



**ADDIS ABABA UNIVERSITY
SCHOOL OF POST GRADUATE STUDIES**

**BENEFITS OF SHIFTING FREIGHT DELIVERY TO NIGHT TIME,
CONSIDERING ROUTING AND ENVIRONMENTAL EFFECTS FOR
ADDIS ABABA CITY**

**A Thesis submitted to
School of Civil and Environmental Engineering**

**In partial fulfillment of the requirements for degree of
Masters of Science in Civil Engineering (Road & Transport Engineering)**

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ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

M.Sc. Thesis on

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CONSIDERING ROUTING AND ENVIRONMENTAL EFFECTS FOR
ADDIS ABABA CITY**

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DECLARATION

I certify that this research work titled “**BENEFITS OF SHIFTING FREIGHT DELIVERY TO NIGHT TIME, CONSIDERING ROUTING AND ENVIRONMENTAL EFFECTS FOR ADDIS ABABA CITY**” is my own work. The work has not been presented elsewhere for assessment and award of any degree or diploma. Where material has been used from other sources it has been properly acknowledged/ referred.

Abel Kebede

Name

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Signature

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Date

Dedication

“This work is dedicated to my lovely brother Sam & his wife Selam for all the things you make it throughout the times, Emaye for all the Love, Support and Kind sharing, my lovely brother Heni and Sister Selam for your support and encouragement next to almighty God.”

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ABSTRACT

The study aims develop the efficient system of goods distribution from the gates to a city centers of Addis Ababa. The Night Delivery System enables the distribution of goods from freight doors (gates) to the city centers efficiently without compromising the living conditions of the city dwellers, negatively affecting the environment and achieving better efficiency of transport operations.

The methods used were conducting classified traffic count at the Gates and adjusted to get final Annual Average Daily Truck Traffic. Using Total Travel time, Length of Travel to Destinations with the classified Traffic Counts both at optimizing the current condition and shifting the whole delivery to the Night has determined the savings in Hour and Kilometer. Finally determination of environmental impacts by conducting direct measurements of pollutant gases at the Heavy Vehicle Inspection Sites.

The results showed that the total of 10,725 Freight Vehicles entering and 12,890 Freight Vehicles leave the city of Addis Ababa on average per day. The Gate of Kality is taken as the Major Gate of Freight Entry and Exit with shares of 70.43% and 73.98% respectively. From the Gate of Kality to city centers of Addis Ababa, there identified 6 chosen Destinations of Freight. The movements at the Day time and Night time, the total travel time taken to reach the destinations at the Night time only takes 60 – 70% of the time at the Day time. Also the Total Passing Time at major junctions at the Night time only 17.65 - 28.43% of the Day. The total estimated Vehicle-Kilometer and Vehicle-Hour also 183,873.11 Vehicle-Kilometer per day and 6,784.96 Vehicle-Hour per day. Everyday estimated amount of 36.84 tons of CO₂ and 100 Kilogram of CO pollutant gases are released to the atmosphere of Addis Ababa City from the movement of Freight Vehicles from Gate of Kality to the Destinations.

The Freight Traffic shows considerable growth over the years, so with the environmental impacts. Most of freight goods delivery are conducted at the day time where as the Night delivery have Vehicle-Kilometer and Vehicle-Hour savings over the Day time delivery. Most of Freight Vehicles are Aged which contribute much towards environmental degradation. Finally, coordinated implementation of City Logistics measures which reduce the traffic problems and the negative environmental impacts is very vital.

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LIST OF ACRONYMS

UFT: Urban Freight Transport

FT: Freight Traffic

UTS: Urban Transport System

FV: Freight Vehicles

ND: Night Delivery

CC: City Cargo

A.A.: Addis Ababa

WHO: World Health Organization

CO: Carbon monoxide

CO₂: Carbon dioxide

ST: Small Truck

MT: Medium Truck

HT: Heavy Truck

TT: Truck Trailer or Articulated Truck

ADT: Average Daily Traffic

AADT: Annual Average Daily Traffic

Kph: Kilometer per hour

Km: Kilometer

1. Introduction

1.1 Problem Background

In the current globally integrated economy, the production and exchange of goods is escalating from time to time resulting in the ever increasing in the rate of traffic intensity. The rapid growth of socio-economic activity in the cities around the world creates also a huge demand for freight transportation and delivery of goods. The rise in demand combines with limited space at cities leads to traffic accident and congestion, and also environmental degradation.

Addis Ababa is the capital city of Ethiopia and also the seat for many International Organizations, the African Union (AU) and for more than 100 embassies and divided with 10 SubCities as shown in **Figure 1.1**. The city population is growing at an annual rate of 3.8% and estimated to contain a population of 5.56 million by 2020. The per capital income is also expected to be doubled by 2020 (CES in association with SABA Engineering, 2005).

Road transport has been serving the major means of transportation for both domestic and international transport services in Ethiopia. About 80% of the vehicles in the country are found in Addis Ababa with yearly growth rate of 5% (CES in association with SABA Engineering, 2005) with 1,329.59 km total length of road, out of which 29.70% is paved and 70.30% is unpaved with only road gross density of 1.45% (Samson F. et. al., 2006).

Addis Ababa experiencing about 700 accidents per month which had share of 60% from all occurred in the country (Berhanu G., 2000) with annual average growth of 31.4% between the years 1989 and 2002 (Samson F. et. al., 2006). Also the city experiencing traffic congestion at different places throughout the day, the average traffic congestion intensity in Addis Ababa expressed in Veh-min or person-min is very high and the result shows on average about 18,500 Vehicle-min or 38 vehicle-days and 169,000 Per-min or 352-person-day are wasted at each intersection legs or congestion spot per day (Taddesse W. et. al., 2011)

City of Addis Ababa also facing another problem related to environmental issues. Vehicles are considered to be the main source of air pollution. The level of air pollution is presumed to be high due to the prevalence of old vehicles and substandard road infrastructures. Recently there is even a

concern that the city might exceed the Carbon Monoxide (CO) 8-hour WHO guideline (Kume A. et. al., 2010).

A total of 82,195 tons of commodities move in to and out of the Addis Ababa on average a day. The challenges related to vehicles focuses on the uncoordinated movement of Freight Vehicles in the city centers. Mainly the Goods movement from outside to within the central area has the largest share of about 31.5% (CES in association with SABA Engineering, 2005).

All the stated points can be summarized with:

- ✓ smaller road network not cop up with the increase of traffic population
- ✓ lack of sound system to manage and coordinate transport
- ✓ higher rate of traffic accident and occurrence of traffic congestion
- ✓ higher rate of exhaust emission from vehicles.

Therefore, it is thought that developing efficient system for delivery of goods to a city centers is the major step to manage Freight Traffic demand, reduce traffic congestion and its effects, reduce traffic accidents occurrence and severity, reduce air pollution and reduce the cost of Urban Freight Transport. Efficient system of Goods delivery mainly focuses on counteracting on the existing freight delivery problems by optimizing the effects of congested movement, improving the efficiency, safety and environmental safeguard of Urban Transport System.



Figure 1.1: Map of Addis Ababa City

1.2. Literature Review

1.2.1 Introduction

Now a day, the movement of Freight from place to place plays important role in the economic and life of the city residents. The movement of freight load from the point of their production to the large cities to get their final consumer, in this process the goods needs to be pass through the gates of the cities then distribute to many locations of the city mainly the market locations of the central areas.

Urban freight represents 10 to 15% of vehicle equivalent miles traveled on city streets and 2 to 5% of the employed urban workforce. 3 to 5% of urban land is devoted to freight transport and logistics. A city not only receives goods, but also ships them: 20 to 25% of truck-km in urban areas is outgoing freight, 40 to 50% are incoming freight, and the rest both originates from and is delivered within the city (Dablance L. et. al., 2009).

In many parts of the developing world, Urban Freight Transport and the transport system in general is characterized by a rapid growth in demand that has overwhelmed transport capacity and weaken the normal activity of the cities. The growth in the economic activities and increase in the number of population will further make increasing trends of growth in the urban freight activities. This growth may have negative impacts on the urban environment. Traffic accident, traffic congestion and emission of hazardous gases to the environment are some of the negative impacts related to urban freight movements.

As pointed out earlier, increase in demand of transport directly linked with the urbanization of the city which is the increase in number of urban dwellers. In European Union region, Urban areas comprised 50% of their total population in 1950, 77% in 2000 and are projected to comprise 83% in 2020. The data showing that during the last decade freight transport movements have increased enormously, study forecasts a 38% increase in the demand for goods transport by 2010, and predicts that heavy goods traffic alone will increase by nearly 50% over its 1998 levels. Currently, the number of vehicles used for freight deliveries in European urban areas represents the 10% of all the vehicles circulating in the cities (OECD, 2003).

The challenges of UFT can be seen from different perspectives of economic, social and environmental. The economic challenges are the aspects of negative impacts having economic interpretation (Ramokgopa L. N., 2004). The external costs caused by freight transport in Italian urban areas are estimated to be equal to 7 billion Euros that accounts 23% of the total amount of externalities generated by urban traffic (European Transport, 2004).

The social costs are mainly related to the costs to clean up the related accidents happened due to urban freight movements. The other is the perception of the society to the urban freight movements and their frequent routes chosen to reach their destination in the urban centers.

Transportation currently depends by 97% on fossil fuels (Evalgelos M. et. al., 2011). Also the congestion levels of urban roads are increasing aggressively due to the increase of traffic demand. This increase in traffic demand has major adverse impact on the environment. The movement of large trucks in city centers produces a substantial amount of air pollutants (emissions of Carbon Monoxide, Nitrogen Oxides, PM (particle material) and other gases) (Dablance L., 2009).

According to Urban Transport Study by Ethiopian Roads Authority in 2005, **19,728 vehicles** of different types enter into, exit from and pass through the city and Freight vehicles have the share of 47.5%. Statistical data from the office of Addis Ababa City Traffic Polices shows that Addis Ababa had experience around 700 accidents per month which accounts for 60 percent of the accident that occurs in the country Ethiopia (Berhanu G., 2000).

Perhaps, the most compelling aspect of these problems is that the urban poor bear the brunt of both congestion and deteriorating environmental quality as they often face the longest commuting times and spend much of their lives out of doors on congested, noisy, and polluted streets (Gebremariam N. et al., 2011).

Market prices for a single product are increasing only because of the ever increasing of logistic cost from point of production to market or retail locations of Customer (Consumer). For instance the Garment processing trade of Ethiopia, Overall transport costs represents around 28% of the total value added. This is a high proportion related to African Standard of 15 to 20 percent and World average of 6.1 percent (Aschenaki B. et. al., 2004).

Most cities around the world have already started to implement measures of the city logistics. These measures at each city have its own solutions to the specified problems at each level. Now a day, the methods are developed with the help of the technological advancements like the advanced travel information and real time tracing of shipment for the customers. The implementation of city logistics systems mainly helps the cities to build their level of livability to the residents and keep-up the economic conditions of the urban markets in a sustainable ways.

1.2.2. City Logistics

The concepts of city logistic are dynamic and changing with the passage of time and develop through the living style of urban populations.

To develop an efficient distribution system of goods to business centers, understanding the concepts of city logistics are the basis for solving the problems clearly and imply the best possible solution(s). In this section, we are going to clarify and describe the concept of City Logistics in details. City logistics is a new area of research originated from the problems faced during the movement of freight goods in the urban territory (Taniguchi et al, 2004).

For planning and developing efficient systems of goods distribution, the concept of city logistics considered as the basis. City Logistics has been defined by Institute of City Logistics as, *“the process for totally optimizing the logistics and the transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the frame work of the a market economy.”* (Dablance L. et al., 2009).

City Logistics concerns the means to achieve freight distribution in urban areas, by improving the efficiency of urban transportation, reducing traffic congestion and mitigating environmental impacts (Shahzad F. et al., 2009).

The concepts of City logistics facilitate integrated solutions for the fundamental dilemma of urban freight transportation: on the one hand, urban freight transportation is fundamental to serve

industrial and trade activities in urban areas, ensuring their competitiveness; on the other hand, negative impacts of freight transportation should be limited (Ehmke J. F., 2012).

The harmonization of efficiency, environmental friendliness and energy conservation is vital for ensuring sustainable development of freight transport in urban areas. Consequently, the goal of city logistics should be to deliver and collect the goods for activities produced in a city in an efficient way, without disrupting the sustainable, mobile, livable and environmental friendly character of the city (Nicolas G. et. al, 2005). The future developments and structure of visions shown in Figure 1.1: Structure of visions for City Logistics (Taniguchi et al 2003).

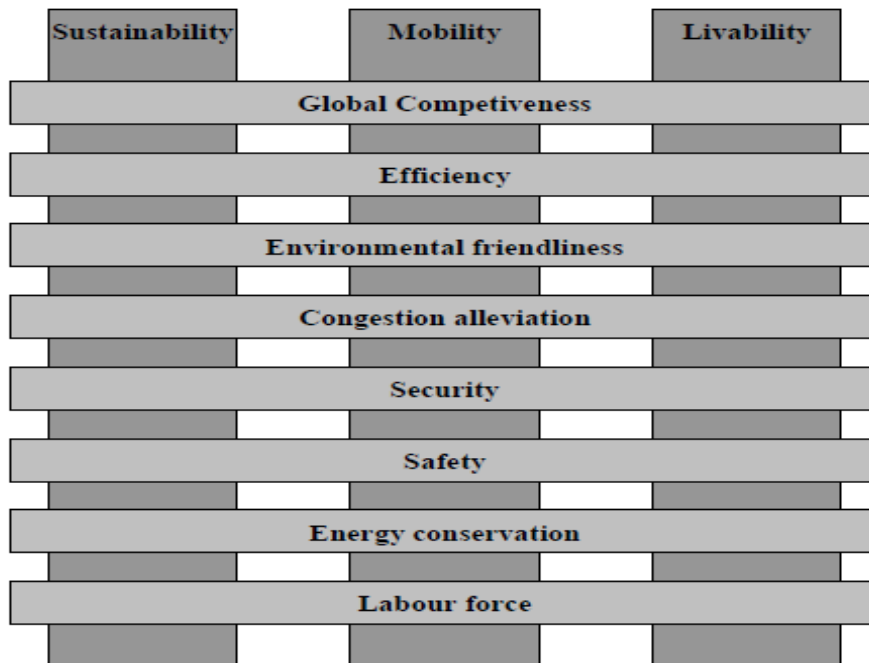


Figure 1.2: Structure of Visions for City Logistics (Nicolas G. et. al, 2005)

1.2.3 Policy Issues and Stakeholders of City Logistics

Based on interest and their views of City Logistics, there are basically four (4) parties involved:

1) Shippers (Manufacturers, Wholesalers, Retailers)

Those that deliver goods to other companies or persons and receive goods. Shippers try to maximize their service with Just-in-time (JIM) frame with reliability (no damage and delay).

2) Carriers or City Logistics service provider (Transporters, Warehouse companies)

Deliver goods to customers with the aim of increasing their benefit by reduction of collection and delivery costs. Now these actors are facing a problem due to traffic congestion in urban area.

3) Consumers

These are people who live, work and shop in the city. Who want very lively and conducive city environment free of any pollution.

4) City Administrators (National, State and City level)

These coordinate and facilitate the relations between the other stakeholders. They mainly passes policy to and regulate other stakeholders to act accordingly trying to improve the economic conditions of the city and reduction of freight transport impacts.

The details of category of Stakeholders and main interest in the context of Urban Freight Transport presented in the **Table 1.1**.

Table1.1: Stakeholder of City Logistics and their interests (DG Move European Commission, 2012)

| Category of stakeholders | Stakeholders | Main interest in context of UFT |
|------------------------------|--|--|
| Supply chain stakeholders | Shippers | Delivery and collection of goods at the lowest cost while meeting the needs of their customers. |
| | Transport operators (own account, third party providers) | Low cost but high quality transport operations and satisfaction of the interests of the shippers and receivers. |
| | Receivers (major retailers, shop owners, etc.) | On time delivery of products, with a short lead-time. |
| | Consumers | Availability of a variety of goods in shops in the city centre. |
| Resource supply stakeholders | Infrastructure providers | Cost recovery and infrastructure performance. |
| | Infrastructure operators (managers) | Accessibility and use of infrastructure |
| | Landowners | Profitability of local areas |
| Public authorities | Local government | Attractive city for inhabitants and visitors, with minimum inconvenience from freight transport, while also having an effective and efficient transport operation. |
| | National government | Minimum externalities from freight transport, while maximizing economic efficiency and effectiveness. |
| Other stakeholders | Other economic actors located in the urban area (manufacturers, service providers, etc.) | Site accessibility and on-time deliveries. |
| | Residents | Minimum inconvenience caused by UFT. |
| | Visitors/tourists | Minimum inconvenience from UFT and a wide variety of products in the shops. |

Source: elaboration from Maggi (2007).

1.2.4 Urban Freight Transport

There are various definitions of Urban Freight Transport (UFT), but for the purposes of this study the following was adopted, “*the movement of freight vehicles whose primary purpose is to carry goods into, out of and within urban areas*” (DG Move European Commission, 2012). The main concern for many studies related to urban transportation can be summarized with one word “*Sustainability*”. Sustainability is a relevant issue for transport, because on one hand transport is connected to economic growth while at the same time it puts enormous pressure on the environment (Andersson J et al., 2005).

The main issue about urban freight transport is very much related to creation and managing of system that can efficiently provide the operation of goods movement in the urban environment without compromising the livability of Cities.

City Logistics imply that the concept is totally about optimizing the freight movement. Each movement at the urban centers has its own coordination and ways of inter-link to show excellent performance in a good ways.

City movements can be classified as external and internal. External movements are those through which goods leave, enter or pass thorough the city, while internal movements take place within the city boundaries. The classes of movements include modal choices, vehicle types and sizes and ranges of goods (Ramokgopa L.N., 2004). The details of city movements illustrated in Figure 1.2.

