ON-STREET TERMINI OPERATIONS OF PUBLIC SERVICE VEHICLES AND THEIR RELATIONSHIP TO TRANSPORT PERFORMANCE IN NAIROBI CBD

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF ARTS DEGREE IN URBAN AND REGIONAL PLANNING

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DECLARATION

This Planning Research Project is my original work and has not been presented for a degree in any other university

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This Planning Research Project has been submitted for examination with my approval as the University Supervisor

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MR. CHARLES OSENGO

(Supervisor)

DEDICATION

To my beloved family and everyone who played one role or another….

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My first acknowledgement goes to the Almighty God for divine guidance and strength throughout the project.

I would also like to appreciate my supervisor, Mr. Charles Osengo, who guided this research tirelessly and put in valuable contributions to the entire work.

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ABSTRACT

A well performing transportation system is both efficient and effective and is a pre-requisite to economic growth, environmental sustainability and social growth among other things. As such, achieving transport efficiency and effectiveness is the ultimate goal of every policy maker, transport service provider and consumer of the transportation services. It is therefore axiomatic that all cities and towns must strive to achieve the required levels of transportation efficiency and effectiveness.

Efficiency in transportation means that the transport system yields more benefits than costs both to the transport service providers and the consumers. The benefits and costs are usually evaluated by assessing the financial expenditures vis a vis the returns, time consumption during travels and the externalities resulting from the system. Effectiveness is on the other hand represented by a transport system from which people derive the highest level of satisfaction. Some of the elements that are normally used to measure the level of satisfaction a transport system offers include affordability of services, traveler's comfort, reliability of the services, safety of the system, speed of travels and environmental friendliness of the system.

It is thus arguable that if a transport system is costly and yields less satisfaction to people, then it is both inefficient and ineffective. More specifically, such a system presents problems such as less affordable travel charges, traffic congestion and jams, environmental pollution, uncomfortable modes and unsafe travels. Many scholars have argued that this situation is caused by a number of factors, some of which include lack of planning and coordination between transportation and land use systems, poor development of mass transport systems, insufficient regulation of the public transport system and inadequate provision of all transport facilities.

This study was initiated to assess the levels of transport efficiency/effectiveness in Nairobi's CBD, which had been noted to face various problems such as traffic congestion, poor transport management, land use/transportation conflicts and inadequate transportation facilities among others. Particular emphasis was made on the roles that the on-street termini play in the whole situation.

The study was informed by the fact that Nairobi CBD plays very crucial socio-economic and administrative roles and so should not be facing such problems as those outlined above. The main purpose of the research was thus to interrogate the emerging trends of on-street termini operations within Nairobi CBD and their effects on transport efficiency/effectiveness, with a view to proposing possible planning interventions which would help to improve the situation.

The methodology designed to carry out the study was systematic. The process began by identification and delineation of the study area. The data needs were then outlined and their potential sources

identified. Afterwards, the researcher identified the potential respondents, including the road users, transport service providers and the key informants. There was also the identification of the units of observation, some of which were patterns of entry and exit to and from the CBD and the termini, land use activities adjacent to termini, modes of vehicles operation in the CBD, conditions of transport infrastructure and road user behaviour.

A sample size for each set of respondents was determined and a sampling design formulated. Stratified random sampling method was used to select the termini from which the road users and vehicle operators would be interviewed. Non-probability sampling method was then used in the selection of individuals to interview. A total of 80 and 50 road users and service providers were interviewed respectively. All the key informants were also interviewed.

The data collection techniques employed included observation, measurement, traffic counts, key informant interviews, questionnaire administration and participatory travel speed evaluation. Analysis of various categories of data was then done. These included qualitative and quantitative data. The former was analyzed using narrative technique, content analysis method and use of anecdotes. Traffic circulation levels were evaluated using Level of Service and Segment Delay analysis techniques. Finally, hypothesis testing was done using the chi-square test method.

The major findings of the study were that (1) the transportation system in the study area is both ineffective and inefficient and that the on-street termini contribute to this; (2) the system is plagued with problems such as insufficient land use and transportation planning, poor traffic management, imbalance between demand and supply of basic transport infrastructure e.g. termini, unregulated public transport system, poorly developed mass transit system and lack of Intermodal integration; and (3) the on-street termini have a few advantages including convenience in accessing terminal services by members of the public, reduction of time taken to look for a PSV to board and attraction of customers to the business premises surrounding the termini.

Some of the recommendations in response to these issues included eradication of the on-street termini adoption of mass transit systems (both road and railway modes) and provision of two major PSV termini close to the CBD, restriction of the smaller PSVs within the residential areas, Park & ride and carpooling policies and policy on land use/transport integration.

The study has thus filled and important knowledge gap and made a number of proposals that can be used to improve the transportation system in Nairobi and other places facing similar problems.

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ACRONYMS

APTA	American Public Transportation Association
CBD	Central Business District
GDP	Gross Domestic Product
GIS	Geographic Information System
GLA	Greater London Authority
G.o.K	Government of Kenya
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
JKIA	Jomo Kenyatta International Airport
KeNHA	Kenya National Highways Authority
KeRRA	Kenya Rural Roads Authority
KNH	Kenyatta National Hospital
KNHPC	Kenya National Housing and Population Census
KRC	Kenya Railway Corporation
KURA	Kenya Urban Roads Authority
LRT	Light Rail Transit
MOA	Matatu Owners Association
MRT	Mass Rapid Transit
NEMA	National Environment Management Authority
NIUPLAN	Nairobi Integrated Urban Development Masterplan
NMT	Non-Motorized Transport
NTSA	National Transport and Safety Authority
PCU	Passenger Car unit
PSV	Public Service Vehicle
R/A	Round-About
SACCOs	Savings and Credit Cooperative Organizations
SPSS	Statistical Package for Social Sciences
UN	United Nations

CHAPTER ONE
INTRODUCTION

1.1 Overview

The performance of a transportation system is determined by its level of efficiency and effectiveness. Notably, the ultimate desire of everyone who has travel needs from time to time is an efficient and effective transportation system. It is also generally agreeable that all travelers, transport service providers and policy makers have the tendency to explore alternatives that can make travels fastest and most comfortable. However, while this is the ideal state, it has remained an elusive achievement in most developing countries, especially in the urban areas. As it has been widely observed, many cities of the developing world are plagued with several transportation problems (Alpizar and Carlson, 2003 in Osengo et al, 2005). Such problems include high road traffic accident rates, excessive demand gap, high fares, captive travelling and extreme vehicular pollution, all operating against a hazy urban transport policy backdrop (GoK, 2009). As such, the urban transportation systems in these cities can neither be said to be effective nor efficient.

According to Shuster (2013), efficiency in transportation is defined as a state in which the transportation system promotes low cost of production due to its ability to give room for minimum transportation costs incurred by producers and consumers of goods and services. It is a system that allows for competitive business in the global market and growth of the economy. In simple terms, an efficient transport system enhances high level of production with fewer resources. It is important to note that the resources referred to in this definition include money, labor and time. Thus, an efficient transport system should promote the delivery of goods and services using the *least possible amount of monetary expenditures* but within the *shortest time possible*.

An efficient transportation is also considered to be one that is able to provide socio-economic opportunities and profits, whose results are positive multiplier effects such as improved accessibility to markets, employment and additional investments (Rodrigue and Notteboom, 2016). Such a system also promotes social inclusivity since it offers a variety of travel options from which different people can choose.

On the other hand, effectiveness is a measure of the satisfaction that the user derives from the transport service delivered to him/her. It is the ability of the transport system to offer consumers the maximum quality of transportation services (Carvalho et al, 2015). The quality of a transport services can be measured using indicators such as level of service supply (per capita passenger trips and passenger trips per hour); travel speeds; average headway[1]; comfort; availability and reliability e.g. the span of service during the week (Eboli et al, 2016).

It is therefore notable that a system that is neither efficient nor effective tends to impose more than necessary costs on people and is generally dissatisfactory, since it offers low quality services. The costs can be monetary or they can occur in form of resource and time losses. Such a system manifests traffic jams, discomfort, social exclusion e.g. of people with disability, unaffordability by many people, safety challenges, unreliability and environmental unfriendliness.

The above problems are caused by a number of factors. The first of these is the rapid rate of urbanization which leads to a high increase in urban population. The increased population in turn leads to urban sprawl and an escalating demand for transport facilities and services. More often than not, the demand outstrips the supply of the much needed transport networks and facilities and as such it becomes difficult to have productive traffic flows and transportation operations.

The other factor that is responsible for the poorly performing urban transportation systems is inadequate or lack of land use planning. A number of studies have revealed that the development of transport networks in the developing world is hardly done in consideration for the inevitable relationships between land use and transportation. As Obiero (1992) observes, land use planning must give a framework for development of sufficient transport networks and facilities based on the land use trends in a city. As a matter of necessity, planners must be able to project future transportation needs as the city grows and its landscape changes. If this does not happen, then it may not be possible to achieve efficiency and effectiveness in transportation.

[1] Headway refers to the average interval of time between vehicles moving in the same direction on the same route.

In Nairobi for instance, the city population has steadily increased over the years, to the point that presently the city harbors over 4,000,000 people, yet without a correspondingly adequate transport system. No wonder traffic congestion disorganized public transport services and inadequate transport facilities are a continuous nightmare (Omondi, 2015). Amidst the changes in population and transportation situation, Nairobi has further witnessed tremendous transformations in the management of road transport system, provision of various transport facilities and land use planning. Some of these changes have caused certain unpleasant conditions that people continue to encounter daily.

In 1948, Nairobi was planned based on the Neighborhood Unit Concept. It also assumed a radial structure where the CBD was located at the centre and the neighborhoods were situated outwards but in all directions from the CBD. It was also spatially organized in such a manner that neighborhoods housed a given population which had access to basic facilities within reachable distances. These neighborhoods were also located in areas that were within a walking distance to the CBD and the Industrial area. As such, transportation problems were non-existent.

However, with time, the city has expanded into a metropolitan region yet with very little proactive planning. As such, urban sprawl and uncontrolled development densities have emerged leading to the need for expansive transportation networks and numerous transport facilities.

Regarding the transport system operations, transitions of different impacts have also been witnessed. In the 1970s and 1980s, the public transport services were for instance well organized and coordinated. During the era of the Kenya Bus service, the buses operated on clear time lines and fare guides. The points of picking and dropping passengers were also clear and no driver was allowed to waste time at those points. Moreover, the buses were of high capacity and so only few of them were needed (Chitere et al, 2012).

Today, the level of regulation of the public transport system is quite insufficient. The system is predominantly run by profit minded private investors who operate low capacity vehicles, fluctuate fares drastically from time to time, promote noise pollution in the vehicles, compromise integrity among PSV operators and manifest unsafe driving behavior.

Given that transportation problems are widely experienced around the world, various attempts have been made to make the transport services better. One of the most widely used approaches is the adoption of transportation options that lean more towards public transport[2] services or mass transit. This is because it has been observed that mass transit (which tend to be public in nature) is able to meet the travel needs of many people per unit time compared to the private means which only serve one or two people (mostly owners) and at most a household. Mass transit therefore makes it possible to have fewer vehicles transporting many people at a time, hence reduced congestion and thus speedy travels (Glover, 2011).

However, it must be noted that having public transport or mass transit services alone will not make the transportation system efficient or effective. Deliberate efforts must be made to ensure that adequate road and rail networks are provided and maintained, support facilities such as bus stops and stations are sufficiently provided and located strategically, the right types and capacities of vehicles are availed and the public transport services are regulated by the state to ensure quality, comfort, cost-effectiveness and good returns to the service providers.

The level of regulation of the Public transportation services for instance affects the general satisfaction that the consumers, service providers and policy makers draw from the service. In other words, the effectiveness of the public transport system is either promoted or hindered by the regulatory tools and methods that the state uses. If it happens that the regulator gives so much room for market forces to dictate the manner in which the service provider operates, then the levels of affordability, comfort, reliability and orderliness expected in the public transport sector cease to exist.

One of the reasons as to why effectiveness and efficiency of the transport system in Nairobi has remained elusive is that mass transit system is still underdeveloped. The problems began with the legal incorporation of matatus (14-seater vehicles) into the system through a presidential decree in 1973. (Chitere et al, 2012). Attempts to revert the situation have remained less fruitful over the years. For instance, the effort to ban the matatus in early 2000s

[2] Public transport is broadly taken to mean transport services made available to the general public (Glover, 2011). The services should however be regulated by the state to ensure effectiveness. There are actually instances where the service is provided by the state at subsidized costs.

was met with resistance from the sector investors and till now, these vehicles have not been phased out. On the contrary, even smaller vehicles such as tuktuks have found their way into the system causing further congestion.

In terms of developing transportation networks and facilities, it is necessary that they are adequately provided in every part of a city, and particularly the Central Business District (CBD). The CBD is one of the most prime sections of an urban area where key economic, social, regulatory, political and state activities take place. It is the core of the city where the highest level of activities takes place and the highest day time population is witnessed. Its primacy results in high levels competition for space therein, yet the supply for such space is so inelastic. Thus if planning is not properly done, certain activities will tend to miss space for location. In cities where poor transportation planning is done, facilities such as Public Service Vehicle termini are often non-existent in critical areas such as the CBD. As a result, on-street termini begin to emerge. This on the other hand has significant implications on the operations of the CBD and the entire city.

On-street termini are those facilities that are located on the spaces along the curbs or shoulders of streets or roads (Olorunfemi et al, 2014). Together with other on-street activities like parking, merchandize display, pedestrian movements and loading and off- loading, the termini affect the traffic flow patterns along the roads. They significantly affect the usability of the road and subsequently the ease of traffic flow.

As Richard and David (2007) note:

> *"The use of on-street parking affects traffic movement in three ways: it reduces a street's capacity, it reduces safety and increases service conflict."*

Similarly, Rye (2010) points out that:

> *"On-street parking causes safety and congestion problems by blocking one or two traffic lanes, reducing visibility and forcing pedestrians to walk in the road if no proper footpaths are provided and it also obstructs access for emergency services, thereby resulting into accidents and affecting traffic movement."*

Furthermore, Olorunfemi (2013) emphasizes that:

> *"If a city provides on-street parking, particularly in commercial areas, it makes conscious choice to provide better access to adjacent land use at the expense of more efficiently moving traffic."*

Based on this discourse, it can be argued that the location of PSV termini on the streets has economic, social and environmental implications since anything that hampers traffic flow automatically interferes with production processes, environmental quality and the general well-being of the travelers. This being the case, it can further be argued that on-street PSV termini have certain implications on the effectiveness and efficiency of the transport system.

On-street PSV termini are common in the cities of the developing world. This is largely as a result of increasing demand for terminal facilities. This demand, coupled with the fact that there is always limited space in the CBDs has compelled the use of the road shoulders for dropping and picking passengers and parking vehicles. Furthermore, inadequate off-street terminal facilities together with ineffective traffic management mechanisms have metamorphosed to the problem of on-street PSV termini (Olorunfemi et al, 2014).

Improper land use planning (or lack of it) in several cities has also immensely contributed to this situation. As Akhuewu (2010) observes:

> *"In most of the cities in the developing countries, the planning of road networks lacks the provision of the entire basic infrastructure needed for safe and orderly movement of vehicles."*

In Nairobi, the reliance on the CBD as the main host of National and County Government offices, state corporations, private sector services and economic activities still compel people from all over the city to frequent the CBD. However, the transport facilities therein have remained inadequate. Moreover, the space in the CBD is hardly adequate to promote easy movement or free circulation of the huge traffic which originates from all parts of the expanded city and beyond

The demand for bus termini has as a result increased so much yet they have not been provided adequately. Subsequently, almost all streets within the CBD serve as bus termini. Car ownership has also increased with the increase in population hence the increasing demand for parking both at the work place and home. The taxi business has similarly thrived over time, leading to an increase in the number of cars parked in the CBD and elsewhere.

These in turn have been seed to affect the transport system operations in the CBD and the city at large. Resultantly, the CBD experiences major transport problems which require urgent solutions.

1.2 Statement of the Problem

Nairobi is the capital City of Kenya. Its CBD is one of the most important zones both locally and internationally. The CBD began to take shape in mid 1920s even though the development of Nairobi began much earlier (in 1899). This happened when Nairobi was planned as a Settler Capital. The plan gave rise to a zoning strategy, which led to the emergence of distinct land use zones in the then small town. The CBD (then a shopping centre) was thus among the emergent zones.

During that time, the CBD was the only area where commercial and administrative activities took place and so it was an important hub. This being the case, the plan of the town made it possible to access the zone with much ease since it was within a walking distance of all the residential zones (Mwaura, 2002). Furthermore, since the population was still low, there was no congestion. Subsequent plans of 1948 and 1973 continued to elevate the CBD by promoting major activities therein. Even the most recent plan (NIUPLAN [2014-2030]) still recognizes the CBD as the primary node which has been assigned to perform crucial functions. This is despite the fact that it introduces secondary nodes in various parts of the city.

Between the year 1920 and today, the city has expanded tremendously, both spatially and in terms of its resident and catchment populations. Consequently, it has developed into a metropolis with several commercial nodes. However, the CBD still remains one of the most crucial districts of the city and the metropolitan region

It houses a significant portion of the service industry as well as production and trading activities. Together with the industrial area and other business districts, the CBD forms the core of the economic fabric of Nairobi and the country at large. Several Kenyans work and therefore earn a living from this part of the city. Supermarkets, wholesale and retail shops, big hotels and restaurants, the city market, media houses, private offices, institutions of higher learning, drug stores, business stalls and bus termini are among the numerous

economic establishments that are all situated within the CBD and from which various Kenyans earn daily incomes.

Nairobi is also the central point for major administrative functions in the country. The parliament, where decisions on the most important issues of the country are made, is situated in the CBD. The Supreme Court, which is the highest court of the land and where the highest level of justice is supposed to be offered, is also in the CBD. The offices of the President and his Deputy are all in the CBD. The Country's Treasury and various government ministries are also housed therein. The City hall, from where Kenya's Capital is governed is located in the same place. It is therefore axiomatic that the Nairobi CBD very important in the management of the country.

The CBD is also well planned with its road network forming a neat grid-iron pattern. Most of the buildings are of high density and are well maintained. Generally, there is notable order in the distribution of activity spaces as manifested by the developments therein. The fact that the district is well planned and developed is a further evidence of the significance that it has been accorded.

The above features notwithstanding, the situation within the CBD's down town, especially along Moi Avenue, Tom Mboya and Ronald Ngala streets among others is generally unpleasant, with traffic congestions and subsequent difficulty in movement. This phenomenon can be traced to various occurrences in the transport and land use planning systems. The first among these is the maintenance of the CBD as a strong central core from which upto six arterial roads radiate. The roads are the media through which huge volumes of traffic are channeled into the CBD daily, thus causing congestion.

The other issue is the introduction of the highly unregulated private investments in the public transport sector which has led to some operators overstepping their mandates and causing ungovernable systems since they have political backing. Consequently, the system is flooded with low capacity vehicles whose operators have negotiated their way into the CBD, where there is hardly any improvement of transport infrastructure, thus resulting into congestion and disorder (Macharia, 2013).

Today, the city centre accommodates three types of traffic, namely the through traffic, the city centre traffic and inter-zonal or inter-city traffic, which do not necessarily need to pass

through the CBD. Traffic congestions in the sections of the CBD with on-street PSV operations occur daily, Monday to Friday (6.00a.m - 9.30p.m) when people go to and come from work and move from one point to another throughout the day while undertaking various errands. It subsides slightly during the weekends, but the levels still get beyond the tolerable limits (Osengo et al, 2005).

Those parts of the CBD are characterized by high density of business activities both in high-rise buildings and small stalls. These activity areas generate enormous amounts of human traffic. Very many vehicles also pick and drop people from within and outside various parts of the city hence great vehicular traffic volumes. The congestion is so much that the motor vehicle speeds reduce to as low as 5km/hr on average, and to make matters worse, there are times when the vehicles literally stop moving for even 2 hours along a very short stretch of the roads (Macharia, 2013).

Displayed merchandize of the hawkers decorate the footpaths all the time, leaving very little space to walk on. Buses and matatus flock the places as they drop and pick people right on the road. Taxis and motorcycles are ever parked by the roadside and even some time within the carriage ways. The volumes of human traffic, handcarts, wheelchairs and *tuktuks*, are always beyond the capacities of those roads (Macharia, 2013).

The road user behavior on the other hand is pathetic. Everyone scrambles to be the first to pass. The matatus drivers and the motorcyclists overlap all the time and are often oblivious of traffic lights and pedestrian crossings. The pedestrians on the other hand are ever too impatient to wait for oncoming vehicles to pass. Simply put chaos and confusion is what defines this part of the city centre (Ibid).

This situation notwithstanding, there have been a number of efforts that have been made from time to time to improve the transport system. In mid 1980s, the government began a parastatal known as the Nyayo Bus Services Corporation to provide public transport services in Nairobi. The corporation managed to run fairly efficient and effective operations. It for instance charged low fares it had subsidized fuel and readily available labor from the NYS trainees. In addition, it had easier access to bus spare parts from foreign markets compared to other operators who faced various restrictions. However, services were wound up in 1992 because of mismanagement of the parastatal.

Thereafter, in the year 2004, the Ministry of Transport introduced new rules meant to regulate the public transport system. The PSVs were for instance required to be fitted with speed governors and the operators were to operate more professionally. However, te rules were bent with time and the system is not any better today.

The third effort was the attempt to regulate public transport routes and journey destinations in the city. Upto the year 2011, public service vehicles serving the eastern suburbs of Nairobi were restricted from entering the CBD and were required by Government order to operate from Muthurwa Bus Station. However, this stopped gradually because both the consumers and the service providers were not receptive to this rule. Today, the County Government has allowed Public Vehicle access to the CBD yet no additional terminal facilities have been developed. As such these vehicles pick and drop passengers along the streets such as Luthuli Avenue, Mfangano Street, Accra Road, River Road, Tom Mboya and Ronald Ngala Streets.

The second solution that has been offered is the expansion of transport networks, both road and railway. The government is in the process of revamping railway transport and expanding roads for mass rapid transit system. However, much of the effort has been put in the improving the networks outside the CBD (e.g. Mombasa Road, Thika Road, Ngong Road, Outering Road etc.) without the consideration that all these roads channel traffic into the CBD. There is also zero to very minimum integration between the road and railway transport systems.

Essentially, there has been very little coordination between the transport networks, land use patterns and the general structure of the City, which is radial in nature (Aligula et al, 2005). As such, it is a common phenomenon for traffic to flow more freely further away from the CBD but as they approach or leave the CBD, serious snarl-ups are inevitable.

The County Government has also made efforts to reduce on street activities such as hawking. It is considered an offence to operate business on the streets if not authorized by the County Government. In this case, the main aim is to create more room for easy movements and circulation of traffic. This effort has also not yielded expected results largely because enforcement is poorly done (Aligula et al, 2005). Furthermore, the on-street traders are hardly offered alternative affordable spaces for locating their businesses. They thus remain adamant and continue to contribute to the congestions.

Furthermore, there have been recent attempts to change traffic management mechanisms in the city. The County Government has deployed personnel to manage traffic within the CBD, together with the Traffic Police. It has also sought smart options to traffic management such as installation of CCTV cameras and more traffic lights. However, the poor road user behavior is still a problem since people are not observant of traffic signals. Thus, some of the traffic flow problems in the CBD are caused by the non-observant road users.

Evidently, none of the above mentioned efforts have dealt with congestion and circulation problems in various parts of the CBD. It is also envisioned that if more effective measures are not sought, the situation may deteriorate further, rendering the district much less productive. It is thus necessary that research is done in order to find out why the traffic congestion has persisted, since it impacts negatively on efficiency and effectiveness in movement, circulation, connectivity and economic productivity.

1.3 Purpose of the Study

The main aim of this research is to interrogate the emerging trends of on-street termini operations within Nairobi CBD and their effects on transport efficiency/effectiveness, with a view to proposing possible planning interventions which would help to improve the situation.

1.4 Research Questions

The study was meant to answer the following questions:

a) What is the pattern of on-street PSV termini within Nairobi CBD?
b) What is the status of transport efficiency and effectiveness in the CBD?
c) What are the consequences of on-street PSV termini on the operations of the CBD?
d) What appropriate interventions can be sought to improve the transport efficiency in the study area?

1.5 Research Objectives

The objectives of this study were:

i. To examine the existing system of on-street PSV termini in Nairobi CBD.
ii. To evaluate the transport efficiency and effectiveness in the CBD
iii. To assess the effects of the on-street PSV termini on the operations of the CBD
iv. To propose appropriate interventions that can improve transport efficiency in the study area.

1.6 Assumptions of the Study

The study is anchored on the assumptions that:

- The random conversion of streets into bus termini has impacts on traffic efficiency and effectiveness in the CBD
- Efficient traffic circulation is desired by and beneficial to the functioning of the CBD
- Efficient and effective transportation can be achieved.

1.7 Hypothesis

The study was meant to test the relationship between the density of on-street PSV termini and efficiency of traffic circulation, where efficiency of traffic circulation is dependent on the density of the points.

Expressed as a null hypothesis, it reads:

H_0: *There is no relationship between the density of on-street PSV termini and efficiency and effectiveness of transportation.*

As a research hypothesis, it reads

H_1: *There is a relationship between the density of on-street PSV termini and efficiency/effectiveness of transportation.*

1.8 Justification of the Study

The study is justified on various grounds. First, there are a number of studies that have been done on the dynamics around traffic flow problems in Nairobi. However, there is still a knowledge gap on the relationship between on street PSV termini and traffic efficiency and effectiveness. This study thus endevours to fill this gap.

Secondly, the study is significant in land use planning. While one of the greatest aims in planning is to achieve seamless connectivity and ease of access to various activity areas, the current traffic situation in the study area manifests a scenario that is contrary. This study is geared towards unearthing the contributions of the on-street PSV operations to the prevailing unpleasant traffic situation in Nairobi CBD, thereby providing a basis upon which planning solutions can be sought in order to improve the situation.

Additionally, the CBD is the heart of the city where major administrative and economic functions of the country are performed. It also plays a major role in defining the character of

Nairobi. All foreigners/visitors and potential investors are likely to get their way to the CBD first, before anywhere else, as they gauge the suitability of Nairobi as a business hub. Furthermore, people pass through the CBD to access vehicles by which to travel to other parts of the city in order to go to work, to school, recreational areas, home and many more. As such, any delay therein causes delay of activities elsewhere.

Delay on other hand causes a lot of economic loss because the net time that people spend working is significantly reduced when they get stuck while on transit. It is tiring and sometimes sickening to stay for long in traffic at whatever point along the transport corridor. The traffic congestions in the CBD also cause a lot of environmental pollution (reduced air quality) yet this should be the cleanest part of the city as it gives Nairobi its identity. It is therefore necessary that congestion and any form of chaos in this part of the city be adequately dealt with.

1.9 Scope of the Study

The area selected for this study is enclosed by, Accra road to the North West, Moi Avenue to the west, Haile Selasie Avenue to the south, Race course road to the East and River road to the North-East. This section is fit to adequately demonstrate the traffic circulatory conditions in the CBD because it has the highest concentration of the on-street PSV journey termination activities and it manifests the major congestion features earlier described.

Secondly, many Public Service Vehicles enter and leave the CBD via different points which are majorly located in this section. It can thus be said that the traffic circulatory conditions in this area have ripple effects on the areas adjacent to the CBD. If this is the case, it can be argued that solving traffic challenges in this section of the CBD would also be beneficial to the areas surrounding the CBD, the entire city and beyond. Additionally, the area offers a very significant portion of job opportunities to people who work in the CBD since it houses several business spaces and offices. It is thus anticipated that traffic issues in this section of the CBD has socio-economic impacts whose magnitude cannot be ignored

Notably though, the area has streets that have high concentration of on-street termini and others which have few termini or none at all. The latter include streets like City Hall Way (where Kencom bus terminal is located) Haile Selasie Avenue and Moi Avenue (where there are fewer termini or none). The researcher compared traffic circulatory conditions in both sets

of streets. This comparison was aimed to help the researcher make informed conclusions about the difference made by existence of the on-street PSV termini.

The information required for this study encompassed theories and concepts on transportation and traffic flow dynamics in the global, regional and local scenes (with particular focus on the study area), the background of the study area, as well as planning standards and policy and legal guidelines on transportation.

The subjects for this study included the Departments of City Planning and City Engineering (Nairobi City County Government), KURA (Ministry of Transport), road users, business people, and matatu operators (Conductors and Drivers).

1.10 Limitations of the Study

The researcher was faced by the following limitations:

1. It was difficult to acquire certain recent statistical information against which to compare the study findings. However, the researcher used the data that was available even though they were sourced from studies carried about 10 years ago.
2. Reaching out to some of the key informants was challenging because they were hardly available. As a result, they gave a chance for very brief discussions, compelling the researcher to ask the most crucial questions only. It is noted that it would have been better if further elaborations on would have been obtained about various issues.

1.11 Structure of the Thesis

The thesis has been organized into seven chapters as follows:

Chapter 1: Introduction

This section includes a logical overview of concepts revolving around the study topic, problem statement, study purpose, study assumptions, research questions, research objectives, hypothesis, justification, scope, limitations and organization of the study.

Chapter 2: Literature Review

This section is composed of a review of theories and concepts around the topic of study and also an examination of findings of past related studies. Also of concern under this section are policy, institutional and legal frameworks as well as planning standards related to

transportation in Kenya. At the end of this section, a conceptual framework has been formulated.

Chapter 3: Research Methodology

The research methodology chapter elaborates the overall study design, indicating the data needs and the procedures followed to acquire the data. The procedures are in relation to activities such as sampling, data collection and data analysis and presentation of study findings.

Chapter 4: Background of the Study Area

This includes physical location of the study area both in the regional and local contexts and physical characteristics of the area, planning and development of the area, population characteristics therein, transport system of the study area and urban transportation history of Nairobi.

Chapter 5: Study Findings

This section articulates the results of the study, which have been organized in accordance with the study objectives. The findings have thus include an analysis of the network of on-street PSV operation points in the CBD; the CBD inherent traffic circulation conditions; and an evaluation of the contributions made by the on-street PSV termini to the prevailing traffic conditions.

Chapter 6: Planning Implications and Recommendations

In this chapter, the researcher has critically analyzed the emerging issues from chapters one to four, in order to translate them into meanings that fall within the context of urban and regional planning. The emerging issues have specifically been analyzed with respect to the main issues, their root causes and their effects.

The recommendations section has been developed in response to the fourth objective of this study i.e. '*to propose appropriate interventions that can improve traffic efficiency and effectiveness in the study area.'*

Chapter 7: Summary and Conclusion

This entails a summarized version of the study findings, the identified problems and the proposals that will appropriately respond to the problems.

CHAPTER TWO
LITERATURE REVIEW

2.1 Overview

There have been several studies about matters related to transport efficiency and effectiveness. These studies have unearthed important information which has informed this research. Such information covers various concepts, including public transportation, terminal facilities, urban transportation system, the Central Business District, transport-land use relationships, transport system in Nairobi and policy, legal, institutional and theoretical frameworks of transportation.

This chapter thus brings out a conceptual background of the factors that surround transport efficiency and effectiveness in CBDs and the entire urban space. It elaborates on the manner in which an urban transport system operates, pointing out the roles that public transportation play. It further details out the manner in which urbanization influences the operations of the urban transportation system. Additionally, there is a discussion on the significance of CBDs and how transportation efficiency and effectiveness affect and is affected by the operations and developments therein. There is also a review of the manner in which land use planning, policies, laws and statutory institutions influence transportation efficiency and effectiveness and the performance of CBDs.

2.2 Public Transportation

2.2.1 Definition

According to Glover (2011), public transport is broadly taken to mean transport services made available to the general public and which should however be regulated by the state to ensure effectiveness. The Cambridge English dictionary on the other hand describes public transport as a system of vehicles such as buses and trains that operate at regular times on fixed routes and are used by the public. A third definition of public transport is “the travel services provided locally that makes provisions for several people to travel jointly along particular routes (Transport for Greater Manchester, 2016).

From the above definitions, it is deduced that public transport systems are defined by features such as mass travels, impartiality to travellers, service commercialization, predetermination of travel routes and system regulation by the state. It is however worth noting that in cases

where the system has been highly privatized, the level of public transport system regulation by the state is usually significantly low. This happens more frequently in the developing world and it is because most of the time the services are provided based on the market forces (Omondi, 2015).

2.2.2 Components of Public Transport Systems

According to the American Public Transportation Association, public transportation systems comprise of vehicles such as buses, ferries and trains; travel ways such as sub-ways, bus routes/lanes, and railway lines; and terminal facilities like bus stops, bus stations and train stations.

The preferred public transport vehicles tend to those of high capacity since they give room for mass transits. In San Francisco for instance, there is the Bay Area Rapid Transit (BART) which majorly offers public train transport services and they serve approximately 366,565 people per day. The Boston's Massachusetts System on the other hand serves about 1.3 million people every day (New Jersey Institute of Technology, 2016).

This kind of scenario is considered more profitable because it saves time and reduces energy consumption significantly. On the other hand, if a public transport system is dominated by low capacity vehicles such as the 14-seater mini-buses in Kenya, it becomes difficult to evade challenges like traffic jams, air pollution and overexploitation of non-renewable energy sources.

The travel ways are also crucial components of the public transport system. The kind of travel ways that will make public transport transportation more efficient are those that are separated from the routes that are used by the other regular vehicles, such as private cars and business trucks. This explains why most public transport systems in the developing countries are such that the bus routes and lanes, rail tracks, light rail lines and Bus Rapid Transit (BRT) bus routes are not open for use by other vehicles than the public ones.

In Boston for instance, there is the Massachusetts Bay Transit Public Transport System which has two Bus Rapid Transit lines, fourteen train lines, four trackless lines for trolley, 183 bus routes, thirteen commuter rail lines and five light rail lines (New Jersey Institute of Technology, 2016). Such a system tends to face minimal traffic flow challenges because there is little or no traffic congestion at all.

Other components of public transport systems are termini. Rodrigue and Slack (2016) define termini as the facilities where passengers and freight are assembled or dispersed. Ideally, terminal facilities are supposed to be provided in the right numbers and at the appropriate locations within the transport networks. It therefore means that that inadequate provision of these facilities will definitely present a problem because it would mean that passengers and freight are picked and dropped at inappropriate points such as on-street locations. When this happens, the chances of experiencing impeded traffic flows become high (Olorunfemi 2013).

In addition to the above, public transport systems also have human and institutional components. These are comprised of the service providers, employed PSV operators and the state organs which regulate the system. The latter are often responsible for setting up the rules within which public transport service providers and consumers are supposed to operate and provision of the required transport infrastructure. They for instance designate the public transport routes, set fare rates and determine the ideal vehicle capacities that are to be used for public transportation (Glover, 2011). The schematic diagram below summarizes the components of the system.

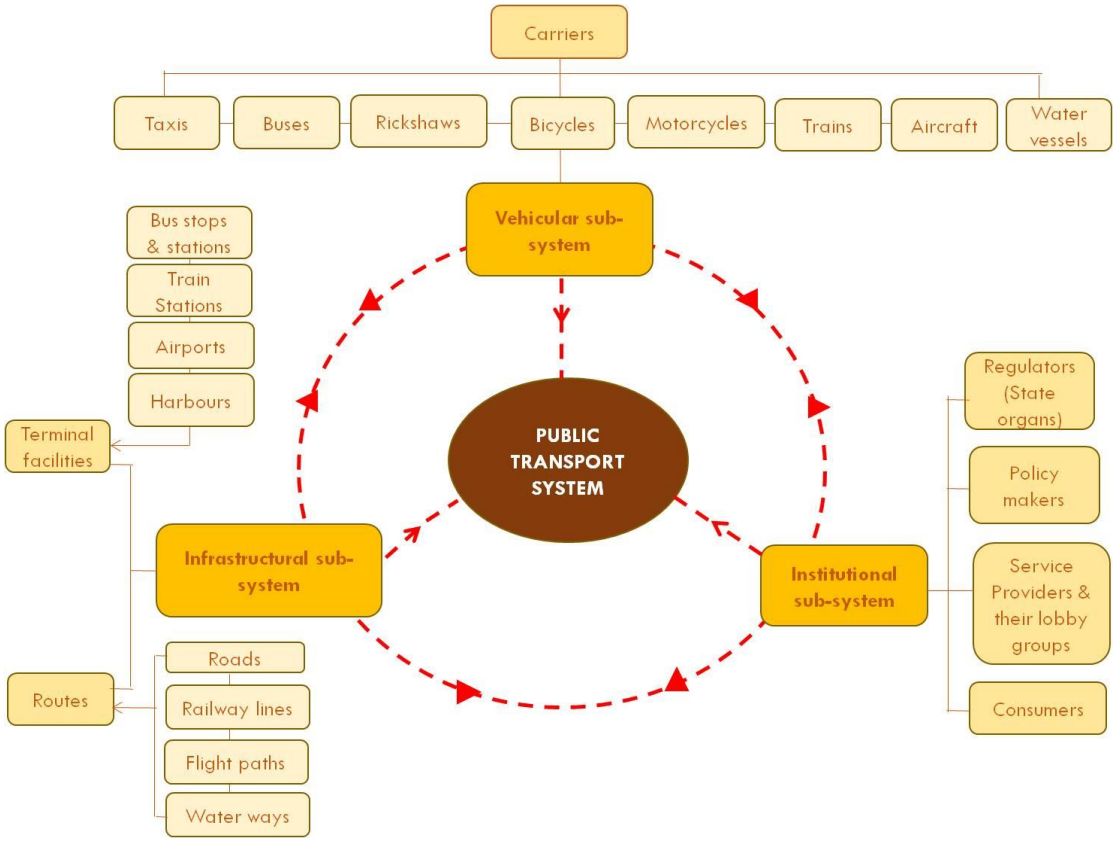


Figure 1: Public Transport System

Source: Author, 2017

In a nutshell, public transportation is a multifaceted system all of whose components must be provided adequately and in a coordinated manner, if efficiency is to be achieved.

2.2.3 The concept of Public Service Vehicle (PSV) Operations

According to Wexford County Council (2016), Public Service Vehicles are vehicles that carry passengers for hire or reward and are separated into two categories:

a. Large Public Service Vehicles (LPSVs) – these are defined as PSVs that are capable of carrying more than eight passengers e.g. buses
b. Small Public Service Vehicles (SPSVs) – these are PSVs that can carry a maximum of eight passengers only e.g. taxis, hackneys and limousines.

Public Service Vehicle operations in the context of this research refer to the activities undertaken in the vehicles either while on transit or in situ. They range from picking and dropping passengers, loading and offloading cargo, cleaning, fuelling and servicing the vehicles as well as parking them.

Each of these operations is ideally supposed to take place in designated points or zones within the transportation system. For instance passengers are picked and dropped in bus stations and stops; loading and offloading occurs in loading zones or on the backstreets of commercial buildings; fuelling occurs in filling stations; servicing takes place in garages and parking is done in parking lots, bays, silos or yards.

In essence, all these facilities must be adequately provided within the transport system in order to ensure that there are no malfunctions therein.

2.2.4 Benefits of Public Transportation

According to Litman (2016), public transport has gained popularity more rapidly since mid-1990. He attributes this situation to a number of factors, among which are the benefits that public transit present over the other modes. He observes that public transportation has the ability to deal with the transportation problems most common in the highly dense urban areas. Such include traffic congestion, parking congestion, traffic accidents, road and parking infrastructure costs, automobile costs to consumers, inadequate mobility for non-drivers, excessive energy consumption and pollution emissions.

The American Public Transportation Association (APTA, 2007), also points out a number of public transport benefits. A lot of their views agree with the points raised by Litman (2016). One such view is that public transportation promotes the strengthening of the economy. The argument brought forth to elaborate this point is that public transport improves business, enhances employment creation, saves individuals time and money and connects people to work places, even those who reside in sub-urban zones of the cities.

It is for instance argued that every 1 billion US dollar that the Federal government invests in national transport infrastructure yields 47,500 jobs. Secondly $10 million worth of investments in public transportation saves both highway and transit users more than $15 million.

The second public transportation benefit that APTA identifies is conservation of energy and reduction of dependence on oil. The Association observes that public transport modes averagely consume one-half of the oil that typical automobile users would ordinarily consume.

Thirdly, APTA observes that public transportation relieves congestion. This is essentially because fewer vehicles are needed to transport several people. This in turn helps to save time that would otherwise be inevitable. In America for instance, it has been noted that public transport services have saved travelers about 1.1 billion hours of added travel time in the most congested cities (APTA, 2007).

The other benefit of public transportation is protection of the environment and improvement of air quality and health. It has been established that the amount of carbon monoxide produced by public transport modes in volatile organic compounds is about 95% less than the much produced by private cars. Additionally, the public transport modes produce about half as much Carbon IV Oxide and nitrogen oxide gases as the private cars.[3]

From the above discourse, it is arguable that public transport systems are very integral to the day to day operations of the society. They should thus be developed and maintained in the right shapes and capacities.

[3] Energy Information Administration, 2003 in APTA, 2007

2.2.5 Costs associated with Public Transport Systems

The main costs typical of public transport include inconvenience, lack of privacy, and high chances of adverse negative effects in case a PSV experiences a breakdown or an accident (Litman, 2017).

Critiques of public transport argue that inconvenience is due to the significant level of inflexibility of public transport routes and boarding cum alighting points. In other words, the people who use PSVs have to walk to particular termini in order to board or alight from the vehicles and they are often restricted to travel along specific routes. This is opposed to the private means where people have the leverage to start journeys at their doorstep and end them conveniently at the intended destinations through various routes. The inconvenience thus causes some delays, which on the other hand depict inefficiency.

The other issue commonly raised is the inability to enjoy privacy while using public transport means. This is basically because one has share the vehicles with very many other people, most of whom are considered as strangers. As such, it becomes difficult for people to do certain things they consider confidential. In fact, there are people who claim that it is also unsafe and uncomfortable to travel with strangers. In other instances, the public transport system have exposed people to thuggary, theft and pick pocketing, leading to loss of property and sometimes life. This in turn renders the system less effective.

There is also the argument that public transport is disadvantageous because the net cost of negative occurrences such as breakdowns and accidents is huge since many people are affected. This reduces its efficiency. It is also apparent that this argument portrays the public transport system as more risky than the private means, thus less effective.

While the above points are valid, it is important to note that they are issues that can easily be countered through the management and regulatory mechanisms employed in the system. As such, they can only affect the efficiency and effectiveness of the system as long as management and enforcement of regulations is not carried out properly.

2.2.6 Sustainability of Public Transport Systems

Sustainability in transportation is evaluated along three main dimensions i.e. environmental, economic and social (Miller et al, 2016). Environmental sustainability connotes the absence or minimal negative impacts of transportation activities on the ecological systems, both

locally and globally (Theis 2012 in Miller et al, 2016). Economic sustainabilty on the other hand refers to the ability of the transport system to promote employment and wealth creation, productivity and the ultimate welfare of a community (Black, 2010 in Miller et al, 2016). Finally, a socially sustainable transport system is one that promotes equity and inclusion Jeon, 2007 in Miller et al, 2016).

Public transport, especially mass transit is generally considered to be relatively more sustainable because it promotes usage of less fuel, emission of less pollutant gases, transportation of more people within a short time (especially if the low capacity vehicles and cars are fewer or when there is lane separation), employment creation in the transport industry, enhancement of the production process by enabling faster transportation of goods and services and social inclusion.

Nonetheless, it must be noted that public transportation system requires deliberate regulation and control if sustainability is to be achieved. Like it has been observed in certain places such as Nairobi, the system has remained unsustainable because private interests have taken precedence over the public good and so it is poorly organized and unable to yield the results expected of a sustainable transport system (Chitere et al, 2011).

