FACTORS AFFECTING THE DEVELOPMENT OF NAIROBI METROPOLITAN RAIL NETWORK

RESEARCH THESIS SUBMITTED IN PARTIAL FULFILLMENT FOR THE AWARD OF A MASTER OF ARTS DEGREE IN URBAN AND REGIONAL PLANNING.

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other university.

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Supervisor's Declaration.

This thesis has been submitted for examination with my approval as a University Supervisor.

Signature…………………………………...Date………………………..

Name of Supervisor: **Dr. Samuel Obiero**

DEDICATION

To my wife and my beloved children, may the Almighty God bless you.

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First and foremost, I give thanks to God Almighty for having brought me thus far. His strength and grace have been my pillars and source of comfort and encouragement throughout my academic life.

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LIST OF ACRONYMS

KRC	Kenya Railway Corporation
KAA	Kenya Airports Authority
KYU	Kikuyu
RIU	Ruiru
AU	African Union
GPS	Geographical Positioning System
CBD	Central Business District
AfDB	African Development Bank

ABSTRACT

Rail transport is the second most important mode of transport in Kenya, after road transport, for both freight and passenger services. The problem of the study was that there is inadequate development of railway network in Kenya, specifically lack of legal framework to development a metropolitan railway system amidst the transportation problem in the city of Nairobi. This thesis presents an analysis of Nairobi metropolitan commuter rail system to define the principles involved. The analysis involves analyzing the status of the operations of the existing commuter rail transit network in terms of accessibility to passengers, routing and convenience and the underlying limitations; determination of the factors affecting development of the Nairobi metropolitan rail system with a view to proposing a sustainable approach to delivery of an effective metropolitan mass transit rail network in Nairobi city and its environs in terms of spatial convenience and accessibility to passenger traffic.

The methodology for the study included both secondary and primary sources. Secondary sources included review of existing literature on metropolitan commuter rail development with a few case studies from both developed and developing countries. Primary data was collected through field survey; administering of questionnaires; observations and interviews. Data analysis was done through statistical, descriptive and geo-spatial analyses. The study found that the Kenya railway Corporation (KRC) has limited experience about improvement of urban railways. The study further concludes that the resources for rail improvement are scarce, and maintenance and management of the work done are hardly enough. In other words, the knowledge and the know-how required for improvement, maintenance and expansion of urban railways have not been acquired adequately. The study recommended the need for KRC to take cognizant of the major changes in the world that present opportunities for the railway industry to play a positive role in national development.

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CHAPTER ONE: INTRODUCTION

1.1 Overview

Rail transport is the second most important mode of transport in Kenya, after road transport, for both freight and passenger services (ERSWEC 2003-2007). The railroad system in Kenya consists of the national railway network transport and the metropolitan network. The Economic recovery strategy for wealth and employment creation identified the transport sector as the third pillar of Kenya's economic recovery. The railway system is under the parastatal management of Kenya Railways (KR) and comprises 2,765 km of track. In addition to provision of freight services within the country, KR also handles transit traffic to and from the landlocked countries in the East African region. The metropolitan rail transit commuter trains were introduced by the Kenya Railway in1992, to help ease transportation to the suburbs and this service was well received despite the high fares (Aduwo, 1990; Obudho 1993b, pp. 91-109).It is important to note at the beginning that there is no exclusive network which has been developed for mass rail transit within Nairobi city and its environs. Rather, the rail transit network was, and has been run on the sections of the main lines and branch lines radiating from the city to the hinterland. The existing network has neither been changed nor improved from colonial times despite the overwhelming need for mass transit services and the changing technology.

Rail commuter services introduced in Nairobi and its environment was circumstantial rather than a deliberate planned undertaking. These services were introduced by Kenya Railways Corporation following a Government directive in May 1992 when Matatu operators staged a series of strikes throughout the country leaving many commuters stranded with Kenya Bus Services completely overwhelmed by the surge of passengers. Kenya Railways Corporation was ordered to come up with a temporary relief by running morning and evening trains to Thika. The services became an overnight success and were later expanded to cover all existing lines within Nairobi. Initially the services were operated using 62- class locomotives but these were changed in 1997 to 93/94 class as the demand increased necessitating hauling longer passenger trains (22-coaches per train for KAA and RIU sections and 14 coaches for KYU trains).Despite the reduction in the number of coaches to less than half since concessioning and despite other operation challenges and lack of investment the services have well been supported by the members of public.