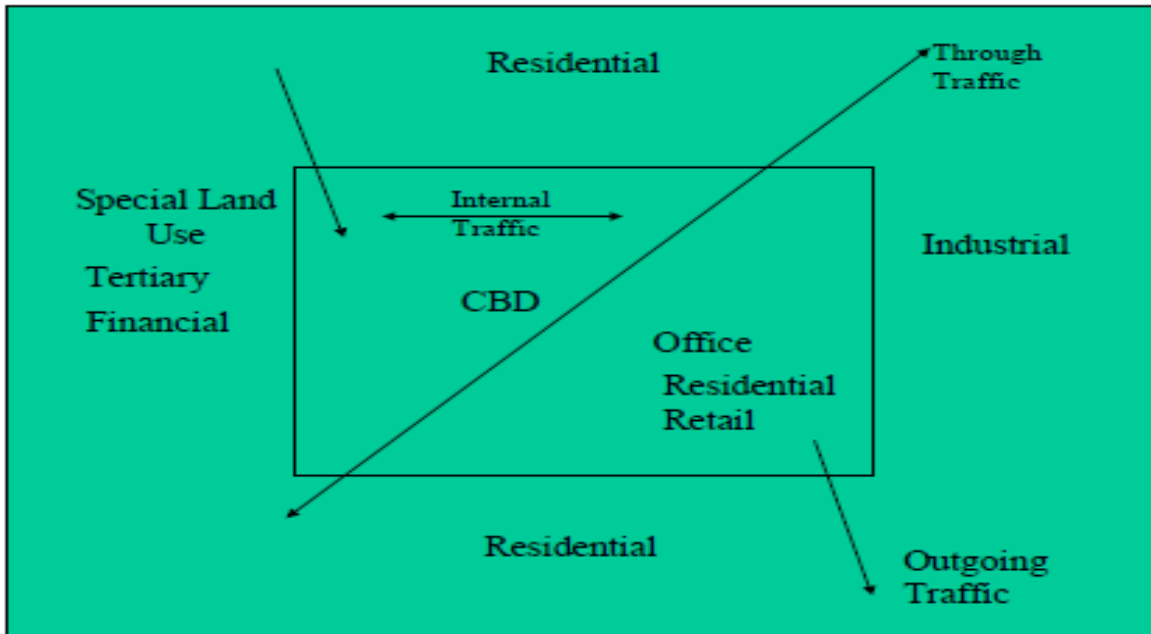


Figure 1.3: Schematic presentation of city movements [adapted from: Ramokgopa L.N., (2004)]

Some of the basic concepts determining the quality of the relation among the movements and the performance indicator at each single inter-link movement are:

For External movements:

- the movements usually are performed using heavy trucks and rails transportation systems.
- the transported good most of the time are not sorted at each item and locations inside the cities.
- the movements most of the time are least coordinated and little attention due to the reason that the movements are taken outside the cities centers.

For internal movements: -

- the movements usually performed using smaller vehicles that are suitable for transportation considering the spatial conditions of the city environment.

- ☞ **Problem:** the use of larger freight trucks for the purpose of last-mile delivery ¹
- the coordination of freight movements based on their destination seen to be essential.
 - ☞ **Problem:** coordination inside and across logistic service providers is less.
- the loading condition of urban freight vehicles when compared to their capacity should be met to reduce the number of trips to some specific area inside the cities.
 - ☞ **Problem:** less load factor and increase of number of trips to specific destinations
- the type and age conditions of freight vehicles (FV) are important factors to suit transportation of specified freight item.
 - ☞ **Problem:** weak in selecting right kind and suitable type of FV especially for transportation of Perishable products mainly food items.
 - ☞ **Problem:** mostly no or loose restrictions over the age of FV making deliveries in the urban environments.
- after the delivery reached its intended destination in the cities, the next operation is unloading and/or loading other items. During these operations the avoidance of contribution to local congestion is highly advantageous.
 - ☞ **Problem:** - since the urban roads are narrow, the parking of freight vehicles for loading and/or unloading operations closes road and create congestions for other road users.

Urban Freight Transportation (UFT) is driven by the need for the delivery of Goods to the locations of final customer. The flow of Freight can be measured in two forms – Commodity and Trucks. The major difference between the two methods is their input data. The determination of the current and forecasting UFT amount at any geographic level, the four step process (see Figure 1.3) is important (FHWA Freight Manual II, 2009).

¹ Last mile delivery – as the name implied the delivery to the final end customer usually conducted by using smaller Freight Vehicles, also aiming for fulfilling the Just-in-time frame works.

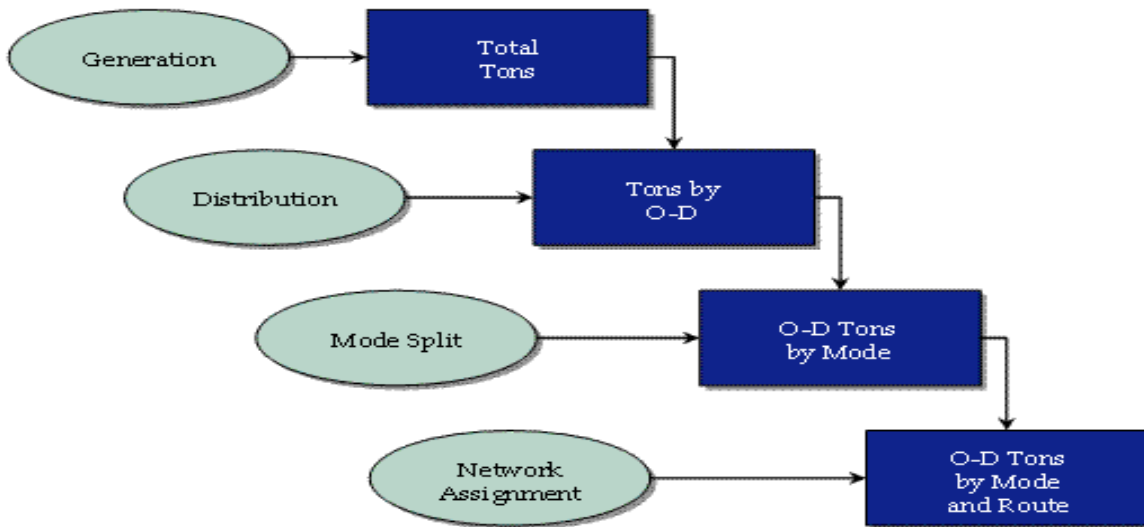


Figure 1.4: Four Step Process for Freight flow determination and forecasting (FHWA Freight Manual II, 2009).

1.2.5 Problems and Challenges of Urban Freight Transport

The varied nature of urban freight must be recognized. Urban freight activities include tasks such as the transport of building materials, waste collection, retail deliveries and courier services. All of these tasks are common to urban areas, but have quite different characteristics are conducted using different types of vehicles, may occur at different times of day and involve quite different patterns in terms of frequency and spatial coverage. Therefore, need to be considered separately (Taylor M., 2006).

City Logistics is the new school of thought for Urban Freight Transport which tries to outline the problems and also give efficient and optimized solutions.

The problems of Urban Freight Transport (UFT) are mainly the challenges that the thought of City Logistics need to give a solutions. The detail of the challenges are discussed above, in this section we will discuss the problems due to UFT. Mainly the problems of Traffic Congestions and Environmental Pollution (Exhaust Emissions) on the operation of UFT and also inefficient delivery (economic efficiency) from the systems are given the emphasis.

Traffic Congestion and Accidents

The problems and challenges seen from different angles that can be summarized as:

From the Social Perspectives (Ramokgopa L.N., 2004):

- ☞ Maneuvering limitation of urban roads (may result in loss of control for the Drivers and then occurrence of accidents)
- ☞ Social perception and results of data records shows truck-populated roads have higher accident occurrence, mainly when concerned with the number of serious accidents.
- ☞ Cost for social services for cleaning accidents and repair of infrastructure increase tremendously.
- ☞ Cost of traffic congestions in terms of time wasting of workers and travelers.

From the Economic Perspectives (Ramokgopa L.N., 2004):

- increased travel times for the service providers,
- increased inventory carrying costs,
- lengthy “time-to-market” delays and
- higher transport costs



Figure 1.5: Traffic Congestion at Truck Populated Roads of Addis Ababa



Figure 1.6: Traffic Accident involving Freight Truck, Addis Ababa

These costs simply pass down the supply chain and compensated by the consumers as in (Table 1.2)

Table 1.2: Classification of the Costs of Transport (*Source: European Commission, 1995*)

| Cost Categories | Social Costs | |
|-----------------------|---|---|
| | Internal/Private Costs | External Costs |
| Transport Expenditure | -fuel and vehicle costs: Tickets/fares | -costs paid by others (e.g. free provision of parking spaces) |
| Infrastructure Costs | -user charges, vehicle taxes and fuel exercises | -uncovered infrastructure costs |
| Accident Costs | -Costs covered by insurance, own accident costs | -uncovered accident costs (e.g. pain and suffering imposed on others) |
| Environmental Costs | -own disbenefits | -uncovered environmental costs (e.g. noise disturbance to others) |
| Congestion Costs | -Own-time costs | -delays/time costs imposed on others |

Congestion is one of the most prevalent transport problems in large urban agglomerations, usually above a threshold of about 1 million inhabitants. Congestion occurs when transport demand exceeds transport supply at a specific point in time and in a specific section of the transport system. Under

such circumstances, each vehicle impairs the mobility of others. Congestion can be perceived as an unavoidable consequence of the usage of scarce transport resources, particularly if they are not priced (Rodrigue J-P, 2013).

Congestion has a significant impact on routes where delivery times are heavily restricted by customer time windows and schedules. In addition, there may be a fairly inelastic relationship between delivery costs and customer's demand characteristics and levels. Also Congestion has a great impact on CO₂ vehicle emissions and fuel efficiency. From an operational perspective, carriers cannot take into account the impact of congestion on emissions unless time-dependent travel times are considered when designing distribution or service routes (Andres M., 2010).

Despite the economic benefits generated by Urban Freight Transport (UFT), there is a justification for intervention by the public sector in the market to redress the balance between social cost and social benefit derived from UFT (DG MOVE European Commission, 2012).

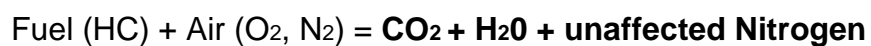
Exhaust Emissions

The technology for vehicular movements widely permits use fossil fuels and result in the release of harmful gases and particulate matters to the environment and also release of noise. This challenge is explained in detail in the next section.

Air Pollution maybe defined as “The disruption caused to the natural atmospheric environment by the introduction of certain chemical substances, gases or particulate matter, which cause discomfort and harm to structures and living organisms including plants, animals and humans” (Tom V., 2012). The vehicle obtains its power by burning of the fuel. The vehicular pollution is majorly caused due to the combustion of fuel which named as exhaust emissions and due to the evaporation of the fuel itself.

The chemical reactions occurring during combustion of fuel (Tom V., 2012):

- During ideal combustion,



- During the typical engine combustion,

$$\text{Fuel (HC) + Air (O}_2, \text{N}_2) = \text{Unburned HC} + \text{NO}_x + \text{CO} + \text{CO}_2 + \text{H}_2\text{O}$$

There are two types of vehicular emissions (Tom V., 2012)

1. Exhaust Emissions: which are emitted through the exhaust pipe when the vehicle is running or started. The exhaust emission type maybe – Start up emissions and running emissions.
2. Evaporative Emissions: include running loses and hot soak emissions produced from fuel evaporation

The details of the pollutants and impacts on humans, vegetations and climate detailed in (Table 1.3)

Table 1.3: Summary of Environmental Damage by Air pollution from Vehicles (OECD, 1997)

| Pollutant | Source | Impact on: | | | |
|--|--|--|--|---|---------------------------|
| | | Humans | Vegetation | Global Climate | Materials |
| Carbon monoxide (CO) | Incomplete combustion | Inadequate oxygen supply; heart, circulatory, nervous system | | Indirect through ozone formation | |
| Carbon Dioxide (CO ₂) | Combustion | | | Major green house gas | |
| Hydrocarbons (HC – includes methane, isopentane, pentane, toluene, etc.) | Incomplete combustion carburetion | Some are carcinogenic Ozone precursor | Build-up in soil, feed, food crops | Methane has high greenhouse potential, leads to ozone formation | |
| Nitrogen Oxides (NO _x) | Oxides of N ₂ and N compounds in fuels | Respiratory damage, various toxic content | Reduce assimilation | | Dirt |
| Soot (diesel) | Incomplete combustion | Carcinogenic | | | Dirt |
| Ozone (formed by interaction of other pollutants) | Photo chemical oxidation with NO _x and HC | Respiratory irritation, aging of lungs | Risk of leaf and root damage, lower crop yields. | High greenhouse potential | Decomposition of polymers |
| Source: Based on Button p. 30, Table 3.6; Kurer pp. 486-490 | | | | | |

The estimation of the exhaust emissions from UFT has many variables and assumptions. Many different estimates have been published of truck air pollutant emissions (OECD, 1997), based on

- miles travelled
- ton-kilometers of goods transported
- quantity of energy consumed, and
- age of Vehicle classes (weighted average emission factor for vehicle class) and Other measures

The total environmental emission for any class of vehicular type transporting freight over the urban link can be given as: (Jun T. Castro et al, 2010)

$$P_{ia} = \frac{F_a \times L_a \times E_{ai}}{1,000}$$

- P_{ai} = Pollutant i that emitted on link a
- F_a = flow of vehicles on link a
- L_a = length of link a
- E_{ai} = emission factor for pollutant i on link a

Figure 3: Traffic Congestion at Freight Trucks populated roads



Figure 1.7: Pollutant Gases from Freight Vehicles release to atmosphere at Addis Ababa City

The Tables 1.4 and 1.5 summarize emission factors from a number of sources, developed in several different countries. However, they do give a probable estimate of the amounts of pollutants release.

Table 1.4: Truck Air Pollution Emission Factors, in grams/ton – km (Source: OECD, 1997)

| Emissions | Kürer (Germany) | | Schoemaker & Boumanb (Netherlands) | | | | Whitelegg (Europe) | Befahy (Belgium) | OECD (Europe) |
|-----------------|--------------------|-----------|---------------------------------------|-------------------|--------------------------------|----------------------|-----------------------|-----------------------------------|----------------------|
| | Local | Long haul | Trucks | Trucks & Trailers | Truck-tractors & semi-trailers | Road freight overall | Road freight overall | Trucks & semi trailers >10 tonnes | Long distance trucks |
| CO | 1.86 | 0.25 | 2.24 | 0.54 | 0.34 | 0.9 | 2.4 | 2.1 | 0.25 |
| CO ₂ | 255 | 140 | 451 | 109 | 127 | 211 | 207 | | 140 |
| HC | 1.25 | 0.32 | 1.57 | 0.38 | 0.34 | 0.68 | 0.3 | 0.92 | 0.32 |
| No _x | 4.1 | 3.0 | 5.65 | 1.37 | 2.30 | 2.97 | 3.6 | 1.85 | 3.0 |
| SO ₂ | 0.32 | 0.18 | 0.43 | 0.10 | 0.11 | 0.20 | n.a. | n.a. | 0.18 |
| Particulates | 0.3 | 0.17 | 0.90 | 0.22 | 0.19 | 0.39 | | 0.04 | 0.17 |
| VOC | | | | | | | 1.1 | | |

Table 1.5: US EPA Truck Emission Factors for Selected Criteria Pollutants (Source OECD, 1997)

| Speed | VOC (grams/mile) | | CO (grams/mile) | | NOx (grams/mile) | |
|--------|------------------|-------|-----------------|--------|------------------|--------|
| | HDGV | HDDV | HDGV | HDDV | HDGV | HDDV |
| 15 mph | 11 726 | 3 162 | 163 533 | 16 063 | 5 875 | 17 192 |
| 25 mph | 7 061 | 2 175 | 95 298 | 9 588 | 6 416 | 14 132 |
| 30 mph | 5 892 | 1 865 | 79 005 | 7 931 | 6 686 | 13 513 |
| 35 mph | 5 109 | 1 634 | 69 201 | 6 866 | 6 957 | 13 389 |
| 40 mph | 4 579 | 1 464 | 64 040 | 6 220 | 7 227 | 13 745 |

HDGV = heavy duty gasoline vehicle. HDDV = heavy duty diesel vehicle
Source: Mullen 1996

Inefficiency in delivery

Inefficiency in distribution in urban areas can be exhibited in the following ways (according to DG MOVE European Commission, 2012):

- ☞ low load factors and empty running;
- ☞ a high number of deliveries made to individual premises within a given time period;
- ☞ long dwell times at loading and unloading points.

The efficiency of delivery mainly linked with the coordination and systematic management of the operations. The inefficiency of the operations results in incurring additional cost for the stakeholders specially the costs comes down to the final consumer. The consumer will pay all the costs related to the failure of disorganization and optimized systems of Transport Operators, Shippers and City Administrators. Mainly the Transport operators are serving the demand arise between the link of Shippers and Consumers, and duly paid for their operations.

1.2.7 City Logistics Measures

The concepts of City Logistics are recently developed to formulate and develop systematic thinking to solve the problems of Urban Freight Transport.

City Logistics schemes which relatively new field of logistics brought by the challenges of moving quantities of freight to, from and within metropolitan cities (Taniguchi, et al, 2004).

To reduce the problems or handle the challenges stated above, some of the concepts taken to consider giving solutions, points taken up are:

-Urban goods aspects to consider (Ramokgopa, L.N., 2004):

- total number of vehicles trip to retail premises
- time/day of vehicle operations
- channel structure
- size /type of vehicle
- vehicle loading/offloading time

-Possible City Logistics solutions (Ramokgopa, L.N., 2004):

- centralized distribution of goods
- vehicle route planning
- tracking and tracing of freight vehicles
- use of environment friendly fuel
- schedules delivery (fixed window periods and shifted time delivery)

The methods implied above are mainly important to make the balance between the social cost and social benefit from Urban Freight Transport (UFT). In theoretical terms the common objective of these measures is essentially the internalization of the external cost of private activities (balancing the marginal private benefit to the marginal social cost) or at least the maximization of the positive effects of UFT while minimizing its negative externalities (OECD, 2004).

These days, many cities around the world are taking counter measures concerning the problems for distribution of goods to the city centers. Here under some of the measures (schemes) applied are presented. The measures and practices taken in the European Cities are categorized as follows (OECD, 2004):

- regulatory measures;
- market-based measures;
- land use planning measures;
- infrastructure measures;
- new technologies;
- management and other measures.