2.3 Terminal Facilities in Perspective

2.3.1 Definition

Terminal facilities are defined as points where passengers and freight enter or leave both Motorized and Non-Motorized transport vehicles or interchange from one vehicle to another. The interchange can take place between vehicles of the same or different modes. A terminal also refers to any locations at which the transportation is originated and/or terminated, or a place where freight is handled. (Rodrigue & Slack, 2016). They play a very crucial role in the transportation system and various studies have revealed their insufficiency or absence automatically triggers a malfunction in the entire system.

2.3.2 Categories of Transport Terminals

Transport termini are broadly categorized into two i.e. passenger and freight termini. Passenger terminals are those that are designed as places where travelers board and alight from the vehicles. Other than airports, passenger terminals tend to be simple in their design because the facilities needed are platforms, parking spaces, shelter, administrative offices for

terminal managers and various service providers and access points. However, there are a few additional activities which may be accommodated because they support human operations. These include restaurants and sanitary facilities (Rodrigue et al, 2016). These are facilities that on-street termini don't have and so they are highly insufficient.

Passenger termini are further categorized based on the modes of transportation in use. They include bus stops and stations (road transport), train stations (Railway transport), harbors (water transport) and airports (air transport). Notably, these facilities vary in size and design because of the sizes of transport vehicles, the volume of traffic handled, the required support facilities and the functions they perform. In this regard, bus stops are the smallest because they serve buses in transit and are places where the only activity that take place is dropping and picking passengers. Airports and harbors are on the other hand expansive mainly because aircraft and water vessels are huge vehicles which require expansive spaces of operation.

Freight termini are on the other hand those that handle cargo or goods, mostly the bulky ones. Unlike the passenger termini, these terminal facilities may require many more infrastructures such as loading and unloading equipment and storage facilities. They may also accommodate both core terminal activities and ancillary activities such as distribution (Ibid). Moreover, the facilities within a freight terminal are highly dependent on the modes of transportation that are involved. For instance termini handling ships, trucks and trains will require berths, loading bays and freight yards respectively. It is however generally apparent that freight termini tend to take up more land/space than most passenger terminals.

2.3.3 Functions of Transport Terminals

According to Rodrigue (2016), terminal facilities play three major roles. These include connectivity, interface and buffer functions. The connectivity function is looked at from the point of view that terminal facilities are the only locations through which travelers enter or exit the transport network. In other words, for one to move from one place to another, the connection points are usually the termini.

Rodrigue also argues that terminal facilities act as interface between one transport mode and another. This is basically because they are the points at which one move from one vehicle to another e.g. from a car to a plane.

Transport terminals provide a buffer by providing space for temporary storage of goods in transit and intermodal transfer of cargo. A facility that acts as a buffer tends to have separate spaces for handling goods from various modes and a point where transloading from one mode to another takes place. Modal space separation makes prevents intermodal activity obstructions. The figure below illustrates a buffer in terminal facility.

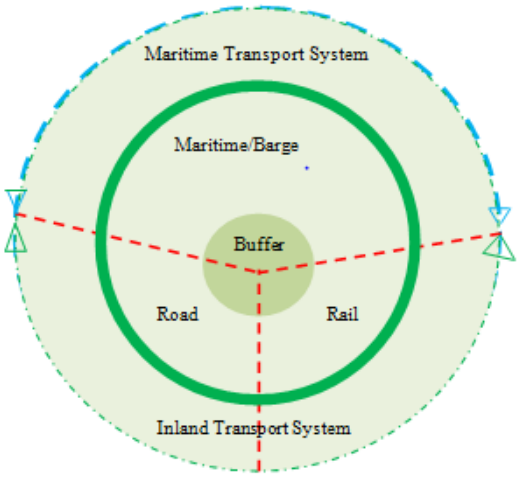


Figure 2: Terminal Facility as a Buffer

2.3.4 Factors that Determine Performance of Transport Terminals

Rodrigue and Slack (2016) have identified a number of factors which improve the performance of terminal facilities. These include location, accessibility and infrastructure. The ideal location of a terminal facility should be within an area where it can serve a large population or a place which is in close proximity to a significant number of industrial and commercial activities. However, it is noteworthy that certain factors may be a constraint to locating a terminal in highly populated zones. For instance, Rodrigue and Slack (2016) observes that new terminals are often located away from central areas because land in such areas tend to be more expensive. Furthermore, a peripheral location may be preferable in order to avoid congestions which are normally frequent in the central areas.

Nonetheless, most of the public transport service providers are biased towards the central areas, where the catchment population is high and the commercial activities are highly concentrated. This makes it possible for the PSV operators to fill up the vehicles fast and make more trips, thus increasing their chance of making more money.

The second factor is accessibility of the facility. The ease of accessing terminal facility is usually dependent on its linkage to the regional transport system and its relationship with

other termini (Rodrigue et al, 2016). Thus, in order to make a terminal facility more accessible, it has to be located strategically within the transportation system.

In regard to the above, a number of terminal facilities are located on-street because there are no provisions for other strategic locations where the termini could be situated. Thus, PSV operators usually negotiate with the regulators to let them operate in the most accessible points, even if such points are not officially designated as termini.

Lastly, Rodrigue and Slack (2016) argue that an efficient terminal facility should be furnished with the kind of infrastructure that can adequately meet the demand, both in the present and in the future. For instance, a freight terminal may require storage facilities and loading areas, beyond what a passenger terminal would require. In the view of this point, it can be argued that the on street termini are less efficient because they hardly have any infrastructure.

Other factors identified by other scholars include adequacy in capacity of a terminus and its usability. A terminal facility which can handle sufficient number of vehicles, passengers and freight that end up in it within the shortest time possible is a well performing one. Such a facility will also allow for optimization of its utilization, thus yielding maximum benefits to its users. These are features that the on-street termini generally lack.

2.3.5 The Impacts of On-Street Termini

On-street termini refer to the points along the transport system where passengers and freight are assembled and dispersed and are located on the spaces along the curbs or shoulders of streets or roads (Rodrigue and Slack, 2016; Olorunfemi et al, 2014). The only terminal facilities that work best on-street are bus stops since they are meant for vehicles on transit and they accommodate no activity beyond boarding and alighting from a bus. Otherwise, if the activities are more intensified than that, then the ideal location becomes the off-street termini. Furthermore, entry into and exit from on-street termini that perform functions that are beyond picking and dropping passengers in transit tend to be complicated because they are often faced with congestion resulting from vehicular and human traffic around them.

Various studies have shown that operating a transport terminal on-street has certain implications, which are both positive and negative. The positive aspects of on-street termini include improved passenger access to the adjacent premises ease of loading and offloading cargo from the nearby plots (Olorunfemi, 2013).

On the other hand, a number of negative impacts of on-street termini have been identified. Richard and David (2007) point out that on-street termini affects traffic movement by reducing a street's capacity, reducing safety and increasing service conflict.

According to Rye (2010), on-street termini block traffic lanes, reduce visibility and make pedestrians to walk in the carriageway when the roads are deficient of good walkways. He also observes that the termini obstruct access for emergency services. As such, the termini have the potential to cause congestion and accidents. In addition, Olorunfemi (2013) notes that on-street termini reduce the efficiency of traffic flow.

From the above arguments, it is evident that on-street termini have more negative impacts than the positive ones. As such, it is important that whenever on-street termini are set anywhere, it must be noted that there will be challenges.

2.4 Transport Efficiency and Effectiveness

2.4.1 Definition

Transport efficiency is defined as a state in which the transportation system promotes low cost of production due to its ability to give room for minimum transportation costs incurred by producers and consumers of goods and services. It is a system that allows for competitive business in the global market and growth of the economy (Shuster, 2013).

It is thus deduced that efficient traffic flow enhances high level of production without making people to inject excessive monetary and time resources. In other words, it does not inflate the production costs either by making people to lose a lot of valuable production time in the traffic jam or by causing them to pay more for transporting goods and services when the transportation service providers charge higher fares to cover for the time lost in the jam.

Transport effectiveness on the other hand is defined as the ability of the transport system to offer consumers the highest quality of transportation services (Carvalho et al, 2015). It therefore means that poor quality transportation services are deemed ineffective.

2.4.2 Factors that Affect Transport Efficiency

Various studies undertaken in Nairobi reveal that there are a number of factors that determine whether or not a transport system will be efficient. They include market forces influencing

transportation services, transport regulatory structures in place, modal composition of vehicles, land use/transport relationships and road network designs/patterns.

The market forces referred to here connote the demand and supply trends operational in the transport sector. It is observable that most of the public transportation systems all over the world are provided by either the state or by both the state and private investors.

Speaking about market forces in relation to efficiency, it has been widely observed that the demand for various transport infrastructures far outstrip their supply, especially in the urban areas, where the urbanization rates have continued to escalate. As a result, the capacities of the existing roads, terminal facilities and NMT infrastructure are often lower than the traffic volumes. This in turn causes congestion, wastage of productive time, increased fares and environmental degradation. All these are excessive costs that inflate the consolidated production expenses, thus making the transport systems less efficient (Aligula et al, 2005).

The second factor that determine transport efficiency levels are regulatory structures operational in a place. These refer to legal, policy and institutional frameworks within which transportation operations take place. They include state organs providing transportation infrastructures and those charged with the responsibility to regulate the services. They also include the laws and policies that provide guidelines along which transportation services are supposed to be offered.

These frameworks are capable of making the transport system either efficient or not. If for example they favor profit maximization by the investor rather than cost reduction, then achieving efficiency remains difficult.

The third factor is modal composition of vehicles operating within a system. It is universally agreed that the dominance of low capacity vehicles within the transport system will often result to traffic congestion since there has to be so many of them along the travel way at any one particular time. Consequently, Public Transport System with such vehicles is highly likely to be less efficient than that which is predominantly made up of high capacity vehicles (Macharia, 2013).

Land use/transport relationships are also very critical in determining the efficiency of a transport system. The type of land use structure that a settlement has will always influence

traffic flow patterns (Obiero, 1992). If a town is planned based on a uninodal structure (like Nairobi), there will be frequent traffic congestions towards and within the CBD, since a big population will have to go there daily, especially during the day. This will cause time loss, environmental degradation, overutilization of energy and reduction in economic productivity, thus inefficiency.

Lastly, transport efficiency is also influenced by road network designs. These relate to aspects such as road intersections, travel way capacities and transport route segregation among others. The manner in which the network pattern is designed definitely determines the traffic flow directions. If poorly coordinated, the network cannot promote efficient traffic flow and vice versa because it will cause a lot of segment delays and related losses (Ibid).

2.4.3 Factors that Affect Transport Effectiveness

The factors that have been observed to affect transport effectiveness include market forces vehicular modal composition and regulatory structures. Effectiveness relate to the quality of services offered to consumers and the level of satisfaction derived thereof. Quality is determined by prices charged, for services, conditions of vehicles and the level of safety and comfort in the system.

Market (demand and supply) forces are essentially affect the prices of transport services (Carvalho et al, 2015). In cases where these forces are dominant (like in Kenya), the fares charged are usually higher than most people can afford regularly. On the other hand, slightly cheaper services are only available for those who are willing to travel in old, uncomfortable and sometimes un-road-worthy vehicles. In fact sometimes even such vehicles still charge high fares, forcing the majority of the low income earners to use NMT modes. These are all conditions that reflect ineffectiveness in the transport system (Aligula et al, 2005).

Modal composition is the second factor that affects transport efficiency. Low capacity vehicles are in most cases squeezed and thus uncomfortable to travel in. They also cause vehicular congestion and an increase in the emission of harmful gasses that are released during combustion of the fossil fuel that power the vehicles. This leads to air pollution. The case becomes even worse if the vehicles are old and poorly maintained because this compromises safety. Furthermore, vehicles that are noisy (majority of which are in Nairobi)

are not only environmentally injurious but are also unhealthy to travelers. Therefore, a system whose vehicular composition exhibits these features is highly ineffective (Ibid).

The other factor that determines transport effectiveness is the regulatory framework under which the system operates. Laws, policies, plans and rules that are less stringent on price standardization, safety, environmental and comfort issues are likely to promote less effective transport systems. On the other hand, if the laws and regulations are properly formulated but poorly enforced (like it is in Nairobi), then the system cannot get any better. In addition, if there is no streamlining of and coordination among the institutions regulating the transport system, there are high chances of ineffectiveness (Carvalho et al, 2015).

2.4.4 The Need for Effective and Efficient Transport System

According to various scholars, an effective and efficient transport system promotes economic growth, community access, high quality of life and highway safety.

Obiero (1992) points out that efficient transportation promotes economic growth by enhancing timely transportation of raw materials and finished products to the market. It also improves access to employment and businesses areas, thereby attracting investors to locate their developments in the easily accessible areas. Furthermore it reduces costs of transportation and by extension the production process. As such, efficient transport system stirs up the production process and consequently increases chances of growth of an area's GDP.

In light of the above preposition, it is argued that a good transportation system is an important selling point for people who aspire to attract developments in their surroundings. Traffic congestion is however an impediment to all these.

According to APTA (2007), an efficient transportation system also makes provisions for everyone, including people with low income, the disabled and the isolated communities living in the rural and suburban zones. Such a system is also accessible to people of all ages. Good community access on the other hand is very important. It enhances social cohesion since people can easily reach each other. It also promotes public safety since the police or fire rescue services can easily be dispensed in case of emergency (APTA, 2007).

Efficiency in transportation is also a prerequisite to the achievement of high quality life (Ibid). The argument is that a good transport system is exposes people to less environmental and health problems that are otherwise caused by traffic congestion. It is for this reason that majority of the rich urbanites often run away from the urban core and settle in the more expensive but less congested suburban residential areas. Furthermore, because such a system is more affordable, it promotes financial savings in communities. It also discourages wasteful consumption of fuel, thereby saving the non-renewal sources of energy as much as it helps people to save time during transportation.

There have also been several observations pointing to the preposition that accidents are more frequent in congested highways than those that manifest free traffic flow. As such, striving for an efficient transport system is equivalent to improving safety of travellers.

2.4.5 Indicators of an Efficient/Effective Transport System

Different studies have shown a number of ways in which someone would know if a transport system is well functioning. The first observation is that, a good transport system is properly coordinated and integrated with the land uses which it connects. This kind of coordination enables efficient patterns of traffic generation and flow. In other words, it enhances seamless connectivity between various activity areas.

Secondly, a good transport system has infrastructural developments whose capacities can accommodate both the prevailing and the projected traffic volumes. It therefore gives no room for congestion or traffic snarl-ups. However, it must be noted that for infrastructural networks to constantly accommodate vehicles sufficiently, car ownership must be strictly regulated because private cars are part of the greatest contributors to traffic congestion.

A good transport system also promotes rapid movement of persons and goods, rather than vehicles (Aligula *et al*, 2005). It makes provision for modes that can move several people per unit vehicle and time. If a system is predominantly made of low capacity vehicles, then it means that the number of vehicles moving would be unnecessarily higher than people and goods. Such a system is deficient because it fails to promote the core business of transportation.

Moreover, a transport system is efficient and effective if it promotes energy conservation and environmental quality. If a transport system compels people to depend on non-renewable

sources of energy e.g. fossil fuels, then it is considered unsustainable (Rodrigues and Racette, 2003; Kenworthy 1999; and Girardet, 1996 in Aligula *et al*, 2005). Furthermore, if the system gives room for traffic congestion and high levels of pollutant emissions, then it is environmentally unfriendly. Such a system tends to rely more on low capacity PSVs than mass transit modes, and is thus a big contributor to deteriorated quality of life and is neither effective nor efficient.

2.5 Urban Transportation

The focus of this research is about one of the major components of the urban transportation system. As such, it cannot be studied in isolation because it influences and is influenced by the other components of the entire system. In other words, it is important to understand the whole system and the operations thereof.

2.5.1 Definition

Urban transport is viewed as a system that provides for movement of people and commodities within an urban area and also links the city to its environs (Aligula *et al*, 2005). Urban transportation systems differ from the rural systems in the sense that the networks are usually denser and the traffic volumes are significantly higher. The infrastructures are also sophisticated sometimes.

2.5.2 Components of Urban Transport Systems

The urban transport system is encompasses four components, including the vehicles, travel way, terminal facilities and policy/legal or regulatory structures. The travel way is defined as the channels, paths and routes of travel. It also refers to the location in space along which the passengers and goods flow (Obiero, 1992). In urban areas, the travel ways form a hierarchy, made of access streets, secondary distributors, primary distributors and major urban roads/urban highway in the ascending order.

The vehicles are comprised of land vehicles (buses, cars, and bicycles among others), air vehicles (aeroplanes and jets) and water vehicles (e.g. ships and tramps). The road vehicles form the biggest proportion of the vehicles. They are animal-drawn (e.g. carts), people – propelled (rickshaws and bicycles), energy fuelled (e.g. cars) and self-propelled (pedestrians). Thus, the vehicular composition in the urban areas is highly diversified (Macharia, 2013).

Terminal facilities are the points along the transport system at which passengers and goods enter and leave the transport system and also include points along the travel way where the passengers and goods can change the mode or vehicle. They include bus-stops, bus stations, air-ports, locomotive shades, railway stations and yards (Rodrigue et al, 2016).

The diagram overleaf is a summary of the urban transport system.

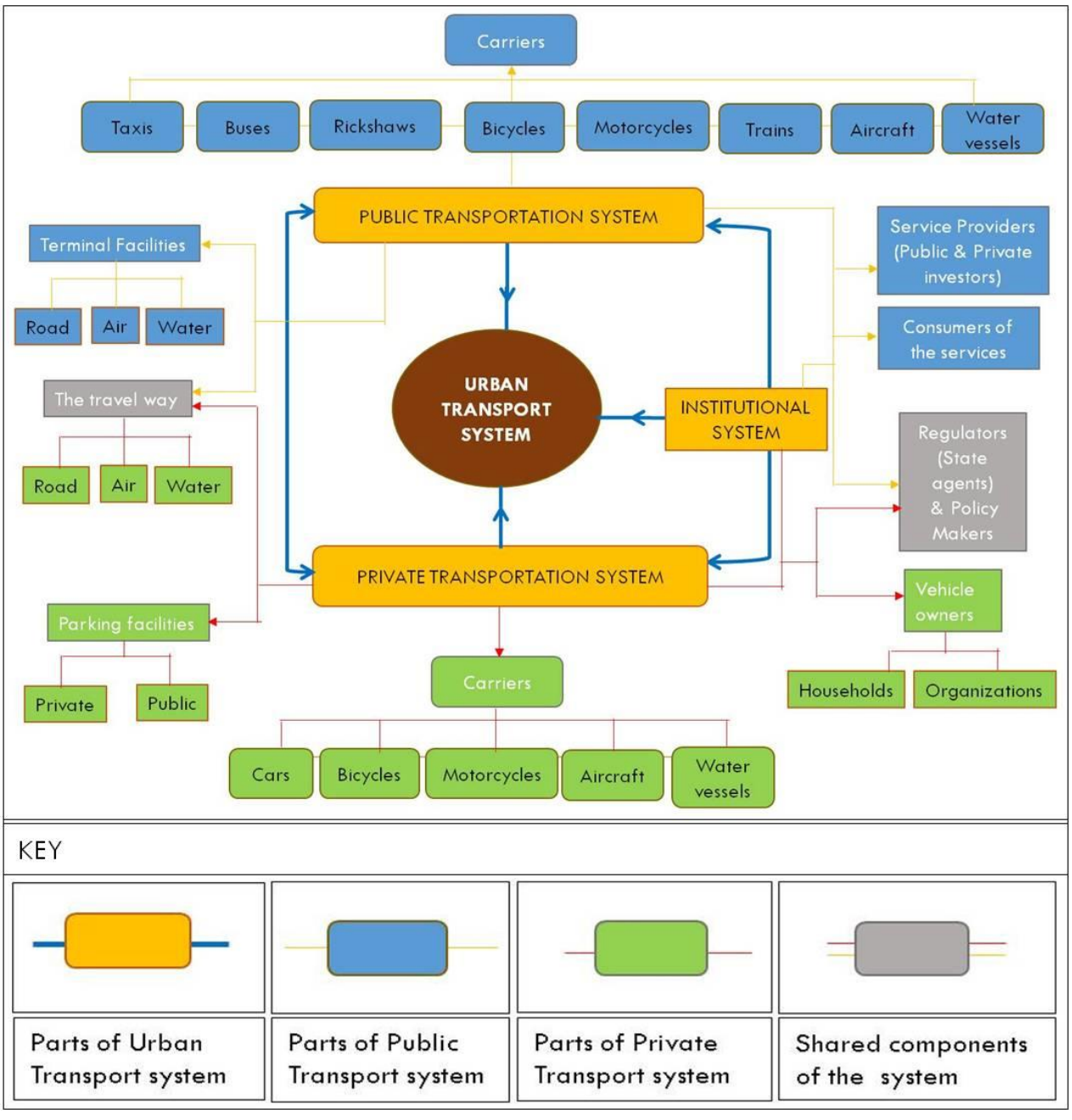


Figure 3: Urban Transport System

Source: Author, 2017

From the above diagram, it can be deduced that a sufficiently operating urban transport system must have all the components which must be operated in a synergistic manner. Furthermore, the management and regulatory sub-system is inevitably vital since it determines the daily running of the entire system.

The CBDs in particular require a network of the travel ways that are well coordinated with the rest of the city. In other words the land use and transport network patterns in place can either promote or inhibit smooth movements to and from the CBD. Thus a sufficient urban transport system is one that also promotes good connectivity between the CBD and other parts of the city.

2.5.3 Characteristics of Urban Transport

According to Aligula et al (2005), urban transport is characterized in various ways. First, it is not a final consumption good but is rather applied by people and firms to satisfy a need at their destinations (derived demand).

Secondly, it is not a purely private good. While the public transport system in countries like Kenya is privatized and run by private investors, it is open for use by members of the public. Additionally, there is a significant level of regulation by the public institutions, especially because of the need to protect the interests of the consumers (public good).

Thirdly, it is a market facilitator. It makes it possible for people from different places to access localized markets for various goods and services. It also facilitates the distribution of the goods and services for people who may not want to go to places where various goods and services are located.

Fourth, Urban Transport generates major non-economic impact. These could either be positive or negative. One of the positive impacts is that it enhances social interactions between people who are located far apart. In this sense, it promotes social cohesion. Negative impacts could include accidents and environmental pollution.

Finally, the demand for Urban Transport is highly qualitative and differentiated. The differentiation is by time of the day, day of the week, journey purposes, speed and frequency among others.

2.5.4 Categories of Urban Transportation Systems

The urban transportation systems are broadly categorized as private and public. Private transportation systems are made up of the travel means which are restricted for owner usage. The common modes under the private category include the low capacity vehicles such as cars and bicycles.

Public transport modes are on the other hand meant for the public, irrespective of whether the services are offered by the state or private investors. The travelers are usually expected to pay for the service (Rodrigue et al, 2016).

2.5.5 The Relationship between Urbanization and Urban Transport System

Urbanization refers to the process of migrating from rural to urban areas and engaging in non-agricultural activities. In this regard, urbanization leads to increase in population in the urban areas (Kasuku, 2001). The other definition of urbanization is the process of becoming urbanized (Merriam Webster Dictionary). It is also referred to as the process of growth of cities (dictionary.com).

In view of the first definition, it has been observed that the rate of urbanization has continued to escalate significantly over the years. In Kenya, the urban population has increased to the point that as of 2009 census, about 33% of the people were living in the urban areas. By 2007, it had been established that the East African urban population had reached 52.3 million out of a total of 247.2 million people. It is further estimated that this population will increased to 131.5 million by 2030 (Obudho, 2008). Such trends have also been witnessed in other parts of the world. Essentially, what this means is that the global urban population is increasingly getting high.

The most notable implication of these urbanization trends on the urban transport system is the increasing demand for various transport facilities. The process of urbanization influences changes in land use patterns and causes development densification thereby increasing the demand for movements. While the demand is highly elastic, the supply of urban land (on which transport facilities are supposed to be laid) is fixed. As such, it is often challenging to constantly increase the supply of roads and other facilities, especially in the already built up urban spaces. On the other hand, vehicles are usually provided as fast as the travel demand increases. Consequently, the vehicular and pedestrian volumes swiftly outstrip the capacities

of the existing transport facilities, hence congestion. The graph below illustrates this phenomenon.

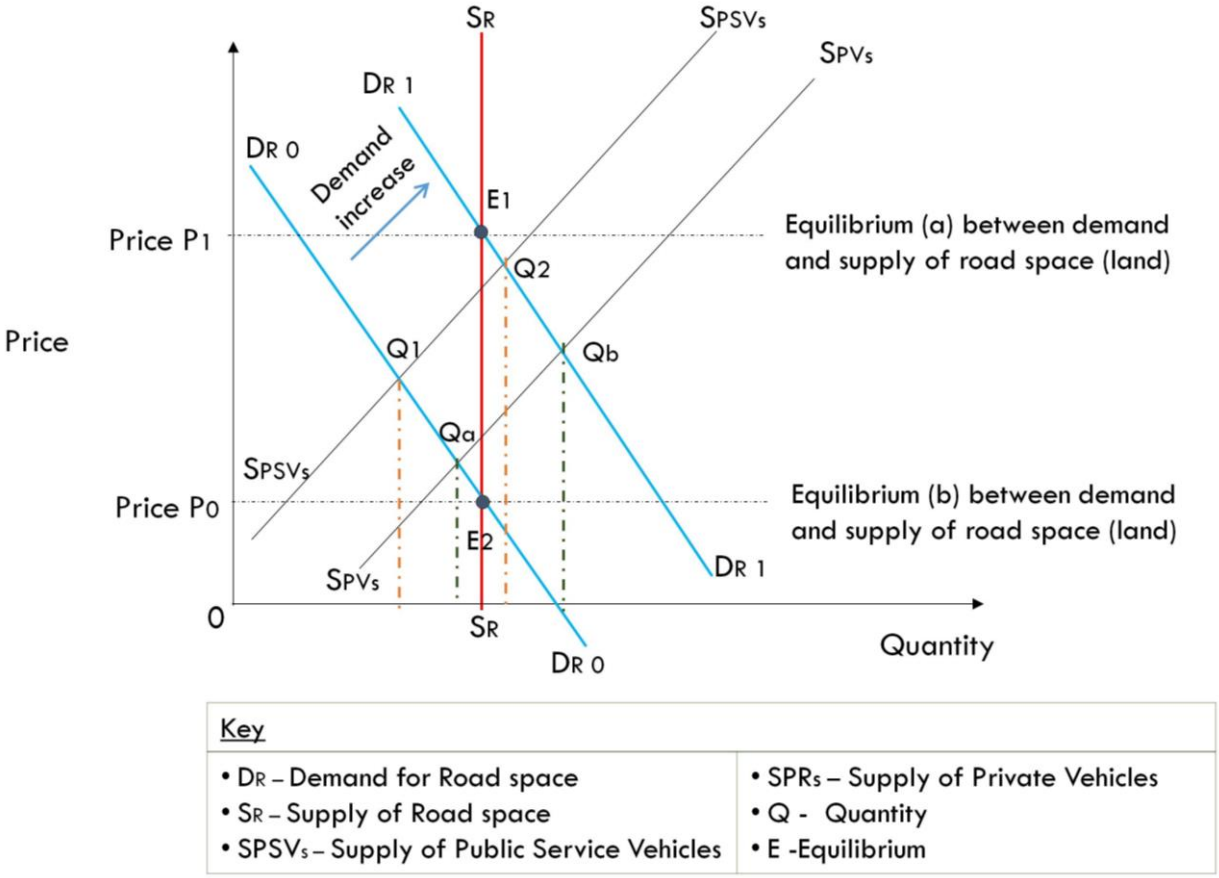


Figure 4: Demand/Supply Relationship in Urban Transportation

Source: Author, 2017

From the above diagram, it is evident that initially (in a new town for example) when the demand for road space is low ($DR_0 – DR_0$), the available road space (at equilibrium E2) is higher than the number of PSVs and private vehicles (Q_1 and Q_a respectively). However, when the demand for road space increases due to urbanization ($DR_1 – DR_1$), the available road space (at equilibrium E1) now becomes smaller than what is required by the number of PSVs and private vehicles (Q_2 and Q_b respectively).

Also notable is that the supply of road space is fixed (inelastic) while the supply of vehicles is elastic. The latter is caused by the increasing urban population which leads to a higher travel demand. Furthermore, the rate at which private vehicles are increasing is higher than that at which PSVs are being supplied. This reinforces the point that private cars are greater contributors to traffic congestion than mass transit modes in urban areas.

In order to deal with the above challenge in an already built up urban space like Nairobi, radical decisions must be made to change land use patterns and provide more space for transport infrastructure; and restrict car ownership and use. Moreover, it is important that more effective ways of projecting the future urbanization trends be devised so that as the infrastructure networks are developed, they can be done in such a way that they will adequately serve the future population.

2.6 The Concept of the Central Business District (CBD)

2.6.1 Definition

According to the dictionary of geography, the CBD is the focal point of a city. It is the commercial, office, retail, and cultural center of the city and usually is the center point for transportation networks. The CBD is also defined as the centre of an urban area where there is intense levels of activities & interaction within a relatively small area leading to prime real estate that necessitates specialized uses.

Murphy (1960) defines the CBD as an area of very high land valuation, characterized by a high concentration of business, office and recreational developments, and high traffic flow. Rosenberg (2015) on the other hand points out that:

> *"The CBD developed as the market square in ancient cities. On market days, farmers, merchants and consumers would gather in the center of the city to exchange, buy, and sell goods."*

Thus for him, the CBD begins as that part of the city where business activities are concentrated. He however recognizes the changing trends with regards to the functions that a CBD performs. He thus observes that over time, the CBD has developed into a center of finance and control or government as well as office space.

He further explains that in the early 1900s, European and American cities had CBDs that featured primarily retail and commercial cores. In the mid-20th century, the CBD expanded to include office space and commercial businesses. By the beginning of the 21st century, the CBD had become a diverse region of the metropolitan area and included residential, retail, commercial, universities, entertainment, government, financial institutions, medical centers, and culture.

2.6.2 Location of CBDs

According to BBC (2014), most CBDs are either located at the geographical centre of a city or the most accessible part of the city or near the oldest part of the city. The latter location is often the point from which the town began. The centrality of the CBD is often defined by convergence of major transport corridors, the ease of accessibility from all parts of the town and the ability of an area to concentrate numerous businesses activities.

2.6.3 Characteristics of CBDs

According to BBC (2014), CBDs are characterized by the following features:

a) High/Multi-Storey Buildings/Skyscrapers or High Density Buildings

CBDs are often contained within a defined zone which is highly contested by people who want to locate their business in accessible and economically vibrant parts of the city. The high demand for space tends to create an inevitable need for expansion. However, because the zone is usually localized, horizontal expansion of buildings becomes difficult. As such people resort to expansion in the vertical dimension, hence the skyscrapers. These buildings tend to have Multi-storey car parks

b) High Land Values

The economic primacy of the CBD makes competition for space there very high. The supply for such space is on the other hand inelastic. Consequently, the land is valued so highly and the only the highest bidders tend to acquire land therein.

c) Major Shopping Premises

These include department stores, shopping malls, specialist shops, like jewellers and many more. The concentration of such premises is for the simple reason that the CBD is a major business zone of the town.

d) Socio-Cultural Centres

Cultural and historical buildings, museums, castles and theatres are some of the socio-cultural areas that are usually located in CBDs. They act as the areas where people can fulfil their social needs after a whole week's work schedule. Furthermore, because cities are cosmopolitan areas where people of diverse cultures reside, the cultural centres offer everyone the chance to reconnect with their traditions, which are otherwise common in the rural areas.

e) Commercial and Administrative/Public Offices

The CBD is one of the greatest employment zones in all cities of the world. As such the bulk of the offices, both administrative and commercial, are within the CBD. The administrative offices are particularly located in the CBD because of its centrality and accessibility to everyone who is in need of public services. The business premises are on the other hand demarcated into rooms as small as less than $10m^2$ in order to accommodate several businesspeople. This shows that the CBDs exhibit the highest employment densities and development intensity, thus the high travel demand to and from the districts.

f) Financial Institutions

The financial institutions such as banks are by default in the CBD since they offer services that are mandatory to business operators. These include both Central and local banks.

g) Bus and Railway Stations

Given that CBDs are experience a population influx every day, they are relatively well served with transport facilities. Major railway and bus stations are thus often located there so that people who come to the CBD for work and business can easily access vehicles plying different routes every morning and evening.

2.6.4 Economic Significance of CBDs

The CBD has been known to be a major contributor to the city's economy. In fact CBDs of capital cities not only impact on the city but also the metropolitan region and the entire nation. The CBD's economic potential revolves around business, employment, industry and tourism.

The CBD is home to many core businesses activities, including retail, wholesale, finance, and various commercial services. These activities cater for a very significant portion of the Gross National Income. They account for a good part of the cash that flows in the economy every single day. In fact without them, the production processes in the manufacturing industries would be rendered non-progressive because whatever is produced will not be sold. In other words, the CBD provides a prime location where people generate income for their products.

The business and financial activities in London's CBD for instance total to over £15.5 billion of exports per annum. These include financial business (such as fund management, banking, and insurance) and business services (such as consultancies, legal, advertising, computing,

architecture, engineering and media). The retail spending on the other hand amounted to over £5.3 billion in the year 2006 only. The CBD's retail floor space was about 6.6 million square feet in the same year (GLA, 2008).

CBDs are also the main areas of employment to millions of city dwellers. The London's CBD for instance offered employment to one and a half million people as of the year 2008. This accounted for about one-third (33%) of London's total employment (GLA, 2008). New York' CBD offers nearly 2,000,000 jobs while Chicago's and Washington's CBDs offer approximately 500,000 and 375,000 jobs respectively (Cox, 2014). These statistics are evidence to the significance of the CBD as a major employment provider. It is thus agreeable that the absence of vibrant CBDs would be an automatic drawback to economic growth.

Additionally, CBDs are some of the major landing sites for tourists in many cities. They tend to be homes for key hotels where foreign tourists are accommodated. The cultural sites located therein also attract the tourists. The tourists are key contributors to national economies, e.g. in Kenya. As such, being able to attract and accommodate them within the CBDs adds to the economic importance of the CBDs.

Furthermore, in as much as heavy manufacturing industries are normally located outside CBDs, there are still a number of light industrial activities which take place there. These also add significantly to the amount of the income that a city earns because the majority of the non-skilled and semi-skilled urbanites are employed in such places.

Evidently, the CBD is a very key economic zone in any city. This is most CBDs are normally well developed and served with key infrastructure, including transport facilities. In cases where this is not done, business performance is not only affected at the local level but also at the regional and national levels.

2.6.5 Centrality of CBDs

Centrality of CBDs can takes two dimensions i.e. locational and functional. From the functional dimension, the centrality of CBDs can further be viewed at the international, national and city levels.

Most CBDs attain the locational centrality by virtue that they are usually situated at points where they can be easily accessed from various parts of the city (Rosenberg, 2015). Looking

at Nairobi CBD for example, it is at a location from which the rest of the city radiates in all directions. This kind of scenario leads to a radial urban structure where the CBD forms a strong central node.

Functional centrality is on the other hand determined by the level of significance of the activities that are housed within the CBD. Such activities tend to be administrative and economic in nature (Rosenberg, 2015). Nairobi's CBD is for example functionally central because it is home to internationally and locally significant establishments which are both of economic and administrative value.

2.6.6 Common Spatial Manifestations in CBDs

Spatial manifestations are considered as the physical visible characteristic of the CBD including urban structure and patterns of transport networks. Some of the most common urban structures in CBDs are radial (e.g. in Lagos and Singapore) and grid-iron (e.g. in Nairobi, Harare and Chicago). A radial structure depicts a pattern of roads radiating from a central point e.g. a public square thus creating a star-like pattern of development. The grid-iron structure on the other hand manifests a system of criss-crossing roads which lead to distinct blocks of developments (Murphy, 1960).

Secondly, CBDs have the highest densities of developments in most urban spaces. A majority of the skyscrapers of the world are located within the CBDs. The high development densities in CBDs indicate high intensity of activities and the resultant (high) travel demand therein.

2.6.7 Common CBD Problems

The CBD is a very prime part of the city, which is in most cases well planned. However, it also has a fair share of problems. They can be categorized transportation, environmental and land related and social problems

The most common of among the transportation problems is traffic congestion, encroachment into road reserves and deteriorated and/or insufficient infrastructure e.g. NMT and parking facilities (BBC, 2014). Traffic congestion is often caused by the fact that the day-time population in CBDs is always very high because very many people go there either to work, to do business or to buy one thing or another. Speaking of London for instance, those who go to the CBD to work only are about 1.5 million in number. The CBD on the other hand takes up

only 2% of London's land space (GLA, 2008). It would therefore not be a surprise if there is traffic congestion in such a zone.

Environmental problems include pollution and inadequate drainage facilities, sanitary services, encroachment into riparian reserves, poor solid waste management. These are most common in developing countries. Pollution occurs in the form of air, water and noise pollution. Air pollution is mostly as a result of the gaseous emissions from the motorized traffic typical of CBDs.

Water pollution is common cities in developing countries, where a river traverses the CBD. Such rivers are usually encroached into and highly polluted e.g. in Nairobi (Meso, 2013). Noise pollution takes place in public service vehicles and congested parts of the CBD e.g. markets and public squares.

The other common CBD problems are land related. They include high cost of land/space and land use conflicts. Land in CBDs is very prime and therefore very highly contested. As such it is valued so highly that the majority of city dwellers cannot afford. However, those who cannot afford the land in CBDs invade the spaces and set up informal business operation zones which in turn cause a lot of congestion and disorderliness. Examples of such people are the hawkers who operate on footpaths and road carriageways (Macharia, 2013).

Lastly, CBDs experience a number of social challenges. These include insecurity; insufficient social amenities. Insecurity mostly arise from the existence of either congested places (which encourage pick pocketing) of secluded and unkempt sections of the CBD, where street families tend to occupy (Meso, 2013).

In summary, CBDs are crucial parts of the cities. They give cities their identities and perform very important urban functions. On the other hand, they have their inherent challenges which must be dealt with from time to time.

2.6.8 The Need for Effective Transportation in the CBD

As indicated earlier in this paper, efficient and effective transportation has immense benefits. It promotes economic growth, highway safety, access and environmental quality (Macharia, 2013). All these are key factors that are as desirable in the CBD as it is in any other part of the city.

More particularly, it has been established that the CBD is a very important economic growth facilitator. If the transport system therein is ineffective or inefficient, the numerous employment and business areas will become less accessible for the millions of the employees. As such, the number of hours that is put into productive work lessens significantly and this in turn affects the entire economy. In other words, good transportation system in the CBD translates to good economic performance for the city and its surrounding.

Secondly, the level of transportation effectiveness in the CBD is a determinant of the level environmental quality achievable therein. If the transportation system is dominated by highly polluting vehicular traffic, this does not work well for the CBD especially because a deteriorated environment is not good for tourist activities therein. This further means that it is possible for a country to lose on its foreign exchange if its major cities have CBDs with inefficient transport system. In essence, transport efficiency in the CBD is very important to the city's growth.

2.7 Transport - Land Use Relationships

According to Osengo *et al* (2005), there exists an intricate correlation between transportation and land use. The relationship occurs both ways and involves the transport system, activity areas and the flows thereof. The transport system encompasses both the tangible and the intangible components, including the entire infrastructures that support urban mobility for both people and goods. The activity areas take various forms. They range from spaces of a single uses such as residence to areas of complex mixes of high density developments.

It has generally been observed that no activity area operates in isolation. Each is usually dependant on another for one reason or another. As such, there have to be movements between various activity spaces and these movements are facilitated by the transportation system. As such, spatial interactions between activity areas will always cause the need for transportation networks connecting them.

Similarly, if it happens that a transport infrastructure is developed in a place or a particular place corridor where there are no activities, sooner or later, it will begin to attract human activities and the related developments (Osengo, et al, 2005). It is thus true to say that the transportation systems influence land use structures and vice versa.

Theoretically, there are certain impacts that land use would have on transportation and vice versa. These are summarized in the table below.

Table 1: Theoretically Expected Impacts of Land Use on Transportation

Direction	Factor	Impact on:	Expected Impacts
Land use - Transport	Residential density	Trip length	High residential density alone will not lead to shorter trips. A mixture of work places and residences can lead to shorter trips if travel costs are increased
		Trip frequency	Little impact expected if trips are shorter, more trips may be made
		Modal choice	Minimum residential densities are pre-requisite for efficient public transport. More walking and cycling trips will be made only if trips become shorter.
Land use - Transport	Employment density	Trip length	Concentration of work places in few employment centres tends to increase average trip lengths. A balance of work places and residences in an area would lead to shorter work trips only if travel becomes more expensive.
		Trip frequency	Little impact expected if trips are shorter, more trips may be made.
		Modal choice	Concentration of work places in few employment centres may reduce car use if supported by efficient public transport. More walking and cycling will be made only if trips become shorter.
Land use - Transport	Neighbourhood design	Trip length	Attractive public spaces and a variety of shops and services can induce more local trips.
		Trip frequency	If trips are shorter more trips may be made.
		Modal choice	Street layout, pedestrian spaces and cycling lanes could lead to more walking and cycling.
Land use - Transport	Location	Trip length	More peripheral locations tend to have longer trips.
		Trip frequency	No impact expected.
		Modal choice	Locations close to public transport stations should have more public transport trips.
Land use - Transport	City size	Trip length	Trip length should be negatively correlated with city size.
		Trip frequency	No impact expected.
		Modal choice	Larger cities can support more efficient public transport systems, so more trips should be made by public transport in larger cities.
Transport - Land use	Accessibility	Residential location	Locations with better accessibility to work places, shops and leisure facilities will be more attractive for residential developments. Higher land prices expected. Improving accessibility locally will change the direction of new development; improving accessibility in the whole urban area will result in more dispersed residential development.
		Industrial location	In locations with better accessibility (motorway and railway), freight terminals will be more attractive for industrial development and will be developed faster. Improving accessibility locally will change the direction of new industrial development.
		Office location	Locations with better accessibility to airports, high speed motorways and railway stations will be more attractive for office development, have higher land prices. Improving accessibility locally will change the direction of new office developments.
		Retail location	Locations with better accessibility to customers and competing retail firms will be more attractive for retail

			development, have higher land prices and be faster developed. Improving accessibility locally will change direction of new retail developments.
Transport - Transport	Accessibility	Trip length	Locations with good accessibility to many destinations will produce more trips.
		Trip frequency	Locations with good accessibility to many destinations will produce more trips.
		Modal choice	Locations with good accessibility by car will produce more car trips. Locations with good accessibility by public transport will produce more public trips.
Transport - Transport	Travel cost	Trip length	There is a strong inverse relationship between travel cost and trip length.
		Trip frequency	There is a strong inverse relationship between travel cost and trip frequency.
		Modal choice	There is a strong inverse relationship between travel cost and choice of travel mode.
Transport - Transport	Travel time	Trip length	There is a strong inverse relationship between travel time and trip length.
		Trip frequency	There is a strong inverse relationship between travel time and trip frequency.
		Modal choice	There is a strong inverse relationship between travel time and choice of travel mode.

Source: Osengo et al, 2005, Pg.23-24

The above analysis shows that the development of transport systems needs to be done in consideration to the prevailing land use structure in as settlement. In most CBDs, the transport networks tend to take up a grid-iron network and this makes it very easy to manoeuvre around. However, it requires conscious planning and traffic management in order to ensure efficient travels. Moreover, the relationship between the CBD and other activity zones in the city must be considered seriously when developing transport networks. In essence, transportation corridors ought to be planned in the context of the surrounding land uses.

2.8 Transportation System in Nairobi

The transportation system in Nairobi has been analyzed with regards to the modes, infrastructure and institutional structures. The details are discussed herein below.

2.8.1 Transport Modes

Nairobi's modes of transport include road, railway and air.

a. Road Transport

Nairobi residents are highly dependent on road transport modes. A study undertaken in 2013 reveals by JICA shows that about 99.3% of the trips are made by road. The people use both

Motorized and NMT modes. The level of use of each mode also varies. The same study by JICA showed variations as shown in the figure below.

