5.5.4 R square interpretation

The R-square statistic measures the regression model's usefulness in predicting outcomes – indicating how much of the dependent variable's variation is due to its relationship with the independent variable(s). The Model Summary table shows the R-square is 0.990, meaning 99.0% of the variation peak parking demand variation be explained by the three explanatory variables. The remaining 1.0% can be explained by other factors that are not in the model.

5.5.5 Adjusted R-square interpretation

In multiple variable regressions, the adjusted R-square statistic is used instead of the R-square because adding even unrelated independent variables to a model will raise the R-square statistic. The adjusted R-square statistic compensates for the number of variables in the model and it will only increase if added variables contribute significantly to the model. The adjusted R-square is 0.985, that's indicates that the model explains 98.5 % of the variation in the respond of the dependent factor. Therefore it can be conclude that this model has such a high explanatory power.

5.5.6 Analysis of variance (ANOVA)

F- Value interpretation: It compares the selected model with a regression model has no predictor is also known as an intercept-only model. The hypotheses for the F-test of the overall significance are as follows:

Null hypothesis: The fit of the intercept-only model and the selected model are equal.

Alternative hypothesis: The fit of the intercept-only model is significantly reduced compared to selected model. The P value for the F-test of overall significance test is less than the test significance level (0.05), the null-hypothesis has been rejected and a conclusion has been drawn that the model provides a better fit than the intercept-only model.

5.5.7 Plot interpretation

The plot interpretation satisfies the assumption equal variance or homoscedasticity as the residuals plot verses fitted has a random pattern. The plot interpretation indicated that most of the residuals are normally distributed. To verify the assumption of normality, a normality test was conducted. The results found that residuals are normally distributed.

5.5.8 Overall Model Significance

The P-values of the explanatory variables PA GFA and EPS are smaller than 0.05. These values lead us to reject the null hypothesis, and indicate that these factors are significant in the model. Although the P-value of the constant is less than 0.05, and indicates that the constant is significant in the model.

5.5.9 Verification of the result

The final purpose of this study was to test the validity of the linear regression equation proposed for describing the parking demand. An empirical comparison between observed and estimated parking demands was carried out for five shopping centers not included in the foregoing regression analysis. These results are given in the below, where the observed existing parking supply is compared with the estimated parking demand. The representative samples for this verification were selected from different areas of the city.

Table 5.14 Observed and fitted parking demands and residuals

S/N	Name of Shopping Center	Observed PPD	Fitted PP	Residual (Obs- Fit)
1	Morning Star Mall (Bole area)	64	73	-9
2	Medhaneale Mall (Bole area)	70	78	-8
3	Metebaber Building (Megenagna)	76	92	-16
4	Military Tera (Merkato area)	78	89	-11
5	Dir Tera (Merkato)	48	61	-13

Fitted values for the sample data were obtained by substituting the values of gross floor areas and plinth areas into the estimated regression equation (Equation 5.8). Table 5.14 contains all the observed and fitted parking demands and their differences i.e. residuals for the sample shopping centers. The small differences between the estimated values and the observed values indicate that the regression equation was fairly reliable for predicting parking demands with the most reasonable degree of accuracy.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

The study of shopping centre parking demand, reported in this paper is a case in point. Many factors influence the shopping trips to a particular shopping centre depending on a number of personal choices which simply cannot be explained in general. It was not possible to identify and measure all the factors due to limitation of time, money and personnel. Apart from this, the study collects data on peak parking demand of SCs in Addis Ababa city, and develops models that express the peak parking demand as a function of the physical features of the SCs and number of shops. Accordingly, a multiple regression model was built to explain the variation in the peak parking demand of shopping centers as the most significant function of gross floor area and plinth area of the shopping centers. The present analysis was not sufficient to some extent but it indicates which variables are important in relation to parking demand studies. The advantage of the evaluated model, then is that the availability of more information to the planner, the calculations become more narrower towards a most reasonable parking accumulation rate.

6.1 Conclusion

Parking demand was greater than parking supply (capacity) for most of the shopping centers. In other words, the parking areas which were studied could not accommodated the number of vehicles who desire to park at each site of the study.