The measures mentioned above are summarized with their solution details are tabulated below in **Table 1.6:**

Table 1.6: Measures and Practices for European Cities (DG MOVE European Commission, 2012)

| Category | Type | Vehicle | Fuel | Traffic |
|--|----------|--|-------------------------------------|--|
| Market-based | Direct | Emissions tax | Differential fuel taxation | Subsidies for less- polluting Vehicles or modes |
| | Indirect | Tradable permits | High fuels taxes | |
| | | Differential vehicle taxation | | |
| | | Tax allowances for new vehicles | | Congestion charges |
| | | | | Parking charges |
| | | | | Charges for truck access |
| Regulation/ "Command and control" | Direct | Emissions standards | Fuel comp. | |
| | | | Phasing out of high polluting fuels | Physical restraint of traffic (such as designated routes or pedestrian zones) |
| | Indirect | Compulsory inspection and maintenance of emissions control systems | Fuel economy standards | Time window |
| | | Mandatory use of low polluting vehicles | Speed limits | Night-time delivery |
| | | Compulsory scrappage of old vehicles | | Bus lanes and other priorities |
| | | Volume or weight restraints on vehicle use | | |
| Land use | Indirect | Provide available loading/unloading zones (especially within or near premises) | | Zoning |
| | | Create reserved parking areas | | Relocation of freight generators (logistics or industrial activities, hypermarkets) according to urban renewal |
| | | Use of reserved zones (bus lanes, taxi zones) and private car parks | | Infrastructure access to freight transport generators |

| | | | | |
|--------------------------------------|----------|--|--|--|
| Infrastructure | Indirect | | | Parking management system |
| | | | | New transport infrastructure (e.g. increasing the road network, rail and waterway connections, underground and tram systems) |
| | | | | Transshipment or intermodal centre |
| | | | | Urban consolidation centers |
| | | | | Collection points |
| | | | | Nearby delivery zones |
| New technologies | Direct | Develop new vehicles (such as electrical vehicles) | Alternative fuels (bio-fuel, CNG, LPG, etc.) | |
| | | Install equipment on the vehicles that allow the monitoring of emission parameters | | |
| | Indirect | Identification system for access control | | Real time traffic information |
| | | Adopt IT technologies to improve the VRS of vehicles | | Identification systems for access control |
| | | | | On line load /unload zone reservations |
| Management and other policies | Indirect | Incentives to increase the load factor | | Foster consolidation strategies and freight carrier cooperation |
| | | Promotion of driver training courses | | Outsourcing of logistics activities |
| | | Regulate driver working time limits | | Create city logistics forum |
| | | | | Combining goods traffic with passenger ones |
| | | | | Foster inter-modality and use of alternative modes of transport (e.g. tramway, underground) |

Source: elaboration from Button (1993), Whiteing et al. (2003); Munuzuri et al. (2005); Ogden (1992).

Some of good practices on City Logistics implemented measures on the Cities around the World.

1.2.7.1 Consolidation Scheme – Bristol

The consolidation center acts as hub center of delivery on the periphery of the city where deliveries are streamlined and travel to the Broadmead (shop center) are reduce significantly. In addition, gives improved service to retailers (SUGAR city logistics Best Practices, 2011).

According to Shahzad F. et al. (2009), some of the benefits from the system where:

- Now serves 70 retailers, reduce delivery movement by 80%
- Retailers save 20minutes per delivery.
- Reduction in emission of: CO₂ equaling 27 tones, NO_x equaling to 870kgs, and PM (particulate matter having size of up to 10 micron) equaling to 25.9kgs.
- By collection mechanism, amount of 17.1 tons of recycle material collected from the shops.

1.2.7.2 City Cargo - Amsterdam

From the delivery points outside the city center the trams would have taken the goods to four or five hubs throughout the center from where the deliveries to the final destinations were to be handled by small electric vehicles. The hubs were to be located strategically just outside the center and the tram cars were to be taken out of the loop to the hubs on specifically built private rail sidings. The city cargo aimed to takeout half the number of trucks enters to the city (means cutting the number from 5,000 to 2,500) (SUGAR city logistics Best Practices, 2011).

They used large trucks for long-distance transport to and from the distribution centre and distribute goods in and out of the city by means of vans and small trucks (Nicolas G. et. al, 2005).

According Shahzad F. et al. (2009), some of the results are:

- Produce a great reduction in city congestion increase in road safety measures and also a reduction in the maintenance cost of roads.
- The saving of the city economy through this means went up to 125 million Euros per year.
- The system created more than 1,200 new jobs in cities.

The limitation of the project was the use in transportation of goods to some items was limited, for e.g. Construction materials were not transported (Shahzad F. et al., 2009).

1.2.7.3 Lorry dedicated Route – Brussels

To reduce the negative impact of heavy freight traffic causes to the quality of life on citizens, Brussels Capital Region (BCR) set up mandatory corridors for heavy freight vehicles and restricting their access to residential areas except only lorries with load less than 19 ton and lorries with special permission to enter the area (Nicolas G. et al, 2005).

In designing and implementation of this scheme, proper design of route with full accessibility and functional capacity is main issue to consider.

1.2.7.4 Night Delivery Scheme – Barcelona

Very high congestion in Barcelona in the morning peak hours towards city center and in the evening peak hours towards the suburbs, where the logistics centers are located, leading to high emission and long driving time for city center deliveries (SUGAR city logistics Best Practices, 2011).

The scheme gives faster delivery service with access to loading/unloading without restrictions. In addition to this, faster delivery of goods and has no contribution to congestion. The important benefits also extend to the optimization of fuel consumption of trucks and higher emission because there is no stop/start operation during driving. The major problems concerning this scheme are noise for the residents, as well as security issue for both the drivers and the goods (SUGAR city logistics Best Practices, 2011).

The Lorries make two trips during the night, one at 11 pm and one at 5 am. These two trips save 7 trips in the peak hours. At 11pm, products that do not need refrigeration are unloaded, at 5am "short life" or perishable products are unloaded. Some peoples mention the project as totally successful (Nicolas G. et al, 2005).

Finally, each specific scheme may have direct application and combination with others but before choosing and deciding for implementation detail analysis based on compressive data from field investigation is mandatory.

1.2.8 Night Delivery System

As the name implies the delivery of goods to the city centers is implemented during the night times. Basically the concept of Night delivery lies in delivering to the city centers when very low activates in the city and traffic movements on the roads. The delivery operation is conducted typically between 10 PM and 7 AM. The system allows the most efficient use of scarce road infrastructure by facilitating the development of Night-time deliveries. The movement at night helps the better use of road infrastructure at off-peak hours but need low noise equipments for operations (driving, loading/unloading) to meet low noise standard (DG Move European Commission, 2012).

According to NICHES (2011), there exist so many potential benefits related to Night Delivery of goods to the City Centers:

- Reduction of the congestion by using the road network during night hours;
- Faster travel times for all vehicles;
- Optimization of vehicle and manpower utilization;
- Reduced emissions;
- Consolidation and clustering of shipments;
- Positive contribution to road safety.

The reduction in traffic congestion at urban streets due to the shift of operation time to the night where faster travel time with higher safety is guaranteed. The reduced emission is mainly related to the reduction in stop/start operation of driving and idle driving conditions due to congestion. The consolidation and clustering of shipment is the benefit related to allowing heavy FV for delivery operations at the night time.

Mainly the disadvantages related to Night Delivery of goods are the issues of truck noise to the residents and the security conditions during delivery. For the successful implementation of this

system many cities around the world uses pilot program so called “silent night delivery trial” and promote the use of cleaner and quieter vehicles for deliveries, example as the case of Barcelona City (Nicolas G. et. al, 2005). The other security problems can be handled with developing strong communication methods with persons at other locations for monitoring and reporting of the conditions happened at the driving operations. Also enough street light for visual purposes to help the vehicular drivers during the night delivery operation are important issue.

1.2.9 Conclusion

Addis Ababa is one of the most developing city of the sub Saharan countries, also facing many challenges related to urban freight movements.

Since Road transport is the most important means of transport used for both the transport of passengers and freight, the increasing demand of road transport system coupled with lack of route planning, lack of transport demand management for urban freight, inappropriate location of freight and mass transport terminals and little infrastructure is resulting high level of congestion, accident and environmental depletion (Gebremariam N. et al., 2011).

In our case of Addis Ababa city, currently there is no much established system to distribute goods. Only time and route restriction to freight trucks is the current controlling mechanism. This mechanism prohibits the movement of truck on peak traffic hours of the day in the city roads except on ring roads. The time windows for the movement’s are, the morning time of 10 to 12 am and afternoon time of 4 to 6 pm. The other issues studied by the Consultants and other stakeholder only to locate freight terminal and Customs locations at the Gates to the city.

So in order to manage and gaining economic benefit with keeping the environment, the city should have a system to efficiently distribute goods to the city centers. The implementation city logistics measures coupled with the technological advancements of the transportation systems will mark a great benefit to the city and further to the country. The implementation of city logistics measures like Urban Consolidation Center (UCC), City Cargo (CC) and Night Delivery systems will promise tremendous benefits in the saving of costs and increase of livability of Addis Ababa in a sustainable way.

From the literature reviewed and the case studies discussed it is understood that few research in the area of city logistics has been done in the city of Addis Ababa and still not see any implementation improvements. But, the area of city logistics has been active area of research in many developed and developing countries for several years. Mainly Europe, USA, Japan, Canada and Australia are pushing forward by conducting proper and continuous researches, and wisely implementing the outputs accompanied by insuring the continuations which finally lead the countries and their cities to the greater benefits. Therefore, conducting a research in the area of City Logistics in Addis Ababa and followed by wise implementation will be a critical point whether to reduce or solve the problems associated to freight movement in the city before the problem even get worsen in the future.

1.3 Research Questions

The main questions that should be answered are: -

- ✚ What are the problems associated with the current goods distribution system (from the City Gates to the City Centers) of Addis Ababa?
- ✚ What can be done to improve the current freight delivery system of Addis Ababa?
- ✚ What better and less costly alternative ways are there for delivery of Freight Goods to a City Centers of Addis Ababa and how the changes can be quantified in comparison to the current system?
- ✚ What are the Negative Environmental Impacts associated with freight distribution in the city of Addis Ababa and how the effect can be quantified?
- ✚ How can the emission and traffic problems related to freight movements for delivery of Goods be reduced?

2. Objective

The main objective of this study was to collect scientific data and develop recommendable Freight distribution system to the City Centers of Addis Ababa that improves the activity of Freight flow and implement the concept of City Logistics, identify the problems of the existing conditions and recommend logistic scheme which could be beneficial for City Residents and Authorities in environmentally sustainable way.

The specific objective lies within the desire to maximize the efficiency of Freight Delivery in the city of Addis Ababa and minimize the negative environmental impacts due to Urban Freight Transport.

The specific objectives were to:

- determine the flow of Goods to and from Addis Ababa City;
- find out the main Destinations for delivery of freight from the Gates to the city centers of Addis Ababa;
- estimate the amount of time spent in Hour and Kilometer travel for delivery of freight at a single day;
- find out convenient time of movement for Freight delivery to the City Centers of Addis Ababa; and to
- estimate environmental damage due to exhaust emission gases from Freight Vehicles on the delivery of Goods to the city centers of Addis Ababa each day.

2.1 Significance and Impact of the Study

The negative impacts of poor Logistics Systems in the city of Addis Ababa in terms of traffic congestion, traffic accident, noise, environmental pollution due to vehicle emission and operating cost are rising in an alarming rate.

The results of the study lay some important points for:

- ✓ **Freight Planners** – shows other alternative system of City Logistics
- ✓ **Freight Operators** – shows ways to reduce their costs and optimize their Freight Delivery Systems.
- ✓ **Environmentalists and Residents** – show the impacts on the environment due to the existing conditions of Freight Delivery with the means of reduction.

The results from the study could help all stakeholders of the city to improve the livability of Addis Ababa by:

- ✓ Minimize the traffic congestion
- ✓ Reduce environmental impacts from the movement of Freight Vehicles
- ✓ Increasing efficiency of Goods Delivery to city centers
- ✓ Reduce the operating cost of Freight Vehicles in the urban territory which will reduce additional cost on the final consumer (customer).

3. Methodology

For producing results which is directed to answer the stated problems and meeting the objectives, efficient and complete methodology of the research based on clear understandings plays vital role in quality outputs.

Studying Freight Transport and City Logistics need many variables to closely be correlated, inspected and analyzed to give good understanding of the pattern and define ways to reach the solutions. Also need defining many variables which could affect the output in many different ways.

The main task of the study is to give possible solution to the stated problem with meeting the stated objectives while compare the results of movement of Freight Vehicles in urban territory on different times of the day (i.e. time window movement of the Day Time (which is 10:00 to 12:00 AM at the morning and 4:00 to 6:00 PM at the Afternoon) and Night Time (after 9:00 PM)).

The main tasks under this research include:

- ☞ Determining the flow of Freight Vehicles to and from Addis Ababa
- ☞ Analyzing the Growth Rate of Freight Vehicles movement to and from Addis Ababa
- ☞ Identifying the Freight Destinations in the City Center for most of entry loads and mapping the movement inside the City territory.
- ☞ Field observations and measurements on different variables.
- ☞ Age distribution of Freight Vehicles by each category
- ☞ Estimation of the Total Vehicle-Kilometer on delivery of Goods to City Centers
- ☞ Estimation of Freight Vehicles Exhaust Emission to the environment.

3.1 Sources of Data

The first step for conducting qualitative study on Freight Transport and City Logistics systems is the collections of pertinent information and data. Collection of Data and Information involves many activities. Some of activates include:

- Collection of primary data from field measurements and field surveys
- Collection of secondary data from Institutions, Research Publications, Traders and Stakeholders in the sector of Freight Transport and Logistics.
- Collection of pertinent information's based on interviews of the actors and regulators of the logistic processes.

The process of Data Collection best illustrated on **Figure 3.1**.

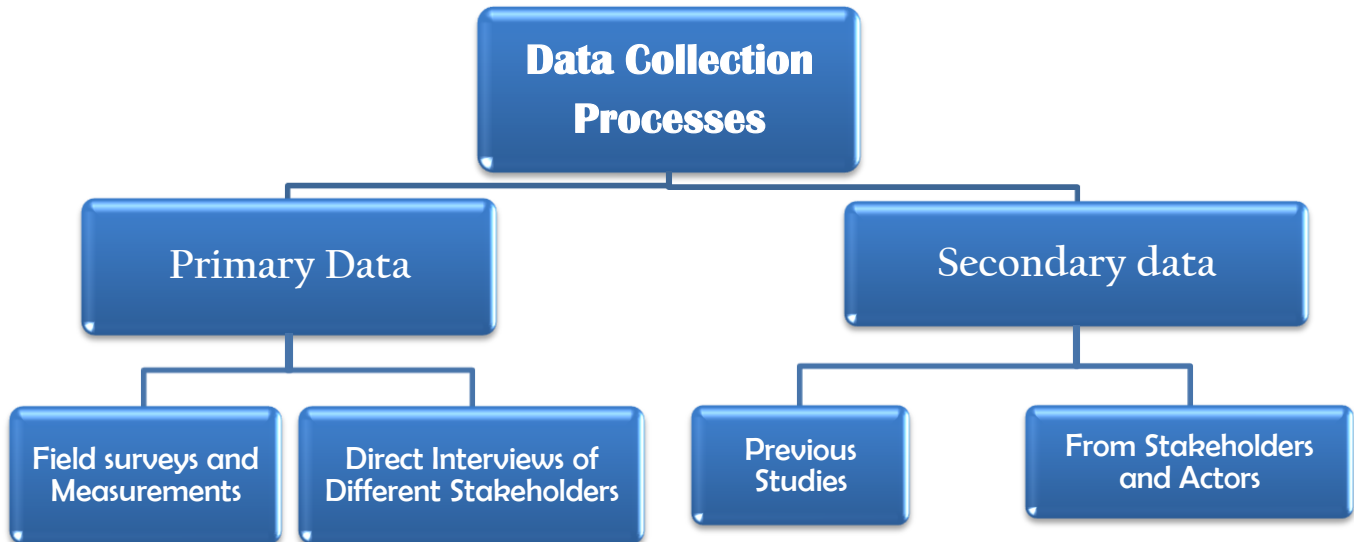


Figure 3.1: Data Collection Sources Structure

3.1.1 Sources of Secondary Data

The secondary data and information for the research are sourced from previous study on a single data type or as whole condition for research and/or other management uses by different stakeholders. The different sources for secondary data and their data type are listed in **Table 3.1**.

Table 3.1: Secondary data sources with data type

| No. | Sources | Data Type |
|-----|--|---|
| 1 | Ethiopian Roads Authority (ERA) | Traffic Data |
| 2 | Addis Ababa City Roads Authority (AACRA) | City Map showing Roads and Facility Locations |
| 3 | Addis Ababa City Road Transport Bureau | Vehicle Registrations with Age Distributions |
| 4 | Addis Ababa City Environmental Protection Bureau | Pilot study on Vehicular Emissions |

3.1.2 Primary Data Collection and Analysis Methods

i. Determine Freight Vehicles Flow to and from Addis Ababa

A. Data Collection

The collection of data for the determination of freight traffic at Addis Ababa has been determined using classified freight traffic count at sites on the Gates to the city/Freight Doors. After the selection of sites for the classified traffic count traffic data collectors were trained on how to collect the data that represent the whole traffic conditions. At the five gates to the city of Addis Ababa counts are taken based on ERA freight trucks classification categories which is based on loading capacities as listed below and illustrated on Annex-A.

- Small Trucks (less than 3 ton)
- Medium Trucks (between 3 and 7 tons)
- Heavy Trucks (between 7 and 12 tons)
- Articulated Trucks (more than 12 tons)

Each five gates to the city with their location of counting are listed as:

1. Ambo Gate at Ambo Road
2. Debrezeit Gate at Kality
3. Dessie Gate at Lege Tafo
4. Gojjam Gate at Entoto
5. Jimma Gate Near to Sebeta

The counts are made on both the Entry and Exit Freight Traffics based on:-

- 3 days 12 hours counting
- 2 days 24 hours counting

The traffic count has made on the days between March 4, 2013 and April 6, 2013.

B. Analysis Methods

After the classified counting at each Gate, the counting has adjusted for:

- a) **Week days Adjustment** – this adjustment considers adjusting the variation of traffic over the days of the week at the day time. The counting has been made for 5 days for 12 hours on day time and averaging the values will give the adjusted Day Traffic on that Gate.
- b) **Night Adjustment Factor (NAF)** – this adjustment considers adjusting traffic variation over a single day (24 hours). At each gate and vehicular class the 2 days 24 hours counting and 3 days 12 hours counting
 - First averaged to each average 24 hours traffic and 12 hours traffic
 - Then the ratio of average 24 hours to average 12 hours traffic will give the Night Adjustment Factor (NAF).
- c) **Seasonal Adjustment Factor (SAF)** – this adjustment factor considers adjusting traffic counting over different seasons of the year. The data source for SAF is Ethiopian Roads Authority which divides the year in to 3 different cycles with their Average Daily Traffic and Previous AADT values. The available data are from the year 2007 up to 2010. The calculation of Seasonal Adjustment Factor is as follows:

- First by taking four sets of data, 1 for AADT of the year and Average Daily Traffic (ADT) on each 3 cycles for that given year.
- Each Seasonal Coefficient Factor (SCF) value has calculated from the ratio of AADT of that year to the single cycle ADT.
- For each year SAF is determined by taking the average SCF factor of the cycles. The final SAF value is determined by taking the average values of seasonal adjustment factor calculated for each year.