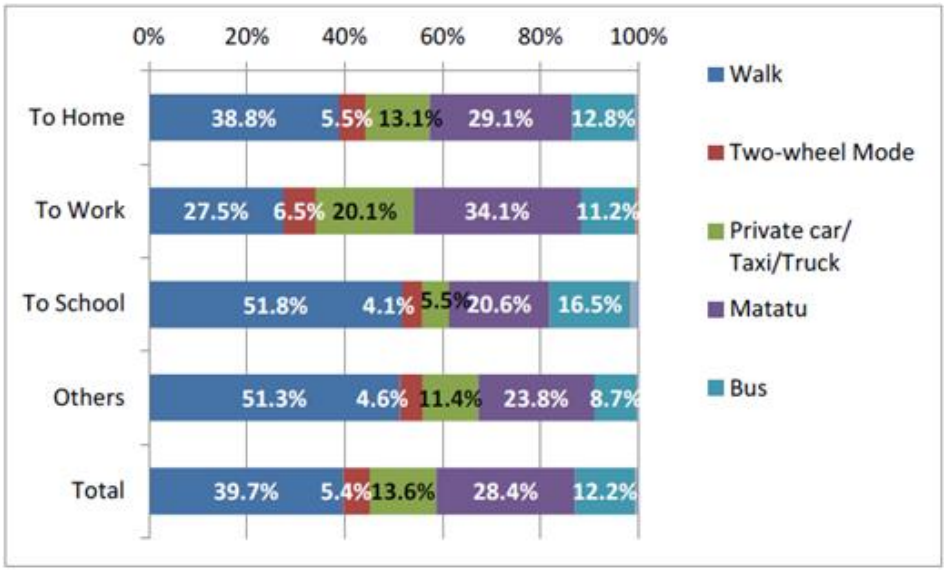


Figure 5: Road Transport Use in Nairobi

Source: JICA, 2013

The study further revealed that the majority (39.7%) of the trips are made using NMT modes, especially walking. The second mostly used mode is matatu, followed by private cars and taxis and then bus. These are in the proportions of 28.4%, 13.6% and 12.2% respectively. The least used modes are the bicycles and motorcycles. The proportion of trips made by them sum up to 5.4% only.

The analysis above shows the over-reliance of the road transport modes compared to the railway and air transport modes. This is because the railway system is underdeveloped while air transport cannot be used for intracity trips which are generally very short. However, road infrastructure is generally inadequate, especially NMT facilities.

b. Railway Transport

The proportion of trips made by railway only makes up 0.75% of all the trips made within Nairobi (JICA, 2013). The existing railway infrastructures serve only a few sections of the city hence the low level of use. However, if better developed, there are high chances that many people will shift to the railway transport modes since railway transportation is generally faster than the congested road transport system.

c. Air Transport

The air transportation modes are only used for intercity and international trips. This essentially because air transportation is more ideal for long distance travels. The modes are also mostly used by politicians and the wealthy people who can afford the services.

2.8.2 Transport Infrastructure

The transport infrastructure covers roads, railway lines and terminal facilities.

a) Road Network

Nairobi has two international roads (Class A) including A109/A104 corridor and Thika Road (A2). Segments of the A109/A104 corridor include Mombasa Road, Uhuru Highway, Chiromo Road, Waiyaki Way and Naivasha Road. A104 extends southwards and connects Nairobi to Tanzania thorough Kajiado and Kamangato. A109 connects Nairobi to Mombasa, on the eastern side and to Uganda on the western direction. A2 Road connects Nairobi to Ethiopia (through Thika town) in the northeast direction.

The other intracity roads are numerous and some of the major ones include Airport North Road, Northern Bypass, Eastern Bypass Road Jogoo Road, Ngong Road, Lang'ata Road, Limuru Road, Dagoretti Road, Naivasha Road, Kiambu Road, Ruiru Road, Outer Ring Road, Magadi Road and Mbagathi Way. These roads are classified as shown in the table overleaf.

The overall road length density is 0.98 km/km^2. This is far much lower than the Japanese standard of 4.0 km/km^2 for a city like Nairobi. Nonetheless, certain areas have more dense networks than others. For instance, the CBD ranks highest at a density of 4 km/km^2 while most parts of Eastlands have densities of between 2 km/km^2 and 3 km/km^2. The overall road length density by population stands at 0.22km/1000 (JICA, 2013).

Table 2: Road Network by Class

Functional Class	Road Class	Functional Class	Alternative Descriptive Term	Description	Indicative Design Standards		Road Examples
					Carriage-way Width in Meters	Design Speed (kph)	
Arterial or Trunk	S	Super Highway	Auto route, Motorway, Expressway	Highways connecting two or more cities and designed to carry safely large volumes of motor vehicle traffic at high speeds	Dual carriage way of min 2 lanes	90-120	•
	A	Major Arterial	Trunk Road	Roads forming strategic routes and corridors, connecting international boundaries and international terminals.	7-14m	70-110	• Mombasa Road • Uhuru Highway • Chiromo Road • Waiyaki Way • Naivasha Road

							• Thika Road
	B	Minor Arterial	Trunk Road	Roads forming important national routes, linking Province headquarters or other important centres to the capital, to each other or to Class A roads.	7 (-14)m	70-110	• Airport North Road
Arterial	H	Major Arterial	Highway	They provide for through traffic and for relatively long distance movements between widely separated parts of the city.	3.5m per lane, 4-6 lanes	70-90	• Northern Bypass • Eastern Bypass
	J	Minor Arterial	Principal Arterial	Minor Arterials provide the main means of moving between different zones of the urban area.	3.5m per lane, 2-4 lanes	50-60	• Jogoo Road • Ngong Road • Lang'ata Road • Limuru Road • Dagoretti Road • Kiambu Road • Ruiru Road • Outer Ring Road • Magadi Road
Collector	K	Major Collector	Primary Distributor	Major Collectors provide the link between Arterials and Local roads, distributing traffic to residential and other defined zones.	7m	30-50	• Mbagathi Way
	L	Minor Collector	District Distributor	These perform a similar function to major Collectors, but generally serve a smaller area, with lower traffic levels.	7m	30-50	• Valley Road • Bunyala Road
Local	M	Major Local	Shopping / Local street	These roads include the main shopping and business streets in the urban CBD or suburbs of larger towns and cities.	5-7 m	30-50	• Moi Avenue • Kenyatta Avenue
	N	Minor Local	Non-residential access	Roads providing direct access to individual or groups of properties, other than residential areas.	5m	30-50	
	P	Local Access	Residential access	Roads providing direct access to groups of residential properties.	3-5m	30-50	

Source: "Kenya Road Classification Manual" July 2009, Ministry of Roads

b) Railway Infrastructure

The main railway network the Mombasa- Nairobi- Uganda line. The commuters in the city use this line from Athi River (South-East direction), Kikuyu (North-West direction), Ruiru, (North-East direction) and Embakasi Village. The track is the meter-gauge type and is composed of 85/90 lb/yard rail with steel sleepers. The network is generally underprovided since it only serves a significantly small proportion of the city's population.

c) Road and Railway Terminal Facilities

The road transport terminal facilities are majorly within the city centre. They include Machakos bust terminus (which serve vehicles that transport people to and from different parts of the rural Kenya), Muthurwa bus terminus, Central Bus Station (located off Ronald

Ngala street) Railway bus station and Koja bus station. The rest of the termini are operated on-street.

The railway stations include Central, Makadara, Imara Daima and Syokimau stations. These are located along the railway corridors and they serve the city commuters as well as the intercity travellers.

d) Air Transport Facilities

The air transport facilities within Nairobi are Wilson airport, Jomo Kenyatta International airport and Moi Military Airbase, Eastleigh. Wilson airport mostly serves people who take local flights.

2.8.3 Public Transport

a) Modes

The public transport modes in Nairobi include large buses, *matatus (midi buses)*, taxis, tuktuks, motorcycles and the train. As of 2013, total number of *matatu* was 72,000 and large buses were 23,000 (JICA, 2013). The matatus have a seating capacity of between 14 and 33 seats while the larger buses accommodate an average of 40 to 60 travelers. This indicates that the high capacity Pubic Service Vehicles are still far much fewer than those with low capacity. This (together with the immensely high number of private cars in the city) leads to the overwhelmingly congested road network.

b) Routes

The public transport routes are mainly the arterial streets and the highways. Each of the routes end up at the CBD as summarized herein below.

Table 3: Public Transport Routes

City Zones	Route Numbers	Destination	CBD terminus
Southern and Western Suburbs	46	Kawangware	Kencom
	32C	Kibera	
	5	Jamuhuri	
	40	Ngumo	
Southern and Western Suburb	7C	Kenyatta	Kencom
	3	Kinoo	Railway stage
	2	Dagoretti market	
	4W	Riruta Satellite	
	1	Dagoretti market	
	111	Ngong	

	8	Kibera	
	33	Ngumo	
	34	Langata	
	16	Nyayo Highrise	Central Bus Station
	15	Langata	
	24	Karen, Hardy	Kencom
	126/127	Kiserian	Railway stage
	14	Nairobi West	Central Bus Station
	12	South C	
	110	Kitengela	Railway stage
	11	South B	Central Bus Station
Northern suburbs	105	Kikuyu	Railway stage
	48A	Kawangware	Latema Road/Odeon stage
	48B	Lavington	
	11A	Highridge	
	23	Kangemi	
	11D	Ukay Centre	
	22	Kinoo	
	118B	Wangige	Old Nation House or Koja Stage
	118	Westlands	
	119	Mwimuto	
	108A	Gachie	Tom Mboya Road Tuskeys stage
	108B	Karura (Kanyugu)	
	107	Karura (Kamurimo)	Old Nation House or Koja Stage
	106	Banana Hill	
	11B	Ruaraka	Latema Road/Odeon stage
	120	Gihunguri	Railway Stage
	100	Kiambu	Central Bus Station
	44	Githurai	Tom Mboya Post Office stage
	45	Githurai	Ronald Ngala Road Stage
	145	Ruiru	
	237	Thika	
	43	Ngumba	Central Bus Station
Eastlands	25	Babadogo	Ngara stage
	42	Dandora	
	29/30	Mathare North	
	30	Mathare North	Gikomba stage
	6,9	Eastleigh	Old Nation House Stage
	46	Huruma	Ronald Ngala Road Stage
	14	Kariobangi North	
	32	Dandora	
	17	Kayole	Gikomba stage
	26	Korogocho	Ronald Ngala Road Stage
Eastlands	8B	Jericho	Gikomba stage
	10	Jericho	Ronald Ngala Road Stage
	7	California	Gikomba stage
	6	Eastleigh	Accra Road Stage (Commercial)
	23	Outer Ring	Central Bus Station
	58	Buruburu	Ambassador

	36	Dandora	Muthurwa stage
	17B	Kasarani	Central Bus Station
	39	Ruai	
	35/60	Umoja	Ronald Ngala Road/ Mfangano Street
	19/60	Kayole	Muthurwa stage/ Mfangano Street
	34B	Greenfield	Ambassador
	33	Embakasi	
	33	Utawala	
	34	JKIA	
	33	Baraka	Accra Road Stage (Commercial)
	33	Transami	
	33	Pipeline	
	71	Likoni Road	Muthurwa Stage
	71	Enterprise Road	
	33	Mombasa Road	Nyayo Stadium

Source: Compiled by Author, 2017

Majority of the above routes end up in the CBD thus making traffic flow therein very active and traffic volumes very high at all times. This has been seen to cause congestion and traffic flow problems within the CBD.

c) Service Providers

Public transport service provision in Nairobi is highly privatized. The service providers are composed of private investors who have organized themselves into SACCOs and companies. The SACCOs employ drivers and conductors, who then deal with the travellers directly. The service providers also have a lobby group known as Matatu Owners Association.

d) Regulators

The regulators of the public transport sector are majorly state organs which comprise of NTSA, Kenya Police Traffic Department and Nairobi City County Government. NTSA's main function is to implement policies relating to road transport and safety. The Police Traffic Department is charged with the responsibility of ensuring free flow of traffic and dealing with matters related to road accidents. Nairobi City County Government traffic marshals monitor adherence to traffic rules within the city roads.

2.8.4 Current Traffic Situation

Based on the Traffic Assessments done by JICA in 2013, almost all the roads leading to city centre (Jogoo, Thika, Mombasa, Waiyaki way and Ngong roads), the circumferential roads and the bypasses (e.g. Outering Road and Eastern By-pass), are currently heavily congested.

The vehicle-kilometer[4] measure stands at 17,780,000 while the vehicle-hour[5] measure is at 431,690 in the Greater Nairobi (the city-region). On the other hand, the vehicle-kilometer and vehicle-hour measures within the city alone are 10,960,000 and 273,910 respectively. If no intervention is sought, it is projected that the vehicle-hour and vehicle-kilometer volumes will be 5.3 times and 2.4 times higher by the year 2030.

The traffic in Nairobi comprise of intracity and intercity traffic. The latter include both through traffic and vehicles which move between Nairobi and other towns. According to the cordon survey carried out in 2013 by JICA, the vehicles which pass through Nairobi are approximately 46,000 per day (through traffic). The survey also reveals that about 98,000 trips made from outside of Nairobi city also end outside of the city. This is about 1.4% of total trips made through Nairobi.

The average travel speed within the city is currently 40km/hour and the volume-capacity ratio[6] is 0.69. This speed is lower than it should be and is further expected to reduce to 20.2 Km/Hr by the year 2030 if no intervention is sought. The volume capacity ratio on the other hand shows that the traffic volumes have not yet exceeded the road network capacity. However, this may not be true for all transport corridors because roads such as Jogoo road already had a ratio of 2.992 by the year 2004 (Osengo et al, 2005).

The above statistics evidently indicate that the traffic situation in Nairobi is generally undesirable. It is thus essential that well thought out plans are engineered in order to make the current transport system better.

2.8.5 Impacts of the Historical Transport Sector Transformations

The city's public transportation system has a fairly long history. It has undergone remarkable transformations, each of which has impacted the city in to a different degree. Today Nairobi is majorly served by buses and matatus. According to Chitere et al (2012), the first buses in the city came with the Kenya Bus Services which came to being in 1934.The company was granted monopolistic powers as the sole public transport service operator in 1966. The

[4] **Vehicle-kilometre** is a measure of traffic flow, determined by multiplying the number of vehicles on a given road or traffic network by the average length of their trips measured in kilometres
[5] **Vehicle-hour** – delay per vehicle multiplied by the peak hour volume on that road segment or network
[6] **volume-capacity ratio** refers to vehicle volumes on a road network compared to the capacity of that network

services were generally efficient and effective as they were provided based on predetermined schedules and reasonable fare guides.

The government also began the Nyayo Bus Services Corporation in 1986. This was a parastatal which provided public transport services in Nairobi. It was operated by the National Youth Service (NYS) as a means to create jobs for youth trainees and phase out matatus. The corporation also provided efficient services. In fact it charged lower fares than Kenya Bus Services Company since it has readily available labor from the NYS trainees and subsidized fuel. In addition, it had easier access to bus spare parts from foreign markets compared to other operators who faced various restrictions.

Meanwhile, matatus (low capacity PSVs of upto 25 seating capacity) also operated in the city as from the 1950s, even though they were considered illegal. Unlike in the Kenya and Nyayo buses, the services offered by the matatu operators were less efficient since their fares and stages were not fixed. They were however officially recognized in 1973 through a presidential decree. This marked the onset of the viral informality that has persisted in the public transport system up to date.

The introduction of legal changes in 2003 (such as banning of standing passengers in big buses) affected the Kenya Bus Company a great deal. It began to face financial difficulties because the number of passengers served per day were for instance fewer. In 2006, the company transformed into a Franchising and Management Company which then gave room for buses owned by private investors. As of 2008, the number of buses managed by the company was 285 from 175 investors (UATP, 2008 in Chitere et al, 2012). The Nyayo Bus Services were also wound up in 1992 because of mismanagement.

Consequently, private bus companies such as City Hopper and Double-M gained entry into the market by 2002. Furthermore, matatus began to dominate the industry despite the high level of informality displayed by their operators. By 2008, 75% of the public transport modal split was made up of matatus (PersComm, 2011 in Chitere et al, 2012).

There have also been significant changes in the public transport routes. In 1934 when the London based Overland Transport Company (OTC) introduced buses in Nairobi, there were only 12 routes (Meja, 2016). The routes were subsequently organized in such a way that some buses operated between Nairobi and other towns while others served Nairobi and its

surburbs. Kenya Bus Service buses in particular plied the routes between the city centre and areas like Karen, Ngong, the Airport and Kenyatta University. The central terminal within the CBD was teh Tusker bus stop (located along Ronal Ngala Street). The buses never stopped at every stop unless someone wanted to board or alight and were therefore faster than the current ones.

With the introduction of the low capacity vehicles, traffic congestion became inevitable and the PSV operators began to informally look for alternative routes. In the year 2012, there was the initiative to map out the routes used by PSVs. By the end of the exercise, 130 routes were identified and the Nairobi Mata Routes Map was released in January 2014. This guides the PSV movements to date, even though congestion has not subsided and the operators are compelled to use access and collector streets from time to time while evading jam on the mainstream routes.

Furthermore, the system is characterized high demand for facilities such as PSV termini, which have not been provided adequately, despite the ever increasing numbers of low capacity PSVs. The high level of informality in the industry also makes the system less effective because the quality of service is generally poor and majority of the operators are after profit accumulation rather than customer satisfaction (Chitere et al, 2012).

2.8.6 Transportation Challenges

Different transportations studies that have been conducted in Nairobi have revealed that the system manifests a number of challenges, which make travelling considerably difficult. Some of these challenges are discussed below.

i. Inadequate Transport Facilities

The persistently increasing rate of population increase in Nairobi has led to a perpetual increase in travel needs and subsequent demand for various transport facilities. On the other hand, as Chitere (2012) notes, the rate of supply of these facilities has continued to lag behind. As a result, the facilities are highly inadequate.

ii. Traffic Congestion and Jams

The dominance of low capacity vehicles in the Public Transport System and the ever increasing rates of car ownership in Nairobi have led to immense vehicular volumes on the

road networks. Consequently, traffic congestions and jams are inevitably persistent in the city (Chitere et al, 2012)

iii. Informality in Public Transport System

The high level of privatization of the Public Transport System has led to high competition among the investors who are mainly after maximizing profits. As such, the degree of informality in their operations cannot go unnoticed. The fares are charged anyhow, the routes are not adhered to, there aren't regular travel schedules, passengers and goods are dropped and picked anywhere, the noise in the vehicles is too much and the operators are highly disrespectful towards the customers (Macharia, 2013). This makes the system uncomfortable, unreliable, unaffordable and oppressive to most people. It is no wonder the majority of the low income earners resort to NMT modes and the high income earners go for private means.

iv. Poor Regulatory Systems

The regulators of the transport system have generally become poor enforcers of the rules and regulations. This is mainly because of the high rate of corruption, in which case the regulators prefer taking bribes from the traffic offenders rather than taking legal action against them. As such, cases of traffic offenses and the resultant accidents are always high. The government has established organs which are supposed to regulate the system. These are mainly NTSA, Kenya Police Traffic Department. The two entities however seem to be competing in taking bribes rather than enforcing the traffic laws (Macharia, 2013).

v. Insufficient Coordination between Land Use and Transportation

Most of the transport network developments in the city have taken place without proper land use planning. As such, the traffic generation and flow patterns have remained less efficient. For instance, there have been recent road expansion initiatives on Thika Road, Mombasa Road, and the ongoing expansion of Ngong and Outer Ring Roads. However, little or no attention has been paid to fact that all these roads channel traffic to the CBD, where no network redesigns are taking place at all. As such, while the traffic volumes on the expanded roads keep increasing, the unexpanding CBD becomes more and more congested because most of these vehicles are allowed therein.

vi. Instances of Poor Road Network Designs

There are instances where road network designs cannot allow free flow of traffic. For instance, there are arterial streets with very many junctions at which collector streets channel traffic. This causes traffic jams along the arterial roads. Additionally, certain roads that were recently upgraded (e.g. Thika superhighway) have been designed without proper drainage systems. Consequently, it is common to experience heavy floods on the carriage way during the rainy season. This impedes traffic flow, making the system generally inefficient.

2.8.7 Current Transport Sector Proposals

A number of transport development projects have been proposed in the city of Nairobi. Some of them were completed recently; others are ongoing while others are still at the conceptualization stage. This study takes cognisance of these projects and attempts to analyze their impacts (observed and expected) on the system efficiency and effectiveness. The aim is to understand the system both presently and in the anticipated future so that any recommendations that will be made in this study shall have been informed by all the preceding initiatives. The projects are as summarized below:

Table 4: Current Transport Sector Proposals

No.	Project	Location	Stage of Execution	Observed/Expected Impacts
1.	Railway city development	Central Railway Station	KRC has developed a master plan, but NIUPLAN proposes its review so that the new city can be coordinated with the CBD	- Removing the functions unnecessary in the CBD, and promote the creation of the Railway City - Strengthening traffic and pedestrian network.
2.	Development of New Bus & Matatu Terminal in Railway City (Green Mall Project)	Central Railway Station	Proposal	Easing of the current congestion in the northern part of Railway Station
3.	Nairobi Viaduct Construction Project (2No. viaducts)	- Viaduct 1 to connect Moi Avenue , Trunk road to CBD, Enterprise Road corridor and trunk road to Central Railway station - Viaduct 2 to guide bus and *matatu* traffic to new terminal in the Railway City, remove the traffic on Landhies Road	Conceptualization	- Dispersing of the traffic on Mombasa Road - Alleviating the congestion around the current Railway terminus in northern part of the station - Removing the traffic on Landhies Road - Improving accessibility to the Southern parts of the Railway station - Improve traffic flows from southern part of the Nairobi city promptly and decongest the traffic in peripheral area.
4.	Widening of Enterprise	Enterprise Road	Conceptualization	Dispersing of the traffic on

	Road			Mombasa Road
5.	Formulation of Intelligent Transport System (ITS)[7] Master Plan	Citywide	Master plan not prepared but component of the program already done e.g. installation of CCTV Cameras	Mitigation of traffic congestion in the city
6.	Vitalization of Commuter Train Operation (to include basic design of track and station rehabilitation)	Existing Railway corridors	Proposal	Improving the existing commuter train operation
7.	Construction of a loop line circulating around CBD	Path to be identified	Proposal	Reduction of congestion in the CBD by diverting MRT/LRT passengers to the loop line
8.	Construction of Northern Part of Circumferential Road C-2	Mbagathi way-Wood land Road-State House Road corridor (From Thika Highway-Uhuru Highway Intersection to Mbagathi Way)	Proposal	The circumferential road C-2 will encircle the CBD area, and lubricate the traffic movement around the CBD
9.	BRT Project	Various corridor e.g. Jogoo Road	Proposal	Improve Public Transportation
10.	Expansion of Outer Ring Road	Outer Ring Road	Ongoing	Expected to ease traffic on Jogoo road

Source: Compiled by Author, 2017

It is notable that the bulk of the above projects are at proposal stage. Nonetheless, it is envisaged that their implementation will help to improve transport efficiency in the city.

2.9 Policy, Legal and Institutional Frameworks for Urban Transport in Kenya

The Urban Transport System in Kenya is operated within particular policy, legal and institutional frameworks. The policies identify and propose solutions to various urban transportation problems while the laws give the directions on how the transport systems should be operated and establishes the institutions responsible. Some of the critical issues that brought out relate to public transportation development, coordination between land use and transportation, transport network development and transport sector regulation mechanisms. Further elaborations are given herein after.

2.9.1 Policy Framework

2.9.1.1 The Kenya Vision 2030

The 2030 vision aspires for a country firmly interconnected through a network of roads, railways, ports, airports, waterways and telecommunications. It envisages that by 2030, it will

[7] **Intelligent Transportation Systems** are advanced applications which, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks

become impossible to refer to any region of the country as remote and so the focus would be on investing in the nation's infrastructure.

This national policy seems to lean more towards investments in road networks but without proposing measures through which to make the networks adequately functional as to be able to ensure effective transportation. This gap could however be filled by developing more detailed transportation plans for various parts of the country.

2.9.1.2 National Development Plans (NDPs)

The national development plans include NDP (1963-1966), NDP (1979-1983), NDP (1984-1988), NDP (1989-1993), NDP (1994-1996), NDP (1997-2001) and NDP (2002-2008). The transport proposals pointed out in these policies include giving special attention to the provision of underdeveloped links and bridges and improvement of existing classified as well as rural access roads throughout the country; strengthening paved roads and upgrading/maintaining unpaved roads; employing labour-intensive methods in road construction and maintenance; and dualing and widening road networks in addition to provision of flyovers, tunnels, grids and by-passes in Nairobi, Mombasa and Kisumu.

These policies seem to propose superficial transportation solutions. This is essentially because there is no evidence of land-use transport integration in these proposals. Without this, it remains difficult to effectively deal with traffic flow issues.

2.9.1.3 National Urban Development Policy (2012)

The policy points out many challenges in urban transportation sector including long waiting hours; poor safety and security standards; high costs for both passengers and freight; limited integration; and unexploited regional potential of the transport system. Other issues include weak public and private institutions; inappropriate modal split; high road maintenance costs; environmental degradation from pollution; lack of an urban transport policy; poor transportation planning leading to inefficiency; inadequate enforcement of legislation; and, a dilapidated, slow and inefficient railway system that is also out-dated..

It is further stated that to address these challenges, National and County governments will:

a) Ensure that all urban areas and cities prepare and implement an appropriate transportation strategy with emphasis on mass transport, pedestrian and cycling modes;

b) Ensure safe, affordable, efficient, comfortable, reliable, inter-connected and sustainable transport systems in urban areas and cities;
c) Ensure that the urban transport system is properly integrated with land use planning and development;
d) Provide, acquire, set aside, and protect land reserves for transportation facilities;
e) Develop a transport system that more efficiently supports the economic development of urban areas and is interconnected with the rest of the country and neighbouring countries;
f) Ensure that the user-pays-principle will be applied wherever feasible;
g) Establish a comprehensive transportation management information system for all transportation modes;
h) Enforce emission testing in all transport modes;
i) Set standards and guidelines for decommissioning of vehicles, marine vessels, aircraft and trains; and,
j) Harmonise the roles and mandates of all transportation agencies in the urban sector.

The policy touches on fundamental issues that are known to influence effectiveness and efficiency of urban transportation systems. It is however important that the National and County Governments formulate specific strategies that will respond to the unique needs in each urban area if the above proposals are to be implemented successfully.

2.9.1.4 Integrated Kenya National Transport Policy (2009)

The policy points out that the road transport sector's main aim is to provide an integrated, efficient, reliable and sustainable road transport infrastructure that meets national and regional passenger and freight transport goals and supports the government's socio-economic development strategies. This is geared towards promoting accessibility to services and the safe movement of people and goods, in an environmentally and economically sustainable manner.

It makes provision for integration between transportation and land use planning, environmental systems and transport networks, transportation and ICT structures, coordination of institutions within the transport system and intermodal integration (including NMT).

Notably, integration of the sub-systems that affect and are affected by transport operations is central to the achievement of an efficient and effective transport system. It is thus essential that developments in the transport system are not done in isolation.

2.9.1.5 Nairobi Metro 2030 (2009)

This strategy takes cognizance of the fact that by the year 2020 more than 57% of the world's population would be living in cities and thus the need for efficient transportation systems (Howe, 1994). It recognizes transport as a key component in creating a competitive business environment as well as a viable means through which other economic and social objectives will be achieved.

This therefore creates the need for an efficient transport system which minimizes travel times and distance. The strategy thus suggests interventions such as promotion of public transport, mobility and freedom of movement. Investment focus is made on construction of new roads and improvement of the existing networks. There are also plans to support mass rapid transit network; improve the main radial routes and the roads which connect these radial routes to the city center; and provide for metropolitan wide non-motorized transport, mobility network. Some of these initiatives are already being implemented.

2.9.2 Institutional Framework for Road Transport in Kenya

The various institutions that play part in the transport system in Kenya include:

2.9.2.1 The Ministry of Transport, Infrastructure, Housing and Urban Development

The ministry (through the State Department of Transport and Infrastructure) has the general responsibility of provision and maintenance of roads infrastructure, in conjunction with of Kenya National Highway Authority, Kenya Rural Roads Authority and Kenya Urban Roads Authority.

2.9.2.2 Kenya Revenue Authority (KRA)

The section of Kenya Revenue Authority that is directly involved in transportation matters is Road Transport Department. Its roles include registration of motor vehicles, licensing of motor vehicles, licensing of drivers and furnishing the domestic tax department with number of vehicles (thus enhancing revenue collection from PSVs).

The department's mandate is given in Traffic Act (Chapter 403), Second Hand Motor Vehicle Purchase Act (Chapter 484) and Transport Licensing Board Act (Chapter 404). Within the Road Transport Department is the Transport Licensing Board which is in charge of licensing both public and private vehicles to be operated in the country. The board operates the Licensing section of the.

The process of registration of vehicles and licensing of drivers is one of the ways through which effectiveness of the transport system can be ensured. This is because it provides a means of following up specific vehicle operators who carry out activities that compromise the quality of transport services. However, this has not been achieved in Kenya partly because of political interference, corruption and the control of the systems by cartels. Furthermore, the level of freedom in private car ownership and licensing has led to the board failing to make substantial contributions to the reduction of traffic jams on the urban roads.

2.9.2.3 Kenya National Highways Authority (KeNHA)

This is an autonomous road agency, responsible for the management, development, rehabilitation and maintenance of roads classified as A, B and C. Class A roads are international trunk roads linking centres of international importance and crossing international boundaries or terminating at international ports. Class B roads are national trunk roads linking internationally important centres while Class C roads are roads that link provincially important centres to each other or two higher-class roads.

In the recent years, KeNHA has undertaken notable developments such as expansion of Thika road. Such efforts have improved efficiency of the transport system, but only partially. The expansion of Thika road has for instance increased the capacity of the road but has not solved traffic jams because of little coordination of land use and transportation and lack of control of car ownership and use.

2.9.2.4 Kenya Rural Roads Authority (KURA)

KeRRA is responsible for the management, development, rehabilitation and maintenance of rural roads (D, E and others). KURA has also made notable improvements on their road networks which like in the case of KeNHA, have only led to increased capacity of roads without creating significant impacts on efficiency of the transport system.

2.9.2.5 Kenya Urban Roads Authority (KeRRA)

Its role is the Management, Development, Rehabilitation and Maintenance of all public roads in the cities and municipalities in Kenya except where those roads are national roads. A number of rural roads in the country are in poor condition and so it is important that KeRRA puts in more effort to improve them.

2.9.2.6 Kenya Roads Board

This Board was established through Kenya Roads Board Act (1999).Its mandate is to oversee the road network in Kenya and thereby coordinate its development, rehabilitation and maintenance and to be the principal adviser to the Government on all matters related thereto. It is the overall coordinator of and works together with all the road sector agencies in ensuring the delivery of an efficient road transport system in Kenya.

2.9.2.7 Kenya Police Traffic Department

The Traffic Police is charged with the responsibility of ensuring free flow of traffic and dealing with matters related to road accidents. It further facilitates sensitization on matters of road safety to the public. The Department currently operates hand in hand with National Transport and Safety Authority and Nairobi City County Traffic Department, even though there is a significant level of role duplication between the said institutions.

2.9.2.8 National Transport and Safety Authority (NTSA)

The Authority was established through National Transport and Safety Act (2012) to address the challenges of safety and harmonize road transport management. More specifically, it registers and licenses motor vehicles, carries out inspection and certification of vehicles, develops and implements strategies for enhancing road safety, regulates PSVs and facilitates education on road safety to members of the public.

Notably, some of the roles that that NTSA carries out depict duplication of roles in institutions. Examples include licensing of motor vehicles (which is also done by Transport Licensing Board) and handling road safety matters (which is also done by Kenya Police Traffic Department). This scenario contributes to the ineffectiveness evident in the system essentially because if two or more institutions are responsible for one task, there are high chances of conflicts and underperformance.

2.9.2.9 Kenya Railways Corporation

This is the corporation that is in charge of all railway system operations. The recent development of the Standard Gauge Railway (SGR) has brought this institution to the lime light. It is generally argued that SGR has improved transport efficiency and effectiveness between Nairobi and Mombasa because it encourages mass transportation at affordable prices and under fairly good conditions. However, the corporation has a lot of work to do in expanding the system to other areas and developing effective commuter systems within the cities and towns like Nairobi.

2.9.2.10 Nairobi City County Government (NCCG)

NCCG, like other County Governments, undertakes traffic counts and management, and runs the public transport system within its areas of jurisdiction. It also provides traffic facilities such as of traffic signs, street lighting and road marking. The Inspectorate Department in particular monitors traffic rule enforcement within Nairobi city. The County Government is also mandated to develop and maintain the roads that are classified as county roads.

It therefore works in collaboration with KURA, NTSA and Kenya Police Traffic Department. There are however notable cases of role duplication between NCCG, NTSA and Kenya Police Traffic Department, which must be streamlined if transport efficiency and effectiveness are to be achieved in Nairobi.

2.9.2.11 Matatu Owners Association (MOA)

MOA is the lobby organization for vehicle owners within the country. Its members are comprised of individual PSV owners and Matatu SACCOs (corporate members). It promotes and protects the interests of its members, settles disputes between its members and the National and County Government Transport Agencies, empowers members to acquire PSVs and carry out business in the industry and carries out road safety campaigns. It is one of the key stakeholders that the government involves during policy and decision making on matters relating to Public Transport.

2.9.2.12 Matatu Welfare Association (MWA)

MWA is also a lobby association whose operations are similar to those of MOA. Its members are however different from those of MOA, even though they are all matatu owners and operators.

Evident from the above institutional framework is that there seems to be a gap in so far as protecting the welfare of the Public Transport Service customers is concerned. Other than safety issues, there is a glaring omission in setting up institutional structures for controlling fares, ensuring customer comfort in vehicles and promoting vehicle designs that are friendly to people with disability among other things.

Furthermore, NEMA has failed to come out strongly in regulating gaseous emissions and noise pollution from PSVs. NCCG also seems to have been carrying out transport development and management with little involvement of the City Planning Department leading to poor coordination between land use and transportation. All these are factors that contribute to the current ineffectiveness of the Public Transport System.

2.9.3 Legislation

2.9.3.1 The Constitution of Kenya (2010)

The Constitution provides for entitlement to reasonable access to all places and public transport by all Kenyans, including persons with any disability. This is anchored on Chapter 4 of the supreme law. Inefficiency in transportation is however contradictory to this legal requirement. As such it is necessary that the transport system is improved at all levels so that everyone can have the required access.

Furthermore, article 62 also provides for land use planning, which includes planning for transport networks and facilities. The constitution also assigns respective transport sector roles to the National and County Governments. This is geared towards promoting orderliness in execution of functions by various institutions.

2.9.3.2 Traffic (Amendment) Act (2012)

The Act makes outlines penalties for various traffic offences in order to enhance observance of all traffic rules and consequently curtail loss of lives through accidents. Making the transport system more efficient and effective is a complementary way to minimize traffic accidents.

2.9.3.3 Physical Planning Act (1996)

The legislation points out that any physical development plan prepared with reference to any public land or private land should serve the purpose of improving the land and providing for

the proper physical development of such land, and **securing suitable provision for transportation**, public purposes, utilities and services, commercial, industrial, residential and recreational areas, including parks, open spaces and reserves and also the making of suitable provision for the use of land for building or other purposes.

This Act is however under review, so that it is aligned with the Constitution of Kenya (2010) and other Land laws that were passed since 2010.

2.9.3.4 Urban Areas and Cities Act (2011)

This is an Act to provide for the classification, governance and management of urban areas and cities; to provide for the criteria of establishing urban areas, to provide for the principle of governance and participation of residents and for connected purposes. The Act establishes Boards of Cities and Municipalities to undertake the provision of social services among other things.

2.9.3.5 Environmental Management and Co-ordination (Amendment) Act (2015)

This Act is mainly concerned with environmental protection. It is based on the fact that human activities, if uncontrolled, can cause major damages to the natural environment and the general health of members of the community. The Act thus identifies a number of projects for which Environmental Impact Assessment has to be done and mitigation measures devised against the potential negative impacts before their implementation. Some of these projects are under the transportation category and they include construction of—

a) All major roads;
b) All roads in scenic, wooded or mountainous areas and wetlands;
c) Railway lines;
d) Airports and airfields;
e) Oil and gas pipelines;
f) Water transport

The major transport projects that have been implemented in Nairobi have had to undergo Environmental Impact Assessment.

2.9.3.6 Kenya Roads Act (2007)

This is an Act of Parliament providing for the establishment of the Kenya National Highways Authority, the Kenya Urban Roads Authority and the Kenya Rural Roads Authority and providing for the powers and functions of the authorities and for connected purposes.

2.9.4. Regulatory Instruments

Other than laws and policies, there are other regulatory instruments that the National and County Governments use to try and improve the operations of the transport system. Some of them are economic in nature while others are operational. The economic instruments include custom duty on imported vehicles, domestic taxes on transport sector businesses and fuel taxation. Some of these taxes are imposed as a punishment to people who seem to engage in harmful activities. For instance, fuel taxes are imposed to control excessive consumption of fuel, thus promoting environmental health.

The major operational instrument in Kenya's transport system is the requirement that PSVs are registered in SACCOs which can assist to control the behaviour of the operators more easily. By so doing, it is envisaged that the customer is protected from exploitation by the profit oriented PSV operators. It is however noteworthy that this has not yielded any fruit since there is poor enforcement of rules which the SACCOs are expected to adhere to.

2.10 Theoretical Framework

There are a number of theories upon which this study has been hinged. They are believed to explain some of the phenomena that are observable in the transportation system in the study area. As such, the conclusions drawn in this study are cognizant of the postulations made in these theories. They theories are briefly discussed herein after.

a) Gravity Model

This model is based on Newton's Law of Gravity. It is used to estimate the number trips between areas. It assumes that the number of trips between areas i and j is proportional to the population or activity density in those areas and is inversely proportional to the distance between i and j. This study has attempted to evaluate the trip attraction patterns to various termini depending on the activity density in the CBD zones which they serve. This evaluation is deemed fit to give a picture of the traffic volumes in various on-street termini.

b) Intervening Opportunities Model

The argument in this model is that individual trip making behavior depends not only on the attractiveness of the intended destination and the distance that has to be covered but also on the availability of opportunities elsewhere; opportunities that are competitive and can satisfy the purpose of the planned trip. The researcher has endeavored to find out the opportunities that trigger trips to the in the study area.

c) Queueing Theory

Queuing theory is concerned about studying the process of queuing for particular services, which mostly occur when the demand for a service exceeds its supply. The applicability of queuing theory in transportation studies manifests mostly in traffic flow analysis. More often than not, travellers tend to wait for vehicles at particular points along the transport system. If it happens that the rate at which the vehicles stream into the place is slower than the traveller's arrival rate, then travellers usually wait in queues. On the other hand, if the vehicles arrive faster than the travellers, then the vehicles will have to queue.

A transportation queuing system is known to be comprised of four parameters, including:

i. Mean Arrival rate (λ) – the rate at which vehicles/travelers arrive at a transport facility, expressed in vehicles/hr. If the time headway (h) is known, mean arrival rate can be calculated as:

   $\lambda = 3600/h$

ii. Mean service rate (μ) - the rate at which vehicles/travelers depart from a transportation facility, expressed in vehicles/hr. If the time headway (h) is known, mean service rate can be calculated as:

   $\mu = 3600/h$

iii. The number of servers
iv. Queue discipline - Queue discipline can be First Come First Served/ First in First Out (FIFO); First in Last Out (FILO); Served in Random Order (SIRO); Priority scheduling; and Processor (or Time) Sharing.

The queuing theory provides for construction of models through which queue lengths and waiting times can be predicted. The models are four and they are applied in different

scenarios, depending on the number of servers and whether or not the arrival and service rates are known.

This study attempts to predict the average length of time that people take in queues while waiting for vehicles at various on-street termini. It is envisaged that the this prediction is useful in establishing the efficiency of traffic flow, based on the assumption that vehicles arrive at a facility faster when the flow is efficient and vice versa. Thus, the average vehicle arrival rate has been calculated at peak and off peak hours in each on-street terminus.

d) Network Analysis

Network analysis involves the description of nodes and their linkage relationships (Raghav, 2016). It provides for measures of centrality of nodes, detours[8] and spread and diameter of networks and connectivity between nodes.

In the case of this study, the study area (Nairobi CBD) is the core node which is known to serve people from very many other nodes within the city. It is thus in the interest of the researcher to assess the level of connectivity to the CBD, as a way to establish whether or not the transport networks are coordinated well enough to promote transport efficiency.

The beta index of connectivity is going to be used in this assessment. It is calculated as the total number of arcs in a network divided by the total number of nodes, thus:

β = arcs/ nodes

If β is less than 1, then the level of connectivity is considered low and vice versa.

2.11 Summary of Literature Review

A number of issues arise from the discourse in this chapter and they are considered critical in evaluating the relationship between on-street termini and transport effectiveness/efficiency. They are discussed herein under.

2.11.1 The Rationale for Efficient and Effective Urban Transport Systems

One of the major revelations of the literature review done in this study is that the importance of an efficient and effective urban transportation system cannot be overemphasized. The kind of economic success that every state and person needs cannot be realized without efficiency and effectiveness of the transportation systems. Furthermore, an effective transport system is

[8] Detour - a long or roundabout route taken to avoid something or to visit somewhere along the way

a prerequisite to good quality of life, better community access, highway safety and high environmental quality.

2.11.2 The Relevance of CBDs

CBDs have been illuminated as key economic drivers of all urban setups. They are home to many core businesses activities, ranging from retail to wholesale, finance, and various commercial services. They are also the main areas of employment to millions of city dwellers. As such, they tend be better developed and serviced than other parts of the city. The development densities are also often higher in the CBDs that anywhere else in a city.

2.11.3 The Influence of Transport Efficiency Levels on CBDs

Given the crucial economic roles that CBDs play, it is undeniable that it must be well connected to and easily accessible from all parts of the city. On the other hand, it is difficult to achieve the level of interconnectedness and accessibility required in the CBD if the transport system if defective. In other words, an efficient transport system is one of the cornerstones to well performing CBDs.

2.11.4 The Role of Public Transport Services in Urban Transportation Systems

Several observations have also been made about the important role that public transport plays in improving the urban transportation system. It is generally agreed that the fact that public transport gives room for mass movement of passengers and freight is advantageous in numerous ways. First, it decongests the transport networks, encourages faster traffic flow, gives access to transportation by all people, enhances energy savings and reduces air pollution. Thus, making a city's public transportation better is a great step towards improving the efficiency of the entire urban transport system.

2.11.5 The Necessity of Planned Termini in the Public Transport System

It is noted that a public transport system is a made up of various components, all of which must function together in order to achieve the desired results. Some of the crucial components are the transport termini. They need to be provided in the right places and quantities if the public transport system is to operate effectively and promote an efficient urban transportation system.

2.11.6 Relationship between Termini, Transport Efficiency & CBD Performance

Transport termini are essential in the public transport operations. As such, the effectiveness of the public transport system is reliant on the availability of well-planned termini. The public transport system is on the other hand a big booster of urban transport efficiency. Similarly, a good urban transportation system is an essential component of well performing CBDs. It therefore follows that sufficient provision of termini is advantageous both to the urban transportation system and the CBD operations.

2.11.7 The Place of Land Use Planning in Transport Efficiency & CBD Performance

It is recognized that in order to achieve efficient traffic flow patterns, transport networks must be properly coordinated with the activity areas. This is essentially because traffic is generated from and distributed to various activity areas. As such, if the transport networks are not appropriately interconnected to the various activity zones, then the traffic flow patterns become chaotic and inefficient. This kind of coordination requires deliberate land use planning, so that all land uses are catered for and space allocated for all infrastructural facilities, including transport termini.

