TRUCK PARKING DEMAND MODEL ON URBAN FREIGHT TRANSPORTATION SYSTEM OF ADDIS ABABA IN CASE OF AKAKI KALITY SUB CITY

MSc. THESIS

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A THESIS SUBMITTED TO THE DEPARTMENT OF CIVIL ENGINEERING
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ADVISORS' APPROVAL SHEET

This is to certify that the thesis entitled **"Truck Parking Demand Model On Urban Freight Transportation System Of Addis Ababa In Case Of Akaki Kality Sub City"** submitted in partial fulfillment of the requirements for the degree of **Master's** with specialization in **Road and Transport Engineering,** the Graduate Program of the **Department of Civil Engineering,** and has been carried out by **Merafe Tadesse** (ID. No. **PGTrRoR/017/11),** under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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EXAMINERS' APPROVAL SHEET

We, the undersigned, members of the Board of Examiners of the final open defense by Merafe Tadesse have read and evaluated his thesis entitled "Truck Parking Demand Model On Urban Freight Transportation System Of Addis Ababa In Case Of Akaki Kality Sub City", and examined the candidate. This is therefore, to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree.

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DECLARATION

I hereby declare that this MSc thesis entitled **"Truck Parking Demand Model On Urban Freight Transportation System Of Addis Ababa In Case Of Akaki Kality Sub City"** is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

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LISTS OF ABBREVIATIONS AND ACRONYMS

AACRA	Addis Ababa City Road Authority
AADT	Annual Average Daily Traffic
AADTT	Annual Average Daily Truck Traffic
AATMO	Addis Ababa Traffic Management Office
CBD	Commercial Business Districts
ERA	Ethiopian Road Authority
ERCA	Ethiopian Revenue and customs Authority
GPS	Global positioning system
GLA	Gross Leasable Area
ICSC	International Council of Shopping Centers
ITE	Institute of Transportation Engineers
ULI	Urban Land Institute.

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TABLE OF CONTENTS

Content **Page**

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Parking demand model represents the available parking needs and forecast the parking demands in the forms of mathematical equation using relatively easily accessible parameters, which represent the real condition. This serves to plan and nourish the continuously growing vehicular parking demands effectively and in order to provide economically feasible parking spaces on high priced urban area lands. Due to their physical appearance and maneuverability requirement, trucks consumed more spaces on parking facilities. So mostly, they provided separate facility from ordinary cars. This paper surveyed and described truck-parking areas besides proposing parking area demand model. Through process, it incorporates extensive surveys on 12 off street parking areas to determine the parking inventory and parking characteristics corresponding with fright vehicle traffic and truck drivers driving manners around Akaki Kality sub city of Addis Ababa. Using quantitative research method and data analysis on the data sourced from primary and secondary sources through coordination of different survey methods such as questioners; parking inventory survey forms and traffic volume studies supplemented by statistical data analysis software have been executed. During inventory, the average area of the studied parking facilities were founded 7817 square meters. In addition, on infrastructural perspectives the truck parking areas were poorly organized and equipped. Based on parking survey the average parking accumulation in studied zone was 111 trucks with parking load 267 trucks hour and parking occupancy of 67.91%. Since the study conducted during period of daytime traffic ban enforcement on trucks, besides showing the increase in the efficiency of off street truck parking during that period it proposes multi-liner regression model.

Keywords: Off-Street Parking; Parking Survey; Parking Accumulation; Parking Occupancy.

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1. INTRODUCTION

1.1. Backgrounds

In freight transportation there is a requirement of infrastructures like parking and warehouses for loading and unloading; load checking; vehicle maintenance and other different desires (DIMTS, et al., 2018). Moreover, Safe and sufficient truck parking have long been a need for a quick stop adjacent to urban area to wait for congestion to be clear or an overnight break to sleep in the middle of a cross-country trip. Truck parking is a concern for commercial motor vehicle drivers; industries that rely on efficient truck-deliveries; government agencies who regulate and maintain highways as well as parking infrastructures (Cambridge Systematics, et al., 2018).

Parking services have given based on an hourly, daily or monthly basis and they provided to set a convenience area for travelers to park vehicle in organized and secured manner. Parking plays major role in the transport system since all vehicles required it when they are not been used. Wall planed parking facilities maximize the efficiency of road space by reducing road congestion, traffic accident and overcome unnecessary traffic disruption on road mobility characters. Accordingly, their uses with increasing traffic demand of those facilities continuously growing. In the study reports, annual registered car parking land demand was bigger than 310 football fields in Delhi. In Lagos the car parking demand of the existing car was equivalent to 115 football fields and in Addis Ababa, the registered parking land demand of the existing car were equivalent to 110 football fields (GIZ, 2017; DIMTS, et al., 2018; Manaye and Berhan, 2019).

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Addis Ababa handles large number of freight vehicles and composes number of warehouses located within and surrounding the city center. Thus, facilities are major freight traffic generating sources to and from the cities. Currently there is shortage of parking infrastructures to serve this huge demand efficiently. Since 2014-transport policy of Addis Ababa identified problem of parking areas as one of the key "infrastructural challenges" in cites. Thus rises idea of planning and providing those facilities and needs understanding the current freight infrastructure like truck parking as much as knowing fright distribution pattern as well as the City's freight demand and supply chain logistics (Chamber of Commerce, 2009; Fortune, 2019). Evidence of truck parking shortage have observed while trucks parked on highway shoulders and ramps (CPCS, 2017). Spotting the current condition of Addis Ababa, it is common situation to see trucks parked along the roadways and at the ramps. There is no enough off-street parking, and too much on-street parking observed. Unfortunately, the problem is aggravated when developers flout the law and do not provide the necessary off-street parking or illegally convert parking areas to other uses (Bank. O, 2014).

Voluminous studies have done on parking demand models for different conditions and various scenarios of different cities in the world having diverse parking behavioral characteristics. The literature offers several methodologies for estimating parking demand. This includes the Institute of Transportation Engineers (ITE) parking generation rates, regression equations, and cumulative distributions that are widely used in urban areas (Kelley K. et.al, 2002).

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1.2. Statement of the Problem

Insufficient infrastructure along commercial routes may cause traffic jam and safety problems (Abel, 2013). Observing Addis Ababa, the city is transforming from a predominantly administrative and service center to an industrial and financial centers. Because of this rapid economic growth and changes, there is a high mobility of goods and passengers resulting higher transportation demand. Although traffic flow generated by parking lot seeking vehicles are a major congestion causing and aggravating factors in the city (Yetnayet, 2012; AACRTB, 2017). In case of freight transportation the existing congested traffic coupled with operational characteristics of heavy vehicles escalate the traffic condition through the capital and it caused the overall infrastructural inefficiency on facilities like parking areas (AASHTO, 2004; Yetnayet, 2012). Since land is expensive and can used for other needs in urban areas, infrastructural development strategies on infrastructures such as on parking areas should be imminent at national and continental level to incur sectorial efficiency (Garber, 2009). In order to estimate and provide enough parking spaces having total capacity that withstands existing parking demand; there should be a way of knowing the available demand that can be attained easily (AACRTB, 2017). Since available parking models, having some variables difficult to find in the freight traffic system of Addis, the models have short comes to use for Ethiopia's case; thus, developing models or spreadsheet, which suites own condition is required.

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1.3. Objectives

Main objective:

The main objective of the research was developing truck parking demand model for freight vehicles of Addis Ababa in case of Akaki Kality sub city.

Specific Objectives:

- To investigate study area's current freight vehicle parking infrastructural condition.
- To conduct the study area's off-street truck parking operational characteristics.
- To develop truck parking demand model with in Addis Ababa freight transporters.

1.4. Research Question

This research is been conducted to answer the following questions:

1. What are the situations of urban vehicular parking infrastructures towards freight transportation?
2. What is the existing performance of the off street parking facilities used by freight transporters?
3. Is it possible to establish the parking demand model?

1.5. Significance of the Study

The study attempts to assess the current truck parking facilities and current parking practices at Addis Ababa scoping on the urban freight transportation commuters. Therefore, it expected that the study contribute significant information on the following issues.

- ✓ The study insights condition of truck parking facilities in Addis Ababa.

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- ✓ Correspond or correlate parking infrastructures statistics with traffic characters, truck operators and parking infrastructural behaviors through regression model.
- ✓ It serves as platforms for other further studies.

1.6. Scope of the Study

This study only focuses on off-street parking facilities that only used by trucks operated in the city. The small enterprises organized by "Wereda" are the owner of those facilities and mostly they entertained Medium, Heavy and Truck Trailers.

1.7. Limitations of the Study

The study concerns about off-street truck parking areas, concentrating only on one sub city called Akaki Kality; this is because of financial and time constraint but this sub-city was selected systematically based on reviews on prior studies and exploratory studies done by the researcher among other freight transporters parking preference areas. Those common parking preference areas are located at Nifasilk Lafto, Jemo Mebrathile and around Merkato.

Although the time interval during in-out survey and volume studies was based on small data therefore this have some effect on the accuracy point of view.

In general, the researcher believes the following difficulty may aggravate the limitations

- ➢ There were lacks of available data source from concerning authority about parking sites.
- ➢ Continuous variability on the hour of traffic ban enforcement were tested the data gathering process.

- Difficulty on including on street parking located at the study area also forced the researcher to get and present a real parking situation in the area.

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2. LITERATURE REVIEW

2.1. Categorizations of Commercial Motor Vehicle.

Commercial Motor Vehicles (CMV) broadly defined as a vehicle that are used at part of a business, involved in interstate commerce weighs 10,001 pounds (4.5 tone) or more, or transports certain commodities (Cambrige Systematics Inc, et al., 2018). Although AASHTO have been defined 20 design vehicles categorized under four general vehicle classes, i.e., passenger cars, buses, trucks, and recreational vehicles (AASHTO, 2004). ERA classified vehicles into eight categories based on their size (four passenger and four fright vehicles). The table below shows the detail vehicle classification.

Table 2.1: ERA Vehicle Classifications System. Source (ERA, 2013)

Classification	Description
A. Passenger Vehicles	
Car	Cars & Taxis
L/Rover	Land Rovers, Jeeps, Stations Wagons, Land Cruisers etc.
S/Bus	Small Buses up to 27-passenger seats
L/Bus	Large Buses over 27-passenger seats
B. Freight Vehicles	
S/Truck	Small and Light Trucks of 3.5 tons load
M/Truck	Medium sized trucks of 3.6 to 7.5 tons load
H/Truck	Trucks and Tankers of 7.6 to 12 tons load
Truck – Trailer	Truck Trailers and Tanker Trailers above 12 tons load

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As stated above categorizations of commercial vehicle in Ethiopia have classified as Multi-Purpose Vehicles, Light freight Vehicles, Medium freight Vehicles and Heavy freight Vehicles. According to Addis Ababa Traffic Management Office (AATMO) studies, from total haulage of freights, 2-Axle trucks and 3-Axle trucks serve 90 percent of goods manipulations and which are under Medium freight Vehicles and trucks above 4-Axles that categorized as heavy goods vehicles. The following picture shows some representative vehicles from each category of Ethiopian fright vehicle classifications (DIMTS, et al., 2018)

Figure 2.1: Commercial Vehicle Categorization: Source (DIMTS, et al., 2018)

Data from transport authority states that the total registered number of vehicles in Ethiopia until July of 2019 was 1,071,345 and 596,084 of them have registered at Addis Ababa (Federal-Transport-Authority, 2019). Although the registered numbers of trucks,

which can carry more than one tone were around 120,000. Since those vehicles have special operational characters on curve maneuvering, on accelerating and braking while traveling at the cities sections having those arrangements as there common features of movement patterns involving number of intersections, signals and curves; This imposes adverse effect on cities traffic flows (AASHTO, 2004; DIMTS, 2018; Fortune, 2019).

Therefor for managing city road congestion the Addis Ababa city traffic office ban the movement of medium trucks to truck trailer from trafficking throughout the city roads at day time July 2019 onwards until enforcement stopped on April 2020 due to COVID 19 pandemic's influence on logistics sectors

Observing 16 years average truck traffic data collected on main trunk roads extracted from ERA it can be clearly observe that Akaki Kality road gateway entertained higher percent of truck traffic. Therefore, the researchers have conducted this study on this area as a case study for Addis Ababa.

2.2. Parking and Rest Area.

Vehicular parking facilities have provided in order to set a convenience area for travelers to park vehicle in organized manner. Parking plays major role in the transport system since all vehicles required a parking location when they are not been used. On Tanzanian parking specification; Surfaced area withstands five tons per axil of load composing a compound light, shelters with seat and some boundary or marking in order to avoid disturbance between light vehicle and trucks is stated as a minimal criterion to be parking area (TANROADS, 2011). The services have given based on an hourly, daily or monthly basis (Manaye and Berhan, 2019).

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Safe and sufficient truck parking has long been a need for a quick stop near an urban area to wait for congestion to be clear or an overnight break to sleep in the middle of a cross-country trip. Therefore, truck parking is a concern for commercial motor vehicle drivers; Industries that rely on efficient truck-deliveries; government agencies who regulate and maintain highways and parking infrastructures (Cambrige Systematics Inc, et al., 2018).

In the study reports, annual registered car parking land demand is bigger than 310 football fields in Delhi, In Lagos the car parking demand of the existing car is equivalent to 115 football fields and in Addis Ababa, the registered parking land demand of the existing car is equivalent to 110 football fields (GIZ, 2017).

Transport Policy of Addis Ababa in 2014 identified parking areas as one of the key "infrastructural challenges" in cites. There is no enough off-street parking, and too much on-street parking observed. The main concerns pertaining parking can analyzed as the overutilization of road space by parked vehicles, lack of off-street parking facilities, and the need to create and incentivize the use of park-and-ride facilities related to mass transit services is indeed an important area of concern for sustainable transport policy. This problem aggravated while there are instances when developers flout the law and do not provide the necessary off-street parking or illegally convert parking areas to other uses. In reorienting parking policy along these lines, parking can be a useful tool to help shape streets as the building blocks in the city (Bank, 2014).

Parking is a major attribute in freight transport infrastructure planning. Wall planed parking facilities maximize the efficiency of road space by reducing congestion, accident and overcome unnecessary traffic disruption on road mobility characters. But

in our case it was conclusive that in the road networks there is poor freight parking infrastructures; there are about 62 locations that trucks stopped in different ways of parking, but Addis Ababa have no single parking facility fitting standards which is why the new master plan proposed parking facilities especially for freight transporters at Five locations. To be more specific the two truck parking facilities planned to build at Akaki Kality (DIMTS, et al., 2018).

2.2.1. Types of Parking and Rest Area.

Based on the location of the facility relative to the roadway; there are two main broad classification of parking, which are ON STREET PARKING and OFF STREET PARKING. These facilities complement each other because eliminating substantial amounts of on-street parking needs provision of additional off-street parking. Off-street parking provision is expensive because it involves purchasing of land for building of parking garages, and takes large time to plan and implement it (Michael Jr., et al., 2018).

2.2.1.1 On-street parking: also called curb facilities (Garber, et al., 2004). In this facility, vehicles parked along sides of the street or on the street itself. As sited by Manaye and Berhan, (2019) parking can also categorize based on the orientation of parked vehicles with respect to the road alignment.

2.2.1.1.1 Parallel parking: In this type of parking orientation; the vehicles are parked along the length of the road and through the process of parking or un-parking, there is no backward movement involved. Hence, it connoted as the safest parking from the accident perspective. However, it consumes the maximum curb length and tolerate a minimum number of vehicles parked on a given curb length. This method of parking

produces least obstruction to the on-going traffic on the road since least road width is used. The figure bellow shows typical Parallel parking orientation (Mathew, 2009).

For the length available to park N number of vehicles,

$$L = N/5.9 \quad \text{….....(Equation ,2.1)}$$

Source (Mathew, 2009)

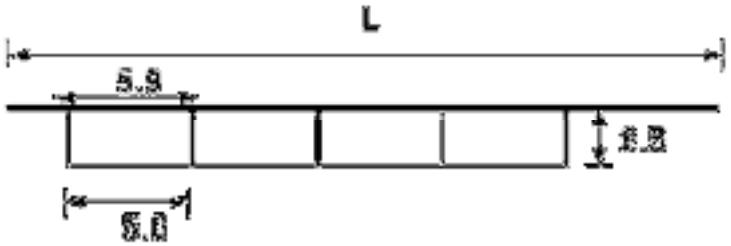

Figure 2.2: Illustration of parallel parking: Source (Mathew, 2009)

2.2.1.1.2 30° parking:

In thirty degree parking, the vehicles stopped at 30° with respect to the road alignment. In this case, more vehicles parked compared to parallel parking. In addition, there is better maneuverability and delay caused to the traffic is minimal. The following figure shows the pictorial representation of 30° parking (Mathew, 2009).

$AB = OB \sin 30 = 1.25$

$BC = OP \cos 30 = 4.33$

$BD = DQ \cos 60 = 5$

$CD = BD - BC = 5 - 4.33 = 0.67$

$AB + BC = 1.25 + 4.33 = 5.58$

For N vehicles,

$L = AC + (N-1)\,CE = 5.58 + (N-1)\,5 = 0.58 + 5N$ ……..… .(Equation, 2.2)

Source (Mathew, 2009)

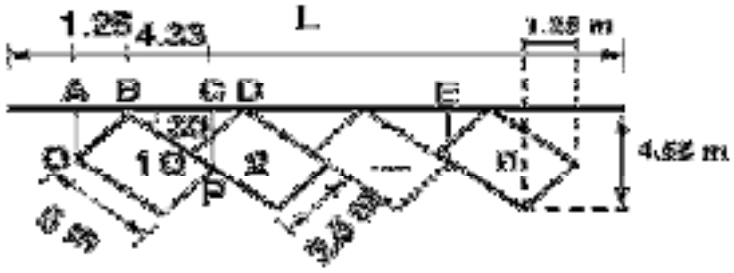

Figure 2.3: Illustration of 30° parking: Source (Mathew, 2009)

2.2.1.1.3 45° parking:

As the angle of parking increases, more number of vehicles can parked. Hence compared to parallel parking and thirty degree parking, more number of vehicles can accommodated in this type of parking. Length of parking space available for parking N number of vehicles in a given curb is

$$L = 3.54\,N + 1.77 \quad \text{..... (Equation, 2.3)}$$

Source (Mathew, 2009)

Figure 2.4: Illustration of 45° parking: Source (Mathew, 2009)

2.2.1.1.4 60 ° parking:

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The vehicles parked at 60° to the direction of road and more number of vehicles accommodated in this parking. Effective in parking area management than the above and Length available for parking N vehicles will be

$$L = 2.89\ N+2.16 \quad \text{..... (Equation, 2.4)}$$

Source (Mathew, 2009)

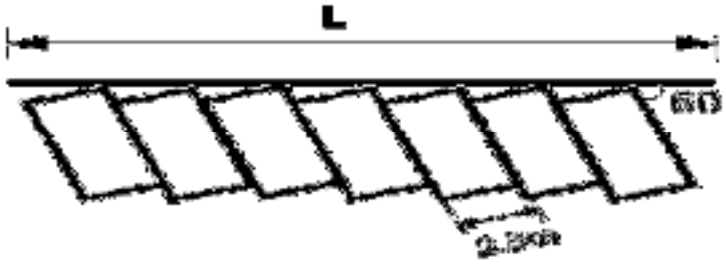

Figure 2.5: Illustration of 60 ° parking: Source (Mathew, 2009)

2.2.1.1.5 Right angle parking:

In right angle parking or 90° parking, the vehicles are parked perpendicular to the direction of the road. Although it consumes maximum width, curb length required is very little. In this type of parking, the vehicles need complex maneuvering and this may cause severe accidents. This arrangement causes obstruction to the road traffic particularly if the road width is less. However, it can accommodate maximum number of vehicles for a given curb length (Mathew, 2009). Length available for parking N number of vehicles is

$$L = 2.5N. \quad \text{..... (Equation, 2.5)}$$

Source (Mathew, 2009)

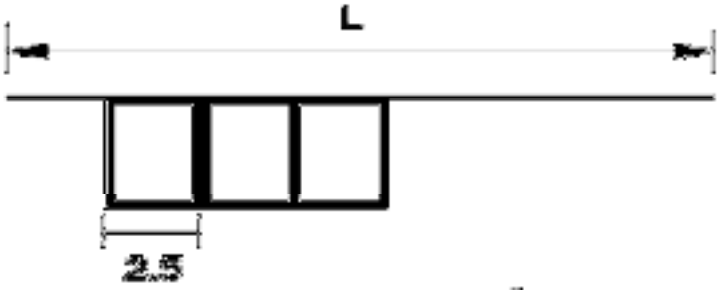

Figure 2.6: Illustration of 90° parking: Source (Mathew, 2009)

2.2.1.2 Off-street parking: In this type of facility, cars parked at particular building or particularly assigned land (Manaye and Berhan, 2019). The facility includes surface lots and garages (Garber, et al., 2004). They may operate either public agencies or private firms. On figure below shows typical layout of off-street parking (Mathew, 2009).