The final AADT of Freight Vehicles is the product of Average Daily Traffic (ADT) (which is adjusted for week days adjustment), Night Adjustment Factor (NAF) and Seasonal Adjustment Factor (SAF).

After the final AADT of Freight Vehicles has determined the traffic composition of each entry to and leaving from Addis Ababa. The Traffic Composition is solely determined from separate counting for entering and leaving traffic at all gates by each vehicular category. Finally Directional Distribution Factor (DDF) is determined using percentage split of traffic for entry and exit at a single Gate.

From previous years and the current year data, Growth Rate and Trend Analysis have done to show the pattern of growth for Freight Traffic. The previous AADT data for 10 years that is from 2002 to 2011 taken from yearly traffic counting of the Ethiopian Roads Authority and the current year AADT that has determined by our study for each category of Freight Vehicles are taken for the analysis.

The Growth Rate at each Gate for the year is determined by the difference of the year total freight traffic with the previous year total freight traffic and divides by the previous year freight traffic. The Growth Rate is determined in percentage. The Total Growth Rate is determined by taking the average value of the Growth Rates at successive years throughout.

Trend Analysis is a graph displaying the pattern of traffic growth. Trend analysis also shows the pattern of growth is determined by a single line with a straight line equation.

At this point depending on the limitations there needs to be selection of one Major Freight Gate as the case to use for the analysis and determination of factors to fulfill the objective also answer our research questions.

Major Freight Gate is one the gate among the five gates to Addis Ababa City having higher share of Freight traffic entry to the city center.

ii. **Choice of Destination and Route Assignment for Delivery of Freight to the City Centers of Addis Ababa**

a) **Data Collection**

After determining the total freight traffic for both entering and leaving traffic, only the entering freight traffic will be considered for further analysis.

The choice of destination is mainly based on direct interview of freight operators and freight track drivers, and structural data of the Addis Ababa City which shows the location of Markets and other facilities.

From the above points outlined 5 (five) major freight destinations has identified based on sample size of 50 freight vehicles from each category with total of 200 Freight Vehicles both for Day and Night times.

The data for the Route Assignment of delivery freight to destinations is collected solely based on interviews of Freight Operators and Freight Truck Drivers with conducting cross checking at the locations. The sample of 10 Freight Vehicles from each category and for each identified 5 major destinations (without the **Destination Others**) for the Day and Night movements is taken and interviewed to determine preferred route choice to travel to a destination. Having a total sample of 400 Freight Vehicles is taken.

Considerations are mainly given for the preferred Route Choices to be on the road hierarchy of higher functional class. For our case, most of the preferred route choices taken to be Urban Arterial Road and Sub-Arterial Road having higher mobility function than accessibility.

b) Analysis Methods

After the Major 5 (five) Destination areas are clearly identified the percentage share of entered vehicles to each destination are identified. The share of also other minor destinations will be identified accordingly.

Freight Vehicle – Destination Matrix (percentage Distribution to each destination) at Day time or Night time develop using the percentage Choice share of the Destinations with the corresponding Freight Vehicle Categories. Then the share of entry freight traffic to each destination will be the product of the percentages at each destination with the vehicular category multiplied by the total entry freight traffic.

Based on the data collected on preferred Route Choice and Freight Vehicle-Destination Matrix then prepare Freight Vehicle-Route Choice Matrix. The Freight Vehicle-Route Choice Matrix determines the number of freight vehicles by each category taking the chosen route corridor to reach the proposed destinations. The length between the Freight Gates of Addis Ababa City to the proposed destinations along each route taken is mapped and measured using AutoCAD 2007 scaled map of the city. The assumption in the measurement of length of movement in urban territory is taken as the region or the area around the destination that can have more than one approach in different directions. The nearest approach along the end of the chosen route to the destination area is taken as the destination points.

After the data collected and analyzed to get the Freight Vehicle-Route Choice Matrix, there developed two scenarios:

Scenario – 1: Analysis using the existing condition

The scenario considers only using the existing real conditions of Freight movements with their time distributions.

Scenario – 2: Analysis by shifting all Freight Vehicles to Night time

The scenario considers shifting of all movements of Freight Vehicles to the Night time taking the shares taken during the data collections at the night time for Scenario-1 of preferred route.

The Freight Vehicle-Destination Matrix and Freight Vehicle-Route Choice Matrix are the basic inputs to estimate the Total Vehicle-Kilometer per day and Total Vehicle-Hour for the delivery of Freight to the City Centers of Addis Ababa.

iii. Estimation of Total Vehicle-Kilometer and Vehicle-Hour per day for Goods Distribution to City Centers of Addis Ababa

a) Data Collection

The data collected is intended to be use for:

- 1) Estimation of Total Travel Time to reach the destinations at Day and Night times separately.
- 2) Estimation of Total Passing Time taken to pass along intersections on the preferred Route to reach the Destination at the Day time window movement and Night time.
- 3) Estimation of Total Vehicle-Kilometer and Total Vehicle-Hour from the chosen Major Gate to each destination along the preferred routes for both Scenario-1 and Scenario-2.

The data for estimating Total Travel Time to reach the destinations is taken by the Data Surveyor traveling with the Freight Vehicles from the Major Gate to each Destination. This travelling together with the vehicles is done for Day time freight window movement (which is 10:00 to 12:00 AM at the morning and 4:00 to 6:00 PM at the Afternoon) and Night time (after 9:00PM). For the two cases the travelling together is done twice for each route and times of movements to the destinations mostly by Medium and Heavy Vehicles category.

The data for estimation of Total Passing Time taken to pass intersections are taken from direct measurements at each intersection. Also the measurement considers the recording of 5 (five) passing time at each intersection for each Freight Time Window movement for the Day Time (one at the morning which is 10:00 to 12:00 AM and one at the Afternoon 4:00 to 6:00 PM) and also recording of 5 (five) passing time at each intersection for the Night Time between 9:00 - 10:00 PM. For selecting intersection for considerations, the intersections are formed from adjoining major roads.

The data set that is used for estimation of Total Vehicle-Kilometer are:

- ✓ For Scenario-1: Freight Traffic counting of 2 (two) days for 24 hours, having separate summary of 12 hours of Traffic by category of Freight Vehicles at Day and Night.
- ✓ For Scenario-2: Shifting of all Freight Vehicles at single day to the Night Time
- ✓ Total length of the route with their percentage preference for each route at each destination.

The data set that is used for estimation of Total Vehicle-Hour are:

- For Scenario-1: Freight Traffic counting of 2 (two) days for 24 hours, having separate summary of 12 hours of Traffic by category of Freight Vehicles at Day and Night.
- For Scenario-2: Shifting of all Freight Vehicles Traffic at single day to the Night Time
- Total travel time to reach each destination along each route with their percentage route preference.

b) Analysis Methods

After the two data are collected for each Route to the Destinations, the average value of the two measurements for each movement at the Day and Night time is taken as the Total Travel time to the destinations.

For Scenario-1: The sum of all travel times by each category of Freight Vehicles separately at the Day and Night is taken to be the estimated Total Vehicle-Hour of freight delivery to urban center per day from the Major Gate.

For Scenario-2: The sum of all travel times by each category of the total Freight Vehicle taking at the Night time to estimate the Total Vehicle-Hour of delivery.

For estimation of Total Passing Time along each route to the destinations, after measuring, the average value of the morning and afternoon 10 (ten) recordings and also the average of 5 (five) recordings for the night are taken to be the passing time at the single intersection at each times. The passing times at each intersections is varying stochastically but here we are trying to limit this variation by only taking normal conditions of traffic without considering accident or other problems on the approach roads and at junctions.

For estimation of Total Vehicle-Kilometer takes the inputs.

Scenario-1: From the Freight Traffic, Day and Night traffic distributions which is the average percentage share of Freight Traffic for the Day and Night taken. Also the Percentage AADT traffic to each destination and within the destination the percentage Route preference by vehicular category is taken as an input.

Scenario-2: From the Freight Traffic, Night traffic which is the percentage share of Freight Traffic for the Night taken. Also the Percentage AADT traffic to each destination and within the destination the percentage Route preference by vehicular category is taken as an input.

The other input is the total length to reach each destination. After these three inputs at each Vehicular Category is assigned the product of Percentage AADT with Percentage Route Preference at Day/Night and Total Length to reach destinations result in the Total Vehicle-Kilometer. The estimation of Vehicle-Kilometer calculated separately for the Day time and Night time.

iv. Estimation of Freight Vehicles Exhaust Emission per day for Goods Distribution to City Centers of Addis Ababa

a) Data Collection

Before stating the data collection process, lets add some background concepts for measuring Freight Vehicles Exhaust Emission.

Based on their compositions or chemical natures exhaust emissions from vehicles are divided in to three categories (Mathew T.V., 2012).

- 1) Organic compounds, such as volatile organic compounds (VOCs); Paraffin; and Aromatic Compounds for example, Polycyclic Aromatic Hydrocarbons (PAHs)
- 2) Inorganic compounds, primarily CO, CO₂, NO and NO₂
- 3) Particulate Matter (PM)

The emission rate of the air pollutants is dependent on many factors including fuel type and composition, vehicle type and age, driver behavior, vehicle maintenance, and travel speed (Mathew T.V., 2012). To get representative value of measurement we need to optimize the effect

of the above factors when setting methods and conditions of measurement. Let's define each factor for our condition to optimize the effects.

Fuel type and Composition

According to pre-assessment on Freight Vehicles in the city of Addis Ababa, most of the vehicles use Diesel Fuel.

Vehicle type and Age

The data on vehicle type (for Freight Vehicles refer to the loading capacity of vehicle) and Age refers to the overall performance features of the vehicles. In our context of entry to the city for distribution, the vehicles are taken as loaded up to full capacity.

Also the Age clearly refers to the number of years from the registered manufacturing year of the vehicles to the present time. The data on Age of the Freight Vehicle is taken from Addis Ababa Road Transport Bureau Data Base based on yearly registration of vehicles and the registration of 2011/12 September is recommended by the Data Base Administrator as more stable by showing good data distributions.

Driver Behavior

The driving behavior can be taken as the driving mode of the vehicles on the road. Driving mode based on the characteristics of the driving divide in to 4 (four) modes.

1. Acceleration
2. Deceleration
3. Cruise
4. Idle

For our case, all types of modes are covered in simplified method during the measurement of exhaust emission from vehicles.

Vehicle Maintenance

Our measurement of exhaust emission is taken at Vehicles Inspection sites; the vehicles owners maintain their vehicles before heading to the sites to pass the inspections. So the vehicles that are measured for our case are maintained well.

A-1) Procedure for Conducting Exhaust Emission Measuring

With the technological advancements, there are three main means of monitoring vehicular emissions are

- 1) Tunnel testing,
- 2) Remote Sensing (typically using non-dispersive infrared and ultraviolet spectrometers) and
- 3) Direct exhaust measurements.

Since there is no tunnel in the roadway of the Addis Ababa City, Tunnel Testing is not applicable. Also Remote Sensing is not applicable due to high investment and unavailability in the country. The method applicable is Direct Exhaust measurement for the measurement of direct emission factor. Direct emission factor is the main factor in the analysis of Exhaust Emission which is measured as Tail Pipe Emissions from the burning of fuel.

According to VOLKSWAGON AG. (2006), during measurements the Driving Cycles of the vehicles is executed on the roller dynamometer or vehicles inspection spot. Based on European Standards of Driving Cycles there are two methods.



Figure 3.2: Vehicle Inspection Pit



Figure 3.3: Vehicle at the Roller Dynamometer for measurement

I. New European Driving Cycle (NECC) with 40-second Lead Time

In this type the Driving Cycle takes 40-second Lead Time before the start of the measurement. This 40-second lead time taken as the Warm-up period.

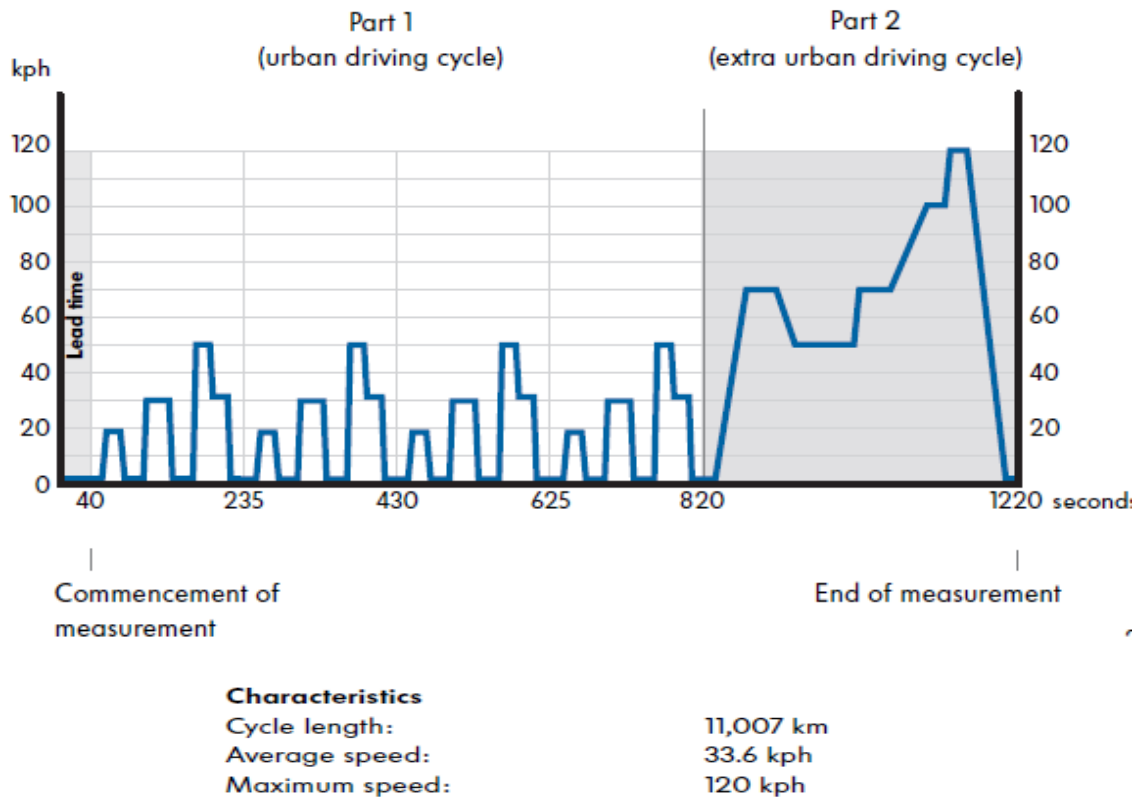


Figure 3.4: Graphical Representation of NECC with 40-seconds Lead time (Source: VOLKSWAGON AG. (2006))

II. NECC without 40-second Lead Time

The measuring cycle is started as soon as the driving cycle is started.

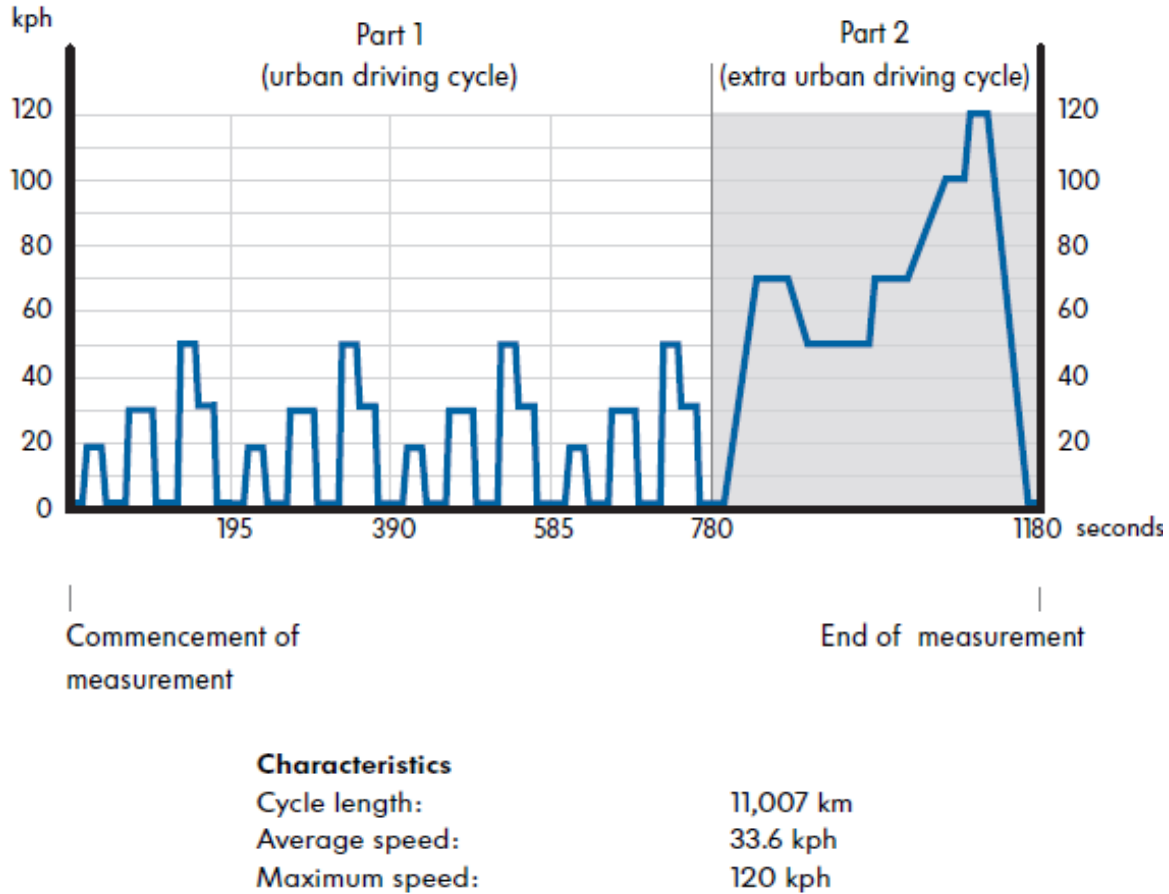


Figure 3.5: Graphical Representation of NECC without 40-seconds Lead time (Source: VOLKSWAGON AG., 2006)

From the above procedure discussed **NECC without 40-second Lead Time** is selected because of the main reason.