Vehicular parking needs to be given adequate consideration in transportation and land use planning, having as bases the parking generation characteristics of developments and situations. The macroscopic model relates the TAR of the SC to the physical features of the SC. Thus the multiple linear regression analysis produced equation relating the parking demand to the PA, GFA and EPS proved to be sufficient to account for a very large percentage of variation in mean peak parking demand. The multiple linear regression model, finally produced statistically the most significant relationship between the dependent variable PPD and the independent variables PA, GFA and EPS can be use full tool in parking demand estimation. In summary it can be said that this mathematical model can furnishing information on shopping centers which have not yet been developed, but which are needed in the future. As a result this model for parking demand estimation furnishes information on shopping centers considers the local conditions and can be a clue to estimate parking demands of shopping centers.

Observed figures also reveal that the existing parking facilities at the sample shopping centers have been provided arbitrarily. Most of the parking lots have been proved to be insufficient to the actual demand.

6.2 Recommendation

These are the recommendations based on the results of the present study:

- ✓Basically traffic generation is a function of land use, so development of shopping centers should be controlled under a comprehensive and integrated land use transportation planning.
- ✓During the planning of new development of shopping centers, this model could be used as guidance in prediction of parking supply.
- ✓ Recommendation for more parking supply based on the current parking demand excesses over the existing parking supply, and the parking generation capabilities of the shopping centers.
- ✓Since the area required by a parking space varies with parking lot's layout, the predicted parking demand is expressed in number of vehicles.
- ✓An overall policy of directing development pattern of retail activities according to the standards for community facilities and guided by area wise development plans.
- ✓A comprehensive enforcement of parking control and regulations for all type of vehicles should be adopted to maintain an optimum necessity.

6.2.1 Recommendation for further study:

Further consideration should be given to such type of factors affecting the parking demand situation, which were not modeled in this study include:

- ✓A single model may not enough accurate to determine adequate parking requirements for the new and proposed shopping centers in all locations as a result it may be needed to gathered more data and verified under every specific condition likely to be encountered.
- ✓ Socio-economic characteristics of the shoppers i.e. residential density, income status of the family, family size and composition, level of vehicle ownership and time of arrival and duration.
- ✓ Factors based on the transportation system i.e. distance and travel times to various shopping centers, the availability of public transit and the amount of traffic congestion.
- ✓ The business type in the shopping centre that is the tenant composition

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APPENDIX A:- Data Collection Formats

Floor area, Parking area/No., Number of shops and shop types Survey Format			
No.	Features	Name of Shopping center	Remark
1	Plinth Area		
2	Gross Floor Area		
3	Gross Leasable Area		
4	Parking Area		
5	No. of Shops		
6	Bank		
7	Office		
8	Bedding Store		
9	Book		
10	Camera		
11	Carpet		
12	Cloth / Garments		
13	Boutique		
14	Commercial Art		
15	Crockery		
16	Doctor's Chamber		
17	Electronics Goods		
18	Electronics Parts		
19	Embroidery		
20	Furniture (Steel)		
21	Furniture (Wood)		
22	Grocery		
23	Hair Dressing		
24	Handicraft		
25	Hardboard		
26	Hardware		
27	Jewellery(Gold)		
28	Laundry		
29	Leather Goods		
30	Library		
31	Medicine		
32	Office		
33	Optics		
34	Pathology / X-ray		
35	Photo Studio		
36	Re'staurant		
37	Construction materials		
38	Ceramics		
39	Sanitary Fittings		
40	Shoe		
41	Sport's Item		
42	Stationery		
43	Bakery/ Snacks		
44	Tailor		
45	Variety Store		
46	Video Cassette		
47	Watches / Clock		
48	AudiCoassette		

Parking Demand Survey Formats

Name of Shopping center_____

Serial No.	የታርጋ ቁጥር / Plate Number	የገባበት ሠዓት / Time of arrival	የወጣበት ሠዓት / Time of departure	የቆይበት ሠዓት / Duration	የመኪናው ዓይነት/category (Auto mobile, Pick up, mini bus, midi bus…)
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
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35					
36					