Moreover, the ability of a CBD to effectively serve all people is highly dependent on its spatial orientation to residential zones and other commercial nodes in the city. For example, if the CBD is poorly connected to other parts of the city or if it's less accessible, then chances are that it will slowly lose it economic primacy because people will find alternative sites for business and related activities. In order to avoid this kind of scenario, land use planning must come in because it helps to achieve a coordinated land use structure in which the CBD can have functional interactions with other zones of the city, thereby ensuring effective economic flows. There is thus an inherent direct relationship between land use planning, transport efficiency and CBD performance.

In addition, land use planning always incorporates the institutional elements (legal, policy and management bodies) in the operations of a city, including transportation system management. This is why this study takes recognition of the institutional framework within which transportation systems are operated in Kenya.

2.12 Conceptual Framework

The figure below is a summary of the conceptual framework derived from the above literature.

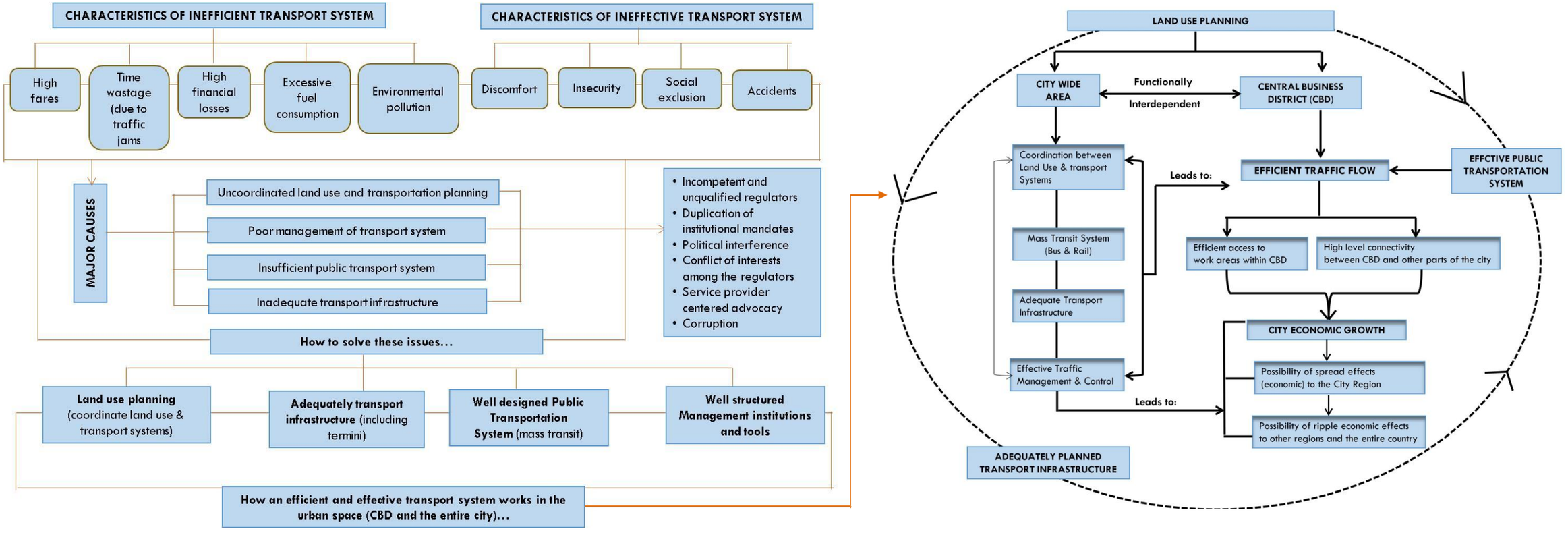


Figure 6: Conceptual Framework

Source: Author, 2017

From the above diagram, it can be deduced that a transport system is inefficient and ineffective if it presents traffic congestion and snarl ups, high financial losses, negative environmental impacts, discomfort to travels, social exclusion of certain groups of the members of the community, safety issues and insecurity.

On the other hand to achieve efficiency and effectiveness in transportation, there is need for land use planning, adequate provision of transport infrastructure (including termini), a well-functioning mass transit system and proper regulatory structures, both in the CBD and the entire city.

Secondly, the CBD needs transport infrastructure which are planned well enough to promote its interactions with other parts of the city. It also needs a public transport system that is dominated by mass transit modes. This is because of the ever increasing travel demand to the CBD, which caused by the high employment density therein. Growth in human population and vehicular volumes in the CBD is highly elastic yet space/land is in fixed supply. As such, there is hardly space for expansion of transport facilities and networks, resulting to the need for more innovative ways of planning for and establishing these facilities. In other words, the performance of the CBD (which is determined by its employment density, income and revenue generation, social inclusivity and environmental quality) is largely dependent on the existing transportation and land use systems.

The performance of CBDs is also central to economic growth of an urban area (owing to the crucial roles that they play in the economy). As such, promoting efficiency and effectiveness of the transportation system is beneficial both to the CBD and the entire city. However, failing to plan for termini and encouraging informal ones on-street inhibits transport efficiency by derailing free traffic flow. Such termini must thus be eliminated and proper ones developed because they are a threat to economic growth. Furthermore, all the sub-stems of the urban transport system must be streamlined in order to achieve transport efficiency and effectiveness.

CHAPTER THREE
RESEARCH DESIGN AND METHODOLOGY

3.1 Overview

This section summarizes the overall study design, indicating the data needs and the activities undertaken to acquire that data to the best possible level of reliability. The research strategy provides a framework for designing a systematic study that would address the study objectives and questions and add to the knowledge regarding the subject matter. In particular, the data needs have been identified based on the study objectives.

3.2 Research Design

A research design is a description of the specific plan that a researcher intends to use in carrying out his/her study in a way that is best suited for achieving the research objectives (Burns and Grove, 2003).

This study went through three phases, i.e. conceptual, narrative and interpretative phases. The conceptual stage involved formulation of the research questions and objectives and literature review, the latter of which was undertaken in order for the researcher to familiarize herself with theories and concepts related to the subject under study.

The narrative phase majorly involved the process of planning for the study. The researcher demarcated the study area extent, the routes and points where the surveys and observations were to be conducted, the data needs, sampling procedures and the techniques that were to be used to collect, analyze and present the data.

The interpretive stage came after data collection, cleaning and analysis. At this point, the researcher attempted to make sense out of the study findings and answer each of the research questions. An important part of this phase was hypothesis testing, in which case the researcher assessed the existence and the type of relationship between on-street PSV termini and transport efficiency and effectiveness.

In addition, this study focused on exploring the relationship between on-street public service vehicle termini and transport efficiency and effectiveness. It was thus correlational in nature and the research approaches used were qualitative, quantitative and exploratory. According to Holloway and Wheeler (2002) qualitative research focuses on the manner in which people interpret their experiences and their surroundings. A qualitative approach was taken in this

study because the need to explore and describe the perceptions that the transport service providers and consumers had about the relationship between on-street PSV termini and transport efficiency and effectiveness.

On the other hand, the quantitative approach was employed in cases where there were need to give numerical accounts of the situations in the study area. For instance, the researcher endeavoured to measure the amount of time taken to travel along stretches of roads with on-street termini and those without and the road capacities in each case. Such numerical data was meant to give factual assessment of the level of effectiveness of the transport system in areas with and without on-street termini.

As an exploratory research, there was the review of past literature related to the subject under study. The aim of using this approach was to relate the findings of this study to the relevant theories earlier postulated by various scholars. This way, it was possible to understand the phenomena that have been studied in relation to the subject matter and to assess the validity of the findings in this study.

3.3 Area of Study

The study area was the part of Nairobi CBD enclosed by, Accra road to the North West, Moi Avenue to the west, Haile Selasie Avenue to the south, Race course road to the East and River road to the North-East. It covered routes with high density of on-street PSV termini (e.g. Ronald Ngala and Mfangano streets) and areas with very few or no on-street terminal at all (e.g. a section of Moi Avenue and City Hall way).

The termini include Central Bus Station, Ronald Ngala Street, Mfangano Street, Accra road, Luthuli Avenue, Ambassador, Kencom, Tom Mboya and Moi Avenue. The vehicles served by the termini in this section ply route numbers 6 (Eastleigh Section 1&2), 19/60 (Kayole), 23 (Outering), 33 (Embakasi village and Pipeline), 34B (Greenfield), 35/60 (Umoja), 36 (Dandora), 39 (Ruai) and 58 Buruburu.

Furthermore, it covered sections with high traffic volumes and high concentration of business activities as well as sections with high concentration of offices and less traffic volumes. The figure below illustrates the study area extents.

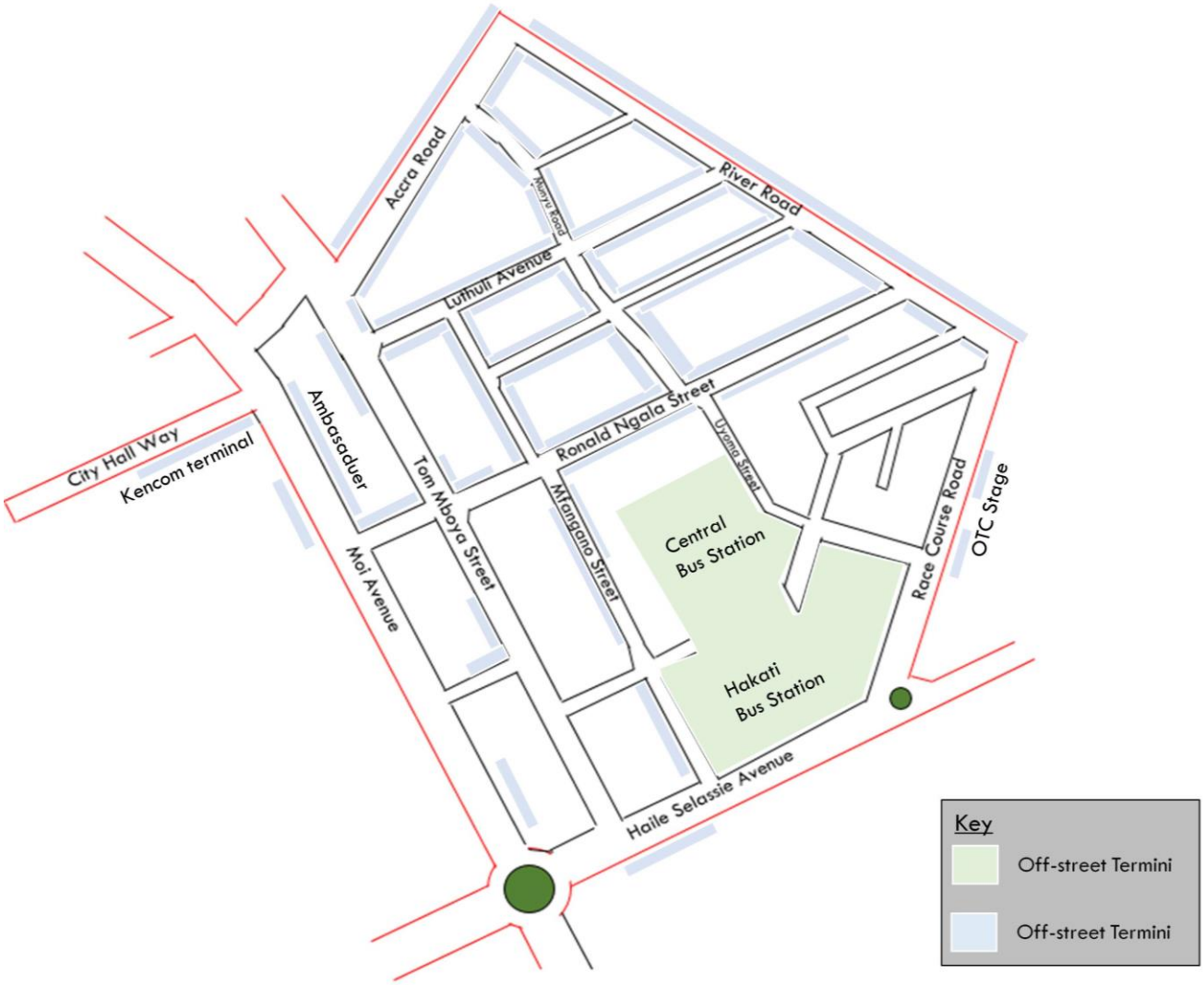


Figure 7: Study Area Extent

Source: Author, 2017

3.4 Variables

The variable in this study were:

i. Density of on-street PSV termini (d), which is the **independent** variable

ii. Efficiency and effectiveness of transport system (e), which is the **dependent** variable

This is expressed mathematically as:

e = f (d)

I.e. transport **efficiency** is a function of on-street termini **density**.

Density was measured the number of on-street termini in the study area while efficiency of transportation was measured by the time taken to travel through sections of roads with and

without on-street termini while the density of the termini was measured by the numerical counts thereof.

3.5 Types of data

The data required in this study falls under two categories namely primary and secondary data. The primary data included that which was to be acquired directly from the field while secondary data was obtained from past literature such as relevant research papers, journals and books.

3.5.1 Primary Data

The primary data needs in this study were identified in relation to the objectives of the study as follows:

i. Data needed to examine the existing system of on-street PSV termini in the CBD
ii. Data needed to evaluate traffic efficiency and effectiveness within the CBD
iii. Data needed to assess the effects of the PSV termini on traffic efficiency & effectiveness

This is further elaborated on below.

a. Data needed to examine the existing system of on-street PSV termini in the CBD

The data requirements under this objective included location of the points, a brief background of each of them, their capacities, vehicular volumes therein at different times, routes served, the PSVs that operate from each, entry and exit patterns into and out of the termini and the CBD, the adjacent land use activities and development densities in the neighboring plots.

b. Data needed to evaluate traffic efficiency & effectiveness within the CBD

The information needed in this section was inclusive of traffic volumes, space available for Motorized and NMT modes, level of activity concentration, road user behavior, time taken to move through the sections of the CBD at different times, tariffs charged, planned and unplanned termini, activities on the pavements and identifiable bottlenecks.

c. Data needed to assess the effects of PSV termini on traffic efficiency & effectiveness

This objective was to be achieved by observing and evaluating traffic situation in parts of the CBD with and without the PSVs. The differences in the two scenarios were identified and relevant conclusions made thereafter. Some of the observations that were made in this regard included length of vehicle queues, length of the queues made by passengers awaiting to board

PSVs, time taken to leave the CBD, fuel consumption levels, peak and off-peak fares and pollution effects.

3.5.2 Secondary Data

The secondary data needs were inclusive of the information which would help to propose appropriate interventions for improved traffic efficiency. These included standards on land use-transport planning and development, international and national policy directions on land use-transport planning, laws and regulations governing transport systems, hierarchy of institutions in the transport sector and their responsibilities and case studies.

Aside from the above set of data, other relevant pieces of information that have informed the study include:

- Study area background and development trends over the years
- Road user mobility experiences.
- Effects of traffic congestion on business and work in the area.
- Dynamics surrounding traffic management in the CBD
- Dynamics of Transport infrastructure provision and maintenance.
- Theories and concepts on transportation and traffic flow

These came from both primary and secondary sources.

3.6 Sources of Data

The data was sourced from various places. The bulk of the data were obtained through observation, counting and measurement. The data that was acquired through counting was inclusive of traffic volumes (both MT and NMT) and adjacent development densities i.e. number of plots and number of building floors therein. Measurement was used to acquire data on road widths and space occupied by different activities. The information obtained by observation is inclusive of road user behaviour, types of land uses, vehicle entry and exit patterns into the CBD the undesignated termini and the vehicles using different streets.

Information on the study area background and development trends; theories and concepts on transportation and traffic flow; planning standards, policy and legal frameworks on transportation issues; and case studies was sourced from review of literature.

The data on road user mobility experiences and the effects of traffic congestion on business and work in the area was obtained by way of administering questionnaires to travelers and

vehicle operators. The information on the dynamics surrounding traffic management in the CBD was acquired from Nairobi City County Government and Traffic Police Department. Lastly, data on the provision and maintenance of transport infrastructure was sourced from Nairobi City County Government and KURA.

3.7 Methods of Data Collection

The following methods were applied:

3.7.1 Methods of Collecting Primary Data

a. Observation (Participant and Non- Participant):

This was used to gather information on physical aspects such as activities ongoing in the study area and road user behaviour among other things.

b. Traffic counts

To acquire information on traffic volumes, traffic counts were done in the sections of interest. Specific cordon points were at the entrances and exits of the termini.

c. Measurements

Geometric information was acquired through measurements. For the extremely congested sections, GPS was used to pick relevant points and the required extents calculated on ArcGIS program.

d. Personal Interviews or Key Informant Interviews

Open-ended interviews were undertaken, especially with the key informants.

e. Questionnaire Administration

Questionnaires were also be administered to the road users and business operators/workers.

f. Participatory Travel Speed Evaluation

The researcher took rides along different routes, including those with and without on-street termini. Using a stop watch, she evaluated the time taken to cover a given distance along each route. This was done during peak and off-peak times and during week days and weekends for comparison purposes.

3.7.2 Methods of Collecting Secondary Data

This was mainly literature review which involved data collection from books, past research reports, research journals, print media, publications and the internet.

3.8 Instruments of Data Collection

The following instruments were used to obtain various types of data:

a. Observation Guides

The observation guides were used in collecting data on observable features.

b. Tally Sheets

Tally sheets were used for traffic counts and travel speed evaluation. In the case of traffic counts, the sheet had slots for the targeted modes passing through the cordon points.

c. Interview Guides

Interview guides contained a set of questions which were directed to different key informants. They were thus used to guide the discussions between the interviewers and the interviewees.

d. Questionnaires

Questionnaires were used to interview the road users (including the business people, workers and PSV operators) in the study area. Each target group had its own set of questions.

A copy of each of the instruments has been annexed to this report.

3.9 Sampling Design

Sampling design is defined as a framework or a definite plan for obtaining a sample from a given population (Kothari, 1985, p. 18). In this study, the researcher identified the sampling units, calculated the sample size for each unit and identified the methods of sampling appropriate for each case.

3.9.1 Units of Sampling

Considering the structure of the population set, the sampling units were inclusive of –

i) Road users in the study area – travelers and matatu operators
ii) The business operators/workers in the vicinity
iii) Institutions in charge of management traffic and infrastructure design in the city

3.9.2 Sample Size

The factors considered in selecting the sample size included –

- The level of statistical precision required;
- The variability of the population under study; and
- Budgetary constraint.

A. Road User Sample Size

The road users were inclusive of people working and doing business in the study area or those who go to the CBD for various reasons. These were inclusive of the PSV customers, PSV operators, motorcyclists, pedestrians and private car drivers. The PSV operators were very key in giving information relevant for the assessment of transport efficiency from the perspective of the service providers.

Among other things, the road users detailed out the effects of the on-street termini on their travel conditions, work and daily operations. Particular attention was paid to analyzing how the chaotic environment (typical of the matatu termini – blockage of premise entrances, noise, dust etc) affected mobility, the business activities and the subsequent financial returns.

This group of respondents was interviewed at various termini, which were five in number (Accra, Mfangano, Ronald Ngala, Kencom and Moi Avenue) and sampled from a total of 25 on-street termini. The required sample size for the road users was then calculated using the following method:

$$n = \frac{t^2 \times p\,(1-p)}{m^2}$$

Where:

n - Sample size
t - Confidence level, 95% confidence level, whose standard score is 1.96
m- Tolerable Margin of error (5%)
p – Estimated prevalence to the traffic circulation situation (90% of the total population)

$$n = \frac{1.96^2 \times 0.9\,(1-0.9)}{0.05^2} = 138$$

The calculation gave rise to a sample size of 138 people.

B. Institutional Sample size

The respondents sampled under this category included informants from the Department of City Engineering (Nairobi City County Government), Traffic Police department, Nairobi City

County Government Traffic Management section, Matatu Welfare Association, KRA and KURA. One informant from each institution was interviewed.

3.9.3 Methods of Sampling

The study adopted both probability and non-probability sampling methods. More particularly, stratified random sampling was used to select the termini from which the road users and business operators/workers were found. Two categories of streets were considered as follows:

Category 1: Streets with High concentration of On-street PSV undesignated termini

These streets included streets such as Accra road (serving several intercity, Embakasi and Kikuyu vehicles), Ronald Ngala Street (serving Githurai, Huruma, Umoja and intercity vehicles), Mfangano Street (serving Umoja, Komarock and intercity vehicles).

Category 2: Streets without or with very few On-street termini

These included Moi Avenue (where there is Ambassador and Rongai bus on-street termini) and City Hall Way (where Kencom terminal is located). A comparison of the situations between the two sets of streets was done. This was aimed to help the researcher make informed conclusions about the difference made by existence of the undesignated on-street termini.

The streets are shown in the figure herein after.

Figure 8: On-Street Termini Distribution

Source: Author, 2017

For category one, all the on-street PSV operation points were listed and a sample of three picked. For category two, all the points were included. The on-street termini in category two included Ambassador (located off Moi Avenue) and Kencom (located along City Hall Way).

Non-probability sampling procedure was then used in the selection of individuals to interview. This is because it is impossible to list all the potential respondents given that the population was not known. Thus, the respondents were picked based on their willingness to be part of the study.

From the three points sampled in section 1 of the study area, a total of 50 respondents were interviewed. Each terminal contributed 17 respondents. The remaining 30 respondents were sampled from Section 2. Fifteen of them were selected from the two termini (Ambassador and Kencom) while the remaining fifteen came from the areas with no terminal facilities at all (Haile Selasie Avenue).

3.10 Analysis of Data

The study adopted both qualitative and quantitative methods of data analysis.

a) Analysis of Qualitative Data

The qualitative or descriptive information was analyzed using narrative, content analysis and anecdotes techniques.

i) Narrative technique

As the term suggests, information and results were organized in a logical manner and written up in a narrative style. The key themes under which the narrative was written were distribution of on-street PSV termini, traffic efficiency and effectiveness in the CBD, factors influencing transport operations and effects of on-street termini in the CBD.

ii) Content Analysis

This technique was used to analyze descriptive reports for trends, themes or events and to summarize descriptive information and transform qualitative information into quantitative information. It was also used to set up the coding categories for quantitative tabulation.

iii) Anecdotes

This technique was employed in the use of narratives and quotes to summarize events and conclusions and to add emphasis to inferences from literature review and interview sessions.

b) Analysis of Quantitative Data

Quantitative data analysis was used to summarize information and data through percentages, statistics of spread and statistical tests of significance. Data was analyzed and presented in tables, figures and graphs. The results were subjected to both manual and computer aided analysis, including geographical information system (GIS) and SPSS.

c) Assessing the Traffic Circulation levels

The empirical models employed in assessing the traffic circulation status in the study area included Level of Service (LOS) measures) and Segment Delay (Ds). According to Das et al (2015), these are the major empirical models, which are relevant for assessing traffic congestion in the CBDs of the cities. They were used for assessing the traffic flow situation in Kimberly, South African in 2015.

It is worth noting that since each of the models has its inherent weaknesses, they were used simultaneously for purposes of comparing results from each. The results of this assessment have been used to derive a mechanism to ease the traffic congestion challenges.

3.11 Testing of Hypothesis

The researcher also endeavored to test the study hypothesis. Being a study under the social sciences, a confidence level of 95% or significance level of 0.05 has been considered suitable. Furthermore, the chi-square test was used. The observations made were recorded as symbolized in the table below.

Density of On-street PSV termini	**Ease of traffic circulation (Based on respondents assessment of delay experiences)**		**Total**
	Delay	No delay	
High no. of termini	n	n^1	**50**
Few termini or none	m	m^1	**30**
Total	n+m	$n^1 + m^1$	**80**

N/B: n and m are the counts of respondents indicating whether or not there is delay in the two cases.

Given the number of rows and columns above, the degree of freedom (d.f) was 1. This is calculated as (No. of columns – 1) × (No. of rows – 1). In this case, the d.f = (2 – 1) × (2 – 1).

3.12 Presentation of Data

The results of the research project have mainly been presented in a form of a written report. The written report has also been complemented by maps, drawings, graphic models and photographs to give more visualized impressions of the study findings.

CHAPTER FOUR
BACKGROUND OF THE STUDY AREA

4.1 Overview

The study area, which is the Central Business District of Nairobi, is a unique part of the city. Its activity concentration and development densities compare much less to most zones of the city. It is thus deemed fit in this study to analyze the prevailing situation in the area, with the aim of establishing the current land use and transportation scenarios therein. Some of the specific features that have been discussed include location, traffic flow conditions, urban form and structure as well as land use patterns.

4.2 Location

The study area is located in Nairobi, the Kenya's capital city and its geographical position is at 1.19^{o} south of the Equator and 36.59^{o} east of the Prime Meridian 70. Nairobi is also located to the South, North & East and West of Kiambu, Nakuru and Machakos counties respectively. They together form the Nairobi Metropolitan region and so are functionally inter-related (see figure overleaf).

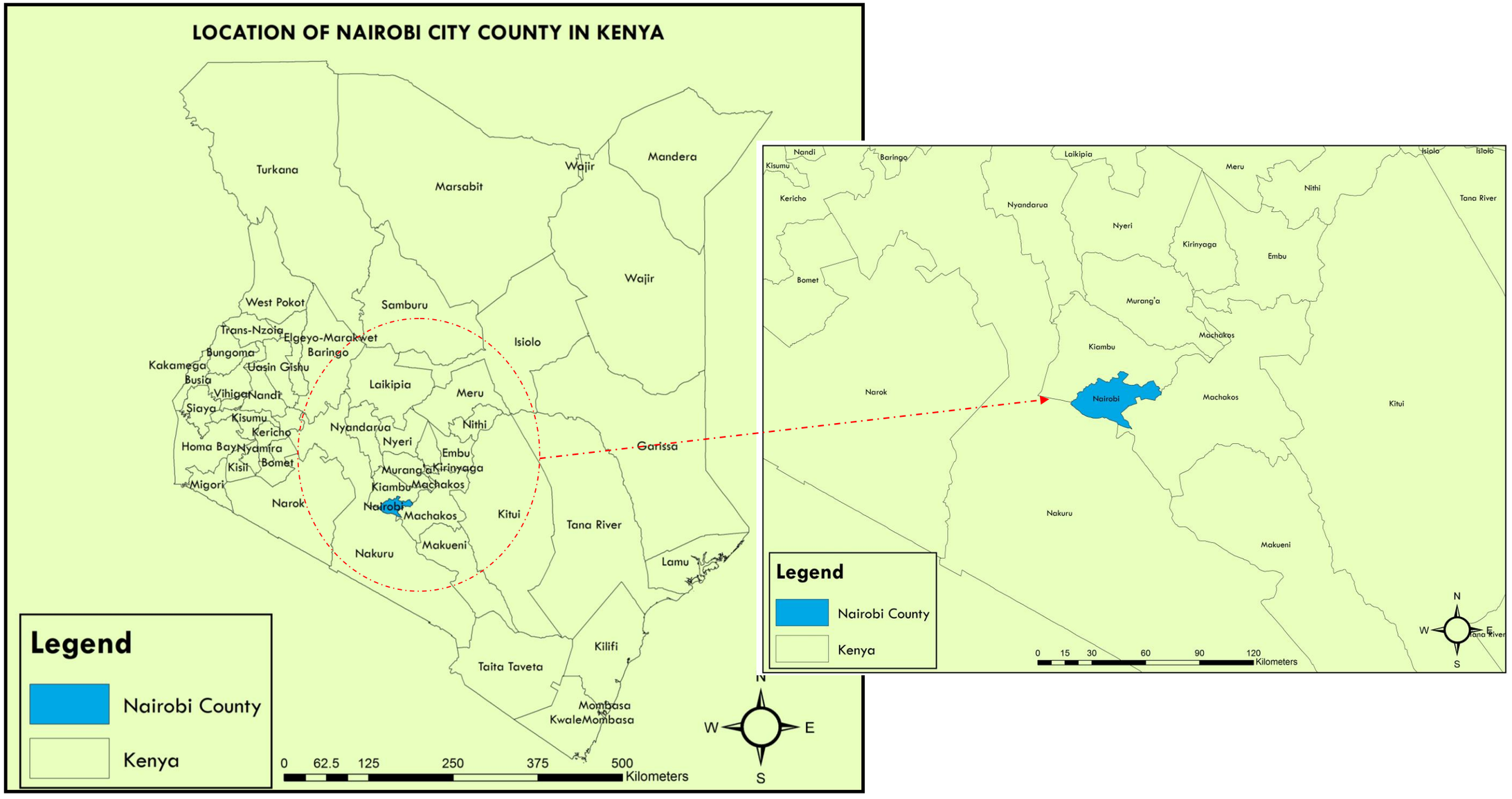


Figure 9: Location of Nairobi County in Kenya

Source: Author, 2017

The study area is specifically within the Central ward of Starehe Sub-county. The location of the ward is shown below

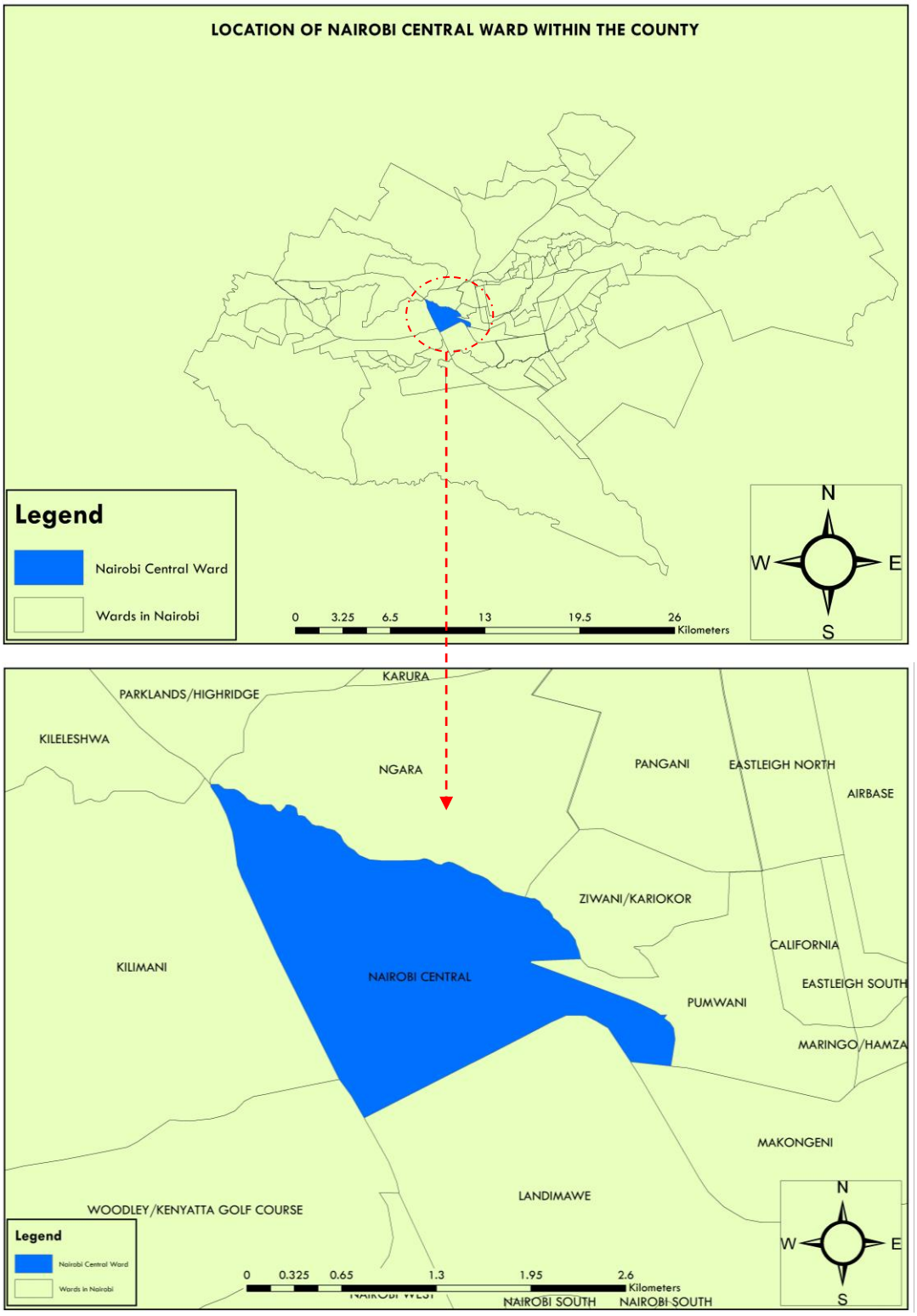


Figure 10: Location of Central Ward in Nairobi *Source: Author, 2017*

The above map shows that the CBD is fairly central to most residential zones of the city and as such the origin of the main arterial roads that serve different zones.

Furthermore, it covers about 70% of the Central ward as shown in the map below.

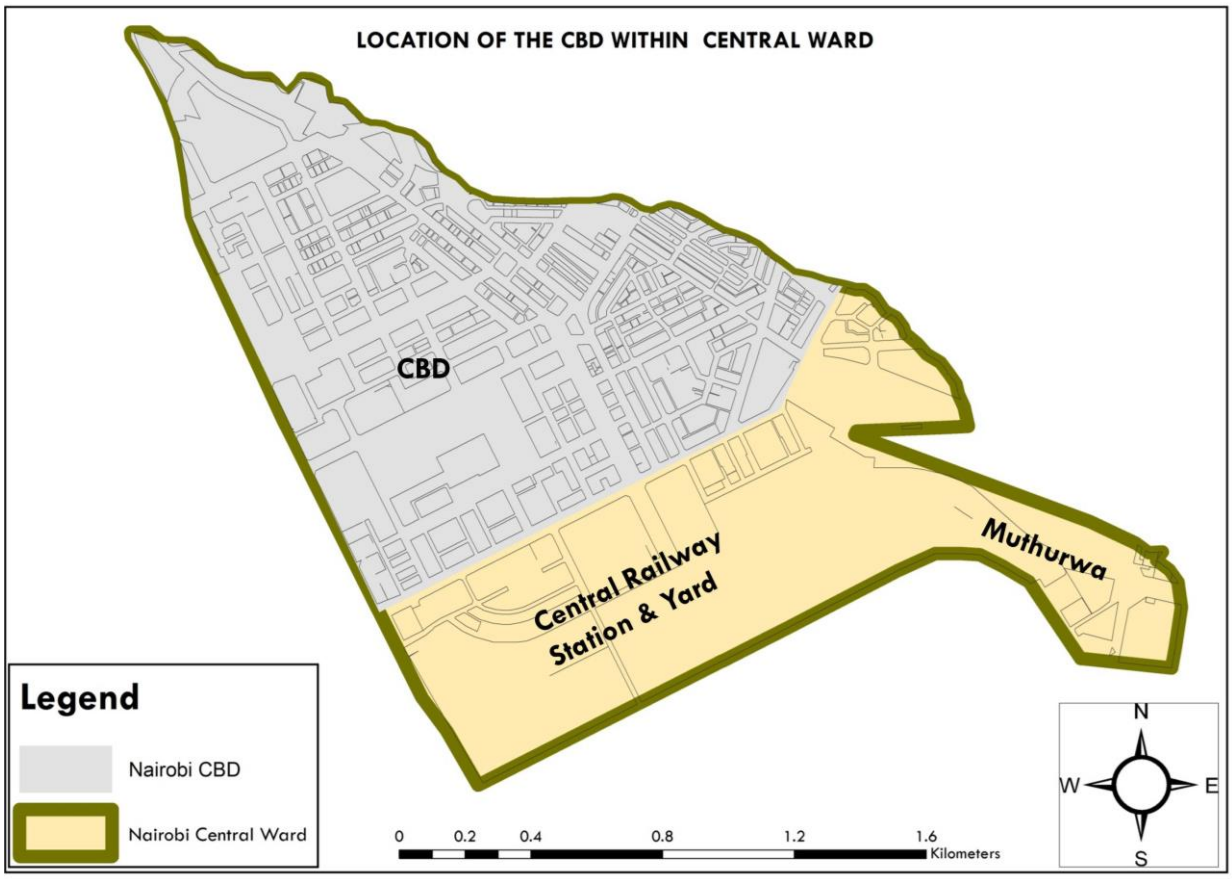


Figure 11: Location of the CBD within Central Ward

Source: Author, 2017

4.3 Extent

The CBD forms an almost triangular shape and is encompassed by Uhuru Highway, which runs along the North-South East axis, Nairobi River which is along the North-East axis and Haile Selassie Avenue located along the South-East axis. It measures about 2.4 km^2. Below is a figure showing the CBD extent.

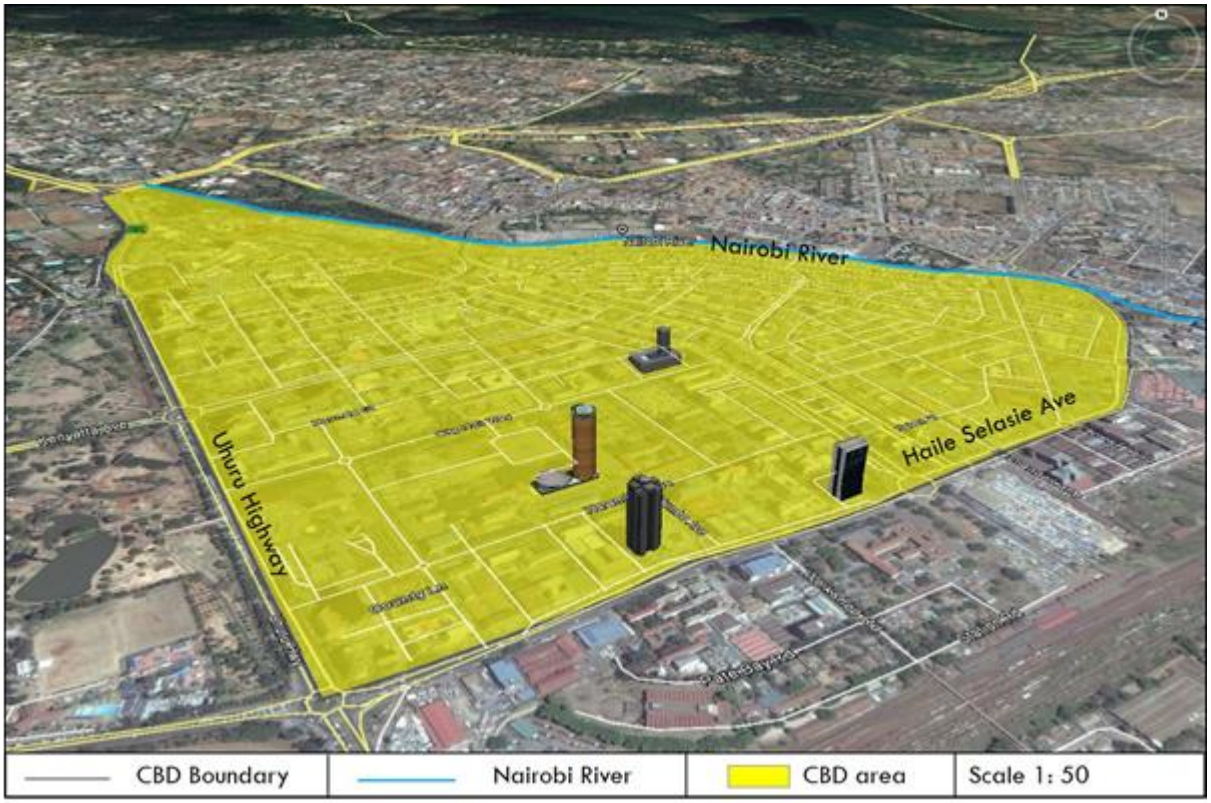


Figure 12: Study Area Extent

Source: Developed by Author from Google Earth Image (2017)

4.4 Physiography

This covers aspects such as climate, topography, hydrology, geology and soils.

Climate

Nairobi's climate is dry and cool between July and August and hot and dry between January and February. It receives an average 900mm. The first peak of monthly rainfall occurs in April and the second peak takes place in November. The mean daily maximum temperature by month ranges from 22ºC to 28ºC and the minimum ranges from 12oC to 14ºC. The figure below illustrates Nairobi's annual climatic conditions.

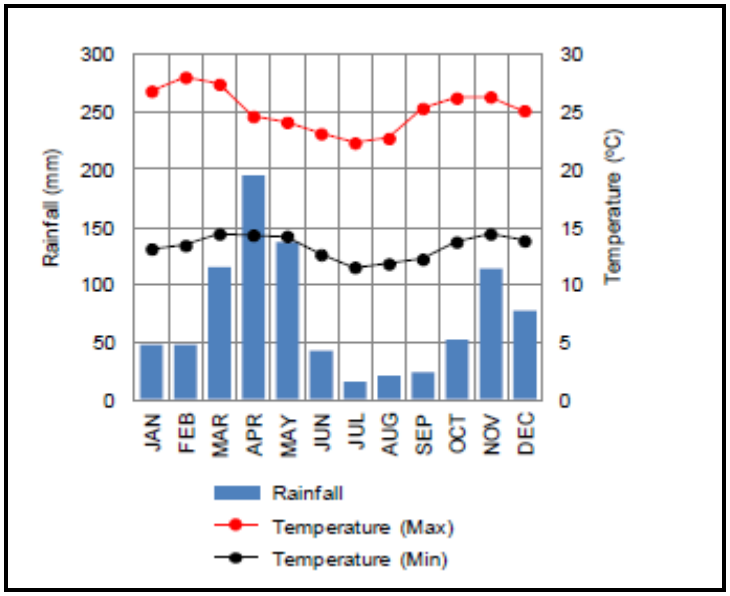


Figure 13: Nairobi's Climatic Conditions

Source: NIUPLAN, 2015

Topography

The CBD has a fairly flat topography and an average elevation of 1690m. Its lowest section is along the Nairobi river basin which is on the Northern edge. The presence of the river makes the northern belt of the CBD to slope at an angle of about 30^{o} towards the river. The topography of the CBD is generally favourable to developments, both buildings and infrastructural networks. The figure below is a cross section of the CBD, showing the topographical characteristics thereon.

Figure 14: Topography

Source: Author, 2017

Hydrology

The study area is drained by Nairobi River, which is permanent but extremely encroached and polluted by all manner of waste dumped therein.

Geology and Soils

The study area is dominated by phonolites of which are found about 2-3 feet below the ground. The soils are on the other hand predominantly of the black cotton type. The CBD is however highly paved, covering the soils significantly. Furthermore, the geological structure in the CBD is generally supportive of high density developments.

4.5 History

This subject has been discussed in two folds. The first looks at the unfolding of events in development and physical growth of the CBD while the second bit is a discourse on the history of planning of its planning.

4.5.1 Growth and Development of CBD

The history of Nairobi CBD dates back to the late 1890s when the very site was established as a railway depot and a passage area for the Kenya-Uganda Railway line which was under construction by the colonial government. Its strategic position and favourable topography was the reason as to why it was chosen as a railway depot and later on the provincial headquarters moved from Machakos to Nairobi (Shihembetsa, 1995 in Mwaura, 2002).

It thus housed the Europeans who were the Senior Railway Officers and the Asian junior officers and businessmen. Africans were then denied official residence rights and those that were within the town were forced to seek accommodation behind railway sheds or go outside the Railway Town in Kileleshwa, an area then referred to as *Maskini*[9] *area* (Ibid).

Nairobi attained a township status in 1903, was made the capital of Kenya Protectorate in 1908 and later on in 1919, it became a municipality. The CBD was initially both a business and residential district. The Senior European Railway Officers had their residences located west of the Railway line while the European and Asian traders provided for themselves residential cum commercial buildings along Station Road (the current Moi Avenue).

As growth continued, other functions began to emerge in the CBD. For instance, most Government offices were developed in along Station road (hence its renaming to Government

[9] Maskini is a Swahili word which means "a poor person."

road in 1901) e.g. Ministry of Land which was located in the present day Moi Avenue Primary and the town hall, which is the present day Imenti House (Kanyeki, 2014) .

