The Congestion and access to Nairobi's Central Business District – A case for Aerial Cable Transport Installation and Use

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Declaration

I, Constant Terence Cap, declare that this work is original and has not been submitted to any other university for an award of a degree

Signed____ Date____________________

Constant Terence Cap (Candidate)

Declaration by Supervisor

This research has been submitted for examination with my approval as University Supervisor

Signed____ Date____________________

Dr. Samuel Obiero (Supervisor)

Dedication

I dedicate this work to my late father, my mother, two brothers and all the educators who have seen me through my life so far.

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Abstract

In less than a generation, 70 % of the world's population will be living in cities. Travel is a necessity in urban areas but roads and other infrastructure have been unable to keep up with the needs of these ever growing requirements. This has led to high levels of traffic congestion that threaten economic productivity, environmental conservation and the overall quality of urban living. Nairobi City is not exempt from these problems.

Several cities in the world have utilized Ropeways and Cable Liners as an innovative and attractive approach to public transport. These have impressive features like ease in passing over barriers, rapid installation, safety, high efficiency and simple integration with other means of transport.

The study aimed at investigating the possibility of integrating Arial Cable Transport (ACT) as a means to supplement some of the solutions proposed for the reduction of congestion in Nairobi.

The literature review of the study covers urbanization and urban growth, urban transportation and urban ACT. It analyzes ACT in Africa, developing world and the developed world. It also looks at the benefits and challenges of ACT investigating the possibility of it being implemented in Nairobi.

The research was a non-experimental or survey research design. The key target population were people who carry out their daily activities in the Central Business District (CBD). Data Collection methods included Observation, photography, interviews, issuing of questionnaires and literature review.

The study revealed that there has been a peak hour shift due to increase in traffic while the main means used to access the CBD are personal vehicles and PSVs. Most people take approximately an hour to access the CBD and about half the time when there is no traffic jam. Majority of those who come to the CBD are youth (age 21-30) and are not happy with public transportation either due to cost, reliability, timeliness and/or efficiency. Those who use rail transport are happy with the timing and convenience but not with the comfort. Roads from the eastern side of Nairobi and the Mombasa Road/Uhuru Highway corridor face the worst congestion while accessing the CBD. The study shows that Nairobi residents want a transport system that is cheap, comfortable, has regular fares, timely, polite crew and reliable. There is need to work on interconnectivity between the proposed MRTS and the current paratransit.

The study also revealed that current public transport does not help people with disabilities. Those in the public transport sector receive little training other than driving, first aid and simple mechanics. There is no emphasis on NMT to access the CBD. The importance of reducing the number of private vehicles entering the CBD is gaining recognition among both civilian respondents and PSV crew.

Most respondents were positive about the use of ACT with respect to usage, impact on traffic congestion, value addition, creation of jobs and general embracement by members of the public.

The study recommends the urgent need for a sustainable MRTS that enables modal variety to access the CBD with fixed and affordable pricing to people of all social classes and those with special needs. Training of public transit crew is critical. ACT is a worthwhile means of urban transportation, though routing has to be well selected based on corridor characteristics. There is, however, urgent need for policy development for this to take place. It will be important to integrate the ACT with the proposed MRTS. Further research should be done to investigate the potential of this system in informal settlements.

Table of Contents

List of Tables

List of Figures

List of Maps

List of Plates

Acronyms

ACT	**Aerial Cable Transit**
AfDB	**African Development Bank**
ART	**Aerial Ropeway Transit**
BRT	**Bus Rapid Transit**
CCTV	**Close Circuit Television**
CBD	**Central Business District**
CCN	**City Council of Nairobi**
CBS	**Central Bureau of Statistics**
CPT	**Cable Propelled Transit**
DP	**Domestic Product**
EIRR	**Economic Internal Rate of Return**
EU	**European Union**
GoK	**Government of Kenya**
JICA	**Japan International Cooperation Agency**
JKIA	**Jomo Kenyatta International Airport**
KenHA	**Kenya Highways Authority**
KBS	**Kenya Bus Service**
LAMATA	**Lagos Metropolitan Area Transport Authority**
LRT	**Light Rail Transit**
MRT	**Mass Rapid Transit**
NMR	**Nairobi Metropolitan Region**
NEMA	**National Environment Management Authority**
NMT	**Non-Motorized Transport**
NUTRANS	**Nairobi Urban Transport Study**
PRC	**Peoples Republic of China**
TDM	**Transport demand management**
TOD	**Transit Oriented Development**
OECD	**Organization for Economic Co-operation and Development**
UNEP	**United Nations Environment Programme**
UNHABITAT – United Nations Human Settlements Programme	
UPT	**Urban Public Transport**

Chapter 1: INTRODUCTION

1.1 Background of the Study

According to UN-HABITAT[1], approximately 50% of the world's population lives in cities, and this figure will increase to 70% in less than a generation. As a result of the growing distance between home and workplace, as well as urban sprawl, settlement structures are becoming ever more complex and existing transport infrastructures are increasingly pushing capacity limits. For this reason, it is essential to find new solutions to eliminate current and future transport problems.

Lupala (2002) says that one of the challenges confronting cities in non-industrialized countries today is the fact that cities are growing at unprecedented rates, size and densities. Growth trends in these cities are largely unregulated.

In our modern society, mobility is a driving force of human development. The motives for travel trips are not confined to work or educational purposes, but reach a spectrum of diverse goals. Mobility is more than a keystone to economic growth; it is a social opportunity offering the people the opportunity for self-fulfillment and relaxation (Cools, 2009). Travel is derived from social and economic needs. Thus, it is how we arrange physical space and organize urban activities that set the stage for trip-making. Transportation should be subservient to urban environments, a means to achieving broader personal and societal objectives – earning a living or creating livable communities (Cervero, 2009). Transport forms a key component in creating a competitive business environment as well as a means through which various economic, social, and environmental objectives will be achieved. (GoK, Vision 2030, 2008)

In the last 30-40 years, the city commuter distance has tremendously increased. The average commuter distance was 0.8 km in 1970 and this increased to 25km in 1998. The 2008 present average commuter distance has increased to over 30-40km (Omwenga, 2008).

The road capacities of megacities, however, have failed to keep pace with the explosive increases in traffic, and worsening congestion threatens economic productivity and overall quality of urban living.

There is no single broadly accepted definition of traffic congestion. This is mainly because congestion is both a physical phenomenon relating to the manner in which vehicles impede each other's progression as demand for limited road space approaches full capacity and a relative

[1] www.worldurbancampaign.org 15/08/2013

phenomenon relating to user expectations vis-à-vis road system performance. However, what is clear is that congestion prevents us from moving freely and it slows and otherwise disrupts the conduct of business in urban areas (OCED, 2007)

Fiere (2001) states that urban transport and its management play key roles in the economic and social development of a city and its citizens. Transport is a key issue from the point of view of poverty alleviation: the urban poor are often excluded from adequate public transportation. Transport policies need to be sustainable financially, socially and environmentally. Transport systems need to improve physical access to jobs and to provide all people with mobility.

While rail (which would include Light Rail Systems and Rapid Rail Systems) has been the focus of most planning for Transit Oriented Development (TOD), there has been recent interest in bus-related TOD with an emphasis on new Bus Rapid Transit (BRT) systems (Currie, 2006). Bus Rapid Transit System (BRTS) is an innovative, high capacity, lower cost public transport solution that can significantly improve urban mobility (Agarwal 2010). In Kenya, Ogonda (1992) notes that since 1973 when matatus were given a presidential decree to operate, they have grown to compete and complement the public bus transport companies in towns and rural areas in medium- and long-distance passenger transport.

Ropeways and Cable Liners can be part of the solution by providing an innovative and attractive approach to public transport. Ropeways and Cable Liners have impressive features which can benefit cities like ease in passing over barriers, rapid installation, simple integration with other means of transport, safety and high efficiency. Ropeways do not depend on mountains and snow. They simply need urban transport problems and access deficits in the public transport network. Then, they can prove their efficiency and attractiveness as a cost-effective, rapidly installed, innovative link within a successful public transport network.[2]

Medellin, Colombia was the first city in the world to fully integrate ski-lift style gondolas into their public network. The technology was cheap, fast and safe and it furthermore eliminated all topographical challenges. The initial line opened in 2006 and now moves up to 40,000 commuters daily. The idea has now spread. Over two dozen cities in South America are now exploring, building or planning systems of their own. Cities around the world are taking notice. Three cities in Algeria are currently building 5 separate CPT lines; North Palmerstone, New Zealand recently tabled an urban gondola proposal; a scholar in Toronto, Canada has been commissioned to investigate the technology's application in Mecca, Saudi Arabia; and transit officials in Baden,

[2]http://www.doppelmayr.com/en/doppelmayr-international/applications.html 30/7/2013

Switzerland are exploring the idea. Other cities, meanwhile, with no topographical challenges (save for traffic) are also paying attention. (Dale, 2010). Ojo (2013) states that they may be 'a solution to the traffic jams in Lagos.'

There are pros and cons of the system, as Davila (2012) notes that volumes of trans-boundary air pollutants drop as baseline modes of transport are replaced with a system that relies on electricity. Benefits of rope propelled system include dedicated barrier free transport route in addition to a unique ride experience[3]. At the same time it was noted that in Koblenz, to achieve the same transport capacity as cable cars, articulated buses carrying 100 passengers would have to leave the two end points every 1.5 minutes and roughly 100 buses would need to be in service[4].

The study aims at investigating the possibility of integrating Arial Cable Transport as a means to supplement the solutions offered and proposed for the reduction in congestion of the urban areas.

1.2 Statement of the Problem

Rising environmental concerns and problems have brought sustainable urban development in general and sustainable urban transport in particular, to the agenda of almost every city across the world. It is generally accepted that sustainable transport implies finding a proper balance between current and future environmental, social and economic qualities (Yigitcanlar, 2008). Congestion has long been recognized as an environmental problem. Other than causing delay, it causes noise and fumes and increases health risks to road users and residents while the commuters prefer to board/alight at intersections, thus creating informal bus stops which cause hazardous traffic conditions (Agarwal, 2010).

According to Sclar (2012) a world-class urban transport system is one that provides easy, safe and affordable access across the metropolitan region for citizens from all walks of life. As cities all across the world are discovering, they cannot be world-class cities by continuing 20th century transport planning around projects of massive urban highway construction. It is an approach that puts its primary emphasis on road building as a solution to its problem of massive congestion. But as cities as diverse as Los Angeles, Beijing and Sao Paulo have discovered, more roads just lead to more congestion as more people attempt to get cars as it is the only way to travel. Rethinking in this case means making high quality public transport the centerpiece of the strategy and making added highway construction, at best, a supportive add on. As long as mass transit is seen, as it

[3] http://www.doppelmayr.com/en/doppelmayr-international/applications.html 30/7/2013
[4] http://www.doppelmayr.com/en/doppelmayr-international/applications/urban/applications/impressive-speed.html 17/12/2013

currently is in Nairobi, as a system for the poor it will never be more than a poor system; a system that everyone who can will flee at the first opportunity. The only way to solve the congestion problems of Nairobi is to make a massive effort to create quality mass transit for Kenya's rising middle class, and provide this transportation at rates that are also accessible to the poor.

The evolution of public transit modes has been remarkable, fueled by the need for different transit modes to handle different demand levels, urban environment patterns, and natural constraints and barriers. Aerial Ropeway Transit (ART), a type of aerial transportation mode in which passengers are transported in a cabin that is suspended and pulled by cables, is one of the solutions to such cases. ART has its origins in aerial lifts that have been used for decades in Alpine ski resorts to transport skiers and tourists in cable-suspended cabins. The use of aerial transportation in the urban environment, has gained more attention worldwide, and it is now used as a public transit mode in several terrain-constrained urban areas around the world (Alshalalfah et al 2012).

The Nairobi Metropolitan Region contributes approximately 60% of the National DP and is home to over 60% of the urban population. The core of the NMR defined by the county government of Nairobi is experiencing the highest level of immigration resulting into very high pressure on the carrying capacity of a physical and social infrastructure. The most prominent manifestation of this scenario is the persistent traffic congestion being experienced in the CBD. Previously it was a peak hour issue but now currently traffic snarl up is noticeable any time of the day in all directions. (GoK, 2008)

The portion of Kenya population living in urban areas continued to rise. In the last 20 years, the country urban population has increased from 15% to about 30% today. The rapid population in Nairobi has forced many city residents to travel out of the city centre and seek cheap housing in the peri-urban areas (Scar, 2012).

Over the last 20 years, traffic management measures have been discussed at length, but there has been little implementation in transportation planning to change the trend of congested traffic. There are several solutions that have been offered in line as a solution to this problem of traffic congestion. [5]

The Government of Japan implemented the Nairobi Urban Transport Study (NUTRANS) between 2004 and 2006, which designates the traffic networks improvement of the Nairobi Metropolitan

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[5]http://nairobiplanninginnovations.com/projects/nairobi-metropolitan-region-nmr-traffic-decongestion-program/ 1st August 2013

Area. Implementation of projects identified in the study by the Government of Kenya in collaboration with other development partners is ongoing. Notable among these includes construction of several missing link roads supported by GOK and EU, expansion of Thika Road supported by African Development Bank (AfDB) and the People's Republic of China (PRC), and rehabilitation and expansion of Uhuru Highway with support from World Bank and the People's Republic of China. [6]

The Nairobi Metropolitan Ministry also came up with the NMD Traffic Decongestion Programme. The aim of the Traffic Decongestion Program is to relieve the persistent traffic congestion in Nairobi's central business district.[7]

The program has the long term goal of creating a network of monorails and truncated buses. In the short term, the following components will be implemented:

1) Increase Uni-Direction (one-way) traffic movement, 2) Create dedicated bus routes and lanes in the central business district 3) Remove on-street parking. 4) Increase the number of multistory car parks. 5) Create Park and Ride stations. 6) Designate drop off and pick up points 7) Reinforce road reserves on all by bass and ring roads 8) Restrict heavy transit traffic between 07:00-10:00 and 16:00-20:00 on weekdays 9) Allow vehicles with over 60 passengers and standing passengers to use roads within the NMR 10) Expand the Central Business District to include the following areas: Westlands, Pangani, Eastleigh into Jogoo Road, Lusaka Road into Nairobi West, Langata Road, and Mbagathi into Hurlingham.

The Kenya National Highway Authority (KenHA) has also come up with several proposals towards solving this problem of congestion.

1) Decongestion of the city through construction of grade separators i.e. Interchanges at major junctions and construction of bypasses 2) KeNHA has recently introduced performance contracts to ensure maintenance of our roads is a never ending process and is closely monitored to avoid major deterioration on our roads. 3) Traffic congestion which is of critical concern especially during peak hours can be curtailed through development of all modal transport infrastructure including the following: Transport Demand Management (TDM), Expansion and development of existing roads, Construction of urban expressways, Introduction of Light Rail Transport (LRT) and

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[6]JICA Report (2009), JICA

[7]*Ibid*

Bus Rapid Transit (BRT), Regular conducting of urban traffic surveys for demand forecasting and subsequent urban transport planning.

The Syokimau Railway Station was official opened in 2012 and will provide passengers with an affordable, modern and comfortable services to and from the Central Business District. This is the first station to be completed under the Nairobi Commuter rail project others are Imara Daima Station which targets commuters from Industrial Area, Embakasi and Mombasa Road and Makadara Station which target commuters from Buru, Jogoo Road, Jerusalem, Jericho, Uhuru and Hamza Estates.[8]

Recently, digital traffic lights were installed in Nairobi to free up the number of police officers who control roundabouts and junctions across the city. The integrated traffic and security system will also involve the installation of closed circuit television (CCTV). Currently several areas including the Haile Selassie, Westland's roundabout on Waiyaki Way and Kenyatta Avenue-Uhuru Highway roundabout have seen the lights replaced. The new system will be directed from a control room which is yet to be installed, fitted with screens from butterfly cameras installed along the roads to monitor which roads have heavy traffic so as to give them priority (Sato, 2013).

Additionally Uhuru Highway in Nairobi is set for a major makeover with the section between Nyayo Stadium and Museum Hill interchange will have an elevated road with two lanes on each side. The stretch will also have special lanes to accommodate a special BRT system.

Given the link between land use patterns and traffic patterns, much should be done to ensure that congestion management strategies address the relationship between the two. A long term strategic policy to tackle traffic congestion should then include some reference to the coordination of transport policy, urban planning and environmental goals in order to deliver sustainable outcomes (OECD, 2007).

Several other projects have been proposed as a possible solution to curb traffic congestion. Otini (2013) states that the government of Kenya is putting into place a 35 billion shilling plan to regulate the transport sector. It is said that among other things the project will take care of road expansion, bus fares, financing and traffic management. A National Metropolitan Transport Authority will be created to coordinate the policy shift and regulate public transport within the city.

[8]http://www.vision2030.go.ke/index.php/projects/details/Macro_enablers/19526 July 2013

Public transport has the potential to transport as many, if not more people than private cars while at the same time consuming significantly less road space or without consuming any road space at all (OECD, 2007).

Ngari (2002) notes that under provision of land for transportation in the City has resulted in payment of high costs for traffic diversions, land acquisition and compensation. The incoherent land use planning has exacerbated the growth of illegal settlements especially along main transportation routes in the city.

The possibility of the use of ART as an option to supplement the other attempts at reducing traffic congestion in Nairobi has not been studied before. Neither has it been mentioned in any of the transportation plans like the NMG traffic decongestion plan and Vision 2030. Several counties of similar economic level are either looking into or constructing ARTs as a supplement to their public transportation system. Cable car systems are relatively cheap to construct since they require little land acquisition and the technology is quite simple. The cost per kilometer compares favorably with BRT and rail systems (Brand, 2011). Additionally a gondola has the potential to reduce greenhouse gas emissions, increase reliability and cut travel times by one third, attracting more riders to transit (Fisher, 2011). This study aims at looking at how ART can be a sustainable mode of helping reduce the problem of traffic congestion in Nairobi City.

1.3 Objectives of the Study

The general objective of this study is to investigate the viability of having Aerial Cable Transport as a supplement to the public transport system for residents in Nairobi who are travelling to the Central Business District.

In this regard, the specific research objectives:

- Identify, classify and analyze the means of transport used by people moving to the Nairobi Central Business District during peak hours.
- Identify and examine congestion challenges and other challenges that commuters face while moving in and out of the Nairobi Central Business District and possible solutions to these challenges.
- Investigate the potential of aerial cabin transport as a major support in transporting people to the Nairobi Central Business District within identified corridors.

1.4 Research Questions

Consistent with the Research Objectives, the Key Research Questions of this Study are:

- What are the means of transport used by people moving to the Nairobi Central Business District during peak hours
- What are the congestion challenges and other challenges that commuters face while moving in and out of the Nairobi Central Business District and what are some of the possible solutions to these challenges?
- What potential does cable cabin transport have as a major support system in transporting people to the Nairobi Central Business District within identified corridors?

1.5 Assumptions of the Study

The increased vehicle operating costs has been transferred to commuters using public transport through high bus and ‘matatu’ fares within the suburban and the central business district of the city (JICA, 2009).

After years of chaos in the city public transport, the government is putting in place a Sh35 billion plan to regulate the sub-sector. Funded jointly by the World Bank (Sh25.2 billion) and the Kenyan government (Sh9.6 billion), the project will take care of, among others, roads expansion, bus fares, financing and traffic management (Otini, 2012)

The declining population density associated with sprawl has increased travel distances and pushed up the price of public transport (Gwilliam, 2011).

1.6 Scope

The geographical scope will be the Nairobi Central Business District. This covers the area that borders Haile Selassie Avenue to the North, Uhuru Highway to the West, University Way to the South and Moi Avenue/Tom Mboya Street to the East. Entry points of focus will be Valley Road/Kenyatta Avenue, Mombasa Road, Chiromo Road/Waiyaki Way and Jogoo Road/ Landhies Road.

1.7 Justification and Significance of the Study

The main sources of atmospheric pollution in Nairobi are vehicles, industries, emission from the use of charcoal and firewood and other municipal sources such as the open during of waste. The increasing number of cars in the city intensifies traffic and pollution problems. Vehicles emit significant levels of air pollutants, including greenhouse gasses and the precursors of smog (JICA, 2013).

Yagitcanlar, (2008) points out that recent literature highlights five important issues confronting sustainable transport. First, the petroleum upon which almost all (97%) of our transport systems run is a finite resource. Indeed, some argue that peak oil production has already been reached. Second, sustainable transport is environmental in its orientation and it deals almost exclusively with atmospheric pollution. This pollution includes the excessive production of greenhouse gases that contribute to global warming, as well as the emissions that threaten the health and well-being of those who live in urban areas. Third, many of our transport systems are congested, which is a critical problem in many major metropolitan areas around the world, also the transport disadvantage has become a critical problem for social inclusion and sustainable transport. A fourth aspect is accidents and fatalities. Fifthly and finally, a sustainable transport system must be judicious in its use of land and also not generate land sprawl and excessive related costs.

Because cities are often regarded as catalysts to modernization and economic expansion in the developing world, the economic standing of even small towns and rural settlements are hurt to some degree by congestion in big cities (Cervero, 2009). Rising urbanization and high economic growth has led to increased traffic congestion that is costing the country billions of shillings in man hours (Otini, 2012). The rising use of cars has choked roads, endangering the safety of pedestrians and the health of city residents who breathe in automobile emissions (Gwilliam, 2011).

Ultimately Nairobi residents are making location decision not based on any economic but traffic situation. As a result, the region and the country as a whole are losing 30 billion Shillings daily on lost fuels, street, time and environmental degradation (GoK, 2007).

Both operational and user perspectives are important in understanding congestion and its impacts. Ideally, urban transport policies should be developed on the basis that congestion is related to both: The behavior of traffic as it nears the physical capacity of the road system and the difference between road user expectations of the systems performance and how the system actually performs (OECD, 2007).

To lead an efficient policy, governments require reliable predictions of travel behaviors, traffic performance and traffic safety. A better understanding of the events that influence travel behavior and traffic performance will lead to better forecasts. Consequently, policy measures might be based upon more accurate data (Cools, 2009).

1.8 Definition of Terms and Variables

Aerial Cable Transport (ACT): a type of aerial transportation mode in which passengers are transported in a cabin that is suspended and pulled by cables

Cableways: Another name for ACT

CBD Central Business District, Major business hub of the City of Nairobi

Gondola are systems equipped with cabins moving along on a unidirectional loop. The gondola cabins are small, with each commonly able to accommodate between 4 and 40 people. Systems of this kind generally have a declutching mechanism, which allows one car to be slowed or stopped in a station without any impact on the overall flow of cabins on the loop (PCI, 2011)

Congestion – traffic jam, several vehicles on a road such that they can scarcely or hardly move

Nairobi – Capital City of Kenya

Matatu – Privately owned minibuses used for public transportation

Nairobi – Capital City of Kenya

Chapter 2: LITERATURE REVIEW

2.1 Urbanization and Urban Growth

Blanco (2009) says that one out of every two people in this world lives in a city. A sense of wealth and increased opportunities have been traditionally associated with the cities if compared with the rural areas. Nowadays, city expansion is experiencing the growth of large slum areas -notably in developing countries- threatening all levels of quality of life of their population. According to UN-Habitat, since 2007 at least half of the global population resides in cities.

Cities have changed in at least four major ways: size, spatial organization or morphology, the quality and distribution of public services and infrastructure and their employment base. While this situation can be attributed to global urbanization trends, the general poor knowledge on how these cities develop, densify and acquire certain physical characteristics has limited effective urban planning and management. At times, the pervasive knowledge gap has been associated with the lack of relevant theories and concepts to explain the evolution, growth and prevailing spatial qualities. However, the limited research in this field has also contributed to the problem. (Lupala, 2002).

African cities are experiencing rapid population growth, typically between 3 and 5 percent per year over the last decade. In 2000, one in three Africans lives in a city and this share is expected to rise to one in two by 2030 (Gwilliam, 2011). The other problem that confronts the rapidly urbanizing city is continued sprawl that has been manifested in externalities of inadequate infrastructure provision and underutilization of scarce resources, particularly land. (Lupala, 2002)

2.2 Urban Transportation

Transportation and cities are co-dependent, influencing each other in often complex and dynamic ways. It is less the hardware characteristics of roads and transit, and more the software characteristics - notably accessibility benefits- that shape urban environments (Cervero, 2009)

Urban transport is not a mode of transport, of course, but rather a collection of modal facilities and services found in a particular location. It is the density and complexity of these services and facilities that differentiate one system of urban transport from another (Gwilliam, 2011). Urban transportation normally plays a vital function in the daily life of a city. There are often various modes of transport which move people and goods within the city boundaries and these give rise to forever changing pattern of activities (Ombura 1989).

Traffic congestion in urban areas is often the outcome of successful urban economic development, employment, housing and cultural policies that make people want to live and work relatively close to each other to attract firms to benefit from the gains of productivity derived. (OECD, 2007).

If public transport successfully draws travelers away from cars, other urban travelers will not remain insensitive to the fact that the roads have become less crowded and that the travel times have improved on corridors that have experienced a mode shift in favour of public transport. (OECD, 2007).

Sustainable transport implies finding proper balance between current and future environmental, social and economic qualities (Yigitcanlar, 2008). Transport systems are vital for any city (Fiere, 2001). Financial sustainability is crucial to the life of a transport system and to the ability of the local government to support it. Social sustainability means including the poor and the often underserved, particularly women, into the urban management picture by increasing access and affordability. Environmental sustainability must include initiatives for road safety as well as lowering levels of air pollution through cost-effective reduction of particulates and use of alternative fuels and cleaner gasoline. International experience shows 3 key factors for any transport system: well-designed basic infrastructure network, proper management of the traffic system; public transportation and buses – with priority for buses, dedicated bus lanes and integrated facilities (Fiere, 2001).

Well thought out public transport policies remain a fundamentally important congestion management strategy. In particular, when public transport is well supported by local authorities or the private sector and when it provides a quality of service that approximates that which car drivers have previously been used to, it contributes to maintaining a high level of access in urban areas despite a drop in car use (OECD, 2007).

The importance of mobility is recognized by governments at different policy levels (Cools, 2009). Effective transportation plans are central to maintaining the productivity, health and safety of communities and regions. A transportation plan guides the investment in and timing of improvements to the transportation network to meet community mobility, accessibility, safety, economic and quality of life needs (Steiner, 2007).

There are various problems related with public transport such as tremendous increase in number of accidents, environmental degradation, congestion, overcrowding due to inadequate system, frequency of service and schedules not strictly adhered. Bus Rapid Transit (BRT) Systems have emerged as one of the important modes of public transport. They are motorized, comparatively flexible, easily accessible, and efficient and also cost effective in terms of being able to transport a large number of people (rather than vehicles) (Agarwal 2010).

2.3 Urban Aerial Cable Transport

Real world applications of conventional transport technologies in urban areas might not be always feasible due to several factors that are not necessarily attributed to passenger demand. This includes the high capital and operating cost of these systems, the limited availability of real estate to expand or create new systems and the presence of geographical and topographical barriers (Alshalafah 2013).

A good example is between 2003 and 2005, when an elevated highway covering Seoul's Cheonggyecheon River was demolished to improve the area's environmental and aesthetic condition. Now a city highlight, it is visited by 90,000 pedestrians daily. The restored river is also a model for urban renewal projects worldwide. In 2000, the Korean Society of Civil Engineering had found that the road and elevated highway had severe structural problems that would cost approximately US$95 million to fix. In addition, downtown Seoul was experiencing serious traffic congestion and poor air quality from the mass use of private vehicles, while public transport was in need of a thorough upgrade (Mayer, 2013)

We tend to associate cable cars with mountains and skiing, rather than urban life and work, but they are gradually taking root in our cities (Landrin, 2012). Cable systems can, however, be used in urban areas. Several metropolitan areas (Medellín, Caracas, Rio de Janeiro, Portland, New York, Algiers and others) have even incorporated gondolas and aerial tramways into their public transport networks. Emblematic projects such as these can provide an effective urban transport solution (Clément-Werny, 2011). Additionally, one of the needs is the desire to overcome geographical and topographical barriers such as mountains, valleys and bodies of water, which cannot be conquered by conventional transit modes without very large investments and changes made to natural topography, (Alshalafah 2012).