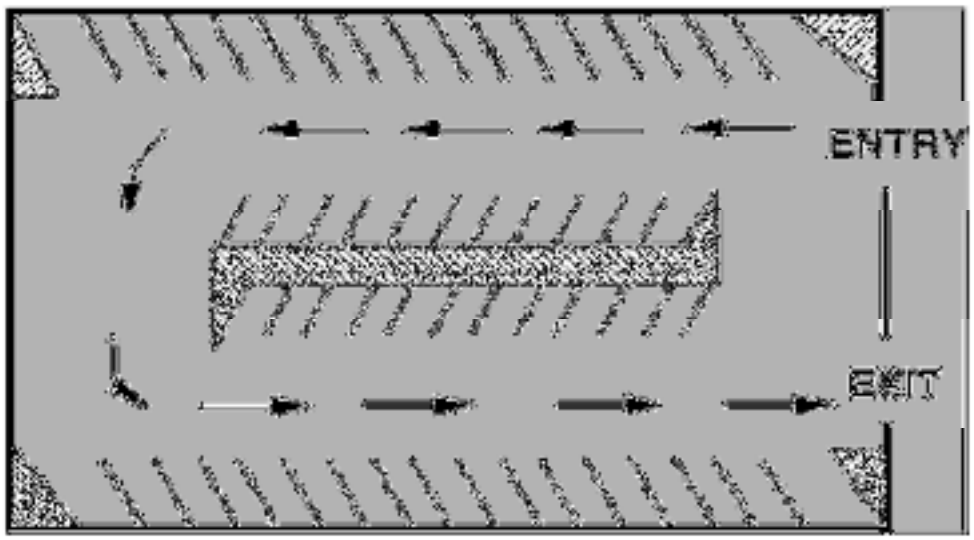

Figure 2.7: Illustration of off-street parking. Source (Mathew, 2009)

2017's vehicle parking development directives of Addis Ababa classified off street parking in to Smart Parking, Building Parking, Basement Parking , Underground Parking and Surface Parking (AACRTB, 2017). Whereas according to Tanzanian

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geometric design manual the minimal area for parking facilities are stated as 1000 square meter and classified parking areas as miner parking, major parking and truck parking area.

a. Major Rest Area

Mainly provided along highway route at interval of 100 to 120 km. it manly served a long distance travellers. It will indicate with unique name to reflect the geometrical location and to enables clear identification of the rest area for effective management (TANROADS, 2011).

b. Minor rest area

It primarily designated to satisfy short-term rest break area. Some may have constraining factors that limit the suitability for safe access for heavy vehicle and which signed as not suitable for trucks. These facilities have recommended being present in interval of 50 to 60 km interval of routes (TANROADS, 2011).

c. Truck parking Area

Parking spaces accommodating minimum of 10 long vehicles. It is off road parking type accessed through deceleration and acceleration lanes. It manly used for short breaks or load checking and accessed 30 to 40 km interval (TANROADS, 2011).

2.3. Parking Studies and Characteristics

2.3.1. Overviews on Parking Facility in Addis Ababa.

In Addis Ababa, the supply of parking spaces has not kept pace with this increasing parking demand. 62 locations of which forty-four are on-street parking locations, ten are off-street parking locations and eight mixed character locations are identifies for parking as surveyed by Traffic Management Office of Ethiopia. There are 8 zones based

on multiple factor such as proximity to prominent markets and industrial areas, major roads that enter into the city etc. It was taken care that the major characteristic of parking locations in a zone would be similar either commercial (markets) or industrial. Zone 1, 2, 7, 8 and 4 are the major entry points into the city. Zone 5 is a prominent market (Merkato), Zone 6 and Zone 3 are major Industrial areas. The figure below illustrates the parking zones and there locations (DIMTS, et al., 2018).

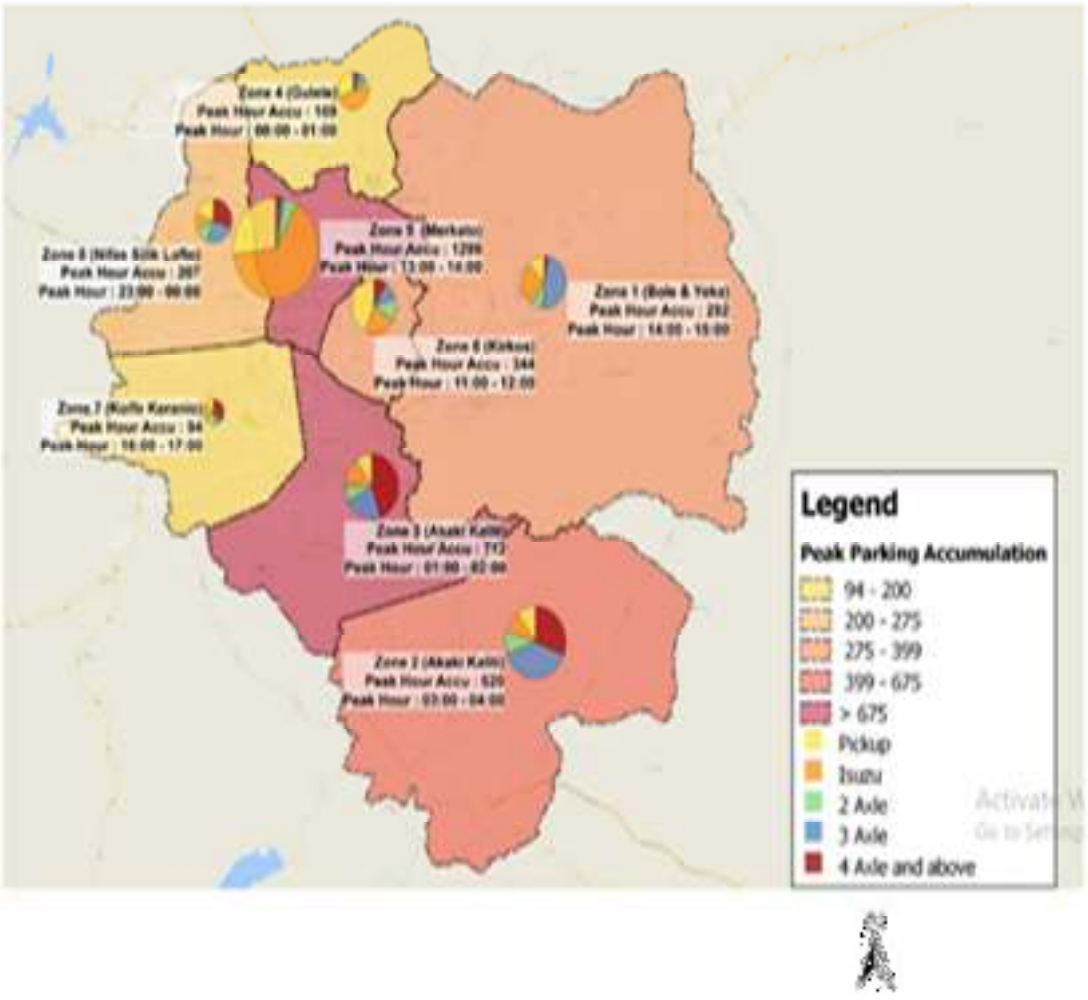

Figure 2.8: Zonal Peak Parking Accumulation by Truck Type. Source (DIMTS, et al., 2018).

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2.3.2. Parking Survey

Parking surveys have conducted to collect the parking statistics. The most common parking surveys conducted is in-out survey, fixed period sampling and license plate method of survey (Mathew, 2009).

1. **In-out survey**: In this survey, at the beginning the occupancy counts in the selected parking lots are been taken. Then the numbers of vehicles that enter the parking lot for a particular time interval ware counted. The numbers of vehicles that leave the parking lot have taken. The final occupancy in the parking lot is been taken. Here the labor required is very less. Only one person may be enough. However, we could not get any data regarding the time duration for which a particular vehicle used that parking lot. Using this method parking duration and parking turnover are cannot obtained. Hence, we cannot estimate the parking fare from this survey.
2. **Fixed period sampling**: This is almost similar to in-out survey. All vehicles will count at the beginning of the survey. Then after a fixed time interval that may vary between 15 minutes to i hour, the count is again taken. Here in this method there are chances of missing the number of vehicles that parked for a short duration.
3. **License plate method of survey**: This method's result gave the most accurate and realistic data. Every parking stall is will monitored at a continuous interval of 15 minutes or more and there license plate numbers are noted. This will give the data regarding the duration for which a particular vehicle was using the parking bay. This will help in calculating the fare because it estimated based on

the duration for which the vehicles been parked. If the time interval is shorter, then there are less chances of missing short-term parkers. However, this method is very labor intensive.

Various characteristics of parking facilities operating properties have presented by the following parking statistics. Some of those are parking accumulation, parking volume, Parking load and Average parking duration

Parking accumulation: It is defined as the number of vehicles parked at a given instant of time. Normally this expressed by accumulation curve. Accumulation curve is the graph obtained by plotting the number of bays occupied with respect to time as shown on the following figure.

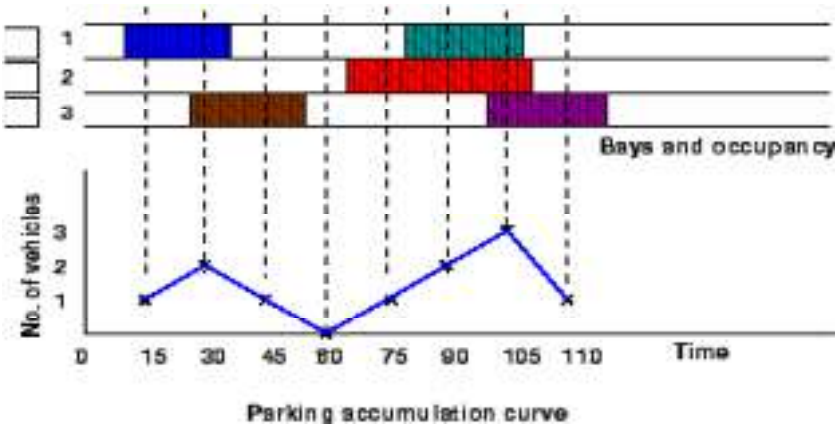

Figure 2.9: Parking accumulation curve. Source (Mathew, 2009)

Parking volume: Parking volume is the total number of vehicles parked at a given duration of time so that the actual volume of vehicles entering in the facility is been recorded. However, this does not account for repetition of vehicles.

Parking load: Parking load which expressed by vehicle hours. Moreover, it gives the area under the accumulation curve. It can also obtained by simply multiplying the

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number of vehicles occupying the parking area at each time interval with the time interval.

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

$$\text{Parking duration} = \frac{\text{Parking load}}{\text{Parking volume}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation, 2.6)}$$

Source (Mathew, 2009)

Parking turnover: It is the ratio of number of vehicles parked in duration to the number of parking bays available.

$$\text{Parking turn over} = \frac{\text{Parking volume}}{\text{No.of bays avilable}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation, 2.7)}$$

Source (Mathew, 2009)

This can expressed as number of vehicles per bay per time duration.

Parking index: it also called occupancy or efficiency. It can define as the ratio of number of bays occupied in time duration to the total space available. It gives an aggregate measure of how effectively the parking space have utilized. We can found parking index as follows.

$$\text{Parking index} = \frac{\text{Parking load}}{\text{Parking volume}} * 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(Equation, 2.8)}$$

Source (Mathew, 2009)

2.4. Policies and Regulations Affecting Truck Parking

As sited on Cambrige Systematics Inc, et al. (2018). “The American Department of Transportation with respect to highways under its jurisdiction may place official traffic-control devices in which they prohibiting stopping, standing or parking of vehicles on

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any such highway where, in it is dangerous to those using the highway or where the stopping, standing or parking of vehicles would unduly interfere with the free movement of traffic thereon. It is unlawful for any person to stop, stand or park any vehicle in violation of the restrictions stated on those devices."

Although some states place limits on the periods when trucks may park in public rest areas or welcome centers. For example, California limits parking for all drivers to eight hours in any twenty-four hour period. Nevada allows overnight parking and has a twenty-four hour stay limit, meaning trucks can utilize available public rest areas to meet the long-term parking needs.

Size and weight limits and the regulations that govern the movement of permitted loads this can have a number of impacts on truck parking. Mismatch in permitting requirements could cause delays if not all of the necessary permits are obtained ahead of time. Trucks may need to park at a state border to wait for permits to been issued.

Addis Ababa's traffic policy on banning the truck traffic during daytime also considered as one of policies that affect truck-parking areas. The policy have enforced at 8 July 2019; revised on 6 October 2019, and fully lifted on March 2020.

2.5. Truck Parking Studies

Parking management is widely practiced in many European cities but the development of plans has been limited. Only five U.S. cities that responded to the survey have official plans for parking management, which shows that a vital element of transportation system management has not yet arrived. Twenty-seven cities (16 percent) reported that a parking management study had been conducted and thirty-eight (22 percent) indicated that studies were under way (Michae Jr., et al., 2018). Addis Ababa

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also proposed parking facilities on coming master plan (DIMTS, et al., 2018). The following sections summarize some of truck parking studies conducted.

1. Study of Adequacy of Commercial Truck Parking Facilities.

According to the study Conducted by Federal Highway Authority (FHWA) of USA in 2002; the location and quantity of commercial truck stop parking facilities, travel plazas, and public rest areas and analysis of shortages, as well as a plan to address the parking shortages by engaging a number private and public-sector stakeholders throughout the study, and provided technical guidance. The full report involved four major sections: (1) estimation of parking demand using a modeling approach, (2) inventory of public and commercial truck spaces, (3), identification of deficiencies, supply, and demand, and (4) recommendations.

2. Dealing with Truck Parking Demands

Studies by National Cooperative Highway Research Program of America (NCHRP) Synthesis 317 in 2003 indicates that extreme shortages of commercial vehicle parking. The outreach determined that legislative authority plays a significant role in managing commercial vehicle parking, and the development of parking spaces in the United States paralleled the development of the Interstate Highway System. However, as the motor vehicle carrier industry grew, the parking capacity at public rest areas has not been able to accommodate increased demand. Although states have implemented a number of alternative approaches to manage the demand for commercial vehicle parking, no single entity is responsible for providing parking facilities. Nationwide, the study found a shortage of more than 100 percent in public parking places but an overabundance of private truck parking availability

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3. Commercial Motor Vehicle Parking Shortage by FHWA in 2012.

This report, which produced after “Study of Adequacy of Commercial Truck Parking Facilities of America”, continued on these findings and provided updates on estimates and forecasts of long-distance trucking activity, information from the Truck Parking Pilot Grant Program, as well as observations from safety enforcement officers.

The data collected was largely subjective, but the study concluded that truck-parking shortages remain widespread, particularly in certain geographic areas. Unless utilization of and investment in parking capacity is improved, shortages were expected to increase with growth in demand for the trucking industry.

4. National Coalition on Truck Parking: Activity Report

In August 2015 stakeholders including the trucking industry, commercial vehicle safety officials, state departments of transportation, and the truck stop industry came together to conduct regional meetings to share ideas for improving truck parking through increased parking capacity, technology and data, funding, finance and regulations, and government coordination. Key themes from national coalition on truck parking regional meetings to develop approaches to the truck parking issues categories as parking capacity expansion; technology and data; funding, finance, and regulations and state, regional, and local government coordination.

4.1. Parking Capacity Expansion

- Use public land within highway right-of-way to develop additional truck parking capacity.
- Update the national standard for parking facilities, considering the needs of oversized trucks, security and lighting, and maximizing the capacity of a rest area.

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- Integrate shippers/receivers into the conversation to address truck-parking needs at industrial sites.
- Address truck-parking needs in the context of improving efficiency of the entire supply chain.

4.2. Technology and Data

- Disseminate real-time information about parking availability at highway rest areas and private truck stops.
- Establish connectivity to existing technology commonly available to drivers, such as smartphones.
- Use connected vehicle and vehicle to-infrastructure technology to guide drivers to available parking.

4.3. Funding, Finance, and Regulations

- Provide a dedicated funding source for capital and maintenance funds for public rest areas and truck parking facilities on the national highway network.
- Promote "industrial park co-operatives" or industrial tax districts for pooled parking in areas with heavy concentrations of terminals, distribution centers and other industrial sites.
- Establish public privet partnerships to develop new and expanded parking facilities.
- Implement truck-parking fees to provide a source of capital and operating revenue for truck parking facilities.

4.4. State, Regional, and Local Government Coordination

- Educate the public and elected officials about the importance of truck parking in freight transportation and industrial development.

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2.6. Parking Demand Model.

In many areas of intense residential, business or industrial activity areas demand for parking space exceeds supply. Space available for parking must allocated on a priority basis. In such cases, the responsible authority will need to estimate the total demand and allocate priorities among the competing interests (AACRA, 2008). But in order to estimate enough parking space having total capacity that satisfy demand and supply of parking requirement should be known; this can be done by developing a way of forecasting future accumulation through developing models and software or spreadsheet templates. There are various models developed in different part of world. Here under the common parking demand models reviewed:

Model 1: **The International Transportation Engineer's Parking Generation Model.**

The 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 (Dessie and Azanaw A, 2016). 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

$$P = (3.62 * X) + 120. \quad \text{(Equation, 2.9)}$$

Source (Kelley K. et.al, 2002).

Where

P = peak parking demand (spaces)

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

Model 2: The Urban Land Institute (ULI) Models

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

P= 2.90 * X …….. (Equation, 2.10)

Source (Garber, et al., 2004).

Where

P = peak parking demand (spaces)

X = 1,000 square feet of gross leasable area Retail less than 400,000 square feet

P = 0.70 * X …….. (Equation, 2.11)

Source (Garber, et al., 2004).

Where

P = peak parking demand (spaces)

X = 1,000 square feet of gross leasable area Retail more than 400,000 square feet

Model 3: The Corridor Truck Parking Demand Model

Kelley K. et.al, (2002) states that a location-specific parking demand model was developed and calibrated to assess the demand for truck parking at individual rest areas; but these models have many short comes. Therefore, a new model formulated. A model that bases parking demand on a segment of highway or corridor rather than an individual parking facility (Kelley K. Pécheux, et al., 2002)

Seasonal peak daily truck volume using the AADT

Vt = AADT * Pt * FS ……..…… (Equation, 2.12)

Source (Kelley K. Pécheux, et al., 2002).

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Where

AADT = annual average daily traffic (vehicles/day)

Pt= percent of total traffic that is trucks

FS=seasonal peaking factor the average truck travel time

TT, for the segment calculated in hours per truck:

$$TT = \frac{L}{S} \quad \text{…… (Equation, 2.13)}$$

Source (Kelley K. Pécheux, et al., 2002).

Where

L = analysis segment length (km)

S =speed limit or average truck speed (kph)

Total Daily Truck-Hours of Travel, THT, for short-haul and long-haul trucks can be estimated:

THTSH = PSH * V * TT……..……...…….. (Equation, 2.14)

Source (Kelley K. Pécheux, et al., 2002).

THTLH = PLH * Vtt * TT….……..……... (Equation, 2.15)

Source (Kelley K. Paychex, et al., 2002).

Where

P = proportion of total trucks that are short-haul

PSH= proportion of total trucks that are long-haul

The Daily Short-Haul Truck-Hours of Parking Demand, THP, estimated as:

$$THPSH = \frac{DST * THT * 60}{60} = \frac{THTSH}{12} \quad \text{……..… (Equation, 2.16)}$$

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Source (Kelley K. Pécheux, et al., 2002).

Where

D= duration of short-term stops per hour traveled (min/hour)

To estimate the Daily Long-Haul Truck-Hours of Parking Demand, THP, on the segment:

$$THPLH= \frac{Parking/_{week}}{Deriving/_{week}} * THLH + \frac{DST*THTLH}{60} \text{…….. (Equation, 2.17)}$$

Source (Kelley K. Pécheux, et al., 2002).

Where

DST= duration of short-term stops per hour traveled (min/hour)

The Peak-Hour Short-Haul and Long-Haul Parking Demand, PHP, respectively calculated as:

$$PHPSH = PPFSH * THPSH \text{ …..……. (Equation, 2.18)}$$

$$PHPLH = PPFLH * THPLH \text{ ……..…….. (Equation, 2.19)}$$

Source (Kelley K. Pécheux, et al., 2002).

Where

PPFSH = peak-parking factor for short- haul trucks,

PPF = peak-parking factor for long-haul trucks

2.7. Summary and Gap of Reviewed Literatures

The major findings from reviewed articles summery discussed as the follows:-

- In study investigation, most of the articles focusing on the parking demand model are on developing ways to minimize parking problems such as searching time,

walking distance to final destination, parking price and waiting time in queuing specifically for smaller vehicle classes but there is lack of focus on truck traffic.

- Previously developed parking demand models such as International Transport Engineers (ITE's model) is been used only at urban areas and it does not include commercial vehicle trucks. Whereas the Urban Land Institute (ULI) Models uses mixed land uses losable areas mostly at shopping and market area without correlating active traffic conditions and not effective for less organized land use areas.
- Federal Highway Authority and Department of Transport developed both macro and micro leave models. The Macro Leave Models consider the effect of traffic flows on parking demand but it have a failure of considering non traffic factors and the effect of nearby parking facilities. Whereas the Micro Level Model cover the drawback of the Macro Level Model but it do not forecast future demand and not identified the specific locations of shortfalls.
- There is also other parking demand model like The Corridor Truck Parking Demand Model; this model contends the predicting variables that are not exist on our countries case. Instance the hour of service rules, parking factors. Therefor this study aims filling the gaps described above scoping on trucks; surrounding traffic conditions; parking and operating time for the sack of using the model achieving the seated objectives.