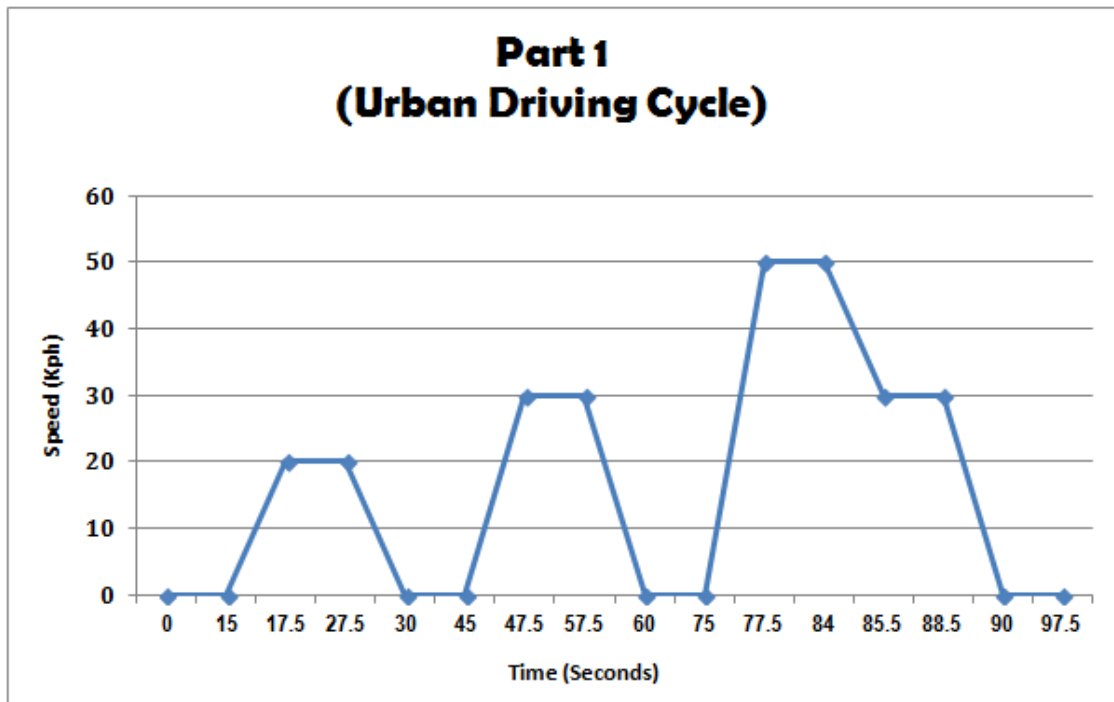
- ☞ There is no need for the vehicles to take the 40-second lead time or warm up time due to the fact that vehicles are already travelled some kilometers to reach Vehicle Inspection site.

For our case we have developed simplified procedure of Driving Cycle for Emission Measurement based on the NECC without 40-second Lead Time.

Simplified Procedure of NECC without 40-seconds Lead time

The simplification for the measurement of vehicles is required because of the reasons:

- Part 2 (extra urban driving) seems to be less important due to the reason that most of the vehicles travel in the urban area and the maximum speed is shown not to be more than 60 kph which is half of the value given.
- The time taken to conduct a Driving Cycle for measurement on a single vehicle takes about 13 minutes, which is by far larger time that will be difficult to get the willingness from owners to make the measurements at Vehicle Inspection Sites.



Cycle Length = 0.91 Km

Average Speed = 33.6 kph

Maximum Speed = 50 kph

Figure 3.6: Graphical Representation of Simplified Procedure NECC without 40-seconds Lead time

A) Analysis Method

Using the data collection method stated above, the measurement has done for two pollutants CO and CO₂. From the simplified method developed,

Cycle Length is 0.91km with Average Speed of 33.6 Kph, the measurement amount in grams of CO and CO₂ is per 0.91 km that will be change to per km amount.

The measurement for each category of Freight Vehicle and Age group taken twice and the average value will be taken as the amount of pollutant in grams per kilometer.

The estimated Total Emission (in Ton/day) for each vehicle category will be the product of the average value of emission factor using weighted values of percentage age distribution and Total Vehicle-Kilometer.

$$\text{Total Emission for Pollutant} = [[(AG1 \times EF1) + (AG2 \times EF2) + (AG3 \times EF3)]/3] \times \text{Total Vehicle-Km}/10^6$$

(Ton/day)

AG and EF are Age Group and Emission Factor from each Age group for each vehicle category.



Figure 3.7: Emission Measuring Devices

4. Results

4.1 Traffic Analysis

4.1.1 Annual Average Daily Entering and Leaving Traffic

The city of Addis Ababa is connected to other regions by 5 (Five) regional road. These connecting regional roads are named the Gates to the city. Traffic count is taken at each gate to determine the flow of Freight Vehicles to and from Addis Ababa City. According to the count, it was found that the total of **10,725 Freight Vehicles enter** and **12,890 Freight Vehicles leave** the city of Addis Ababa **on average per day**. From 10,725 Freight Vehicles Entering 6.19%, 7.71%, 9.77%, 5.90% and 70.43% are shared from gates of Ambo, Dessie, Jimma, Gojjam and Kality Gates respectively, where the vehicles of 23.55%, 27.25%, 26.31% and 22.90% share from Small Truck, Medium Truck, Heavy Truck and Truck Trailer respectively.

Also from 12,890 Fright Vehicles Leaving 6.49%, 6.04%, 6.36%, 7.23% and 73.98% are share from gates of Ambo, Dessie, Jimma, Gojjam and Kality Gates respectively, having the vehicles of 25.07%, 26.50%, 24.28% and 24.15% share from Small Truck, Medium Truck, Heavy Truck and Truck Trailer respectively. The details of Freight Traffic entered and leave by Freight Vehicle category shown with charts in **Figures 4.1, 4.2, 4.3 and 4.4**.

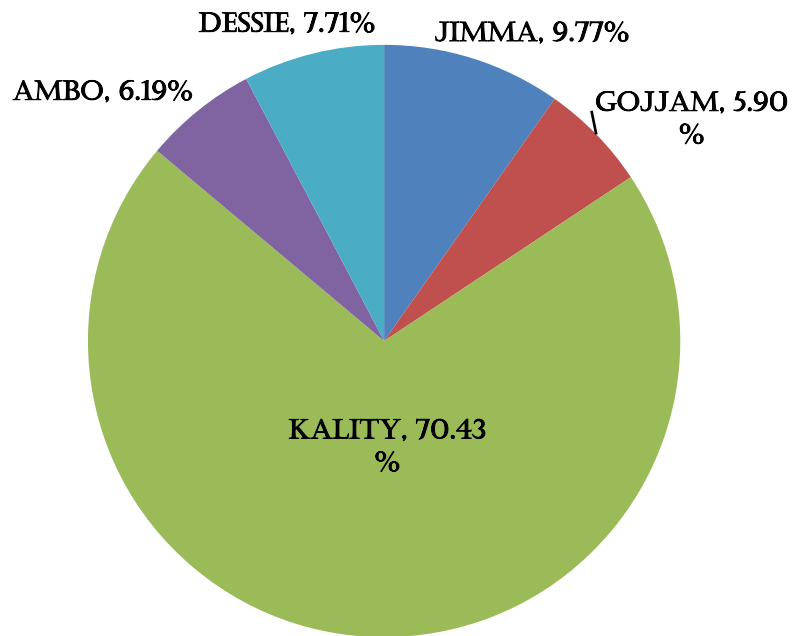


Figure 4.1: Proportion of Freight Traffic Entering to Addis Ababa (by Gate)

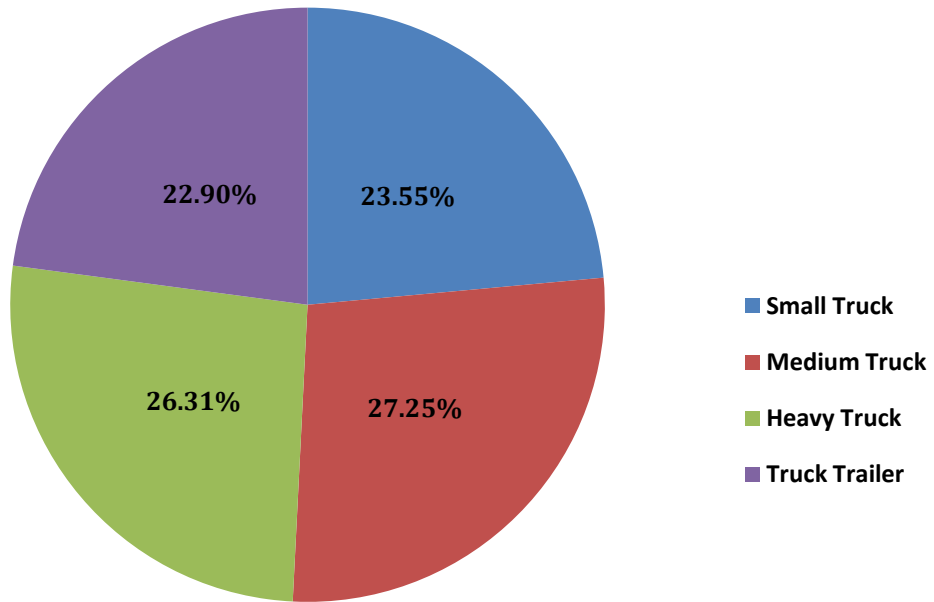


Figure 4.2: Proportion of Freight Traffic Entering Addis Ababa by Vehicluar Category

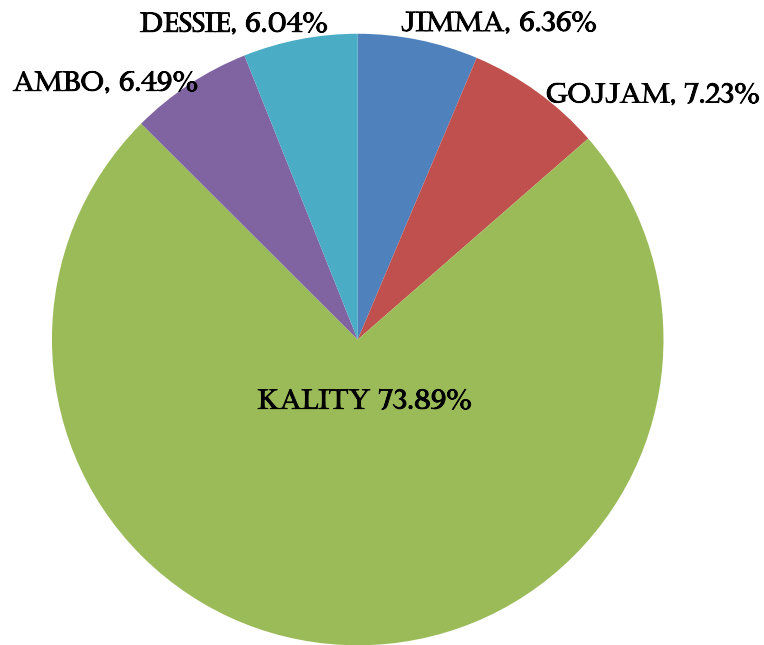


Figure 4.3: Proportion of Freight Traffic Leaving Addis Ababa (by Gate)

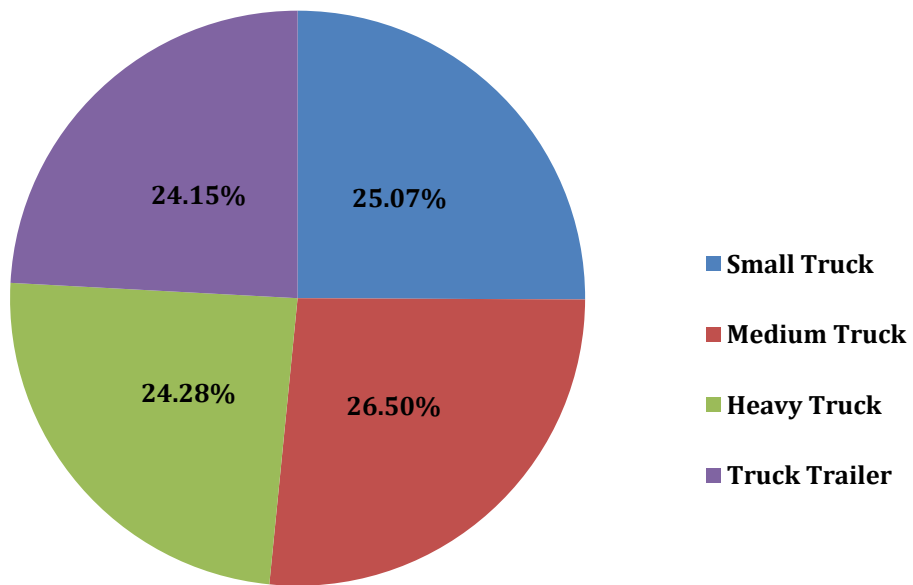


Figure 4.4: Proportion of Freight Traffic Leaving Addis Ababa by Vehicular Category

4.1.2 Directional Distribution Factor (DDF)

The directional distribution based on the directional traffic counting made at the five gates of the city of Addis Ababa is presented on **Table 4.1**.

Table 4.1: Directional Distribution Factor

| SN | GATE | Entering Traffic | Leaving Traffic | DDF (%) | |
|----|--------|------------------|-----------------|----------|---------|
| | | | | Entering | Leaving |
| 1 | Jimma | 1048 | 820 | 56.10 | 43.90 |
| 2 | Gojjam | 633 | 932 | 40.45 | 59.55 |
| 3 | Kality | 7554 | 9524 | 44.23 | 55.77 |
| 4 | Ambo | 664 | 836 | 44.27 | 55.73 |
| 5 | Dessie | 827 | 779 | 51.49 | 48.51 |

4.1.3 Trend of Total Freight Traffic Entering and Leaving

The trend in the growth of Freight Traffic Entering and Leaving the city of Addis Ababa is using the secondary data of 10(ten) years Freight Traffic AADT from Ethiopian Roads Authority (ERA) and the current year traffic counting made at each gates to the city. The results are presented using graphs by each gate in the **Figures 4.5, 4.6, 4.7, 4.8 and 4.9.**

i. Debrezeit Road at Kality Gate

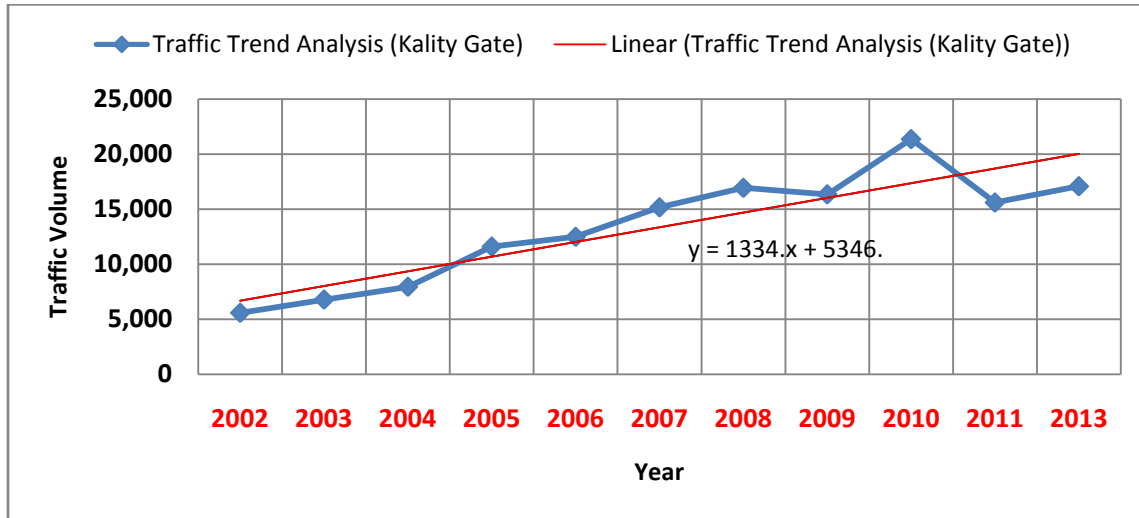


Figure 4.5: Traffic Trend Graph (Kality Gate)

ii. Ambo Gate

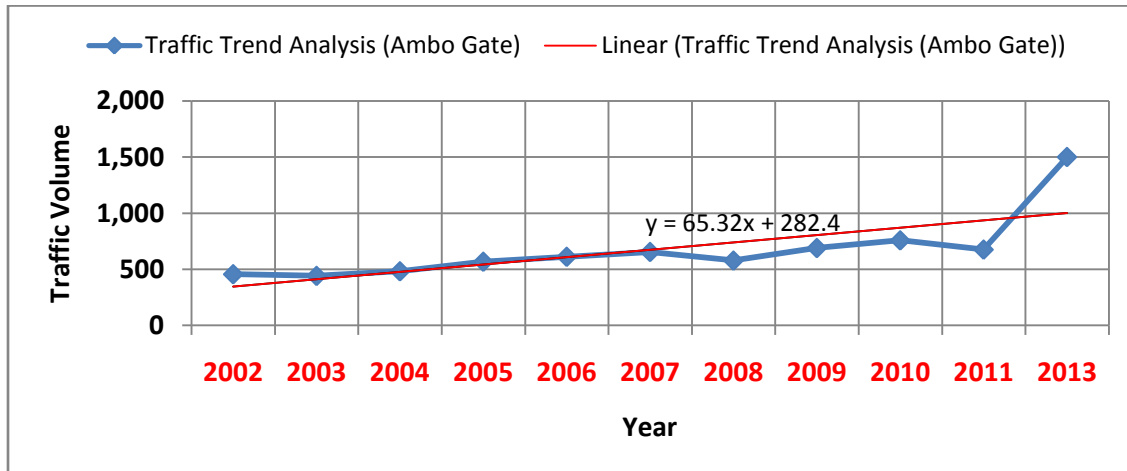


Figure 4.6: Traffic Trend Graph (Ambo Gate)