Ropeways simply need urban transport problems and access deficits in the public transport network to prove their efficiency and attractiveness as a cost-effective, rapidly installed, innovative link within a successful public transport network. [9]

Dale (2010) states that like BRT before it, CPT is the perfect example of what Harvard professor Clayton Christensen calls a Disruptive Technology. According to Christensen,

[9] http://www.doppelmayr.com/en/doppelmayr-international/applications.html 30/7/2013

Disruptive Technologies are "simple, convenient-to-use innovations that initially are used by only unsophisticated customers at the low end of markets." Because higher market competitors tend to either ignore or dismiss Disruptive Technologies when they're in their infancy, these technologies and industries can make mistakes, learn lessons, build their coffers, and gain market share and experience without ever having to aggressively compete for business. Should these innovations prove competitive in more developed markets, the innovations leap up the value chain and become coveted by those higher markets, completely remaking and disrupting existing industries.

2.4 Empirical Studies

Unconventional public transportation technologies have found notable success in recent years in many urban areas around the world like Aerial Ropeway Transit (ART) technology, which is a type of aerial transportation mode in which passengers are transported in cabins. (Alshalafah et al, 2013). We tend to associate cable cars with mountains and skiing, rather than urban life and work, but which are gradually taking root in our cities (Landrin, 2012).

Leigner (2010) says that the most environmentally friendly forms of travel in the city are walking and bicycling. These are followed by means of public transportation. Individual motorized transport fishes last, because of a series of ecologically negative characteristics (exhaust fumes, noise, tire wear, space for roads, parking etc.). With transport capacities of 5,000- 8,000 cableways fall under the range of buses and streetcars.

Medellin's first line has been highly successful and runs at full capacity, approximately 30,000 passengers a day. Replacement of the fossil fuel operating vehicles by a system of hydro-electric powered cable cars was projected to contribute to a reduction of up to 121,029 t $C0_2$ between 2010 and 2016. (Davila, 2012)

Cableways travel along their own route which they do not need to share with any other means of transportation. For entry they require stations and departures take place within the shortest time intervals. This means that passengers do not need to observe scheduled departure times. They have a small carbon footprint, do not require an operator on board and offer no conflict with other traffic users. They require just one motor to move several vehicles and can run with a small number of operating personnel.

The commercial speed of cable systems depends mainly on the speed of the traction cable and on the distance between stations.

The capacity of cable transport systems depends primarily on the capacity of the cabins, on the spacing of cabins on the cable and the speed of the traction cable. One of the advantages of these systems is that they operate within their own dedicated space, and are therefore independent of constraints to which other modes of transport operating on the road network may be subjected

According to Clement- Werny (2011), technologies differ depending on the number of cables and their function:

Monocable technology is a term is used when a single cable is used to pull and support the cars (examples: Medellin in Colombia and Caracas in Venezuela). This type of technology means using small cars (generally fewer than 16 places) and limiting the distances between pylons (maximal distance: 600 to 800 metres).

Bicable or tricable technology terms are used when one cable is used to pull the cars whilst one or two others support their weight (example: Coblenz in Germany). This type of system allows longer distances between pylons (up to several kilometres) and larger cars.

With a tricable circulating ropeway, speeds of up to 7 m/s i.e. 25.2 km/h are possible. Unlike a shuttle bus, which shares the existing road system with other vehicles and is therefore confronted with numerous obstacles, the ropeway saves time and energy consumption because it is a direct, barrier-free link. This can be illustrated using the example of the BUGA ropeway in Koblenz. The ropeway has 18 carriers and covers a distance of 1 km as the crow flies. Passengers benefit from the service every 38 seconds and a trip time of 5 minutes. The ropeway is capable of transporting 7,600 passengers an hour in each direction.

They also have several advantages over other means of public transportation. The service frequency of the gondolas at stations varies significantly between systems, from tens of seconds to around 15 minutes. With gondola systems, the cars can arrive into stations and depart on an almost continual basis.

The availability levels of cable systems are equivalent to metro systems (generally above 99.5 %, all events combined).

Cable systems are one of the safest transport systems in the world, based on the ratio of the number of accidents to the number of people transported per kilometer.

Cable systems are relatively cheap to construct since they require little land acquisition and the technology is quite simple. The cost per kilometer in urban areas compares favorably with BTR and rail systems (Brand, 2011)

Cable transport technology requires a straight line (or practically) between two stations; which can be restrictive, especially in urban environments.

2.5 Aerial Cable Transport in Africa and the Developing World

According to Ojo (2013), a company called Ropeways Transport is investing $500 million (about N81 billion) to launch a cable car mass urban transit system in Lagos. Ropeways has signed a 30-year franchise agreement with the Lagos Metropolitan Area Transport Authority (LAMATA) and the Lagos State Government for the execution of the project. The project is expected to be fully completed and commissioned by early 2015. This will shorten the resident's journey time from a typical one and a half-hour journey home to 20 minutes as well as have huge impact on the health of the people. It does not produce any pollution as there are no emissions of carbon dioxide and carbon monoxide. The cable cars receive their power from the station. This also creates employment at each station, and bus operators will create bus-stops nearby to carry passengers who arrive with the cable car.

Table Mountain Aerial Cableway Company operates within a South African National Park and a World Heritage Site. "This is a very sensitive environment and we all know that we are privileged to operate in this location, so must accept responsibility", explains Sabine Lehman, CEO. As far back as 1997, when the cable cars were upgraded, some forward-thinking decisions were made as to how the cableway would be built and how the top of the mountain would be preserved during the building process and beyond. "So it is definitely not a recent thing. These principles have been at the core of this business for 14 years". All staff are very aware that when people come to the mountain and use the cableway, it is because they want to have an experience that touches the earth lightly.[10]

The most significant experiments were made in the 2000s by Medellin, Colombia, and Caracas, Venezuela. Cable cars, rethought as a means of mass transport, were clean, producing no carbon dioxide emissions directly, and ended the isolation of the poorest neighbourhoods. The concept has been such a success in Medellin that the city council is considering a fourth route (Landrin, 2012).

The cable car system, which is integrated with the Metro System of Caracas, is 2.1 km in length and employs gondolas holding 8 passengers each. Metro Cable's capacity allows for the movement of 1,200 people per hour in each direction. Two stations in the valley connect directly to the Caracas public transportation system. Three additional stations are located along the mountain

[10] http://www.responsiblecapetown.co.za/resources/how-to-guide/case-study-table-mountain-aerial-cableway-company/

ridge, on sites that meet the demands of community access, established pedestrian circulation patterns, and also spatial availability for construction, ensuring minimal demolition of existing housing (Blanco 2009). The introduction of the Metro cable in one of the most marginalized areas of the country was the beginning of a physical and social transformation within the area not just in terms of reducing the transport gap between the inhabitants of the peripheral neighborhoods (which commonly needed to walk long routes before being able to access the Metro system or the urban buses network), but also in terms of recognition of these areas by institutional bodies and even encouraging self-recognition for their inhabitants, who when commuting by air were able to observe better their neighborhood (Blanco 2009).

Each station differs in configuration and additional functions, and the separate stations include cultural, social and system administrative functions; replacement of demolished residences with more homes, as well as public spaces; a gym, supermarket, and daycare center; and a link between the cable car system and the municipal bus circuit (Blanco 2009).

2.6 Aerial Cable Transport in the Developed World

TransLink, with the support of the British Columbia Ministry of Transportation and Infrastructure and P3 Canada, is reviewing the potential for a high-capacity gondola connecting Burnaby Mountain to the nearest SkyTrain rapid transit station. The mountain accounts for 25,000 daily transit passenger trips and is home to the main campus of Simon Fraser University, with 18,200 students, growing to 25,000 in future, and the UniverCity sustainable community, with residents increasing from 3,000 to 10,000. While the mountain is only 2.7 kilometres from the nearest SkyTrain station, it is almost 300 metres higher in elevation. Approximately 45 diesel buses arrive on the mountain in the peak hour but pass-ups are common and the service is often disrupted in winter weather. An initial study indicated that a high-capacity gondola could replace most of the bus service, with bus cost savings covering the gondola operating cost and a portion of capital.

Cable cars, not streetcars might be the solution to the issue of Toronto's public transport. Steven Dale believes that cable technology could significantly decrease costs and be available for more people at the same than the streetcars in Toronto are. Cable technology can be either embedded under the vehicles (iconic cable cars) or it can be used above street level. In the words of Dale, the cable cars system is less expensive, greener and faster that the streetcars. "Light rail, for me, is not the best technology." he said. "It happens to be stuck between a technology we don't like – buses – and a technology we can't afford – subways." Dale admits people might think that cable cars are slow and of low capacity. It is not true they are fast if compared to Toronto's streetcars and can carry about 6,000 people per hour per direction. Also, it doesn't take that much energy to move them (Davis, 2010).

Just before the 2012 summer's Olympics, London launched the Emirates Air Line. Its 34 cars bridge the Thames between Greenwich and the Royal Docks, running 90 metres above the ground. Visitors to Barcelona can climb to the top of Montjuic hill in a gondola lift. Its counterpart in Koblenz spans the Rhine then rises to the Ehrenbreitstein fortress. Rio de Janeiro, New York, Portland, Algiers, Oporto, and Bolzano: the list of cities equipped with a cable car is growing longer every day (Landrin, 2012). Running between North Greenwich and the Royal Docks, Emirates Air Line provides easy access to the O2 Arena and Excel London. The terminals are also close to the Tube, DLR, buses and river boat services. The Emirates Air Line cable car system is designed to operate throughout the year and in most weather conditions. However, cable cars are not designed to operate in extreme weather conditions and, for safety reasons, the service may close due to: Threat of lightning and thunder, Very strong winds. The Emirates Air Line was built to support current and future regeneration in east London.[11]

In France, the law identifies cable systems as one of the alternatives that could offer an efficient solution as part of a policy of reducing pollution and greenhouse gas emissions. And some cable transport projects are currently being run by local authorities (Clément-Werny, 2011).

Landrin (2012) states that Brest, in Brittany, will be "wired" in 2015. The local council chose this solution to cross the river Penfeld and connect the city centre to the Plateau des Capucins. The projected cable cars will carry 2,000 people an hour. The alternative of a shuttle bus would mean a 7 km detour with the obstacles of vertical rise, River Rhine crossing point and traffic lights as well as other toad users resulting in a trip time of 25 minutes. To achieve the same transport capacity, articulated buses carrying 100 passengers would have to leave the two end points every 1.5. Minutes and roughly 100 buses would need to be in service.

2.7 Benefits of Aerial Cable Transport

Clément-Werny (2011) sates that Cable systems are one of the safest transport systems in the world, based on the ratio of the number of accidents to the number of people transported per kilometer. Conversely, the comfort of cable systems is not comparable to other forms of public transport. In terms of accessibility, cable transport systems are subject to the regulations governing

[11] http://www.tfl.gov.uk/modalpages/23863.aspx

guided transport systems. It is however possible to adjust the capacity of a cable system to respond to periodic fluctuations in demand. Cable transport systems are relatively energy efficient overall

As any new form of transport infrastructure, the development of a cable transport system can have contrasting effects on the area from opening up, developing and redeveloping particular neighborhoods and renovating the built environment and public spaces, to increased pressure on land and suburbanization (Clément-Werny, 2011).

Cable transport systems can achieve the same levels of capacity and commercial speed as tramways or BHLS (Bus with a High Level of Service) Cable transport systems do, however, offer a solution to demands which traditional transports systems (buses, tramways, and metro systems) are unable to address satisfactorily because of technical or financial constraints. They can open up areas which were previously poorly served because of obstacles or changes in level.

According to Leigner (2010), under realistic circumstances, municipal buses transport between 1,500 and 3,500 people per hour per direction. Streetcars are able to carry 10,000 people per hour per direction. Light rail can handle thrice that. Subways operating with high frequency are able to transport up to 60,000 per hour.

Cable-car systems are relatively cheap and quick to construct, as little land needs to be publicly acquired and the technology is well-tested. Although measurement of the social and economic consequences of the Metro cables is fraught with difficulties, from an environmental and social perspective the impact of the aerial cable-cars can be said to be largely positive on balance. The system has helped to improve the quality of life of the urban poor by making it easier for them to access the opportunities of the city, by enhancing the visibility of the socially stigmatized areas in which they live, and by improving air quality (Davila, 2013).

2.8 Challenges of Aerial Cable Transport

Clement –Werny (2011) notes that the integration of the stations in a constrained area can be problematic. The actual minimum dimensions for stations are around 10 meters wide by 25 meters long (50 meters for intermediate stations). The level at which people enter the cabin influences how much land is needed. Where passengers enter at ground level, the space needed to lift the cars up with sufficient clearance has to be allowed for.

The visual impact of cable transport systems is a subject eminently subjective and complex to describe.

The origins of the emission of noise coming from the cable transports systems are mainly located at the station as they pass under pylons (Clement-Werny, 2011).

The not so successful impact of the second cable-car line in Medellin, suggests that, to be economically and socially significant, cable-car systems require specific minimum conditions in terms of urban morphology and population density, as well as careful integration with the existing mass public transit network. (Davila, 2013)

2.9 Nairobi City

Nairobi occupies an area of about 700 km^2 at the south-eastern end of Kenya's agricultural heartland. At 1 600 to 1 850 m above sea level, it enjoys tolerable temperatures year round (CBS 2001, Mitullah 2003).The western part of the city is the highest, with a rugged topography, while the eastern side is lower and generally flat. The Nairobi, Ngong, and Mathare rivers traverse numerous neighborhoods and the indigenous Karura forest still spreads over parts of northern Nairobi. The Ngong hills are close by in the west, Mount Kenya rises further away in the north, and Mount Kilimanjaro emerges from the plains in Tanzania to the south-east (UNEP, 2009)

In 1901, there were only 8 000 people living in Nairobi. By 1948, the number had grown to 118 000 and by 1962, the city had a population of 343 500 people (Rakodi 1997, CBS 2001). Following its founding in 1902, Nairobi took roughly 40 years to exceed a population of 100 000 people. By independence, 20 years later it had reached around 350 000 people (Olima 2001). Rapidly increasing population has been ongoing since, surpassing one million in the 1980s, two million in the 1990s. While the annual rate of growth has at times exceeded ten per cent, it has more recently decreased to below four per cent per year — still very high by global standards. Nairobi is projected to top 3.8 million by 2015. Nairobi's early growth was fuelled by rural migrants and an explosion of growth took place between 1979 and 1989 when772 624 newcomers came to the city (NEMA 2003). The forces motivating rural-urban migration to Nairobi include better economic prospects, opportunities for higher education and higher wage employment, and the attraction of Nairobi as a market for goods and services.

Nairobi's population growth rate is 4%. The city population as a share of the national population is 12 % while the city population as a share of the urban population is 29%. The population density is 5.7(100/square kilometer).

The phenomenon of urban sprawl in the city has also manifested itself in terms of rapid expansion of satellite towns. These town include- Kiambu, Karuri, Limuru and Kikuyu to the North; Ngong, Ongata Rongai and Kiserian to the West; Kitengela, Mavoko (Athi River) and Machakos to the South; and Thika, Ruiru Kangundo and Tala to the East. In the last 100 years, the city boundary has been extended to cover a greater region. It has been extended to include rich agricultural and livestock area in Kiambu, Kajiado and Machakos district. The city boundary has also been extended to include the Nairobi National Park. The city boundary covered 77km^2 in 1927 and this was expanded to 686 km^2 in 1963. Under the 2008 newly created Ministry of Nairobi Metropolitan Development, Nairobi (Omwenga 2008).

2.10 Nairobi Public Transportation

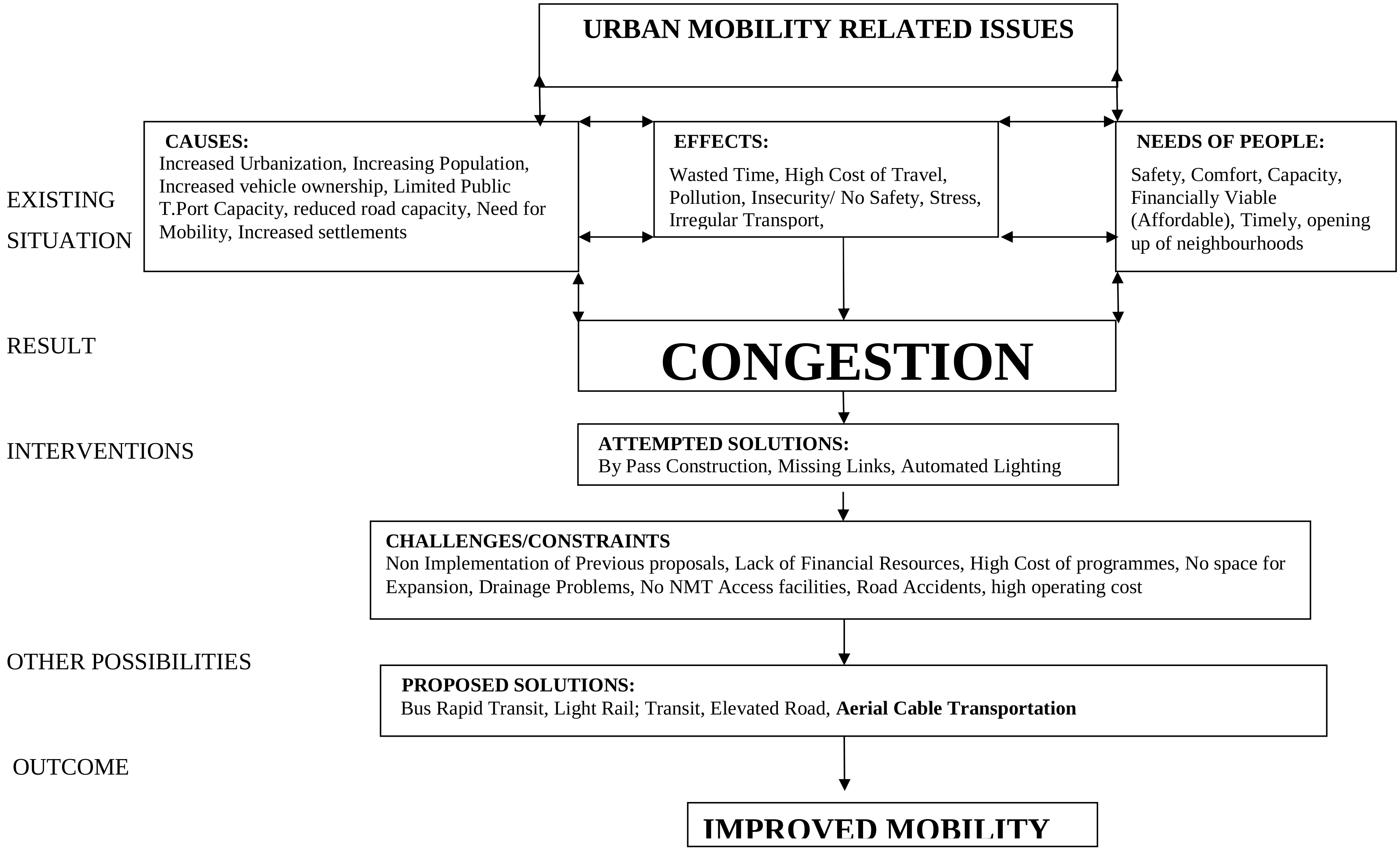
Public transport in Nairobi can be traced to the Kenya Bus Services (KBS) which started operations on 5 January 1954 as a modest fleet of 12 buses. The need for public transportation increased particularly for the African population thus in the 1950s there emerged the so called private taxis. After a presidential decree in 1973 that acknowledged Matatus as public transport vehicles, thereby breaking the franchise agreement between KBS and the then Nairobi City Council, Nairobi's urban transport scene has evolved into a two pronged affair much criticized by commuters, officials, academics alike. (Kiraithe, 1989)

Most of bus and *matatu* terminals are located around the Nairobi railway station, but are not systematically located by direction or destination. Outside the city centre, lay-bys for bus stop are prepared on the trunk roads, but along minor roads, *matatus* and buses often stop at roadsides or intersections for picking up passengers, which cause obstacles in traffic flow of the roads. According to the interview to the public transport passengers, three major requirements of bus/*matatu* passengers were 1) Improvement of bus stop facility/Information, 2) Improvement of accessibility, and 3) Improvement of regularity/punctuality (Nairobi Draft Masterplan, 2013).

As a result of the screen line survey, total number of *matatu* was 72 thousand and large bus was 23 thousand. Applying the average number of passengers of 10 passengers per *matatu* and 27 passengers per a large bus, total passengers crossing screen line by *matatu* is 720 thousand and 620 thousand by bus.[12]

[12] Nairobi City County Draft Masterplan 2013

2.11 Conceptual Framework



There are several urban mobility related issues that affect the City of Nairobi. The existing situation is affected by increased urbanization coupled with increased urban population mainly due to rural-urban migration. Together with this there exists a major problem of limited public transport capacity and a limited road capacity.

The result of this is wasted time, a high cost of travel for citizens leading to use of various means of travel that may have a polluter effect on the environment and may not be safe for the citizens. At the same time, perennial traffic jams and long waiting hours for public vehicles have led to increased stress levels among citizens.

The people are in need of a safe, comfortable and timely mode or modes of public transportation that are financially viable for both the provider and the user. There is also need to open up certain neighborhoods to enable easier access and improved mobility.

These issues have all culminated in the problem of congestion. Traffic congestion in Nairobi is a major factor in people's day to day lives and affects literally every citizen in one way or another.

There have been various attempts at solving this problem like the recent bypass construction that aims at diverting transit by circumventing it round the metropolitan area other than passing through the Central Business District. In order to open up the existing framework of roads within the city, several missing links have been constructed and others continue to be constructed. The latest attempt has been to synchronize traffic by putting up digitally controlled automated traffic lights.

In spite of these attempts, there remain various challenges and constraints towards solving the problem of congestion. There have been several proposals and plans over the years that have not been implemented either due to lack of financial resources or lack of good will from those in authority. Road expansion is also limited in some areas as a result of the built environment that has grown over the years. Additionally, the City's perennial drainage problems limit mobility during heavy rains. With little or almost no emphasis on Non-Motorized Transport facilities, people are forced to move around the city using vehicles. This has lead both directly and indirectly to the perennial road accidents experienced in the city.

There have been other proposed solutions made by various stakeholders. Bus Rapid Transit has been proposed on some corridors while Kenya Railways has shown intention to set up a Light Rail Transit system. At the same time, Kenya National Highway Authority would like to put up an elevated road on Uhuru Highway.

This Study looks into the possibility of Aerial Cable Transportation being used as a mode of mass transportation in order to reduce congestion and improve mobility.

Chapter 3: METHODOLOGY

Chapter 3 includes a review of the research method and design appropriateness, a discussion on the population and the sample. In addition, Chapter 3 will explain the data collection, inputting, analysis and presentation.

3.1 Research Design

The research was a non-experimental or survey research design that intended to identify the means of transport used by people travelling to the CBD, the challenges they face and look into the suitability of using Aerial Cable transit (also known as cable cars or Gondolas) as a supplement in urban transportation for those travelling towards the CBD. It looked at the social, economic and environmental effects that the cable transit would have as a supplement to other urban transportation means. It took into consideration the fact that a draft master plan has been prepared and published and already suggests various ways of reducing the transport congestion problem.

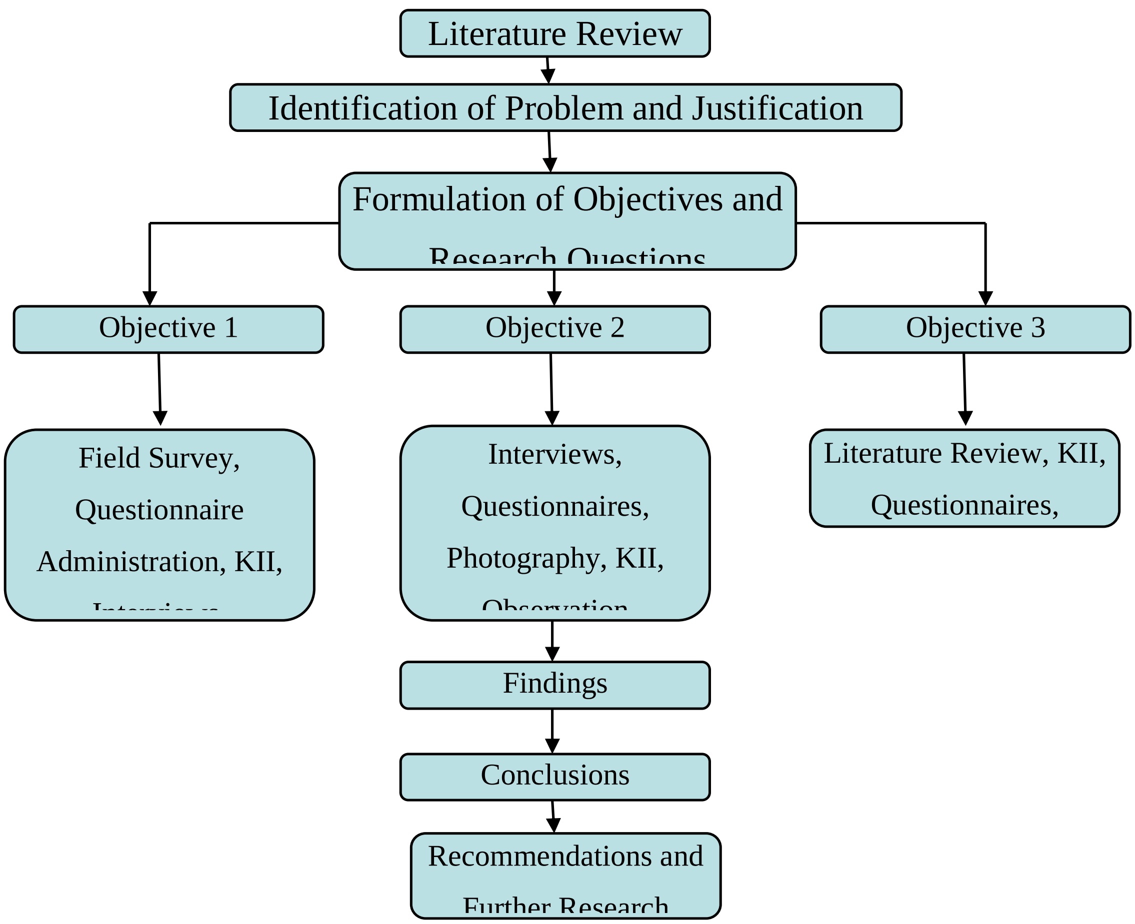


Figure 1 Chart showing Research methodology used

The Data matrix on page 31 shows a tabulated summary of how each objective was tackled bearing in mind the literature already collected in the study area. In order to the able to attain the objectives of the study, various emerging factors were identified. These related directly with the objectives from where the types of data required and the sources were easily identified. The methods of collection from each of the sources are listed as well as methods of analysis and presentation as will be explained better in the methodology.

3.2 Target Population

The key target population in this study was people who carry out their daily activities in the Central Business District. These included people who work in the CBD, people who study (at various universities and colleges), people who run businesses (shops, stalls and other commercial activities) in the CBD and those who conduct other affairs in the CBD. Officials of the Nairobi City County, Central Government, Traffic Policemen and other experts in this field were also to be considered as part of the study.

3.3 Sampling Plan

Sampling Unit was all people in the Central Business District.

The sampling frame included pedestrians (those walking in the CBD), office occupants, shop attendants, drivers/motorists and commuters.

The initial sample size of 270 was to be used as 1.02% of the estimated day time Central Business District Population. 1.02 was used as a sample size in order to be able to obtain results in line with the proposed Nairobi City County Master Plan. With an estimated day time population of 274, 607 (2009 census) in the central division of Nairobi (CBD and close environs) this sample size will be 270 individuals. Those who drive inside or through the CBD were not be considered as they were not easy to interview.

Due to time constrains and difficulties in obtaining information from office bearers and drivers in town, it was only possible to get information from 230 respondents. However, an effort was made to ensure that at least 30 respondents from each group of people in the sampling frame were issued with questionnaires.