Further the following table contains different type of models developed under different conditions and cites

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Table 2.2: Different Models Developed In Time. Source (Janak Parmar , et al., 2019)

Author	**year**	**Model/ Analysis Type**	**Application Area**	**Factors Considered**
Mc Guiness and Mc Neil	1991	Least square regression	Pittsburgh, USA	Location, tenant type, condition and state of building
Hunt and Teply	1993	Choice (nested logit)	Edmonton, Canada	Distance, waiting time at stall, cost of parking, parking surface condition, winter provision
Wong et al.	2000	Linear regression and unit graph technique	Hong Kong, China	Different types of land use variables in terms of relevant units
Hensher and King	2001	Nested logit model	Sydney, Australia	Egress time, parking price, line-haul time, in-vehicle time, personal income, etc
Lau et al.	2005	Unit graph technique	Hong Kong, China	Search time, walk time, parking fee, in addition to different land use variables
Hollander et al.	2006	Game theory (logit model)		Parking facility variables and choice behaviour of travellers
Chakrabarti and Mazumder	2010	Linear regression	Kolkata, India	Age, income, distance travelled, time index, search and walk time
Bai et al.	2011	Principal component analysis (quantitative analysis)	Jinzhou, China	Land use of planning area, vehicle population, population and post number

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Wu and Fan	2011	Gray correlation analysis	Shanghai, China	Nature of land use, traveller behavior and parking characteristics, parking generation rate, employment and area of building
Hilvert et al.	2012	Discrete choice	Tel-Aviv, Israel	Price per hour, search time, waiting time, walk time, duration
Cheng et al.	2012	Linear regression analysis	Tianjin, China	Parking generation rate, average turnover rate, utilization rate, parking price impact coefficient, LOS, growth coefficient of motor vehicles
Aderamo and Salau	2013	Linear regression analysis	Ilorin, Nigeria	Ward population, number of vehicles parked, vehicle ownership
Yao and Zhang	2013	Random utility theory	Daoli, China	Snow and ice factor, traffic volume, travel choice probability for car, standard car berth conversion rate
Tong et al.	2013	Unitgraph technique (network equilibrium approach)	Hong Kong, China	Search time, walking distance, parking fee, in addition to different land use variables
Lee	2014	Multiple regression model	Dong-gu, Korea	Factors of detached housing and its area, neighborhood convenience
Sen et al.	2016	Linear regression analysis	Kolkata, India	Vehicle ownership, parking duration, mode choice (car and transit)
Ghuzlan et al.	2016	Regression analysis	Amman, Irbid, and Zarqa, Jordan	Building age, No. of floors and apartments, floor area, income, price of apartment, car ownership
Das et al.	2016	Multiple regression and AHP	Kolkata, India	Parking generation rate, average turnover rate, utilization rate, parking price impact coefficient, LOS, growth coefficient of

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				motor vehicles, cost factor, choice of car over transit
Lim et al.	2017	Four-stage modeling approach	Knoxville, USA	Generalized cost, walking distance, volume/capacity ratio
Fiez et al.	2018	Gaussian mixture model Seattle,	USA	Parking fees, occupancy, seasonality, land use
Ajeng and Gim	2018	Linear regression model	Yogyakarta City, Indonesia	Parking volume, street length, land use, type of street

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3. METERIAL AND METHODS

3.1. Description of Study Area

The urban population of Ethiopia is concentrated in few urban centers, predominantly. Addis Ababa, the Capital city of Ethiopia is the country's largest, political and economic center, having area of 540 sq. km. It located in the horn of Africa with geographical coordinates of 9º 1' 48" and 38º 44' 24" North East and with an average elevation of 2355m above sea level (Seada and Emer, 2019). The city is the seat of government, Center for education, industry and services and nearly 40% of the country's GDP have generated from this region, and it is among the fastest growing cities in the World. The city's trunk road network has discharged form five major roads radiating out of the Central Business District (CBD) into the outskirts. Those exit roads are Ambo, Jimma, Gojam, Debrebrehan and Debrezeyt road. This includes trunk roads, which links Ethiopian with neighboring countries like Djibouti, Eretria, Sudan and Kenya (Yetnayet, 2012).

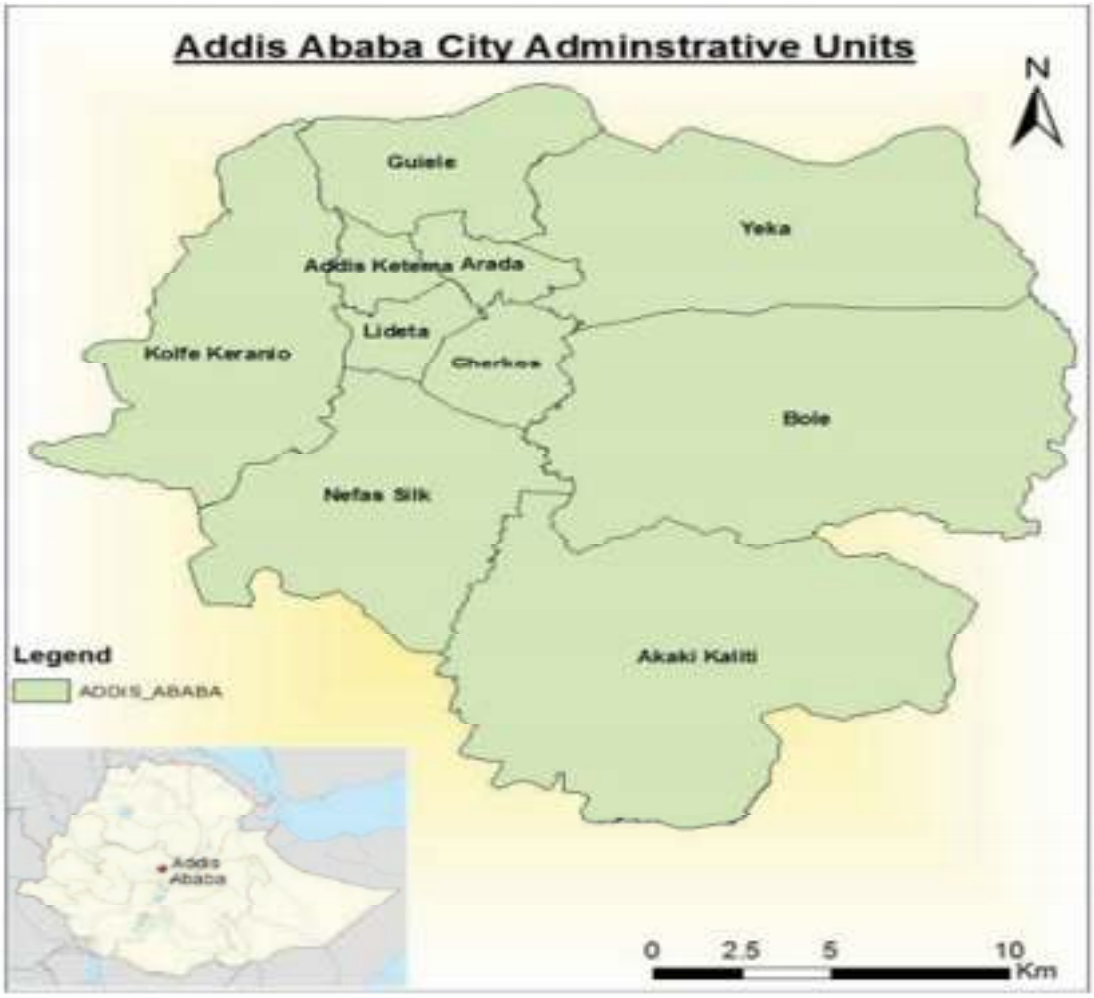

Figure 3.1: Addis Ababa City's Administrative Map. Source: (Addis Ababa City Municipality, 2017)

3.2. Study Period

The study conducted mainly on 2020 starting from February to April. Under these periods, 45 days have consumed for data collection purpose.

3.3. Research Design

The study started from selection of representative study areas in the city. This were done by observing a field conditions viewed under researcher's exploratory survey on the truck traffic domination at the existing traffic flow; observed heavy vehicle parking

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condition and on the distribution of fright commuters in the area. For instance, there was 56 % share of truck traffic along study section around Akaki Kality. This was 1%; 7%; 9%; 10%, and 13% higher than A.A to Debrebrhan; A.A to Alemgena; A.A to Ghion; A.A to Ambo and A.A to Comando roads respectively.

Through the process quantitative data that accessed through direct observation or survey, statistical analysis on data extracted from data sources are used. The figure below shows the process followed during the study of this research diagrammatically:

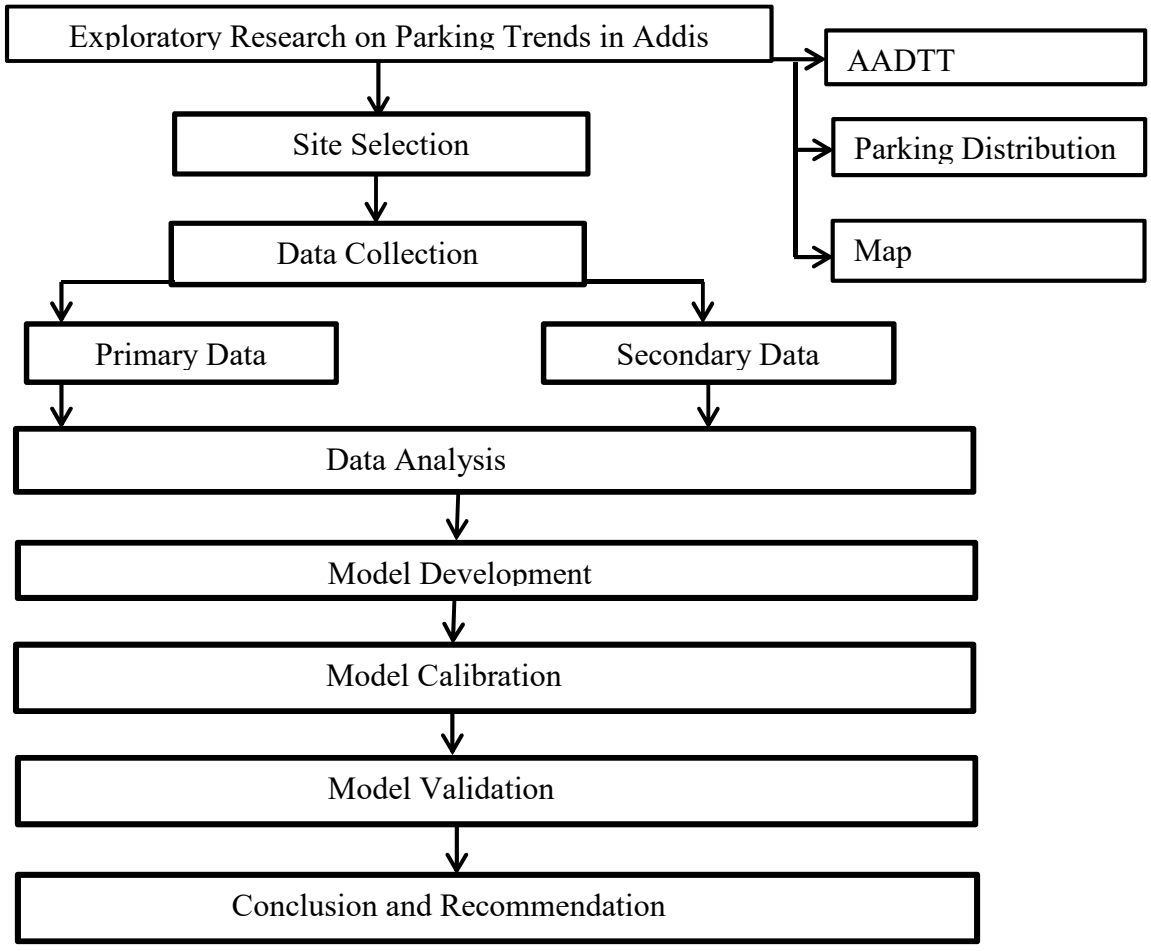

Figure 3.2: Schematics of the Research Flow

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3.4. Population

This study have done on selected 12 off street parking facilities located at the study area and the existing truck traffic along the road routs. The facilities selected for detail analysis based on their surroundings high truck traffic and higher truck parking conditions. 7 parking areas around Gelan Condominium and 5 parking areas around Tulludimtu Condominium have selected. Whereas truck traffic categorized under Medium, Heavy and Track Trailers are the subject of the study. Therefor generally, the overall concern of this research is those freight trucks under traffic ban enforcement during the time and selected off street parking facilities in the study area.

3.4.1. Sample Size Determination.

When it became difficult to know the total number of study population, it makes standard deviation (δ) to be unknown. Therefor 385 samples that can statistically represent the population have used as computed by the equation below for random sampling method:

$$N = \frac{pqZ^2}{e^2} \quad \text{.....(Equation 3.1)}$$

Source: (Blueman, 2009; Othman. A., 2016)

Where

N = number of sample

z = standard normal value (it is taken 1.96 using a confidence level of 95%)

e = Error (5% acceptable error is used)

p and q = probability to be selected or not selected as a sample respectively. (50% Chance is been taken here)

`

3.4.2. Sampling Techniques and Procedure

Surveys especially during the study of truck operators operating and parking behavior; the study uses questioners; the randomly selected and collaborated truck drivers arrived at fuel stations are asked to fill the questioners prepared for data collection. Those fuel stations used as data collection station are NOC Ethiopia, Oil Libya, Total Ethiopia, Gomeju Oil Ethiopia, and TAFF Ethiopia. Additionally data have collected at Akaki custom checkpoint "Akaki Kela" found along old road and at Addis –Adama expressways. Those place where purposively selected because of their high number of truck customers and the existence of elapsed time during filling gas or during loading check. During filed traffic data collection, samples have taken according to Federal Highway Administration Traffic Data Collection and Computation guidelines. The following section describes how each traffic surveys conducted.

a. **Number of Truck traffic (Truck Traffic volume)**: To conduct classified traffic count on trucks under study; the number of stations which represents the area's traffic condition with respect to traffic streams were should be known. The required number of those stations can be calculated using equation 3.2. Which is the found 7 but because of total blockage of 1 link due to construction the traffic count was done on only 6 stations.

$$n = \frac{t^2\frac{\alpha}{2},N-1*(\frac{s^2}{d^2})}{1+\left(\frac{1}{N}\right)*\left(t^2\frac{\alpha}{2},N-1\right)*(\frac{s^2}{d^2})} \quad \text{..... (Equation 3.2)}$$

Source (Garber, et al., 2004).

`

Where;

n = Minimum number of count locations required

N= Total number of links (population) from which a sample is to be selected

t = Value of the student's t distribution with (1 - α /2) confidence level (N - 1 degrees of freedom)

α = Significance level

v =Degree of freedom

s = Estimate of the spatial standard deviation of the link volume

d = Allowable range of error

Volume study at each stated stations done on month of March 2020 on Tuesday, Wednesday, Thursday, Saturday and Sunday in the following 2 manners.

1. Data collected at weekends

This data have collected at Saturday and Sunday; which is traffic ban exempted days, this means the normal traffic flow trends is existed. so that traffic count have been conducted at known pick hours with the help of recorded video and traffic count tally sheets starting from 8:00 am to 10: 00 am on the morning and 4:00 pm to 6:00 pm at the afternoon. The maximum values among 4 intervals of 15 min. in each 1 hour have taken as a candidate for selected randomly for regression model development.

2. Data collected at weekdays.

Data collection conducted beginning from 11:00 am to 3:00 pm. This is because of the shifting of pick hour of truck traffic due to city daytime truck traffic ban. Under this category the data collection done only by tally sheets and mobile phone stopwatch. The sample candidates have selected according to the way described earlier.

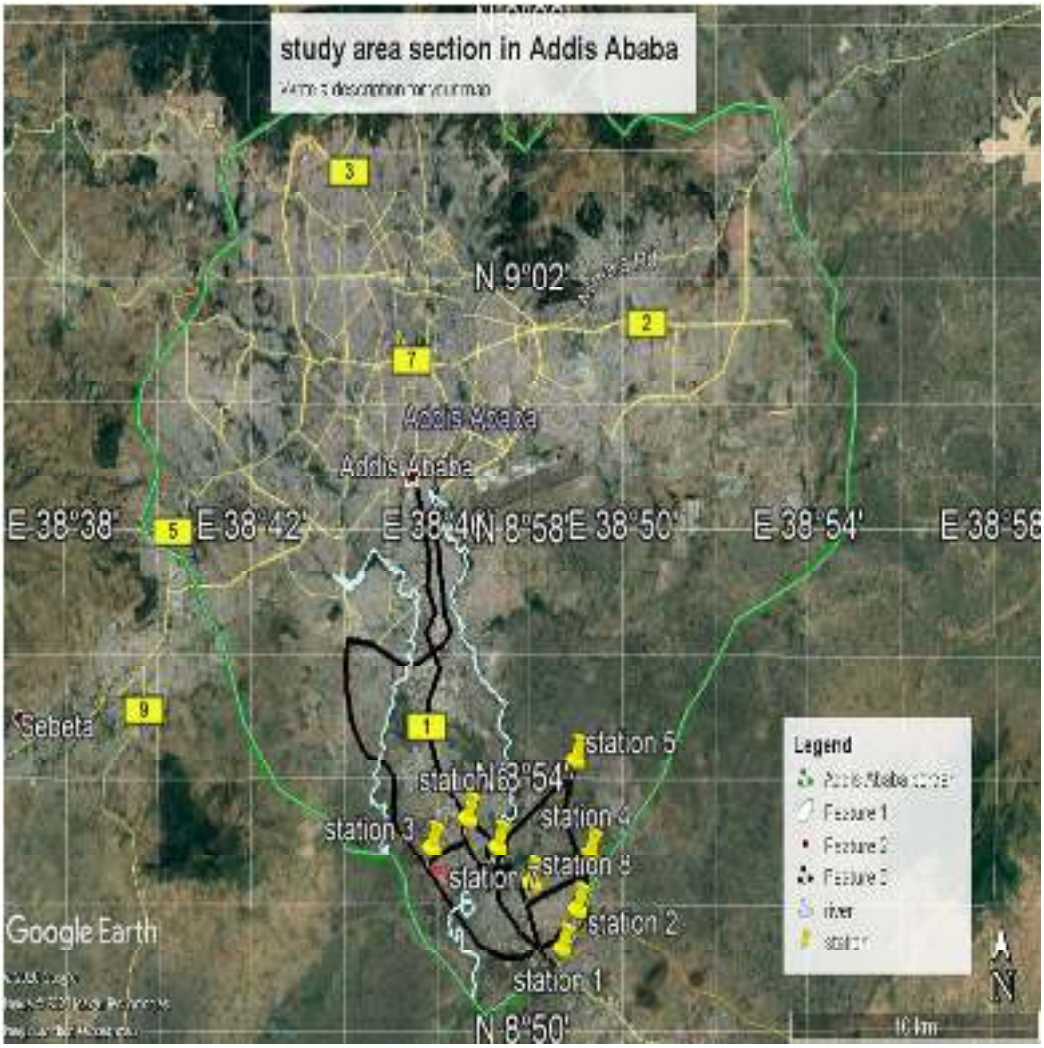

Figure 3.3: Location of Stations for Truck Volume Study

(Source: Google Earth; March 2020)

Table 3.1 summarizes the truck traffic count conducted on March 2020 at 6 stations. In addition, how it converted to other month's (February and April) truck volume data using seasonal factors. Table 3.1 show the data collection stations and table 3.2 provides counted data on truck traffic volume counted data summery at each station respectively.

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Table 3.1: Data Collection Stations.

stations	Location
Station 1	Around Akaki Michel church
Station 2	Tuludimtu pedestrian crossing around UNSAA
Station 3	Gelan pedestrian crossing
Station 4	Tuludimtu Roundabout
Station 5	Alem Bank
Station 6	Selam Building
Station 7	Akaki Korkoro (closed due to construction)

Table 3.2: Track Traffic Count Data at March 2020.

Day	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Tuesday	304	400	396	388	464	456
	332	436	456	480	448	480
	352	516	520	396	372	396
	372	496	396	512	380	512
Wednesday	292	460	512	456	436	456
	276	500	452	480	364	480
	276	480	520	396	308	456
	320	508	548	512	328	480
Thursday	328	460	500	456	388	396
	364	400	492	480	476	512
	368	340	416	396	396	456

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	336	468	508	512	512	480
Saturday	324	456	456	456	440	396
	316	432	420	480	480	512
	316	428	392	396	396	456
	308	516	476	512	512	480
Sunday	380	468	312	456	456	396
	316	476	360	480	480	512
	396	400	304	396	388	456
	340	464	300	512	320	480

In order to find the traffic data for the month April 2020 the seasonal factor stated on the table 3.3 have used. The seasonal factor value was found to be 0.91 so that each value in table 3.2 are multiplied by 0.91 and give the expected truck traffic at April 2020. Similarly for 2020's February volume data can be found by multiplying the collected data at March by 0.90 which is found by dividing seasonal factors for March (0.91) by February's factor (1.01). The computed result for the remaining two month is been found at the appendix IV.

Then as stated by Green (1991) minimum sample for multiple regression model having 3 predictor is computed using equation 3.3 and the researcher used 80 randomly selected samples from counted data at March and computed data form February and April at station 1, station 2, station 3 and station 6 for model development.

$$N \geq 50 + 8P \quad \text{……..(Equation 3.3)}$$

Source (Green. S.B, 1991).