The existing track configuration alignment, routing and parameters are all meant for freight and long distance passenger profit. It was therefore not necessary to have the CBD with the track density and routing as enjoyed by industrial areas. To meet the requirements of commuter mass rail transit system two major aspects must be considered, route destination and convenience and commuters comfort and safety. An ideal commuter train network for a city should ferry commuters from convenient neighborhoods in their suburban homes. It should therefore take consideration of origin and destination. Mass rail transit system are designed to be rapid system this entails the large volume of embankment and disembankment rapidly. They also involve closely spaced stations and halts.

Rail commuter services are now considered the most ideal means of transport within and around large cities like Nairobi and judging by the number of cities worldwide, which have embraced it or are in the process of doing so at planning or implementation stages, this mode of transport will continue to be relevant. The users all over the world like it for being stress free, fast, comfortable, reliable and predictable, and are ready to pay a small premium compared to road transport and operators like it for ease of operation. Also governments all over the World are promoting it for being environmentally friendly. There is no doubt that commuter services provided on KR lines within and around Nairobi have been a major success judging by their popularity (sustained patronage) since the operations was revitalized some sixteen years ago. These services are currently offered only during the morning and evening rush hours along the following routes: Nairobi-Kikuyu, Nairobi-Ruiru and Nairobi-Embakasi village.

According to various study reports on mass transit systems development in Nairobi, there is an overwhelming demand for a convenient, efficient and descent mass rail transit system within and around Nairobi. They also highlight the fact that there exists an underutilized railway network that can be modernized and expanded to increase rail commuter numbers.

This study is the beginning of serious attempt to critically look at the status of existing Metropolitan rail network. The main focus of this research will be to identify the factors affecting the development of Nairobi metropolitan rail network and propose a sustainable approach that may enable delivery of an effective mass rail transit system.

1.2 Problem statement

Since the 1970s, there has been a significant increase in urban rail investment (Babalik 2000). Some 139 new urban rail systems (Bushell 1997, Taplin 2000), metros and light rail systems have been built worldwide in the past three decades. These investments were in general planned as instruments to solve transport and land-use problems associated with extensive use of the road. Africa has a railway network of about 89,000 km[1] for an area of about 29.6 million sq km. This represents a density of about 2.5-km/l, 000 sq. km, compared to 40km/1,000 sq.Km, for Europe. African railways consist mostly of single lines penetrating inland from the coastal sea ports with little interconnections except in South Africa. The average technical speeds of African railways are about 30 to 35 km/hr. Commercial speeds are a little lower/worse (AU 2008). Most of the railway network in African countries was design mostly for freight and long distance passenger profit. Railways are suited for traffic movement of huge masses of passengers and freight for long distances. The relative advantage of the rail system against other modes is the advantage it has gained from recent economic and technological trends including higher energy prices, speeds containerization and new increases in flows of bulk trade and traffic. Most of the railway network in the sub-Saharan Africa was inherited from the colonial regimes and not much has been developed from then on.

Generally in Nairobi the inherited transport patterns, together with the additional travel generated mainly by an increased population, exerted demands on the urban form and its infrastructure that they were ill equipped to meet. A major problem here has been the centralization of the civil service, commerce, and other service activities in the CBD and industrial area, where it is estimated that over 75 per cent of commuters are employed. Much of the employment in wholesale and retail trade, restaurants and hotels, transport and communications, finance, insurance, real estate, and business services is located within the CBD. The CBD has for a long time been subjected to numerous traffic problems, which have been exacerbated by lack of space in its vicinity. The post-independence period also witnessed a relaxation (not by design) of traffic

[1] The length quotations for African railways in Kms are not uniform because differences exist on whether it is expressed in route km. or track km. lengths. The figures given are expressed in route km.

regulations, parking restrictions, and land-use control. Hence within a few years after independence much of the formal land-use urban pattern of the original settlement structure was eroded. Since 1970, the city has expanded tremendously and a new population distribution pattern has emerged. Even more important is the fact that a large percentage of low-income users of public transport now live further away from the CBD. Expansion of the city to the east, south, and north has not been matched by an expansion in transport facilities and services. The annual rate of growth of daily passenger journeys is currently estimated to be almost 6 per cent. A clear manifestation of the unmet demand for public transport services are the daily stampede and jostling at most of the city's transport terminals, especially during the rush hours, and the overflowing number of passengers transported by the existing modes of public transport. The lack of integrated approach to development of the various modes of transport has also contributed to the existing problems of transportation in Nairobi. This has resulted to over reliance on vehicular and non motorized modes of transport which alone could not cope with the surge of commuters in the city. Rail transport is the second most important mode of transport in Kenya, after road transport, for both freight and passenger services. The railway system is under the parastatal management of Kenya Railways Corporation (KRC) and comprises 2,765 km of track. The existing metropolitan rail network comprises of paltry 61 Km with an average daily passenger traffic of 19,000. The Kenya Government has over time experienced financial, technical and operational problems as a result of prevailing political, institutional, economic, environmental, socio-cultural factors thus inadequate investment (AfDB/OECD 2006). Thus the development of metropolitan rail system has not been spared. According to a commuter services study report commissioned by the Kenya Railway Corporation 2007, there is an overwhelming demand for a convenient, efficient and descent commuter rail service within and around Nairobi. It also highlights the fact that there exists an underutilized railway network that can be modernized and expanded to increase rail commuter numbers. Due to changing landuse configuration of Nairobi metropolis the distance of journeys from residential places working places has increased. This coupled with poor road network and lack of public transit calls for alternative mode of transport.