Table 1: Data Matrix

Objectives	Emerging Factors	Types of Data	Sources of Data	Methods of Data Collection	Methods of Analysis	Methods of Presentation
Identify, classify and analyze the means of transport used by people moving to the Nairobi Central Business District during peak hours.	Means of Transport used Modes of Transport Main activities in CBD Peak Transport Hours	Primary and Secondary Data (Person Trip Survey, Stated Preference Survey)	Shop Owners County Government Traffic Police Literature Review' Pedestrians Matatu operators	Field Survey Questionnaire Administration Discussions with Key informants Interviews Observations	Descriptive analysis, Frequency distribution, Central Tendency Linear Regression	Reports Charts Maps Photos Frequency Distribution on means and modes of transport
Identify and examine the congestion challenges and other challenges that commuters face while moving in and out of the Nairobi Central Business District and possible solutions to these challenges.	Safety Time (intervals) Fares Capacity Routing Cost of Maintenance Pollution Land use space for expansion	Primary and Secondary data (pedestrian and motorist information)	Pedestrians Shop Owners/Business Persons Traffic Police Literature Review	Interviews Questionnaires Photography Discussions with Key informants Observation	Descriptive Analysis Measures of Central Tendency Variability	A comprehensive report with Charts, Maps and Photos
Investigate the potential of aerial cabin transport as a major support in transporting people to the Nairobi Central Business District within identified corridors.	Pass Over Barriers Rapid Installation Integration with other models Safety Efficiency Cost of Implementation	Secondary and Primary (documentation, policies and regulation)	Literature Review Key Informants Case Studies	Literature Review Interviews Observation	Descriptive Analysis	Written Report

3.4 Sampling method

Selection of the streets, parks and bus-stops was done by Purposive Non-Random Sampling. This is because they were be selected on a basis of:

a. Having a good number of people coming in and out of the Central Business District

b. Security concerns for the research assistants

c. Being close to a major bus stop

The streets selected were Koinange Street, Tom Mboya Street, Moi Avenue, Biashara Street and some parts of Haile Selassie Avenue.

On the selected streets, systematic random sampling was used for shop owners with every other shop attendant being issued with a questionnaire starting with the first shop along the street. The same method was used at the various bus-stops like General Post Office, Kencom Bus Stop where every other willing seated or standing person waiting for a vehicle was interviewed.

Purposive Non-Random Sampling was also used to select bus stops for interviews with Matatu and bodaboda crew. Here, once a cooperating crew member was found, snowball sampling was used. Many of the crew suspected the researcher to be an officer from the National Transport and Safety Commission (NTSC) and were therefore reluctant to respond to the some questions.

Convenience Non Random Sampling has been done for offices. The selected offices within the CBD were chosen on the basis of the researcher knowing occupants in those buildings. These included Ambank House, International House, Nation Centre and Victoria House.

Judgment sampling has been done to send questionnaires and interview key informants. These included experts in the field of cable transportation, and urban green transportation both locally and in other parts of the world. Unfortunately those in Central Government, Traffic Department and County government have not been interviewed because of delays in the issuing of a research permit as well as the attempted impeachment of the Nairobi City County Roads and Transport minister.

3.5 Data Collection

Data Collection methods included collection of both Primary and Secondary data.

Primary Data was collected through observation, interviews and issuing of questionnaires. Photographs were taken to record various observations related to the study. Experts in the field of Aerial Cable transportation and urban green transportation were sent interview questions via email.

For the questionnaires and interviews, pre-printed questionnaires and interview forms had been prepared and attached to this proposal at the appendices section.

Secondary Data on usage of the personal trip surveys, cordon line and screen line was available from the Nairobi City County draft master plan. Other Secondary data was obtained from previous plans and proposals that have been prepared for the city of Nairobi like the Study of Urban Transport Needs of Nairobi (Transurb Consult, 1986), The **Nairobi Metropolitan** Region Traffic Decongestion Program and the 2030 Nairobi Metropolitan Spatial Plan.

Two research assistants were hired to collect data from commuters/citizens and business and shop owners. The Research assistants were recruited and trained on how to conduct interviews and deal with respondents. They were also briefed on research ethics.

3.6 Cleaning and Editing Procedures

Once the data was collected, I collated all the questionnaires and other information collected, cleaned and edited it myself.

3.7 Data Inputting

Data inputting for analysis of statistical data was done by the researcher. This was done using SPSS after coding the information.

3.8 Data Analysis

Descriptive Analysis has been used for the qualitative data that has been collected. Measures of central tendency and frequency distribution have been used to analyze the data collected from the various sources particularly on the working characteristics and conditions of public transportation crew. Cumulative frequency charts have been used to analyze public service vehicle fares. Further descriptive analysis has been used to investigate the potential of aerial cabin transportation using case studies.

Whenever computer analysis is possible, it has be used so as to speed up calculations and ensure accuracy. This was done using SPSS.

3.9 Data Presentation

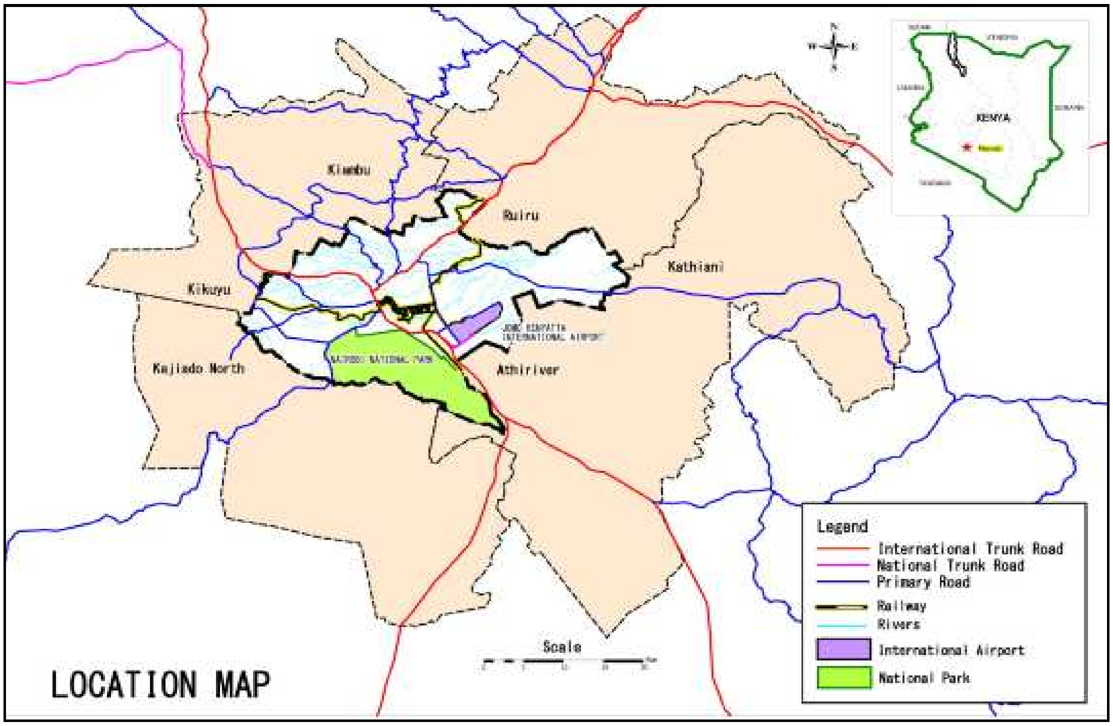
Statistical Data has been presented in the form of pie charts, bar graphs and tables. Photographs have been used where necessary while written reports have also been presented. Frequency distribution charts and maps have been used where necessary and appropriate.

3.10 Ethical Implications

Participants gave voluntary informed consent to participate in the study. They were informed appropriately about the study and the implications of their responses. There was no bias on the basis of gender, disability, tribe or political inclination with regard to issuing of questionnaires. The personal information that they gave like names and telephone numbers will not be shared with anybody.

Chapter 4. AREA OF STUDY

4.1 Area of Study: Nairobi



Map 1: Nairobi City County and its close environs
(Source: Nairobi Urban Master Plan 2013)

In addition to being Kenya's capital, Nairobi is its largest and most populous city, with about eight per cent of the nation's citizens. It accounts for about half of Kenya's economic activity. A high rate of natural growth and the influx of rural migrants are exploding the city's population. Huge areas occupied by informal settlements and slums, ubiquitous traffic jams, and a lack of adequate city planning challenge its ability to address environmental problems such as air and water pollution (UNEP, 2009).

The City County of Nairobi covers an area of 695.1 Km^2 with a population of 3.1 million (JICA, 2013). Excluding Nairobi National Park, the population density is about 5,429 per Km^2. The central division and Pumwani (Kamkunji) division tend to have a higher density than others, in excess of 20,000 per Km^2 (2009 Kenya Population and Housing Census). In 1901, there were only 8 000 people living in Nairobi. By 1948, the number had grown to 118 000 and by 1962, the city had a population of 343 500 people (UNEP, 2009)

4.2 History

Nairobi's name comes from the Maasai phrase "*enkare nairobi*" which means "a place of cool waters". It originated as the headquarters of the Kenya Uganda Railway, established when the railhead reached Nairobi in June 1899. The city grew into British East Africa's commercial and business hub and by 1907 became the capital of Kenya (Mitullah 2003, Rakodi 1997).

4.3 Growth of Nairobi

From 1976 to 2005, as seen by the satellite images below, the city seen growth in settlement both within and beyond its boundaries. It has experienced a lot of sprawl in particular along the major highways.

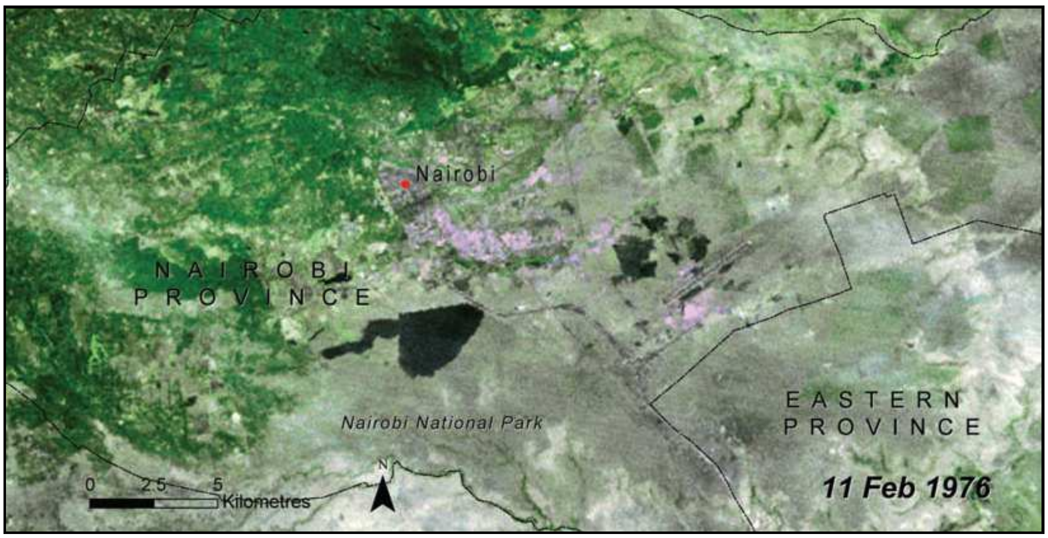


Figure 2 Satellite image of Nairobi 1976

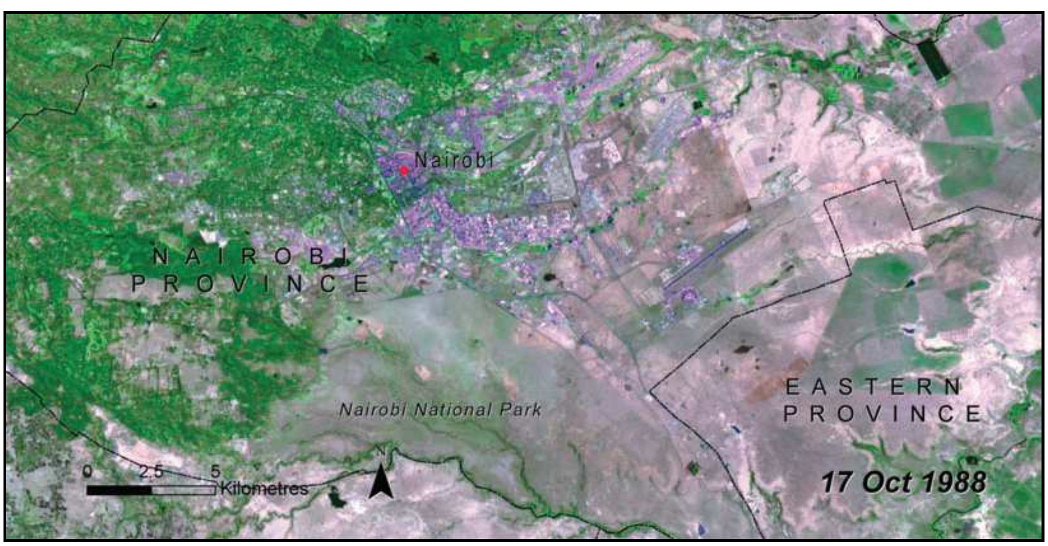


Figure 3 Satellite image of Nairobi 1988

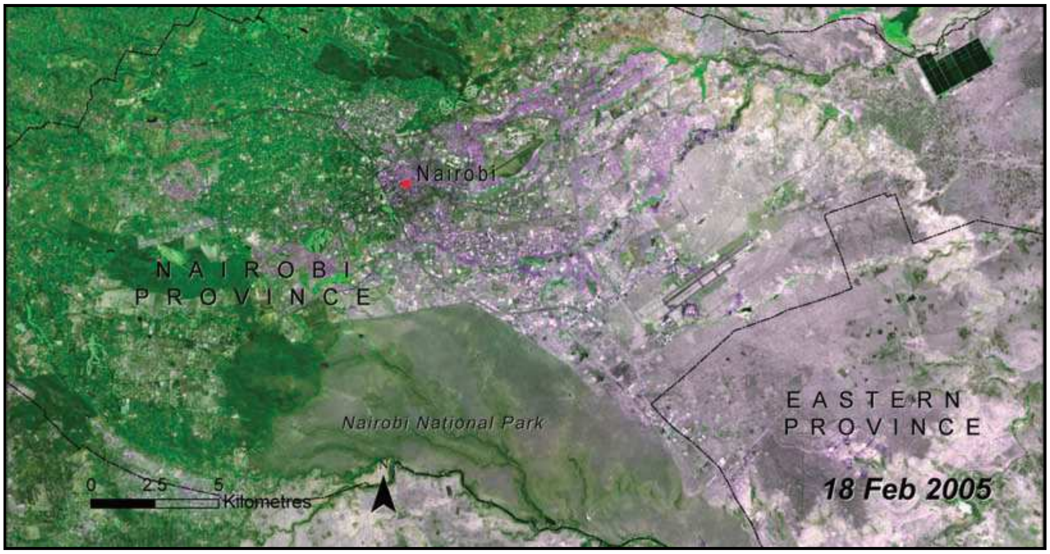
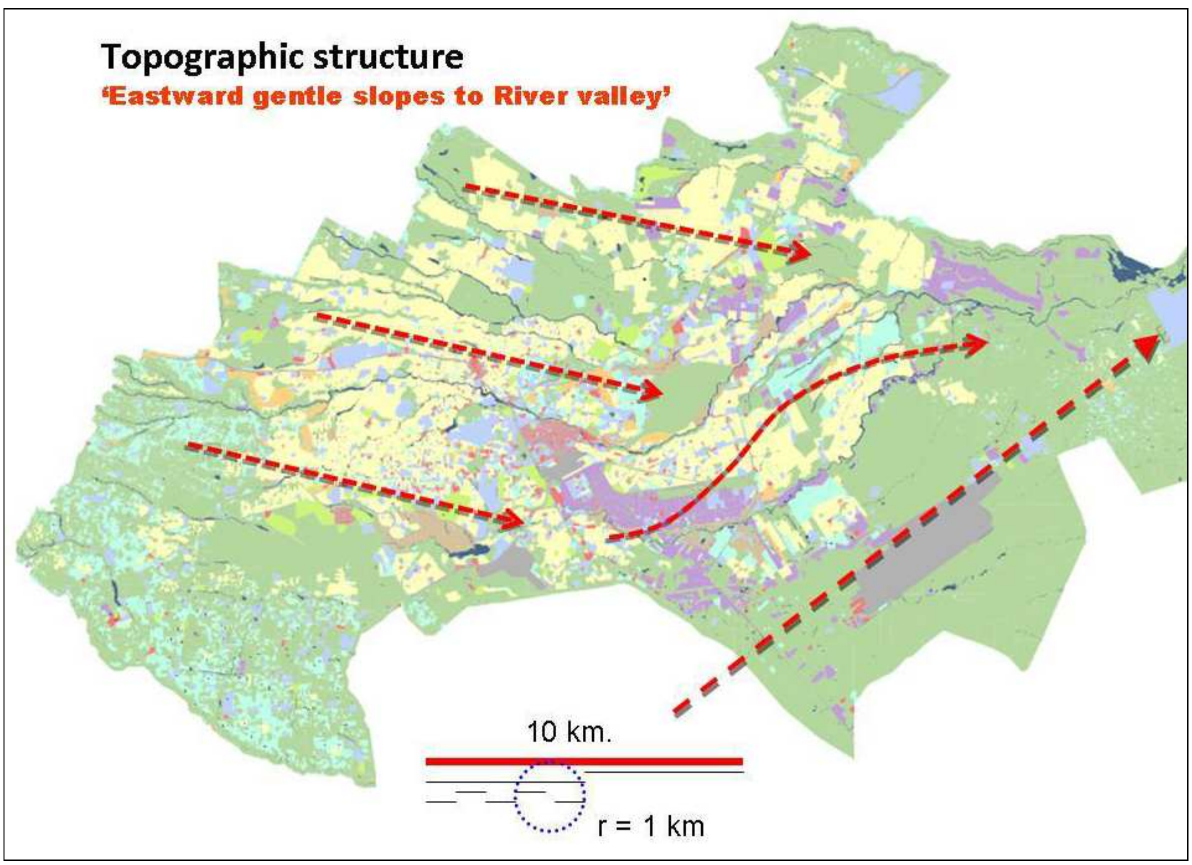


Figure 4 Satellite image of Nairobi 2005
Three Satellite Images showing the Expansion of Nairobi City (Source: Kenya Atlas, UNEP, 2009)

4.4 Physical Features: Climate, Drainage, Soils, Land Use



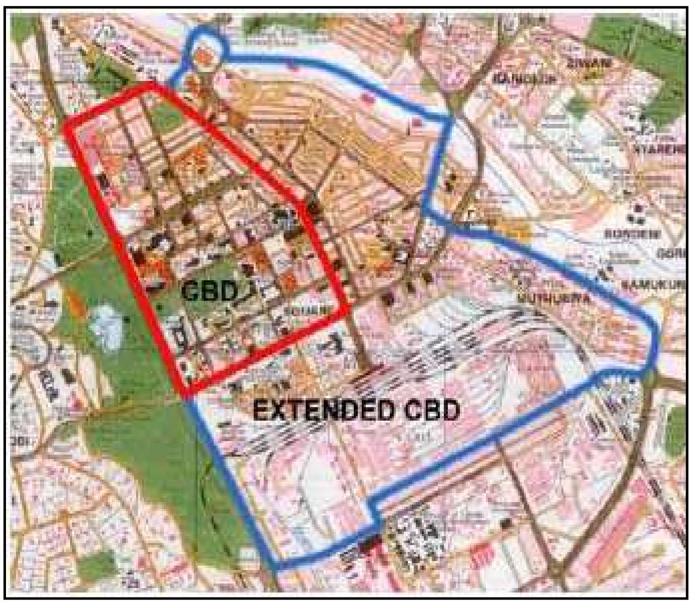
Map 2: Topographic Structure of Nairobi
(Source: Petro Ortiz, World Bank, 2011)

The city of Nairobi is characterized by undulating hilly topography with an elevation in a range of 1,460 m to 1,920 m. Lowest elevation occurs at the Athi River at the eastern boundary of the city and highest at the western rim of the city. It is unique that the city has the Nairobi National Park with the area of 117 km^2 within its administrative area, extending along the western boundary and attracting a large number of international and domestic tourists annually (JICA, 2012).

The climate in Nairobi City is usually dry and cool between July and August but hot and dry in January and February. The average annual rainfall in Nairobi is about 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 28^{o}C to 22^{o}C and the minimum ranges from 14^{o}C to 12^{o}C (JICA, 2012).

4.5 Environment

Nairobi has the greatest concentration of industrial and vehicle air pollutants when compared to any other urban centre in Kenya. Car congestion is an increasing problem and traffic-related costs are estimated at 50 million Kenyan Shillings a day through increased fuel consumption, mechanical damage, and pollution (UNEP 2009). As Nairobi's settlements sprawl outwards, they take over forested and agricultural land, fragmenting and degrading remaining natural areas. The main sources of atmospheric pollution are vehicles, industries, emissions from the use of charcoal and firewood, and other municipal sources such as the open burning of waste. The increasing number of cars in the city intensifies traffic and pollution problems. The Nairobi River also receives improperly treated effluents from the Dandora Sewage Treatment Plant and several drainage channels that gather storm water from Nairobi City.



Map 3 : Spatial Planning Concept for Nairobi Metropolitan Region

(Source: CBD of Nairobi City County)

4.6 Planning in Nairobi

Nairobi Metro 2030 (prepared in 2008) and Spatial Planning Concept for Nairobi Metropolitan Region (prepared in 2013) are considered umbrella plans for the present the Nairobi Integrated Urban Development Master Plan (NIUPLAN). Some of the recommendations and proposals in the Spatial Planning Concept for Nairobi Metropolitan Region will be integrated in NIUPLAN. (JICA, 2013)

Urban design and regional landscape is also proposed in the Spatial Planning Concept, particularly in CBD of Nairobi City County. Following interventions are recommended in the Plan.

(i) Establishment CBD as a City Precinct

(ii) Redevelopment of Moi Avenue

(iii) New Square development in the CBD Area.

(iv) Air force Station area reorganization

(v) Industrial area reorganization & linkages

(vi) Capitol Complex development

(vii) Nairobi riverfront development

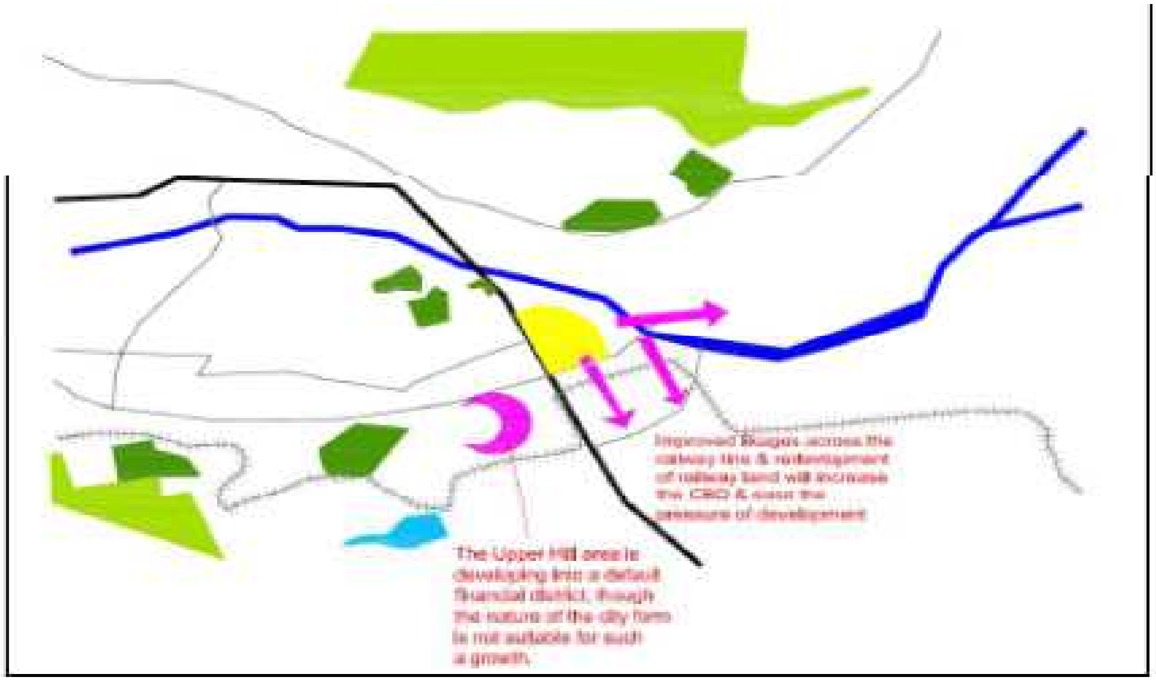
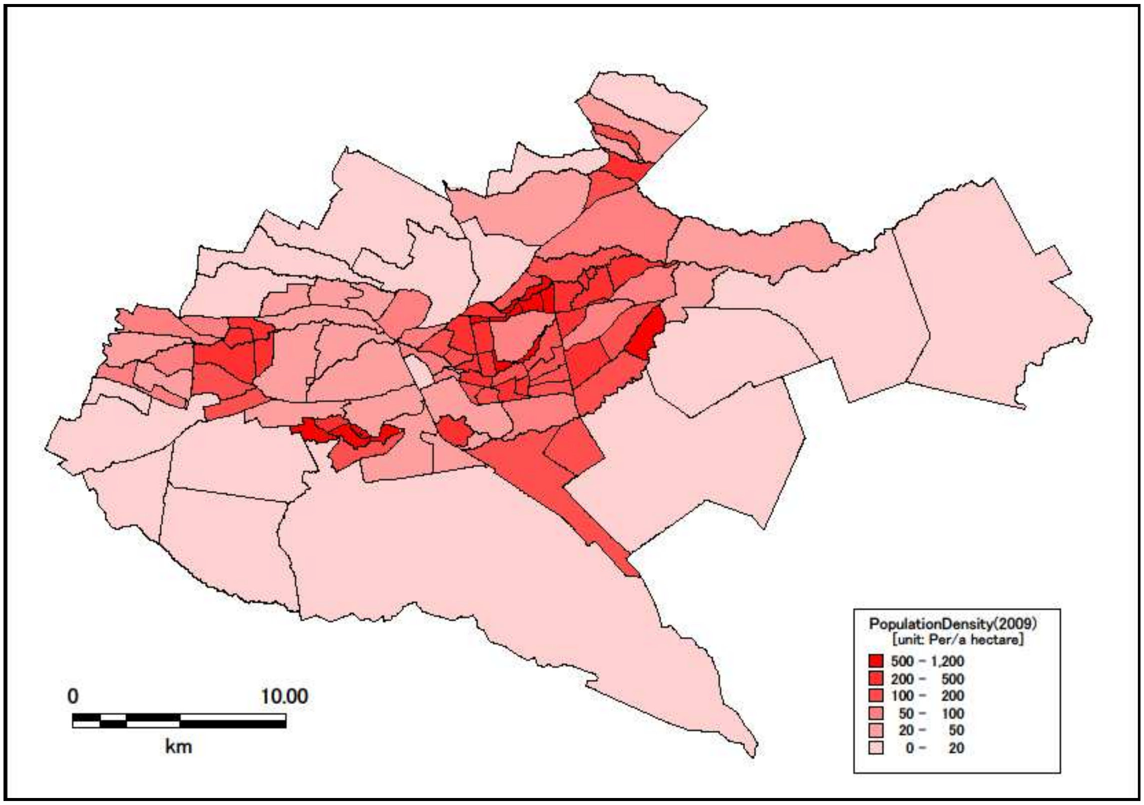


Figure 5 CBD and Its Linkage to Railway, Upper Hills
(Source: Spatial Planning Concept for Nairobi Metropolitan Region)

4.7 Population of the Study Area

The Population growth quoted has over the years dictated changes in the city boundary from 76.8 km^2 in 1927 to cover approximately 680.9 km^2 by 1963. With this type of pressure, a lot of stress has been laid on the provision of public services including health, water and transportation. Transport in this context becomes a burden on both the public and the private sectors because the functioning of any urban centre, like Nairobi, would depend very much on an efficient public transport system (Ombura, 1989).