`

Where

N is number sample used

P is number of predictor or independent variables. (In our case, p is 3).

b. Seasonal peaking factor: it used to distribute the data acquired at specific month through the year. During a research the seasonal factors used by DIMT report directly adopted. On the report, the consultant used the secondary data collected from various sources like Ethiopian Roads Authority (ERA), Ethiopian Fuel Trade Enterprise (EFTE) and Fuel companies like NOC & Oil Libya.

Monthly data was collect from the above sources, which mentioned below.

1) Last two years truck traffic data from ERA for all the Load check stations located surrounding the periphery of Addis Ababa city
2) Last three years fuel sales data from EFTE for the Addis Ababa city
3) Last three years fuel sales data from Fuel companies of NOC & Oil Libya for the Addis Ababa city

Table 3.3: Monthly Seasonal Factors from different sources.

Month	ERA	NOC	Oil Libya	Average
Jan	1.01	1.07	0.96	1.01
Feb	0.99	1.06	0.97	1.01
Mar	0.89	0.95	0.88	0.91
Apr	1.04	1.03	0.93	1.00
May	0.95	1.00	0.94	0.96
Jun	0.93	1.00	0.91	0.95

Jul	1.11	0.98	1.11	1.07
Aug	1.05	1.02	1.17	1.08
Sep	1.22	1.04	1.25	1.17
Oct	1.25	1.15	1.03	1.14
Nov	0.94	0.95	1.05	0.98
Dec	0.9	0.91	0.9	0.90

The seasonal factors for February, March and April are been used in the research in order to transcribe the traffic counted data at the March to the other months.

c. **Truck parking and operating time**: extracted from questioners on the survey of 385 drivers. The data collected by distributing the questioners for truck drivers at fuel stations and Ethiopian Revenue and Customs Commission checkpoints located in the study area. Than the 80 data used for the model have selected randomly and the result gives the average operating hours of the vehicle as well as the time spent parked extracted.
d. **Average distance recently traveled**: extracted from questioner on the survey of 385 drivers. Than the 80 data used for the model selected randomly and the result gives, the average distance traveled recently.
e. **Parking in-out survey data:** This activity where done on first fifteen days of the three months of 2020 namely February, March and April by dividing the study area in to two zones having their respective number of parking areas. The figure below shows the pictorial description of those zones.

a. Zone One

b. Zone Two

Figure 3.4: Parking Areas Located in Akaki Kality (a. Zone One; b. Zone two)

(Source: Google Earth; March 2020).

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The in-out survey data collections have started from 8:00 am up to 6:00 pm at the interval of 3 hours. At the start of each interval, the initial numbers of trucks founded in the parking areas have counted. Then the vehicle leaving and entering the facility will tallied on the sheets by the data collectors assigned at each parking facilities.

3.5. General Division of the Study Sections.

The variables needed for the analysis of the data in this study area are:

- Variable related to the parking facility
    - Parking Area Capacity
    - Parking Accumulation
    - Parking Volume etc…
- Variable related to Truck Traffic characters
    - Truck traffic volume

The parking generation is been believed to vary with time of the day, day of the week and depends on at least one or a few significant parameters. One of the factors influencing the parking demand is the prevailing vehicular volume on the major road (MHA, 2008). Therefore, this study conducted to determine the effect of vehicular volume on major road on parking demand at Rest Area.

- Variable related to truck operators
    - Average Time of resting and operating
    - Average distance traveled

`

3.6. Software and instruments

The data processing and analyzing have done by using Microsoft Excel 10. Since our predictors are 3, the Excel 10 can analyze the regression without any limitations and provides the graphical analyses results, tables and multivariate regression results.

As stated earlier GPS; mobile phone camera and stopwatch, papers and tapes are used additionally.

3.7. Data Sources

This study involves extensive data collection. The data collection includes the primary surveys in the field and at the secondary data collection from various sources. This chapter presents the details of methodology adopted including the figure 3.5 presenting the data sources along with methodology presented in the research.

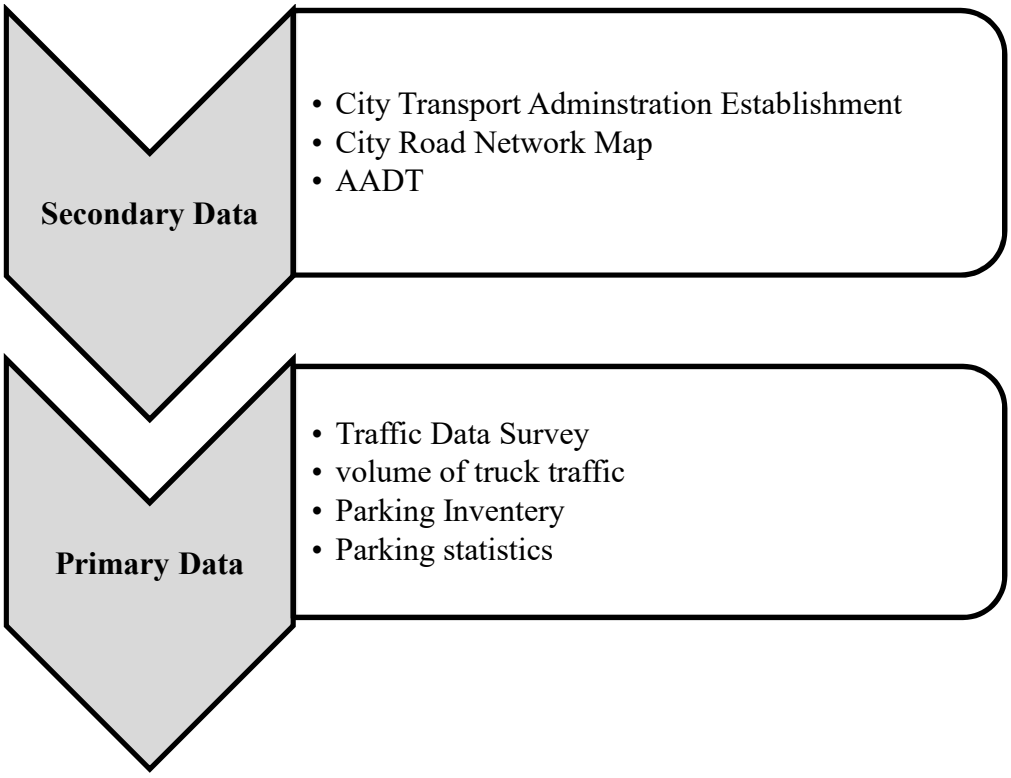

Figure 3.5: Data Type with Respective Sources.

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3.7.1. Primary Data

This is a data collected by the researcher first-hand using different data collection mechanisms. The researcher-surveyed locations mostly used by the freight commuters including their location using global coordinates. Throughout the process, data from traffic survey like volume of truck traffic, The ratio of trucks staying to truck leaving the study area, Parking inventory as well as parking accumulation collected by using instruments like video camera, hand GPS, paper and pencil. Additionally there where a questioners (open ended and closed ended) used to get truck transportation commuters behaviors to represent in model parameters. The List of Primary surveys conducted with their main objectives and outcomes have listed in the table below.

Table 3.4: List of Primary Data Sources with Their Respective Purpose.

Primary Data Sources	**Data purpose**
Freight parking inventory	For identifying the location and condition of existing parking facilities; In out Parking survey (included on Specific objectives in the paper).
Traffic survey	For computing the representative study area Percentage of truck out of total operating Traffic Volume on the roads in the selected cordon area.
Truck operator survey	Understanding the parking characteristics, and Average time the truck remained parked.

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3.7.2. Secondary Data

All the necessary documents where gathered from different public organizations such as; Ethiopian shipping and logistics service enterprise (ESLSE), Ethiopian Road Authority (ERA), Addis Ababa Traffic Management Office (AATMO), Addis Ababa City Road Authority (AACRA). Moreover, related documents from previous researches, local news reports and papers served as source.

Table 3.5: List and Purpose of Secondary Data Sources.

Secondary Data Sources	Data purpose
Freight Transporting Agencies	Available Trucks service property, parking property and truck service
Addis Ababa City Administration Office	City map, trucks and trailers to get seasonal peaking Patterns
ERA; AACRA and Addis Ababa Traffic Authority	City road map, AADT
Traffic Management Office; Addis Ababa Traffic Authority and Civil Service Office	Previous researches on freight transportation.

3.8. Data Processing and Analysis

In order to show some highlights on how each seated objectives are attend on the process of conducted study; the section bellow describe the strategies as follow.

3.8.1. Methodology Used For Respective Objectives.

On achieving the objectives of the study, various methodologies are used. This section covers the method used upon meeting each objective one by one.

`

3.8.1.1. Truck Parking Inventory Survey.

Up on attaining this objective, descriptive researches have used. City parking locations mainly used by freight transporting trucks surveyed and the locations have showed on the map of focused highway section of a city.

The inventories have done by the following steps. After selecting the study routes at the study areas through pre-exploratory research, data collection on existing infrastructures along the selected sub cities commercial routes have collected through inventory forms. This overviewed through traveling to all studied parking sections to observe payment rating; parking capacity; parking pavement condition of facility they contend personally by taking photo. Therefore, the inventories on 12 parking areas have done on the facilities one by one using the above process together with the use of inventory forms indicated on appendix II.

3.8.1.2. Methodology Used For Parking Area Arithmetical Survey

For understanding the arithmetical data trend in the city, the parking Accumulation; parking index or Parking occupancy and parking load have calculated based on In-Out parking survey conducted on the 15-days of February; March and April months of 2020. The survey classified in to an interval of 3 hours. The data collection sheet/ forms used through each data collection periods filled by assigned data collector at each place. Typical data collection sheet is can be shown on appendix V.

3.8.1.3. Methodology Used for Modeling the Parking Demand

The linear regression model is multivariate linear regression model having 3 independent variables developed by the steps stated below.

`

Step 1: Identify Trucking Corridors and Select Analysis Areas and Segments.

Here in this step, the exploratory research are conducted and the common commercial route of the city that trucks used to travel and parking along the sections are determined to be used as inputs data sources for modeling. Based on their condition and GIS location data of areas are been collected.

Step 2: Studying Truck Parking Facilities

Adopting inventory forms, direct observation and parking area survey the truck-parking trend on selected parking facilities are studied. Than the amount of truck parked on those locations and other parking statistical survey data such as parking accumulation, parking occupancy and parking load obtained.

Step 3: Identify Truck Traffic Conditions and Truck Drivers Operating Behaviors.

Under this step the truck traffic volume, the average time of operation and rest time along with the average distance traveled recently will gathered through the distributed 385 questioners for freight personals who was randomly selected during the survey and resulted handled in the way they used in the model development..

Step 4: Apply Truck Parking Demand Model.

Data gathered at each previous step classified as dependent and independent variables and after statistical manipulation of data to find the relation and correlation between them; regression model for parking demand will developed.

After data collection process ended, the final step composes statistical tests on independent variables. This process started by checking correlation among the independent variables in order to protect multicollinearity effect on the regression model. Using Microsoft excel analysis result the correlation between our 3-predictor

`

variables can be decided as week or strong by observing the analysis output value relative to 0 and 1 in the interval -1 to 1. If the correlation coefficient is around 1 or -1 the correlation of the variable said respectively being strong positively or negatively. The value lay in this category have effects on the regression model whereas the coefficient that comes around 0 shows the weak correlation among the variables and have no multicollinearity effect on the proposed regression model. Than after running the multi linear regression analysis, the overall goodness-of-fit measures to understand how well our linear regression model presents the real data is checked.

Finally interpretation of regression coefficients with respective standard errors; t Stat and P-value for intercept and predictors are achieved.

In the data analysis result, let β_j denote the population coefficient of the j th predictor (Volume of Truck, Length of Trip and Time Spent Parked).

- Column "Coefficient" gives the least squares estimates of βj.
- Column "**Standard Error**" gives the standard errors (i.e. the estimated standard deviation) of the least squares estimates b_j of β_j.
- Column "**t Stat**" gives the computed t-statistic for H0: $\beta_j = 0$ against Ha: $\beta_j \neq 0$. This is the coefficient divided by the standard error. It is compared to a t with (n-k) degrees of freedom where n = 80 and k = 3.
- Column "**P-value**" gives the p-value for test of H0: $\beta_j = 0$ against Ha: $\beta_j \neq 0$. This equals the Pr{|t| > t-Stat} where t is a t-distributed random variable with n-k degrees of freedom and t-Stat is the computed value of the t-statistic given in the previous column. Note that this p-value is for a two-sided test. For a one-sided test divide this p-value by 2 (also checking the sign of the t-Stat).

`

- Columns "Lower 95%" and "Upper 95%" values define a 95% confidence interval for β_j.

3.9.2. Parking Demand Model Development

3.9.2.1. General Concept

The model is useful for indicating the trends and projecting the situation in future by correlating the existing parking demand with different influencing variables in mathematical equations. The concept of multiple linear regression model where describe how a single response variable Y depends linearly on a number of predictor variables (X1, X2,…XK) and a multiple linear regression model with K predictor variables X1, X2,…XK and a responses Y, can be written as.

$$Y = \beta + \beta1*X1 + \beta2*X2 + \ldots + \beta k*Xk + \varepsilon \quad \text{(Equation 3.4)}$$

Source (Cameron, 2020)

Table 3.6: Description of Each Symbol.

Dependent variable	Independent variable
Peak Truck Parking Demand (Pd)	X1: Volume of Truck Traffic
ß0 to ß3 are coefficient	X2: Average Distance Traveled on recent 3 trips
£ is standard error	X3: Truck's Average Time Spent on Parking

In this research, our dependent variable parking accumulations have described by the independent variables Volume of Truck Traffic; Length of Trip Traveled Recently; and Time Spent Parked.

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4. RESULTS AND DISCUSSIONS

4.1. Parking Inventory Survey Analysis.

The existing parking condition including their location through geographical coordinates, type of pavement the facilities have, the services provided other than parking, lighting and condition of fencing have investigated and the tabular summary have provided in the section below.

The exploration gave that all the facilities found in the study area section have no utilities like toilet and water tap.

The additional service given at the parking areas were tire maintenance and routine garage services like oil changing and tire change. All the studied parking areas collect fees such as 60 Birr from truck trailer and 30 Birr from medium and heavy trucks for 24-hour stay. The trucks stayed less than 24-hour are not mandated to pay seated parking price but they just gave tips for the parking facility operators.

4.1.1. Parking Inventory on Zone 1.

This study zone found between the lines formed by Akaki River at the bottom and a river crossing Gelan to Seffera road (which also called Akaki River) at the top. Graphical illustrations of this zone have shown on previous chapter as figure 3.5. The zone includes Gelan Condominium; Kality Industrial Area; Administration office of Akaki Kality Sub City etc. under this section seven parking areas were studied and those are the main model developing data sources. In addition, photographical presentations of each parking areas have showed on appendix part of the paper.

`

. Table 4.1: General Over View of Parking Areas

Name	Geographical coordinate	General condition				
		Area (m2)	**Pavement**	**fencing**	**lighting**	**service**
P1	N:8º52′42.05″ E:38º45′53.02″	5100	Un-Surfaced	Fenced	Have lighting	Additional service
P2	N:8º52′38.94″ E:38º45′54.69″	5000	Un-Surfaced	Fenced	No lighting	Parking only
P3	N:8º52′31.14″ E:38º46′00.91″	4000	Concrete and Un-Surfaced	without fence	No lighting	Additional service
P4	N:8º52′36.16″ E:38º45′48.11″	1400	Un-Surfaced	Fenced	No lighting	Parking only
P5	N:8º52′32.02″ E:38º45′51.47″	4600	Un-Surfaced	without fence	No lighting	Additional service
P6	N:8º52′39.75″ E:38º45′49.44″	No permission	Un-Surfaced	without fence	No lighting	Additional service
P7	N:8º52′33.28″ E:38º46′04.17″	14500	Un-Surfaced	without fence	No lighting	Additional service

`

4.1.2. Parking Inventory on Zone 2.

This study zone founded below Akaki River up to the South East border of Akaki Kality composing Tuludimtu Condominium; Kilinto Condominium; ASTU etc. this area is used as the validating standard for multi linear model developed based on data gathered from the first zone.

Table 4.2: General Summery of Inventory on Parking Areas.

Name	Geographical coordinate	General condition				
		Area (m²)	Pavement	fencing	lighting	service
P8	N:8º52′42.05″ E:38º45′53.02″	9200	Un- Surfaced	Fenced	No lighting	Additional service
P9	N:8º52′38.94″ E:38º45′54.69″	4900	Un- Surfaced	Fenced	No lighting	Parking only
P10	N:8º52′39.75″ E:38º45′49.44″	3900	Un- Surfaced	Fenced	No lighting	Parking only
P11	N:8º52′36.16″ E:38º45′48.11″	9900	Un- Surfaced	Fenced	No lighting	Parking only
P12	N:8º52′32.02″ E:38º45′51.47″	2900	Un- Surfaced	No fence	No lighting	Additional service

`

4.2. Parking Area Arithmetical Survey Results

The table below summarizes the survey data of zone one found through data gathered at first 15 days of the 3 months and the steps in finding the calculated value is presented below followed by a sample calculation. The total parking capacities of studied parking areas found to be 198 trucks. Remaining data been presented in the appendix.

Table 4.3: Zone One Parking Survey Data

Month	Day	Time Interval	Initial No. Of Parked Vehicles (X_0)	No. Of Truck Entering (in)	No. Of Truck leaving (out)	Accumulation	Occupancy	Parking load
February	1	8:00am-11:00am	156	36	27	165	83.33%	495
		11:00 am-2:00pm		31	47	149	75.25%	447
		2:00pm-5:00 pm		29	23	155	78.28%	465
		5:00 pm -8:00 pm		37	34	158	79.80%	474
	2	8:00am-11:00 am	127	63	45	145	73.23%	435
		11:00 am-2:00pm		56	40	165	83.33%	495
		2:00pm-5:00 pm		48	32	181	91.41%	543
		5:00 pm -8:00 pm		41	69	153	77.27%	459

`

Sample Calculation for February 1 / 2020 data collected starting from 8:00am -11:00am

A. Parking accumulation

The parking accumulations for first day of February was calculated as discussed earlier; the accumulation is the sum of initial number of vehicle in the parking area and trucks arrived in to the parking areas deducted by the number of trucks depart from the parking facility in seated common time interval. The researcher used 3-hour interval in order to correlate the parking data with the road's peak hour volume and to couple with traffic ban period.

$$\text{Parking accumulation} = X_0 + IN - OUT \quad \text{.....(Equation 4.1)}$$

Where

X_0: sum of Initial number of vehicle in the parking's in zone

IN: total number of trucks arrived to parking's in zone in 3-hour interval

OUT: Total numbers of trucks depart from to parking's in zone in 3-hour interval

For instance, during the first day first interval of hours at 7 parking zones, the truck arrived and departed in time was 36 and 27 respectively and there were 156 vehicles initially. Then parking accumulation calculated according to the calculation below:

$$\text{Parking accumulation} = X_0 + IN - OUT$$

$$= 156 + 36 - 27$$

$$= 165 \text{ vehicles}$$

The accumulation curves on February have shown as follows.

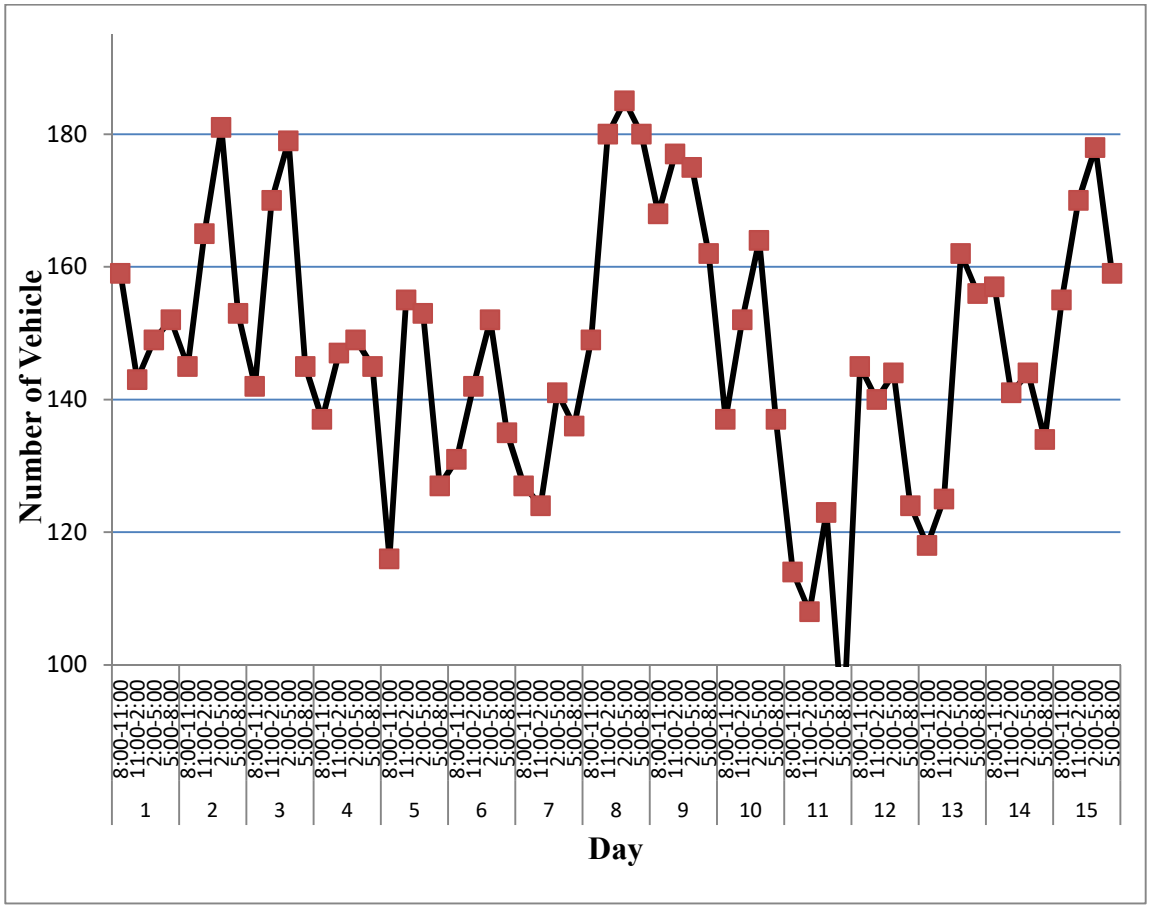

Figure 4.1: Accumulation Curve on February 2020.