1.3 Purpose of the study

This study therefore is aimed at developing a better understanding of the factors and the fundamental premises that limits the implementation of an effective Metropolitan rail system in Kenya and proposes an enabler approach to development of a sustainable mass rail transit system in future**.**

1.4 Scope of the study

This study was carried out within the Nairobi Metropolitan area.

1.5 Research questions

1. What are the factors affecting development of an effective Nairobi metropolitan mass transit rail system?
2. Is the existing network conveniently accessible to high passenger potential areas?
3. What are the priority needs of the commuters and stakeholders as far as mass transit rail system is concerned?
4. What is the possible effective approach to the development of an efficient sustainable mass transit rail system?

1.6 Objectives of the study

1.6.1 General Objective

The main aim of this research was to identify the factors affecting the development of Nairobi metropolitan rail network. Despite its apparent important role in decongesting the city transportation network, it has not seen any improvement in the intensification of the network (thus services) within the city and its environs. This is particularly in reference to the existing rail network and its impact on the delivery of mass transit rail services in Nairobi city and its environs.

1.6.2 Specific Objectives

1. To determine the factors affecting development of the Nairobi metropolitan rail system
2. To determine whether the existing rail transit network is adequate to provide the passenger services within the Nairobi City and its environs.
3. To identify the limitations of the existing metro rail transit network in terms of accessibility to passengers, routing and convenience.
4. To propose a sustainable approach to delivery of an effective metropolitan mass transit rail network in Nairobi city and its environs in terms of spatial convenience and accessibility to passenger traffic.

1.7 Significance of the Study

The explosion of urban centers is a phenomenon being experienced in many Kenya towns especially within the Metropolitan Region. With changing social environment and demand, new factors affecting the sustainability of railway development will evolve over time.

Throughout the railway planning and implementation process, governments and railway companies should be alert and take into account the wider social, economic and environmental and social effects in order to create 'livable communities' and facilitate the dynamics of the city.

Railway can be an effective tool for facilitating urban growth if planned and designed appropriately and properly tied in with urban development.

1.8 Limitations of the study

The study area was within Nairobi and its environs. It relied on the secondary data sources available in the various public institutions relevant to area and objectives of the research. The research was limited to exploration of the factors and the fundamental premises that limits the implementation of an effective Metropolitan rail system in Nairobi. It was also aimed at proposing an enabler approach to development of a sustainable mass rail transit system in future**.** This was to be within the development of the rail network. The focus was the relationship between the spatial distribution of existing rail transit network in terms of adequacy, accessibility and convenience, and, proximity to passenger potential areas/population distribution. It did not focus on impact of other aspects and characteristics such as railway gauges in use, braking system, traction in use and the Permanent Way to provision of mass transit passenger services.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The problems associated with rise of railways as a mode of transport has attracted a lot of interest from both scholars and practitioners. Rail has come into favor by regional and national governments because of its capabilities of increasing attractiveness and quality of urban public transport (Du &Malley, 2006), thereby contributing to a sustainable and efficient transport network. Rail is still the most energy efficient mode for the movement of freight and passengers (Ministry of Transport, 2005b), and is capable of transporting large numbers of people at high speeds. Rail systems are generally implemented when urban populations and car dependence levels congest transport networks and decrease standards of living. Implementing new rail systems into dispersed urban environments can initially be difficult; however the long- term benefits are permanent.