iii. Jimma Gate

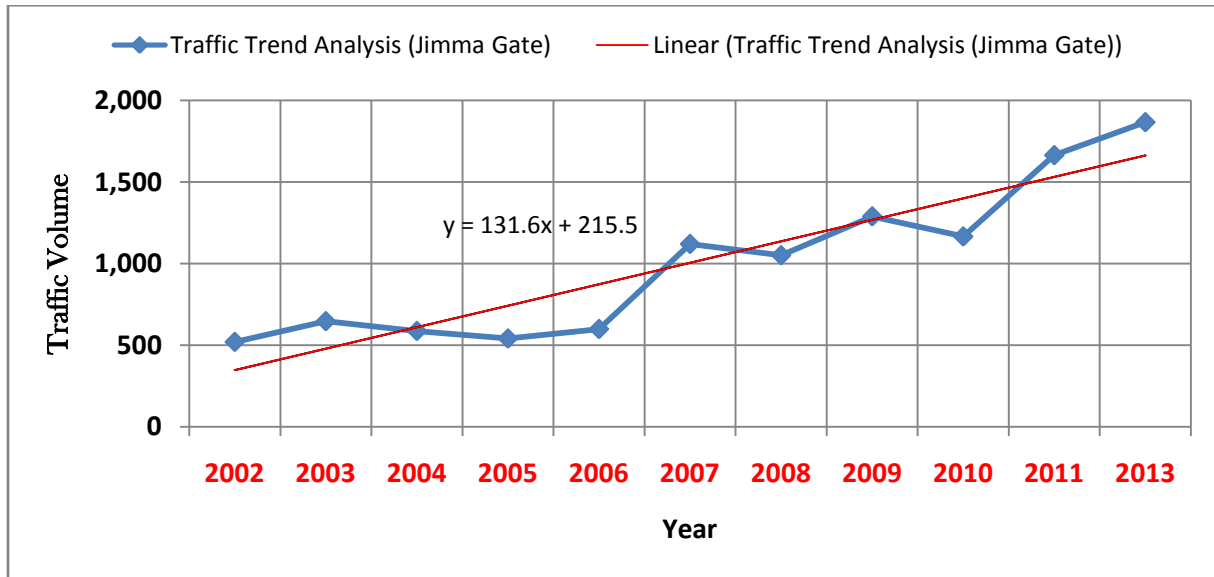


Figure 4.7: Traffic Trend Graph (Jimma Gate)

iv. Dessie Gate

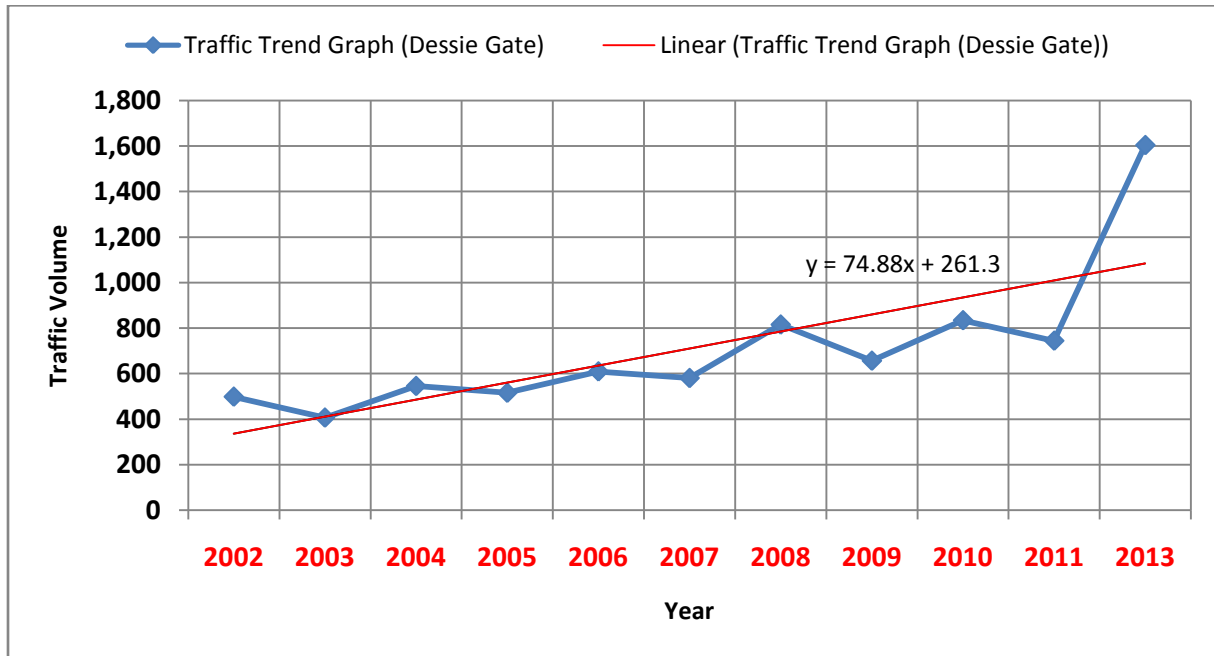


Figure 4.8: Traffic Trend Graph (Dessie Gate)

v. Gojjam Gate

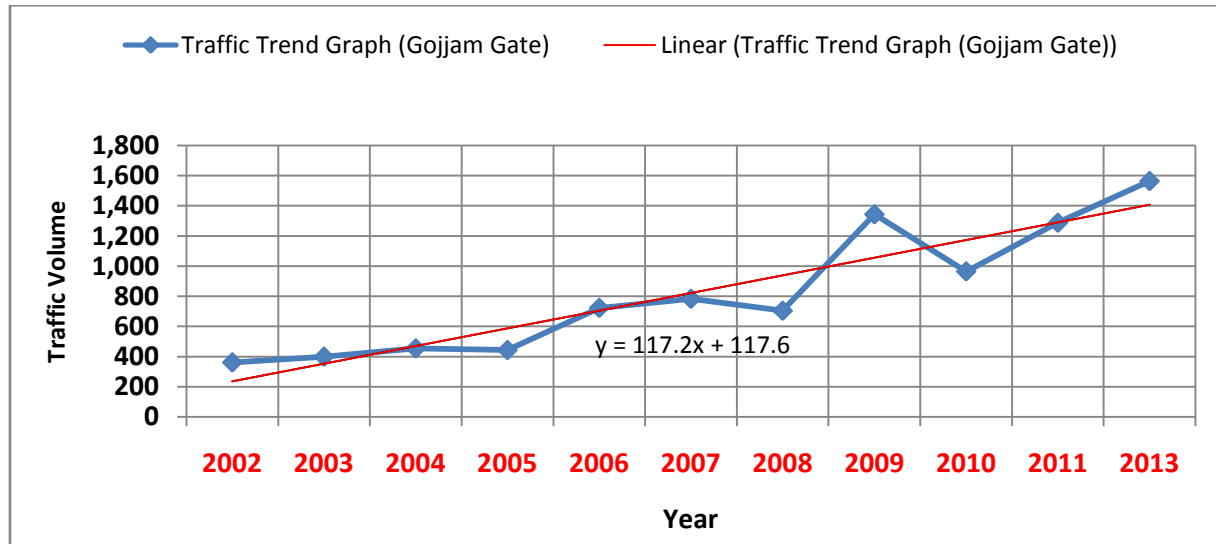


Figure 4.9: Traffic Trend Graph (Gojjam Gate)

4.1.4 Freight Traffic Growth Rate

The Annual Average Daily Traffic data of 10 years collected from Ethiopian Roads Authority and the current year data collected at each gate are used to determine the Freight Traffic Growth Rate for entering and leaving at each gate. The result is presented in **Table 4.2** below.

Table 4.2: Freight Traffic Growth for entering and leaving traffic at each Gate

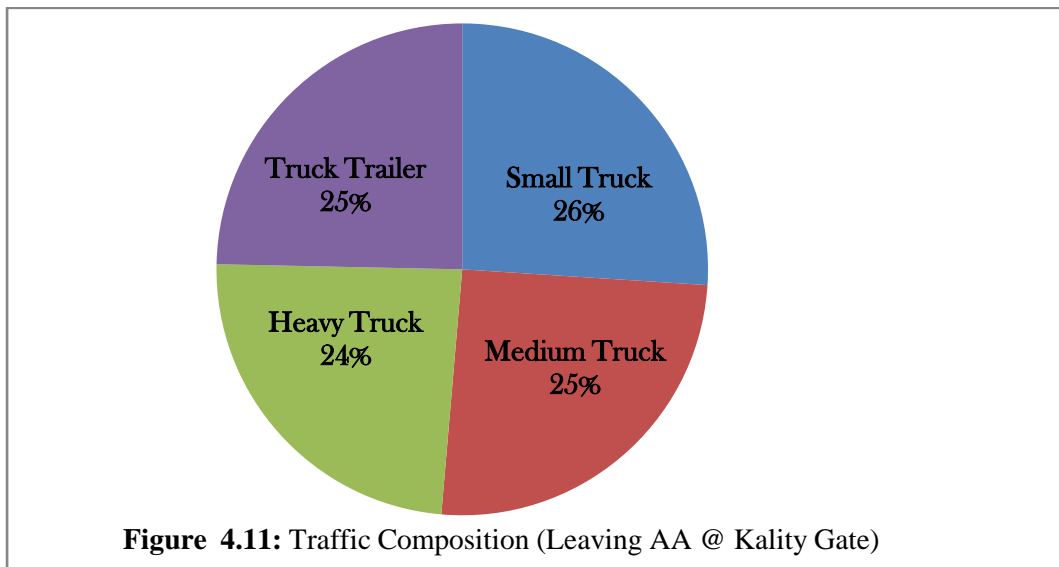
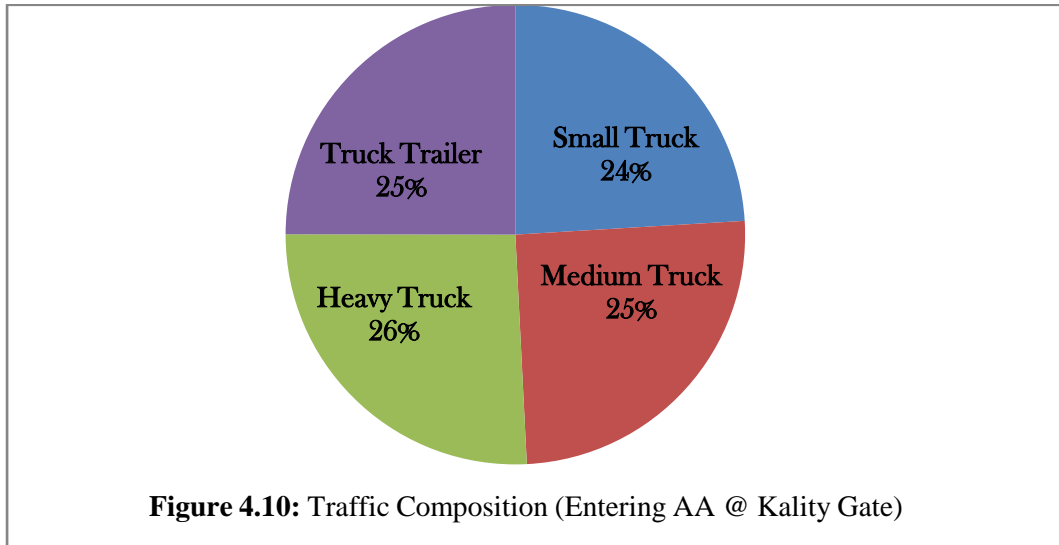
| SN. | Gate | Growth Rate (%) | Average DDF (%) | | Average Growth Rate (%) | |
|-----|--------|-----------------|-----------------|---------|-------------------------|---------|
| | | | Entering | Leaving | Entering | Leaving |
| 1 | Kality | 13.49 | 44.23 | 55.77 | 5.96 | 7.52 |
| 2 | Ambo | 16.69 | 44.27 | 55.73 | 7.39 | 9.30 |
| 3 | Jimma | 16.66 | 56.10 | 43.90 | 9.34 | 7.31 |
| 4 | Dessie | 17.64 | 51.49 | 48.51 | 9.08 | 8.56 |
| 5 | Gojjam | 20.10 | 40.45 | 59.55 | 8.13 | 11.97 |

4.2 Freight Vehicle – Destination Matrix and Freight Vehicle – Route Choice Matrix

4.2.1 Destination and Rote Choice Matrix for Major Gate of Entering

From the results of Figure 4.1 above, the shares of freight vehicles entering to Addis Ababa by gate are 70.43%, 6.19%, 7.71%, 9.77% and 5.90% on the gate of Kality, Ambo, Dessie, Jimma and Gojjam. The Major Gate chosen as defined in Chapter 3: Methodology, Section 4.1.2, Sub-section i (B), is accordingly the gate of Kality is taken as the Major Gate.

The proportion of category of Freight Vehicles entering and leaving the gates of Kality illustrated in **Figure 4.10, and 4.11**:



After taking primary data of direct interviews and secondary data of previous study and research in addition to structural data of Addis Ababa City, the analysis is carried out resulting with 6 (six) possible Freight Destinations from the gate of Kality. The list of possible Destinations with their respective notations (in bracket) is:

- 1) Kality - Gotera Major Arterials adjacent sides (**Kality G**)
- 2) Merkato Area (**M**)
- 3) Kera - Le Gare Route adjacent sides (**Kera L**)
- 4) Megenagna Area (**Meg A**)
- 5) CMC Area (**CMC**)
- 6) Other locations (**O**)

The percentage proportion of total entering Freight Traffic on the Gate of Kality to the Destinations at the Day time and Night time using 50 (fifty) vehicles from each 4 (four) vehicular category that is a total of 200 vehicles is resulted as **Freight Vehicle – Destination Matrix** for entering freight population. The results are presented in **Table 4.3 and 4.4**.

Table 4.3: Percentage Distribution of Freight Vehicles – Destination Matrix

| | | Freight Vehicle by Category | | | | |
|--------------|----------|-----------------------------|--------------|-------------|---------------|--------|
| | | Small Truck | Medium Truck | Heavy Truck | Truck Trailer | Total |
| Destinations | Kality G | 18% | 12% | 34% | 36% | 25.00% |
| | M | 48% | 52% | 28% | 26% | 38.50% |
| | Kera L | 14% | 18% | 14% | 16% | 15.50% |
| | Meg A | 10% | 8% | 12% | 12% | 10.50% |
| | CMC | 6% | 8% | 8% | 6% | 7.00% |
| | O | 4% | 2% | 4% | 4% | 3.50% |

Table 4.4: Distribution of Average Daily Freight Vehicles to Destinations

| | | Freight Vehicle by Category | | | | |
|--------------|----------|-----------------------------|--------------|-------------|---------------|-------|
| | | Small Truck | Medium Truck | Heavy Truck | Truck Trailer | Total |
| Destinations | Kality G | 327 | 228 | 663 | 679 | 1897 |
| | M | 872 | 988 | 546 | 491 | 2897 |
| | Kera L | 254 | 342 | 273 | 302 | 1171 |
| | Meg A | 182 | 152 | 234 | 226 | 794 |
| | CMC | 109 | 152 | 156 | 113 | 530 |
| | O | 73 | 38 | 78 | 75 | 264 |

For sample size of 40 Freight Vehicles from each 4 Freight Vehicular Categories for Day and Night times of movements with 5 (five) Freight Destinations, a total of 400 vehicles are surveyed. The Route Choice taken to reach each destination is presented below. The study of all 400 vehicles of the sample size is based on direct survey of using interviews of Drivers and Freight Operators. (The map showing the Preferred Route to the Destination is attached on appendix-E).

Destinations with Preferred Route Choice (**D - Destination, R - Route**)

1. Kality - Gotera Major Arterials adjacent sides (Kality G) - D1

- a) On sides of Major Arterial from Kality - Gotera (**D1-R1**)

2. Merkato Area (M) - D2

- a. Kality Interchange - Gotera Interchange - Le Gare - Piazza - Merkato (**D2-R1**)
- b. Kality Interchange - Gotera Interchange - Old Airport - Merkato (**D2-R2**)
- c. Kality Interchange - Ayertena - Old Airport - Merkato (**D2-R3**)
- d. Kality Interchange - Megenagna - Sidist Kilo - Piazza - Merkato (**D2-R4**)

3. Kera - Le Gare Route adjacent sides (Kera L) - D3

- a. Kality Interchange - Gotera Interchange - Kera - Le Gare (**D3 -R1**)
- b. Kality Interchange - Lebu (Junction before Jemo) - Kera - Le Gare (**D3-R2**)
- c. Kality Interchange - Lafto - Kera - Le Gare (**D3-R3**)

4. Megenagna Area (Meg A)

- a. Kality Interchange - Bole Airport - Megenagna (**D4 -R1**)

5. CMC Area (CMC)

- a. Kality Interchange - Bole Airport - Megenagna - CMC (**D5 -R1**)
- b. Kality Interchange - Bole Airport - Gerji (by turning on the Ring road before reaching Megenaga) - Gurd Shola (Sehalite Mihret Church) - CMC (**D5 -R2**)

From the above Routes to the destinations, the results of the analysis are presented below.

a) To Destination D1

All the Freight Vehicles are moving on one road which is D1-R1 having 100% shares of all the vehicles moving to destination D1 for both Scenario-1 and Scenrio-2.

b) To Destination D2

For Route Choice to reach destination D2, the results of Percentage preference presented in **Table 4.5 and 4.6.**

Table 4.5: Route Choice to Destination D2 at Day time

| % Route Preference | | | | | |
|-----------------------------|--------------|------------------|--------------------|------------------|--------------------|
| Destination D2 (M) | | | Time: - Day | | |
| Freight Vehicle Mode | | | | | |
| Route Choice | | Small Tr. | Medium Tr. | Heavy Tr. | Tr. Trailer |
| | D2-R1 | 20% | 10% | 10% | 0% |
| | D2-R2 | 30% | 20% | 30% | 20% |
| | D2-R3 | 40% | 50% | 40% | 60% |
| | D2-R4 | 10% | 20% | 20% | 20% |
| | Total | 100% | 100% | 100% | 100% |

Table 4.6: Route Choice to Destination D2 at Night time

| % Route Preference | | | | | |
|-----------------------------|--------------|------------------|----------------------|------------------|--------------------|
| Destination D2 (M) | | | Time: - Night | | |
| Freight Vehicle Mode | | | | | |
| Route Choice | | Small Tr. | Medium Tr. | Heavy Tr. | Tr. Trailer |
| | D2-R1 | 60% | 50% | 50% | 30% |
| | D2-R2 | 20% | 20% | 10% | 0% |
| | D2-R3 | 0% | 10% | 10% | 30% |
| | D2-R4 | 20% | 20% | 30% | 40% |
| | Total | 100% | 100% | 100% | 100% |

c) To Destination D3

For Route Choice to reach destination D3, the results of Percentage preference presented in **Table 4.7 and 4.8.**

Table 4.7: Route Choice to Destination D3 at Day time

| % Route Preference | | | | | |
|--------------------------------|--------------|------------------|--------------------|------------------|--------------------|
| Destination D3 (Kera L) | | | Time: - Day | | |
| Freight Vehicle Mode | | | | | |
| Route Choice | | Small Tr. | Medium Tr. | Heavy Tr. | Tr. Trailer |
| | D3-R1 | 20% | 10% | 10% | 0% |
| | D3-R2 | 40% | 60% | 50% | 60% |
| | D3-R3 | 40% | 30% | 40% | 40% |
| | Total | 100% | 100% | 100% | 100% |

Table 4.8: Route Choice to Destination D3 at Night time

| % Route Preference | | | | | |
|--------------------------------|--------------|------------------|----------------------|------------------|--------------------|
| Destination D3 (Kera L) | | | Time: - Night | | |
| Freight Vehicle Mode | | | | | |
| Route Choice | | Small Tr. | Medium Tr. | Heavy Tr. | Tr. Trailer |
| | D3-R1 | 70% | 80% | 70% | 60% |
| | D3-R2 | 20% | 10% | 20% | 30% |
| | D3-R3 | 10% | 10% | 10% | 10% |
| | Total | 100% | 100% | 100% | 100% |

d) To Destination D4

All the Freight Vehicles are moving on one road which D4-R1 having 100% shares of all the vehicles moving to destination D4 at both Scenario-1 and Scenario-2. Most of the road section is passing through the Ring Road.

e) To Destination D5

For Route Choice to reach destination D5, the results of Percentage preference presented in Table 4.9 and 4.10.