Figure 4.1 indicates the trends of parking accumulation of trucks accommodated the parking areas in average at the interval of 3 hours on each 15- day. Ware as figure 4.2 and figure 4.3 shows the time interval which maximum average parking accumulation of 178 trucks observed; which happened between 2:00 pm and 5:00 pm. Moreover, Sunday was the day that the maximum average parking accumulation of 166 trucks appeared. This can generalized as a cause effect of the traffic ban exemption on

weekends. This means the truck operators prefer resting on Sunday with or without traffic ban enforcement.

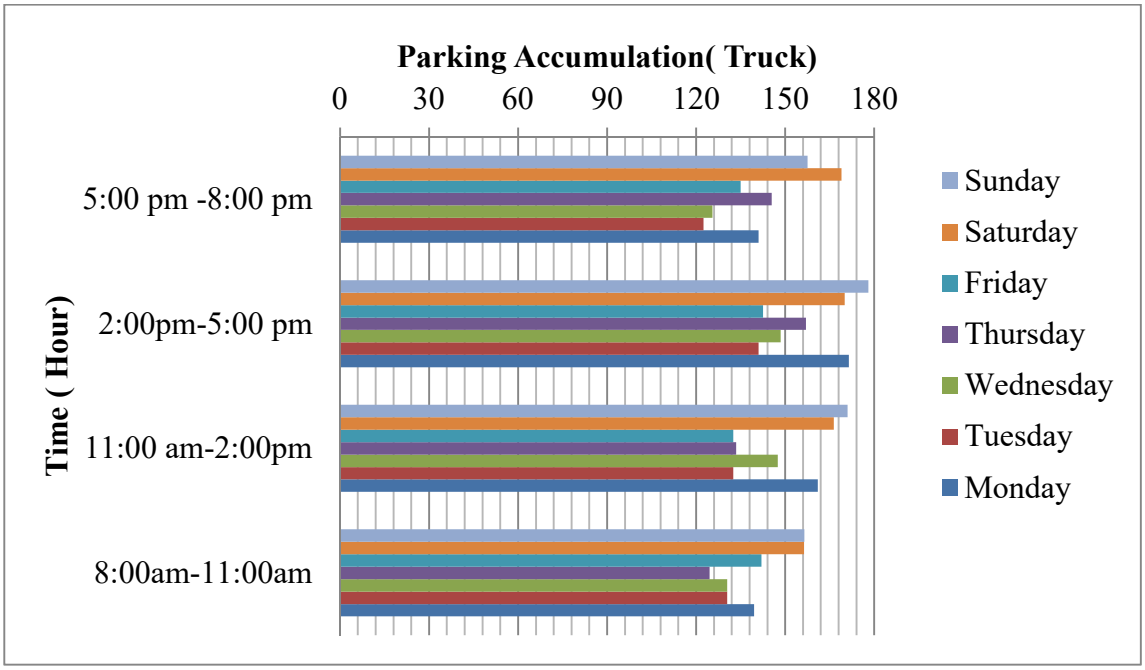

Figure 4.2: Bar Chart Showing Average Parking Accumulation on Time Interval vs. Week Days of February 2020.

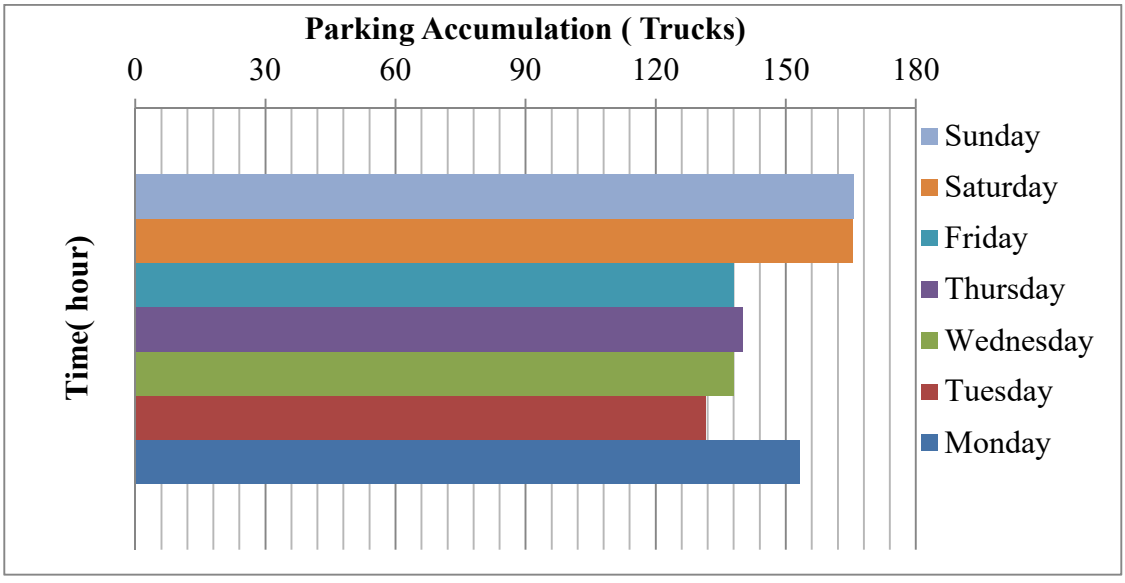

Figure 4.3: Average Accumulation vs. Days of Week on February 2020.

The accumulation curve on March also shown as follows

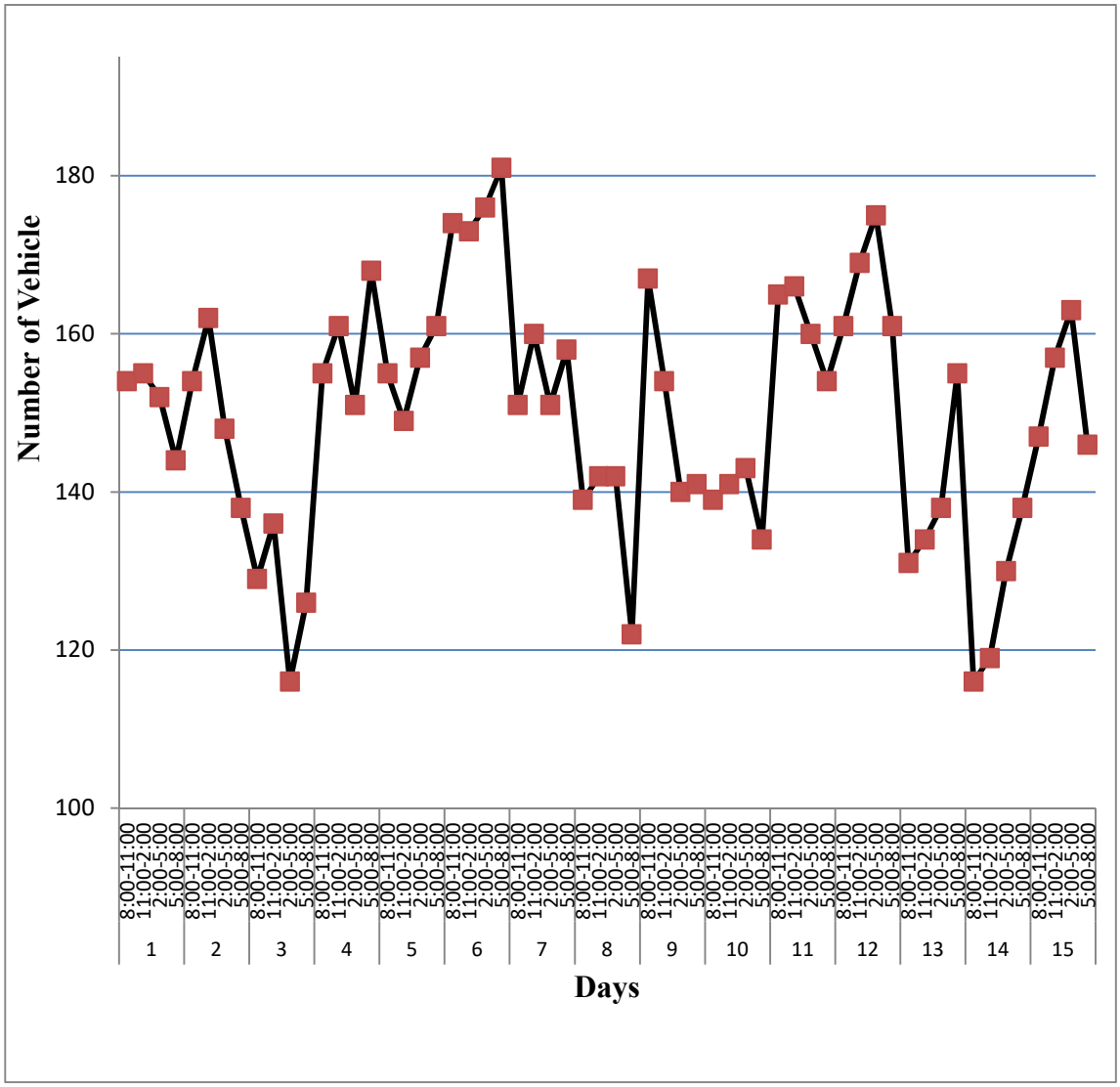

Figure 4.4: Accumulation Curve on March 2020.

The figure 4.4 indicates the trends on how many trucks accommodate the parking area in the study time interval. The maximum and minimum point on the curve was 181 and 116 trucks respectively.

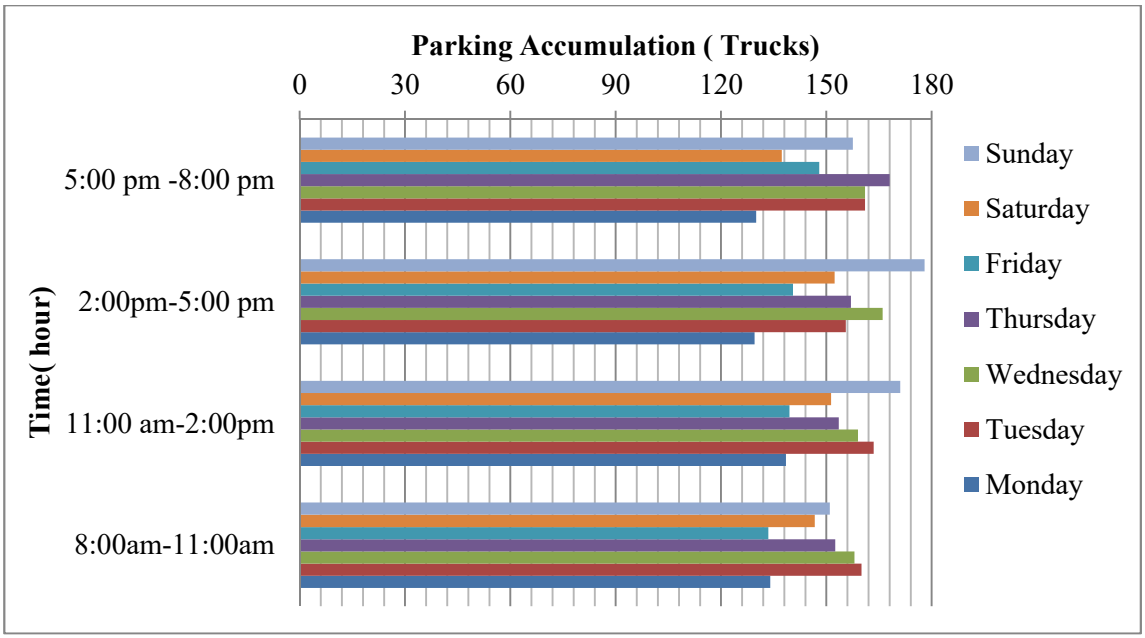

Figure 4.5: Bar Chart Showing Average Parking Accumulation on Time Interval vs. Week Days of March 2020.

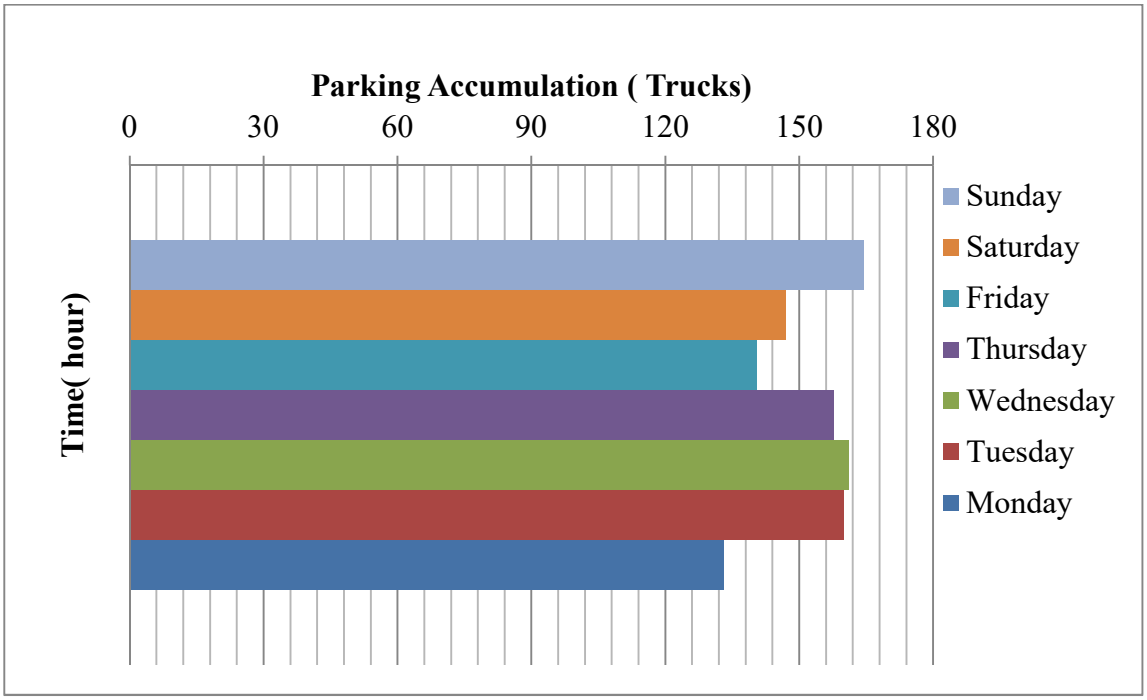

Figure 4.6: Average Accumulation vs. Days of Week on March 2020.

Although the maximum average parking accumulation observed was during 2:00 pm and 5:00 pm with the value of 178 trucks. In month of March, the relative difference between days of the week such as Tuesday; Wednesday; Thursday and Sunday became smaller. This was because of the truck ban exemption on those two days. This means the truck operators prefer resting on Sunday with or without traffic ban enforcement.

On the other hand, the ban was released due to the COVID 19 pandemic so the accumulation tendencies shown as higher at the early time of the day and lowering after 12: 00 pm as shown on figure 4.5 and figure 4.6.

The accumulation curve for gathered on April also shown as follows.

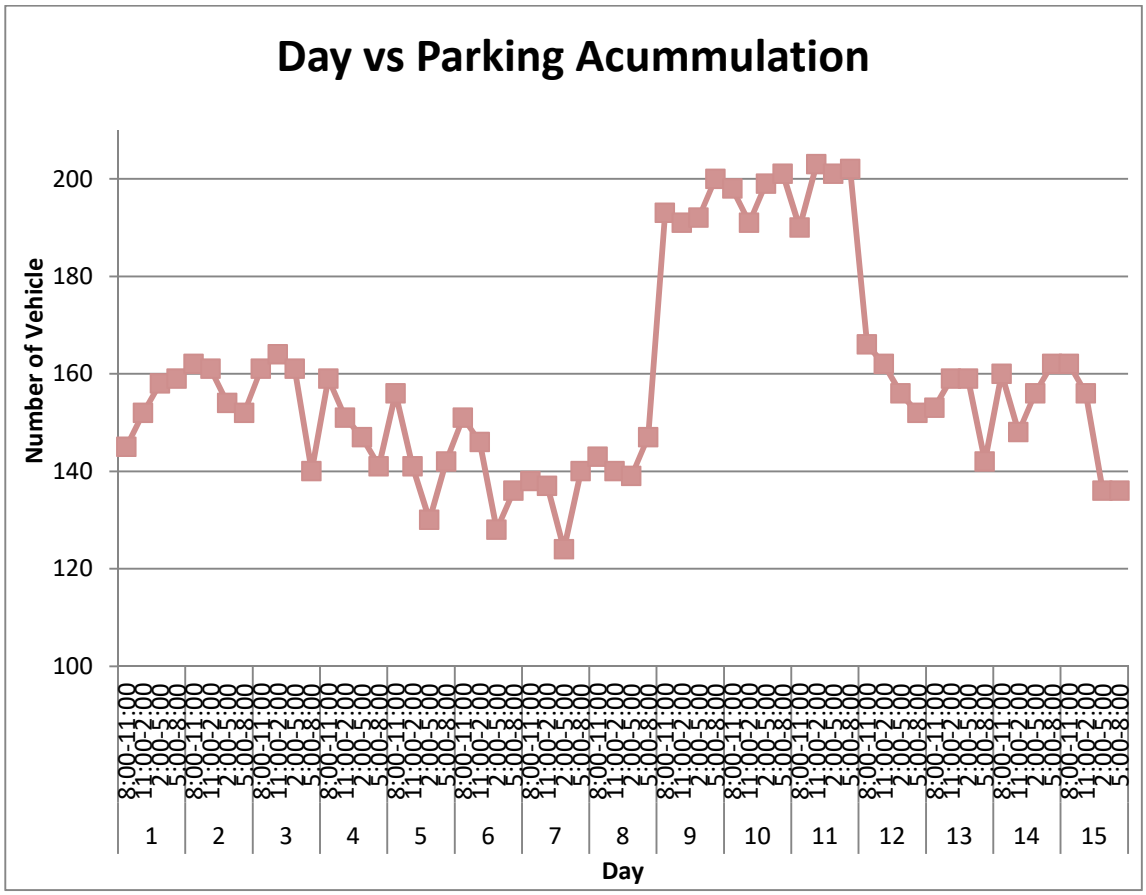

Figure 4.7: Accumulation Curve on April 2020

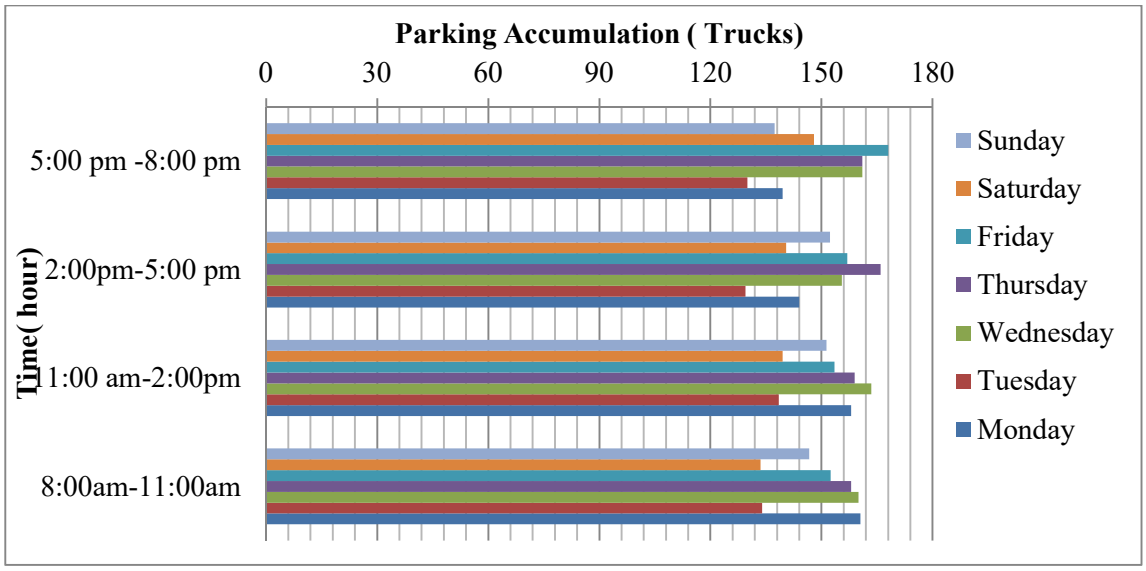

Figure 4.8: Bar Chart Showing Average Parking Accumulation on Time Interval vs. Week Days of April 2020.