The nature and densities of buildings also kept changing with time. Some the prominent high-rise buildings developed in the 1960s were the National and Grindlay's Bank (the present day National Archives) built in the late 1940s Ambassador Hotel, built in 1960s, Cotts' House (Currently St. Ellis House located at the junction between City Hall way and Wabera street) and New Stanley Hotel. The then photos of the above buildings are shown below.

Figure 15: Some of the Earliest High-Rise Buildings

(a) National & Grindlay's Bank and Ambassador Hotel (b) New Stanley Hotel

Source: http://www.mccrow.org.uk/eastafrica/kenya/kenya.htm, Jan 2016

Public transportation facilities were also provided within the geographical spaces currently occupied by the CBD. A good example is the Hardinge Street Bus Stance whose photo is shown below. Hardinge Street is the current Kimathi Street.

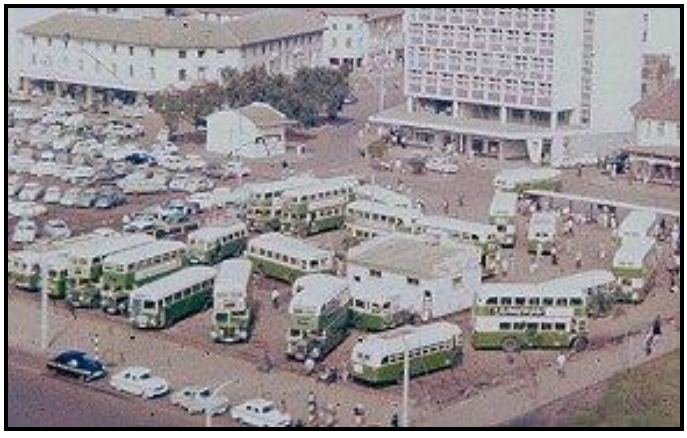


Figure 16: Hardinge Street Bus Stance

Source: http://www.mccrow.org.uk/eastafrica/kenya/kenya.htm

During the post-independence period, the city's growth became exponential especially because the natives could freely come and stay with their families. By 1973 (only 10 years

after independence), the policy makers had begun conceiving Nairobi as a city region rather than a single municipality. As the growth of the entire Nairobi continued, the CBD was not left behind. More particularly some of the most globally recognized skyscrapers began to come up and the concentration of activities increased so much that today most parts of the CBD are always congested.

4.5.2 History of Urban Planning in Nairobi

The first planning attempt was preparation of a plan for Nairobi as a railway town in 1906. By this time the town was only 18km^2 (even though it was extended to 25 Km^2 in 1920) This plan provided for few activity areas including depots, shunting areas, workshops for the European railway staff, trading areas and residential zones for Europeans and Asians.

In 1927 there came the second plan officially referred to as the *Plan for a Settler Capital.* This plan saw the extension of Nairobi to 77 Km^2 and proposed the clearance of drainage and swamps, regulation of development densities and traffic regularizations in order to promote access to the expanded zones.

The third plan was the 1948 Master Plan for a Colonial Capital. This plan zoned the town into seven broad land use areas i.e. Kenya Centre, business and commerce, industrial, residential, official buildings, official housing and open spaces. The plan proposed neighbourhood units in which people could live, shop, play and have access to all basic public facilities such as schools and health services.

Later on in 1973, the Metropolitan Growth Strategy was prepared. The strategy had two major proposals one of which was intracity and the other regional. In respect to the first aspect, the strategy proposed service centres within different districts of the city in order to reduce overdependence on the CBD for employment. These service centres were envisioned to have their independent residential, administrative, commercial and industrial sub zones.

The second proposal was about expanding Nairobi along Thika Road and promoting of growth of Thika, Machakos and Athi River towns so that these would functionally interact thus improving developments beyond Nairobi. It was as such envisioned that there would be a Nairobi Metropolitan Region as growth continued.

The most recent plan affecting the CBD is NIUPLAN which was prepared in 2015 and has a time horizon of upto 2030. NIUPLAN also proposes various secondary centres such as Donholm and Makadara, which are aimed to promote the decentralization of the functions currently performed by the CBD. It also proposes the development of major public transport networks (e.g. BRT routes) aimed at decongesting the CBD and improving its connectivity to various parts of the city.

4.6 Land Use

4.6.1 Land Use Distribution

There are a number of land uses within Nairobi CBD, including pure commercial, commercial cum offices, educational, recreational, public purpose, public utilities and transportation. The bulk of the land is occupied by commercial cum office developments which are distributed all over the city centre.

Pure commercial establishments are majorly between Tom Mboya Street and River road. Others include City market, Maasai market (which is also a cultural centre), a number of super markets and hotels like Intercontinental, Six Eighty, Tratoria, Sarova Stanley, Hilton and Ambassador among others.

The area between River road and Kirinyaga road are mostly commercial cum residential. There are also educational facilities, the most conspicuous of which are the University of Nairobi and Moi Avenue Primary School.

The only recreational facility within the CBD is the Jivanjee Garden which is fronted by Moi Avenue and Muindi Mbingu Street to the south and north respectively. There are also various social and entertainment spaces located in various buildings. The public purpose zones cover government offices and buildings such as the Parliament and KICC among others. Transportation land use is represented by the road network and the terminal facilities. The figure herein below illustrates the land use distribution in the land use distribution in the CBD.

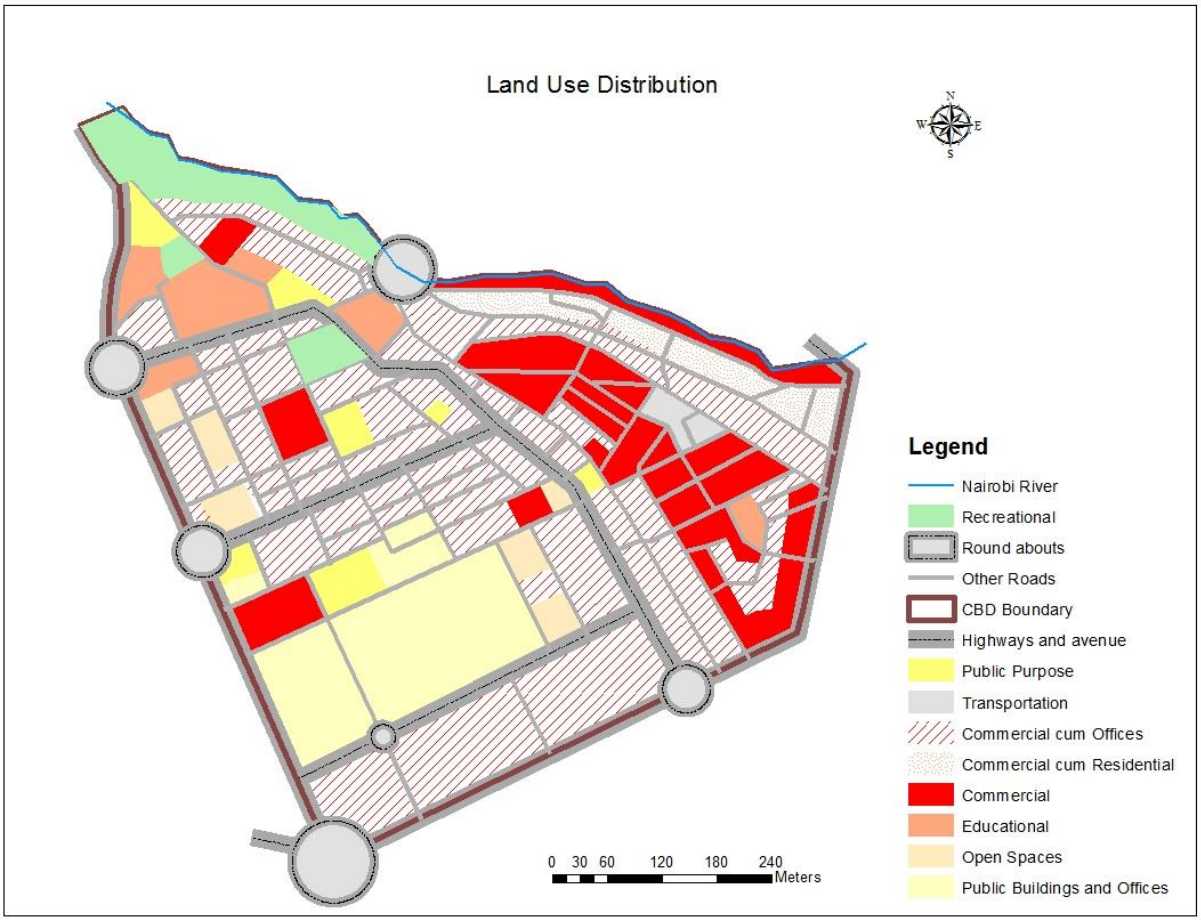


Figure 17: Land Use Zones

Source: Author (2017)

4.6.2 Land Use Density

Most of the buildings in the CBD are between 1 to 15 floors but a few others are higher as summarized below.

Table 5: CBD Buildings with Heights above 15 Floors

Corridor	Developments	Height
Haile Selasie Ave.	Times towers	33 floors
	Cooperative Bank House	25 floors
Kenyatta Ave	ICEA Building	19 floors
	I&M Bank Towers	18 floors
City Hall Way	International House	17 floors
Uhuru Highway	Nyayo House	27 floors
	View Park Tower	20 floors
	Hazina Towers	24 floors
University Way	University of Nairobi towers	21 floors
	Anniversary Towers	26 floors
	Ambank House	22 floors
Moi Avenue	Uchumi House	21 floors

Koinange street	Teleposta Towers	27 floors
Muindi Mbingu street	Ecobank towers	20 floors
Kaunda Street	Lonrho House	22 floors
Mama Ngina Street	Hilton Hotel	17 floors
Harambee Avenue	KICC	28 floors
Tom Mboya street	Afya Centre	21 floors

Source: Field Survey, 2017

4.7 Transportation

This section elaborates on the road network, terminal facilities and their capacities, street character and parking and circulatory patterns and conditions.

4.7.1 Road Network

The CBD's road network generally forms a grid iron pattern and is composed of roads of various capacities. The grid network is illustrated in the figure below.

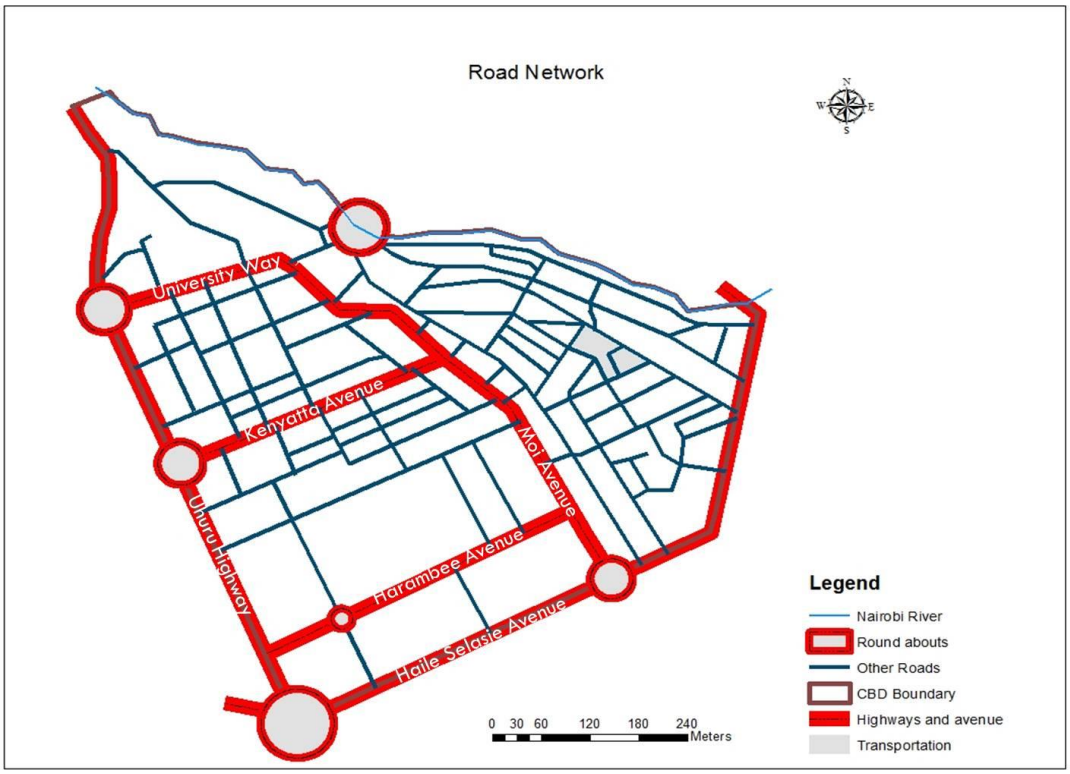


Figure 18: Street Pattern

Source: Author, 2017

This pattern of road network presents several junctions within the CBD. The junctions on the other hand encourage serious traffic delays, especially in the congested sections. This is because vehicles, pedestrians, motorcyclists and bicyclists have to converge at those

intersections from time to time thus causing movement in all directions difficult. As such, vehicles and people have to enter and exit the junctions in turns.

The widths of the road and number of lanes thereof are as tabulated below.

Table 6: CBD Road Hierarchy

Road	Width	No. of Lanes
Uhuru Highway	60 m	6 and a median
University way	40 m	6
Kenyatta avenue	40 m	6
Harambee Avenue	40 m	4
City Hall Way	25 m	4 and a median
Moi Avenue	25 m	4
Aga Khan Walk	25 m	Used by pedestrians
Race Course Road	30 m	4
Tumbo Avenue	30 m	4
Haile Selasie Road	25 m	4
Accra Road	25 m	4
Latema Road	25 m	4
Tom Mboya	21 m	2
Taifa Road	21 m	2
Mama Ngina Street	21 m	2
Muindi Mbingu Street	21 m	2 and a median
Loita street	21 m	2
Kimathi Street	21 m	2
Voi Road	21 m	2
Ronald Ngala	18 m	2
Koinange street	18 m	2
Banda Street	18 m	2
Murang'a Road	18 m	2
Lagos Road	18 m	2
Market Street	18 m	2
Kilome Road	18 m	2
Temple Road	18 m	3
Standard street	15 m	2
Uyoma Street	15 m	3
Wabera Street	15 m	2
Kirinyaga Road	15 m	2
Harry Thuku Road	15 m	2
Kijabe Street	15 m	2
Monrovia Street	15 m	2
Moktar Daddan Street	12 m	2
Biashara Street	12 m	2
River Road	12 m	2
Keekorok Road	12 m	2
Kigali Road	12 m	2
Kumasi Road	12 m	2
Taveta Road	12 m	2
Tsavo Road	12 m	2
Dubois Road	12 m	2
Sheikh Karume	12 m	2
Mfangano Street	12 m	2
Luthuli Avenue	12 m	2
Jeisala Road	12 m	2
Tubman Road	9 m	2
Duruma Road	9 m	2
Cross Road	9 m	2
Ambala Road	9 m	2

Mwimbi Road	9 m	2
Gaborone	9 m	2
Munyu Road	9 m	2
Kamae Road	9 m	2
Kweria Road	9 m	2
Price Road	9 m	2
Ngarama Road	9 m	2
Ndumberi Road	9 m	2
Lanes	3 to 9m	-

Source: Field Survey, 2016

4.7.2 Vehicular Circulatory Patterns

The circulatory patterns are discussed at two levels including intra and inter district patterns.

i. Inter-district patterns

These refer to circulation patterns between the CBD and other districts of the city. Generally, Vehicles enter and exit the CBD through roads that connect to the major arteries including Langata road, Waiyaki way, Mombasa road, Ngong road, Thika road and Jogoo road. The points at which the vehicle join and leave the CBD are illustrated herein after:

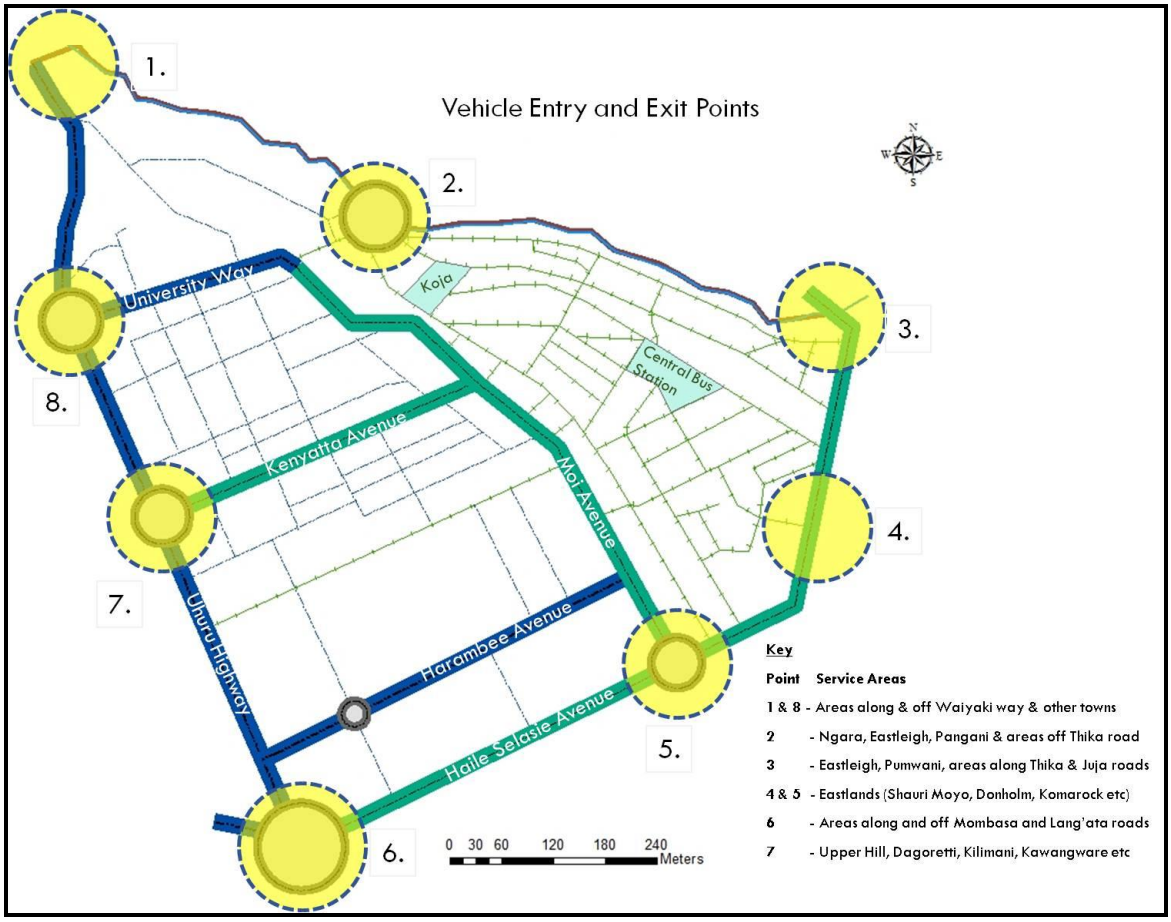


Figure 19: Vehicular Entry and Exit Points

Source: Author, 2017

ii. Intra-district pattern

The intra-CBD traffic circulation patterns vary depending on whether a street is one-way or two-way. Taking the section marked by Uhuru Highway, University Way, Moi Avenue and Haile Selasie Avenue, the circulation pattern is as shown overleaf.

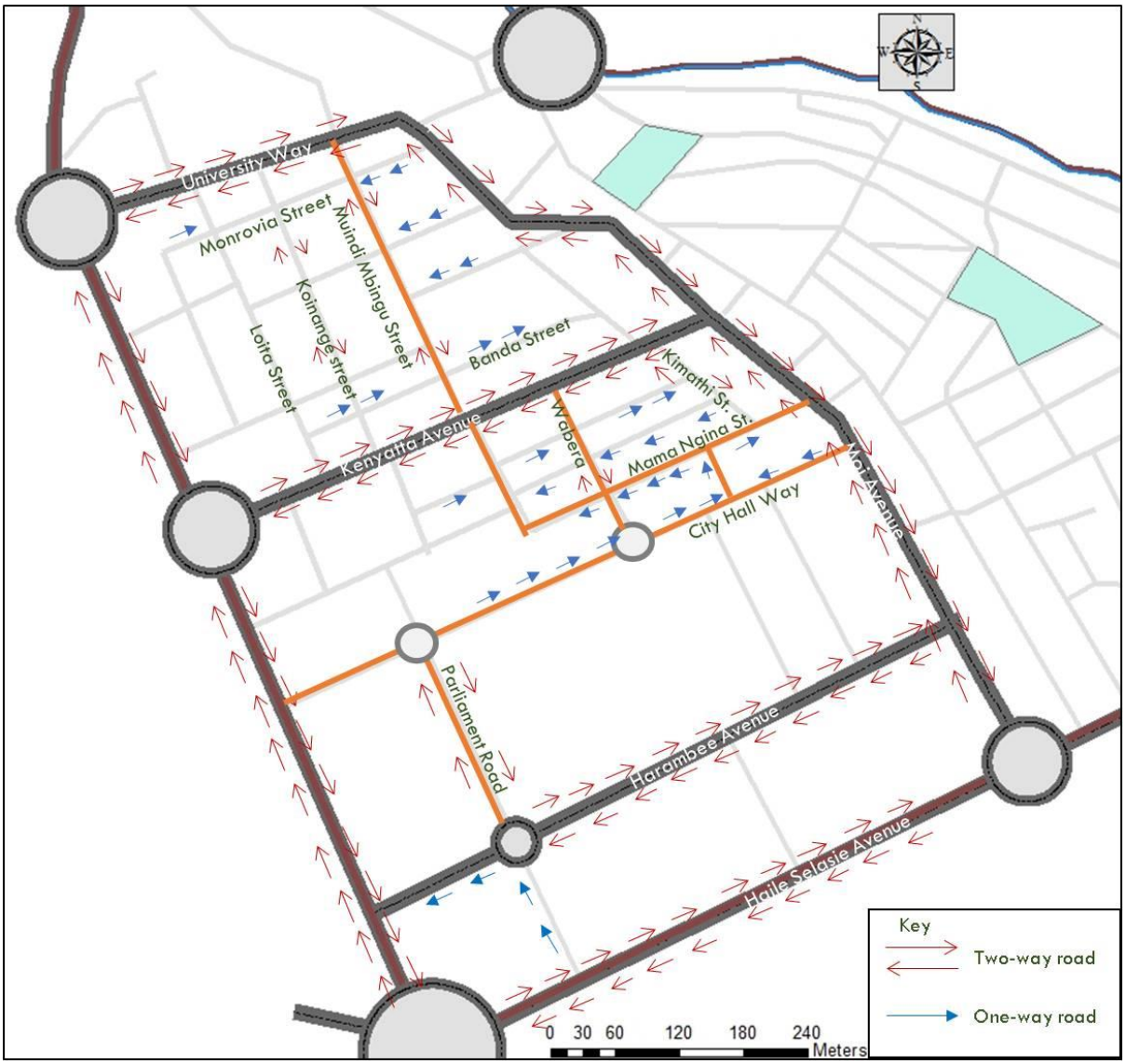


Figure 20: Intra- CBD Vehicular Circulation Pattern

Source, Author, 2017

4.7.3 Street Character

Street character has been defined based on the widths, number of lanes, number of ways, building heights, greening efforts and activity concentration and types (both on-street and off-street) Sample streets have been elaborately described herein after.

<u>Streets Enclosed by Uhuru Highway, University Way, Moi Avenue and Haile Selasie Avenue</u>: Most roads are between 12 m and 25 m wide. 1 way roads include Monrovia Street, Utalii Street, Njugu lane, Biashara Street, Tubman lane, Banda Street, Standard Street, Kaunda Street and Mama Ngina Street. Others are 2-way roads. The roads mostly front office cum commercial developments and have on-street parking (taxis). Most buildings have canopies over walkways. The roads have street lighting, storm water drainage channels, round-abouts, medians and they manifest landscaping

Kenyatta Avenue

Moi Avenue

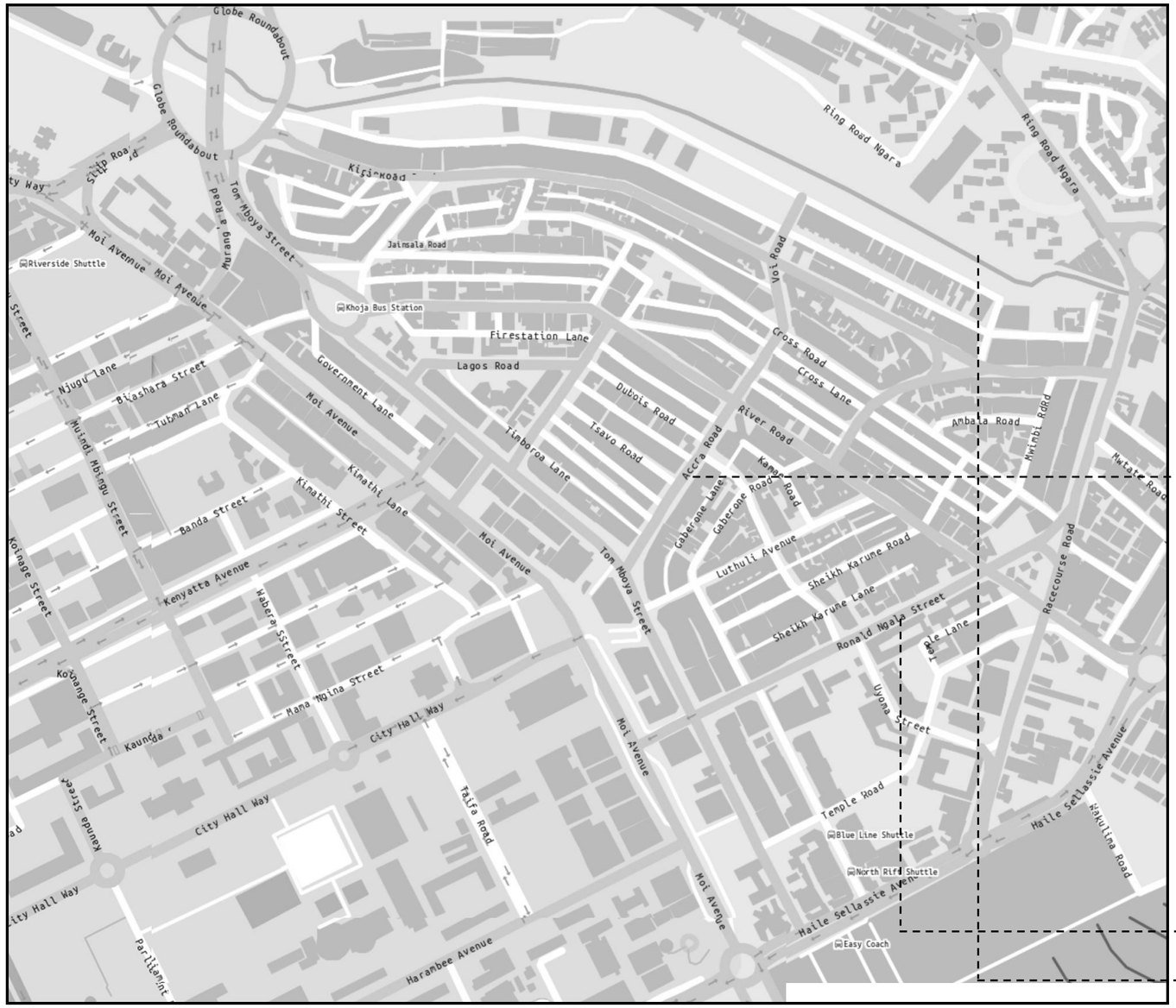
Mama Ngina Street

Parliament Road

City Hall Way

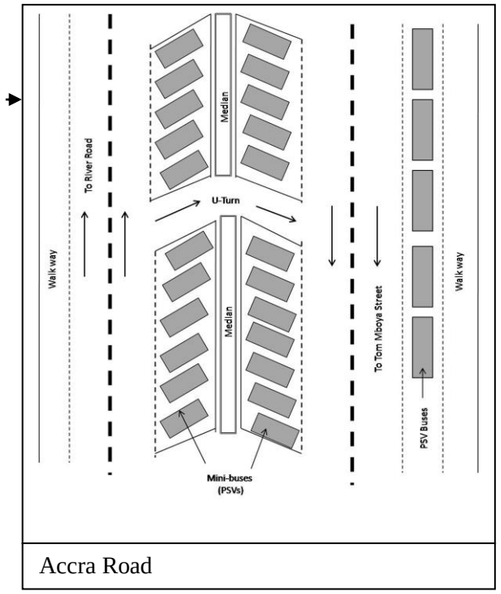
Harambee Avenue

Source: Nairobi CBD Study Report done by University of Nairobi MA (Urban Planning) Student) in March 2016

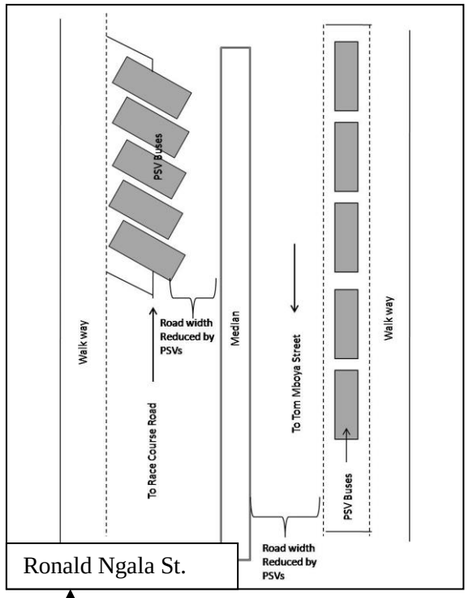


Streets Enclosed by Tom Mboya Street, Slip Road, Nairobi River, Race Course Road and Haile Selasie Avenue: Most roads are between 9 m to 12 m wide and are 1-way. They are very busy and congested, are used for on-street parking and they act as undesignated PSV termini. They are dominated by street vendors, hawkers, pedestrians, handcarts, motorcyclists and cyclists amid PSVs and cars. Most building along the roads are pure commercial and residential cum commercial and are mostly between 2 to 5 floors.

Common businesses are electronic shops (Luthuli Avenue), hotels, brothels, chemistries, tailoring shops (river road) and autospare shops (Kirinyaga road). Metal fabrication and other light industrial activities are also common. Backstreets are used to dump solid waste and are homes to street families.



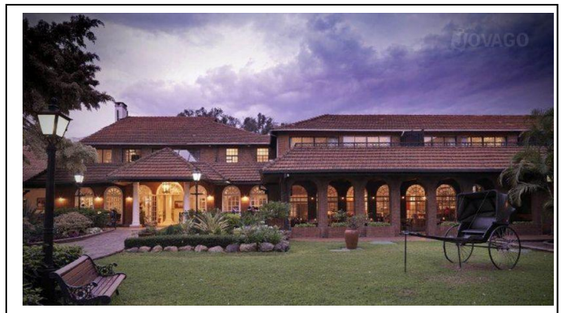
Accra Road



Ronald Ngala St.

Source: Nairobi CBD Study Report done by University of Nairobi MA (Urban Planning) Students in March 2016

Kijabe Street: 15 m wide, 2 lanes, 2-way, on-street parking (taxis) and it fronts mixed use developments. Majority of buildings are two floors.

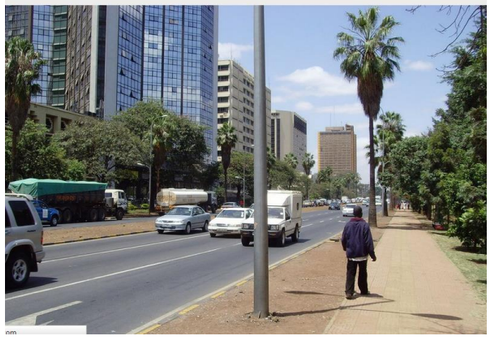


Norfolk Hotel

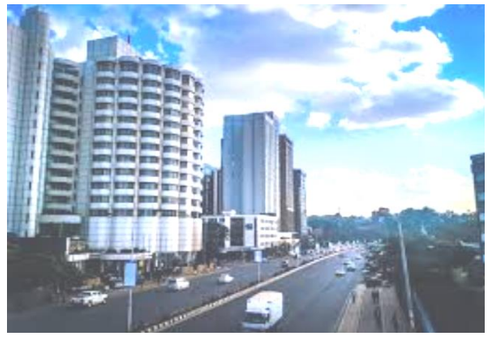
University of Nairobi Engineering wing

Harry Thuku Road: 15 m wide, 2 lanes, 2-way, on-street parking (taxis) and it fronts media houses, institutional developments and hotels

The Carriageway



High rise buildings



High rise buildings

University of Nairobi

Uhuru Highway: Inter-City (Class A) highway, 60 m wide, 6 lanes, 2-way, has green spaces, fronts several types of land uses from section to section. Tall buildings like Nyayo house, Hazina towers and View Park towers are along the road. It also fronts Uhuru & Central parks

University Way: 40 m wide, 4 lanes, 2-way, and it fronts mixed use developments (mostly office blocks). It majorly serves University of Nairobi, Kenya Methodist University and office blocks. Some of tallest buildings like Anniversary, Ambank and UoN Towers are along the road.

Source: Nairobi CBD Study Report done by University of Nairobi MA (Urban Planning) Students in March 2016

4.7.4 Parking

Parking within Nairobi CBD is both on-street and off-street. On-street parking takes place on all spacious roads other than Uhuru Highway and University way. Off-street parking spaces are on the other hand within buildings and open spaces. Examples of off-street parking spaces are within buildings like the Law Courts Car Park on Taifa Road & Sunken Car Park. These have 220 and 243 parking spaces respectively. Each of them has a daily turnover of over 700 cars

The number of parking lots operated by Nairobi City County Government adds upto 9,000. These cater for approximately 10,000 cars per day. The rest are provided by private entities such as parking silo owners, office operators, supermarkets and hotels among others.

4.7.5 Terminal Facilities

According to Chitere et al (2011), Nairobi had 34 termini by the year 2011. These served both intra-city and inter-city PSVs. The further point out that five termini were developed between 2006 and 2009 by the then Ministry of Local Government and Nairobi City Council in order to reduce congestion in the CBD. These termini include Westlands, Globe, Hakati, Muthurwa and Railways. The Central Bus Station was also improved to accommodate vehicles that were then operating along Tom Mboya Street.

These were arguably planned and placed strategically at major entry and exit points of the CBD. It was therefore envisaged that they would help to control the entry of PSVs to the inner parts of the district. However, with time, as the demand for these facilities increased, the County Government opted to transform streets into termini (as elaborately discussed section 5.2.1 of this report) and today very few CBD roads are devoid of PSV terminal activities. The latter are not planned at all and are therefore characterised by congestion and disorder. There is thus a glaring evidence of continuous non-provision of the required well-planned terminal facilities in the city of Nairobi.

4.8 Socio-Economic Significance

Like any other, Nairobi CBD plays very important socio-economic roles, both to the residents and non-residents. It is one of the greatest contributor's to the city's GDP as it houses major economic investments and work areas. It further serves as the main administrative district since significant government offices and establishments are located therein.

Its international image is also an added advantage in the sense that it lures several international events and the global population. In this regard, it adds to the tourism potential that the country has. It also provides for several social and entertainment spaces for Nairobi residents thus enabling them to break from the daily hustle and bustle of the city. Essentially, Nairobi CBD is undeniably an important district whose shortcomings must be rectified and potentials utilized for maximum benefits.

4.9 Emerging Issues

A number of points emerge from the discussion in this chapter. First, the CBD has a number of strengths and opportunities which make it a very important part of the city. It has comparatively higher levels of economic contributions to the city and Nairobi Metropolitan Region; a big prospective market for goods and services due high day time population; better infrastructural development; a higher aesthetic value (uptown section); and it depicts better land use planning. Its central location relative to most parts of the zones of the city, makes it fairly accessible. Its international repute also makes it attractive to economic investments tourists from the global community.

Secondly it is noted that the travel demand to the CBD has continuously grown over the years. This is because it has remained central in performing employment, business, educational and administrative functions. Additionally it has the highest employment density in the city, thus attracting a very high population every day. This has in turn led to high level of densification of activity spaces because land is generally in fixed supply.

Evidently therefore, the vehicular and pedestrian volumes are constantly on the rise. On the other hand, the road network, terminal facilities, parking areas and other infrastructural networks have not been expanded adequately, partly because of lack of additional space. As a result there have emerged on-street termini and parking lots. Furthermore, the high population of pedestrians and vehicles operating on a space whose supply is never increasing has led to serious cases of hawkers crowding the streets and traffic congestion cum snarl-ups. Congestion on the other hand continues to inhibit mobility and promote insecurity (pick-pocketing and theft), a situation that portrays ineffectiveness of the transport system.

The grid network of roads in the CBD has also led to serious traffic flow problems, especially at the intersections. The high traffic volumes moving along various roads are compelled to meet at these intersections where they delay because they have to move in turns.

The delays are a depiction inefficiency in the transport system since they are costly both to the transport service providers and consumers. The service providers waste valuable business hours in the jam and also have to use extra fuel while on transit. They thus incur significant losses. The consumers lose a lot of time which would otherwise be put into productive activities. They also have to pay extra for transport services because the vehicle owners charge higher fares to recover the money lost during the jam.

Other challenges evident in the CBD include encroachment into riparian reserves e.g. Nairobi River; Pollution (air, water and noise pollution), poor solid waste management and land use land use conflicts. All these can be solved if proper planning mechanisms are employed.

4.10 Conclusion

Nairobi CBD is a very significant part of the city socially, economically and historically. Similarly, it presents major problems which interfere with its ability to function optimally. Nonetheless, its proper operations cannot be forfeited for anything whatsoever, hence the need to deal with its shortcomings effectively.

CHAPTER FIVE
FINDINGS OF THE STUDY

5.1 Overview

This chapter presents the study findings of the study. The discussion covers aspects such as termini distribution in the study area, transport efficiency and effectiveness qualities therein and the relationship between the on-street termini and transport efficiency and effectiveness. The assessment of transport efficiency and effectiveness has been informed by the examination of factors such as level of service of the transport routes, segment flow durations at peak and off peak periods and costs related to the current transport systems. At the end of the presentation, the study findings have been compared with the results from review of literature and various conclusions derived.

5.2 The Existing System of Termini in the CBD

This section elaborates of the location of the termini, the vehicles they serve, their characteristics and the vehicular traffic volumes therein. The traffic volumes are based on the traffic counts that were undertaken between 13th and 18th April 2017.

5.2.1 Location of Termini

The CBD has both on-street and off-street bus termini. However, only two of them are off-street i.e. Central Bus Station and Koja. The on-street termini are located along more than 50% of the roads and streets. The only corridors without on-street termini include Uhuru Highway, University way, Harambee Avenue, Parliament Road, Taifa road, Muindi Mbingu, Koinange, Loita, Monrovia, Kimathi, Mama Ngina, Wabera, Banda, Standard and Biashara streets. The figure below shows the distribution of the termini.

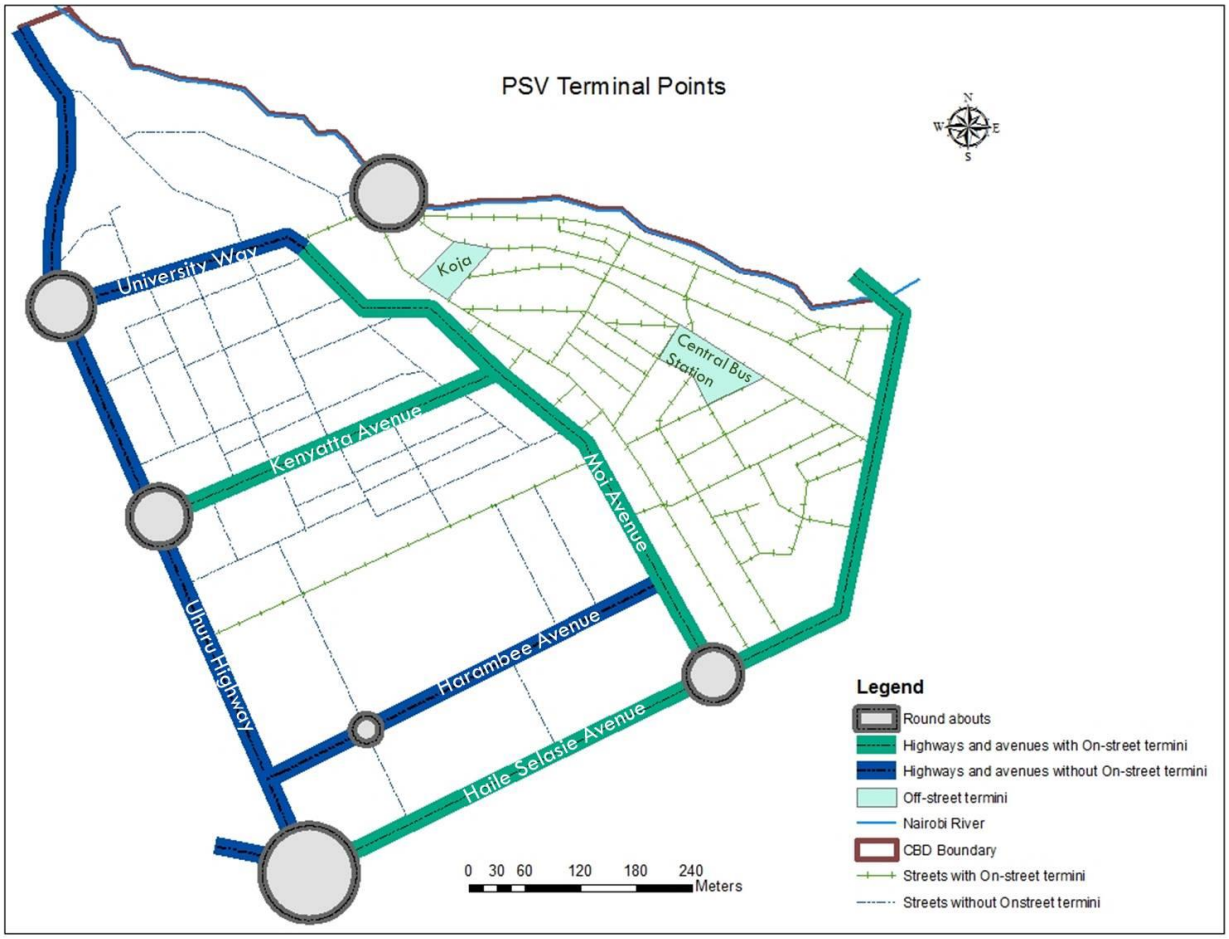


Figure 21: Distribution of PSV Terminal Points

Source: Author, 2017

5.2.2 Vehicular Traffic Volumes

The traffic volumes data presented is based on the findings of the traffic counts which were undertaken during the peak (6.00 to 9.00am and 5.00 to 9.00 p.m.) and off-peak hours (10.00 am to 4.00 p.m.) of weekdays and weekends. The average volumes were thereafter calculated and are presented in the tables below.