Map 4: Population Density per Hectare of Nairobi City in 2009
(Source: 2009 Census)

4.7.1 Age Structure Pyramid and Projected Population of Nairobi

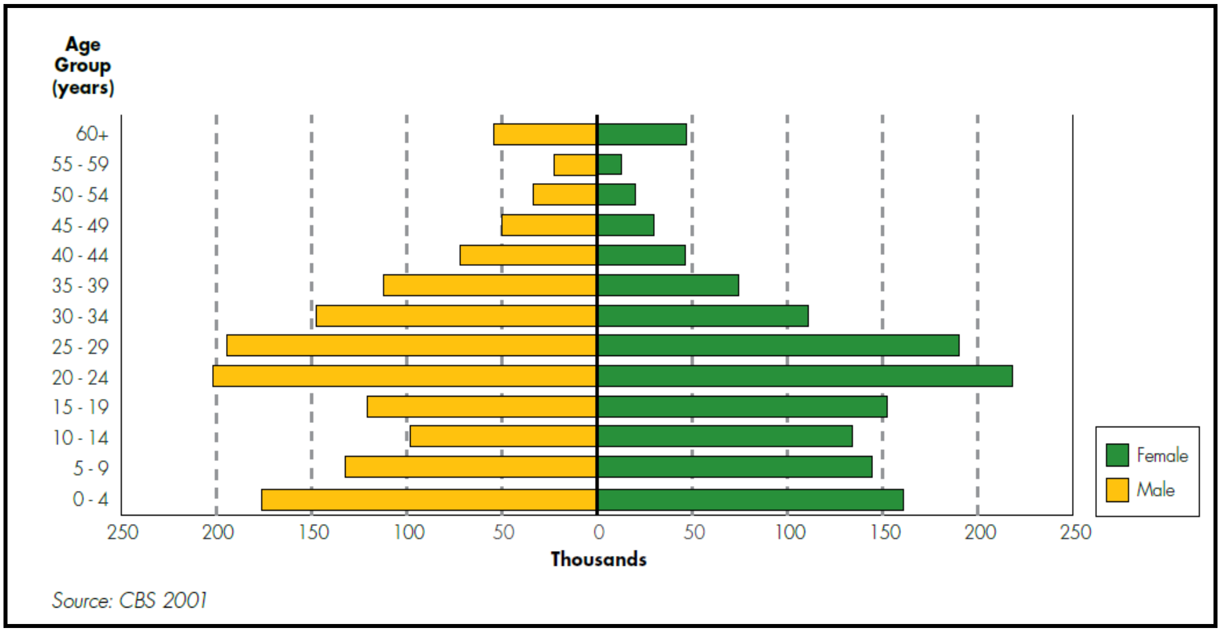


Figure 6: Age Structure Pyramid of Nairobi

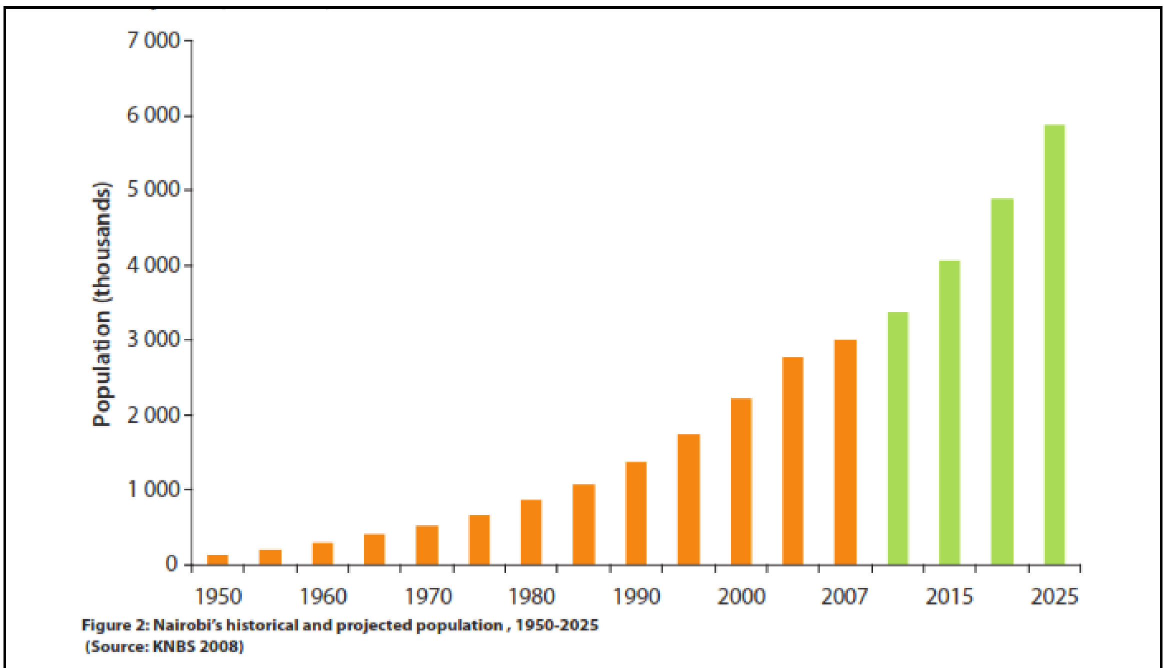


Figure 7 Nairobi's historical and Projected Population, 1950-2025
(Source: KNBS 2008)

This population growth has also seen an increase in the motor and car vehicle ownership. Rising income among the middle class has given rise to increased consumption. This is reflected in increasing car ownership in Nairobi and Kenya in general. The total vehicle ownership in Kenya was 749, 680 units in 2005 and the car population was 320,068.

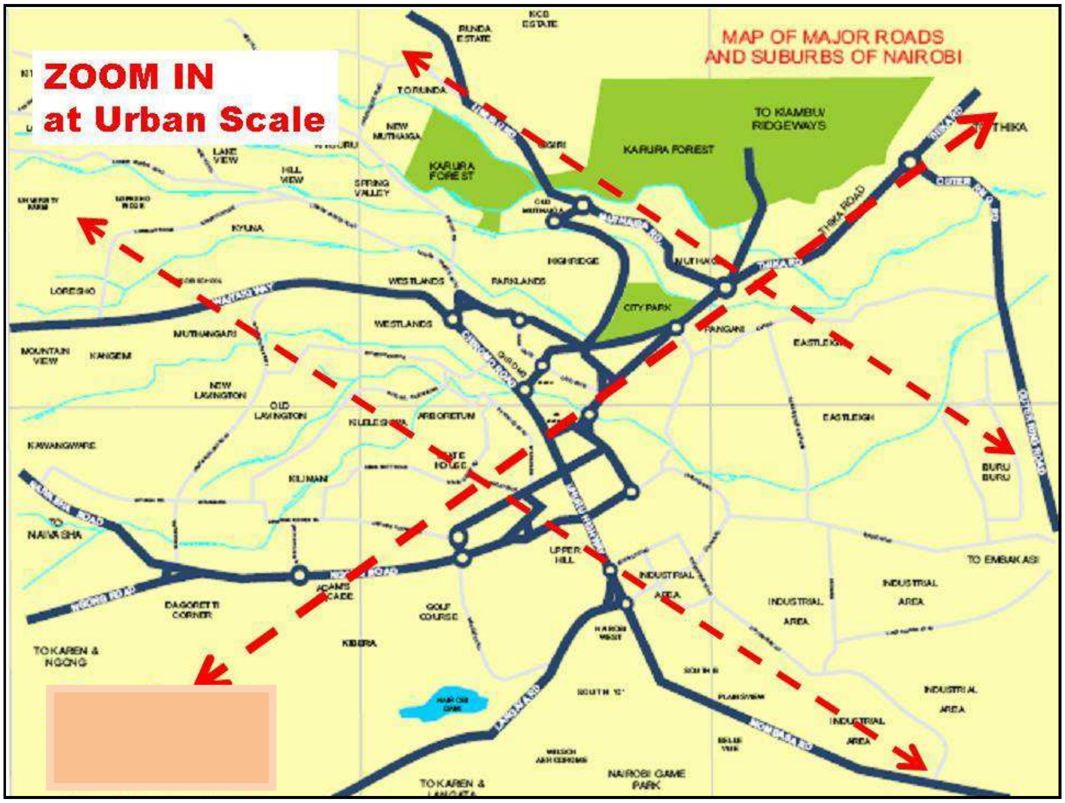
It is however estimated that the city of Nairobi accommodates about 30% of the car vehicle ownership in Kenya.

Year	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Car	211,916	225,078	132,864	244,836	255,379	269,925	286,281	307,772	329,068
Total Vehicle	485,151	549,913	576,477	594,154	611,268	637,613	668,508	711,142	749,680

Table 2 : Estimated Vehicle ownership in Nairobi
(Source: Omwenga M, 2008)

Oritz (2011) states that the current motorization ratio is 0.1 cars per inhabitant (as at 2007) which is expected to increase with time (developed countries have a ratio of 0.7 cars). Should Nairobi reach that ratio, it would imply having a car stock of 2.5 million, based on the population trends (see above) this could easily get to 3.5 million cars by 2020. (Source: Nairobi Propositive analysis)

4.8 Urban Structure of the Study Area



Map 5: Urban structure of the City of Nairobi
(Source: World Bank 2011)

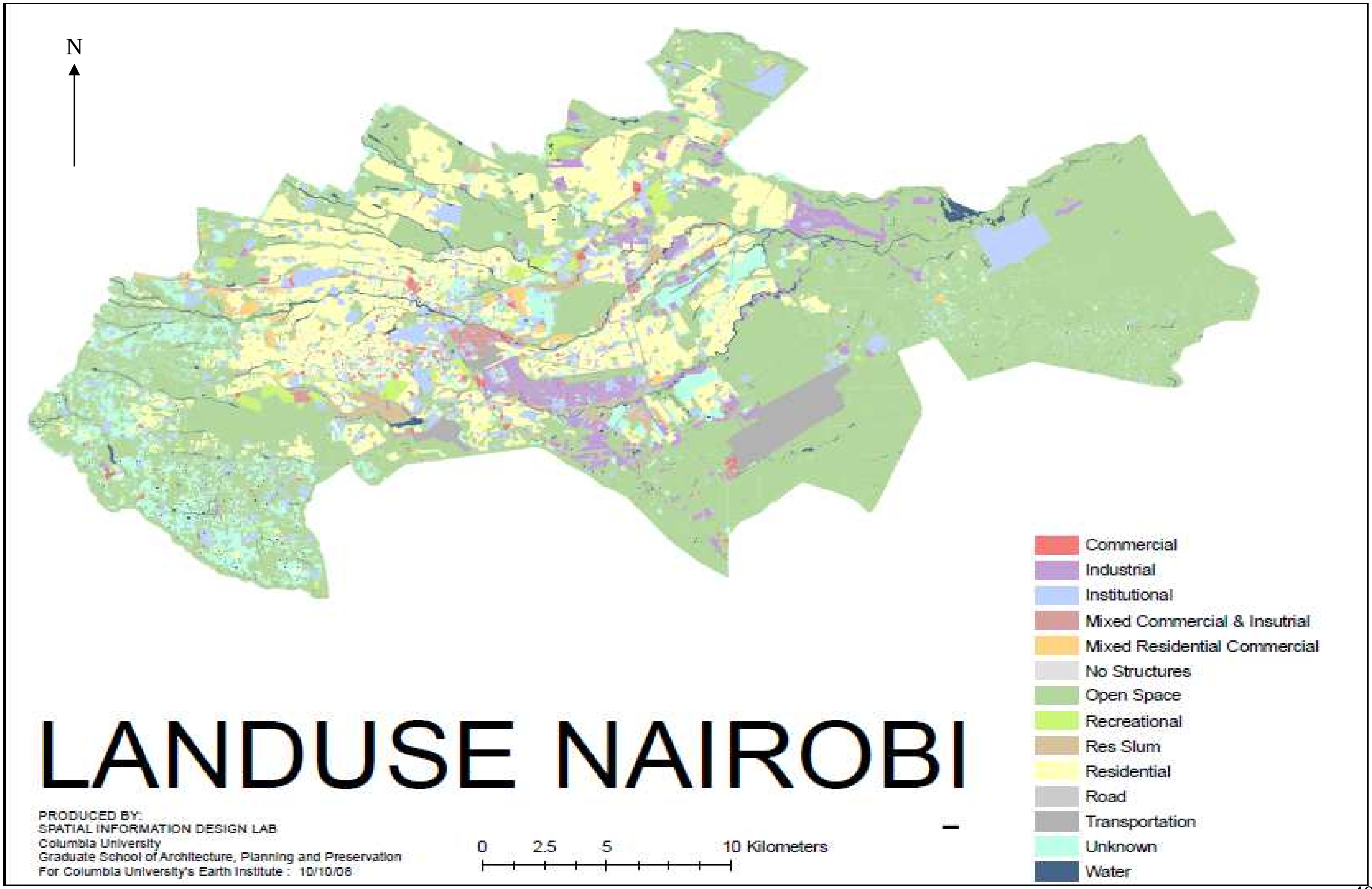
As mentioned earlier, Nairobi slopes from the Western side to the Eastern parts, which lie at flat plains. The urban forms has been stated to have been *defined by the river and followed both by the runways of the international airport and the rail line to Thika.* As seen in the map above the centre of the City is located at the intersection of the axis (Pedro, 2011), forming the Central Business District.

According to Oritz (2011) this feature should be taken into account when confronted with the need to articulate an urban transit system.

The development of the City has been 'disjointed instrumentalist' (Oritz, 2011) not considering the underlying structure or morphology of the area.

4.8.1 Land Use in Nairobi

Map 6: Map showing major land use in Nairobi
(Source: Columbia University)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LANDUSE NAIROBI
PRODUCED BY:
SPATIAL INFORMATION DESIGN LAB
Columbia University
Graduate School of Architecture, Planning and Preservation
For Columbia University's Earth Institute : 10/10/06
0 2.5 5 10 Kilometers
Commercial
Industrial
Institutional
Mixed Commercial & Insutrial
Mixed Residential Commercial
No Structures
Open Space
Recreational
Res Slum
Residential
Road
Transportation
Unknown
Water

4.9 Transportation Factors in Nairobi

Transport in Nairobi has been subject to a number of major studies – 1973, 1979, 1986, 1990, 1993, 1996 and 1998. While most of the studies acknowledged the dominance of trips while walking and public transportation, recommendations have tended to favour the latter and by implication other motor vehicles. Few of these recommendations of these studies have yet been implemented. Lack of financial resources has been the main reason, but failure of Nairobi City Council as both a political and administrative organization has also contributed to the stalemate (Howe 2000).

Plate 1: Traffic Congestion on Mombasa Road towards the CBD
(Source: field Study)

Kiraithe (1989) states that many of the problems that plague public transport operations in Nairobi are attributed to high population growth rate, the poor utilization of infrastructure facilities, the form of urban structure, particularly the location of densely residential areas as well as inadequate policy developments.

Various attempts are being made to decongest the roads in Nairobi. Njoroge (2012) points out projects like the bypasses financed by the Government of Kenya and Chinese government to channel traffic away from the city centre. The Eastern bypass connecting Mombasa Road to

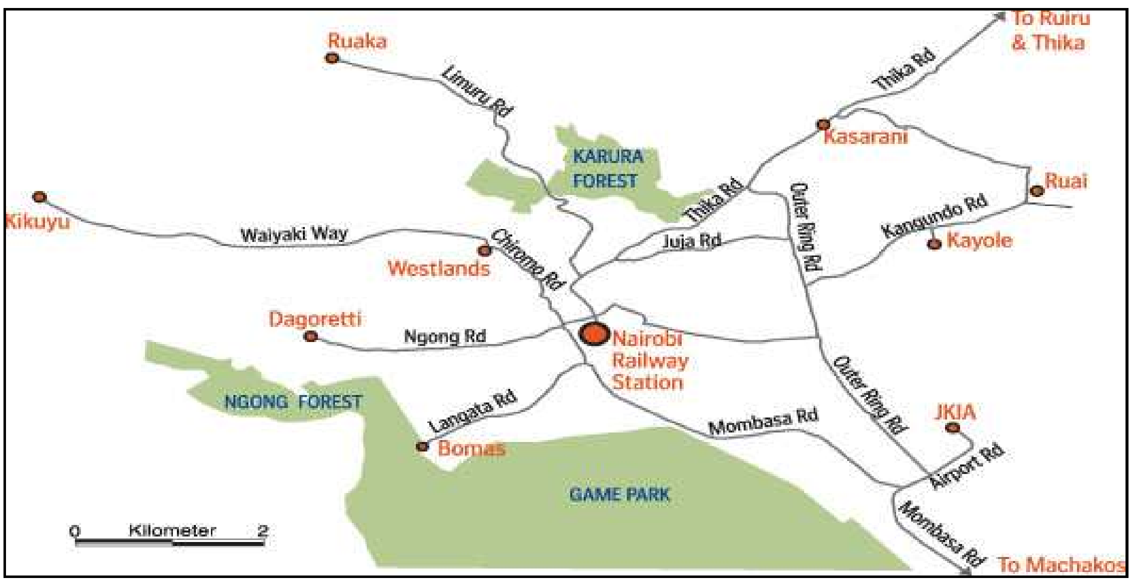
Thika Road, Northern bypass connecting Thika Road and Ruaka area and will eventually connect to Nairobi-Nakuru Highway. Non-Motorized facilities have also been intergraded including walkways, cycle tracks and footbridges.

There are also plans for Light Rail Transit, Bus Rapid Transit Corridors and a proposed Uhuru highway toll road

The current railway line, follows, for engineering reasons, a line of minimum slope and long-term direction. The long-range rail design (to Uganda, to Mombasa, etc.) fits the short-range metropolitan settlement pattern. (Oritz, 2011) The rail line fits within the urban structure of Nairobi serving the main areas of density in Nairobi and the slums. It is thus both an economically efficient socially equitable.

The First Phase covers 25 commuter stations. This will serve 100,000 inhabitants per station, resulting in 2.5 million inhabitants overall.

The second commuter extension is expected to take care of 3 million inhabitants.



Map 7: Proposed new Railway Routes
(Source: Business Daily Africa)

The 2013 Draft Master plan shows plans for a Mass Rapid Transit System (MRTS) though the main Corridors to the Central Business District.

Corridor	EIRR (%)	NPV@12% (mill Ksh)
MRTS 1: Waiyaki Way	11.09%	(-)2,255
MRTS 2: Thika Road	25.52%	97,057
MRTS 3: Juja Road	16.53%	17,598

MRTS 4: Jogoo Road	19.80%	18.654
MRTS 5: Outer Ring Road	20.81%	22.198
MRTS 6: Ngong Road	18.99%	18,431
MRTS 7: Limuru Road	22.31%	8,537
MRTS 8: Langata Road	28.98%	6,775
MRTS 9: Mombasa Road/Athi River	14.23%	2,598
All Corridors Together	19.88%	189,592

Table 3: Results of Economic Evaluation of Mass Rapid Transit System
(Source: Mass Rapid Transit System for the Nairobi Metropolitan Region (MRTS), June 2011)

The results indicate that all the corridors, except Waiyaki Way, are economically viable, as the EIRRs are greater than 12 percent. BRT corridors have higher EIRRs because of their relatively lower costs compared with LRT costs.

Plate 2: Nairobi Central Business District
(Source: Field Study)

Map 8: Major Roads in Nairobi
(Source: Columbia University)

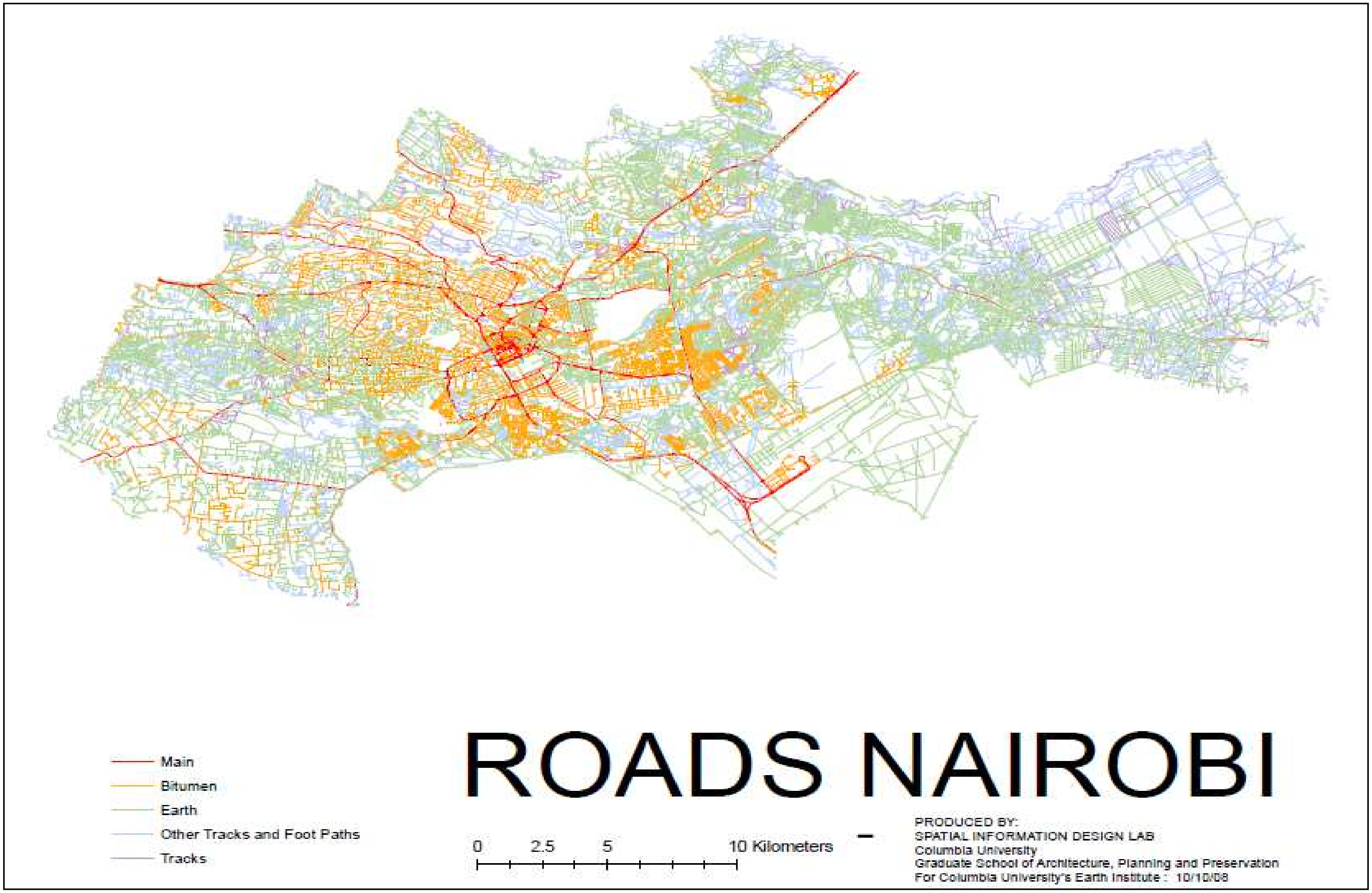
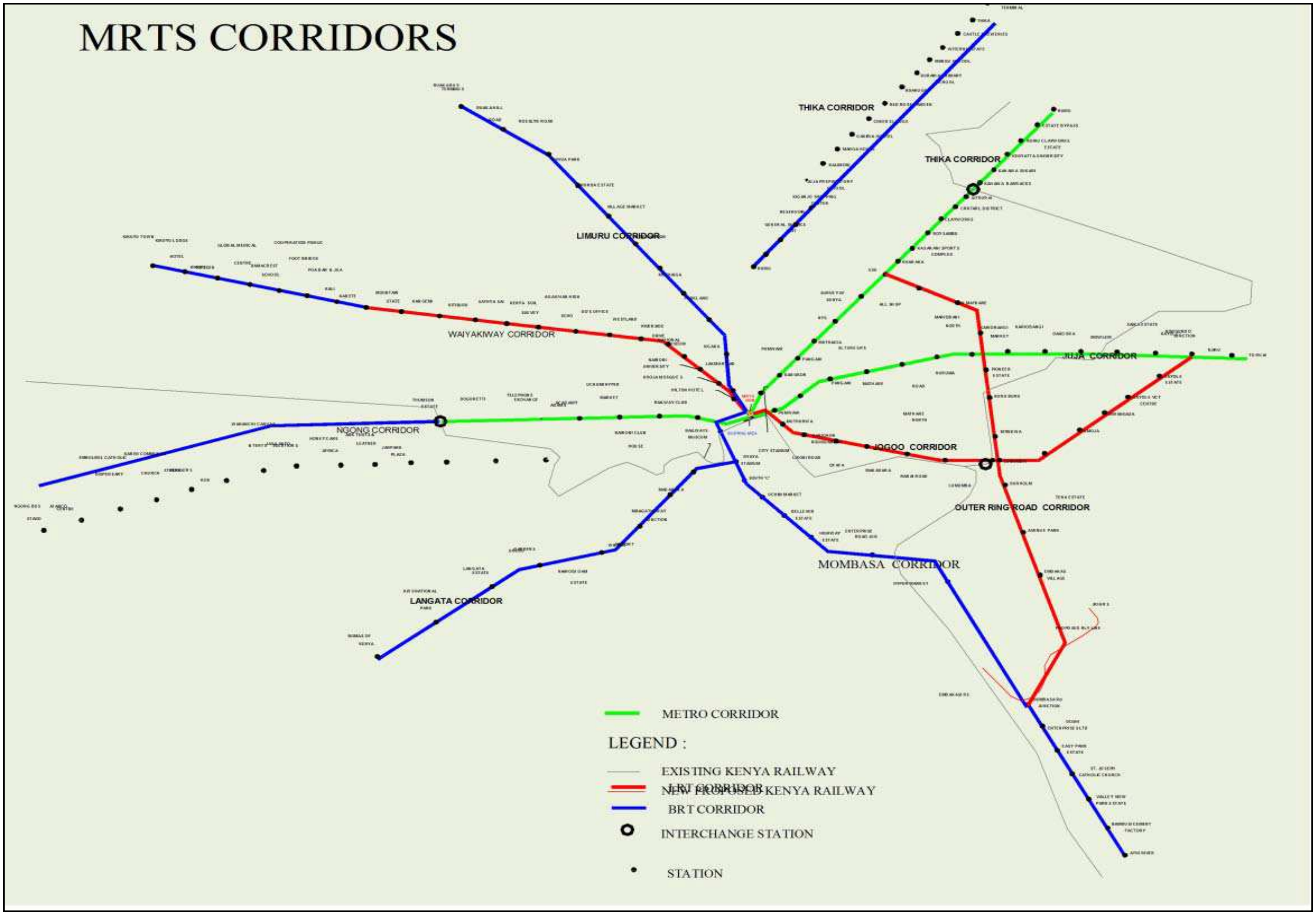


Figure 8 Diagram Showing the Proposed Mass Rapid Transport System Corridors,



4.10 Nairobi Transportation Problems

According to JICA (2008) Nairobi lacks efficient circumferential roads, with the rapid growth in population, traffic congestion in the city has intensified over the years.

Khisa (2013) says that according to various studies, Nairobi Urban Transportation Problems include: 1) Lack of adequate road reserve for expansion of roads coupled with high compensation fees for effecting (compulsory) acquisition. 2) Drainage problems i.e. clogged cross and access pipe culverts, box culverts and side drains. 3) Vandalism of guard rails and other road furniture installed along the roads. 4) High population growth (4%) and urbanization (7-8%) while transportation facilities expansion remains nearly stagnant. 5) Nairobi city has a concentric urban structure with radial transport corridors and concentration of work places is within the CBD. Stiff competition for limited road space including few packing spaces. 6) Traffic congestion on radial trunk roads occasioned by vehicular conflict on at-grade junctions and poor state of roads. 7) Inadequate funding; Lack of adequate financing has led to the deplorable state of roads. This scenario has however changed in the recent past as the Government continues to allocate more funds for improvement of to many urban roads including Nairobi. 8) Uncomfortable public transport characterized by high and unpredictable fares including overloaded and overcrowded passenger transport. 9) Lack of adequate provision for Non-Motorized traffic i.e. footpaths for pedestrians and Cycle tracks for cyclists. 10) Traffic snarl-ups in the city are also occasioned by sub-contractors carrying out installation of utility services on city roads by cutting certain road sections. 12) The high rate of traffic accidents in our city is a very worrying problem; Most road crashes are largely due to a range of human errors (about 80% nationally) resulting from failure to observe traffic rules and a weak enforcement as well as road condition and vehicle factors. 13) In Nairobi, air pollution from vehicular traffic is the major cause of a lot of respiratory diseases.