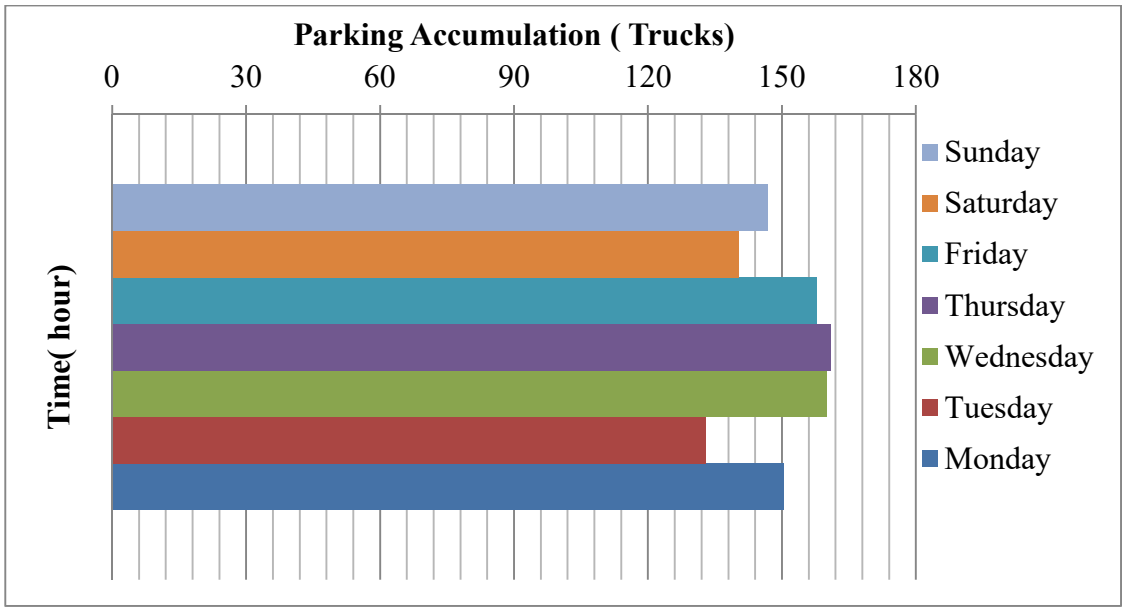

Figure 4.9: Average Accumulation vs. Days of Week on April 2020.

On this month, the traffic ban ware partially exempted and the relative numbers of trucks using the facility are lower than the two months weekdays. As shown in the

figure 4.7 the maximum average parking accumulation happened between time intervals of 5: 00 pm to 8: 00 pm on the other hand as shown on figure 4.8 and 4.9 the relative average accumulation gaps between weekend and weekdays became smaller, this indicates the change in trends of working and resting behavior of truck operators. Moreover, as expected the parking accumulations on the two holydays in this month where shown higher than other days.

B. Occupancy or Parking index

$$\text{Occupancy or Parking index} = \frac{\text{Parking load}}{\text{Parking volume}} * 100 \quad \ldots\ldots\ldots\ldots \text{(Equation 4.2)}$$

Where the total number of bays in the first zone is 198 and using the calculated result of parking accumulation; the occupancy can be computed as.

$$\text{Occupancy or Parking index} = \frac{\text{Parking load}}{\text{Parking volume}} * 100$$

$$= \frac{165}{198} * 100$$

$$= 83.33\%$$

To summarize the data collected during the study period the following table presents the distribution and characteristics during each interval of period as follows.

Table 4.4: Data Summary

		February	March	April	zonal Avg.	total Avg.
Parking Accumulation	zone 1	149	150	159	153	
	zone 2	80	67	63	70	111
Parking Occupancy	zone 1	73.21%	73.76%	78.25%	75.07%	
	zone 2	68.03%	59.89%	54.30%	60.74%	67.91%
Parking Load	zone 1	446	449	477	457	
	zone 2	239	201	191	210	267

`

In February, March and April there is no significant parking occupancy variation among the three months at each zone. This is because of lack of enforcements on restriction on using on- street parking in the area. So that in did the trucks are immobile at the time of the traffic ban but there is no law forcing them to park the truck on the available off street parking areas.

C. Parking load

The survey is been conducted at each parking areas under study zone by interval of three hours. So parking load where calculated as

Parking load = Parking accumulation * Interval of time

= 165 * 3

= 495 vehicle hour

The average parking load per day during the study period of February 2020 is 1783 vehicle hours.

4.3.2. Analysis Results on Independent Variables of Multi-Linear Regression Model

4.3.2.1. Results on Counted Truck Traffic Volume Data

The truck traffic volume count were conducted on March 2020 at six stations which shown on table 4.5. Moreover, the calculated results for the other two months shown on the appendix.

Table 4.5: Track Traffic Count Data at March 2020.

Day	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Tuesday	304	400	396	388	464	456
	332	436	456	480	448	480
	352	516	520	396	372	396
	372	496	396	512	380	512
Wednesday	292	460	512	456	436	456
	276	500	452	480	364	480
	276	480	520	396	308	456
	320	508	548	512	328	480
Thursday	328	460	500	456	388	396
	364	400	492	480	476	512
	368	340	416	396	396	456
	336	468	508	512	512	480
Saturday	324	456	456	456	440	396
	316	432	420	480	480	512
	316	428	392	396	396	456
	308	516	476	512	512	480
Sunday	380	468	312	456	456	396
	316	476	360	480	480	512
	396	400	304	396	388	456
	340	464	300	512	320	480

`

4.3.2.2. Results of Collected Data on Average Distance a Truck Traveled.

In the questioner it have observed that the driver which park their trucks at Addis Ababa at daily base are found traveled lower distance compared with the drivers used parking rarely. To represent this condition in the model three recently traveled trips and the average distance are used. Table 4.6 gave the summarized collected data.

Table 4.6: Average Distance Traveled by the Trucks

No.	1st	2nd	3rd	Avg. of three trips
1	814	515	73	467
2	427	359	348	378
3	896	896	896	896
4	515	381	935	610
5	98	98	98	98
6	112	82	98	97

For instance, the driver number 1 traveled from Addis Ababa to Djibouti Galafi; Addis Ababa to Diradewa and Addis Ababa to Mojo. This means it traveled 814 km, 515km and 73 km respectively. So that the average distance traveled by this truck found to be 467 km.

4.3.2.3. Results on Average Truck Time Spent Parked.

Generally, the total time spent by the truck throughout its service life can classify as time spent driven during operation and time spent during non-operating time. Trucks

used parking during operation while loading unloading and at non-operating time during maintenance and while drivers are resting. The research studied this condition through 385 questioners.

In the analysis the average times spend driving; time spend parking; time spent at routine maintenance and time spent loading unloading are extracted from the questioner survey.

Table 4.7: Time Spent Parking Sample Extracted Data.

	Operating Time (To)	Resting Time (Tr)			Maintenance Time (Tm)	Loading & Unloading Time (T l/u)	Parking Time (hr per day)		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
No.5	No.7	No. 8	No.10	Avg (3,4)	No.11	No.12	Sum (5,6)	24hr-(2)	Avg (8,9)
	hr/day	hr/day	hr/day		hr/day	(hr)			time
8.00	12.0	10.29	4.40	7.34	1.20	1.08	10.02	12.00	10.51
28.0	12.0	5.14	2.00	3.57	3.20	3.00	9.77	12.00	11.29
4.00	12.0	5.14	2.00	3.57	1.20	3.00	7.77	12.00	10.2
4.00	20.0	5.14	2.00	3.57	2.40	4.00	9.97	3.50	7.14
4.00	20.0	20.57	5.60	14.30	1.20	1.50	16.19	3.50	10.04
12.0	12.0	2.11	2.00	2.26	3.20	1.50	6.56	12.00	9.28

`

Sample calculation for shaded part:

Computation 1: Tt = To + Tp

Where

Tt : total time per day (24 hour/ day is universal truth)

To: total time the truck spent at operation/ driven

Tp: total time the truck spent at parking

Here to compute the total parking time (Tp) from a single questioner

To = 12 hour/ day (drivers answered at the questioner)

The Tp is been calculated as

Tp = Tt – To = 24-12

=12 hour/day

Computation 2: Tp = Tr + Tm + T l/u

Where

Tp: total time the truck spent at parking

Tr: total time spent resting

Tm: total time spent at periodic maintenance

T l/u: total time spent parking during loading /unloading

Tr = 7.34 hour/ day (average of drivers answered at the questioner for Q.8 and Q.10)

Tm = 1.20 hour/ day (drivers answered for Q.11 at the questioner)

Tl/u= 1.08 hour (drivers answered for Q.12 at the questioner)

Therefore T p = 7.34 + 1.20 +1.08

= 9.02 hour/ day

To be more accurate we use the average of the two calculated T p.

`

$$Tp = \frac{9.02 + 12}{2}$$

$$= 10.51 \text{ hour}$$

The average parking times (Tp) is been computed from each single questioner and the 80 randomly selected samples are used for model development. Table 4.8 summarizes the overall data used for liner regression model, which are extracted form data analysis discussed earlier.

Table 4.8: The input values used for the development of the regression model.

	Y	X1	x2	x3
	Avg. Parking Accum.	Volume of Truck	Length of Trip	Time Spent Parked
1	157	512	896	4.03
2	161	460	378	4.89
3	159	400	698	5.66
4	155	480	610	6.74
5	138	392	515	9.64
6	140	400	515	9.28
7	132	480	653	4.89
8	174	500	701	8.63
9	171	432	1036	14.24
10	148	480	427	8.88
11	109	468	823	13.74
12	138	512	952	11.37
13	140	468	263	9.89
14	144	308	515	9.64
15	166	512	822	4.03
16	151	436	697	7.00
17	151	396	680	8.49
18	127	480	683	8.39
19	159	500	686	8.29
20	156	456	689	8.18
21	176	508	691	8.08
22	155	456	694	7.98
23	136	476	697	7.88

`

24	151	480	700	7.78
25	139	464	703	7.68
26	161	480	706	7.58
27	167	396	708	7.48
28	140	396	711	7.38
29	126	388	714	7.27
30	153	480	717	7.17
31	154	320	720	7.07
32	157	500	722	6.97
33	157	480	725	6.87
34	150	512	728	6.77
35	142	448	731	6.67
36	140	492	734	6.57
37	135	320	737	6.47
38	142	436	739	6.37
39	194	432	742	6.26
40	197	456	745	6.16
41	199	396	748	6.06
42	159	456	751	5.96
43	153	480	753	5.86
44	157	380	756	5.76
45	148	456	759	5.66
46	145	456	896	4.49
47	165	480	868	13.39
48	181	396	378	11.29
49	153	480	22	12.27
50	168	456	84	11.49
51	177	432	822	11.25
52	175	428	653	15.17
53	162	516	489	14.43
54	165	456	823	10.29
55	168	420	403	10.49
56	153	392	208	6.54
57	168	476	224	8.38
58	153	168	823	4.03
59	145	244	613	14.24
60	145	244	98	13.14
61	181	236	629	11.02
62	137	420	570	10.49

63	147	480	384	8.07
64	149	396	689	13.51
65	145	512	341	9.46
66	114	436	896	7.69
67	108	516	570	10.49
68	123	496	206	9.49
69	90	460	22	13.04
70	123	456	297	5.29
71	137	520	868	9.05
72	145	396	277	7.32
73	149	512	515	9.34
74	137	436	175	10.09
75	108	136	242	9.14
76	90	232	384	4.39
77	114	228	381	9.03
78	116	456	94	11.11
79	155	480	823	14.14
80	153	396	275	14.29

To observe the relation between our predicting variables with our dependent variable the following section uses figure for each respective predictor respectively.

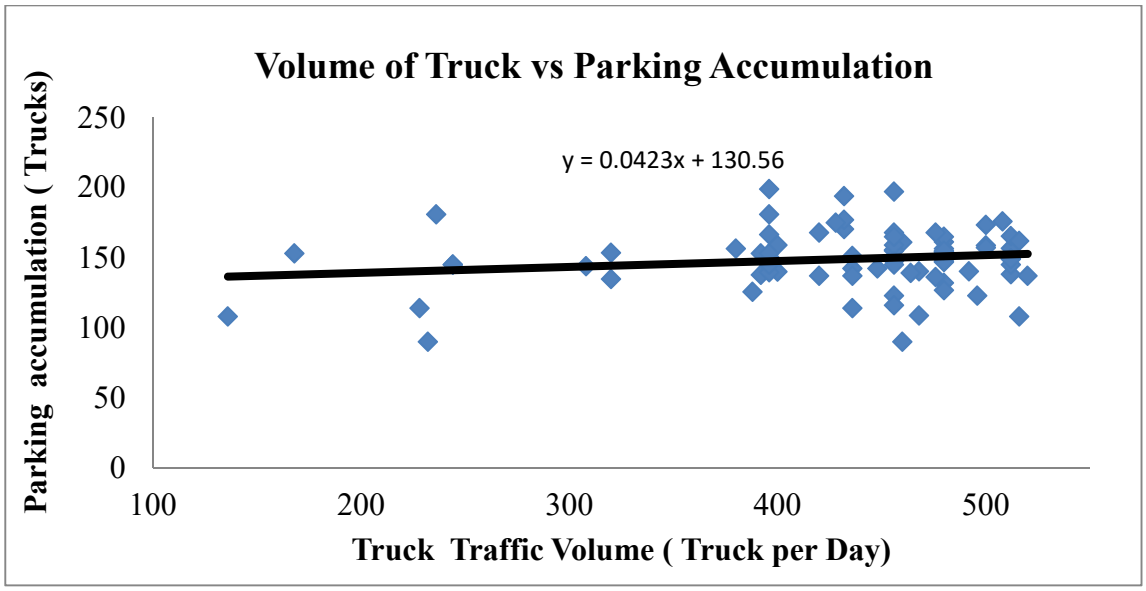

Figure 4.10: Truck Volume vs. Parking Accumulation

Figure 4.10 shows the relationship between the truck traffic volume and Average parking accumulation and it can interpret as the two variables are directly related but with small slope which indicate weak relation between the variables. This means the higher the number of trucks around the area makes the probability of trucks parked at the area higher so that the parking demand be coming higher.

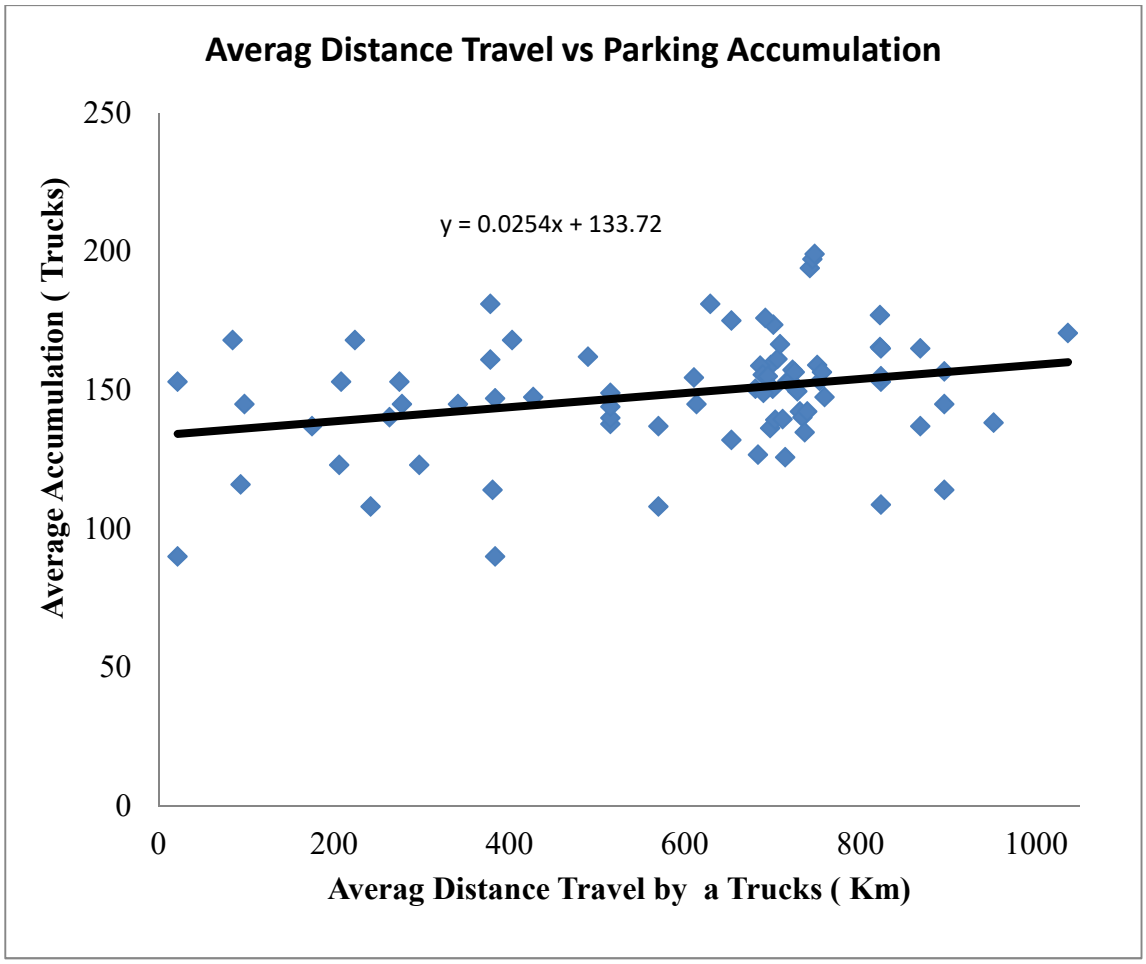

Figure 4.11: Distance Traveled Vs. Parking Accumulation

The relationship between the average distance traveled by trucks and Average parking accumulation is been shown on figure 4.11. The two variables have a direct relation; so the higher the average distance traveled by the trucks makes the parking demand higher.

The researcher was hypothesis that truck traveled far have the probability using parking at the city became lower because the frequency of using parking in the city and staying at the city became lower. However, figure 4.11 shows the indirect relation this may be reasonable when we considering the routine maintenance effects on the use of parking areas.

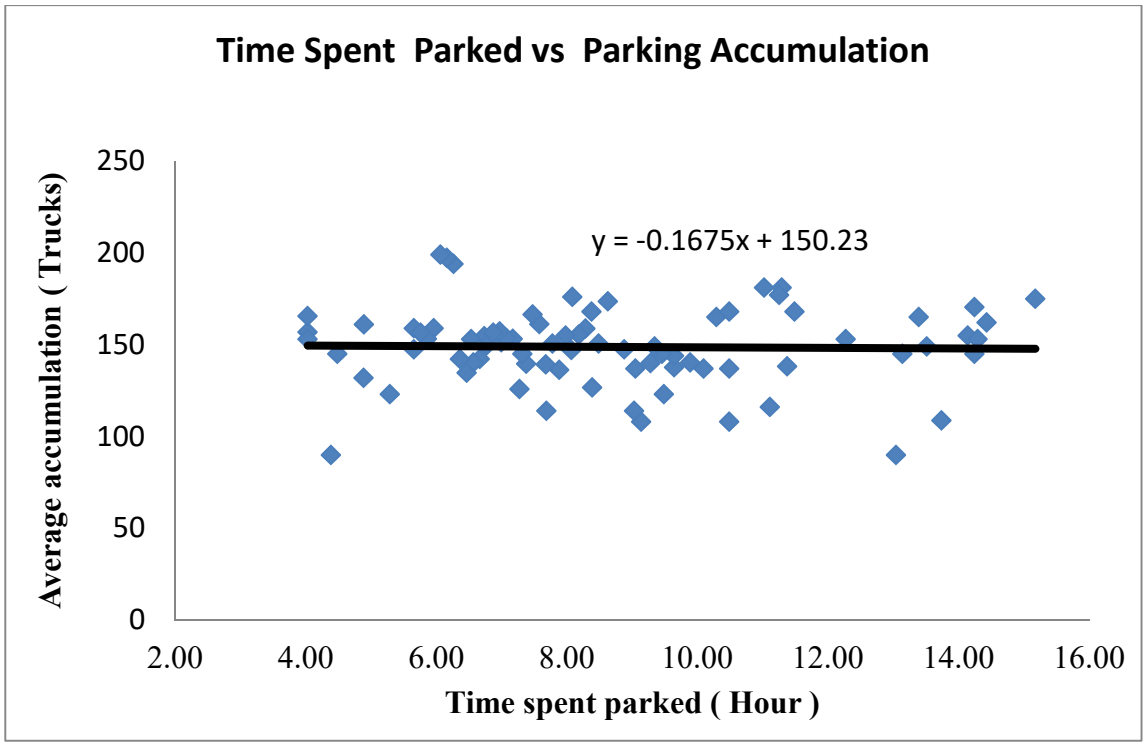

Figure 4.12: Parking Time vs. Parking Accumulation

Figure 4.12 show the relationship between the truck times spent parking and Average parking accumulation. It can observe that they are indirectly related. This means the higher the truck time spent parking makes the parking demand lower. The reason behind this is the higher the parking user consume the available lots forced the newcomer to shifts it's choose of parking area.

`

4.5. Parking Demand Multi-linear Regression Model.

Correlation between Independent Variables

The correlation among the independent variables are shown in the following table

Table 4.9: Correlation among Independent Variables.