Table 7: Average Week Day Traffic Volumes per Terminal

Mode	Time														
	Peak morning					Off peak (day time)					Peak evening				
	Mfangano	Ronald Ngala	Accra	Kencom	Moi Ave	Mfangano	Ronald Ngala	Accra	Kencom	Moi Ave	Mfangano	Ronald Ngala	Accra	Kencom	Moi Ave
Cars	21	186	37	107	45	21	26	24	122	37	15	48	24	130	27
Minibuses (15-33 seats)	34	92	89	37	58	34	41	62	31	78	74	52	59	18	32
Buses (>33 seats)	30	30	5	80	22	30	23	5	62	19	23	31	11	82	33
Total	**85**	**308**	**131**	**224**	**125**	**85**	**90**	**91**	**215**	**134**	**112**	**131**	**94**	**230**	**92**

Table 8: Average Weekend Traffic Volumes per Terminal

Mode	Time														
	Peak morning					Off peak (day time)					Peak evening				
	Mfangano	Ronald Ngala	Accra	Kencom	Moi Ave	Mfangano	Ronald Ngala	Accra	Kencom	Moi Ave	Mfangano	Ronald Ngala	Accra	Kencom	Moi Ave
Cars	21	43	46	88	21	16	38	26	98	14	15	17	50	97	19
Minibuses (15-33 seats)	25	83	44	28	20	38	19	32	32	33	32	36	54	65	76
Buses (>33 seats)	26	39	4	32	3	22	18	2	54	4	28	16	5	53	16
Total	**72**	**165**	**94**	**148**	**44**	**76**	**75**	**60**	**184**	**51**	**75**	**69**	**109**	**215**	**111**

Source: Field Survey, 2017

From the above statistics, the following analysis has been done;

1. The Difference between Peak and off-peak traffic

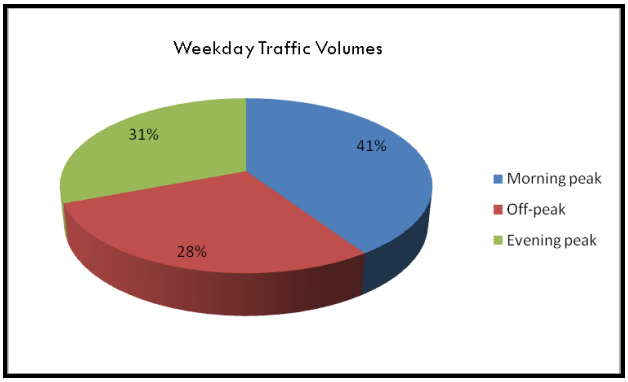
a. On Weekdays

In general, it was observed that the traffic volumes are highest during the morning peak (6.00 to 9.00 am), followed by the evening peak (5.00 to 9.00 pm) and lastly off-peak hours (10.00 am to 4.00 pm). This is as illustrated below.

Table 9: Weekday Traffic Volumes

Time	Traffic volume	Percent
Morning peak	869	40.6%
Off-peak	611	28.6%
Evening peak	659	30.8%
Total	2139	100.0%

Source: Field Survey, 2017



However, the scenario changes from one terminal to another. In Mfangano Street, the morning peak and off-peak traffic volumes are almost the same while the evening peak has higher volumes. This is explained by the fact that PSVs arrive at the station, drop passengers and move back to the origin estates almost immediately since there are very few people who leave the CBD between 8.00 am and 4.00 pm. In the evening however, the vehicles have to queue and wait for people who are then expected to travel back to their respective homes after work, hence the higher volumes.

In Ronald Ngala, the morning peak volume is highest especially because there are so many private cars using the road at those times and they get stuck in the jam because of the high

concentration of on-street activities, very many pedestrians and several on-street PSV termini. However, the PSV volumes tend to change in a similar manner as in Mfangano.

In Accra, the morning peak volumes are highest because of the high volumes of the intercity PSVs. As soon as a big proportion of these vehicles leave by 10.00a.m, the bulk of the remaining vehicles are the ones operating within Nairobi. Like in other stations, the volumes then reduce during the off-peak hours only to increase later in the evening when most people are leaving the CBD for home.

In Kencom, there are no major volume differences between the peak and the off-peak hours. This is because the cars that use the road are hardly caught in jam around the area and the PSVs rarely queue there for more than 30 minutes at any time of the day. In other words, while the numerical vehicular flows are generally high at Kencom, the free flow of traffic throughout the day makes the volume differences minimal.

The case in Moi Avenue is almost similar to that in Kencom, except that the evening peak volumes are lowest. This is because the vehicles that join Moi Avenue tend to come from very many routes, most of which experience traffic jam in the evening. As such the rate at which the vehicles join the avenue is lower. The figure below illustrates these volume differences.

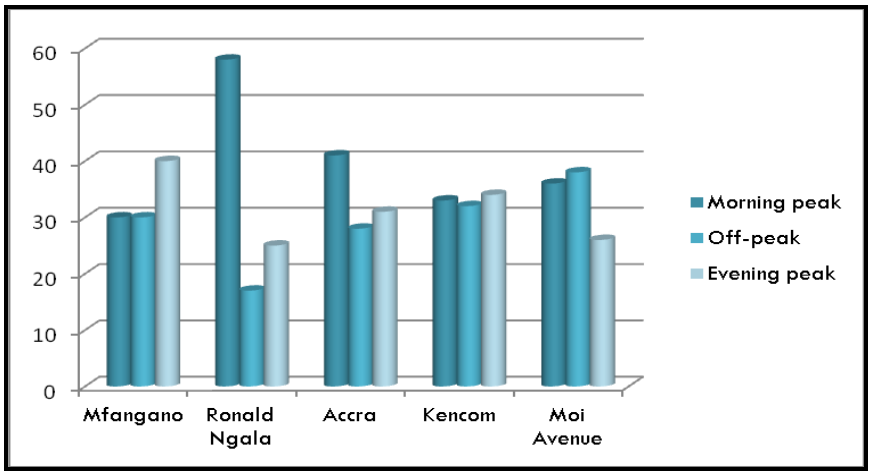


Figure 22: Weekday Traffic Differences by Terminal

Source: Field Survey, 2017

The actual statistics are tabulated below.

Table 10: Weekday Traffic Differences by Terminal

Time	*Mfangano*		*Ronald Ngala*		*Accra*		*Kencom*		*Moi Avenue*	
	Volume	*Percent*	*Volume*	*Percent*	*Volume*	*Percent*	*Volume*	*Percent*	*Volume*	*Percent*
Morning peak	85	30%	308	58%	127	41%	224	33%	125	36%
Off-peak	85	30%	90	17%	87	28%	215	32%	134	38%
Evening peak	112	40%	131	25%	94	31%	230	34%	92	26%
Total	**282**	**100%**	**529**	**100%**	**308**	**100%**	**669**	**100%**	**351**	**100%**

Source: Field survey, 2017

b. On Weekends

The weekend traffic volumes are about 1.4 times less than the week day volumes. Furthermore, unlike the weekdays, the evening peak volumes are highest since majority of the people go to the CBD after 9.00 am. By evening also the vehicles tend to queue for long because the people who use the vehicles are fewer and must be waited for longer than it happens during the weekdays. The figure below shows the proportions of traffic volumes at various times of the day.

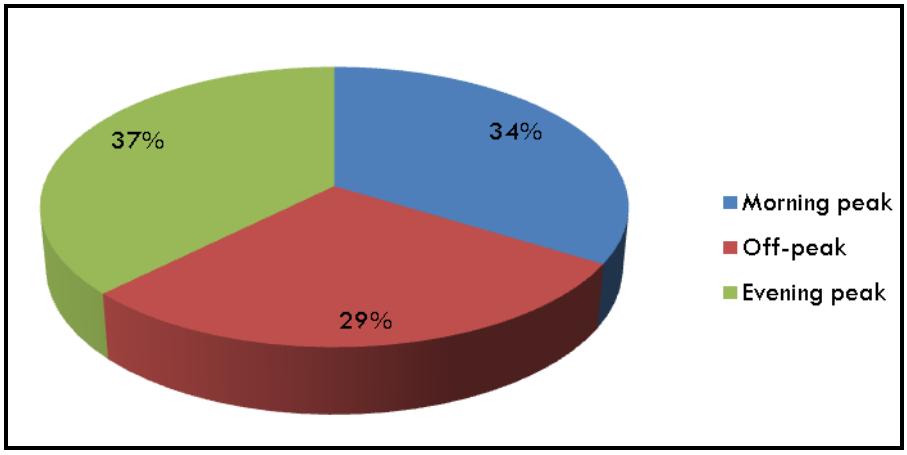


Figure 23: Weekend Traffic Volume Proportions
Source: Field Survey, 2017

Like the weekdays, the volumes on weekends also differ from one terminal to another as summarized in the table below

Table 11: Weekend Traffic Differences by Terminal

Time	*Mfangano*		*Ronald Ngala*		*Accra*		*Kencom*		*Moi Avenue*	
	Volume	*Percent*	*Volume*	*Percent*	*Volume*	*Percent*	*Volume*	*Percent*	*Volume*	*Percent*
Morning peak	72	32%	165	53%	94	36%	148	27%	44	21%
Off-peak	76	34%	75	24%	60	23%	184	34%	51	25%
Evening peak	75	34%	69	22%	109	41%	215	39%	111	54%
Total	**223**	**100%**	**309**	**100%**	**263**	**100%**	**547**	**100%**	**206**	**100%**

Source: Field Survey, 2017

From the above table, it is observed that the evening peak traffic volumes are highest in all the termini except Ronald Ngala. It is also notable that the weekend traffic volumes are lower than the weekday volumes in each of the stations.

The highest difference is noted along Ronald Ngala and Moi Avenue, where there is highest number of private cars during the weekdays. This means that people use their private cars to the CBD when they have to come to work. Accra registers the lowest difference of 15% only since the majority of the vehicles there are intercity and they travel in similar patterns both on weekdays and weekends. The table below summarizes the differences.

Table 12: Traffic Volume Differences between Weekdays and Weekends

Terminal	*Weekday traffic (T)*	*Weekend traffic (t)*	*Difference (T-t)*	*% decrease*
Mfangano	282	223	59	21%
Ronald Ngala	529	309	220	42%
Accra	308	263	45	15%
Kencom	669	547	122	18%
Moi Avenue	351	206	145	41%

Source: Field Survey, 2017

2. Traffic Volume Differences by Density of On-Street Termini

The volume differences are summarised below

Table 13: Volume Differences by Density of On-Street Termini

Category	*Terminal*	*Weekday traffic (T)*	*Weekend traffic (t)*
High density of on-street termini	Mfangano	282	223
	Ronald Ngala	529	309
	Accra	308	263
Low density of on-street termini	Kencom	669	547
	Moi Avenue	351	206

Source: Field Survey, 2017

From the above table, it is observable that the total traffic volumes are comparatively high in the areas with low density of on-street termini. However, considering the modal composition in each terminal, it is notable that a good percentage of the vehicles in the areas with low density on-street termini are personal cars. More particularly, 48% and 36% of the vehicles in are personal cars in Kencom and Moi Avenue respectively. This is quite higher than in Mfangano and Accra where the personal cars form only 25% and 29% of the total traffic respectively. The congestion in by PSV vehicles on Mfangano and Accra The chart below illustrates this further.

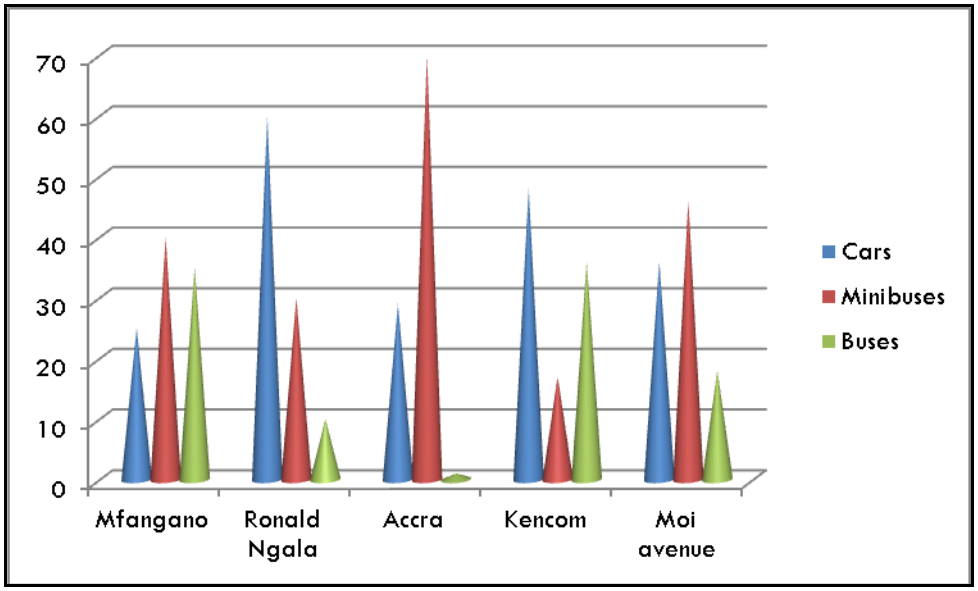


Figure 24: Traffic Volume Differences by Density of On-Street Termini

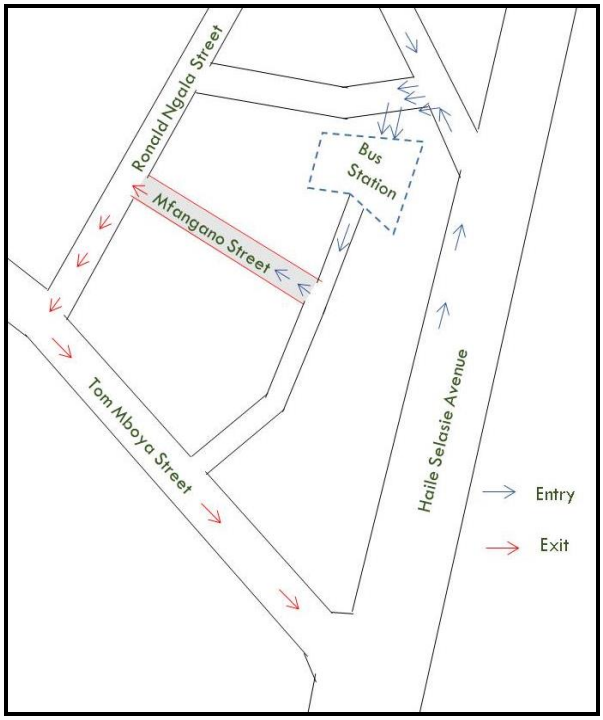
Source: Field Survey, 2017

The implication of these scenarios is that there are more through traffic in the areas with low density of on-street termini (which are majorly the cars) than in areas with high density of on-street termini. This further means that traffic flow is faster in the areas with low density of on-street termini hence most personal car owners are encouraged to use those routes.

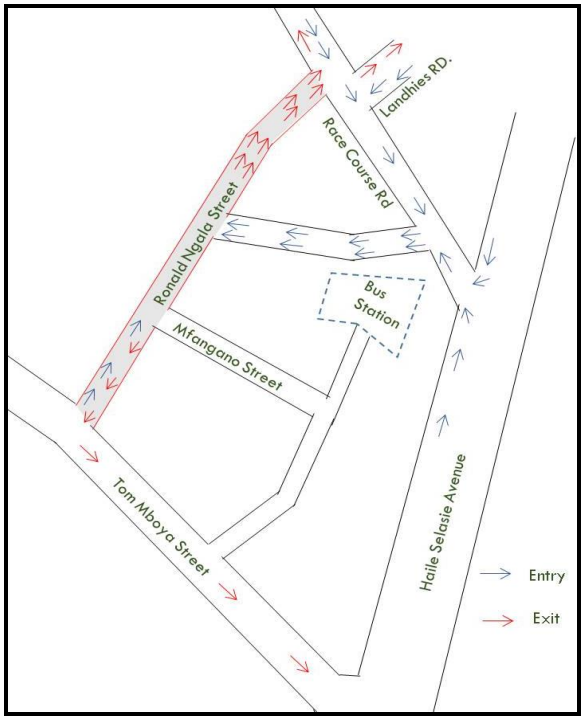
Notwithstanding the general trend in the areas with high density of on-street termini, the case in Ronald Ngala is significantly different in the sense that about 60% of the vehicles are private cars. Nonetheless, it must be noted that some of these cars are not through traffic. They end up parked along the road and this is evidenced by the high number of on-street car parks along Ronald Ngala compared to Kencom and the southern section of Moi Avenue where the traffic counts were conducted. Furthermore, Ronald Ngala street functions as a key link between the city centre and the corridors located to the east of the CBD and as such most cars are forced to use the road, despite the traffic conditions thereon.

5.2.3 Vehicle Entry and Exit Patterns

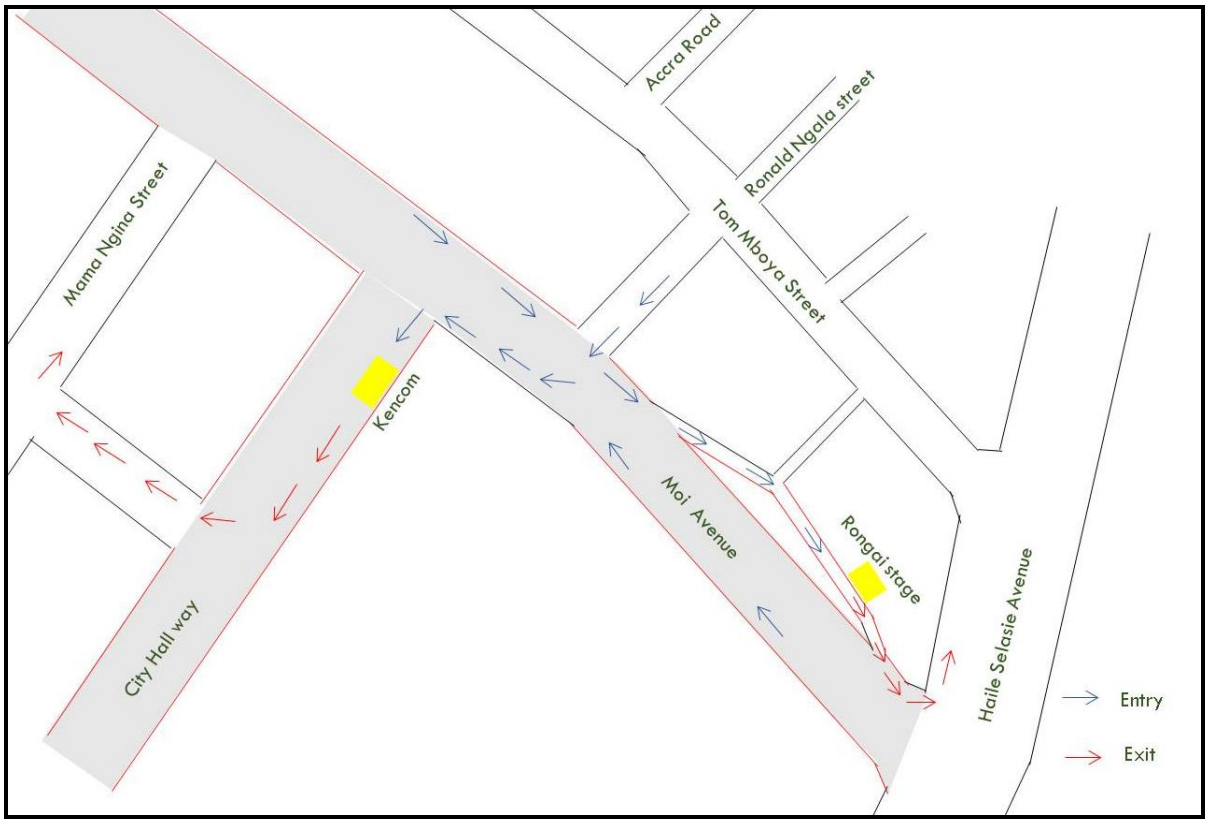
The vehicular entry and exit patterns in the termini are as illustrated herein after.



Sketch 1: Pattern in Mfangano Street

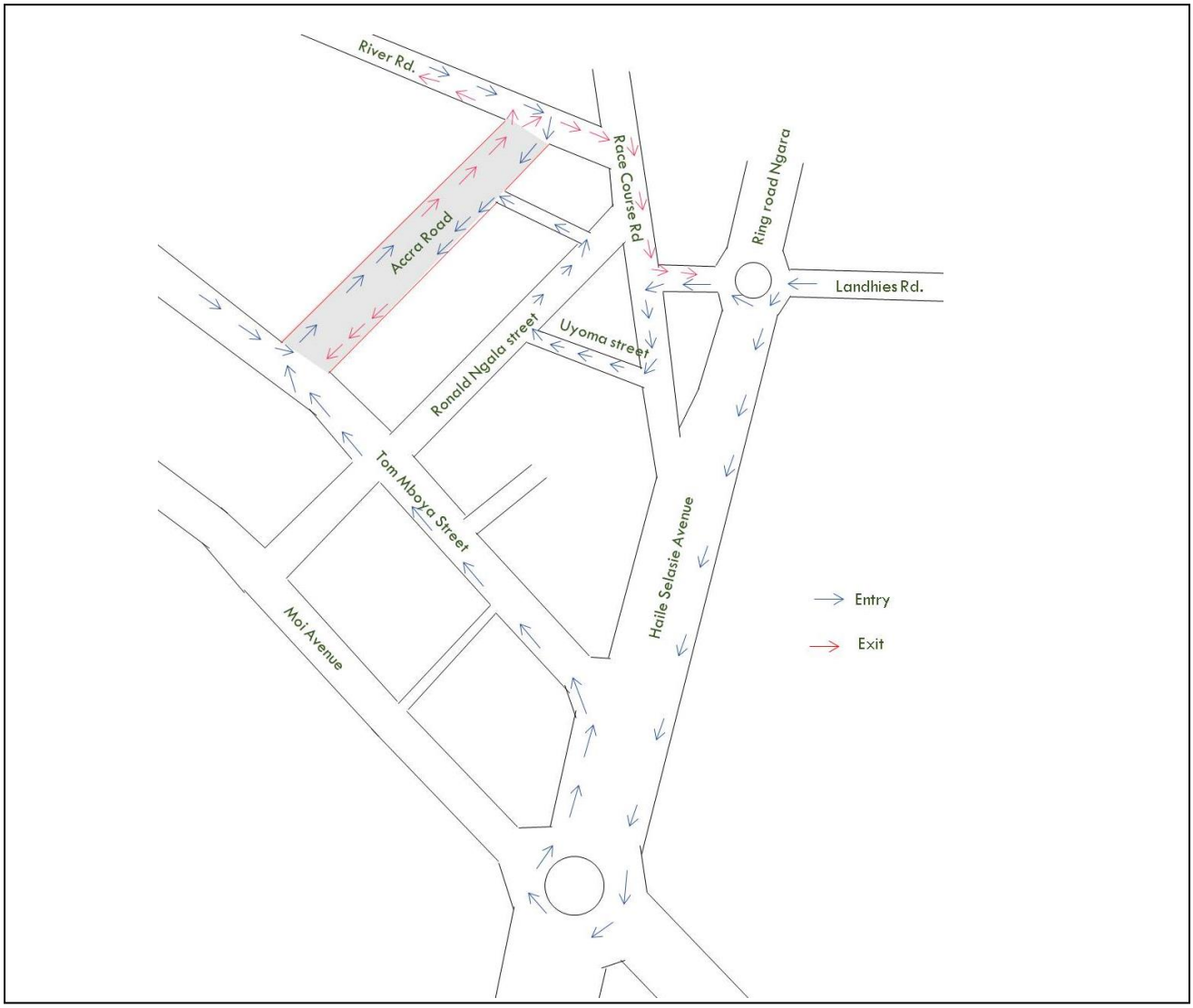


Sketch 2: Pattern along Ronald Ngala Street



Sketch 3: Patterns at Kencom and Moi Avenue

Source: Author, 2017



Sketch 4: Pattern along Accra Road

Figure 25: Vehicle Entry and Exit Patterns

Source: Author, 2017

From the above patterns, an analysis has been done to assess the ease of access to those termini. This is as follows.

Table 14: Ease of Access of Termini Based on Vehicle Entry and Exit Patterns

Category	*Terminal*	*Ease of access*	*Reasons*
High density of on-street termini	Mfangano	Difficult	• Narrow access road • On-street termini on both sides of the road • Vehicles have to pass through the constricted bus station route • Conflicts with vehicles terminating journeys at the bus station • Conflicts with vehicles along Ronald Ngala street • Conflict with NMT users, hawkers and motorcyclists
	Ronald Ngala	Difficult	• Several on-street termini on both sides of the road hence need for access in both directions • A major bottleneck at the junction between Uyoma street and Ronald Ngala street

			• Conflicts with through traffic • Many vehicles terminate journeys at the terminal
	Accra	Very Difficult	• Long distances covered to access terminal • Several junctions • Narrow adjoining roads e.g. river road • Vehicles have to go through several roads hence conflict with so many vehicles • Termini on both sides of the road and at the middle hence lots of vehicular conflicts • Very many vehicles terminate journeys at the terminal and neighboring ones
Low density of on-street termini	Kencom	Easy	• Wide access road • One junction • One way traffic flow • Terminal located slightly off the carriageway
	Moi Avenue	Easy	• Wide access road • No junction • One way traffic flow to and from the terminal • Terminal located away from the carriageway

Source: Author, 2017

5.2.4 Characteristics of the Termini

The factors that have been considered in assessing the characteristics of the termini include their sizes, activity concentration and PSV Parking style. It is also noteworthy that these characteristics were observed in sample termini, including Mfangano Street, Ronald Ngala Street, Accra road, Moi Avenue and Kencom bus termini. The first three represented area with high density of on-street termini while the latter two represented those with low density of the termini.

The characteristics are summarized in the table below;

Table 15: Characteristics of the Termini in the Study Area

Category	Termini	Size	PSVs served	Activity concentration	Parking style.
High density of termini	Mfangano Street	12 m wide road reserve	Komarock, Umoja and Kayole vehicles	1. On-street car parking 2. Many on-street vendors 3. Heavy pedestrian movements 4. High concentration of off-street business activities	1. PSVS are on **both** sides of the road 2. Parked behind one another
	Ronald Ngala Street	18 m wide road reserve	Githurai, Umoja, Huruma and intercity (e.g. Thika) vehicles	1. On-street car parking 2. Very many on-street vendors 3. Heavy pedestrian movements 4. High concentration of off-street business activities 5. Motorcycles parked	1. PSVs are on **both** sides of the road 2. Parked side by side and behind each other at different sections of the road 3. Side by side parking is angular
	Accra road	25 m wide road reserve	Donholm, Buruburu,	1. Very many on-street vendors	1. PSVs are on **both** sides of the road

			Embakasi and intercity (e.g. Nyeri, Murang'a, Kisumu, Kakamega etc.) vehicles	2. Handcarts parked 3. Heavy pedestrian movements 4. High concentration of off-street business activities 5. Motorcycles parked	2. Parked side by side and behind each other at different sections of the road 3. Side by side parking is angular
Low density of termini	Moi Avenue	25 m wide road reserve	Rongai, Kawangware, Embakasi, Buruburu and JKIA vehicles	1. Few on-street vendors 2. Relatively few pedestrian movements 4. Fairly low concentration of off-street business activities	1. PSVs are on **one** sides of the road 2. Parked behind one another
	Kencom	25 m wide road reserve	Dagoretti, Kawangware, KNH and Karen vehicles	1. Very few on-street vendors 2. Relatively few pedestrian movements 3. Very low concentration of off-street business activities	1. PSVs are on **one** side of the road 2. Parked behind one another

Source: Author, 2017

5.3 Traffic Efficiency and Effectiveness of in the CBD

In assessing traffic efficiency and effectiveness, the factors that have been examined include level of service, segment flow durations, costs resulting from the traffic situation and effects of the On-street termini

5.3.1 Level of Service

The LOS concept is used to assess effectiveness of transport corridors based on traffic operating conditions and the drivers' perception of the conditions. There are six LOS ranks (A to F) which are usually defined for each type of facility. LOS A represents the best operating conditions and LOS F depicts the worst conditions.

LOS can either be measured by time delays per vehicle (in seconds) at junctions or the ratio of traffic volume to the design capacity of a road section (V/C). In this study, the second measure has been to be used and the criteria thereof are as follows.

Table 16: LOS Criteria for Road Sections

Level of Service	Description	Volume to Capacity Ratio (V/C)
A	Free flow conditions with drivers un affected by other movements in the traffic streams	<0.6
B	Stable flow with drivers having reasonable freedom to maneuver	0.65-0.75
C	Stable flow, but drivers somewhat restricted.	0.75-0.85
D	Approaching stable flow limits with drivers significantly restricted	0.85-0.95
E	Unstable flow, traffic t or close to capacity with drivers severely restricted	0.95-1.0
F	Forced flow, over capacity limits	>1.0

Source: HCM, 2010

The findings of the study indicate the following volume capacity ratios:

Table 17: Level of Service Analysis

Road	*Carriageway Width*	*Design Capacity (Q*	*Peak Volume (V)*	*Volume/ Capacity Ratio*	*Level of service*
City Hall Way (Kencom)	21 m	2450	230	0.093	A
Moi Avenue	21 m	2450	124	0.05	A
Accra Road	18 m	1350	127	0.094	A
Ronald Ngala	14 m	1000	308	0.31	A
Mfangano Street	9 m	600	112	0.19	A

Source: Field survey, 2017

The corridors along which the termini are located all operate at LOS A. Nonetheless, the ones with high density of on-street termini (Mfangano, Accra and Ronald Ngala) have poorer LOS scores than those with fewer termini (City Hall Way and Moi Avenue).

5.3.2 Segment Flow Durations

Segment flow durations were assessed in two ways. The first was by asking the PSV users to evaluate the time they often take to leave the CBD and the second was by taking a ride in the PSVs at the respective termini and alighting at various points outside the CBD (an average distance of 3km)

The response from a majority of the respondents indicated that the average time taken to leave the CBD once the vehicle was full was between 20 and 45 minutes. This is shown in the chart below:

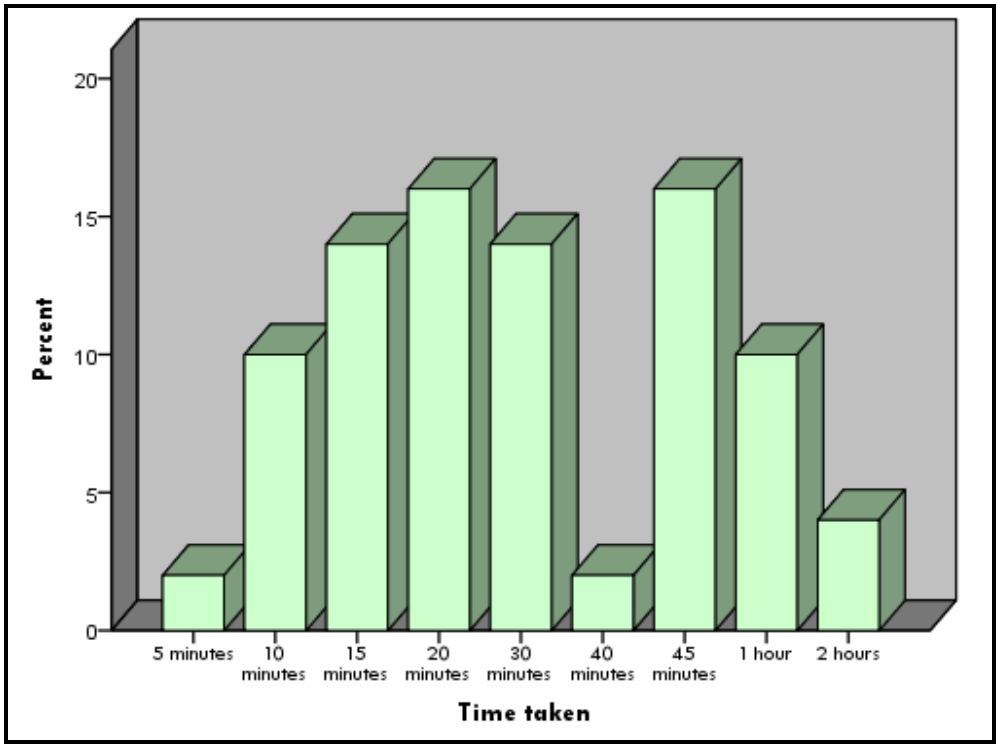


Figure 26 : Average Time Taken to Leave the CBD

Source: Field Survey, 2017

In addition to this, the respondents were also asked to estimate the average time the PSVs take to get full. This is summarized below.

Table 18: Average Time PSVs Takes to Get Full

Time taken	*Respondents (%)*
5 minutes	2%
10 minutes	24%
15 minutes	16%
20 minutes	16%
30 minutes	24%
1 hour	6%

Source: Field Survey, 2017

In regard to the above statistics, it is noted that majority of the travellers waited between 10 to 30 minutes for the vehicles to get full. As such, the cumulative time taken within the CBD after one has boarded a vehicle ranges between 30 minutes and $1^{1}/_{4}$ hrs. Generally, when a transport system allows for one to take over 1 hour to cover a distance of 3km only, it means that there are serious shortcomings.

In addition to the respondents' estimates, the researcher's records of the segment flow durations were found to vary from one terminal to another. The statistics are indicated in the tables below.

Table 19: Weekday Segment Flow Durations

Road	*Time taken to fill up the vehicles*	*Time taken to leave the CBD(3km distance)*	*Time taken to get back to the terminal (3km distance)*
City Hall Way (Kencom)	8 minutes	18 minutes	22 minutes
Mfangano Street	17 minutes	19 minutes	23 minutes

Source: Field Survey, 2017

Table 20: Weekend Segment Flow Durations

Road	*Time taken to fill up the vehicles*	*Time taken to leave the CBD(3km distance)*	*Time taken to get back to the terminal (3km distance)*
City Hall Way (Kencom)	7 minutes	3 minutes	4 minutes
Mfangano Street	9 minutes	6 minutes	6 minutes

Source: Field Survey, 2017

There are a number of deductions that can be made from the above statistics. First, Average total time taken within the CBD after a PSV is full on a weekday is approximately 36 minutes on areas with high density of on-street termini and 26 minutes on areas with fewer termini. This implies an approximate of 10 minute difference between the two cases.

Secondly, the average total time taken to access the termini from outside the CBD on a weekday is almost the same for the two cases (about 22 – 23 minutes). This is because the traffic flow speeds depend on the conditions encountered along the roads outside the CBD.

Third, the average time taken to leave the CBD on a weekend is about 15minutes and 10 minutes for areas with high density on-street termini and those with less respectively. This implies a 5 minute difference.

Fourth, the average total time taken to access the termini from outside the CBD on a weekend is reduces upto about 4 to 5 times. This is because the traffic volumes on the roads within and outside the CBD are significantly reduced on weekends, hence faster flow.

Lastly, there is a general positive relationship between traffic volumes and the time taken to leave the CBD or get back to the termini i.e. the higher volumes in the CBD and its surrounding, the more the time taken to leave and/or access the on-street termini.

5.3.3 Costs Resulting from CBD Traffic Conditions

The costs resulting from the traffic conditions in the study area have been categorized as social, economic and environmental. They have been analysed based on the perspectives of both the travellers and the PSV operators.

a. Economic costs

According to the results of this study, a majority of the PSV operators have worked in the industry for several years. This is as summarized in the table below.

Table 21: Duration of Work in the Public Transport Industry

Duration	*Percent*
Less than 1 year	3.3%
1 to 5 years	36.6%
6 to 9 years	23.4%
10 years and above	36.6%
Total	**100.0%**

Source: Field Survey, 2017

Furthermore, upto 64% of the travellers interviewed indicated that they went to the CBD for work and business. Others went to school and for social purposes. (See chart below).

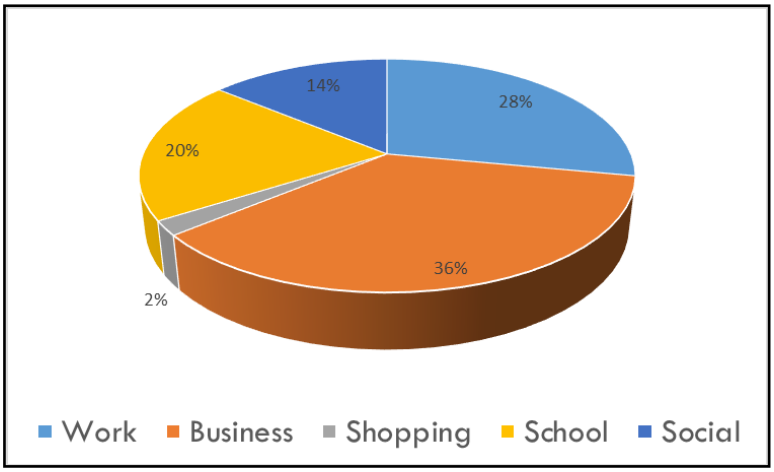


Figure 27: Trip Purpose

Source: Field Survey, 2017

The above statistics reveal that the sector is a major source of livelihoods for a significant proportion of Nairobi residents. As such, a majority of them have to go to the CBD daily as depicted below.

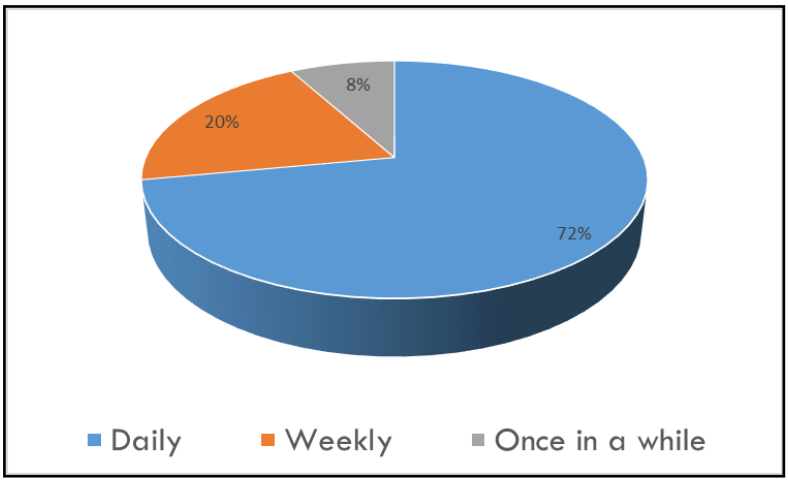


Figure 28: Frequency of Visit to the CBD

Source: Field Survey, 2017

From the foregoing, it is established that majority of those who go to the CBD have to contend with the traffic situation as frequently as almost daily. Furthermore, since most of them go there for work or business, it can be deduced that the shortcomings of the transport system affect them economically. Furthermore, the excess fare they pay during traffic jam is an economic cost to them.

The analysis done in sections 5.1, 5.2.1 and 5.2.2 above shows that the traffic situation in the CBD is characterised by congestion especially around areas with on-street termini; significant segment delays; difficulty in entry into and exit from termini; traffic collision and commotion; and transport/land use conflicts

The economic impacts of these factors as cited by the respondents include loss of valuable economic time and lateness to work/business place; reduced number of trips made by PSV operators hence lower financial returns; reduced profits for business operators as a result of lateness; loss of property by business people operating in congested areas which tend to be insecure; loss of property to thieves who tend to operate in the congested areas and increased expenditure on fuel by PSV operators.

A majority of the interviewed operators indicated that they spent an additional amount of between Ksh. 500 and 2500 per day when traffic jam is experienced. The tables below shows the statistics derived from this study.

Table 22: Amounts Spent on Fuel by PSV Operators

Amount spent on fuel when there is **NO** delay in the CBD	Amount spent on fuel when there is delay in the CBD	Difference (Ksh)	% of respondents
Ksh. 2200	Ksh. 3000	800	3.3%
Ksh. 3000	Ksh. 4000	1000	6.7%
Ksh. 3500	Ksh. 4000	500	3.3%
	Ksh. 5000	1500	3.3%
	Ksh. 6000	2500	3.3%
Ksh. 4000	Ksh. 4800	800	3.3%
	Ksh. 5000	1000	6.7%
	Ksh. 6500	2500	3.3%
Ksh. 4200	Ksh. 5000	800	3.3%
Ksh. 4500	Ksh. 5000	500	3.3%
	Ksh. 6000	1500	3.3%
	Ksh. 7000	2500	3.3%
Ksh. 5000	Ksh. 5500	500	3.3%
	Ksh. 5800	800	3.3%
	Ksh. 6000	1000	10.0%
Ksh. 5500	Ksh. 5500	0	3.3%
	Ksh. 6000	500	10.0%
	Ksh. 7000	1500	3.3%
	Ksh. 7800	1800	3.3%
Ksh. 6000	Ksh. 6000	0	6.7%
	Ksh. 7000	1000	3.3%
	Ksh. 8000	2000	3.3%
No response	No response	N/A	3.3%

Source: Field survey, 2017

From the above tables, the daily differences in fuel expenditure between the time when there is delay and the time when there isn't are shown below.

Table 23: Daily Differences in Fuel Expenditure

Difference (Ksh)	**Percentage**
0	10.0%
500	20.0%
800	13.3%
1000	26.7%
1500	10.0%
1800	3.3%
2000	3.3%
2500	10.0%
N/A	3.3%

Source: Field survey, 2017

Considering that the highest number of operators spent 1000 shillings (10 USD) more every day, if the delays were to be experienced five days a week (which is mostly the case), the monthly loss per vehicle would be Ksh. 20,000 (200 USD).

Given that the estimate number of PSVs getting to the five termini studied per day is not less than 1500 (as depicted by the analysis in section 5.1.2 above), the total loss in fuel amounts to Ksh. 30 million per month. This is extremely high and therefore a major cause to retrogressive growth of the public transport sector economy.

b. Social costs

Social factors are cross-cutting. They essentially touch on the matters that affect human growth and interactions. In the context of this study, the social costs have been analysed under three categories, namely; education, health and travellers' Comfort.

Educational costs

From the analysis done on the purposes for which people went to or pass through the CBD, it is revealed that upto 20% of the travellers make the trips in order to go to school. Just as much as the other travellers, this set of people also has to contend with the traffic situations within and around the CBD. A cross-tabulation between trip purpose and the effects of difficulty of circulation in the CBD depict that the highest number of respondents who were affected by lateness were the school going population (see the table below).

Table 24: Effects of Difficulty of Circulation in the CBD

Effects	**Trip purpose**					
	Work	Business	Shopping	School	Social	Total
Lateness	2	4	0	7	4	17
Attracts customers to business premise	0	2	0	0	0	2
Causes loss of customers	3	5	0	0	0	8
Forces travellers to use longer routes	2	2	0	0	0	4
Makes it difficult to manoeuvre handcarts	1	0	0	0	0	1
Encourages late operation of businesses	1	0	0	0	0	1
No effect	0	1	0	1	0	2
Makes transportation difficult	0	1	0	0	0	1
Collision with people	0	1	0	1	0	2
Inconvenience	0	0	0	0	1	1
Slows down speed of movement in the CBD	2	0	0	1	0	3
Time wastage	0	1	0	0	1	2
Prevention from regular visits to the CBD	0	0	0	0	1	1
No response	2	2	0	0	0	4
Encourages pick pocketing and theft	0	0	1	0	0	1
Total	**13**	**19**	**1**	**10**	**7**	**50**

Source: Field survey, 2017

Considering the lateness statistics expressed as percentages, it is noted that 41.2% of the affected are those that go to school. This is shown in the table below.

Figure 29: Proportions of People Affected by Lateness

Effect	Traffic Purpose				
	Work	Business	School	Social	Total
Lateness	11.8%	23.5%	41.2%	23.5%	100.0%

Source: Field survey, 2017

Some of the effects of lateness to the students include failure to attend classes on time thus affecting their ability to catch up with important lessons and inability to reach exam rooms on time during exam periods. These effects increase the chances of poor performance in school. Poor performance on the other hand could have a range of severe impacts, including class repeats (which waste the student's time and parents resources), stress and depression among some students and loss of career paths by those who quit school all together.

From the above discourse, it is evident that efficiency in transportation is very important to students because it can influence their success in life in one way or another.

Health Related Costs

The study also revealed that there were a number of health complications that arose from the traffic situation in the CBD. More specifically, the respondents cited respiratory diseases and headaches as part of the problems that were caused by the motor vehicles gaseous emissions and noise respectively. Several studies have further shown that such diseases result in major financial costs, which are incurred during treatment and sometimes death which leads to more significant losses in the economy.