There has been a tendency to focus on improving the increasingly unsatisfactory conditions for the journey to and from work, as manifest in main road and junction congestion, slow journey times, high fares, etc. The issue of the affordability of public transport, its management in an increasingly laissez faire operating environment, and, as a consequence, the extension of services to the more remote communities, received little serious attention until the study in 1998. Similarly improved facilities for walking and the restoration of an environment that would reinstate cycling also received little attention until the 1998 report. (Howe 2000)

The result has been a steady deterioration in almost all transport infrastructure, and worsening congestion. The main transport modes used by the poor – walking and public transport – or which might be used by them (cycling) have been especially disadvantaged. (Howe 2000)

Ninety three per cent (93%) of traffic at Nairobi boundary originate or arrive at Nairobi, while about 7% is pass through traffic. Passenger cars/pickups command about 70% of Nairobi vehicle counts, 3% are Buses and 27% Matatus. The above 70% of car/pickups users in Nairobi would change traffic mode if parking fees and fuel prices were increased by over 50%. This is a vital consideration in weighing interventions of decongesting our city from vehicular traffic. However, 30% of the car users would not change even if parking fee was increased by 300% or fuel price increased by 100% (Khisa, 2013)

4.11 Attempts at Curbing the Problem of Congestion in Nairobi

Some focus should be made on addressing trip generation and its management through urban planning tools. Land use can influence locations of trip generating facilities and activity patterns. Influencing demand through urban planning can therefore contribute to decreased road traffic and help migrate congestion. (OECD, 2007).

Land use planning includes growth management e.g. regulation of location, density, quality and rate of development. Transport policy, on the other hand, aims to manage existing and future traffic levels that are and will be generated by shifts in trip-making activity, itself linked to land use decisions. (OECD, 2007).

Thus, in order for policy to address the upstream drivers of the traffic that is circulating on a regions roads, it is necessary to integrate traffic planning with land use planning.

A number of studies have been done to look into the transportation problems of Nairobi.

(Ombura 1989)The first major one was the Nairobi Metropolitan Growth Strategy report (1973) which had four main recommendations: 1) Restrictions be placed upon the growth of the present business district. 2) That movement by road be accommodates on a system of new and upgraded existing road. 3) That the whole system of movement be based on a policy of minimizing the need for capital investment by locating workers housing near employment areas by restricting the growth of car ownership and finally by developing a cheap and efficient public transportation service based on an increase in bus service and the establishment of special ways. 4) That the city council establish an autonomous transport authority to control public transport operations and to increase its share to a controlling interest in the operations of KBS in Nairobi

The second is the Nairobi Urban transport project (1979). It appreciated the role of various public transport modes and advocated for the increase in their operating speed through the introduction of protected right of way for the exclusive used of high occupancy vehicles, especially in the central area and its approaches and also creation of new lay-byes for buses and matatus in industrial area and its approaches and adequate access roads in several low income neighbourhoods (Ombura 1989).

The world bank project on urban transportation (1980) notes that Nairobi suffers from -inadequate public transport service and quality, traffic congestion due to obsolete junction designs and inadequate signalization, insufficient road capacity in major road corridors and several key gaps in road networks, a decline in road equipment maintenance standards due to inadequate budgets and obsolete facilities and pedestrian safety. (Ombura 1989)

In 1986 Transurb consul gave three different transport systems to satisfy demand: Bus ways with articulated buses, guided buses operated in separate rights of way or in mixed site and light rail transit operate on segregated rights of way. It argues that bus way would only be relevant in short term, as it can only serve the immediate transport demand problems. Guided buses can meet the demands and be implemented in a short period but is very expensive. Light rail is seen to have the main advantage of solving Nairobi's public problem on term basis, even given that it can only be implemented after long periods of time as it requires long design and implementation (Ombura 1989).

The study also noted that the prevailing traffic congestion problem in Nairobi, and like the 1973 Nairobi Metropolitan Growth Study Group, re-emphasized and restrained car trips into Nairobi's CBD through high parking charges (Ombura 1989).

Statistics have shown that over 47 % of Nairobi's residents walk to and from work (Njoroge, 2012).

JICA (2009) Gave the following anticipated outcomes from their study mentioned earlier: 1)Shorter travel time at off peak 2) Security, safety and convenience of pedestrians and bicycle users 3) Decongestion of surrounding roads 4) Improved accessibility of logistics contributing to the growth of regional economy. 5) Improved living environment for the residents generally through appropriate road network designs and safety standards

According to Mutebi (2012) Nairobi commuters are set to enjoy improved transport services as the government implements a Sh400 billion railway and road master project linking the city to several satellite towns. The project covers 167 kilometres of new roads and rail transport. One of the two corridors to be implemented first is a 13 kilometre light railway line and tram that will run from Nairobi Railways Station (NRS) to Ruiru. It also entails constructing a 28km bus rapid transit system to be used exclusively by special buses, which will charge lower rates than passenger service vehicles. An eight-km tram service connecting NRS and Dagoretti Corner makes up the second project.

“These routes were chosen due to the volume of traffic they handle on a daily basis with the hope that the special bus and rail routes will significantly decongest the city,” said George Wanjau, the Deputy Chief Economist at the Ministry of Transport. The BRT route will be a single carriageway and will run in the middle section of the highway from Jomo Kenyatta International Airport (JKIA) to Kikuyu. (Adhiambo, 2012)

According to an initial blueprint of the project, dubbed Nairobi Toll Road (NTR), would entail paving of a 77-kilometre overpass between the Athi River Junction on Mombasa Road and Kikuyu on the Naivasha Highway. (Adhiambo, 2013). The section between Nyayo National Stadium and the Museum Hill Interchange would have an elevated road with two lanes on each side. (Adhiambo, 2013)

Nduati (2008) proposed that Public service vehicles should be kept out of the CBD. They conduct their businesses at the expense of other businesses and therefore they should not be allowed to cause the increased costs for other businesses. There should be one company allowed to operate in the CBD. The CCN and GoK should establish private parking at the periphery of the CBD – Nyayo Stadium, Muthurwa, Westlands, Muthaiga. Buses should originate from these centres to the CBD. The penalty for traffic offences in the CBD should be deterrent, imposed and payable on the spot. Creation of one way traffic flows. All new buildings should have parking spaces reserved for customers. The current measures of keeping hawkers out of the CBD should continue.

If Nairobi is ever to attain the full economic promise of its talented and hardworking residents, it is going to need to rethink its land use and transport planning around notions of good mixed use land uses supported primarily by a world-class public transit for all supported by safe non-motorized (i.e. bicycle based) transport and walking. To succeed in this decision makers will need to think again about how to support such systems using modern finance mechanisms such as value capture techniques to underwrite continued high quality transport as well as ways to ensure that the high quality system is accessible to both the poor, who can pay little and the middle class who can pay a bit more (Sclar, 2012)

Chapter 5. CASE STUDIES

Over a period of just six years, the cable industry doubled the capacity of their aerial systems and almost doubled their speed. The industry learned how to implement multi-station systems, long lines, full-integration with existing transit technologies and how to accomplish extreme turns.

Additionally, the absurd nature of urban gondolas allowed the technology to fly under the radar of virtually all competitors and a lack of existing research prevented those competitors from learning about cable. (Dale, 2010)

Dale, (2011), further states that hundreds of years of engineering innovation have progressed cable technology to an exciting point in its legacy: The urban Public Transport (UPT) market.

CPT now competes with the performance characteristics of other more common urban transport technologies. It is well known that efficient movement of city dwellers through urban areas is a fundamental requirement for achieving sustainable development. However, he points out that a significant shift in thinking will be required to better market and adapt cable transport technology for cities, eventually fostering its use as a mainstream transportation option.

There are two major challenges that CPT has faced over the years. The first mistake, as pointed out by Dale (2011) is allowing of inaccurate information to flourish and the resulting 'urban disconnect.' The second mistake is the opportunity cost of chasing the wrong installation. Here, planners have installed CPT with a specific focus on the tourism market in the urban environment.

Examples of such failed systems include:

• Harbor Gondola - Baltimore, United States

• Montréal Telécabine - Montreal, Canada

• Freedom Gondola - Detroit, United States and Windsor, Canada

Several metropolitan areas, however, like Medellín, Caracas, Rio de Janeiro, Portland, New York, Algiers and others; have incorporated gondolas and aerial tramways into their public transport networks. Emblematic projects such as these can provide an effective urban transport solution (2001, PCI).

5.1 Gondola Lifts

	Medellin	**Telluride Colorado**	**Roosevelt Island Tramway**	**The Metrocable San Agustin Caracas, Venezuela**
Operational Date:	2004	1996		2010
Cabins:	90	32		50
Cabin capacity:	10 persons	8 persons		
Intervals:	12 seconds	60 seconds	8 minutes peak 15 minutes off peak	24 seconds
Length:	2000m	4000m		1200
Max Speed (Kph)	18	18		18
One-way-trip time:	9 minutes	12 minutes		9 minutes
two-way capacity (phi):	6000	1200		
Construction and funding	55% public, 45% transport authority	Bonding and federal grants		
operation funding	N/A	Real estate and taxes		
Ownership	City/Private	City		
Construction Cost	23 M USD	16 M USD		
2008 Cost/Km	USD 13M	USD 6M		
Function	transit/tourism	transit/tourism		
Yearly Person Trips	14m	14m		
Daily operation	19h daily	16h daily, 275 days/year		

Table 4: Comparison of features of Gondola Systems
(Source: Burnaby Mountain Feasibility Study 2009)

5.1.1 Medellin Metro cable Gondola: (Integrated into a Mass Transit System)

This Metro cable, completed in 2004 is considered to be the first true integration of an aerial passenger ropeway with an existing mass transit network. It is integrated with the subway system in and the passengers are not charged extra fees. The aerial ropeway solution was selected because of the densely populated, challenging terrain as well as to reduce reliance on fossil-fuel-powered vehicles.

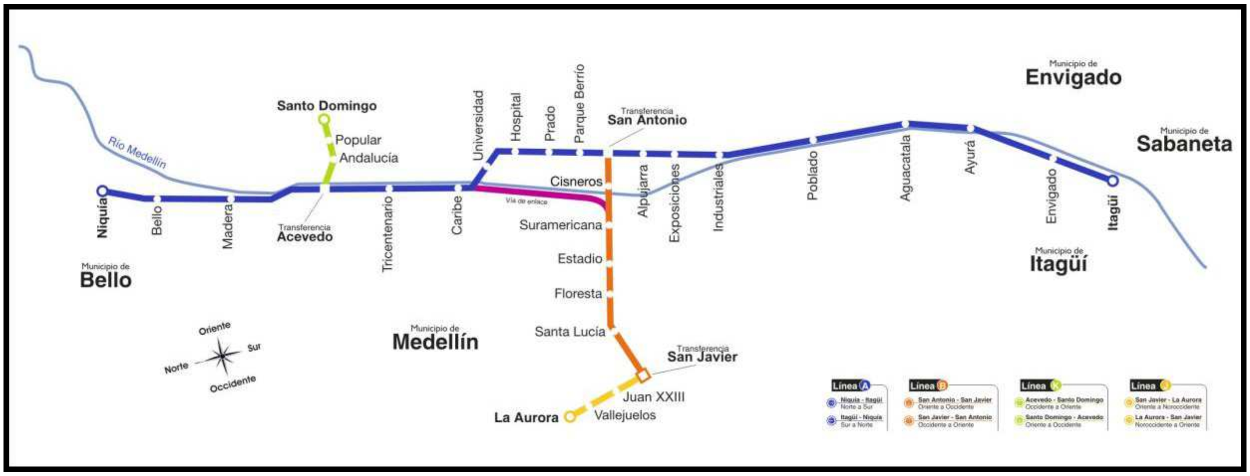


Figure 9 The Metro system with Cable-cars (yellow dotted lies J and K)
(Source: Metro de Medellin)

5.1.2 The Metrocable Mariche – Caracas, Venezuela

This cable is based in a location that has high population, high levels of traffic congestion with a large quantity of heavy trucks and mass transit vehicles, hundreds of jitneys and moto-taxis. It has diversified and mixed middle class neighborhoods as well as low-income zones, commercial zones, factories and educational services. There are long travel times due to road congestion poor transit services (Olivares, 2013).

Figure 10 Image of Metro cable Mariche
(Source: Olivares, 2013)

Characteristics:

Year: 2012•

Length: 4.813 m•

Cabins: 144

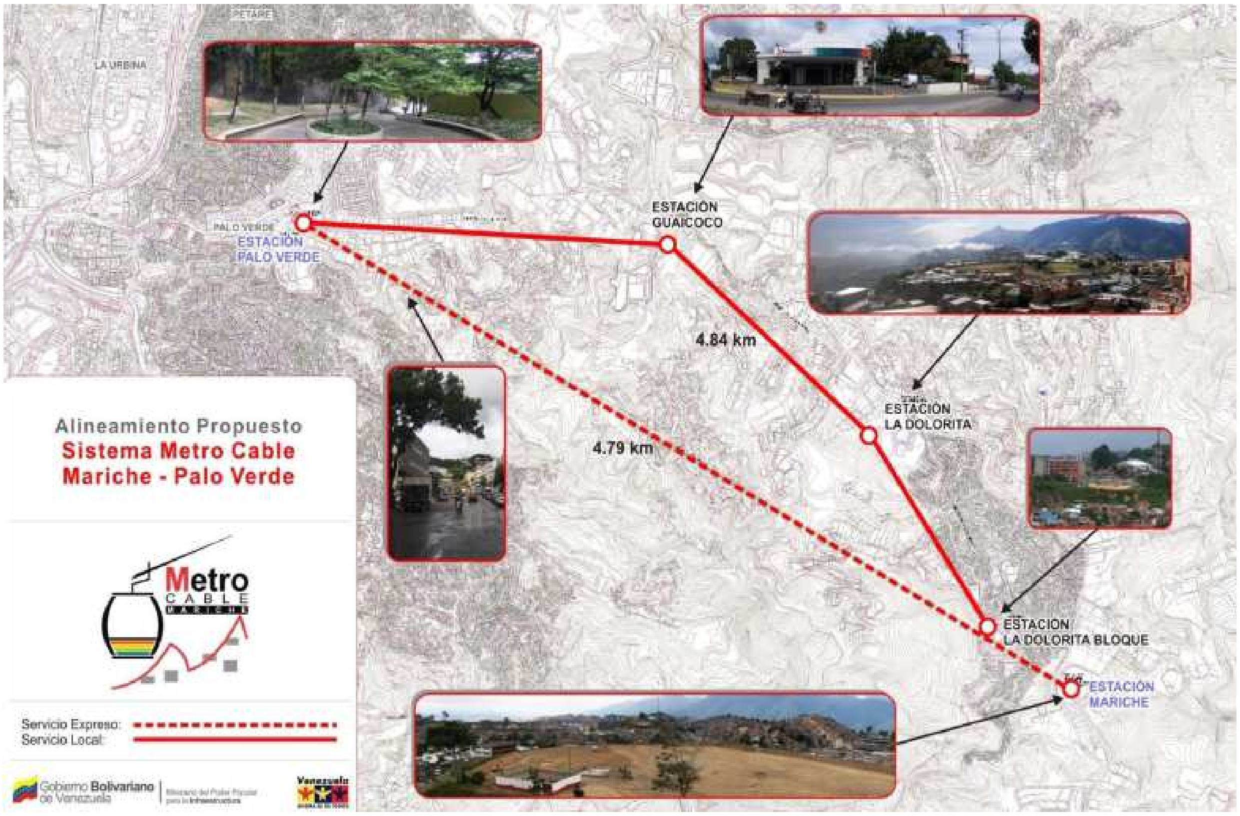
Interval: 14,4s

Towers: 32

Capacity: 2.000 PPHPD

Trip Time: 17,3 min

Speed: 18 km/h



Map 9 : Mariche metro cable line
Source: (Olivares, 2013)

5.2 Key Characteristics from the Successful Case studies in Cable Transportation

5.2.1 Land Use

Gondolas do not occupy large amounts of space. They are beneficial where there is room for road expansion is not available. Case Example: Medellin

Cable systems do have the advantage of overcoming the difficulties associated with getting over dealing with changes in level. Their land take at ground level is very limited, as the space beneath under the cables can be used for other purposes (2001, PCI).

In Caracas, the large stations were built as community centers with spaces for a concert hall, educational facilities, a library with internet access, shops, restaurants, and a sports hall (Olivares, 2013).

The actual minimum dimensions for stations are around 10 meters wide by 25 meters long (50 meters for intermediate stations). The level at which people enter the cabin influences how much land is needed.

5.2.2 Environment and Health

Gondolas have minimum emissions and negative impact on air quality. Thus do not negatively influence climate change like vehicular transport. Case example: Burnaby Mountain

5.2.3 Politics

Gondolas have been seen to have a positive impact in transporting the masses and therefore can win favour of politicians easily. Politicians will invest in what will bring them back into position. The challenge though is where one has fragmented governments; many departments can slow down the development of urban transport. Case example: Caracas

5.2.4 Safety

Over 10,000 aerial passenger ropeways have been built worldwide with an estimated 3.9 billion passengers transported annually. Gondolas, trams and chairlifts are considered to be a safe and secure technology for the transportation of people. Travelers are 20,000 times more likely to be involved in fatal accident in a car than they are in a gondola. The capacity of a cable transport is strictly limited by the maximal weight the cars that the cables can carry. This safety limit imposes a reliable control of the passenger loading on board (Olivares, 2013)

Their real impact on the operation is not so important. The maximum acceptable wind speeds vary from 70 to 110 km/h depending on the technology used. Bicable and tricable systems are more resistant to wind speed.

5.2.5 Energy Use

Electric motors use either diesel motors or generators. They can also use wind tech, as one car climbs the other comes down (Round Rock, Texas).

5.2.6 Disability

One can put a bike or a wheelchair inside the gondola. In some parts of the world, lifts and ramps have been used to access the stations for those with disability. There are ways to stop the gondola if someone needs it to stop and station attendants are there to handle special cases (Round Rock, Texas, 2013). These are beneficial for persons with disability.

5.2.7 Gender

Travel times of women and the nature of their trips are different from those of men. Women may need to be protected from harassment and gondolas take this into consideration though security checks and clear open windows. (Burnaby Mountain) The Caracas system has increased and improved the mobility speeds and options for children, elderly individuals, and pregnant women (Olivares).

5.2.8 Affordability

People are able to use it every day to go to work, school, markets, doctors etc. Cities with lower capital income should not charge high fares so as to enable inclusivity.

5.2.9 Livelihoods

People who must take large trips to reaching workplace ordinarily incur high costs. As a result, people seek jobs in limited areas and vice versa. The system enables them to spend less on transport thus opening up employment options. Employment opportunities are also created within the transport system.

5.2.10 Policy

In the case of France, French regulations governing the design, safety and operation of cable transport systems are split between the Tourism Code (which applies to specific tourist areas) and the Transport Code (2011). Urban transport authorities will be the competent authority for services provided within an urban transport area (PTU).

5.2.11 Economics/Costs: (costs per mile)

5.2.11.1 Costs of construction

The proposal for Aerial Cable line in Round Rock Texas (2013) brought about a comparison between the various costs of implementing transportation projects.

Mode	Cost per mile
Freeway	1 line expansion: $ 2.5 million +
Light rail	35 $ million+
Monorail	132 $ million +
Subway	400 $ million +
Urban Cable	12-24 $ million

Table 5: comparison of costs of construction of various modes of transport
(Source: Round Rock Texas)

5.2.11.2 Operation Costs

It is stated that there still is too little data available on urban cable transport systems to be able to calculate average investment costs accurately (2001, PCI). However, estimates have been made based on various experiences.

System	Monocable	Tricable
Drive station[7]	2.5 to 3 M€	4 to 5 M€
Intermediate station	1.2 to 1.5 M€	
Return station	1 M€	3 to 4 M€
8 to 10 seats cabin	30 000 €	-
35 seats cabin	-	300 000 €
100 seats cabin	-	1 M€
Pylon	100 000 €	500 000 €

Table 6: Breakdown of investment costs in mountain area
(Source CETE of Lyon, manufacturers)

Maintenance and operation costs of cable systems are not well understood outside the manufacturing base. For example: for simple cable systems (one section of line and two stations), these costs are estimated at €1.5 million a year on the basis of 7,000 operating hours. Operating costs are closely related to the salary and overhead costs of operational staff (2001, PCI).

The Burnaby mountain feasibility study estimates operational expenditures per year to be about 3.14 M dollars, consistent with the 3.5 M of Telluride Gondola and Portland 1.3 M, inclusive of consumables and major repairs. Operational costs are based on Energy, Salaries, Maintenance, Insurance and Capital Reserve (Tupper, 2009)

Tupper (2009) also states that the Gondola can be financed in a 'back-end loaded' with payment that are less at the start and more at the end of the 30 year term. When combined with the operational costs, this loan structure produces annual payments less than that of the bus service. Cumulative costs cover 30 years for the gondola and bus is equal to 328 $ and 499$ respectively. Gondola being better value for money (Burnaby Feasibility Study, 2009)

5.2.12 Security of Cabins

Akaigwe (2013), points out that the plan in Lagos for security on cabins is to have CCTV (close circuit television), video displays, passengers address system, all of these have to be built into the cabin. In Caracas it is stated that riders add "eyes on the streets" thereby helping to reduce crime in the area.

5.2.13 Number of Commuters to be transported

The Lagos cabin intends to transport 250, 000 a day when they start operating. When the system itself is fully operational and every cabin is full from morning till night, they plan to carry a million per day (Akaigwe, 2013).

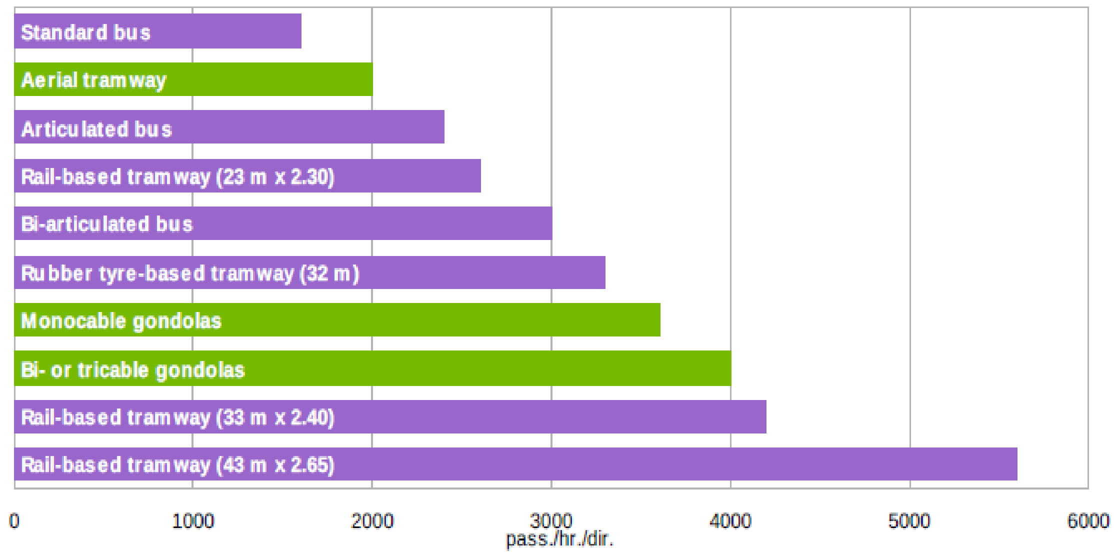
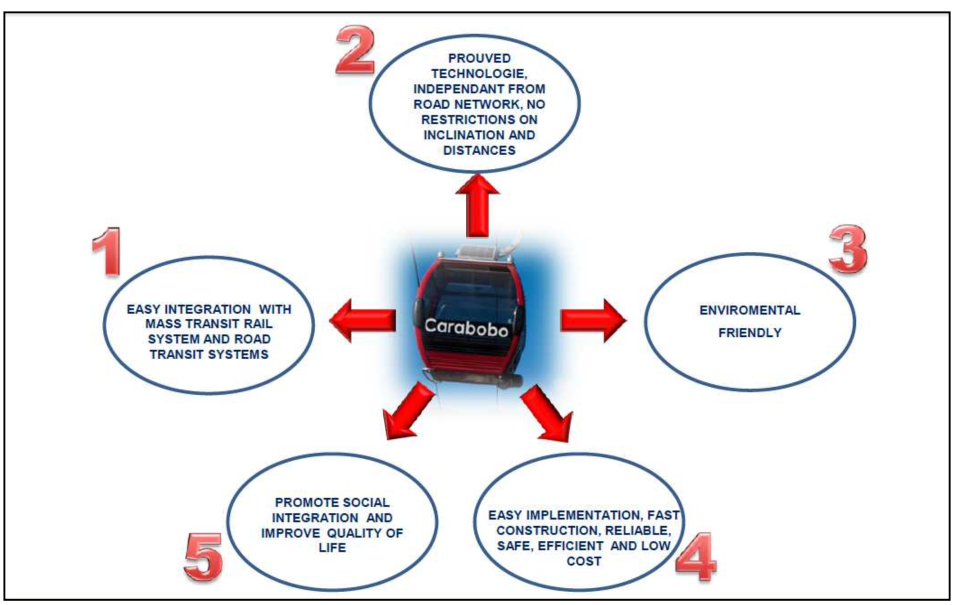


Figure 11: Maximum theoretical capacity of systems – 3 minutes frequency, 4 passengers/m² for buses and tramways
(Source: Certu, manufacturers).

5.2.14 Other Characteristics

In general people do not want to be forced to conform to timetables. They like to have their personal space, and do not like to travel in crowded spaces. In many places, mass transit is dirty as compared to personal cars and this is adequately provided by the gondolas (Round Rock, 2013).

Figure 12: Advantages ropeways solutions *(Source: los metros de Caracas, 2013)*



The Caracas Metrocable has been such a success, Metro de Caracas is planning at least another 9 systems in the city, and the system is acting as a showcase for other cities in Latin America (Olivares, 2013).

Other Newly Proposed Cable Lines include Lima, Peru, Haiti; Mexican Government plans to build 5 Gondola lines near Mexico City while Turkey recently opened a new Gondola system

5.3 Carrying Capacity

Hoffman (2006) states that an important parameter for the assessment of a transport system is the carrying capacity. The carrying capacity Fu of circulating aerial ropeways or funiculars in passengers per hour is given by:

$$F_u = 3600\frac{P}{t}. \qquad (1)$$

In equation (1), P is the number of passengers in a car and t the sequence time in seconds. The sequence time is given by the space A between two successive cars and the travelling speed vF of the system:

$$t = \frac{A}{v_F}. \qquad (2)$$

The carrying capacity FP of shuttle systems results from:

$$F_P = 3600\frac{P}{t_{ein} + t_b + \frac{L^*_{ges}}{v_F} + t_v + t_{aus}}. \qquad (3)$$

With t_{ein} as embarkation time and t_{aus} as disembarkation time of passengers in the stations, t_b the time taken for acceleration of the car on leaving the station and t_v the time taken for deceleration of the car on entering the station, L^*_{ges} the route length over which the car travels at constant speed. From equation (3) it can be seen that the carrying capacity of shuttle systems falls with increasing route length. A larger number of passengers increases the carrying capacity, but also increases the embarkation and disembarkation times.