Parking Demand Survey Format

Name of Shopping Center

No.	Vehicle Plate Number	Time (Minute)												
		0-15	15-30	30-45	45-60	60-75	75 - 90	90-105	105-120	120-135	135-150	150-165	165-180	>180
1														
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3														
4														
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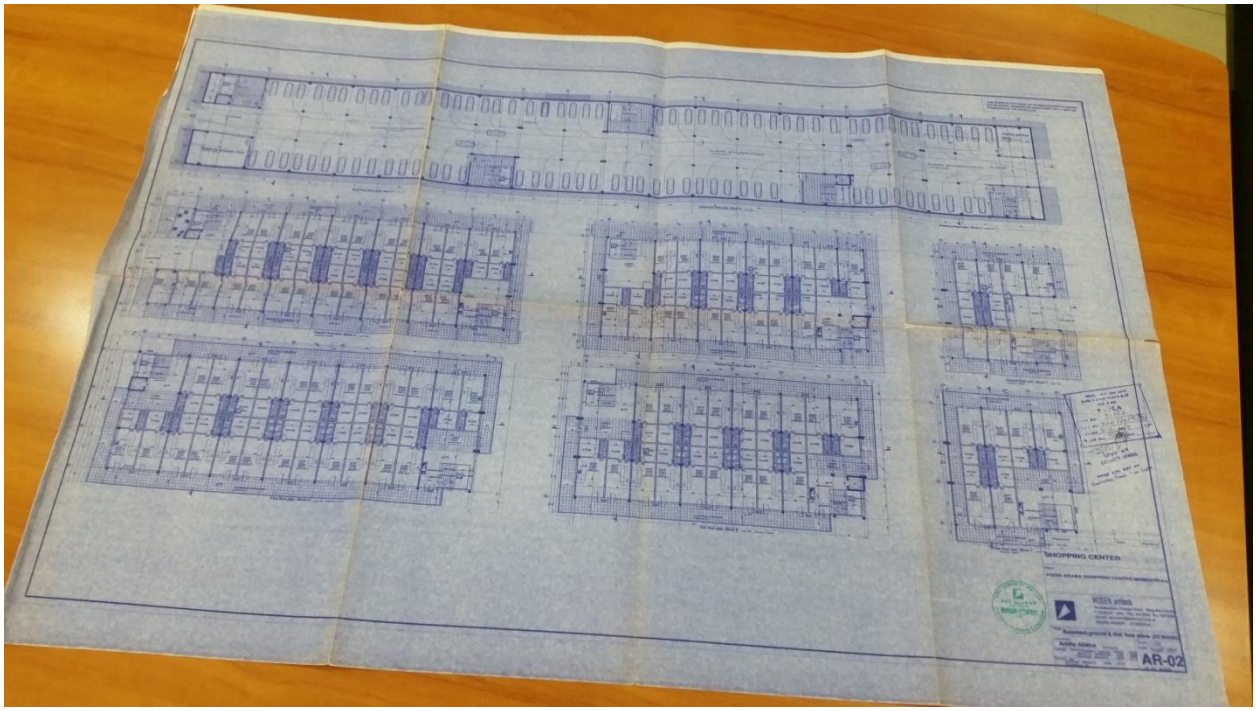
Parking Inventery Survey Format	
Name of Shopping Cent	
1 Type and number of parking spaces	
2 Times of operation	
3 Types of Ownership	
4 Parking Fee, if any, method of collection	
5 Restrictions on use	
6 Probable degree of permanency (can the facility regared as permanet or a temporary)	
Remark	

Typical plan drawing of a shopping center used to collect the explanatory variables



Appendix B: Collected Pictures (Parking Conditions in the Shopping Center)

Parking conditions in Merkato area

Addis Ababa Shopping Center(Mintaf Tera)

Parking condtion (west side of the shop)

Parking of conditions around Addis Ababa Shopping Center (east side)

Under Ground Parking of Addis Ababa Shopping Center (left side pic) and open space parking in front of Military Tera (right side pic)

Parking conditions in Piazza area

Parking conditions in Piazza area, Kelifa business center (left pic) and Churchill street (right pic)

Parking conditions in Olympia area

Underground (basement parking in Dembel City Centers

Parking Conditions around Megenagna

Parking condition behind Zefmesh Grand Mall