Table 4.9: Route Choice to Destination D5 at Day time

| % Route Preference | | | | | |
|-----------------------------|--------------|------------------|--------------------|------------------|--------------------|
| Destination D5 (CMC) | | | Time: - Day | | |
| Freight Vehicle Mode | | | | | |
| Route Choice | | Small Tr. | Medium Tr. | Heavy Tr. | Tr. Trailer |
| | D5-R1 | 60% | 50% | 40% | 30% |
| | D5-R2 | 40% | 50% | 60% | 70% |
| | Total | 100% | 100% | 100% | 100% |

Table 4.10: Route Choice to Destination D5 at Night time

| Destination D5 (CMC) | | | Time: - Night | | |
|-----------------------------|--------------|------------------|----------------------|------------------|--------------------|
| Freight Vehicle Mode | | | | | |
| Route Choice | | Small Tr. | Medium Tr. | Heavy Tr. | Tr. Trailer |
| | D5-R1 | 50% | 60% | 70% | 80% |
| | D5-R2 | 50% | 40% | 30% | 20% |
| | Total | 100% | 100% | 100% | 100% |

4.2.2 Total Travelling Time on the Routes and Passing time at Major Intersections

The total travelling time from the Major Freight Gate of Kality to each Destination along the preferred Routes in Day time and Night time separately with passing time at intersections along the Routes is presented in Annex-G. The result for total traveling time at the Night have average percentage values of 60.92%, 62.23%, 69.73%, 61.90% and 63.78% of the time taken during Day time to Destinations D1, D2, D3, D4 and D5 respectively.

The time taken to pass all the intersections along the preferred route to the destination at Night time has taken average percentage values of 23.52%, 28.43%, 28.13%, 17.65% and 21% of the time taken at the Day time to Destinations D1, D2, D3, D4 and D5 respectively.

4.3 ESTIMATIONS OF VEHICLE – KILOMETER, VEHICLE – HOUR AND EXHAUST EMISSION

4.3.1 Estimation of Total Vehicle– Kilometer for delivery from Kality Gate to Freight Destinations

After taking the input values of

- Calculated AADT for the current year
- 2 day 24 hours total traffic with their percentage distribution at the Day and Night time for Scenario -1 and also considering the whole AADT shifted to Night Traffic for Scenario -2
- Percentage Route Choice to Destination
- Total Length from the gate of Kality to each Freight Destinations

The values of estimated Vehicle-Kilometer have calculated using the method stated in the Methodology part. The results of the calculation for each Route and Destination for each Day and Night times are attached in Annex-H. The summary of the result Vehicle-Kilometer for each Vehicle category and Destinations at the Day and Night times for Scenario -1 is presented in **Table 4.11** and Scenario-2 is presented in **Table 4.12**.

Table 4.11: Total Vehicle-Kilometer from Kality Gate to Destinations (Scenario – 1)

| Freight Dest. Zones | Time of Day | Vehicle Category | | | | Total | Percentage Share | Night as % of Day |
|--|-------------|------------------|------------------|------------------|------------------|-------------------|------------------|-------------------|
| | | Small Truck | Medium Truck | Heavy Truck | Truck Trailer | | | |
| D1 | Day | 5,076.05 | 3,505.99 | 10,272.12 | 10,545.90 | 29,400.07 | 17.04% | 6.55% |
| | Night | 321.68 | 259.56 | 677.45 | 667.17 | 1,925.86 | | |
| D2 | Day | 23,595.19 | 27,776.47 | 15,243.31 | 14,302.94 | 80,917.91 | 46.72% | 6.16% |
| | Night | 1,355.58 | 1,833.22 | 929.14 | 867.41 | 4,985.34 | | |
| D3 | Day | 6,266.17 | 8,531.28 | 6,874.60 | 7,796.83 | 29,468.88 | 16.94% | 5.71% |
| | Night | 347.05 | 525.20 | 386.93 | 422.62 | 1,681.80 | | |
| D4 | Day | 4,097.67 | 3,396.27 | 5,268.00 | 5,107.94 | 17,869.88 | 10.36% | 6.61% |
| | Night | 259.68 | 251.44 | 347.43 | 323.14 | 1,181.69 | | |
| D5 | Day | 3,202.84 | 4,399.30 | 4,523.29 | 3,270.55 | 15,395.99 | 8.94% | 6.79% |
| | Night | 201.82 | 327.55 | 303.44 | 212.87 | 1,045.68 | | |
| Total Vehicle-Kilometer (Day) | | 42,237.93 | 47,609.33 | 42,181.32 | 41,024.15 | 173,052.74 | | 6.25% |
| Total Vehicle-Kilometer (Night) | | 2,485.81 | 3,196.98 | 2,644.39 | 2,493.20 | 10,820.38 | | |
| Total Vehicle-Kilometer | | 44,723.75 | 50,806.31 | 44,825.71 | 43,517.35 | 183873.11 | | |

Table 4.12: Total Vehicle-Kilometer from Kality Gate to Destinations (Scenario – 2)

| Freight Destination Zones | Time of Day | Vehicle Category | | | | Total |
|--|--------------|------------------|------------------|------------------|------------------|-------------------|
| | | Small Truck | Medium Truck | Heavy Truck | Truck Trailer | |
| D1 | Night | 5,397.74 | 3,765.55 | 10,949.57 | 11,213.07 | 31,325.93 |
| D2 | | 22,746.13 | 26,595.10 | 15,017.54 | 14,578.46 | 78,937.22 |
| D3 | | 5,823.37 | 7,619.26 | 6,253.94 | 7,102.89 | 26,799.47 |
| D4 | | 4,357.35 | 3,647.71 | 5,615.43 | 5,431.08 | 19,051.57 |
| D5 | | 3,386.53 | 4,751.91 | 4,904.47 | 3,577.63 | 16,620.54 |
| Total Vehicle-Kilometer (Night) | | 41,711.11 | 46,379.54 | 42,740.95 | 41,903.14 | 172,734.74 |
| Total Vehicle-Kilometer | | 41,711.11 | 46,379.54 | 42,740.95 | 41,903.14 | 172,734.74 |

4.3.2 Estimation of Total Vehicle– Hour for delivery from Kality Gate to Freight Destinations

After taking the input values of

- Calculated AADT for the current year
- 2 day 24 hours total traffic with their percentage distribution at the Day and Night time for **Scenario -1** and also considering the whole AADT shifted to Night Traffic for **Scenario -2**.
- Percentage Route Choice to Destination
- Total Travel Time from the gate of Kality to each Freight Destinations

The values of estimated Vehicle-Hour have calculated using the method stated in the Methodology part. The results of the calculation for each Route and Destination for each Day and Night times are attached in Annex-H. The summary of the result Vehicle-Hour for each Vehicle category and Destinations for **Scenario-1 (Day and Night times)** is presented in **Table 4.13** and for **Scenario-2 (Night time)** is presented in **Table 4.14** (Shifting to Night time).

Table 4.13: Total Vehicle-Hour from Kality Gate to Destinations (Scenario – 1)

| Freight Dest. Zones | Time of Day | Vehicle Category | | | | Total | % Share | Night as % of Day |
|----------------------------|-------------|------------------|-----------------|-----------------|-----------------|-----------------|---------|-------------------|
| | | Small Truck | Medium Truck | Heavy Truck | Truck Trailer | | | |
| D1 | Day | 202.30 | 139.73 | 409.39 | 420.30 | 1,171.73 | 17.96% | 3.99% |
| | Night | 7.81 | 6.30 | 16.45 | 16.20 | 46.76 | | |
| D2 | Day | 933.67 | 1,066.21 | 595.62 | 523.62 | 3,119.13 | 47.97% | 4.34% |
| | Night | 37.37 | 49.47 | 25.40 | 23.09 | 135.34 | | |
| D3 | Day | 284.25 | 388.93 | 311.49 | 352.88 | 1,337.56 | 20.55% | 4.23% |
| | Night | 11.67 | 17.80 | 13.01 | 14.11 | 56.59 | | |
| D4 | Day | 68.29 | 56.60 | 87.80 | 85.13 | 297.83 | 4.68% | 6.61% |
| | Night | 4.33 | 4.19 | 5.79 | 5.39 | 19.69 | | |
| D5 | Day | 117.83 | 163.61 | 170.06 | 124.30 | 575.79 | 8.85% | 4.26% |
| | Night | 4.78 | 7.71 | 7.10 | 4.94 | 24.54 | | |
| Total Vehicle-Hour (Day) | | 1,606.35 | 1,815.09 | 1,574.36 | 1,506.24 | 6,502.04 | | 4.35% |
| Total Vehicle-Hour (Night) | | 65.96 | 85.48 | 67.75 | 63.73 | 282.91 | | |
| Total Vehicle-Hour | | 1,672.31 | 1,900.57 | 1,642.11 | 1,569.96 | | | |
| | | 6784.96 | | | | | | |

Table 4.14: Total Vehicle-Hour from Kality Gate to Destinations (Scenario – 2)

| Freight Dest. Zones | Time of Day | Vehicle Category | | | | Total |
|-----------------------------------|--------------|------------------|-----------------|-----------------|-----------------|-----------------|
| | | Small Truck | Medium Truck | Heavy Truck | Truck Trailer | |
| D1 | Night | 131.05 | 91.42 | 265.84 | 272.23 | 760.54 |
| D2 | | 627.02 | 717.73 | 410.58 | 388.14 | 2,143.48 |
| D3 | | 195.82 | 258.23 | 210.30 | 237.07 | 901.43 |
| D4 | | 72.62 | 60.80 | 93.59 | 90.52 | 317.53 |
| D5 | | 80.29 | 111.88 | 114.68 | 83.08 | 389.94 |
| Total Vehicle-Hour (Night) | | 1,106.81 | 1,240.06 | 1,095.00 | 1,071.05 | 4,512.92 |
| Total Vehicle-Hour | | 1,106.81 | 1,240.06 | 1,095.00 | 1,071.05 | 4512.92 |

The comparison for the movement at the Day and Night time using Total Vehicle – Hour and Total Vehicle – Kilometer is presented in **Table 4.15**. The table showed the variation of the amount for the number of hours and kilometers at each Day and Night time separately for delivery of goods using a single Freight Vehicle.

Table 4.15: Comparison of Scenario – 1 (Day and Night) and Scenario – 2 (Night) delivery

| Scenario | Time of Day | Total No. of Freight Vehicles | Total Vehicle - Hour | Total Vehicle - Kilometer |
|-------------------|--------------|-------------------------------|----------------------|---------------------------|
| Scenario 1 | Day | 7082 | 6502.04 | 173,052.74 |
| | Per Vehicle | | 0.918 | 24.436 |
| | Night | 472 | 282.91 | 10,820.38 |
| | Per Vehicle | | 0.599 | 22.925 |
| Scenario 2 | Night | 7554 | 4512.92 | 172,734.74 |
| | Per Vehicle | | 0.597 | 22.867 |

4.3.3 Estimation of Exhaust Emission

After taking the input values of

- ☞ Estimated Vehicle-Kilometer by each category of Freight Vehicle at Day and Night separately for Scenario-1 and only Night time for Scenario-2.
- ☞ The weighted average value of emission factor measured for each age group and vehicle category

The estimated values of Exhaust Emission (in Ton/day) is the product of the above two inputs. The results of the estimation for each Freight Vehicle Category at Scenario-1 and Scenario-2 attached in Annex-I.

Scenario-1

The estimated total exhaust emission of CO₂ for the Day time is 32.59 ton/day and for the Night time is 4.26 ton/day. Also the estimated total exhaust emission of CO for the Day time is 88.9Kg/day and for the Night time is 12Kg/day.

Scenario-2

The estimated total exhaust emission of CO₂ is 29.18 ton/day and total exhaust emission of CO is 90Kg/day.

5. DISCUSSION

5.1 Freight Traffic Analysis

The Annual Average Daily Traffic (AADT) for Freight Vehicles 10,725 entering and 12,890 leaving the city the Gate of Kality (Debrezeit) is the highest by taking the share of 70.43% entering and 73.98% leaving Freight Vehicles which has taken to be the Major Gate for further analysis. These showed that Freight Activity of import and export are mainly take place through the port of Djibouti and the Gate also connected to the regions of the Southern Ethiopia.

The trend in Freight Traffic growth over the year, the total trend at each gate showed the increasing trend. The growth over some years shows increasing and decreasing but overall trend of traffic showed increase. These increase in trend implied that there is a growth in business activity of the country inside and outside, and also the increase in sectors of construction, trade and Industry growth over the years.

The Major gate of Kality showed smaller growth rate of 13.49% when compared to other 4 (four) gates of the city with 16.69% of Ambo, 16.66% of Jimma, 17.64% of Dessie, 20.10% of Gojjam. The smaller growth of Freight Traffic in this Major Gate even implied that higher growth in number of Freight Vehicles with its most of shares of Freight Traffic. **For example**, the 1% percentage growth of Freight Traffic at Kality Gate is much more than growth rate at Gojjam Gate (which is the Gate with highest growth rate). A 1% of AADT growth at Kality means 171 Freight Vehicles and at Gojjam Gate means 16 Freight Vehicles.

The Major Gate of Kality (Debrezeit) has selected as a Major Gate and the entering freight distribution to the city centers impacts are taken for further analysis. From the selected destinations **Merkato (D2)** has attracted the highest share of entering Freight Traffic with 2,897 vehicles with percentage of 38.5% and the least is the **Destination-Others** with 264 vehicles with percentage of 3.5%. The Merkato Area has attracted much of the entering Freight Vehicles since the area is the biggest market center in the Country and even in Africa. The other destinations have attracted 25%, 15.5%, 10.5% and 7% at Kality-Gotera, Kera-Le Gare, Megenagna Area and CMC Area respectively. The higher percentage at Kality-Gotera is due to the area is the location of Industry Zones that the raw materials for production are transported

from the Djibouti Port. The other share of 15.5% from the destination of Kera-Le Gare might be the area is known with its market of Vehicles Spare Parts and Garages.

For the separate consideration of Day and Night time movements on the analysis, separate study of the preferred Route Choice to the Destinations at each times have considered. For the day movements to skip the congested traffic at city centers most of Freight Vehicles use via the Ring Roads. The Night movements from the Gate of Kality to the destinations mainly focus on using the shortest possible route to reach the destinations. **For example**, to reach Destination D2-Merkato Area, take Routes **D2-R1 (which is passing through the city center)** and **D2-R3 (entirely on the Ring Road)** with length of 23.38 and 31.57 Kilometers respectively.

At the Day time, **Route D2-R1** have 20%, 10%, 10% and 0% preference route choice from Small Trucks, Medium Trucks, Heavy Truck and Truck Trailer respectively, but at the Night time the route has 60%, 50%, 50% and 30% preference route choice from Small Trucks, Medium Trucks, Heavy Truck and Truck Trailer respectively, which showed the increased preference at the Night time.

At the Day time, **Route D2-R3** have 40%, 50%, 40% and 60% preference route choice from Small Trucks, Medium Trucks, Heavy Truck and Truck Trailer respectively, but at the Night time the route has 0%, 10%, 10% and 30% preference route choice from Small Trucks, Medium Trucks, Heavy Truck and Truck Trailer respectively. The longer length of this route not much favored at the Day time for the preference by the operators.

The total travel time taken to reach the destinations at the Night time is much less than the total travel time elapsed at the Day time to reach the same destination. The travelling time at the Night only taken 60 – 70% of the time taken to reach the destinations at the Day time. Also the Total Passing Time at major junctions at the Night time only 17.65 - 28.43% of the Total Passing Time taken at the Day time.

The above points mainly shows there is a considerable traffic problems at the Day time on the junctions and also on the route segments. I think the traffic problem mainly arise due to lack of planning and managements at the junctions and the lack of alternative routes in the traffic

network, also free movement of Freight Vehicles inside the urban territory at time window movements resulting in congestion to the junctions (intersections) and urban route segments.

5.2 Estimation of Vehicle-Hour and Vehicle-Kilometer, Exhaust Emission of Freight Vehicles

The total estimated Vehicle-Hour from the Major Gate of Kality to the Destinations for distribution of Freight is 6,784.96 Vehicle-Hours per day for Scenario-1 and 4,512.92 Vehicle-Hours per day for Scenario-2. For Scenario-1, among all Destinations the highest percentage share of 47.97% to the **Destination D2- Merkato Area** and lowest share of 4.68% to **Destination D4- Megegnagna Area**. Since Vehicle-Hour is the time spent to reach the destination along the preferred route, the Night movements are good in reducing the time elapsed to reach the same destination than the Day time window movements of Freight. **For example**, the movement to reach **Destination D2** along the route **D2-R1** has taken average time of about 76.15 minutes at the Day and only 39.43 minute at the Night which is nearly half of the time at the Day time movement. From the overall result, the Night time accounted 4 - 6.61% of the Day time which is very low.

The total estimated Vehicle-Kilometer from the major Gate of Kality to the Destinations for the distribution of Freight to the City Centers were 183,873.11 Vehicle-Kilometer per day for Scenario-1 and 172,734.74 Vehicle-Kilometer per day for Scenario-2, the highest share of 46.72% and 45.70% was the Vehicle-Kilometer contribution of delivery for Scenario-1 and Scenario-2 respectively to **Destination D2- Merkato Area** and the least share of 8.94% and 9.62% for delivery to **Destination D5- CMC Area** for Scenario-1 and Scenario-2 respectively. Mainly the reason for **Destination-D2** was that the area is the largest marketing and trading activity center for the City and at large for the country. When there is increase in Vehicle-Kilometer for the delivery of Freight in the urban territory, the direct impacts of environmental degradation and inefficiency of Freight Operations will increase. I think to reduce this effects the operation at Night time rather than Day time window movement were preferable for Freight delivery to city centers. To reach to the same destination, Freight Vehicle Operators and Drivers

prefers longer Kilometer route but less traffic route like the Ring Road at the Day time to skip the congestions at the shortest routes passing along the City Centers which the Night time movements smoothly takes place. From the result shows that, for a single Freight Vehicle to deliver goods need an average of 0.92 hour and 24.44 kilometer at the Day time which was much higher compared to 0.60 hour and 22.92 kilometer at the Night time.