The limit values take into account currently valid European standards for cableway systems for passenger traffic and those for inclined lifts take into account the European standards for lifts.

type	limit acc. to standard	limits of realized or precently planned types			
	driving speed in m/s	driving speed in m/s	route lenght/section in m	capacity in passengers/car	carrying capacity in passengers/hour
continuous movement bicable aerial ropeway	6 to 7 [1]	5 to 7	up to 5,500	up to 17	up to 4,000
continuous movement monocable aerial ropeway	6 to 7 [1]	5 to 7	up to 5,000	up to 15	up to 4,000
continuous movement funicular	12 [1]	10 to 14	up to 5,000	up to 50	up to 5,000
reversible funicular	12 [1]	10 to 14	up to 5,000	up to 450	up to 8,000
inclined lift	undetermined [2]	1.5 to 5	up to 300	up to 30	up to 500

[1] ... according to [5]
[2] ... according to [4]

Table 7: Limits/Capacities of cable drawn urban transport systems
(Source: Hoffman, 2006)

Chapter 6. RESEARCH FINDINGS

6.1 Gender of Respondents

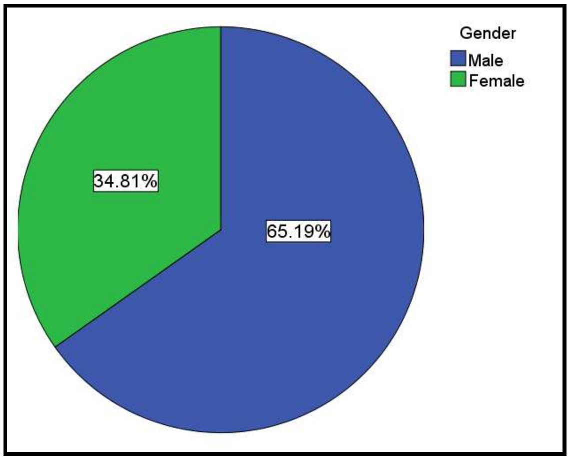


Figure 13: Gender of respondents
(Source: Field Study, 2014)

The vast majority of respondents were male who stood at 65.19 %. Female respondents were 34.81 %

6.2 Ages of Respondents

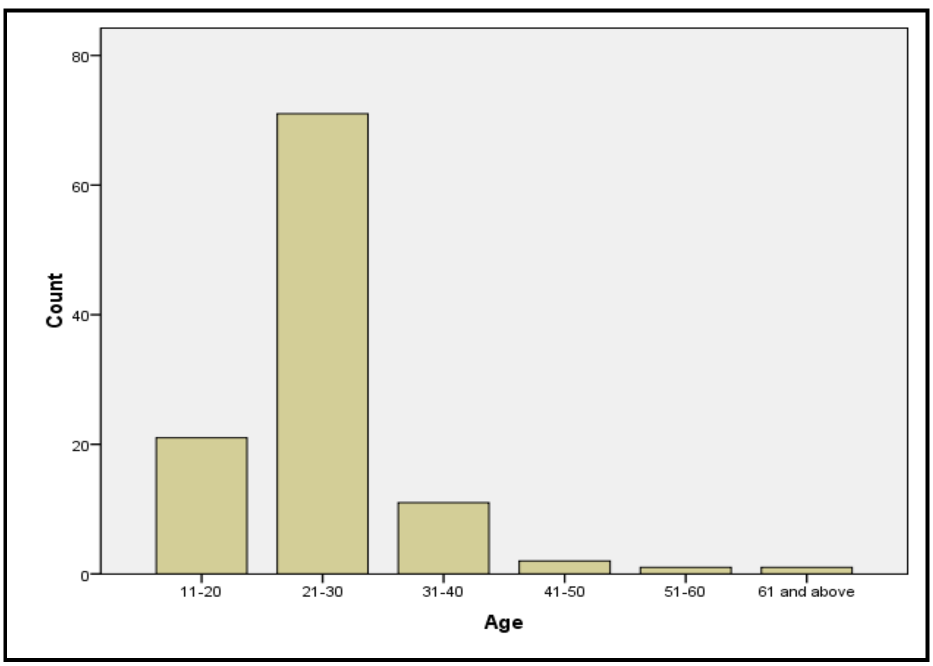


Figure 14: Ages of respondents
(Source: Field Study, 2014)

Majority of the respondents were between the Age group and 21-30 followed by 11-20, most of who were between 18 and 20. There were less than 20 respondents who were between the age groups of 31-40, 41-50, 51-60 and very few whose age was 61 years and above.

6.3 Estates of Residence and PSV routes used to access CBD

The respondents come from a large variety of neighbourhoods and estates in and out of the county of Nairobi. These cover several different matatu and bus routes. A few of them are covered by the train system. Respondents came from over 55 different estates within the city of Nairobi. Those who use public means use over 40 different routes. Estates Varied from Ngumba, Highrise, Zimmerman, Karen, Ngara, Kayole, Buruburu, South C, Huruma and Several Others. There were also respondents who are based in the Central Business District but reside outside the county in places like Syokimau, Kikuyu, Ongata Rongai and Juja. Thus citizens from all sub-counties within the county were interviewed. However, there were very few people from informal settlements interviewed. This was because of the sampling frame chosen. Studies have shown than most people from informal settlements walk to their workplaces and are involved in either semi-skilled or unskilled labour which is not found within the CBD.

6.4 Purpose of people in the CBD

Most of the people interviewed were in the Central Business District for professional purposes, employment, business and students. A few were in transit and other reasons.

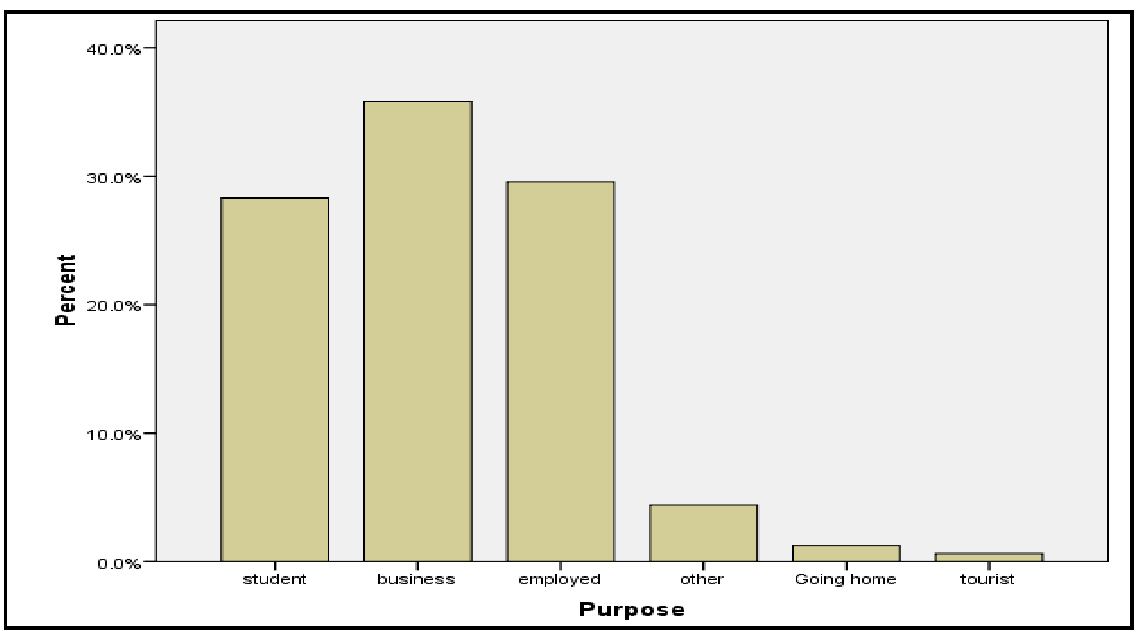


Figure 15: Ages of respondents
(Source: Field Study, 2014)

6.5 Means used to travel to CBD

Although it is stated that majority of Nairobians walk to the workplace (Nairobi Masterplan 2013), as most of the respondents were not from the informal settlements, majority of those interviewed access the Central Business District through public transport i.e. buses and matatus. A good number also access with personal vehicles.

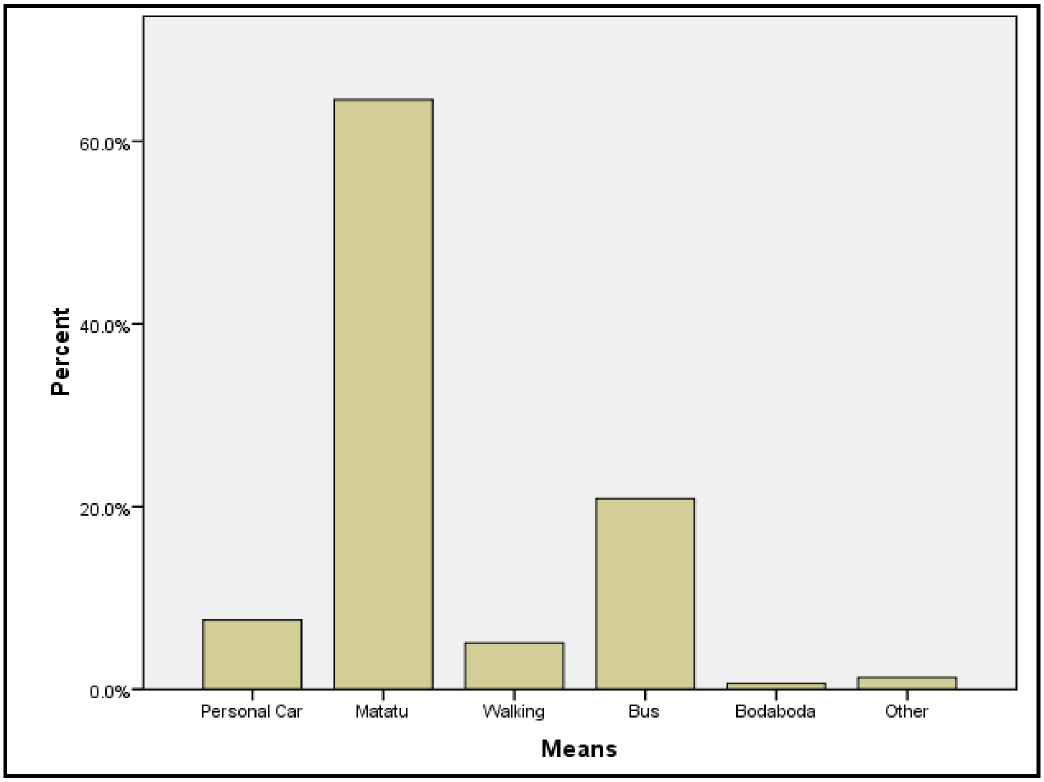


Figure 16: Ages of respondents
(Source: Field Study, 2014)

6.6 Routes used to access the CBD

The data collected on routes used to access the CBD as per the figure below, conforms to secondary data collected via cordon line survey done for the Nairobi County government Integrated Development Master Plan identified Jogoo and Landhies road as having the most dense vehicular traffic. Closely following was Mombasa road, and based on these findings, one must note that those using Langata join into Mombasa Road to Uhuru Highway via Nyayo Stadium Round-about or Aerodome road.

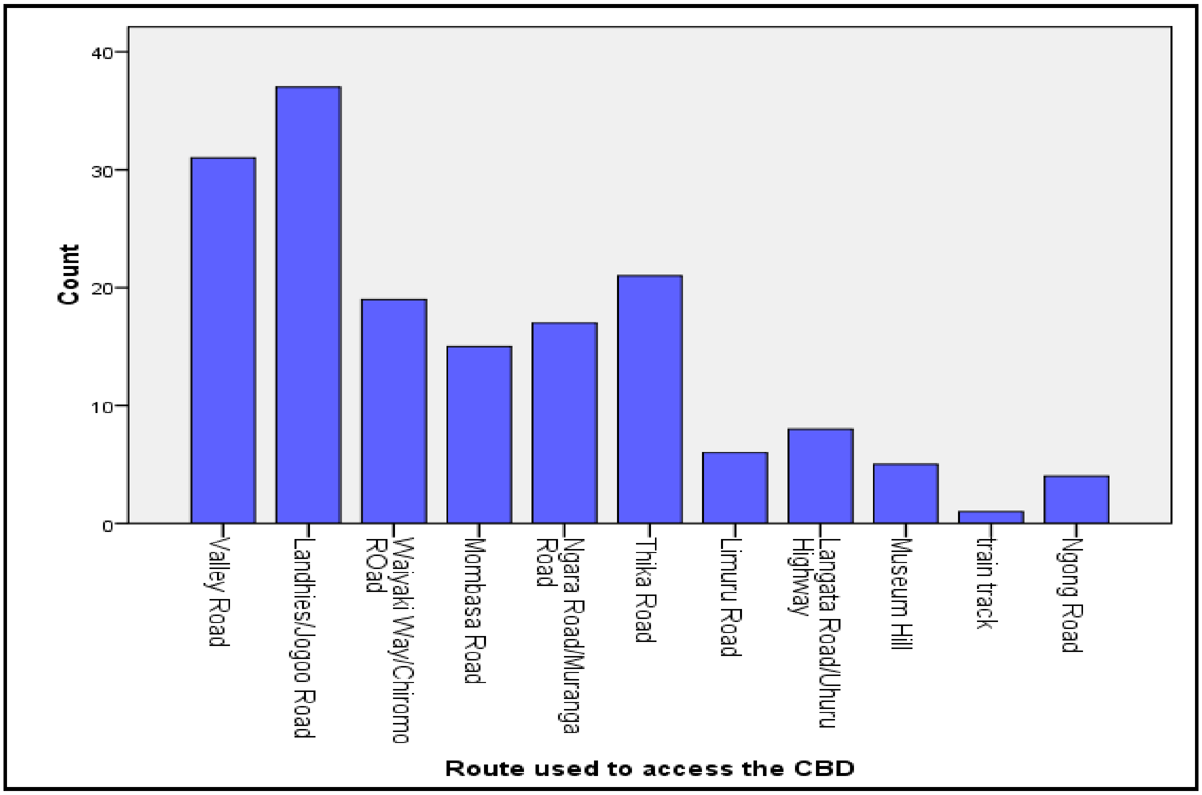


Figure 17: Routes used to access the Central Business District
(Source: Field Study, 2014)

Comparison of 24 hour total traffic volume between 2004 and 2013 shows a change from 121,096 vehicles top 204, 675 vehicles.

Increase in private car from 106,000, which is a 63 % of vehicle increase. Though there is a small increase in matatu use, the number of passengers each carries gives a lot of weight to the number of people accessing the CBD.

Road	**Count in 2004**	**Count in 2013**	**Method used**
Waiyaki Way	15,943	25,014	screen line 12hours
Chiromo Road	31,943	57,159	Roadside traffic count
Mombasa Road (Near Nyayo Stadium)	42,448	46,767	Roadside traffic count
Langata Road	33,049	36,049	Roadside traffic count
Haile Selassie Avenue	36,012	25,564	Roadside traffic count
Jogoo Road	56,161	42,711	Roadside traffic count

Table 8 : Screen Line and Road Side Traffic counts have shown the following results on the major access roads to the CBD

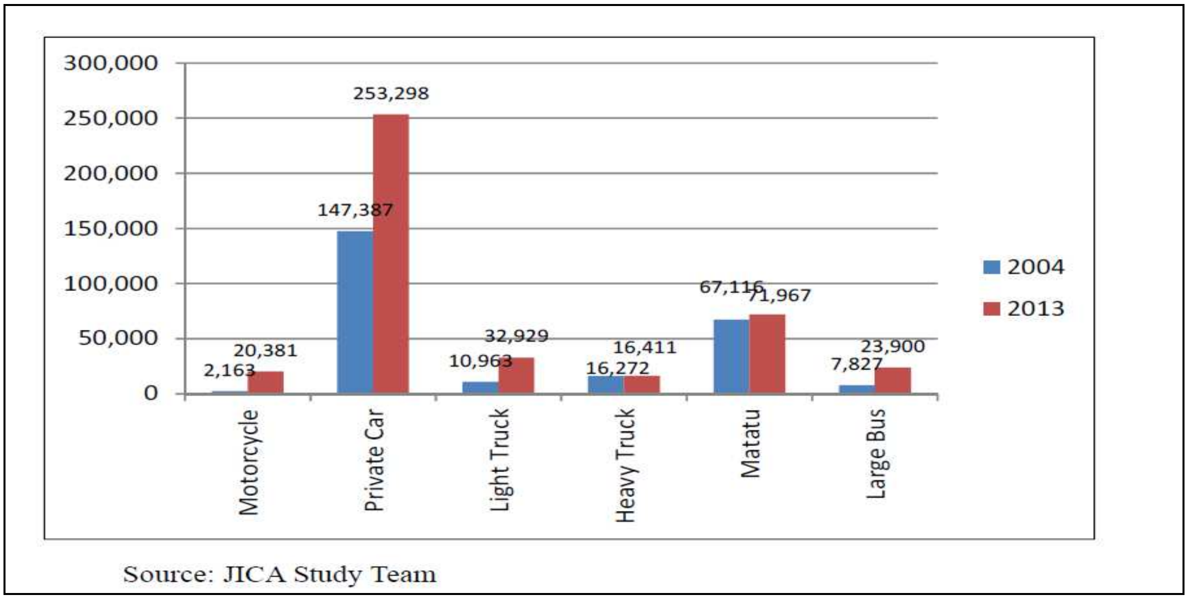


Figure 18: **Comparison of Screen Line traffic by volume of vehicle type between 2004 and 2013**
(Source: JICA)

6.7 Public Transport: Time spent going to CBD

The amount of time it took people who use public transport to travel from their boarding point (bus stop) to the Central business district varied but most take over fifty minutes to get to the Central Business District.

Figure 19: Time it takes to get to the central business
(Source: Field Study)

This is in spite of the fact that there has been a shift in the peak hours in the City of Nairobi as shown in the chart below. Nairobi has seen a change in this from 7:00-8:00 a.m. to 6:00 -7:00 a.m. evidently the morning peak starts from 5:00-6:00 a.m.

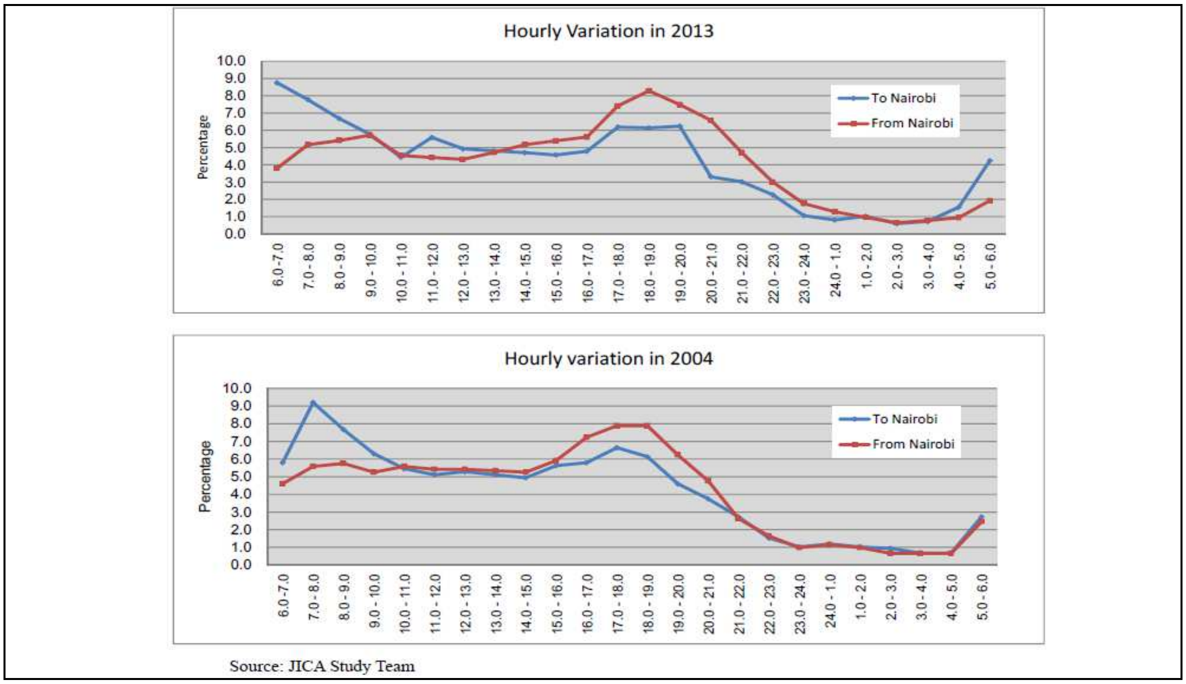


Figure 20: Comparison of cordon line hourly traffic variation between 2004 and 2013
(Source: JICA)

Only 18 percent of the respondents had used Rail to come to the CBD. However, of even those who did not use rail, 80%percent felt that rail transport was a positive option in decongesting the city. 13 percent do not think so while 4 % are not sure.

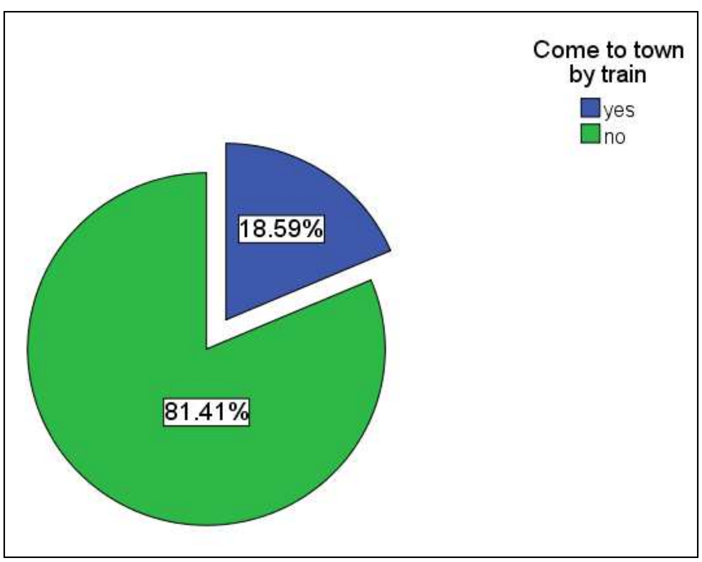


Figure 21: percentage of respondents to come to town by rail
(Source: Field Study)

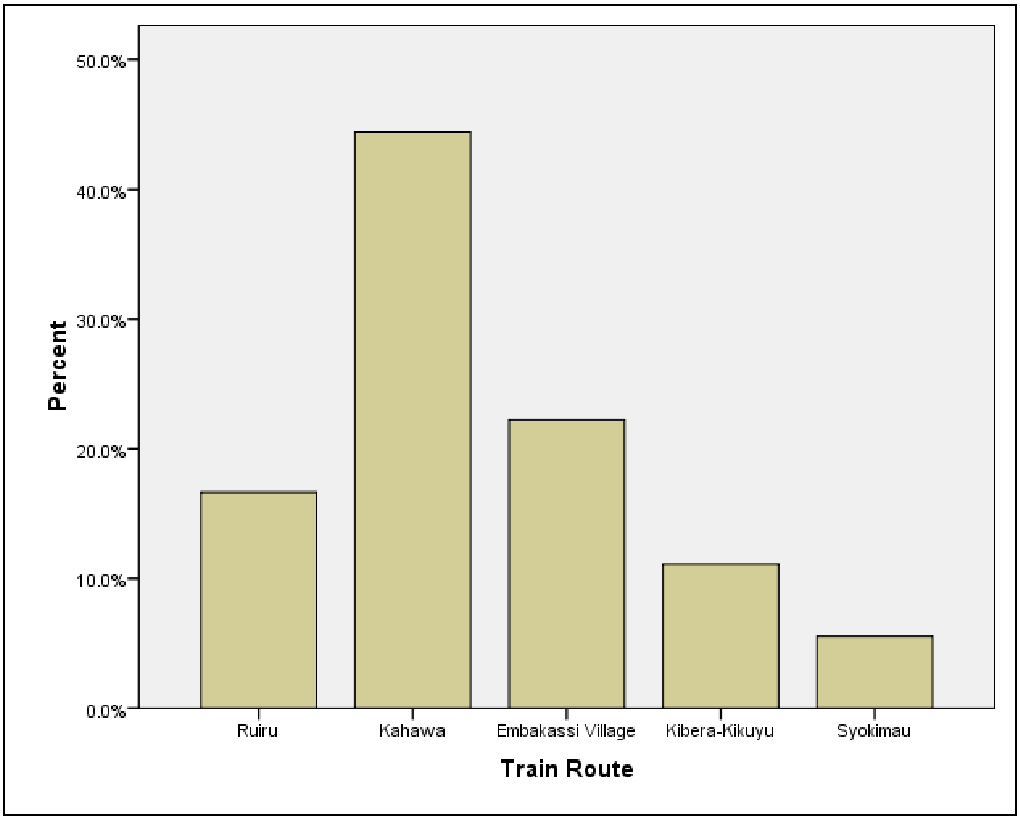
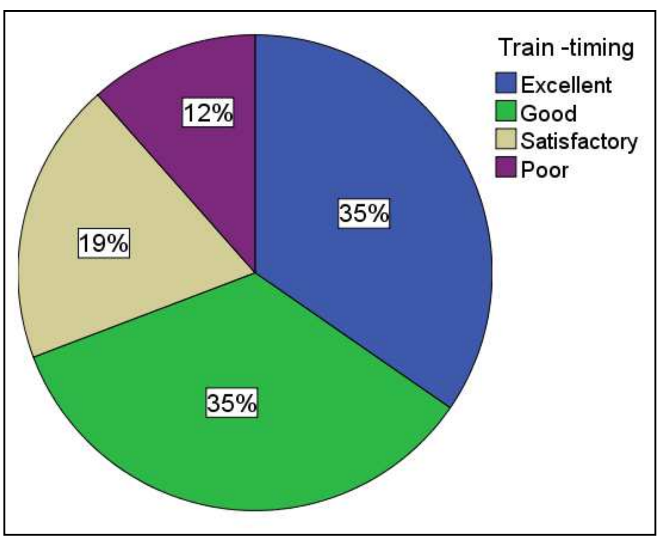


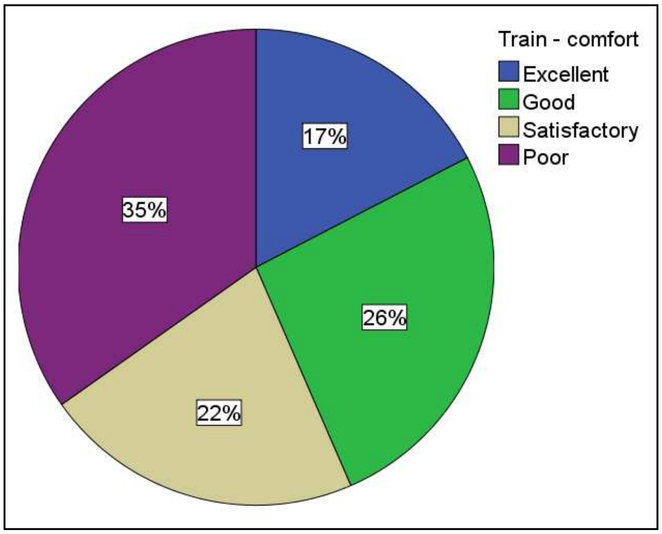
Figure 22 Train routes used by respondents who access the CBD
(Source: Field Study)

Of those who come to the CBD by rail most use the Kahawa Sukari line. The comments on the quality of service were as follows:



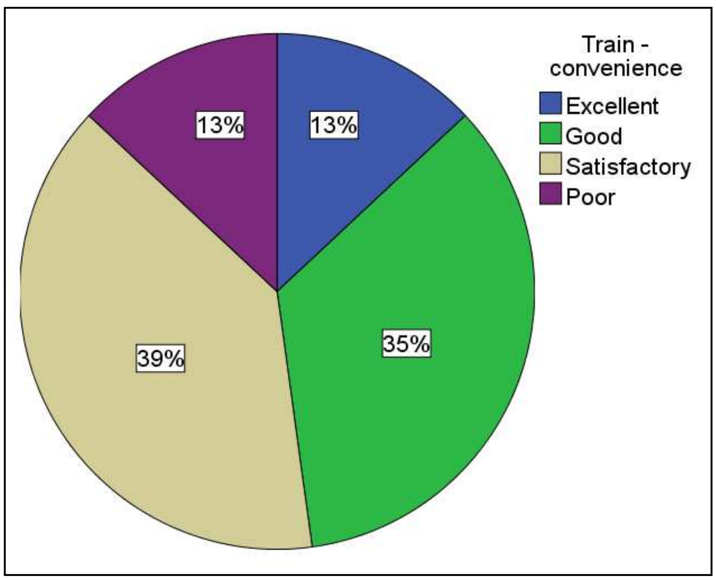
A good number of respondents were happy with the timing of the train service (35% Excellent and 35 % Good) and only a minority found the timing to be poor.

Figure 23 Respondents Views on the timing of the commuter train service
(Source: Field Study)



The majority of those who use the commuter train service do not find it comfortable with 35 % stating that it was poor and 22 % stating that it was Satisfactory.

Figure 24 Respondents Views on the timing of the commuter train service
(Source: Field Study)



35 % of the commuter train users interviews find the convenience to be 'Good' while 39 % found it to be satisfactory. A minority of 13% found it to be wither excellent or poor.

Figure 25 Respondents Views on the timing of the commuter train service
(Source: Field Study)

6.8 Public Transport Bus Fare

Majority of people coming to the CBD pay bus fare in the range of KES 51 to 100 for one way and the same amount while travelling back home.