	Volume of truck	length of Trip	time spent parked
Volume of truck	1.00	0.17	-0.02
length of Trip	0.17	1.00	-0.25
time spent parked	-0.02	-0.25	1.00

Table 4.10: Regression Statistics results

Regression Statistics	
Multiple R	0.98417
R Square	0.96858
Adjusted R Square	0.95478
Standard Error	27.1473
Observations	80

Table 4.11: ANOVA results

	df	SS	MS	F	Significance F
Regression	3	1749391.753	583130.5842	791.2463967	3.3442E-57
Residual	77	56747.24735	736.9772383		
Total	80	1806139			

`

Table 4.12: Regression coefficients

`	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.					
Volume of Truck	0.1859	0.02617	7.1023	5.E-10	0.1338	0.2380
Length of Trip	0.0537	0.01243	4.3219	4.E-05	0.0290	0.0785
Time Spent Parked	3.9565	0.92069	4.2974	5E-05	2.1232	5.7899

A simple summary of the above output is that the fitted line represented by the following equation

$$y = 0.1859 * x1 + 0.0537 * x2 + 3.9565 * x3 \quad \text{……Equation 4.2}$$

Where

y: average parking demand

x1 :Volume of Truck Traffic

x2: Average Distance Traveled by Trucks Recently.

x3 :Time Spent Parked by Trucks

4.6. Calibration of the Regression Model

Calibration involves estimating the values of various constants and parameters in a model structure. This Calibration of model's coefficients and constants done by solving the model equation for the parameters of interest after supplying observed values of both the dependent and independent variables, or by manipulating the constants parameters to obtain a match between known values and the model's estimated values.

The model calibration done by comparing the surveyed data with computed parking accumulation found and using two independent variables by setting the remaining one independent variable constant in order to determine its effects on the resulting regression equation.

`

1. Calibration of the model by setting counted volume of trucks constant.

For calibrating the predicting variables effects on the model, the researcher makes truck volume (x1) constant and observes the effects as follows.

Table 4.13: Constant Truck Traffic

	x1	x2	x3	Y cal.	Ycounted
	Volume of Truck	Length of Trip	Time Spent Parked	Avg.Parking Accum.	Avg. Parking Accum.
1	0	896	4.03	64	157
2	0	378	4.89	40	161
3	0	698	5.66	60	159
4	0	610	6.74	59	155
5	0	515	9.64	66	138
6	0	515	9.28	64	140
7	0	653	4.89	54	132
8	0	701	8.63	72	174
9	0	1036	14.24	112	171
10	0	427	8.88	58	148
11	0	823	13.74	99	109
12	0	952	11.37	96	138

As indicated on the figure 4.13 below the calculated parking accumulation is laying under the counted one. This implies the model cannot accommodate the existing

demands. So it can be concluded that the truck volume (x1) have a significant effect on the model.

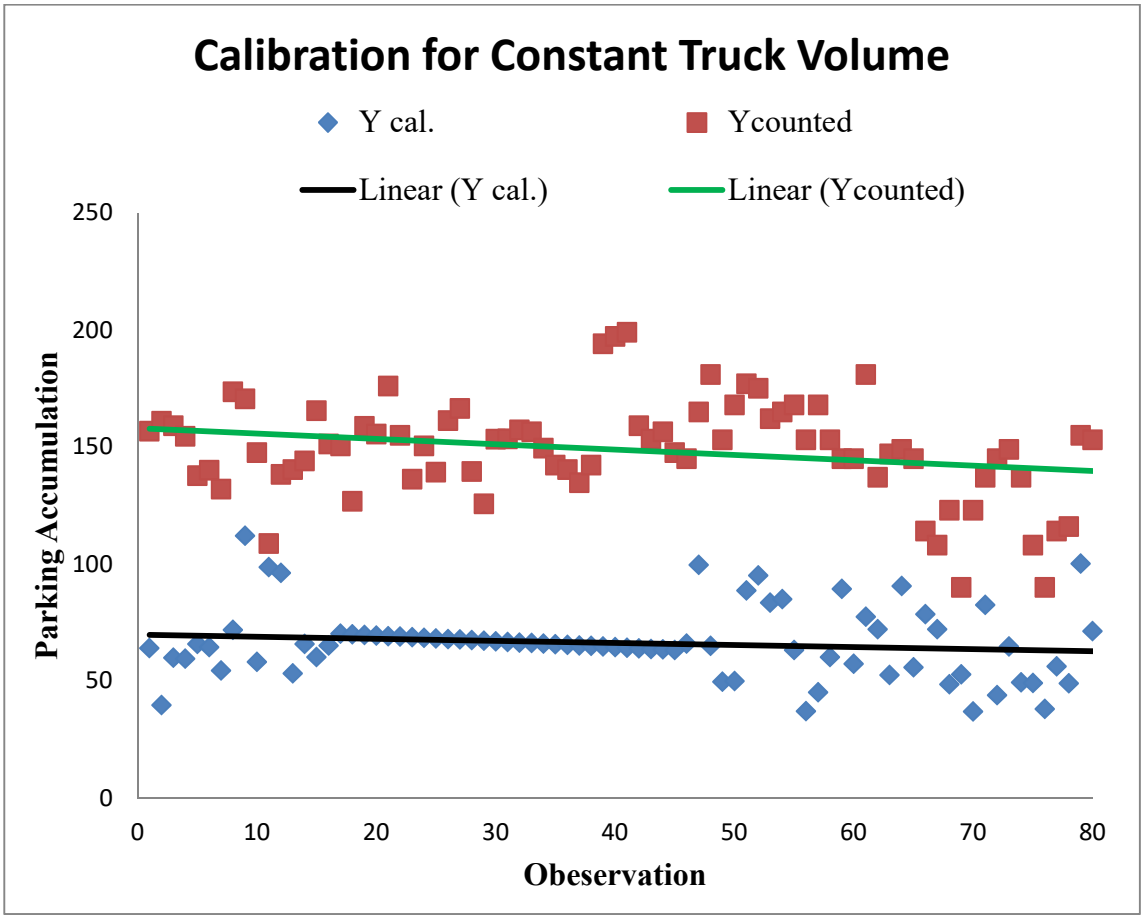

Figure 4.13: Calibration for Constant Truck Volume

2. Calibrating a model for constant average distance truck traveled recently.

In same process used for the first independent variable; making the average distance travelled by trucks (x2) constant impose influence on the model out puts by making the calculated parking accumulations to lay below the counted parking accumulation at most scatter points of the graph. This implies the model cannot accommodate the existing demands. So it can be concluded that the average distance travelled recently by the trucks (x2) have a significant effect on the model as shown on figure 4.14.

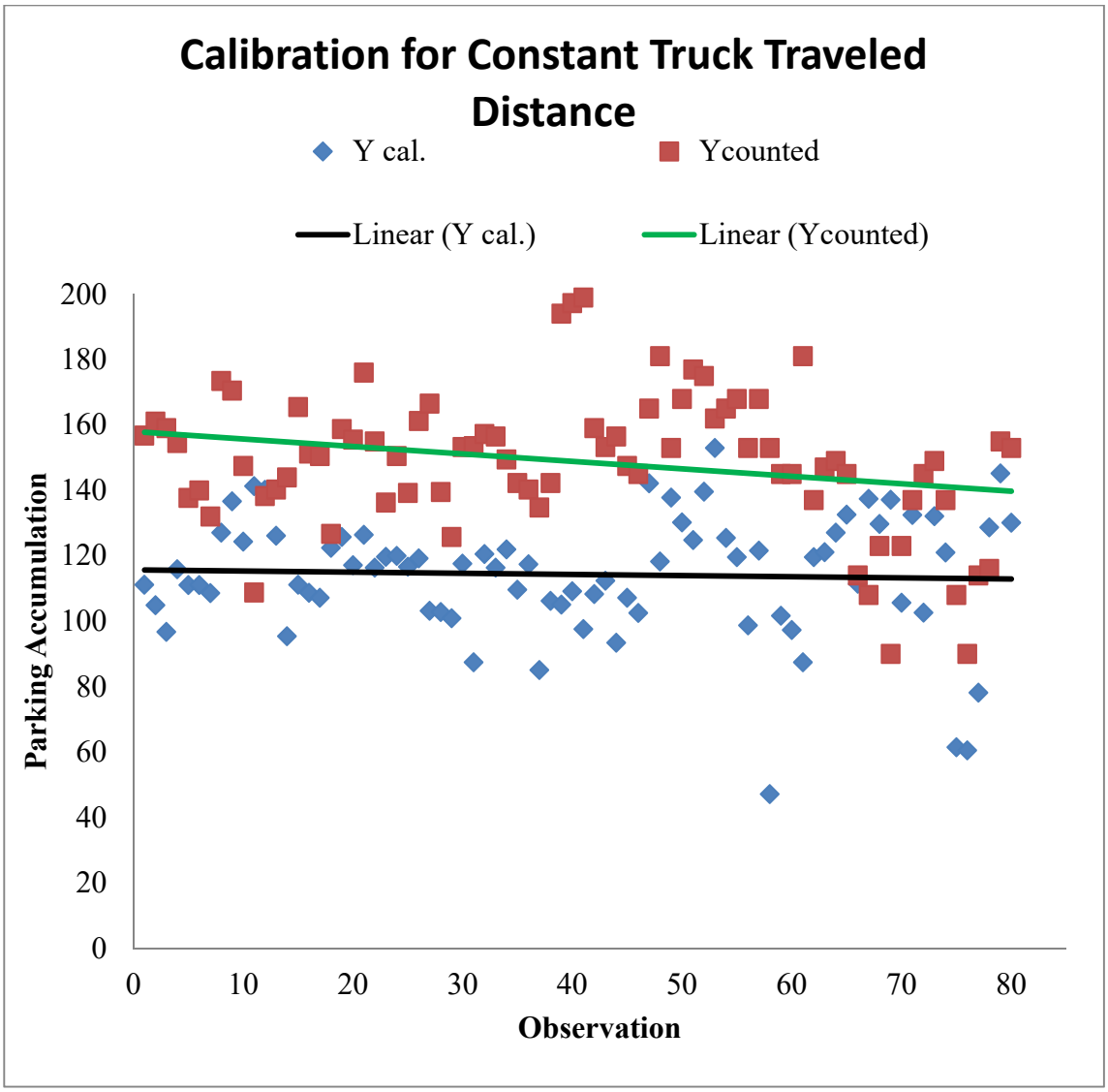

Figure 4.14: Calibration for Constant Length of Trip

3. Calibrating a model for constant Time Spent Parked

The faller of the model coping with the counted parking accumulation due to the manipulation of the third variables helps us to conclude that all our predictors have influence on the developed parking demand model. As indicated on the figure below the calculated parking accumulations are laying below the counted parking accumulation at most scatter points of the observations. This implies the model cannot

accommodate the existing demands at some of the observations. Therefore, we can conclude that the time spent parked (x3) have a significant effect on the model. Figure 4.15 shows graphical illustration of the point discussed earlier.

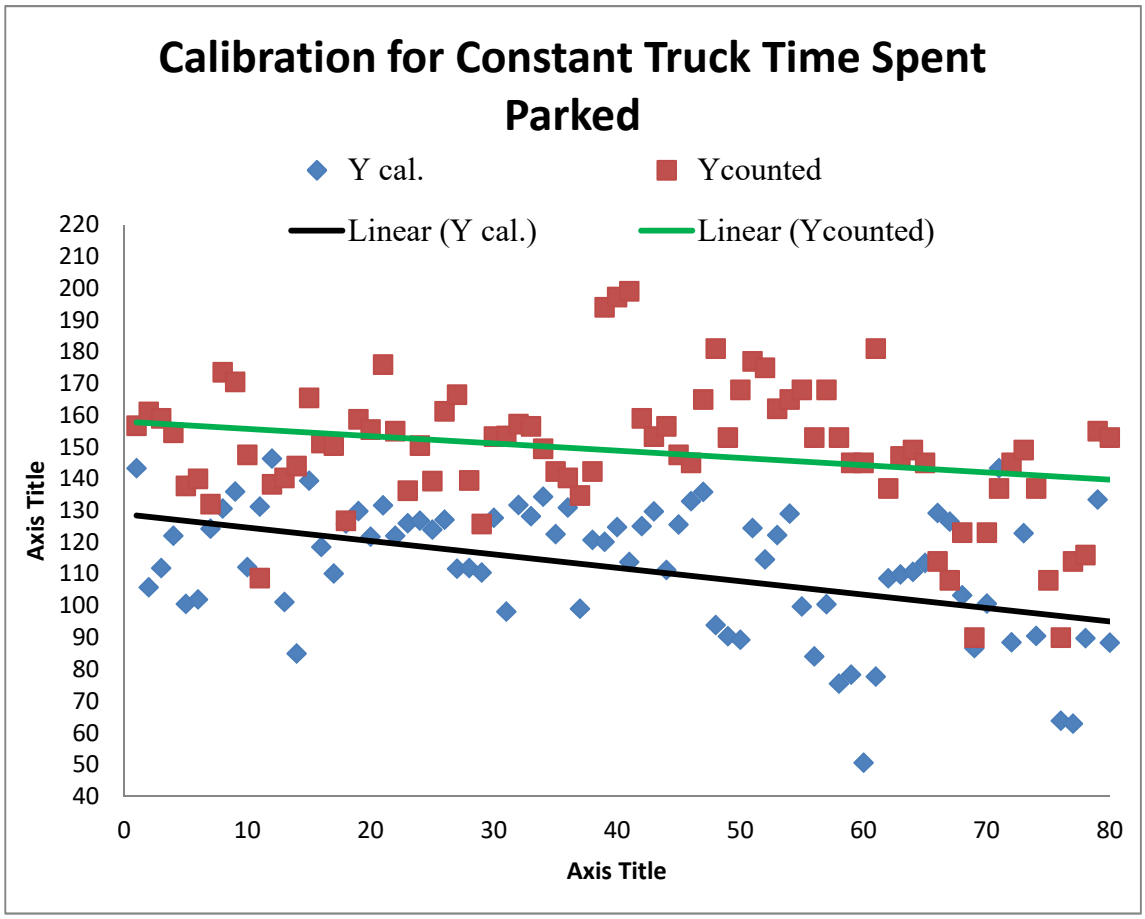

Figure 4.15: Calibration for Constant Time Spent Parking

4.5. Validation of the Regression Model

In order to validate our model we select area that relatively same condition with our study area. Hear in our case, zone two have selected because it have somewhat same condition with our zone that our model developed.

`

Table 4.14: Summary of Statistical Data for Model Validation.

	X1	x2	x3	Y cal.	Ycounted
	Volume of Truck	Length of Trip	Time Spent Parked	Avg Parking Accum.	Avg Parking Accum.
1	436	100	9.89	126	115
2	480	210	12.00	148	137
3	456	320	11.37	147	97
4	396	430	3.00	109	121
5	444	540	3.74	126	159
6	420	515	1.61	112	194
7	456	610	9.89	157	115
8	468	653	9.64	160	157
9	512	680	9.64	170	115
10	436	683	9.28	154	159
11	512	686	8.88	167	118
12	400	689	8.63	145	156
13	396	691	8.49	144	161
14	512	694	8.39	166	92
15	512	697	8.29	165	160
16	436	697	8.18	151	120
17	396	698	8.08	143	137
18	496	700	7.98	161	154
19	464	701	7.88	155	155

`

20	436	703	7.78	150	116
21	428	706	7.68	148	166
22	456	708	7.58	153	159
23	460	711	7.48	153	125
24	512	714	7.38	163	90
25	480	717	7.27	157	149
26	480	720	7.17	156	125
27	456	722	7.07	152	152
28	400	725	7.00	141	156
29	500	728	6.97	160	102
30	480	731	6.87	156	125
31	468	734	6.77	153	116
32	496	737	6.74	158	152
33	396	739	6.67	140	199
34	480	742	6.57	155	194
35	468	745	6.47	153	115
36	508	748	6.37	160	158
37	436	751	6.26	146	71
38	456	753	6.16	150	156
39	512	756	6.06	160	159
40	512	759	5.96	160	121
41	480	822	5.86	157	159

`

42	456	823	5.76	152	102
43	512	896	5.66	166	102
44	396	952	4.89	144	155
45	468	1036	4.03	159	155
46	536	698	14.29	194	165
47	496	698	11.17	174	109
48	580	698	11.02	189	161
49	600	698	5.46	171	157
50	556	697	9.03	177	156
51	556	697	7.42	170	116
52	576	697	11.24	189	139
53	580	694	14.37	202	132
54	564	694	10.50	184	71
55	580	690	10.32	186	160
56	496	689	4.03	145	109
57	496	686	9.24	166	118
58	488	686	10.11	168	159
59	580	683	10.49	186	118
60	420	669	15.32	175	154
61	600	653	8.07	179	90
62	580	653	10.42	184	157
63	612	625	9.53	185	165

`

64	548	610	8.38	168	153
65	592	586	10.29	182	142
66	420	586	9.22	146	158
67	536	563	11.17	174	160
68	532	563	10.54	171	159
69	556	515	11.33	176	159
70	496	515	10.14	160	137
71	556	467	10.39	170	166
72	580	467	9.28	170	178
73	480	427	15.32	173	101
74	556	396	14.29	181	149
75	612	259	8.38	161	132
76	568	259	11.33	164	157
77	408	224	9.51	125	153
78	612	224	10.49	167	162

Sample calculation for observation one (Shaded part on the table above). The calculated y ware found by inserting the predicting variables, which collected according to the methodology, used earlier using the model equation. So that

$$Y\ cal = 0.18588^* x1 + 0.05372^* x2 + 3.95654^* x3$$

$$= 0.18588 *436 + 0.05372 * 100 + 3.95654 * 9\ .89$$

$$= 126$$

`

Moreover, the counted accumulation of parking areas at zone two found as 115. So the difference have computed as

$$\text{Diff.} = 126 - 115$$

$$= 11$$

The difference is excess but can sustain the demand. Furthermore, the figure below shows the calculated parking accumulation and counted parking accumulation for zone two. It have observed that except at one observation the estimated accumulation is higher than the counted parking accumulation at all scatter points. This means one can use the model and provide sufficient parking lot for existing parking demand. But at some point the difference is not economical in this case the model provide excessive lots; since the samples used in the research was only 80 ; so that the researcher suggests using more data for accuracy.

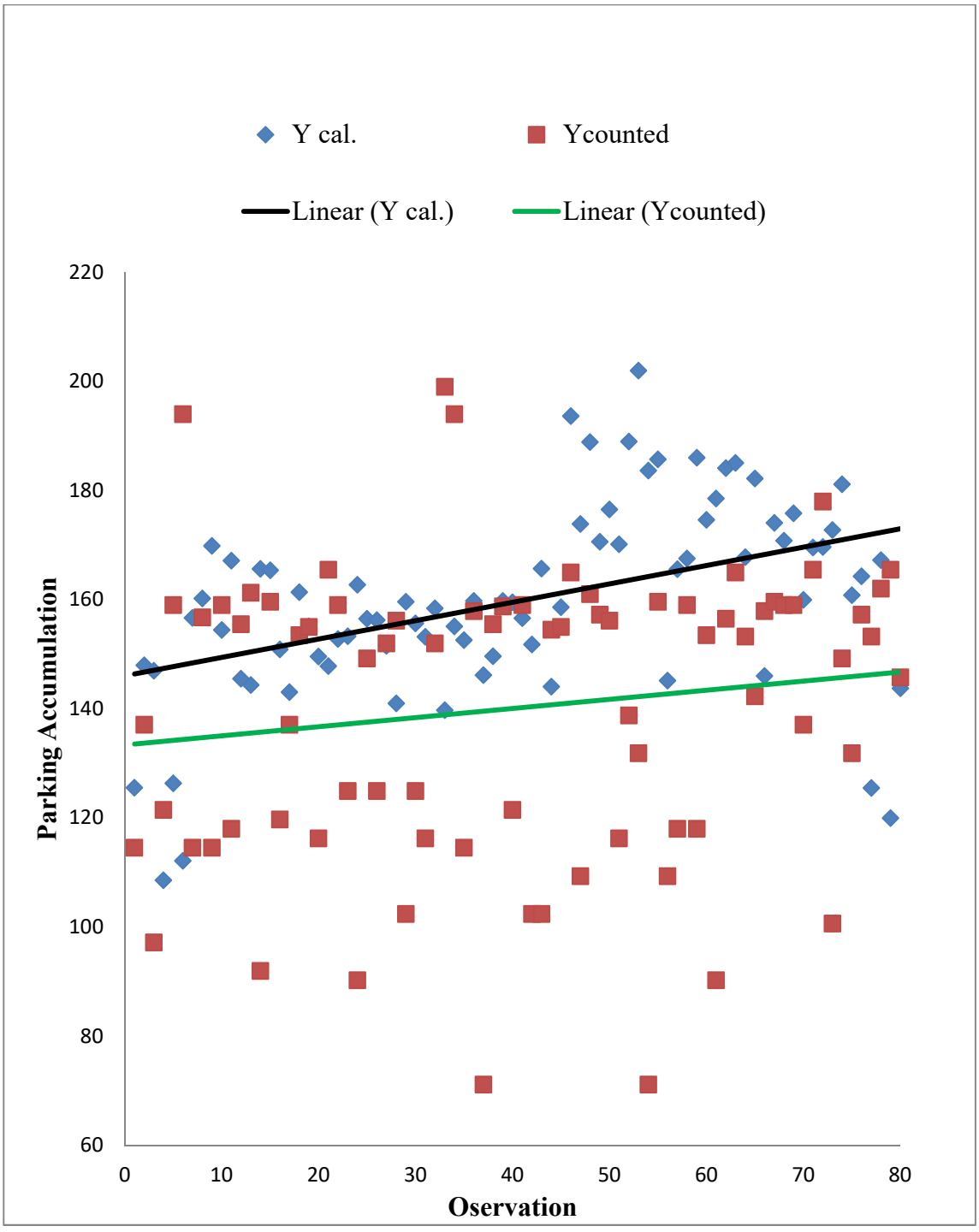

Figure 4.16: Validation of the Model on Zone Two

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5. CONCLUSIONS AND RECCOMENDATIONS

5.1. Conclusions

From the analysis and surveys, one can make the following conclusions.