Travellers' Comfort and Safety

About 58% of the respondents in this study mentioned that the Public transport system was uncomfortable due to congestion and noise. Another 76% were of the opinion that the system was not safe. About 62% of those that felt unsafe pointed out that the travellers were faced by insecurity issues (such as theft) while 14% mentioned that the system was prone to accidents. These statistics show that the effectiveness of the system is below the standards.

c. Environmental Costs

The environmental costs revealed in this study were related to pollution and overexploitation of the non-renewable resources. The forms of pollution include air pollution, noise and dust.

The results of the study points out that 54% of the people in the CBD are affected by air pollution were, 56% by noise pollution and another 54% by dust. Furthermore, air pollution affects people by causing disease and discomfort, reducing visibility and contamination of food commodities (See table below)

Table 25: The Manner in Which Air Pollution Affects People

Effect	*Percent of people affected*
Gaseous emissions cause discomfort	8%
Causes diseases	80%
Smoke from the buses reduces visibility	4%
Contamination of food commodities	4%
No response	4%
Total	100%

Source: Field survey, 2017

Noise pollution on the other hand results to interference with concentration; hindrance to communication efficiency; psychological disturbance; damage to the eardrum and scares customers away from business premises. The proportion of the population affected be each of these issues is shown in the table below.

Table 26: The Manner in Which Noise Pollution from PSVs Affects People

Effect	*Percent of people affected*
Interference with concentration	25%
Hindrance to communication efficiency	39%
Scaring customers away from business premises	7%
Psychological disturbance	21%
Damage to the eardrum	7%
Total	100%

Source: Field survey, 2017

Lastly, dust leads to dirt on commodities being sold, diseases and allergies and double cleaning of the business premises (see the table below).

Table 27: The Manner in Which Dust Affects People

Effect	*Percent of people affected*
Double cleaning of the business premises	18.5%
Causes dirt on commodities being sold	25.9%
Causes diseases	44.4%
Causes allergies	7.4%
No response	3.7%
Total	100.0%

Source: Field survey, 2017

Other than the pollution related costs, the study results also showed that there was overexploitation of fuel, which a non-renewable source of energy. The analysis done on fuel expenditures indicate that the PSVs operating on the five termini considered for this study

consume an additional fuel worth 30 million shillings per month due to traffic delays. On average, 1 litre of petrol cost Ksh. 100. This means that the extra fuel consumed per month is approximately 300,000 litres. This is a clear indication of overexploitation of this non-renewable resource and this connotes unsustainable development.

5.4 Factors Influencing Nairobi's Transport Operations

The preceding analysis shows that the current transport system is operating below the required standards. The main factors that are attributed to this include;

a. Insufficient land use and Transportation Planning

Research findings reveal that the Department of City Planning is never involved in the decisions of locating bus termini in the CBD, neither has there been any recent land use plan to guide the same. This is partly responsible for the haphazard siting of these termini all over the CBD. In addition, bus stops and streets have been transformed into termini without a system-wide study and analysis (both current and future), something that the planning department should do.

Secondly, the recent infrastructural developments (such as Thika road expansion) have only been focused on the areas outside CBD, without adequate consideration that the bulk of the traffic ends up in the CBD. As such, the daytime vehicular volumes in the CBD are extremely high, especially since they are channelled from five major corridors radiating to different parts of the city, and which have all been expanded.

Thirdly, there are several on-street activities taking place within the CBD. This is an indication that there is little planning for various land uses, leading to a situation whereby some activities end up without appropriate spaces of operation. Good examples include on-street vending (hawking) and car parking. These result in congestion and major land use/ transport conflicts.

b. Poor Traffic Management

Traffic management in the CBD is done by the county Government and Kenya Traffic Police Department. However, these two entities hardly work in collaboration with each other. Rather, they focus on receiving bribes from the traffic offenders.

There has also been inadequate implementation of major transport reforms. For instance in the year 2003, it had been passed that the 14-seater mini buses would be phased out in order to pave way for bigger PSVs which would help to reduce the traffic congestion in Nairobi and other town. However, this was not fully implemented. Instead there has been the introduction of even smaller PSVs in the form of *tuk-tuks*, which have access to the CBD and contribute to the congestion

c. Inadequate provision of transport infrastructure

The entities in charge of provision of urban transport infrastructure are KURA and Nairobi City County Government. The Key Informant Interview conducted at KURA offices on 10th March 2017 revealed that there is little coordination between the two entities, which could be one of the reasons behind the insufficiencies. In fact there are so many on-street termini because there has not been provision of any additional one in the recent past, yet the vehicular volumes keep increasing.

d. Unregulated public transport system

The public transport operations are majorly based on the market forces. The demand for the service is unquestionably high and as such the private entrepreneurs have massively joined the industry to do business. They are therefore more profit oriented than they are concerned about public interest. The government is on the other hand carrying out very little regulation of the system, hence impunity and lack of decorum from most of the service providers.

e. Poorly developed mass transit system

The main form of mass transit operational in the city is the commuter rail system. The railway services are however inadequate since only very few sections of Nairobi are served, the trains are poorly maintained and the railway network is generally underdeveloped. The bus mass transit system is on the other hand almost non-existent since the most of the biggest buses are 33 seaters only. As such traffic congestion has continued to ail the city.

f. Lack of Intermodal integration

There is no integration between railway and bus transport systems at all, yet they are the main modes of transportation. The only attempt that has been made most recently is the development of a park and ride facility at Syokimau railway station. However, this only serves a very small proportion of the population who are actually rich car owners who live in

the outskirts of the city. There is therefore need to integrate these systems in such a manner that anyone (rich or poor) is able to operate between them complementarily. This will improve the public transport system so significantly.

5.5 Outcomes of the On-Street PSV Termini in the CBD

The on-street termini impact on traffic circulation, street capacity and travelers' safety. The impacts are both positive and negative. The positive effects include convenience in accessing the termini within the CBD, reduction of time taken to look for a PSV to board and Attraction of customers to the surrounding business premises. The negative outcomes are on the other hand inclusive of difficulty in circulation; reduction of carriage way space, traffic jams; commotion/ disorderliness in transport operations; blockage of entrances to business premises; difficulty in picking and dropping passengers by PSVs and reduction of road functionality.

5.5.1 Effects on Ease of Traffic Circulation

The assessment of the difference in ease of movement between areas with on-street termini and those without was done by the travellers as summarized in the table and chart below.

Table 28: Ease of Movement in Areas without On-Street Bus Termini

Ease of movement	Percent
Easy	94%
Not easy	6%
Total	100%

Source: Field Survey, 2017

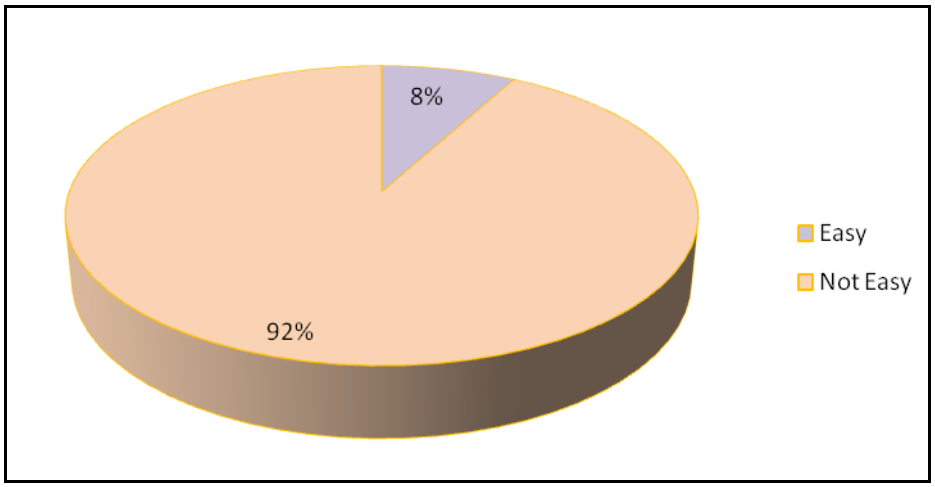


Figure 30: Ease of Movement in Areas with On-Street Bus Termini

Source: Field Survey, 2017

Evidently, the assessment of over 90% of the respondents was that movement is much more difficult in areas with on-street termini than those without.

The researcher also sought to know the specific ways in which the on-street termini affected circulation in the study area. The following responses were given.

Table 29: Ways in which On-Street Termini Affect Ease of Movement

Way	*Percent*
Reduction of carriage way	47.6%
Cause traffic jam	28.6%
Cause commotion/ disorderliness	14.3%
Causes difficulty in dropping passengers	4.8%
Reduces road functionality	4.8%
Total	*100.0%*

Source: Field Survey, 2017

The PSV operators were also asked to assess the ease of accessing and exiting the on-street termini and a majority (67%) of them pointed out that it was difficult. This is shown in the graph below.

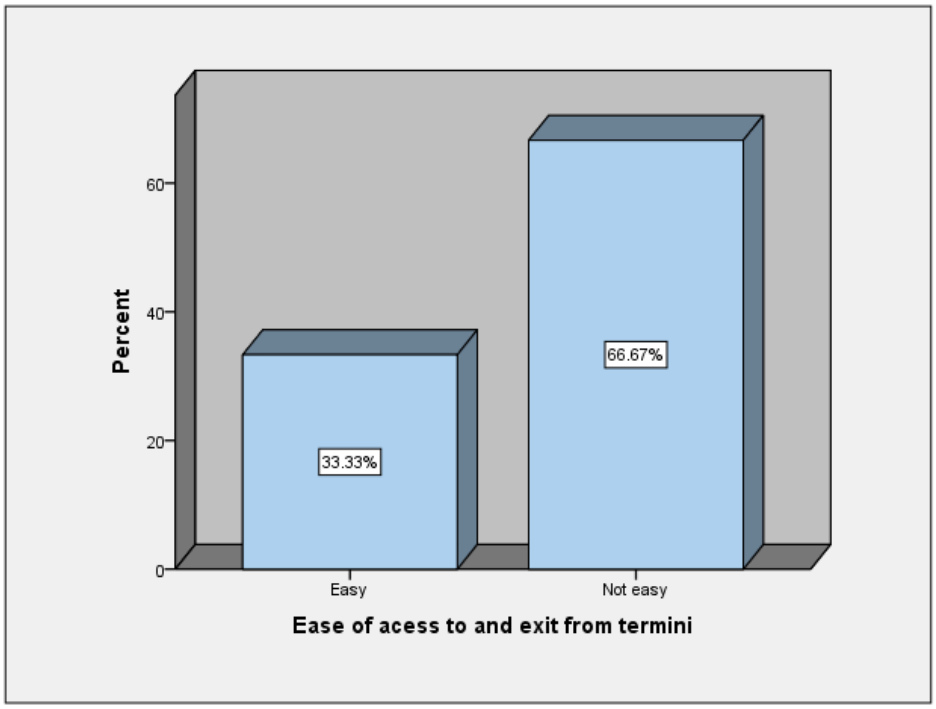


Figure 31: Ease of Accessing & Exiting On-Street Termini by PSVs

Source: Field Survey, 2017

When requested to explain the reasons for which they said access to and exit from was either easy or difficult, the responses given were as summarized in the two tables below.

Table 30: Reasons for Ease of Access to and Exit from Termini

Reason	*Percent*
There is proper traffic management at the termini	10%
There are slots into which vehicles are parked at the terminal	20%
There is no traffic jam along the corridor through which the termini are accessed	50%
There are no bottlenecks	20%
Total	*100%*

Source: Field Survey, 2017

Table 31: Reason for Difficulty in Accessing and Exiting from Termini

Reason	*Percent*
Traffic congestion	45%
Narrow roads	10%
Vehicles take long before leaving the terminal hence congestion	5%
Blockage of the road by long buses	10%
Inadequate space at the termini	25%
The place is not a designated terminal	5%
Total	*100%*

Source: Field Survey, 2017

The factor that was most quoted to cause difficulty in accessing the termini was traffic congestion. This means that the entire transport system has shortcomings.

Further to the above the respondents were asked to point out the impacts of the difficulty in accessing and exiting the termini. The following responses were given.

Table 32: Effects of Difficulty in Accessing and Exiting from Termini

Effect	*Percent*
Time wastage	65%
Fuel wastage	5%
Reduction of number of trips made in a day	20%
Profit loss	5%
Payment of fines when caught waiting for or dropping passengers off the terminal	5%
Total	*100%*

Source: Field Survey, 2017

5.5.2 Effects on Street Capacity

The study revealed two main effects of on-street termini on street capacity. These are overcrowding of the street and reduction of the street space (see the chart below).

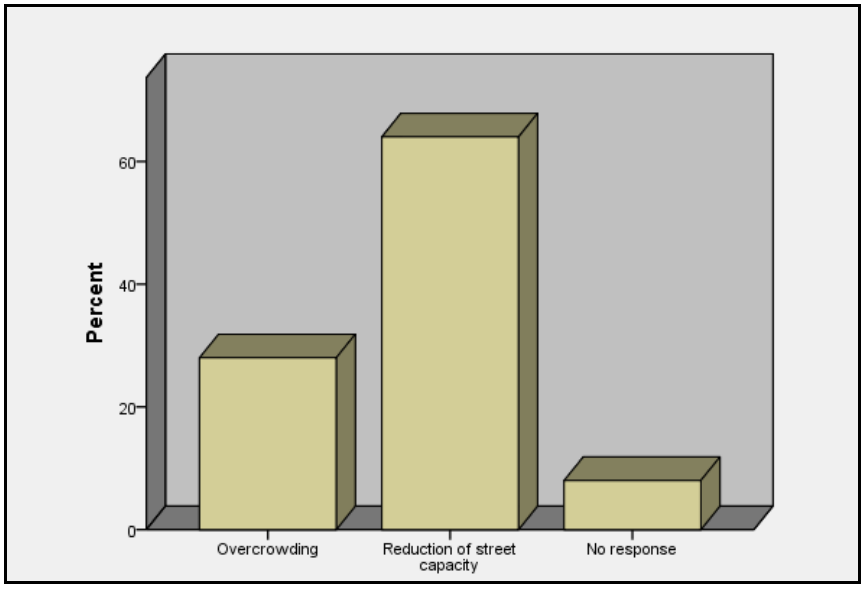


Figure 32: Effects of On-Street Termini on Street Capacity

Source: Field Survey, 2017

Evidently, on-street termini have negative effects only on the street capacity.

5.5.3 Effects on Traveller Safety and Security

According the findings of this study, the effects of the termini on travelers' safety and security are as outlined in the table below. It is notable that the majority of travelers are of the opinion that the on-street termini do not promote safety.

Table 33: Effects of the On-Street Bus Termini on Travelers' Safety and Security

Effects	*Percent*
Increases insecurity	62%
No effect	14%
Increases chances of accidents	14%
No response	10%
Total	*100%*

Source: Field Survey, 2017

5.5.4 Positive Effects

The positive effects of the on-street termini were revealed in this study as convenience in accessing the termini within the CBD; reduction of time taken to look for a PSV to board and attraction of customers to the surrounding business premises. Notably though, 36% of the respondents were of the opinion that there is no positive effect of the on-street termini at all (see the table below).

Table 34: Positive Effects of On-Street Termini

Effect	*Percent*
None	36%
Convenience in accessing the termini within the CBD	28%
Reduction of time taken to look for a PSV to board	8%
Attracting customers to the surrounding business premises	20%
No response	8%
Total	100%

Source: Field Survey, 2017

5.5.5 Negative Effects

From the analysis done in sections 5.3.1, 5.3.2 and 5.3.3 above, the main negative effects of on-street termini include difficulty in circulation around the areas where they are; reduction of carriage way space; traffic jams; commotion/ disorderliness in transport operations; blockage of entrances to business premises; difficulty in picking and dropping passengers by PSVs and reduction of road functionality.

All these reduce the level of transport efficiency and effectiveness in the CBD. More particularly, congestion and difficulty in circulation cause travel delay. Reduction of space on the roads is a recipe for traffic congestion and jams, which is known to cause financial losses both to the transport service providers and customers. It also reduces the functionality of roads Blockage of business premise entrances is a potential cause of economic losses in business since it reduces customer access to shops. These are signs of transport inefficiency because they cause financial and time losses.

Disorderliness and commotion on the other hand reduces travellers' comfort. They also increase chances of theft and accidents, thereby compromising safety and security in the transport system. This shows a reduction in the level of transport effectiveness.

5.6 Testing of Hypothesis

As indicated in the methodology section of this report, the chi-square test is used. A significance level of 0.05 and degree of freedom of 1 is used in this test. The counts of the respondents indicating whether or not there is delay in the different scenarios of on-street termini densities are as follows;

Density of On-street PSV termini	**Ease of traffic circulation (Based on respondents assessment of delay experiences)**		**Total**
	Delay	No delay	
High no. of termini	42	8	**50**
Few termini or none	5	25	**30**
Total	**47**	**33**	**80**

The expected counts (Calculated as Row total / Grand total × Column total) are on the other hand as follows;

Density of On-street PSV termini	**Ease of traffic circulation (Based on respondents assessment of delay experiences)**		**Total**
	Delay	No delay	
High no. of termini	29	21	**50**
Few termini or none	18	12	**30**
Total	**47**	**33**	**80**

Chi square statistic = sum of {(observed count – expected count)^2 / expected count)}

The values of (observed count – expected count)^2 / expected count per cell are as follows;

Density of On-street PSV termini	**Ease of traffic circulation (Based on respondents assessment of delay experiences)**		**Total**
	Delay	No delay	
High no. of termini	$(42-29)^2/29 = 5.83$	$(8-21)^2/21 = 8.05$	**50**
Few termini or none	$(5-18)^2/18 = 9.39$	$(25-12)^2/12 = 14.08$	**30**

Thus, the chi square statistic = 5.83 + 8.05 + 9.39 + 14.08 = 37.35

Considering the excerpt of the chi-square table in annex 8, it is notable that at a significance level of 0.05 and degree of freedom of 1, the critical value is 0.004. It is also noted that the chi-square statistic (37.35) is way higher than the critical value (0.004).

As such the null hypothesis (which states that ***there is no relationship between the density of on-street PSV termini and efficiency and effectiveness of transportation)*** is thus **REJECTED.**

Therefore, the results of this study show that there is a relationship between density of on-street PSV termini and efficiency/effectiveness of traffic circulation and that **the higher the density of on-street termini, the less effective and efficient a transport system becomes**.

Moreover, it can be concluded that:

Effectiveness and efficiency of transportation (e) is a function of density of on-street termini (d)

OR

Effectiveness and efficiency of transportation (e) is dependent on the density of on-street termini (d)

I.E.

$e = f(d)$

5.7 Relationship between Study Findings and Past Literature

The relationship between the study findings and the past literature reviewed in chapter two are summarized in the table below.

Table 35: Relationship between Study Findings and Past Literature

Concept Under Discussion	Findings from Literature	Study Findings	Remarks
The Rationale for Efficient and Effective Urban Transport Systems	• Economic success depends on efficiency and effectiveness of the transportation systems. • An effective transport system is a prerequisite to good quality of life, better community access, highway safety and high environmental quality	Nairobi's transport system has major problems which make lead to serious socioeconomic and environmental losses	Study findings agree with past literature
The Relevance of CBDs	• CBDs are key economic drivers of all urban setups. • They are home to many core businesses activities, ranging from retail to wholesale, finance, and various commercial services. • They are also the main areas of employment to millions of city dwellers. • They tend be better developed and serviced than other parts of the city	• Nairobi's CBD houses very many work places and business areas • It is one of the most significant economic hubs of the city and Nairobi Metropolitan Region • Nairobi CBD can be said to be the best planned part of the city	Study findings agree with past literature
The Influence of Transport Efficiency Levels on CBDs	• CBDs needs to be well connected to and easily accessible from all parts of the city given its crucial economic roles. • A defective transport system cannot promote the required levels of connectivity and accessibility in CBDs.	• Nairobi CBD is not easily accessed from various parts of the city • This is majorly because of its strong centrality and the radial structure of the city, which lack appropriate designs of the connecting road	Study findings agree with past literature

	• Thus, an efficient transport system is one of the cornerstones to well performing CBDs	networks • Traffic snarl-ups are thus a constant problem at CBD entry/exit points along the roads inside the district	
The Relationship between Urbanization and Urban Transport System	• High rates of urbanization increase the demand for various transport facilities. • If the rate of supply of such facilities fail to measure up to the demand levels, traffic volumes tend to supersede the capacities of the existing infrastructural networks, traffic jams crop in and thus cities' economic performances begin to deteriorate	• Nairobi's rate of urbanization has been on the rise over the years. • The rate at which infrastructure is developed has however not been up to speed with the demand • The city dwellers have thus continued to suffer from major setbacks in the transportation sector	Study findings agree with past literature
The Role of Public Transport Services in Urban Transportation Systems	• Public transport gives room for mass movement of passengers and freight • It decongests the transport networks, encourages faster traffic flow, gives access to transportation by all people, enhances energy savings and reduces air pollution. • A good public transportation system promotes efficiency of an entire urban transport system	• Public transport system in Nairobi lacks mass transit modes and thus relies on fairly low capacity PSVs • It is also largely unregulated and thus operates based on the market forces of demand and supply • As a result the city and the CBD faces serious traffic problems such as congestion and this means it is neither effective nor efficient	Study findings agree with past literature
The Necessity of Planning for Termini in the Public Transport System	• A public transport system is a made up of various components, all of which must function together in order to achieve the desired results. • Transport termini crucial components of the system • They need to be provided in the right places and quantities if the public transport system is to operate effectively and promote an efficient urban transportation system	• The study area manifests poor planning of termini • Thus the street spaces have ended up serving this purpose • The result is more transportation problems than there are benefits	Study findings agree with past literature
The Place of Land Use Planning in Transport Efficiency and CBD Performance	• In order to achieve efficient traffic flow patterns, transport networks must be properly coordinated with the activity areas. • This kind of coordination requires deliberate land use	• Transport developments in Nairobi are hardly coordinated with land use patterns • Land use planning and development control is so minimal that the land	Study findings agree with past literature

	planning • The ability of a CBD to effectively serve all people is highly dependent on its spatial orientation and connectivity to residential zones and other commercial nodes in the city • There is thus an inherent direct relationship between land use planning, transport efficiency and CBD performance	use impacts of the new transport networks are hardly controlled hence the constant traffic flow problems	
The place of laws, policies and institutional arrangements on transport efficiency	• Good laws and policies and properly coordinated institutional operations boost the efficiency and effectiveness of transportation systems	• The institutional competitions and parallel operations in the Kenya's transportation system makes the management of system chaotic and implementation of the laws and policies difficult	Study findings agree with past literature
Relationship between Termini, Transport Efficiency	• Termini are an integral part of the transport system which must be provided adequately and located appropriately in order for the system to operate efficiently/effectively. • On-street termini cause numerous problems in the transport system	• Termini provision in Nairobi CBD is inadequate leading to high density of on-street termini which are partly responsible for the traffic flow problems therein	

Source: Author, 2017

5.8 Study Findings in Relation to Theories

This study reviewed four main theories, which were found relevant to the variables under study. These were the gravity model, intervening opportunities model, queueing theory and network analysis model. In this section, the study findings are compared to the theories in order to assess whether or not the situation in the study area agree with the theories.

a) Gravity Model

According to this model, the number of trips between areas i and j is proportional to the population or activity density in those areas and is inversely proportional to the distance between i and j.

The study reveals that the CBD is one of districts with the highest concentration of business, work, administrative and social activities in the city. As such, a very huge number of the

residents make trips daily to the CBD. Secondly, the area bound by Nairobi River, Accra Road, Tom Mboya and Haile Selasie Avenue has higher number of business enterprises than the remaining part of the CBD, thus registering very high daytime population. As such it can be said that the situation in Nairobi CBD depicts the postulation of this model.

b) Intervening Opportunities Model

This model postulates that individual trip making behaviour depends not only on the attractiveness of the intended destination and the distance that has to be covered but also on the availability of opportunities elsewhere.

From the analysis done on the roles that Nairobi CBD plays, it has been established that there are numerous socio-economic opportunities that the CBD offers over and above what other parts of the city offer. As a result, the trips made to this district emanate both from within and outside Nairobi.

c) Queueing Theory

This theory is used in undertaking traffic flow analysis in a transport system. One of its applications is in the calculation of mean Arrival rate (λ), which is the rate at which vehicles/travellers arrive at a transport facility, expressed in vehicles/hr. the theory states that if the time headway (h) is known, mean arrival rate can be calculated as:

$\lambda = 3600/h$

From the observations made in this study, the average time headway (h) of vehicles coming to the CBD is 30 minutes (1800 seconds). As such,

$\lambda = 3600/1800 = 2$ vehicles per hour.

This means that, on average, only 2 vehicles arrive at the CBD termini per hour. This this explains the long travellers' queues witnessed at these termini, especially during the peak hours.

d) Network Analysis

Network analysis involves the description of nodes and their linkage relationships and is used to assess the level of connectivity between nodes. The beta index of connectivity has been applied to assess the level of connectivity between the CBD and other nodes in the city. The

index is calculated as the total number of arcs in a network divided by the total number of nodes, thus:

β = arcs/ nodes

The theory stipulates that if β is less than 1, then the level of connectivity is considered low and vice versa.

The diagram below shows the nodes linked to the CBD and the arcs linking them.

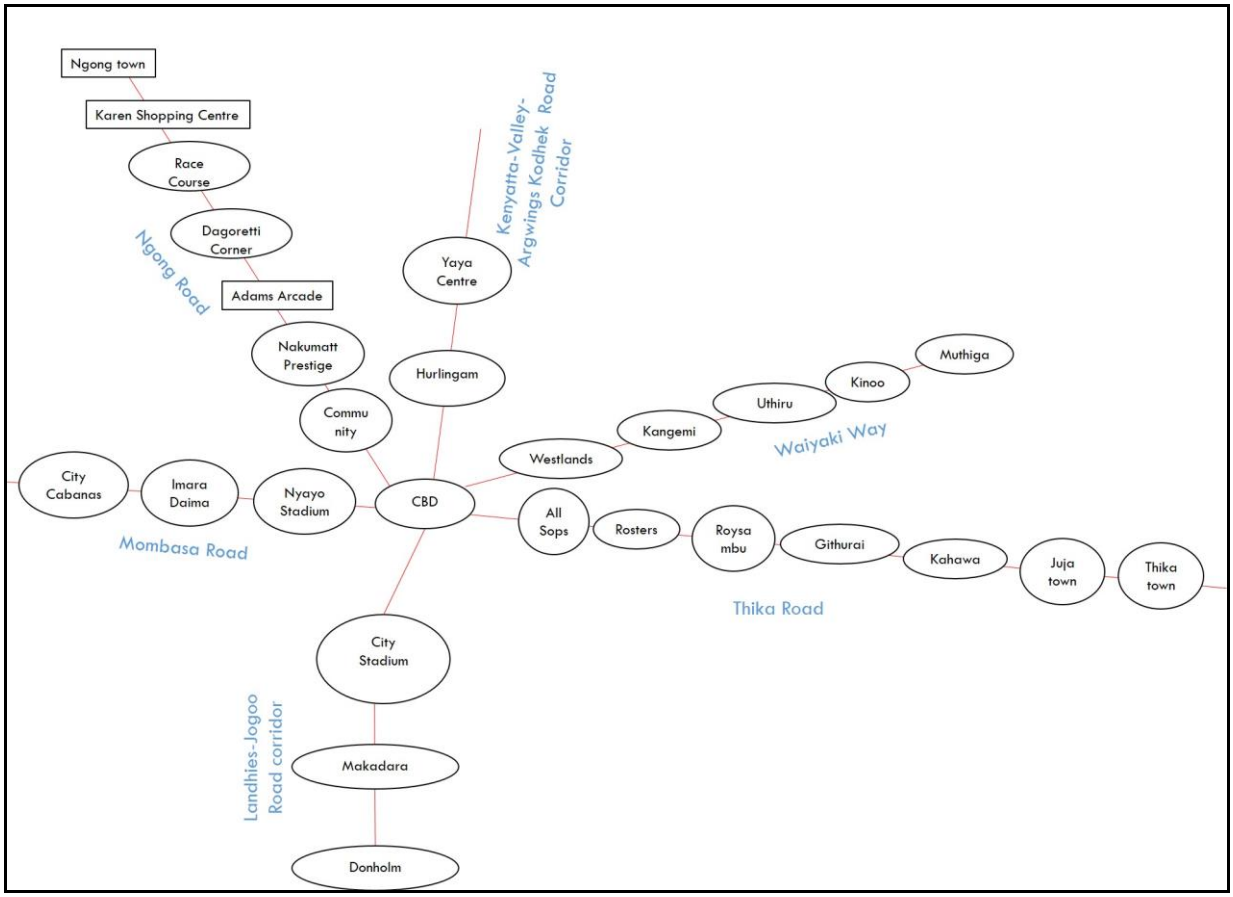


Figure 33: Nodes and Arcs Linked to Nairobi CBD

Source: Author, 2017

Evidently, there are six main arcs connecting about 28 nodes. Thus, the beta index of connectivity is calculated as follows;

6 / 28 = 0.214

The index is less than 1 and so it means that overally, the internodal connectivity in Nairobi is poor, which is why most of the traffic moving from one zone of the city to another tend to pass through or close to the CBD, thus causing traffic congestion and jam therein.

The above discussion is summarized in the table below.

Table 36: Relationship between Study Findings and Theories

Theory	Theoretical Postulation	Study Findings	Remarks
Gravity Model	• The number of trips between areas i and j is proportional to the population or activity density in those areas and is inversely proportional to the distance between i and j	• The high concentration of business, work, administrative and social activities in Nairobi CBD attract numerous daily trips therein	Study findings agree with theory
Intervening Opportunities Model	• Individual trip making behavior depends not only on the attractiveness of the intended destination and the distance that has to be covered but also on the availability of opportunities elsewhere	• The numerous socio-economic opportunities that the CBD offers over and above what other parts of the city offer attract very many trips.	Study findings agree with theory
Queuing Theory	• Theory relevant in establishing rates of traffic flow	• Vehicular traffic flow rate to termini in the CBD is quite low, hence long queues in the peak hours. This shows inefficiency	Study findings agree with theory
Network Analysis	• If the beta index of connectivity is less than 1, then the level of connectivity is considered low and vice versa	• The level of connectivity between the nodes directly linked to the CBD is less than 1, indicating low level of intermodal connectivity. • Most of the interzonal traffic thus tend to pass through or near the CBD, hence congestion and jams	Study findings agree with theory

Source: Author, 2017

5.9 Summary of Findings

The study findings reveal a number of key issues. First, it is observed that the termini in Nairobi's CBD are both on-street and off-street. The former are informal and have been established as a quick fix to the gap between demand and supply of termini and other transport facilities. The latter are on the hand better planned and equipped, even though they have insufficient capacities and are not designed to the modern standards. Generally, the on-

street termini outnumber the off-street ones and are located in more than 90% of the roads in the CBD.

Entry and exit patterns of vehicles to these termini are aligned to the structure of the existing road network, which is grid-iron. This pattern of road network encourages bottlenecks at road junctions thereby interfering with traffic flow and access to the termini. Similarly, entry and exit patterns of vehicles to the CBD has been shaped by the radial urban structure that Nairobi manifests. The vehicles join and leave the CBD via six arterials (Jogoo road, Mombasa road, Waiyaki way, Thika road, Ngong and Kenyatta Avenue). These roads channel huge traffic volumes (both vehicles and people) into the CBD causing immense congestion.

The on-street termini lead to congestion by PSVs on the roads, making it difficult for other vehicles, pedestrians, bicyclists and motorcyclists to navigate around the CBD. They also impede entry and exit into and out of the termini and bus tops. Moreover, they are characterised by land use conflicts which arise from pedestrian and vehicular movements, on-street vending activities, parking and the business activities established in the buildings that front the streets. This in essence causes commotions, disorderliness and insecurity.

The existence of these termini is therefore costly in one way or another. The traffic congestion resultant from the termini causes time and financial losses. The PSV operators lose a lot of time in the jams, thus incurring financial losses. However, in their bid to recover the losses, they overcharge the customers who therefore end up losing money, other than the time they waste on transit. Additionally, the PSV operators spend more money on fuel and this implies overconsumption of the otherwise non-renewable source energy. This is further environmentally unsustainable. All these costs imply that they transport system is inefficient.

The termini also contribute to the current quality of the transportation services, which are generally poor. The congestion that is typical around the termini encourage theft and pick-pocketing. The commotion further makes the travelling uncomfortable. In addition to this, the fact that the PSV operators lose a lot of time to access or/and leave the CBD, makes them impatient and as soon as they reach the roads outside the CBD (where there is less congestion), they tend to over speed to recover the lost time. This in turn leads to accidents

which cause to loss of life and property as well as health complications, making the system unsafe. This kind of a transport system is therefore ineffective.

The above notwithstanding, it is noted that the termini also have positive contributions. They are generally conveniently located close to work places (unlike the off-street termini – Muthurwa, Koja, Railway and Central Bus stations), making access to PSVs much easier for people working in the CBD. Secondly, the population that they attract form a huge market to the businesses that front the streets from which they are operated. Availability of a market for goods and services is economically advantageous.

It is also important to point out that the on-termini are not the only cause of inefficiency and ineffectiveness in the system. Other factors are institutional and managerial in nature. The state organs regulating the transport system are general poor at enforcing various regulations which are supposed to streamline operations in the sector. Corruption is for instance very rampant and it comes as a result of the regulators bending rules in exchange for bribes from transport service providers. This is the reason safety rules are hardly observed by drivers.

Secondly, there are evident cases of duplication of roles among the regulating institutions. This brings about operational conflicts thereby reducing effectiveness in the management of the transport sector. There is also a high degree of privatization of the public transport system, leading to domination by profit minded groups who exploit the members of the public extensively. They for instance charge high fares (and fluctuate the same as much they please), they show a lot of misconduct towards the customers and create noisy and uncomfortable travelling environment.

The situation is worsened by the fact that some of the PSV owners are powerful politicians who influence government decisions to fit their selfish interests. Others are also cartels who work with the authorities to make things work only in ways that are beneficial to them. As such the members of the public are forced to contend with the exploitative system.

Evidently the transport system is faced by major problems which require system-wide and radical solutions if any improvement is to be realized. The solutions relate to land use re-organizations, institutional adjustments and infrastructural developments.

5.10 Conclusion

Based on the findings of this study it is notable that the CBD is a very important district of Nairobi City, both socio-economically and administratively. However, the provision of transport infrastructure (such as termini) is inadequate and there is a general lack of coordination between land use and transportation in the city. There are also significant shortcomings in the operations of the institutions managing the transport system in the study area. As such the transport system is generally ineffective and inefficient and the on-street termini contribute to this in a significant way. It is thus important to undertake a system wide analysis of the situation, as a result of which effective solutions can be sought.

CHAPTER SIX
PLANNING IMPLICATIONS AND RECOMMENDATIONS

6.1 Overview

This chapter presents an analysis of the study findings in relation to land use planning. The analysis is founded on the premise that efficiency and effectiveness of a transport system tends to rely significantly on land use planning and the appropriate coordination between transport networks and various activity spaces.

The findings of this study indicate that the coordination between land use and transportation in the study area is generally poor. As such, it is deemed fit to highlight the implications thereof, and thereafter make recommendations that will help to achieve the necessary design and operational standards usually expected in the land use/ transportation relationships.

Secondly, having undertaken an in-depth analysis of the study findings and answering the study questions, it is noted that there are various issues that require intervention in the study area. Overally, it has been found out that the transportation system in Nairobi CBD and its environs is both ineffective and inefficient. As such, recommendations have been made in this chapter, which are considered to be capable of addressing the problems identified. The recommendations have been grouped into two categories including;

- Design recommendations
- Policy recommendations

Furthermore, each recommendation has been made in response to a specific problem(s).

6.2 Planning Implications

6.2.1 Implications of the Location and Distribution of PSV Termini in the CBD

The study reveals that the PSV termini in the CBD are mainly located on-street. They are also distributed in more than 50% of the roads. Some of these locations were previously bus stops but the majority are just road carriageways. This means that they have not been planned for since they are not only located inappropriately but are also ill equipped. They do not have proper parking spaces and other terminal facilities such as platforms, shelters, access points and administrative offices for terminal managers and various service providers. They therefore have more negative impacts on the operations of the CBD than the positive ones. As

a result, it is noted that the CBD requires well planned termini which are located off-street, are better equipped and strategically distributed in space and time.

6.2.2 Implications of the Existing Public Transport System

The assessment of the public transport system and its planning implications has been done with respect to three main components thereof, including: public transport routes/network; public transport modes and public transport management.

6.2.2.1 Public Transport Routes/Network

The transport routes that connect the CBD to other parts of the city have been noted to form a radial pattern while those within the district form a grid-iron pattern. The former have recently been interlinked with a few ring roads (e.g. Outering road) and by-passes (Eastern and Southern bypasses). However, the nodes connected by the few corridors are so many that the level of internodal connectivity is still quite low in the entire city. As such, the vehicular volumes on those roads tend to exceed their capacities, rendering the system less efficient and thereby reducing the productivity levels of the CBD and other economic nodes. The network within CBD (which forms a grid-iron pattern) also presents a series of bottlenecks to traffic flow, especially at the road intersections.

Consequently, it is observed that the development of transport routes in any part of the city requires a guiding framework in which activity nodes are well coordinated with the transport routes and traffic generation patterns for the entire city are wholesomely considered in the orientation of the same routes. This can only be done by deliberate land use planning rather than the isolated road designs and developments which have recently been witnessed in the city. There is also a need for integration of transport routes serving the various public transport modes such as road and railway.

6.2.2.2 Public Transport Modes

This study reveals that there is an overall overdependence on the road transport modes in Nairobi. Furthermore, it has been observed that the mass transit modes (which have been proved to be the most effective and efficient) are highly underprovided.

It is thus recognized that planning for the transport system need to make significant provisions for mass transit systems (both rail and road), if transport effectiveness and efficiency is to be realized in Nairobi.

6.2.2.3 Public Transport Management

It is noted that sufficient management is an essential software in achieving transport efficiency and effectiveness. As it is in the study area, the management component of the transportation system manifests major shortcomings. The management system currently consists of both public and private institutions.

The former are mainly the regulators and law enforcers. They are generally are underperforming because of corruption, political interference, conflict of interest (which arise from the fact that some of the individuals are in public transport business) and role overlap between the many institutions involved in transportation affairs. The private management institutions (in form of Matatu SACCOs) are on the other hand profit minded than they are interested in offering high quality services.

As such, it is considerably important that planning for transportation be done in a manner that will create effective structures for proper implementation of transportation policies and enforcement of various rules and regulations.

6.2.3 Implications of the Prevailing Traffic Situation

The traffic situation is generally unproductive. There are high congestion levels, leading to major travel delays among other things. It is thus recognized that there is need to plan an integrated transport system which will give room for high capacity (mass transit) vehicles and well-coordinated networks.

6.3 Recommendations

The recommendations made here have been informed by the key issues that emerge from this study and are geared towards the achievement of effectiveness and efficiency of the transport system. The conceptual framework in this study indicates that the transport system that is inefficient and ineffective is highly costly and has poor quality of services. More specifically, such a system presents problems such as traffic congestion and snarl ups, high financial losses, negative environmental impacts, discomfort to travelers, social exclusion of certain groups in the community, safety and insecurity issues among others.

A well performing transport system on the other hand manifests proper coordination between transport and land use systems, adequate transport infrastructure, functional institutional/ management structures and facilities and leans towards a well designed mass transit system. Thus if a system is inefficient and ineffective, there has to be deliberate effort to solve the problems in each of the sub-systems.

In other words, it is noted is that effectiveness and efficiency in transportation are dependent on the well-being and the level of inter-connectedness between the sub-systems therein i.e. land use, infrastructural, vehicular and institutional. As such the recommendations made cross-cut all of these subsystems and are grouped as design and policy recommendations

6.3.1 Design Recommendations

Design recommendations are considered as those that will guide physical developments in space. They are made as follows;

6.3.1.1 Transport Network Proposals

These proposals are meant to solve **traffic congestion and delay**. They include:

a. Development of Mass Transit routes including Bus Rapid Transit and Light Rail Transit Routes. The proposed BRT routes are the main arterials in the city, including Waiyaki way, Mombasa road, Uhuru Highway, Ngong road, Jogoo road and the adjoining major corridors. The light rail corridors to be developed alongside the existing railway line.

   The proposed design for BRT routes is illustrated in the figure herein after.

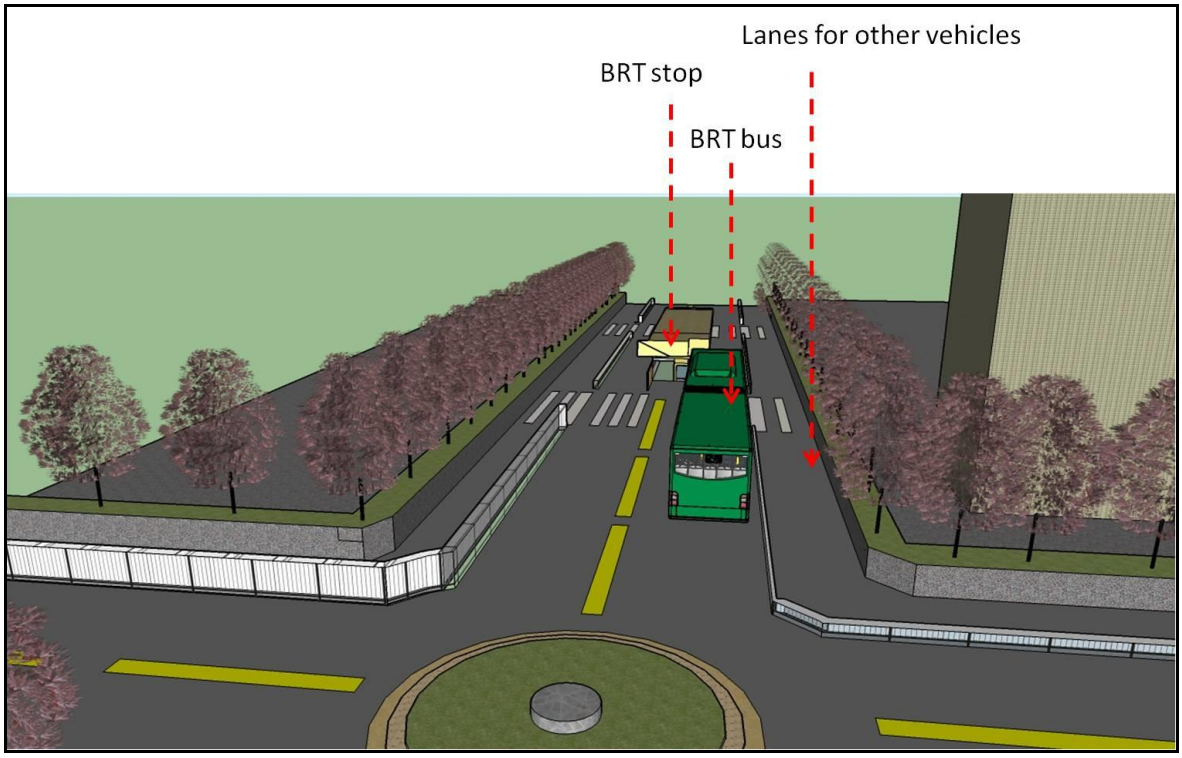


Figure 34: Proposed BRT Route Design

Figure 35: A Cross-Section of the BRT Route

Source: Author, 2017

b. Development of overpasses and underpasses for through traffic in the CBD. This is envisaged to prevent the congestion caused by such traffic within the CBD. The figure below shows one of the proposed f the routes for through traffic (connecting Haile Selasie avenue to Uhuru Highway or traffic from Eastlands to Westlands).