Table 9: Fare spent by people while travelling to town from their areas of residence
(Source: Field Study, 2013)

Fare: town from home						
		Shillings	Frequency	Percent	Valid Percent	Cumulative Percent
Valid		0-20	11	5.3	7.2	7.2
		21-50	52	25.2	34.0	41.2
		51-100	72	35.0	47.1	88.2
		101-200	9	4.4	5.9	94.1
		201-300	4	1.9	2.6	96.7
		301-500	4	1.9	2.6	99.3
		501 and above	1	.5	.7	100.0
		Total	153	74.3	100.0	

Table 10: Fare spent by people while travelling from town to their areas of residence
(Source: Field Study, 2013)

Fare: Travelling Home					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-20	5	2.4	3.2	3.2
	21-50	46	22.3	29.7	32.9
	51-100	86	41.7	55.5	88.4
	101-200	8	3.9	5.2	93.5
	201-300	5	2.4	3.2	96.8
	301-500	3	1.5	1.9	98.7
	501 and above	2	1.0	1.3	100.0
	Total	155	75.2	100.0	

6.9 The Capacities of PSVs used by the respondents were as follows

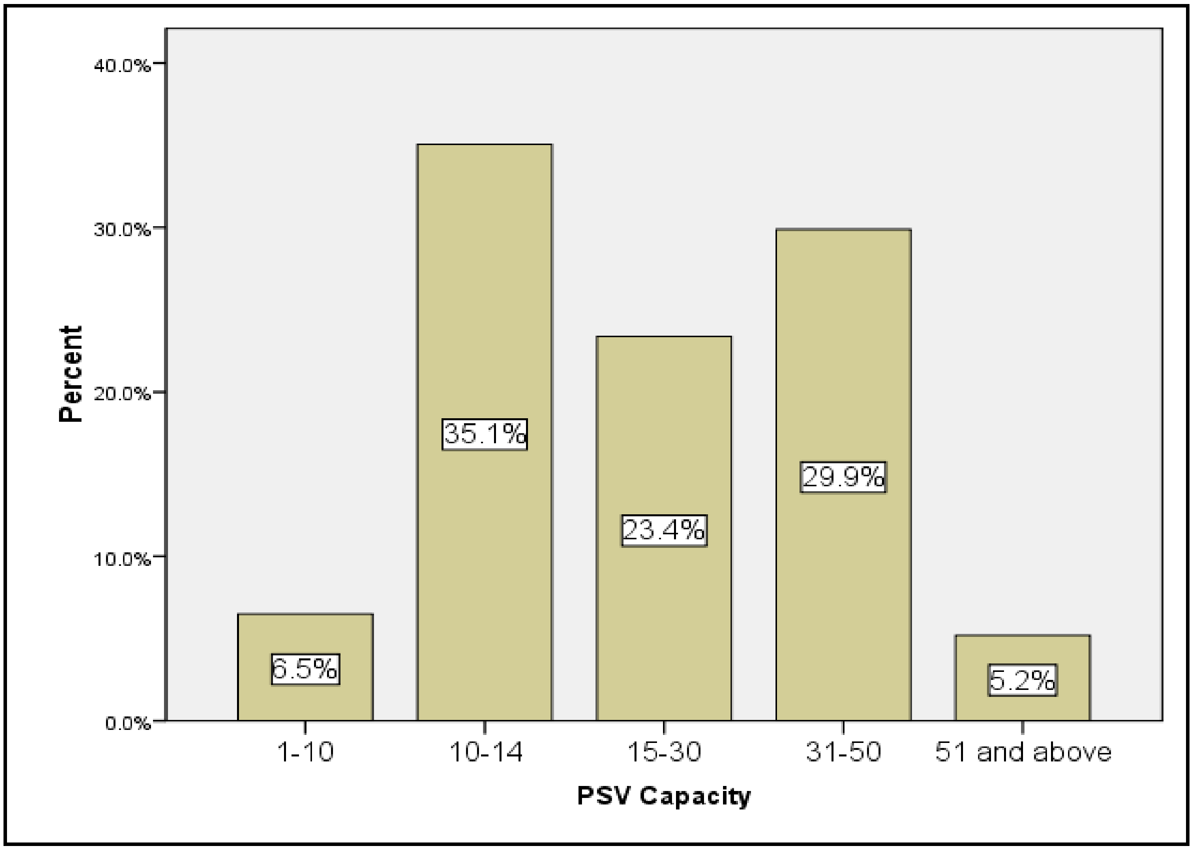


Figure 26 Capacities of PSVs used by respondents
(Source: Field Study)

Majority of the respondents used 14 seater matatus but a recent shift in vehicle type along some routes may have inclined more towards using 15-30 capacity vehicles. 31% and above tend to be those who used buses. Only 19% stated that their vehicles were overloaded while 14% had been involved in an accident at one point in their lives while using public transport to come to the CBD. The conditions of the PSVs used by the respondents on the day varied as follows:

	Condition	Valid Percent	Cumulative Percent
	Excellent	7.8	7.8
	Good	37.0	44.8
	Satisfactory	41.6	86.4
	Poor	13.6	100.0
Total		100.0	

Table 11: conditions of PSV Vehicles
(Source: Field Study)

69 % do not find the public transport system convenient. Among the reasons why they do not find the system convenient include unreliable (29%), uncomfortable (19%), speed i.e. slow (20.7%), not scheduled (11%). A few of them are not happy with the rude conductors while others complain of spending too much time in traffic jams.

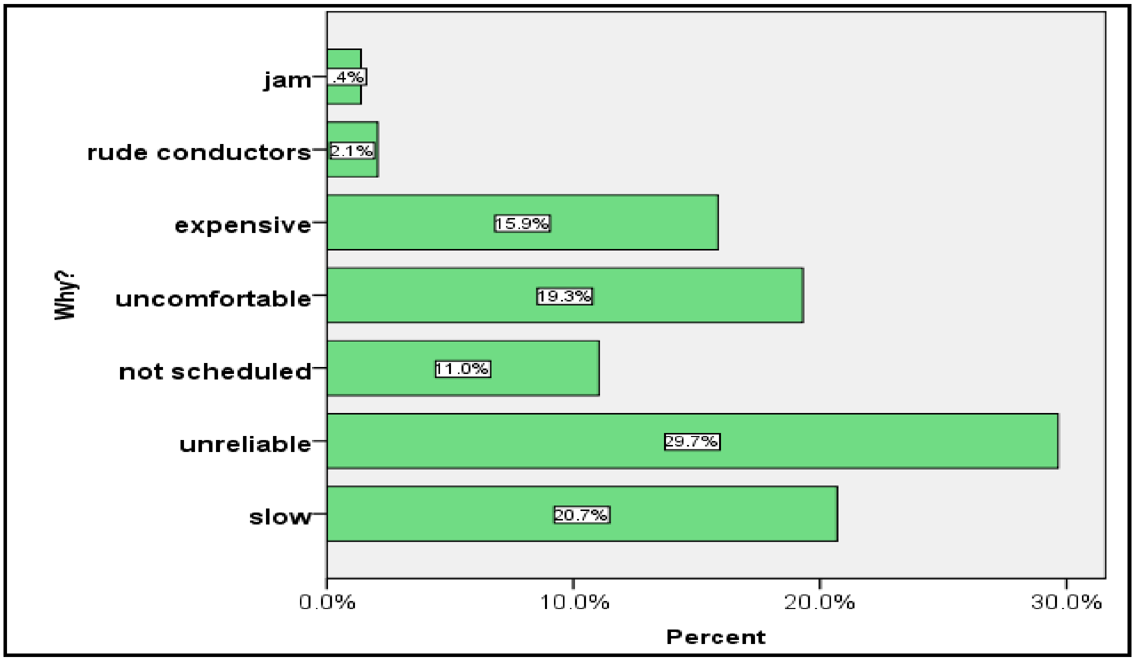


Figure 27 Reasons why people do not find the transport system convenient
(Source: Field Study)

6.10 The key expectations of a good transport system:

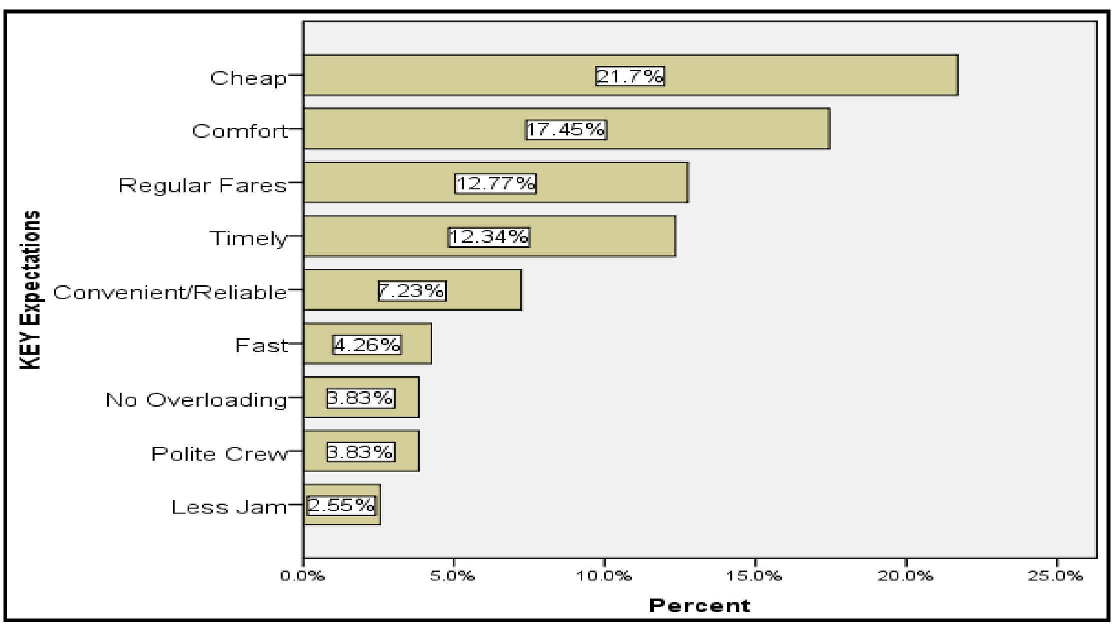
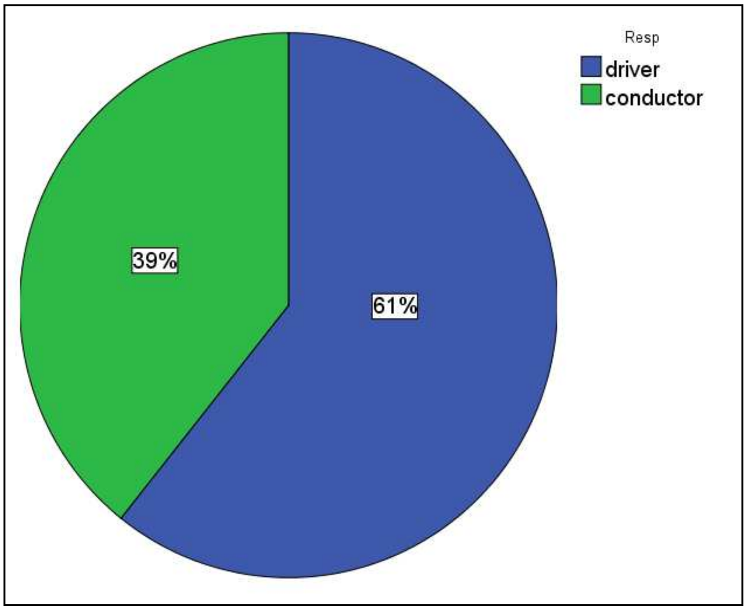


Figure 28 Key expectations of a Good transport System
(Source: Field Study)

Most respondents stated that they wanted a cheaper transport system that had regular fares. There was also expectation comfort in the transport system as well as timeliness.

6.11 Public transport crew interviewed



61 % of respondents were drivers, these included *bodaboda* (passenger motorcycle) drivers while 39 % were conductors.

Figure 29 Ratio of public transport crew interviewed
(*Source: Field Study)*

The average time that public transport crew get up in the morning to get to work is 4:00 a.m. Most travel up to 8 trips to town per day, spending slightly under two hours from their points of origin to the Central Business District during both morning and evening rush hours. Time of the last trips vary with some finishing as early as 7 p.m. and others extending till almost 10 p.m.

	Time start working (a.m.)	Time to town (minutes)	Peak hour travel (minutes)	Time of last trip	Trips per day	Rush hour - evening
Mean	4.11	115.10	100.69	8.4400	8.52	114.63
Median	4.00	120.00	90.00	9.3000	8.00	120.00
Mode	4	60	60	7.00	7	120

Table 12 measures of central tendency of various characteristics of public transport crew
(Source: Field Study)

6.12 People with disabilities

Public Transporters views on how they deal with people with disabilities. A good number of them stated that they try to help those with disabilities with some stating that they can carry them free of charge. 21 % however ignore people with disabilities as they find them to be stressful.

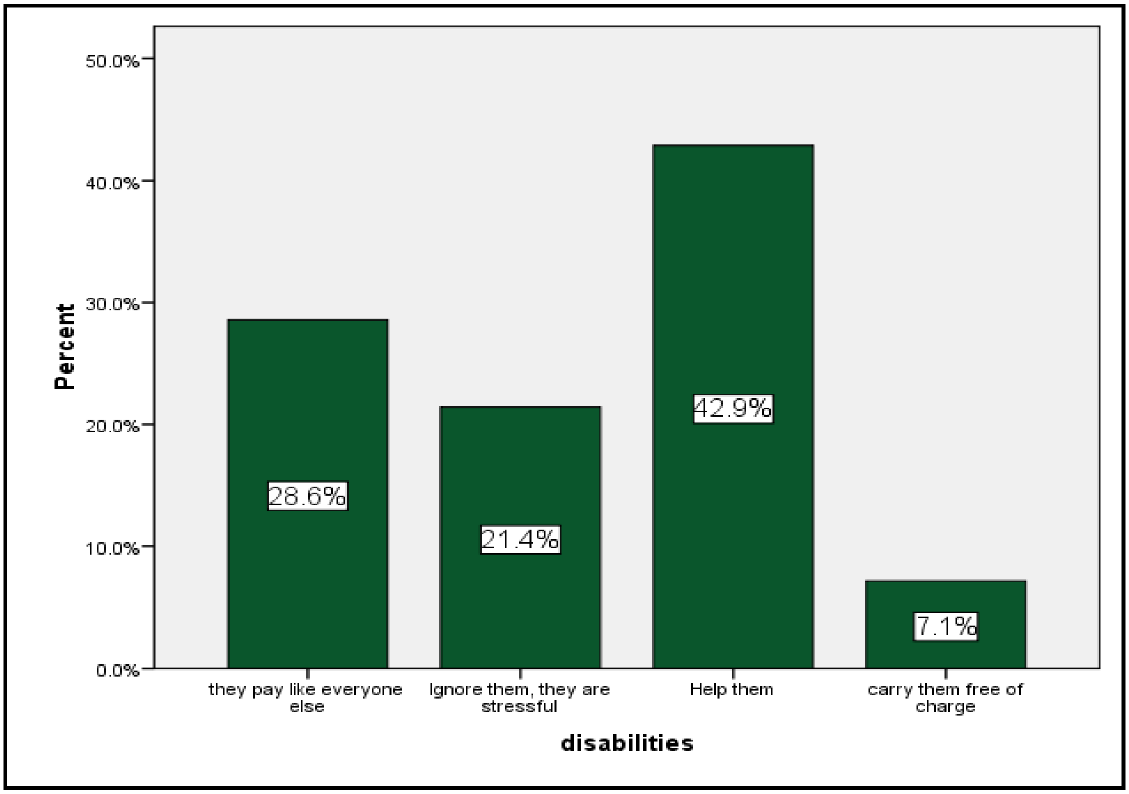


Figure 30 How public Service Vehicle crew deal with people with disabilities
(Source: Field Study)

71% think that the 3rd lane on Mombasa road has helped reduce congestion but 19 % think it has not. At the same time 87% of the respondents welcomed the idea of a double-decker road on Mombasa road while 4.3 % did not 4.2 % were skeptical about any positive impact it will have on congestion

6.13 Suggestions on solving the Traffic Congestion Problem

The respondents have different ways suggest the traffic congestion problem can be solved. The vast majority suggest the extension and expansion of roads while others (14%) would like to see the promotion of rail transport as a means of mobility. 8.97% of the respondents would be happy to have a more organized Public Service Vehicle Sector like busses. Other suggestions included removal of personal cars from the CBD, removal of PSVs from the CBD, more stringent measures of traffic offenders, better and more use of traffic lights and removal of round abouts.

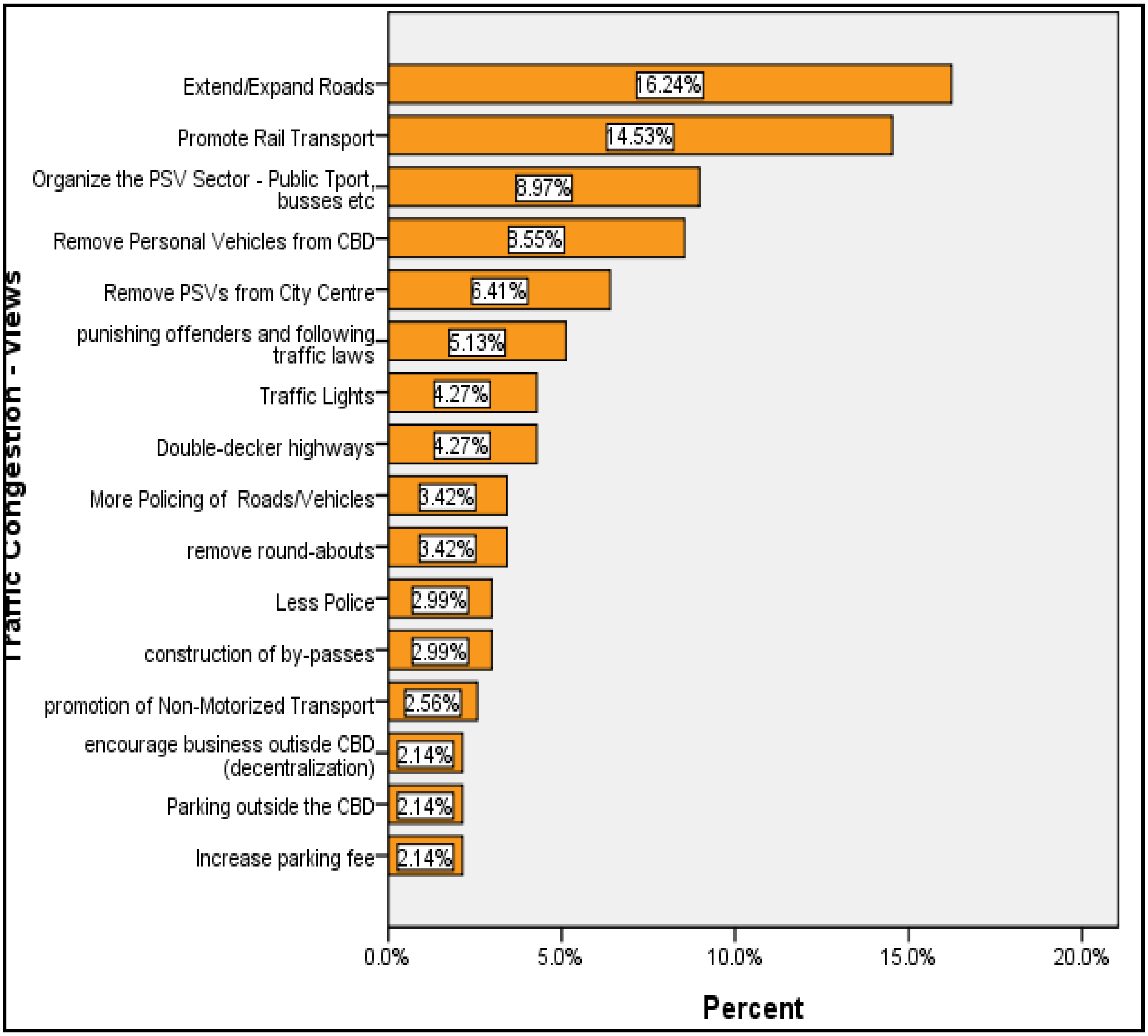


Figure 31 Respondents views on how to deal with traffic congestion
(Source: Field Study)

6.14 Public Service Vehicle Views on Reduction of Traffic Congestion

The public transport crew also suggested the expansion of roads but were also for the idea of reducing the number of personal vehicles in the CBD. They also suggested well trained traffic marshals to manage traffic and use of other means of mobility.

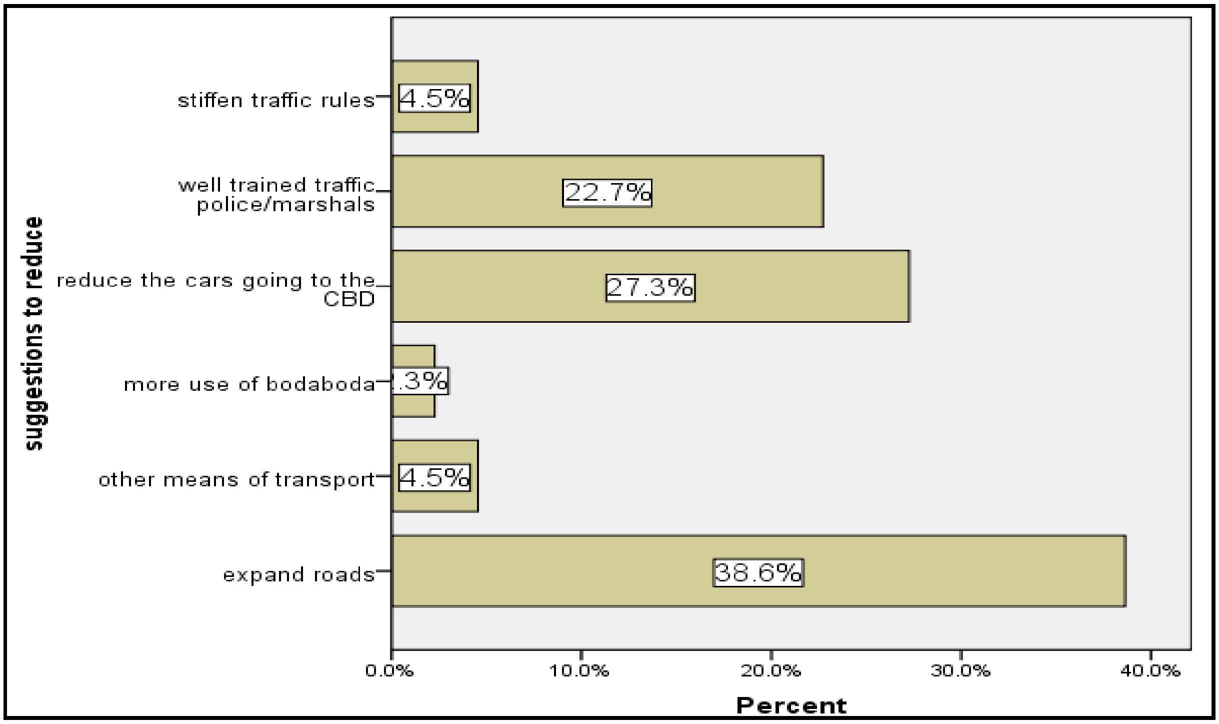
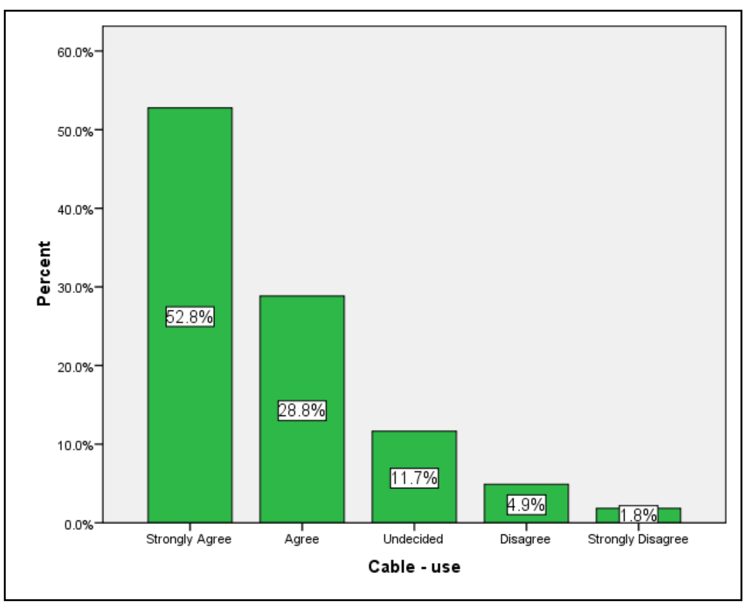


Figure 32 Ways of reducing congestion, suggestions from public transport crew
(Source: Field Study)

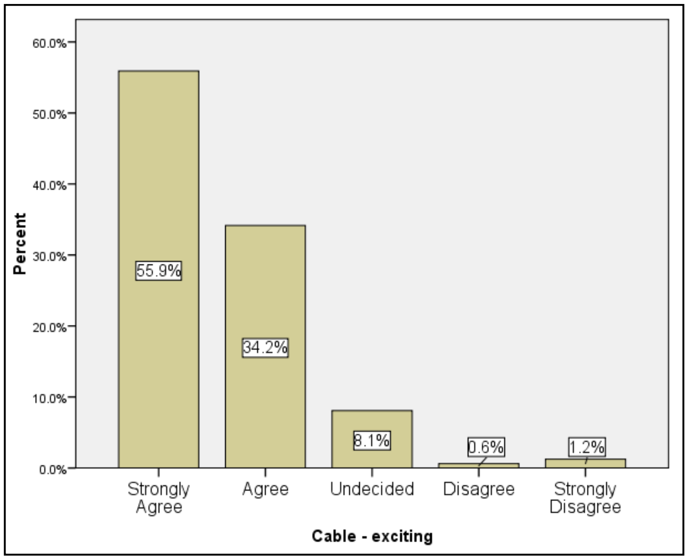
6.15 Views on Aerial Cable Transportation



Over 50 % of respondents indicated that they would use ACT if it were introduced as a means of travel in Nairobi, in particular with regard to access to the CBD.

Figure 33 Response on whether respondents would use Aerial Cable Transportation

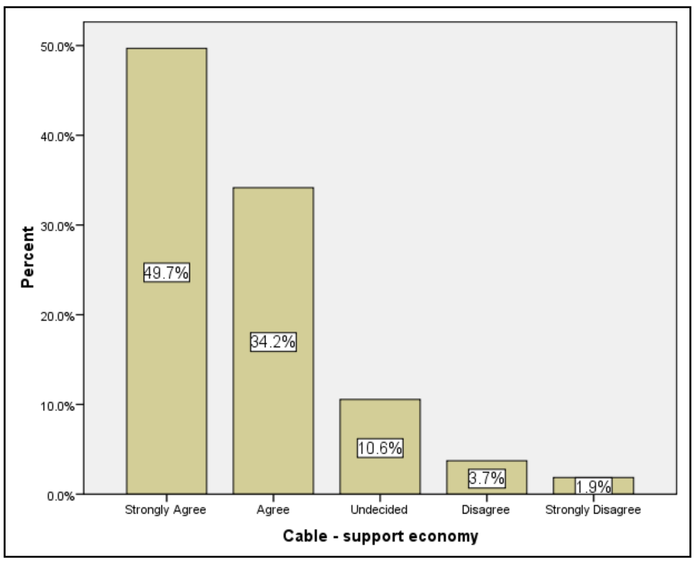
(Source: Field Study)



Over 55 % of respondents strongly agree that the use of ACT would be an exciting mode for people to travel in the City of Nairobi. 34 % agree.