1) The inventory survey of parking shows that most of the parking areas are less organized and poorly equipped. Moreover, there are no documents justifying the permanency of the facilities on urban area plane and the suitability of the areas are questionable during rainy season.
2) The result of parking arithmetical study indicates the average parking accumulation for total studied period at selected parking area is 111 trucks; the hourly average-parking load (volume) is 267 veh/hr during all period and the average parking occupancy/efficiency of off-street truck parking is around 67.91%. So that there is insufficiency of parking space as well as efficiency of parking areas are not function at full capacity.
3) Comparing the efficiency during different period of traffic ban enforcement the average efficiency was higher at February and the efficiency was lower at April after the traffic ban partial exemption and influence of COVID 19 pandemic. Generally we can say because of this traffic ban policy enforcement the operators parking habits in the city where changed.
4) Hence, the model satisfies statistical conditions and tests the parking accumulation can represented by the multi linear regression model. Therefor one can forecast the parking demand using the data that periodically collected such as truck traffic volume; average distance traveled by trucks and time spent parked by the trucks.

`

5.2. Recommendation

1) The concerning body should help the operators financially; professionally through providing training that empower the parking area staffs and by providing permanent parking facility land certificate to pursue initiatives related to truck parking issues. In addition, a consideration, that reducing distribution of truck parking around condominium must practice. Since the combustion of engine emits gas that may affect the air quality of localities the concerned body should consider a solution for this problem.
2) There is lack of clearly stated parking standards in the country especially for trucks related facilities; so new standards should incorporate the subject vehicle should develop with the addition of demand computing equation for determining the future.
3) Conduct additional studies. Refine study results to develop a more detailed assessment of strategies of specific highway locations. Establish a multi-state committee to evaluate alternatives and recommend solution to addressing truck staging and just-in-time deliveries. Conduct additional research to improve the truck parking demand model.
4) Encourage the formation of public-private partnerships (P3s). Provide low-interest loans or grants to commercial truck stops to help increase capacity. Construct state-owned lots adjacent to commercial truck stops and plazas, and enter into agreements for owners to lease or maintain lots. Work with owners of commercial truck stops to help promote availability of parking charters.

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APPENDICES

Appendix I: Questioners

Appendix II: Truck traffic volume percentage for each gates of Addis baba

Appendix III: Determination of Number of Count Stations

Appendix IV: Parking Survey Data

Appendix V: Collected Truck Traffic Volume Data

Appendix VI: Appendix VII: Average Distance Traveled by Trucks Recently

Appendix VII: Collected Data on Time Spent Parked by Truck

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Appendix I: Questioners

Questioner 1: Questioner for Truck Operators

Part 1: Choice the best answer that represent your opinion.

1. What is the minimum hour you spent driving in a day?

   a) Less than 8 hour b) from 8 to 16 hour c) from 17 to 24 d) more than 24

2. What is the minimum hour you spent rest in a week?

   a) Less than 1 day b) from 1 to 2 days c) From 2 to 4 days d) more than 4 days

3. How much time do you spent with your family in a month?

   a) Less than 1 day b) from 1 to 4 days c) From 4 days to one week d) more than one week

4. How much time did your truck spent at periodic service?

   a) Less than 1 day b) from 1 to 2 days c) from 2 to 4 days d) more than 4 days

5. What is the average amount of time required for loading your truck?

   a) Less than 30 minutes b) From 1 to 2 hour c) From 2 days to 4 hour d) More than 4 hour

Part2: Fill in the blank space.

6. Which month of the year makes you free? List the months in the rank from one to three?

   1st_____

   2nd_____

   3rd_____

7. Where was your last three trips

No.	Starting	Destiny
1		
2		
3		

`

Questioners 2: Parking Inventory Survey Form.

Part 1: <u>select the best option that represent your observation on the facility better.</u>

1. Number of trucks a parking facility can hold.

   a) Less than 30 b) between 30 and 50 c) Between 50 and 70 d) more than 70

2. Frequency of accidents or difficulties happened on parking place.

   a) Frequently b) Sometimes c) Rarely d) Not before

Part 2: <u>select the best option that represent your opinion better.</u>

3. Jot the geographical coordinate of the facility at its representatively central location.

Name of the facility	Latitude	Longitude

4. Facility or services that the parking area have or serve.

No.	Provided Service		Mark (√)
1	Demarcation	Physical barrier(fence)	
		Barrier that prevent unauthorized vehicle passing.(”kela”)	
2	Lighting and Visibility(Trimmed vegetation) at night		
3	Entrances and exits check		
4	CCTV		
5	Staff	Organizational structures	
		Trained operators	
6	service	Toilet	
		shower	
		Water tap	
		Snack and drinking area	
		shop	`
7	Pavement	Asphalt	
		Concrete	
		Sub base	
		Rad ash	
		Un- Surfaced	

`

Appendix II : Truck traffic volume percentage for each gates of Addis baba

Year	to Debrebrhan	to Comando	to Akaki	to Ambo	to Ghion	to Alemgena
2002	17.64%	7.36%	57.51%	7.77%	8.01%	1.72%
2003	10.87%	4.06%	70.09%	4.83%	6.86%	1.58%
2004	12.47%	5.02%	76.87%	5.16%	6.22%	1.71%
2005	13.91%	6.03%	70.98%	7.27%	6.95%	1.40%
2006	13.75%	5.25%	75.23%	5.50%	6.67%	2.10%
2007	14.30%	4.86%	67.57%	6.07%	10.38%	6.27%
2008	15.56%	7.03%	65.89%	5.30%	10.00%	4.75%
2009	12.79%	5.12%	67.13%	5.36%	10.94%	6.34%
2010	14.40%	6.15%	68.93%	5.95%	9.53%	3.30%
2011	9.82%	3.50%	76.48%	3.37%	8.77%	4.37%
2012	12.29%	4.41%	74.92%	4.28%	7.70%	4.27%
2013	13.87%	5.94%	65.19%	7.54%	10.01%	5.37%
2014	14.57%	5.60%	52.49%	10.00%	16.39%	9.90%
2015	16.79%	6.17%	31.37%	17.12%	24.07%	15.11%
2016	13.24%	5.03%	31.64%	18.15%	26.25%	13.90%
2017	10.71%	4.15%	32.64%	22.99%	22.45%	13.63%
2018	10.03%	3.88%	30.84%	22.90%	24.37%	14.14%

`

Appendix III: Determination of Number of Count Stations

$$n = \frac{t^2\frac{\alpha}{2},N-1*(\frac{s^2}{d^2})}{1+\left(\frac{1}{N}\right)*\left(t^2\frac{\alpha}{2},N-1\right)*(\frac{s^2}{d^2})}$$

n	n = Minimum number of count locations required	6	8	7
N	N= Total number of links (population) from which a sample is to be selected	6	8	
t	t= Value of the student's t distribution with (1 - a/2) confidence level (N - 1 degrees of freedom)	4.029	0.711	
a	a= Significance level	0.025	0.025	
v	v =Degree of freedom	5	7	
S	s= Estimate of the spatial standard deviation of the link volume	613691	613691	
d	d= Allowable range of error	219.5	219.5	

Appendix IV; Parking Survey Data on Each Zone

A; Parking Survey Data on Zone One

3	8:00am-11:00 am	140	28	26	142	71.72%	426
	11:00 am-2:00pm		45	17	170	85.86%	510
	2:00pm-5:00 pm		31	22	179	90.40%	537
	5:00 pm -8:00 pm		34	68	145	73.23%	435
4	8:00am-11:00 am	126	47	26	147	74.24%	441
	11:00 am-2:00pm		40	30	157	79.29%	471
	2:00pm-5:00 pm		36	34	159	80.30%	477
	5:00 pm -8:00 pm		49	51	155	78.28%	465
5	8:00am-11:00 am	116	31	31	116	58.59%	348
	11:00 am-2:00pm		49	10	155	78.28%	465
	2:00pm-5:00 pm		27	29	153	77.27%	459
	5:00 pm -8:00 pm		56	82	127	64.14%	381
6	8:00am-11:00 am	129	36	34	131	66.16%	393
	11:00 am-2:00pm		37	26	142	71.72%	426
	2:00pm-5:00 pm		56	46	152	76.77%	456
	5:00 pm -8:00 pm		38	55	135	68.18%	405
7	8:00am-11:00 am	119	42	34	127	64.14%	381
	11:00 am-2:00pm		21	24	124	62.63%	372

	2:00pm-5:00 pm		33	16	141	71.21%	423
	5:00 pm -8:00 pm		37	42	136	68.69%	408
8	8:00am-11:00 am	153	30	34	149	75.25%	447
	11:00 am-2:00pm		49	18	180	90.91%	540
	2:00pm-5:00 pm		32	27	185	93.43%	555
	5:00 pm -8:00 pm		15	20	180	90.91%	540
9	8:00am-11:00 am	122	74	28	168	84.85%	504
	11:00 am-2:00pm		26	17	177	89.39%	531
	2:00pm-5:00 pm		29	31	175	88.38%	525
	5:00 pm -8:00 pm		40	53	162	81.82%	486
10	8:00am-11:00 am	107	53	23	137	69.19%	411
	11:00 am-2:00pm		29	14	152	76.77%	456
	2:00pm-5:00 pm		34	22	164	82.83%	492
	5:00 pm -8:00 pm		34	61	137	69.19%	411
11	8:00am-11:00 am	122	34	42	114	57.58%	342
	11:00 am-2:00pm		26	32	108	54.55%	324
	2:00pm-5:00 pm		41	26	123	62.12%	369
	5:00 pm -8:00 pm		16	49	90	45.45%	270
12	8:00am-11:00 am	133	50	38	145	73.23%	435
	11:00 am-2:00pm		20	25	140	70.71%	420
	2:00pm-5:00 pm		23	19	144	72.73%	432
	5:00 pm -8:00 pm		28	48	124	62.63%	372
13	8:00am-11:00 am	141	38	61	118	59.60%	354
	11:00 am-2:00pm		29	22	125	63.13%	375
	2:00pm-5:00 pm		61	24	162	81.82%	486
	5:00 pm -8:00 pm		14	20	156	78.79%	468
14	8:00am-11:00 am	142	41	26	157	79.29%	471
	11:00 am-2:00pm		38	54	141	71.21%	423
	2:00pm-5:00 pm		31	28	144	72.73%	432
	5:00 pm -8:00 pm		29	39	134	67.68%	402
15	8:00am-11:00 am	153	38	36	155	78.28%	465
	11:00 am-2:00pm		35	20	170	85.86%	510
	2:00pm-5:00 pm		29	21	178	89.90%	534
	5:00 pm -8:00 pm		8	27	159	80.30%	477

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B; Parking Survey Data on Zone Two

	Day	X_0	In	Out	Avg. Accumulation	Parking index	Parking load
February	1	81	50	41	90	76.92%	270
	2	69	74	72	71	60.68%	213
	3	75	63	78	60	51.28%	180
	4	76	82	79	79	67.52%	237
	5	71	81	86	66	56.41%	198
	6	69	82	84	67	57.26%	201
	7	73	83	76	80	68.38%	240
	8	66	83	67	82	70.09%	246
	9	82	64	60	86	73.50%	258
	10	84	61	61	84	71.79%	252
	11	90	72	76	86	73.50%	258
	12	86	70	66	90	76.92%	270
	13	88	71	77	82	70.09%	246
	14	74	80	62	92	78.63%	276
	15	70	77	68	79	67.52%	237
March	1	61	68	61	68	58.12%	204
	2	68	55	70	53	45.30%	159
	3	67	65	66	66	56.41%	198
	4	54	73	59	68	58.12%	204
	5	59	70	66	63	53.85%	189
	6	78	41	37	82	70.09%	246
	7	79	32	55	56	47.86%	168
	8	61	51	53	59	50.43%	177
	9	63	62	62	63	53.85%	189
	10	71	44	49	66	56.41%	198
	11	53	78	75	56	47.86%	168
	12	56	73	38	91	77.78%	273
	13	89	51	58	82	70.09%	246
	14	68	71	73	66	56.41%	198
	15	60	66	59	67	57.26%	201
April	1	59	60	58	61	52.14%	183
	2	69	62	62	69	58.97%	207
	3	77	70	78	69	58.97%	207
	4	53	72	73	52	44.44%	156
	5	60	65	64	61	52.14%	183

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	6	49	74	82	41	35.04%	123
	7	52	69	63	58	49.57%	174
	8	54	59	57	56	47.86%	168
	9	59	61	33	87	74.36%	261
	10	59	66	55	70	59.83%	210
	11	69	56	59	66	56.41%	198
	12	47	79	54	72	61.54%	216
	13	54	68	64	58	49.57%	174
	14	54	69	47	76	64.96%	228
	15	73	48	64	57	48.72%	171

Parking One (P1).

Parking Two (P2)

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Parking Three (P3)

Parking four (P4)

Parking five (P5)

Figure I: Photo for each Parking Location in zone one

(Photo Taken on June 25 2020)

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Appendix IV: Collected Volume Data Collected At Seven Stations.

Station one: Road from Akaki to Bishoftu

`		Time Interval	Medium Truck	Heavy Truck	Truck and trailer	
Tuesday	11:00 am -12:00am	15min	12	38	10	
		15min	31	40	5	
		15min	18	39	7	
		15min	39	41	25	
	max of interval		39	41	25	
	volume		156	164	100	420
	12:00am-1:00pm	15min	39	31	25	
		15min	29	40	32	
		15min	17	51	40	
		15min	18	30	35	
	max of interval		29	51	40	
	volume		116	204	160	480
	1:00pm-2:00pm	15min	19	25	40	
		15min	22	19	36	
		15min	30	22	37	
		15min	16	29	35	
	volume		30	29	40	
	max of interval		120	116	160	396
	2:00pm-3:00pm	15min	43	24	46	
		15min	50	32	38	
		15min	47	29	45	
		15min	25	31	40	
	max of interval		50	32	46	
	volume		200	128	184	512
	11:00 am -12:00am	15min	12	38	27	
		15min	31	40	34	
		15min	18	39	33	
		15min	39	41	25	
	max of interval		39	41	34	
	volume		156	164	136	456

	12:00am-1:00pm	15min	39	31	25	
		15min	29	40	32	
		15min	17	51	40	
		15min	18	30	35	
	max of interval		29	51	40	
	volume		116	204	160	480
	1:00pm-2:00pm	15min	19	25	40	
		15min	30	22	37	
		15min	16	29	35	
	max of interval		30	29	40	
	volume		120	116	160	396
	2:00pm-3:00pm	15min	43	24	46	
		15min	50	32	38	
		15min	47	29	45	
		15min	25	31	40	
	max of interval		50	32	46	
	volume		200	128	184	512
Thursday	11:00 am -12:00am	15min	12	38	27	
		15min	31	27	35	
		15min	18	39	33	
		15min	35	41	25	
	max of interval		35	41	35	
	volume		140	164	140	444
	12:00am-1:00pm	15min	39	31	25	
		15min	29	40	32	
		15min	17	51	40	
		15min	18	30	35	
	max of interval		29	51	40	
	volume		116	204	160	480
	1:00pm-2:00pm	15min	19	25	27	
		15min	22	19	36	
		15min	29	22	37	
		15min	18	26	35	
	max of interval		29	26	37	
	volume		116	104	148	368
	2:00pm-3:00pm	15min	35	24	40	
		15min	34	31	27	
		15min	38	29	36	
		15min	25	31	30	

	max of interval		38	31	40	
	volume		152	124	160	436
	8:00 am -9:00am	15min	12	38	27	
		15min	31	40	34	
		15min	18	39	33	
		15min	39	41	25	
	max of interval		39	41	34	
	volume		156	164	136	456
	9:00 am -10:00am	15min	39	31	25	
		15min	29	40	32	
		15min	17	51	40	
		15min	18	30	35	
	max of interval		29	51	40	
	volume		116	204	160	480
	4:00 pm -5:00pm	15min	19	25	40	
		15min	22	19	36	
		15min	30	22	37	
		15min	16	29	35	
	max of interval		30	29	40	
	volume		120	116	160	396
	5:00pm-6:00pm	15min	32	37	46	
		15min	30	30	38	
		15min	37	34	45	
		15min	30	31	3	
	max of interval		37	37	46	
	volume		148	148	184	480
Sunday	8:00 am -9:00am	15min	12	38	27	
		15min	31	40	34	
		15min	18	39	33	
		15min	39	41	25	
	max of interval		39	41	34	
	volume		156	164	136	456
	9:00am -10:00am	15min	36	34	16	
		15min	37	38	24	
		15min	29	40	28	
		15min	36	32	32	
	max of interval		37	40	32	
	volume		148	160	128	436

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	4:00pm- 5:00pm	15min	22	19	36	
		15min	30	22	37	
		15min	16	29	35	
	max of interval		30	29	40	
	volume		120	116	160	396
	5:00pm-6:00pm	15min	43	24	19	
		15min	50	32	20	
		15min	47	29	23	
		15min	25	31	15	
	max of interval		50	32	27	
	volume		200	128	108	436

Table a: Calculated Truck Traffic on April 2020.

Day	S 1	S2	S3	S4	S 5	S 6
	382	397	415	353	422	415
	437	470	473	437	408	437
	360	451	360	360	339	360
Tuesday	466	419	466	466	346	466
	415	455	411	415	397	415
	437	437	473	437	331	437
	360	364	360	360	280	415
Wednesday	466	462	499	466	298	437
	404	419	455	415	353	360
	437	364	448	437	433	466
	335	309	379	360	360	415
Thursday	397	426	462	466	466	437
	415	415	415	415	400	360
	437	393	382	437	437	466
	360	389	357	360	360	415
Saturday	437	470	433	466	466	437
	415	426	284	415	415	360
	397	433	328	437	437	466
	360	364	277	360	353	415
Sunday	397	422	273	466	291	437

Table b: Calculated Truck Traffic on February 2020

Day	S1	S 2	S 3	S 4	S 5	S 6
	378	392	410	349	418	410
	432	464	468	432	403	432
Tuesday	356	446	356	356	335	356

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	461	414	461	461	342	461
	410	450	407	410	392	410
	432	432	468	432	328	432
	356	360	356	356	277	410
Wednesday	461	457	493	461	295	432
	400	414	450	410	349	356
	432	360	443	432	428	461
	331	306	374	356	356	410
Thursday	392	421	457	461	461	432
	410	410	410	410	396	356
	432	389	378	432	432	461
	356	385	353	356	356	410
Saturday	432	464	428	461	461	432
	410	421	281	410	410	356
	392	428	324	432	432	461
	356	360	274	356	349	410
Sunday	392	418	270	461	288	432

Appendix VI: Average Distance Traveled by Trucks Recently

No.	1st trip	2nd trip	3rd trip	Avg. of three trips
1	896	896	896	896
2	427	359	348	378
3	896	817	381	698
4	515	381	935	610
5	515	515	515	515
6	515	515	515	515
7	572	572	814	653
8	507	798	798	701
9	1400	814	896	1036
10	427	427	427	427
11	896	679	896	823
12	1578	381	896	952
13	306	297	187	263
14	515	515	515	515

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Appendix VII: Collected Data on Time Spent Parked by Truck

No,	Number of times using parking at A.A per week		resting time at home or just resting per week			Truck service				Time spent loading and unloading	parking time	
			Tr					Ts		T L/u	hr per day	
	1	2	4	5	6	7	8	9	10	11	12	#
	No.5		No. 8		No. 10)		Avg. of No.8 & No. 10	No.11		No. 12	parking time	total parking time
			day/week	hr/day	day/month	hr/day		day / month	hr/day	hr	hr per day	
1	2	8	3	10.29	5.5	4.4	7.34	1.5	1.2	1.08	10.02	10.81
2	7	28	1.5	5.14	2.5	2	3.57	4	3.2	3	10.17	10.89
3	1	4	1.5	5.14	2.5	2	3.57	1.5	1.2	3	10.17	9.89
4	1	4	1.5	5.14	2.5	2	3.57	3	2.4	4	10.37	6.74
5	1	4	6	20.57	7	5.6	13.09	1.5	1.2	1.5	16.19	9.64
6	3	12	0.5	1.71	2.5	2	1.86	4	3.2	1.5	6.56	9.28
7	3	12	1.5	5.14	2.5	2	3.57	1.5	1.2	1.5	6.27	4.89
8	6	24	0.5	1.71	0.5	0.4	1.06	1.5	1.2	3	5.26	8.63
9	2	8	6	20.57	2.5	2	11.29	1.5	1.2	4	16.49	14.24
10	3	12	0.5	1.71	2.5	2	1.86	3	2.4	1.5	6.16	8.88
11	3	12	1.5	5.14	2.5	2	3.57	3	2.4	1.5	7.47	13.74
12	4	16	3	10.29	0.5	0.4	5.34	3	2.4	3	11.14	11.37
13	1	4	1.5	5.14	2.5	2	3.57	1.5	1.2	3	8.17	9.89

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