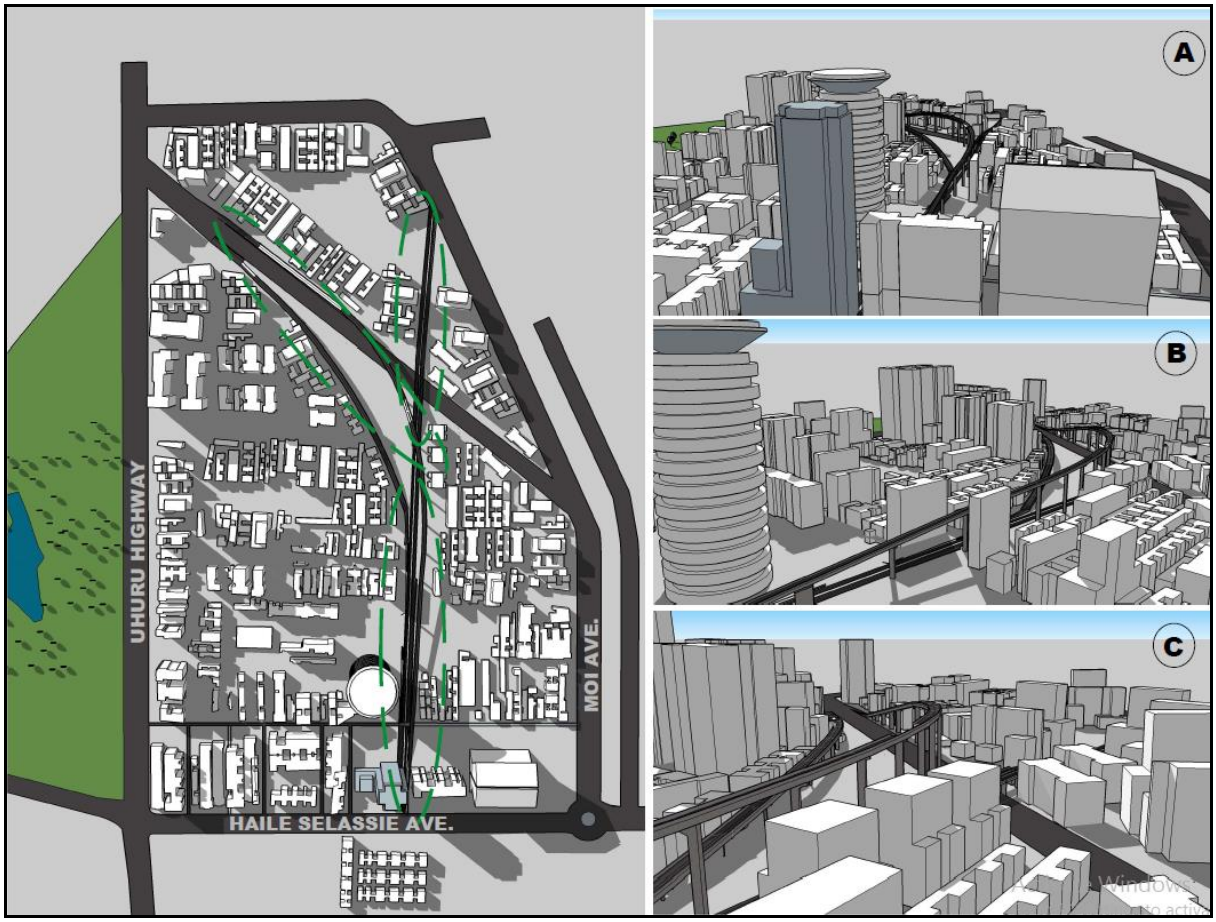


Figure 36: Proposed Overpass

Source: Author, 2017

c. Development of ring roads to connect various nodes in opposite zones of the city, so that the vehicles can avoid passing through or near the CBD when moving between such nodes. A good example is a road that should be developed is one that will connect **Eastlands area to Westlands**.

6.3.1.2 Termini Proposals

The proposals under this category are geared towards solving the following problems:

- Unplanned and chaotic operations of termini activities on-street
- Insufficiently furnished termini

The proposals include:

i. Elimination of on-street termini in the CBD.

ii. Planning for and strategic distribution of off-street bus termini at various points at the outskirts of the CBD. It is proposed that a maximum of two termini be developed, one

serving Eastlands area, areas along Ngong road corridor, Kawangware and its environs and areas along Mombasa and Lang'ata Road corridors; and a second one serving areas along Westlands and Thika road corridor.

The first one should be located in the current Railway bus terminal (which is located adjacent to the Central Railway Terminal) so that people alighting from the train can easily join the bus transport system and vice versa. The second terminal is proposed to be located at Koja.

The termini should be of high capacity, properly designed and equipped. It is important that the facilities in both termini are developed on, above and below the earth surface. The inlets and outlets of these termini should also be well coordinated with the corridors serving the different parts of the city.

iii. Improvement of the Central Railway Terminal (located south of the CBD) to cater for the needs of a light rail system. The proposed design for the bus terminal and the improved railway terminal are shown below.

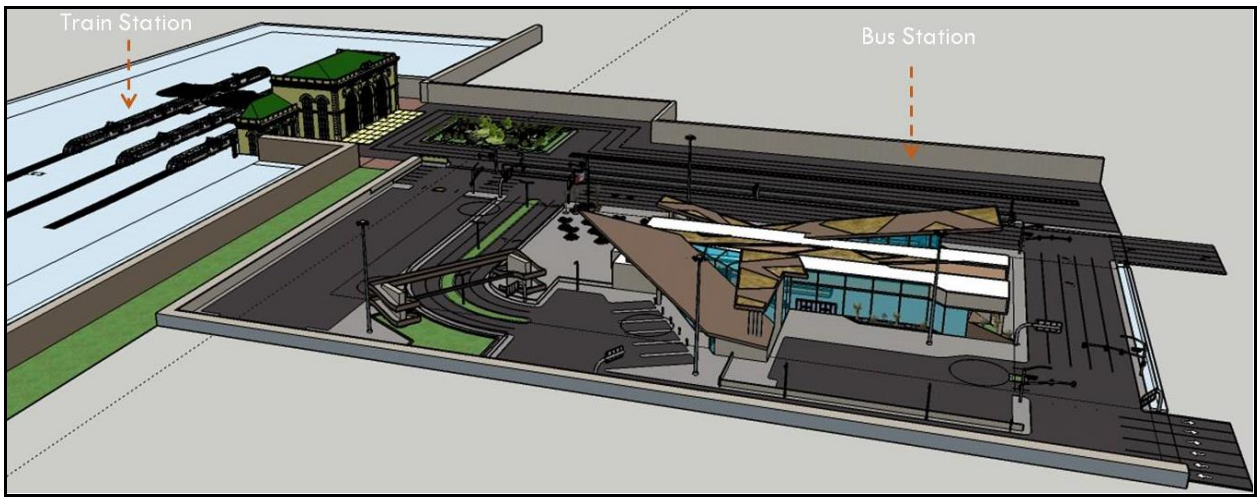


Figure 37: The Bus and Train Stations Integrated

Source: Author, 2017

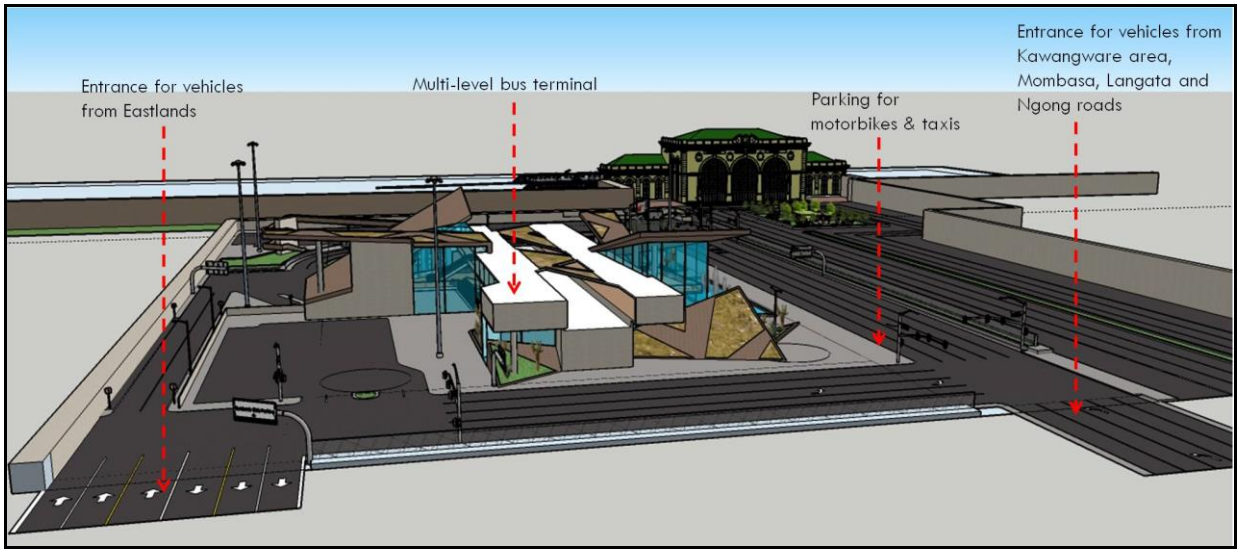


Figure 38: Front View of the Bus Terminal

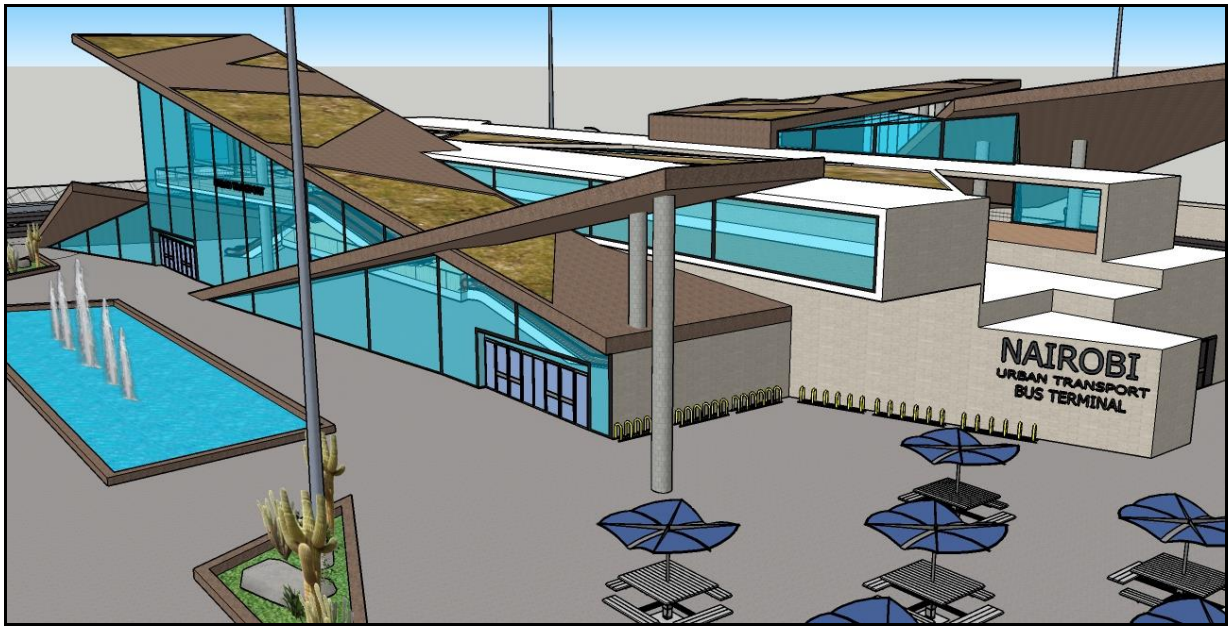


Figure 39: The Multi-Level Bus Terminal Structure

Source: Author, 2017

Figure 40: Circulation Area and Utilities in the Bus Station

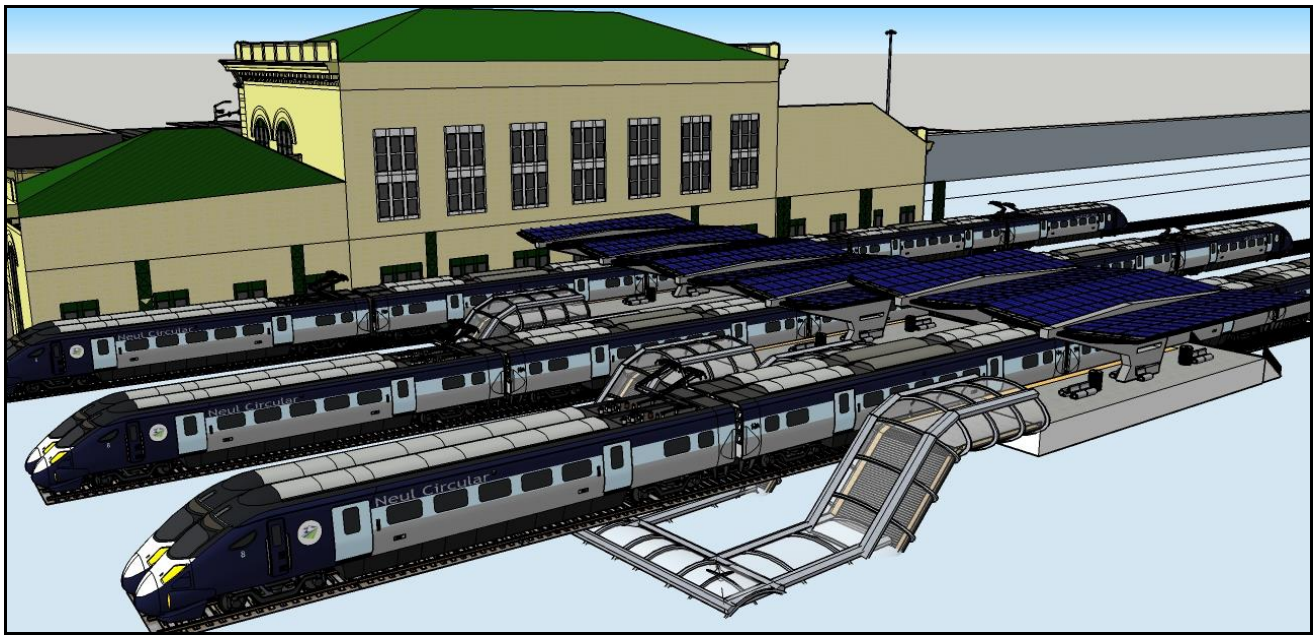


Figure 41: The Proposed Train Station (Improved)

Source: Author, 2017

iv. Development of park and ride facilities at points where people join the BRT networks. This will help to limit the number of private cars entering the CBD. The park and ride facilities are proposed at:

- Nyayo stadium along Mombasa road
- Donholm and Makadara Railway Station along Jogoo road

- Kinoo and Westlands along Waiyaki Way
- All Sops along Thika Road
- Karen Shopping Centre and Dagoretti Corner along Ngong Road
- Yaya Centre along Argwings Kodhek road

The proposed park and ride facility at Nyayo stadium is illustrated below.

Figure 42: Proposed Park and Ride Facility at Nyayo stadium

Source: Author, 2017

The facility is located north of the stadium and it has ample parking spaces and support facilities

v. Restricting the operations of smaller public service vehicles within residential zones only so that they terminate journeys at points where the people join the BRT networks and avoid congesting the CBD and the corridors channelling traffic therein. Proper bus termini should be developed at those points.

6.3.1.3 Land Use Proposals

The land use proposals are envisaged to deal with problems of:

- Inappropriate location of various land use activities

- Land use conflicts

They include:

a. Development of spaces for hawkers within the CBD. These spaces are proposed to be located on elevated areas along particular streets, so that there is no congestion caused on-street.

b. Land use segregation and development of thematic land use precincts which would help to deal with land use incompatibilities and the chaos that arise from them. The precincts are proposed as follows:

   i. The recreational precinct in the area between Nairobi River and River Road. This area is proposed to be thematized as the **Green Belt** and it should have very low density of physical developments if any, and entry of private cars to this zone should be totally barred.

   ii. The **Core Business Zone** which should be located in the area bound by River road, Haile Selasie Avenue and Tom Mboya Street. The zone should accommodate well developed shopping malls and retail market such as the current city market. Because of high population would be expected in this zone, car entry should be restricted.

   iii. The last precinct is proposed to be thematized as the **White Zone** (located between Moi Avenue and Uhuru Highway), where quieter activities would be located. Such activities should include offices, hotels, libraries and education centres.

   The highest densities of buildings (skyscrapers) should be encouraged in this zone and they should have off-street parking facilities so that it would be the only zone where private cars would be allowed. However, the car owners should be made to practise car pooling so that the cars coming to this zone would not be allowed in unless they are fully occupied.

   The land use zones are illustrated herein below.

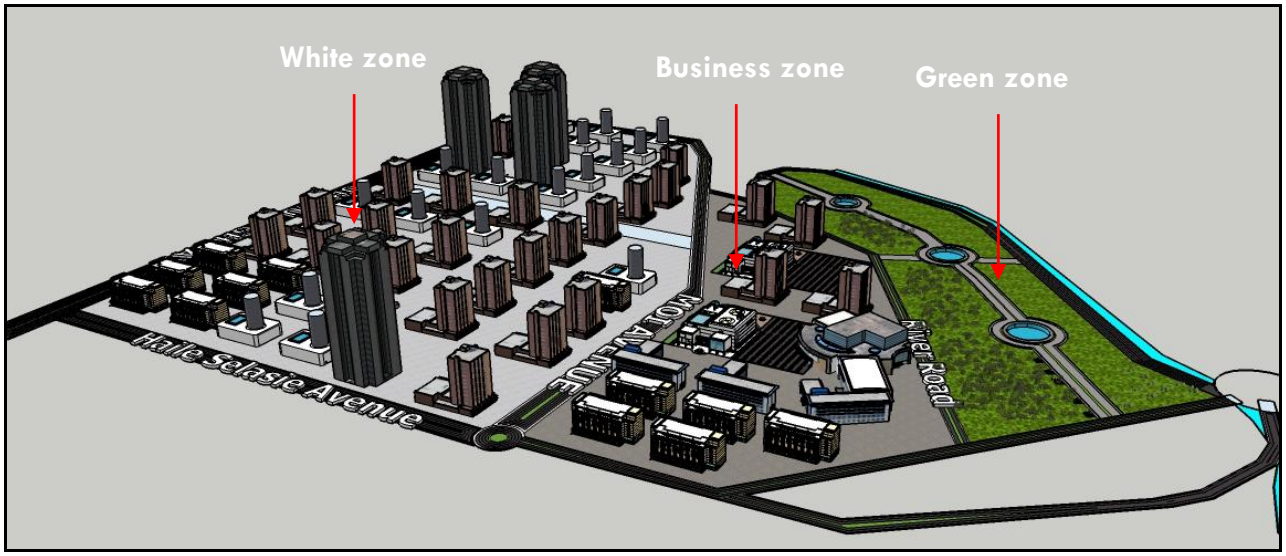


Figure 43: The Proposed Thematic Zones

Source: Author, 2017

These zones are further shown in detail as follows:

Figure 44: A Section of the Green Zone

Source: Author, 2017

Figure 45: A Section of the Core Business Zone

Source: Author, 2017

6.3.2 Policy Recommendations

Like the design recommendations above, the policy proposals are meant to solve certain specific problems, which have been found to contribute to the ineffectiveness and inefficiency of the transport system. These are as outlined herein after.

a. Development of Policy Guidelines on Integration of Land Use and Transportation Planning by the County Government.

This recommendation is made to solve the problem of poor integration between land use and transport planning. The policy above, once developed, should be used to guide the approval of all transport infrastructural developments. The Roads Engineers must be required to involve land use planners in all transportation projects and as such they must demonstrate that all land use and transportation relationships are appropriately considered in all transport network designs before they can be approved by the County Government.

Essentially, the project planners must delineate the area which a proposed road development is expected to have impact on and a land use plan prepared effectively. The plan should have a comprehensive report outlining the impacts of transportation projects on land use and traffic generation/distribution patterns. This should then be submitted together with the road network designs to the County Director of Physical Planning for his/her approval before any construction work commences. Furthermore, the County Government will need to be more

vigilant to the developments influenced by the newly developed transport corridors and as such carry out sufficient development control in such areas.

b. Control of 50% of the Public Transport System by the National Ministry in charge of Transport.

The Ministry of Transport in the national government should control not less than 50% of the Public Transport System so that regulation of fares, travel schedules, route schedules and PSV capacities becomes easier than it is the private sector dominated system currently operational. The ministry should thus promote mass transit systems more. Particular attention should be given to the development and maintenance of BRT and LRT systems. The private sector can then be left to operate the intermediary modes of transport such as smaller PSVs that would connect people from the areas of residence to the main Public Transport Routes. This will deal with the problem of ineffective public transport system**.**

c. Frequent Studies to Assess the Changing Demand for Transport Facilities

The other problem that has to be solved is lack of forecasts on future transportation trends and demands. It is thus proposed that the County Government should carry out frequent studies to assess the changing demand for transport facilities. The studies should be undertaken at least once every two years since the urbanization rates are so high that the demand for various urban facilities increases so rapidly. These studies would then inform the decisions made by policy makers and developers in the provision of such facilities.

d. Development of a Policy on Control of Private Car Usage and Operation of Low Capacity PSVs

This recommendation is made to solve Traffic Congestion issues. Several studies have shown that the private cars and the low capacity PSVs are the major causes of traffic congestion in Nairobi. It is thus suggested that their use should be controlled. For instance, it would be important to introduce carpooling, park and ride operations and zonal restriction of low capacity PSVs (e.g. causing them to operate within residential estates only)

e. Re-structuring the Institutional Framework for Transport Development and Management

This is proposed as a solution to poor coordination between Institutions managing Urban Transportation systems. The institutional framework restructuring should provide for an

overall entity responsible for harmonizing the operation of the existing institutions and from which all transportation decisions are made.

Furthermore, some of the institutions such as KURA, KeNHA and KURRA should be collapsed into one entity so that they operate as sections under one management. This would help to prevent the disconnected operations and the isolated decisions currently arising from the autonomy enjoyed by each of them. It would also promote coordination of transport infrastructure developments.

Traffic management should also be the sole responsibility of the Kenya Traffic Police Department so that the current confusion and completion between the department and the county traffic marshals can be eliminated.

f. Significant Penance to Regulators & Legislators Operating Transportation Businesses

It is notable that some of the mismanagement cases in the transport system arise from the fact that some of the regulators operate businesses in the industry and are thus often faced with conflict of interests whenever they are required to make certain decisions. They therefore tend to lean towards the decisions that would profit their businesses, rather than those that would improve efficiency and effectiveness of the system. Others are the legislators who take a similar trend when they are expected to pass laws and policies that would improve the system.

As such it is recommended that such personalities be barred from operating in transport businesses. It should also be passed by law that those that defy this directive be tried in a court of law and if found culpable, a hefty penalty be charged against them.

g. Engagement of Strictly Qualified Personnel in the Transport Regulatory Bodies

It must be established that a person is qualified for a position of responsibility in the transport sector before they are engaged in respective a capacities. S/he needs to demonstrate that s/he has the qualifications on transport regulation matters (which should be prescribed in an Act of Parliament). Such personnel should then be accorded a certain level of legally prescribed indemnity and autonomy from political forces so that they operate free of negative political influence. Furthermore, there must be a well established system meant to instil transparency and accountability of these personnel to the members of the public.

h. Establishment of an Advocacy System for the Public Transport Service Consumers

The situation currently depicts a scenario where the consumers of Public Transport Services are victims of circumstances who have nobody to turn to. They either have to bear with the situation (noise, hiked fares, unsafe rides, abusive PSV operators among other things) or use personal means (either private cars or NMT modes).

It is thus essential that a legally recognized system of advocacy be established to ensure that the regulators and the service providers are not undermining the need for an effective and efficient transport system.

6.4 Conclusion

While the recommendations made in this paper respond to various issues, it is recognized that they need to be implemented simultaneously if notable results are to be realized. This preposition is informed by the fact that solving the deficiencies of a transport system requires a holistic and integrated approach, which would ensure that none of the sub-systems is dysfunctional. Moreover, it is noted that the achievement of the desired state of affairs is dependent on the concerted efforts from the very many actors in the system, including the regulators, the service provider, the consumers and the policy makers. Lastly, additional proposals would help to improve the results of the recommendations put forward here.

CHAPTER SEVEN
SUMMARY AND CONCLUSION

7.1 Overview

The prime purpose of this study was to examine the relationship between the on-street termini within Nairobi CBD and transport efficiency and effectiveness, with a view to bring out key emerging issues and propose interventions that can improve the situation. The entire process was systematically organised and it generally turned out to be fruitful.

The findings of the study have articulated transport efficiency and effectiveness issues both in the study area and the entire city. It has also brought out the relationship between the on-street termini and transport effectiveness/efficiency. As such, it has filled a major ***knowledge gap*** in the transportation development sector.

The findings are more specifically expected to inform policy makers, investors and members of the public on the prevailing situation of the transport system so that they can all take one or another measure geared towards improving the system. Furthermore, the research proposes various recommendations which can be scrutinized and applied both in Nairobi and elsewhere for purposes of improving transport systems.

7.2 Summary of the Study

The first objective of this study was to examine the existing system of on-street PSV termini in Nairobi CBD. The findings in this regard are that over 90% of the termini are located on-street; the bulk of the on-street termini are located down town; the termini are located in relation to the parts of the city served; and the vehicular entry and exit patterns to the termini are shaped by the grid-iron road network.

The second objective was to evaluate the transport efficiency and effectiveness of in the CBD. The main finding was that the transport system in Nairobi is both inefficient and ineffective. Inefficiency is depicted by time financial losses to the public service providers resulting from delay in traffic and overconsumption of fuel. It is also shown by the time and financial losses incurred by customers as a result of traffic jam and service overcharge respectively. There are also environmental costs which are as a result of overconsumption of fuel (a non-renewable source of energy), noise pollution, air pollution and dust emissions. Finally accidents that common in the system also cause loss of property and life.

Ineffectiveness is on the other hand depicted by discomfort (resulting from poorly designed and squeezed vehicles, noise and dirt), unaffordability of transport services (causing social exclusion), insecurity (caused by theft, pick pocketing and mugging in some cases) and safety issues (caused by accidents).

The factors that have caused transport ineffectiveness and inefficiency include insufficient land use and transportation planning; poor traffic management; inadequate provision of transport infrastructure; unregulated public transport system; poorly developed mass transit system; and lack of intermodal integration

The third objective was to assess the effects of the on-street PSV termini on the operations of the CBD. In regard to this objective, the study revealed that there are both positive and negative effects of on-street termini. The positive effects include convenience in accessing the termini within the CBD; reduction of time taken to look for a PSV to board and attraction of customers to the business premises surrounding the termini. The negative effects are on the other hand inclusive of difficulty in circulation; reduction of carriage way; traffic jams; commotion/ disorderliness in transport operations; blockage of entrances to business premises; difficulty in picking and dropping passengers by PSVs; and reduction of road functionality

The other finding is that there is a relationship between density of on-street PSV termini and efficiency/effectiveness of transportation. The relationship is such that ***the higher the density of on-street termini, the less effective and efficient a transport system becomes***.

The fourth and last objective was to propose appropriate interventions that can improve traffic efficiency. The recommendations are grouped as design and policy proposals. The former are further categorized as transport network development, Termini development and land use proposals.

The network development recommendations include development of Mass Transit (Bus Rapid Transit along Waiyaki way, Mombasa road, Uhuru Highway, Ngong road, Jogoo road and the adjoining major corridors and Light Rail Transit alongside the existing railway line); development of overpasses and underpasses for through traffic in the CBD; and development of ring roads to connect various nodes in opposite zones of the city.

The termini proposals include elimination of on-street termini in the CBD; planning for and strategic distribution of off-street bus termini at various points at the outskirts of the CBD; improvement of the Central Railway Terminal (located south of the CBD) to cater for the needs of a light rail system; and development of park and ride facilities at points where people join the BRT networks.

The land use proposals include development of spaces for hawkers within the CBD, land use segregation and development of thematic land use precincts which would help to deal with land use incompatibilities and the chaos that arise from them.

Finally the policy recommendations include formulation of policy guidelines on integration of land use and transportation planning; control of not less than 50% of the Public Transport System by Ministry of Transport so that regulation of fares, travel schedules, route schedules and PSV capacities can be improved; frequent studies to assess the changing demand for transport facilities; development of a policy on control of private car usage and operation of low capacity PSVs; and re-structuring the institutional framework for transport development and management to provide for an overall entity responsible for harmonizing the operation of the existing institutions and from which all transportation decisions are made.

In conclusion, the study has achieved all the objectives set out and accomplished the purpose thereof. It has made valuable contributions to the knowledge relating to transport efficiency and effectiveness and the roles of terminal facilities. On the other hand, it is noteworthy that a few limitations were experienced during the study. Such were the difficulty to access some key informants and a few sets of recent statistical data. However, these did not interfere with the credibility of the findings.

7.2 Areas for Further Research

The following areas are proposed for further research;

1. **Institutional factors influencing the operations of the transportation system in Kenya.**

The findings of this research show that there are transportation issues arising from the existing institutional framework but has not dug deep into the actual factors at play. It is thus the researcher's assessment that there is need proper studies in this area since if the system is not managed properly, very little improvement or none at all can be achieved.

2. A trend analysis on the interactions between land use and transportation in Nairobi

It has also been observed that Nairobi is a rapidly changing landscape with major infrastructural developments and major changes in development densities having taken place over the last five to ten years. It would thus be important to carry out a city wide study on to assess the manner in which the changes in transportation have impacted on land use and vice versa. This study is expected to inform the efforts that would be put in future to coordinate and bring harmony between the two systems.

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APPENDICES

Appendix 1: Travellers' Questionnaire

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

QUESTIONNAIRE FOR PEOPLE OPERATING IN THE CBD

DECLARATION: This questionnaire is an instrument used in the study on the On-Street Termini Operations of Public Service Vehicles and their Relationship to Traffic Efficiency & Effectiveness in Nairobi CBD, in partial fulfilment of the requirements for M.A (Urban and Regional Planning). Any information provided is confidential, and will be used for this purpose only.

Name of respondent (Optional)…….....
Name of Interviewer…… ……..**.....**
Date of interview…….....Time of interview……....

A. GENERAL INFORMATION

1. Gender of respondent: Male [ ] Female [ ]
2. Age: [ ]
3. Marital status: [ ]
4. Education level: Primary [ ] Secondary [ ] College [ ] University [ ] None [ ]

B. CIRCULATION IN THE CBD

1. How often do you visit the CBD?
   Daily [ ] Weekly [ ] Once in a while [ ]

2. What is the common purpose for which you come to the CBD?
   Work [ ] Business [ ] Shopping [ ] School [ ] Social [ ]

3. What modes do you commonly use in the CBD
   Private car [ ] Public vehicle [ ] NMT modes [ ]

4. When using a private vehicle, which type of parking mode do you easily have access to?
   On-street parking [ ] Off-street parking [ ] Both [ ]

5. (a) When using the public means, where do you pick and alight from your vehicle?
   Within a terminal facility [ ] On-street [ ]

   (b) What is the average time the vehicle takes to get full?

   .....

   (c) How often does the vehicle leave the terminal without getting full?

   Never [ ] Once in a while [ ] Always [ ]

(d) What is the average time a vehicle takes to leave the CBD from the terminal?

.....

6. How easy is it to move through:
   i) Areas **with** on-street bus termini and car parks

   Easy [ ] Difficult [ ]

   ii) Areas **without** on-street bus termini and car parks

   Easy [ ] Difficult [ ]

7. (a) How long have you experienced difficulty in circulation as a result of on-street termini?
   .....

   (b) What do you do to ease your movement in such areas?

   .....

   .....

   (c) Has your solution in (b) above worked?

   Yes [ ] No [ ]

   (d) If no, why

   .....

   .....

8. (a) Please comment on the orderliness in boarding a PSV on an on-street terminal
   Very Orderly [ ] Fairly Orderly [ ] Disorderly [ ] Very disorderly [ ]

   (b) Please explain your answer in (7a) above

   .....

   .....

9. In your opinion, what are the effects of the on-street bus termini on the following:
   i) Ease of movement (circulation)
      .....
      .....
   ii) Traveller safety and security
      .....
      .....

   iii) Street capacity
      .....
      .....

   iv) Traveller Comfort
      .....
      .....

10. How does difficulty in circulation within the CBD affect you, your work or business?

.....
.....
.....
.....

11. i) Are the following factors which emanate from on-street termini an issue to your business/work place:

(a) Noise	**Yes ( )**	**No ( )**
(b) Blockage of work place entrance	**Yes ( )**	**No ( )**
(c) Dust	**Yes ( )**	**No ( )**
(d) Air pollution	**Yes ( )**	**No ( )**
(e) Overcrowding	**Yes ( )**	**No ( )**
(f) Insecurity	**Yes ( )**	**No ( )**

ii) If yes, kindly explain how each affects your work/business

(a) Noise

.....
.....
.....

(b) Blockage of work place entrance

.....
.....
.....

(c) Dust

.....
.....
.....

(d) Air pollution

.....
.....
.....

(e) Overcrowding

.....
.....

.....
.....

(f) Insecurity

.....
.....
.....

12. What are some of the positive effects of on-street termini?

.....
.....
.....

13. What can be done, in your view, to improve circulation within the CBD?

.....
.....
.....
.....

Appendix 2: PSV Operators' Questionnaire

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

PUBLIC SERVICE VEHICLE OPERATORS' QUESTIONNAIRE

DECLARATION: This questionnaire is an instrument used in the study on the On-Street Termini Operations of Public Service Vehicles and their Relationship to Traffic Efficiency & Effectiveness in Nairobi CBD, in partial fulfilment of the requirements for M.A (Urban and Regional Planning). Any information provided is confidential, and will be used for this purpose only.

Name of Respondent (Optional)…….....
Name of Interviewer…… Transport Route…….....
Time of interview……. Date…….....

1. For how long have you worked in the public transport industry?
   .....

2. How long have you operated from this terminal facility?
   .....

3. Please rate the following

Item	**Score [1 – Very good; 2 – Good; 3 – Fair; 4 – Poor; 5 - Very Poor]**
Conditions of roads and related infrastructure	
Capacity of roads	
Capacity of terminal facilities in town	
Management of traffic within CBD	
Others (Specify)	

4. i) Do you like the way you drop and pick passengers on the CBD streets?

   Yes [ ] No [ ]

   ii) Explain your answer in 3(i) above
   .....
   .....
   .....
   .....

5. i) How easy is it for you to access and leave your terminal point in the CBD?
   Easy [ ] Not easy [ ]

   ii) Explain your answer in (i) above

.....
.....
.....
.....

iii) If not easy, how does it affect your operations?
.....
.....
.....
.....

iv) What do you normally do to avoid the difficulties?
.....
.....
.....
.....

6. i) Do you think on-street termini affect the ease of movement of vehicles and NMT users within the CBD?
   Yes [ ] No [ ]

   ii) If yes, how?
   .....
   .....
   .....

7. In your view, do the following factors also reduce the ease of movement in the CBD?

i.	Pedestrian crossings	Yes [ ]	No [ ]
ii.	On-street car parking	Yes [ ]	No [ ]
iii.	Handcarts	Yes [ ]	No [ ]
iv.	Tuktuks	Yes [ ]	No [ ]
v.	Motorbikes	Yes [ ]	No [ ]
vi.	On-street vending	Yes [ ]	No [ ]

8. How much more do you spend on fuel daily when you delay to leave the CBD due to jam?
   Ksh.....

9. What are the positive effects of on-street termini?
   .....
   .....
   .....

10. What can be done, in your view, to improve:
    i) Terminal facility provision?
    .....
    .....

    ii) Circulation within the CBD?
    .....
    .....

Appendix 3: Observation Guide

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

OBSERVATION GUIDE

DECLARATION: This observation guide is an instrument used in the study on the On-Street Termini Operations of Public Service Vehicles and their Relationship to Traffic Efficiency & Effectiveness in Nairobi CBD, in partial fulfilment of the requirements for M.A (Urban and Regional Planning). Any information provided is confidential, and will be used for this purpose only.

Name of station…….....

Day of Observation…… **Date**…….. **Time** ……

Items of observation	**Remarks**
PSVs that operate from the point	
Vehicle entry and exit patterns (into CBD and the termini)	
PSV Parking style	
Adjacent land use activities	
Development density	
Traffic volume	
Modal composition	
Road user behaviour (both drivers and pedestrians)	
Road Condition	

Appendix 4: Key Informant Interview Guide

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

KEY INFORMANT INTERVIEW GUIDE

DECLARATION: This interview guide is an instrument in the study on the On-Street Termini Operations of Public Service Vehicles and their Relationship to Traffic Efficiency & Effectiveness in Nairobi CBD, in partial fulfilment of the requirements for M.A (Urban and Regional Planning). Any information provided is confidential, and will be used for this purpose only.

City Planner

1. What role do the planners play in the location of termini in the CBD?

2. What is your opinion about effects of the on-street termini especially on land use?

3. How, in your, opinion can the traffic efficiency be improved in the CBD and its surrounding?

4. Are there any planning proposals to provide additional off-street termini in the CBD and the surrounding?

City Engineer

1. What role do the Engineers play in the location of termini in the CBD?

2. Are there design considerations that are made before a street is earmarked as a PSV terminal?

3. If yes, which are the considerations?

4. How does the County Government collaborate with the KURA in provision of transport infrastructure?

5. What is your opinion about effects of the on-street termini?

6. How, in your, opinion can the traffic efficiency be improved in the CBD and its surrounding?

7. Are there any proposals to provide additional off-street termini in the CBD and the surrounding?

NCCG Traffic Management Department

1. Why has the County Government allowed the use of on-street PSV termini in the CBD?

2. How are the on-street termini allocated to PSV companies/SACCOs?

3. Are permits to given to PSV companies before they operate in those termini?

4. How often are the permits renewed?

5. Do the Matatu SACCOs pay to use the spaces?

6. How do you collaborate with the Traffic Police Department in managing the CBD traffic?

7. What are some of the traffic management challenges you face in the CBD?

8. What is your opinion about effects of the on-street termini

9. How, in your, opinion can the traffic efficiency be improved in the CBD and its surrounding?

Appendix 5: Traffic Counts Tally Sheet

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

TRAFFIC COUNTS TALLY SHEET

DECLARATION: This tally sheet is an instrument in the study on the On-Street Termini Operations of Public Service Vehicles and their Relationship to Traffic Efficiency & Effectiveness in Nairobi CBD, in partial fulfilment of the requirements for M.A (Urban and Regional Planning). Any information provided is confidential, and will be used for this purpose only.

Enumerator's Name……	**Name of station**……..	**Day**…….	**Date**……

TIME	CARS								MATATUS (<14)							MINIBUSES (15-33)							BUSES (>33)					

Appendix 6: Speed Evaluation Tally Sheet

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

SPEED EVALUATION TALLY SHEET

DECLARATION: This tally sheet is an instrument in the study on the On-Street Termini Operations of Public Service Vehicles and their Relationship to Traffic Efficiency & Effectiveness in Nairobi CBD, in partial fulfilment of the requirements for M.A (Urban and Regional Planning). Any information provided is confidential, and will be used for this purpose only.

Enumerator's Name…… **Day**…… **Date**……..… **Time**……..……

Route Name	From Point A	To Point B	Distance (m)	Time taken (sec)	Speed (metres/sec)

Appendix 7: Research Authorization Letters

a. University of Nairobi Introduction letter

University of Nairobi
Department of Urban and Regional Planning
School of the Built Environment
P.O. Box 30197, 00100 GPO Nairobi, Kenya
e-mail:durp@uonbi.ac.ke
Tel. 020 4913526

5th April, 2017

TO WHOM IT MAY CONCERN

RE: ONG'INJO BETTY AWUOR – B63/76216/2014

This is to confirm that the above named is a M. A. (Planning) student in the Department of Urban & Regional Planning, University of Nairobi.

As part of the continuous assessment culture in the Planning Programme our students are encouraged to acquire some experience through training in the field of Urban and Regional.

We wish to request you to allow her collect data from your institutions/households for her research project whose research topic is "The Impacts of On-Street PSV Terminal on the Efficiency and Effectiveness of Transportation"; A case study of Nairobi CBD.

Thank you.

University Of Nairobi
Department Of Urban and Regional Planning
P.O. Box 30197 - 00100 Nairobi

DR. KARANJA MWANGI, MKIP FKIP
CHAIRMAN
DEPARTMENT OF URBAN & REGIONAL PLANNING

KM/pk

b. Research Permit National Commission for Science, Technology and Innovation

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349,3310571,2219420
Fax: +254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/17/47782/16927**

Date: **4th May, 2017**

Betty Awuor Onginjo
University of Nairobi
P.O. Box 30197-00100
NAIROBI.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Onstreet termini operations of public service vehicles and their relationship to traffic efficiency & effectiveness in Nairobi CBD,"*** I am pleased to inform you that you have been authorized to undertake research in **Nairobi County** for the period ending **4th May, 2018.**

You are advised to report to **the County Commissioner and the County Director of Education, Nairobi County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Nairobi County.

COUNTY COMMISSIONER
NAIROBI COUNTY
P. O. Box 30124-00100, NBI
TEL: 341666

The County Director of Education
Nairobi County.

c. Research Permit the Ministry of Education

Republic of Kenya

MINISTY OF EDUCATION
STATE DEPARTMENT OF BASIC EDUCATION

Telegrams: "SCHOOLING", Nairobi
Telephone: Nairobi 020 2453699
Email: rcenairobi@gmail.com
cdenairobi@gmail.com

When replying please quote

REGIONAL COORDINATOR OF EDUCATION
NAIROBI REGION
NYAYO HOUSE
P.O. Box 74629 – 00200
NAIROBI

Ref: RCE/NRB/GEN/1 VOL. I

DATE: 5th June, 2017

Betty Awuor Onginjo
University of Nairobi
P O Box 21774-0000
NAIROBI

RE: RESEARCH AUTHORIZATION

We are in receipt of a letter from the National Commission for Science, Technology and Innovation regarding research authorization in Nairobi County on "**Onstreet termini operations of public service vehicles and their relationship to traffic efficiency & effectiveness in Nairobi County**".

This office has no objection and authority is hereby granted for a period ending **4th May, 2018** as indicated in the request letter.

Kindly inform the Sub County Director of Education of the Sub County you intend to visit.

NAIROBI
05 JUN 2017

MAINA NGURU
FOR: REGIONAL COORDINATOR OF EDUCATION
NAIROBI

C.C

Director General/CEO
Nation Commission for Science, Technology and Innovation
NAIROBI

Appendix 8: An Excerpt of the Chi-Square Table

	$P(X \leq x)$							
	0.010	0.025	0.050	0.100	0.900	0.950	0.975	0.990
r	$\chi^2_{0.99}(r)$	$\chi^2_{0.975}(r)$	$\chi^2_{0.95}(r)$	$\chi^2_{0.90}(r)$	$\chi^2_{0.10}(r)$	$\chi^2_{0.05}(r)$	$\chi^2_{0.025}(r)$	$\chi^2_{0.01}(r)$
1	0.000	0.001	0.004	0.016	2.706	3.841	5.024	6.635
2	0.020	0.051	0.103	0.211	4.605	5.991	7.378	9.210
3	0.115	0.216	0.352	0.584	6.251	7.815	9.348	11.34
4	0.297	0.484	0.711	1.064	7.779	9.488	11.14	13.28
5	0.554	0.831	1.145	1.610	9.236	11.07	12.83	15.09
6	0.872	1.237	1.635	2.204	10.64	12.59	14.45	16.81
7	1.239	1.690	2.167	2.833	12.02	14.07	16.01	18.48
8	1.646	2.180	2.733	3.490	13.36	15.51	17.54	20.09
9	2.088	2.700	3.325	4.168	14.68	16.92	19.02	21.67
10	2.558	3.247	3.940	4.865	15.99	18.31	20.48	23.21

Appendix 9: Anti-Plagiarism Test Results