Figure 34 Response on whether respondents find ACT an exciting mode of urban travel

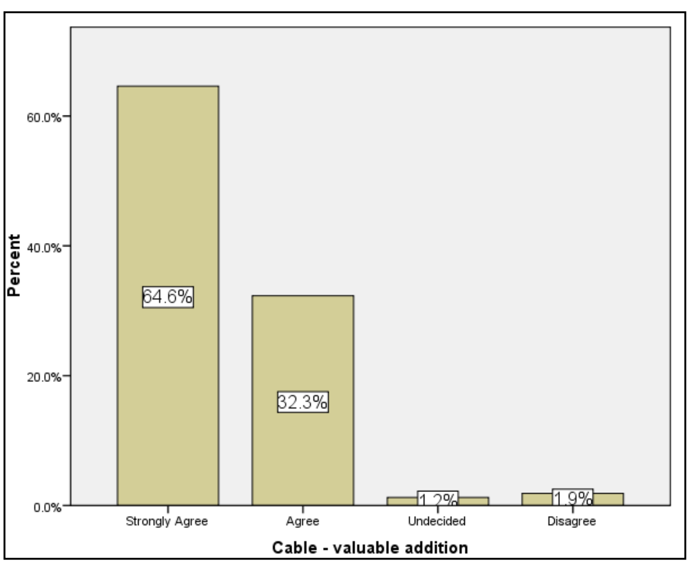
(Source: Field Study)



49 % and 34 % of the respondents strongly agree and agree respectively that the use of Act would be of high benefit to the economy of the country. A minority of 10 % were undecided.

Figure 35 Response on whether respondents think Act would support the Kenyan Economy

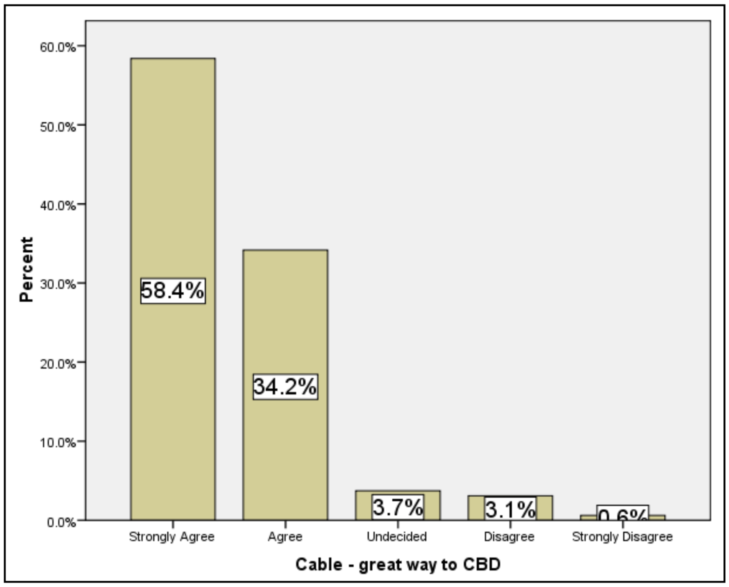
(Source: Field Study)



64% and 32 % of the respondents strongly agree and agree respectively that the use of ACT would be a valuable addition to the means of travel available in the City of Nairobi.

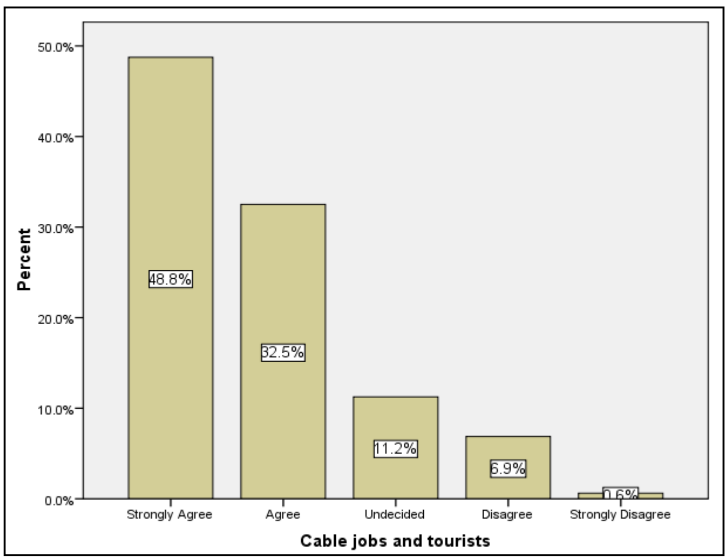
Figure 36 Response on whether respondents would be a valuable addition to the

(Source: Field Study)



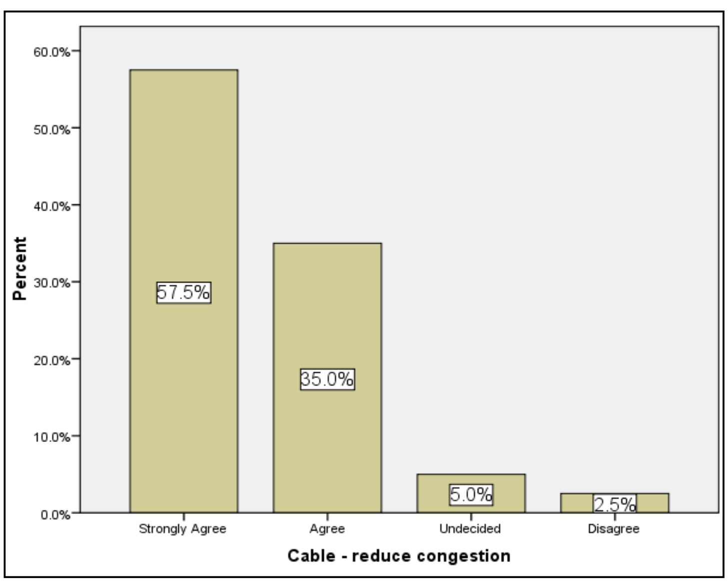
58 % of the respondents strongly agree that ACT would be a great way of accessing the CBD. 34 % of the respondents agree.

Figure 37 Response on whether respondents find ACT a great way of accessing the CBD
(Source: Field Study)



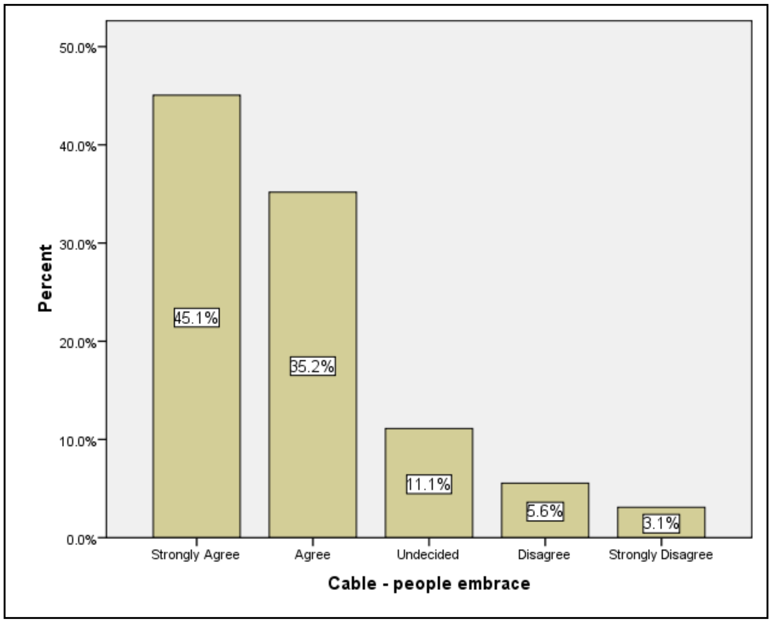
48 % of the respondents strongly agree that ACT would create jobs and be beneficial to tourism in the City of Nairobi. 32 % agree, 11 % are undecided while a smaller minority of 6.9 % and 0.6 % disagree and strongly disagree respectively.

Figure 38 Response on whether cable transportation would create jobs and attract tourists
(*Source: Field Study)*



57% of the respondents strongly agree that ACT would help reduce traffic congestion in the City of Nairobi. 35 % agree, 5 % are undecided while a 2.5 % disagree.

Figure 39 Response on whether respondents think that ACT would assist in reducing
(Source: Field Study)



45% of the respondents strongly agree that people would embrace ACT in the City of Nairobi. 35 % agree, 11.1% are undecided while a smaller minority of 5.6 % and 3.1% disagrees and strongly disagree respectively.

Figure 40 Response on whether respondents think people would embrace ACT
(Source: Field Study)

Respondents were also asked for their views, most, 67 % stated that it was a feasible idea that could work. 7.1 % stated that it may take a while for people to embrace it due to its difference from the normal modes of transportation. 6.2 % noted their concerns about the safety of the system. And 1 % were concerned about the effect of power outbreaks that may affect the system.

From key informant interviews the transport situation in Nairobi County was described as bad, leading to wastage in productive man hours. Associated stress could lead to health hazards. Public transportation is disorganized and unpredictable. Private vehicles face the challenge of limited parking while carrying only one or two passengers. There has been a low investment in mass rapid public transportation, several cases of insecurity in public buses and public transportation is viewed as something for the less privileged. Plans towards improving the congestion issue is being seen in the construction of missing links roads and MRTS plans.

On October 10th 2013, the Senate requested the ministry of Transport and Infrastructure to develop a policy as regards the use of cable transportation. This was followed a proposal towards use of Arial Cable Transportation, tabled before the governor in November 2013.

The main challenges would be to obtain rights of way above people's property, raising the capital for infrastructure and convincing users that the technology is secure.

The implications of this will be a demonstration of technology as a cheaper infrastructure alternative within the MRT system, reduction of on land required to extend roads, better predictability to transit times, thus saving a lot of productive man hours. Within the system there will also be job creation.

The process of acquiring the system would require policy formulation and laws governing use of this technology have to be enacted by relevant authorities. Capacity building will need to be undertaken to ensure the ACT solutions are efficiently utilized and maintained. Sensitization programmes have to be put in place to ensure the culture of potential users is aligned with the technology.

Additionally, political leaders will have to be convinced of the value of the success of the project and potential political leverage gained. EIA studies will also need to be undertaken on project basis.

Further key informant information revealed that ACT systems, though generally built over topographically challenging areas, can be built in almost any urban condition including flat land. These can be built to solve immediate transport challenges (older neighbourhoods) or to serve anticipated future demands (newer neighbourhoods).

The challenges in setting up the system depend on local context but cultural differences play a major role. For example, in the Western context, protecting and upholding privacy is important in decision-making. From experience though, a major challenge has been the huge gap in knowledge. Many proponents have failed to understand the basics of a cable transit system and what it could offer. This however, is slowly beginning to change as more urban gondolas are built.

When a proposal is first launched, most citizens are inquisitive. They are concerned about safety, speeds, why cable car, sustainability etc. Experience shows that authorities should be well versed in the technology, understand how a cable transit can benefit their community and be prepared to answer any questions.

Cost-wise, cable cars are priced very competitively with other forms of rapid transit. Often times at 1/3 to 2/3 the price of standard rapid transit technologies.

When opting for ACT, it is key to analyze the local conditions and determine the most important factors. These could vary from wait times, travel distances, topographical challenges, budgetary constraints etc. Cable cars are very effective tools for resolving last mile problems in cities, especially ones with obstacles either natural and man-made i.e. rivers, gorges, plateaus or urban settlement patterns, traffic congestion, poor road network.

Chapter 7. CONCLUSIONS and RECOMMENDATIONS

7.1 Summary of Findings

7.1.1 The First Objective:

To Identify, classify and analyze the means of transport used by people moving to the Nairobi Central Business District during peak hours.

In the City of Nairobi, there has been a peak hour shift related to increase in number of people and vehicles accessing the CBD and the subsequent congestion created. This is also seen by the time that PSV drivers have to start working (4.00 a.m.). This shift affects both the morning peak hours and the evening peak hours.

The main means used by people to access the Central Business District are personal vehicles and PSVs, particularly busses and matatus. Of these, most are the 14 seater matatus of which they describe as 'satisfactory.' There are several personal vehicles and observation shows that many do not carry more than two passengers, thus contributing to congestion. Personal Vehicle use is on an increase due to the benefits to the individual users. Rail transit is limited to those who live along the rail corridors.

Large number of youth (age 21-30) who are coming to the CBD, increasing population trends and increased building construction will make these numbers continue to increase.

Most people use public transport but are not happy with it either due to cost (most bus fares range from 50-100, which are very high for the urban poor), reliability, timeliness and efficiency. The lack of schedule and rude conductors are also a challenge of the system.

A proportion of Nairobians use rail transport but this is dependent on areas of residence as the train only covers certain corridors. Those who use rail transport are happy with the timing and convenience but not with the comfort.

There are several people using public transport and private vehicles from the Eastern side of Nairobi and the Mombasa Road/Uhuru Highway corridor. These are the roads that face the worst congestion while accessing the CBD. Increasing Sprawl towards the south is not making it better. Continuous increase in personal vehicle use is not improving the traffic situation based on the increase in personal vehicle ownership.

Nairobi has come up with an MRTS. Nairobians would want a transport system that is Cheap, comfortable, has regular fares, timely and reliable. Polite Crew and not held in traffic are further expectations. There is need to analyze interconnectivity between the proposed MRTS and the current paratransit. With several operators it will be difficult to apply a single fare.

7.1.2 The Second Objective:

To identify the congestion challenges and other challenges that commuter's face while moving in and out of the Nairobi Central Business District and possible solutions to these challenges.

One major challenge is lack of focus on how to assist persons with disabilities. Current public transport does not take into account people with disabilities.

Members of the Public transport sector also have minimum training other than driving, first aid and simple mechanics and there are complaints of rude and abusive crew. Crew are also know to change fares based on weather conditions and transport congestion.

Most people still view the idea of expansion of roads as a solution to traffic congestion, this maybe primarily due to minimum options beyond vehicular traffic.

It is taking people approximately an hour to access the Central Business District and almost half the time when there is no traffic jam.

In as much as rail transport is convenient, users are not happy with the comfort levels and there are several cases of overloading.

Simple observation shows no emphasis on NMT to access the CBD, with the exception of the recently constructed Thika road that has a bicycle lane running alongside the road. Other roads have very poor NMT facilities and even pedestrians are not taken care of. Re-organization of the PSV sector has been requested. The importance of reducing the number of private vehicles entering the CBD is also gaining recognition as has been requested by both respondents and PSV crew.

7.1.3 The Third objective:

To investigate the potential of aerial cabin transport as a major support in transporting people to the Nairobi Central Business District within identified corridors

Most respondents were very positive about the use of this mode of travel with respect to usage, impact on traffic congestion, value addition, creation of jobs and general embracement by members of the public.

The system easily overcomes some of the challenges faced by the proposed MRTS e.g. the radial nature of Nairobi's roads will still force people to drive towards the Central Business District as has been observed in spite of the construction of by-passes. Therefore it would be essential for those working in the CBD and its environs to have alternative means of transport.

7.1.4 Benefits over other systems

From the information collected from various sources, ACT requires lower initial capital when compared to other means of mass transit. This is in spite of the large number of people who are transported every hour, which is largely beneficial in addition to the large number of passengers transported per hour.

Unlike most systems of rapid transit, ACT Does not interfere with current system. This is critical especially when one considers the political nature of most public transport system which tend to be controlled by cartels who try to keep competitors out of the system.

System takes care of the main concerns of the citizens, i.e. Affordability (fares are affordable and thus is found in poorer areas in various parts of the world), Human Behavior (does not follow timetable but always available), Clean energy use, considers people with disabilities. It is also comfortable as all passengers get their own seats and there are no standing passengers carried.

The installation of ACT uses minimum land use and land acquisition. This ensures that people are not displaces for the benefit of others. As a result nobody is at loss due to the installation of the system within a city.

The ACT System is economically viable as has been observed in other developing nations e.g. Colombia, Venezuela and the Cost Benefit Analysis done for Burnaby Mountain. The success of the ACT in developing nations is an indicator that it has a potential in areas where commuters are not used to paying large amounts of money as fare but there is adequate demand for people to travel.

As any new industry does, it comes about with job creation and at various stations enables the establishment of businesses.

7.1.5 Major Challenges that will be faced when implementing the system:

As has been seen earlier, installation of ACT, as in all rapid transit systems, requires large initial capital that may not be readily available. This may require the input of external investors who may dictate the direction the project takes.

Due to the nature of going above the ground, there will be concerns about privacy, especially if the system passes near residential areas or offices. This will be a concern to all involved. The system may also have to involve in some land acquisition in order to be able to have adequate and well located pick up and drop off points. This may be difficult in some places especially when dealing with private properties.

As with all new systems, it will take time for citizens to accept. Those who fear heights will be reluctant to use the system as well as those who may be initially concerned about the efficiency and safety of the system.

There are currently no government policies with regard to Aerial Cable Transportation and even though the process to establish policies is going on, it may take time and this will affect the installation of an ACT system. Without any policy in place it will not be possible to set up the system.

There will be concern into how to integrate the ACT system with other systems like matatu's and buses. This is in particular because they do not follow any fixed schedule and change routes depending on market, weather and traffic situations.

7.2 Recommendations

All transport systems in Nairobi, including the current matatu/bus system and the proposed MRTS need to take into account those with disabilities. However, there is urgent need for a sustainable MRTS that enables modal variety to access the CBD with fixed and affordable pricing to people of all social classes and those with special needs.

Training of public transit crew is critical in the implementation of any urban transport project. There is need to train them especially in areas like customer relations.

ACT is a worthwhile means of urban transportation, though routing has to be well selected based on corridor characteristics. Ministry of Transport and other necessary authorities will also have to first come up with the necessary policies as regards its implementation. It is also important that is used for urban transit and not for tourism in urban areas.

As in Caracas, where commuters save money because they can transfer directly to the metro line instead of paying two fares and total travel times have decreased for some residents by over an hour, it will be important to integrate the ACT with the proposed MRTS. Studies on how to integrate it with the paratransit in operation at the moment would have to be done though would pose a great difficulty due to the nature of both systems

7.2.1 Potential Routes for ACT:

With a monocable transporting up to 4000 people per hour over a length of 5 kilometres, a radius of 5 km from the CBD would be an acceptable distance for any proposed cable. Looking at the transit on the various routes, room for road expansion and direct access to the CBD, Jogoo Road –CBD and Waiyaki Way –CBD provide potential routes for the cable transportation. Current transport modes can be used to take people from their various estates to the cable drop-off points. Waiyaki way has over 5 matatu routes while Jogoo Road has intensive transit.

Mombasa Road, which has no room for expansion and faces the challenge of increased commuter transit due to urban sprawl and densification is another possible option for this technology.

As in Round Rock Texas, routes that had been designated for LRT for ACT due to expected demand and cheaper cost of implementation and maintenance. In the context of Nairobi, this would include Haile Selassie - Ngong Road route that also has the challenge of terrain around the Upper Hill area.

Of all the possible MRT options it will be the easiest to implement because of its non-interference with the current transport sector.

7.3 Further Research and Way forward

Further research should be done to investigate the potential of this system in informal settlements e.g. corridors towards Industrial Area. A proper cost benefit with regard to the Kenyan scenario should also be done along all avenues where it is to be implemented.

Should the system be implemented some of the considerations that will need to be looked into include how to help people overcome the initial fear for heights, how to assure people of matters to do with safety and possible ways in which the system can be integrated with the current public transport system.

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Appendices – Research Instruments

Sample Questionnaire to be given out - Pedestrians and Shop Owners

Thank you for completing this Questionnaire. Please be assured that all answers will be kept confidential and used for academic purposes only

Identify, classify and analyze the means of transport used by people moving to the Nairobi Central Business District during peak hours.

1. **Name of respondent: ______________________________**
2. **Age__________**
3. **Tel Number_____________________**
4. **Gender** Male __ Female __
5. **Estate of Residence____________________________**
6. **PSV Route from estate of residence _______________**
7. **What means did you use to travel to Nairobi City Today?**

   Personal Car___ Matatu___ Walking___ Bus___ Boda boda___ Other_________
8. **What is your purpose of being in town today?**

   Student_____ Business_____ Employed_____ Other______
9. **What was the approximate amount of time spent waiting at the Bus Stop for a PSV in the morning**

   Less than 1 hour_____ 1 hour to 2 hours____ More than 2 hours_____
10. **What is the approximate distance from your house to the nearest bus stop?**

    ____
11. **How much time did it take to get to Nairobi CBD from your place of residence?**
    a. From your house___________________
    b. From the bus stop __________________
12. **What was the total amount of time spent in a vehicle when coming to town?**
    a. **PSV _____________________or,**
    b. **Private Vehicle______________**
13. **If PSV, what is the average amount of time spent waiting for a PSV in the evening when going home?**

    ____
14. **What was the approximate amount of time spent travelling back home in the evening yesterday?**
    i) PSV ____________________ or
    ii) Private Vehicle _____________
15. **Have you ever come to town by train? _____________________**
16. **If 'yes' above, which train route? ____**
17. **What is your view on the Syokimau - Imara Daima – Makadara - Nairobi train?**

i) **Timing:** a. Excellent b. Good c. satisfactory d. Poor

ii) **Comfort:** a. Excellent b. Good c. satisfactory d. Poor

iii) **Convenience:** a. Excellent b. Good c. satisfactory d. Poor

18. Do you see the rail travel as a possible option to reduce traffic congestion in Nairobi?

____

Identify and examine the challenges they face and the possible solutions while moving in and out of the Nairobi Central Business District.

19. Which route did you use to get to town

Valley Road____ Landhies/Jogoo Road____ Waiyaki Way/Chiromo Road _____ Ngara Road/Muranga Road____ Mombasa Road____ Other _______________

20. Normally, what is the amount of time spent going home if there is no traffic jam?

____

21. Is the CBD your final destination or are you still travelling to another part of Nairobi?

____

If No, Where are you traveling to? _______________

22. How much bus fare do you spend on weekdays:
a. Coming to town from home: ______________________________________

b. Going home in the evening: ______________________________________

23. Have you ever been involved in a PSV accident while traveling to town?

Yes ___ No ____

If yes, what happened?

____

____

24. Have you ever been involved in a PSV accident while traveling home?

Yes ___ No ____

If yes, what happened?

____

25. What is the capacity of the PSV that you normally use?

a. 10 -14 b. 15-30 c. 31-50 d. 51 and above**:**

26. Do you find the public transport system convenient? Yes ____ No ____
If 'NO,' why?

a. Slow b. unreliable c. not scheduled.
d. uncomfortable e. expensive f Other (Specify) ________________

27. What was the physical condition of Public Service Vehicle you used today?

a. Excellent b. Good c. Satisfactory d. Poor

28. Do you find the current public transport system comfortable? Yes ____ No ____

29. What are the key expectations you have for a public transport system (e.g. with regard to order, comfort, time wise, charges etc.)

30. Do you think that adding the third lane on Mombasa road reduced the traffic congestion?

31. What do you think of the plans to expand Mombasa road by constructing a double decker highway (with respect to traffic congestion)?

Investigate the potential of aerial cabin transport as a major support in transporting people to the Nairobi Central Business District within identified corridors.

Aerial Cable Transport (ACT):

This is a type of aerial transportation mode in which passengers are transported in a cabin that is suspended and pulled by cables.

Cable systems are being used in some urban areas like New York, Algiers, Medellín, Caracas, Rio de Janeiro, Portland, and others in order to transport people within the city. They have been proven to be efficient, cost-effective, rapidly installed, innovative link within a successful public transport network. The cost per kilometer compares favorably with Bus Rapid Transit and Rail Systems. Additionally, Aerial Cable Transportation has the potential to reduce greenhouse gas emissions, increase reliability and cut travel times by one third, attracting more riders to transit and are one of the safest transport systems in the world

Cable transport systems can achieve the same levels of capacity and commercial speed as tramways (street cars) or Bus with a high level of service. Streetcars are able to carry 10,000 people per hour per direction

Image source: http://forum.skyscraperpage.com/

.**If cable transportation was used as a means of transport to Nairobi CBD:**

32. Would you comfortably use an aerial cable car to come to the CBD if the option was available?

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

33. Do you think people would comfortably embrace the new technology if proven to be efficient?

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

34. ‘Aerial cable cars would be an exciting new feature for Nairobi’

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

35. Aerial cable cars would support the economy in the area?

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

36. Aerial cable cars would be a valuable addition to the transport options available, particularly during peak hours.

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

37. Aerial cable cars would provide a great way to get to the CBD

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

38. Aerial cable cars would bring jobs and tourists to the area

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

39. Aerial cable cars would help reduce traffic congestion and road accidents

Strongly agree ___Agree ___Undecided ____Disagree ____Strongly disagree ____

40. Do you have any comments about the proposed Aerial cable cars in Nairobi?

____

____

What are your views on solving the problem of Traffic Congestion in Nairobi:

a. ____

b. ____

c. ____

d.____

e. ____

Questions to Key Informants – Public Transport crew ***(Bodaboda, Matatu and Bus)***

Objective 1: Identify, classify and analyze the means of transport used by people moving to the Nairobi Central Business District during peak hours.

1. Vehicle Type

   Matatu___ Bus____ Bodaboda___ Other_____

2. Responsibility

   Driver_____ Conductor_____ _____ Other______

3. Route number _______

4. Route used to get to town

   Valley Road/Ngong Road____ Landhies/Jogoo Road____ Mombasa Road____
   Waiyaki Way/Chiromo Road _____ Ngara Road/Muranga Road____

5. When do you start work in the morning?

   ____

6. How much time does it take you to get to town from the stage in the morning?

   ____

7. How much time does it take you to get to the last stage from town in the evening?

   ____

8. What is the number of trips taken to town and back per day?

   ____

9. What is the amount of time spent from town to drop passengers in the evening

   ____

10. What is the amount of time spent on a trip if there were no traffic jam?

    ____

11. Have you ever been involved in an accident while traveling to or from town?

    Yes ___ No ____

12. What was the cause of the accident?

    ____

13. Were there any casualties (Injuries or Deaths)?

    ____

    Identify and examine the challenges they face and the possible solutions while moving in and out of the Nairobi Central Business District.

14. Do you find the public transport system convenient? Yes ____ No ____
    If 'NO,' why?

    ____

    ____

15. What are the main causes of traffic congestion in Nairobi?

a. ____
b. ____
c. ____

16. What are your suggestions on reduction of traffic congestion in Nairobi?
    a. ____
    b. ____
    c. ____
    d. ____

17. Who owns the vehicle you use?

    ____

18. How do you deal with traffic police when they find fault with your vehicle or driving?

    ____

19. What are your views on the new traffic lights with regard to congestion?

    ____

20. With regard to reduction of congestion, how effective have expanded highways e.g. 3rd Lane on Mombasa road helped?

    ____

21. What licenses are you required to have to operate?

    ____

    ____

    ____

22. What relationship do you have with the City Council?

    ____

    ____

    ____

23. How do you think public transportation can be improved?

    ____

24. Apart from going to driving school, do you receive any other form of training to do this work?

    ____

25. How do you cater for people with disabilities (customers who use your vehicle)?

    ____

    ____

Questions to Local Expert on Cable Transportation

Name: _________________________ Position: _________________

Identify, classify and analyze the means of transport used by people moving to the Nairobi Central Business District during peak hours.

1. How can you describe the transport situation in Nairobi with regard to the following:

a. The congestion

b. The public transport

c. Private Vehicles

Identify and examine the challenges they face and the possible solutions while moving in and out of the Nairobi Central Business District.

2. What are the key challenges in public transportation in Nairobi?

3. What are the main transport planning problems for the city of Nairobi?

4. What attempts have been made to improve the safety conditions of travel as citizen's travel to the CBD?

5. Do you know of any plans towards reducing congestion to and from the CBD?

6. What is the cost of each of these plans?

7. How will they be integrated with other modes of transport like matatu's, the passenger train and bodaboda's?

Investigate the potential of aerial cabin transport as a major support in transporting people to the Nairobi Central Business District within identified corridors.

8. Aerial Cable Transport is being used in various cities as a means of urban mass transit, has there been any consideration for its installation and use in Nairobi?

9. Is there any policy as regards the installation and use of cable transportation

10. What would be the main challenges in setting up cable transportation in the City of Nairobi?

11. What are the implications of setting up ACT in Nairobi?

12. What would be the process of having the ACT set up with regard to the following:

a. Policy

b. Governance

c. Institutional

d. Social

e. Political

f. Environmental

Questions to Expert on Cable Transportation – *Creative Urban Projects*

Name: ___________________________ Position: __________________

This information is to be used only for academic purposes.

1. What would be the good urban conditions to facilitate a sustainable cable transit system? (Radial or grid networks, what kind of transit numbers on a route)

2. What are some of the challenges in setting up an urban cable system e.g. political, economic, environmental, policy issues?

3. What is the normal reaction of people at first towards ACT and how do the authorities overcome negative perceptions

4. What would make an ACT economically unsustainable in a city?

5. How has the system integrated in the developing world with paratransit systems?

6. Which urban areas has ACT failed and why