The problem of choice of longer Route to skip the congested short paths might be solved using implementation of coordinated City Logistics Systems and use of Advanced Information System incorporating real time information on the traffic conditions of the city.

These two estimated factors Vehicle-Kilometer and Vehicle-Hour are one or the other way directly linked with the amount of exhaust emission of Freight Vehicles. These means higher values of these factors showed higher operation time of the Freight Vehicles which resulted in higher exhaust emissions of gases in to the atmospheric air.

For Scenario-1

Everyday estimated amount of 36.84 tons per day of CO₂ and 100 Kilogram per day of CO pollutant gases are released to the atmosphere of Addis Ababa City. The exhaust emission has share of 12% for Night movement and 88% for the Day time movement. These higher differences on exhaust emission percentage share showed most of the movements of Freight Vehicles were takes place at the Day time.

For Scenario-2

Everyday estimated amount of 29.18 tons per day of CO₂ and 90 Kilogram per day of CO pollutant gases are released to the atmosphere of Addis Ababa City. The exhaust emission has reduced 7.66 tons of CO₂ and 10 Kilogram CO per day compared to Scenario-1. These higher differences on exhaust emission percentage share showed most of the movements of Freight Vehicles were takes place at the Day time.

I think the absence and poor implementation of the concept of optimized freight delivery and coordinated logistics system of the city allowed more unnecessary extra Vehicle-Kilometer,

Vehicle-Hour and also extra grams of exhaust emission during freight delivery to the City Centers of Addis Ababa at the Day time.

Also the Age of vehicles have direct effect on the exhaust emission, as the Age of Vehicle goes higher, then the amount of gases released from the vehicle increase. For example, from our direct measurement the release of CO gas for Truck Trailer of age less than 5 (five) years were 1.14 grams per vehicle-kilometer and for age of greater than 15 (fifteen) years were 3.26 grams per vehicle-kilometer. This factor implied that the use of older Freight Vehicles rather than new Freight Vehicle for Freight transportation have increased the release of gases by more than twice. From the Total Freight Vehicles population registered about 45% are older than 15 (fifteen) years. I believe this might be the result of the lack of policies on vehicles replacement and lack of encouragement from the Government on the use of newer Freight Vehicles.

6. CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

Based on the analysis and the results of this study, the following points can be concluded:

1. From the analysis and the result the Urban Freight delivery of Goods will show significant increase in the future.
2. Among all the gates of Addis Ababa, the Kality (Debrezeit) gate has taken the largest share of entry and exit Freight Vehicular Traffic.
3. Most of the Freight Vehicles for delivery of Goods prefer to use Ring Roads at the Day time window movement and shorter routes passing through the city centers at the Night time.
4. In delivering Goods to the City Centers of Addis Ababa, the Night time delivery has saved an average of 0.32 Vehicle-hour and 1.52 Vehicle-kilometer compared to Day time window delivery on a single delivery operation with a Freight Vehicle.
5. The Shifting of all delivery operations to the Night time has a total saving of 11,138.37 Vehicle-Kilometer and 2,272.04 Vehicle-Hour for delivery at each day, with exhaust emission saving of 7.66 tons of CO₂ and 10 Kg of CO.
6. The movement of Freight Vehicles in the city centers at the Day time has contributed to delay and congestion at intersections and urban roads.
7. Little attention has given to the Age of Freight Vehicles, especially to vehicle category of Truck Trailer or Articulate Truck with the majority of the vehicles was very old and has contributed most of pollutant emission gases.
8. The concern for environmental degradation due to vehicular emission is quite poor.
9. City Logistics measures can give efficient solutions to the problems of Urban Freight Transport.

6.2 RECOMMENDATIONS

The recent growth of economic activity of the country mainly in the sectors of Agriculture and Industry necessitates demand for transportations for exports and import activities. As a result the amount of freight entering and leaving the city of Addis Ababa is increasing. These increase in freight movement affecting the livability of the city and impacting the environment negatively.

To achieve better and efficient Urban Freight Transport in sustainable way, I suggest the following:

- ✚ Night delivery system is a solution to the current Addis Ababa Urban Freight Transport problems which can be implemented easily with policies and saves the problems.
- ✚ Deconsolidation of the main market center of Addis Ababa can be one of solutions related to land use. Mainly the deconsolidation of Merkato market to other nearby locations to the Gate of Kality (Debrezeit), in order to make it near to the main Gate of the city from port of Djibouti.
- ✚ The development of the culture for measuring, registering and storing of many different parameters related to transport accompanied with proper database management system is very important for decision making at any level and conducting researches.
- ✚ Conducting detailed, relevant to the current conditions and progressive Researches regarding City Logistics is very much important. The Researches conducted should be used as a basis by transport planners, policy makers and decisions at any level.
- ✚ Implementation of vehicle replacement policy on Freight Vehicles has huge ability to reduce the environmental impacts and improve the efficiency of operations. These can be better accompanying by vehicles using alternative fuel system like hybrid vehicles and electronic vehicles for urban delivery of Goods.
- ✚ Corporation between all actors/stakeholders of the City Logistics can improve efficiency to the Urban Freight delivery.

REFERENCES

- Ramokgopa, L.N, 2004. *City Logistics: Changing How We Supply*. Proceeding of the 23rd Southern African Transport Conference (SATC 2004). pp 694 - 702
- Taniguchi, Eiichi, Thompson, Russell G. (Eds.), 2004. *Logistics Systems for Sustainable Cities*. Proceedings of the 3rd International Conference on City Logistics June 2003. Elsevier p-1132
- Girma Berhanu, 2000. *Effects of Road and Traffic Factors on Road Safety in Ethiopia*. Trodhium, Norway 2000.
- Faisal Shahzad and Fotabi Mathias Tenti, 2009. *Efficient Distribution Systems for Goods to The City Center*. University of Gothenburg, Masters Degree Project No. 2009:46
- Consulting Engineering Services (India) Pvt.Ltd in Association with SABA Engineering, 2005. *Urban Transport Study and Preparation of Pilot Project for Addis Ababa*. Urban Transport Study and Preparation of Pilot Project for Addis Ababa, Final Report. December 2005
- Dr. Laetitia Dablanc and Dr. Jean-Paul Rodrigue, 2009. *Freight Transport, A key for the New Urban Economy*. World Bank, Freight Transport for Development
- Bemnet Aschenaki and Karim El Aynaoui, 2004. *Transport Costs in Ethiopia: An Impediment to Exports?* a background study for the World Bank's FY04 Country Economic Memorandum for Ethiopia. March 2004
- Michael A P Taylor, 2006. *The City Logistics paradigm for urban freight transport*. University of South Australia, Transport Systems Center. Infrastructure, pp 1-19
- DG MOVE European Commission, 2012. *Study on Urban Freight Transport*. Final Report by MDS Transmodal Limited in association with CTL, April 2012.
- NICHES, 2011. *Innovative Approaches in City Logistics: Inner-city Night Delivery*, Manual on Night Delivery Systems 2011

Organization for Economic Cooperation and Development (OECD), 2003. *Delivering the Goods: 21st Century Challenges to Urban Goods Transport*. OECD Publications 2

Nikolas Geroliminis and Carlos F. Daganzo, 2005. *A review of green logistics scheme used in cities around the world*.

Organization for Economic Cooperation and Development (OECD), 1997. *The Environmental Effects of Freight*. p-33.

U.S. Department of Transportation: Federal Highway Administration, 2009. Freight Management and Operations, Quick Response Freight Manual II.

Nebiyu Gebremariam and Girma Gebresenbet, 2011. *Optimizing of Freight Transport and City Logistics Activities in Addis Ababa*. Addis Ababa University, Masters Degree Project

SUGAR, 2011. *City Logistics Best Practices: a Handbook for Authorities*. www.sugarlogistics.eu

Evangelos Maroudas, Haris N. Koutspoulos and Athanasios Ballis, 2011. *City Logistics for Sustainability, the Case of Stockholm*. Royal Institute of Technology

Jitka Andersson and B. Holmberg, 2005. *Reducing environmental impacts of freight transport sector: The case of the Czech Republic*. Lund University, Masters Degree Project

Tom V. Mathew, 2012. *Fuel Consumption and Emission Studies*. Traffic Engineering and Management, IIT Bombay, April 2012.

Jun T. Castro and Mario R. Delos Reyes, 2010. *Estimating Traffic and Emissions for Various Scenarios of Freight Vehicle Restrictions in Metro Manila*. Proceeding of 12th WCTR, July 2010, pp 1- 17

Fanuel Samson and Chandra, 2006. *Analysis of Traffic Accident in Addis Ababa: Traffic Simulation*. Addis Ababa University, Masters Degree Project

Wondwossen Taddesse and Girma Gebresenbet, 2011. *Assesing and Quantifying the level of Traffic Conjestion at Major Intersections in Addis Ababa*. Addis Ababa University, Masters Degree Project

Abera Kume, K. Charles, Y. Berhane, E. Anders and A. Ali, 2010. *Magnitude and variation of traffic air pollution as measured by CO in the City of Addis Ababa, Ethiopia*. Ethiopia Journal of Health Development 2010.

Miguel Andres Figliozzi, 2011. *The impacts of congestion on time-definitive urban freight distribution networks CO2 emission levels*. Results from a case study in Portland, Oregon. Journal of Transport Research Part C, Elsevier. pp 766-778

J.F. Ehmke, 2012. *Integration of Information and Optimization Models for Routing in City Logistics*. International Series in Operations Research & Management Science 177. Springer Science+Business Media 2012, New York

European Transport Quarterly Journal of Transport Law, Economics and Engineering, 2004. *Special Issue – City Logistics*.

Jean-Paul Rodrigue, 2013. *Urban Transport Problems*. Geography of Transport

European Commission, 1995. *Towards Fair and Efficient Pricing in Transport*. Policy options for Internalizing the External Costs of Transport in the European Union, COM(95)691

A. G. L. Peixoto Neto, M. L. Galves, O. F. Lima Júnior & D. Tacla, 2008. *Challenges of urban transport problems and city logistics: Sao Paulo city center case*. WIT Transactions on the Built Environment, Vol 101. WIT Press

M.I. Piecyk and A.C. McKinnon, 2009. *Environmental Impact of Road Freight Transport in 2020: Full Report of a Delphi Survey*. Logistics Research Center, Heriot-Watt University.

ANNEXES

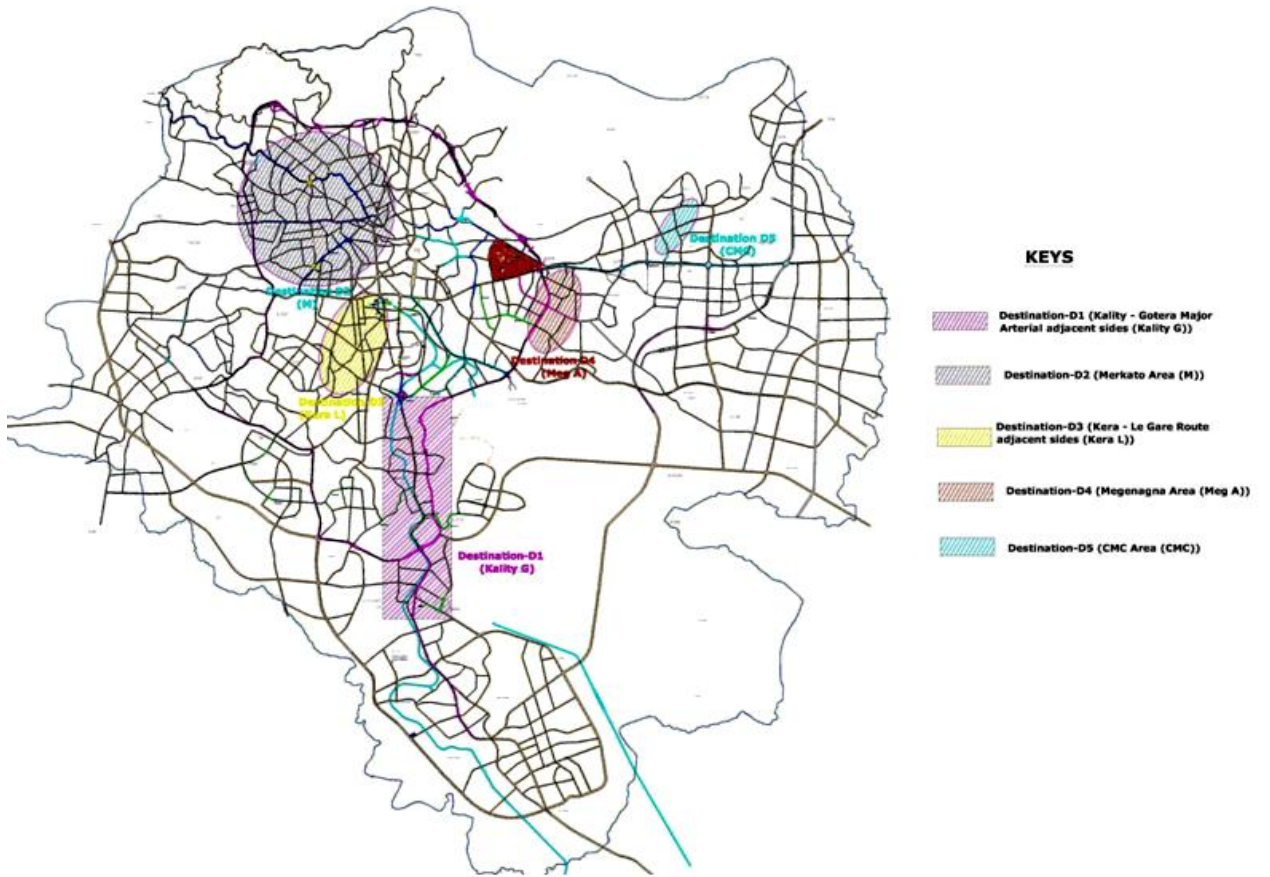
ANNEX – A: Vehicles Category (ERA Classifications)

ANNEX – B: Traffic Data Collected at each Gate by Category

ANNEX – C: Traffic Composition by each Gate

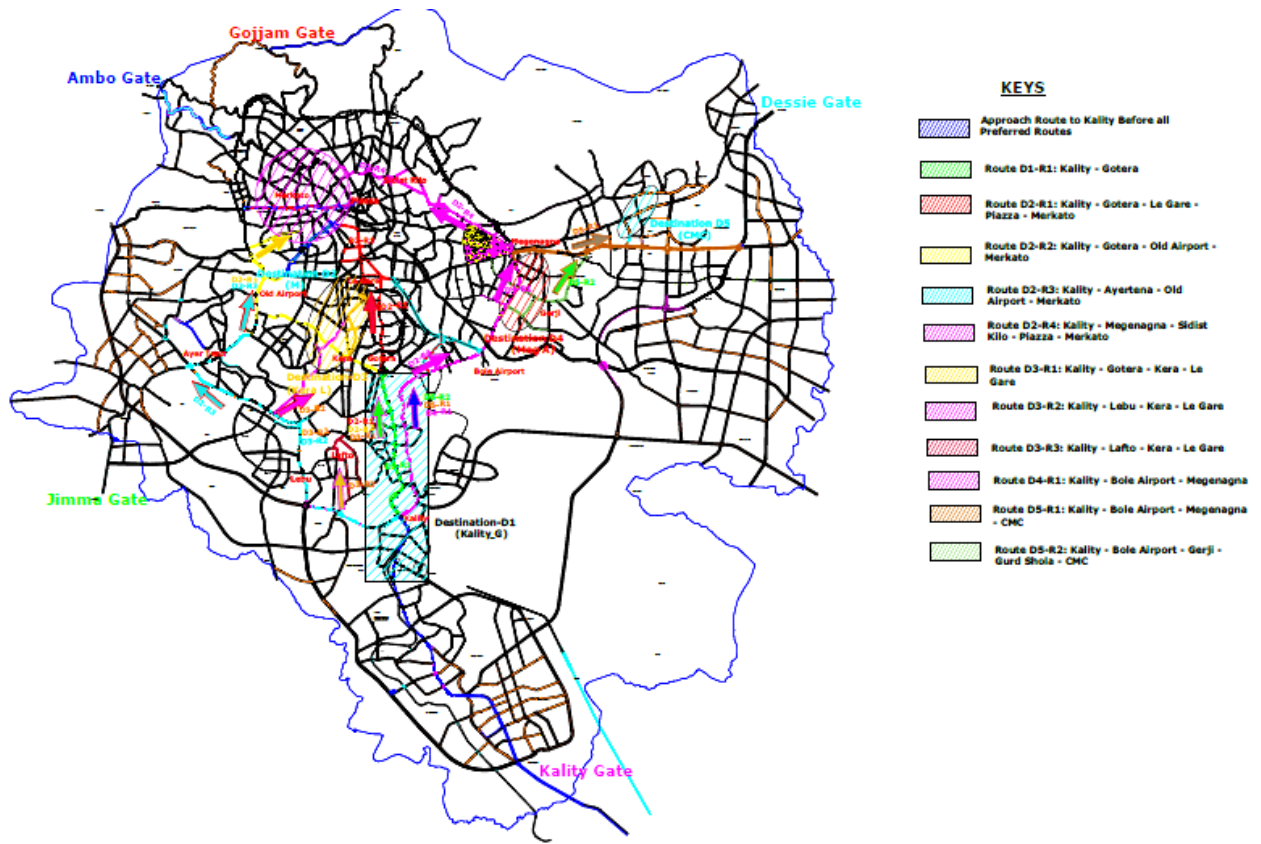
ANNEX – D: Growth Rate Calculations

ANNEX – E: Freight Vehicle – Destination Matrixes



Map showing Freight Destinations

ANNEX – F: Route Choice by Destinations



Map showing Preferred Routes of Freight

**ANNEX – G: Intersections along the Route with their Average
Passing Time**

ANNEX – H: Vehicle – Km and Vehicle – Hour Calculations

**ANNEX – I: Freight Vehicles Age Distribution and Exhaust
Emission**