The benefits of rail are in the fixed nature of the mode. Rail systems have been shown to increase land value around train stations due to the increased levels of accessibility to the area (Du and Malley, 2006) and are highly visible and capable of high speeds. It is stated in transport literature that one of the benefits of suburban rail is that it is a radical, high profile alternative to the private motor-vehicle (Newman &Kenworthy, 1996; Mees, 2000). Other benefits of rail travel include comfort and reliability (Jefferson, 1996). Electrified rail systems can provide increased environmental benefits such as low emissions, noise and vibrations while the fixed nature of rail has been shown to increase pedestrian and passenger safety due to its high visibility and predictable travel path (Jefferson, 1996). Rail platforms also provide the opportunity for level access to the train carriages, which when combined with automated ticketing, decreases the time-spent stationary and increases average travel speeds (Jefferson, 1996). The separation of rail and guided Bus-ways from the road network negates delays caused by congestion or negotiating in and out of traffic at stops. Average travel speeds by bus without the availability of priority space will average travel speeds.

Research has shown railway stations are capable of attracting residential and commercial development resulting in high-density nodes (Edwards &Mackett, 1996; Gibbons &Machin, 2005). Urban development can be planned around the location of stations. Suburban rail can also co-operate with the movement of regional and national freight and increasing rail transport capacities can be achieved through additional carriages. If, as is proposed, public transport increases its proportional shares of all travel, increasing capacities should be an important future consideration in the development of any service. The formation of railway station hubs is important as it represents less dependence on private motor vehicles in the area.

Importantly, rail is renowned for being a potentially reliable form of transport. Reliability is an important consideration in ensuring the success of any public transport system (Anable&Gatersleben, 2005). People enjoy driving because they feel they are in control of their travel. Therefore the accuracy of transport timetables is important in allowing people to control their travel by not having to wait stationary for long periods of time or be subject to in-travel delays on the system.

2.2 Urban Land Use and Transportation

2.2.1. The Land Use - Transport System

Urban land use comprises two elements; the **nature of land use** which relates to which activities are taking place where, and the **level of spatial accumulation**, which indicates their intensity and concentration. Central areas have a high level of spatial accumulation and corresponding land uses, such as retail, while peripheral areas have lower levels of accumulation. Most economic, social or cultural activities imply a multitude of functions, such as production, consumption and distribution. These functions take place at specific locations and are part of an activity system. Activities have a spatial imprint, therefore. Some are routine activities, because they occur regularly and are thus predictable, such as commuting and shopping. Others are institutional activities that tend to be irregular, and are shaped by lifestyle (e.g. sports and leisure), by special needs (e.g. healthcare). Still others are production activities that are related to manufacturing and distribution, whose linkages may be local, regional or global. The behavioral patterns of individuals, institutions and firms have an imprint on land use. The representation of this imprint requires a typology of land use, which can be formal or functional:

Formal land use representations are concerned with qualitative attributes of space such as its form, pattern and aspect and are descriptive in nature.

Functional land use representations are concerned with the economic nature of activities such as production, consumption, residence, and transport, and are mainly a socioeconomic description of space.

Land use, both in formal and functional representations, implies a set of relationships with other land uses. For instance, commercial land use involves relationships with its supplier and customers. While relationships with suppliers will dominantly be related with movements of freight, relationships with customers would include movements of people. Thus, a level of accessibility to both systems of circulation must be present. Since each type of land use has its own specific mobility requirements, transportation is a factor of activity location, and is therefore associated intimately with land use. Within the urban system each activity occupies a suitable, but not necessarily optimal location, from which it derives rent. Transportation and land use interactions mostly consider the retroactive relationships between activities, which are land use related, and accessibility, which is transportation related. These relationships often have been described as a "chicken-and-egg" problem since it is difficult to identify the triggering cause of change; do transportation changes precede land use changes or vice-versa?

Urban transportation aims at supporting transport demands generated by the **diversity of urban activities** in a diversity of urban contexts. A key for understanding urban entities thus lies in the analysis of patterns and processes of the transport / land use system. This system is highly complex and involves several relationships between the transport system, spatial interactions and land use:

- **Transport system**. Considers the set of transport infrastructures and modes that are supporting urban movements of passengers and freight. It generally expresses the level of accessibility.

- **Spatial interactions**. Consider the nature, extent, origins and destinations of the urban movements of passengers and freight. They take into consideration the attributes of the transport system as well as the land use factors that are generating and attracting movements.
- **Land use**. Considers the level of spatial accumulation of activities and their associated levels of mobility requirements. Land use is commonly linked with demographic and economic attributes.

2.2.2 Urban Land Use Models

The relationships between transportation and land use are rich in theoretical representations that have contributed much to geographical sciences. Several descriptive and analytical models of urban land use have been developed over time, with increased levels of complexity. All involve some consideration of transport in the explanations of urban land use structures (Carter, 1995):

- Von Thunen's regional land use model is the oldest. It was initially developed in the early 19th century (1826) for the analysis of agricultural land use patterns in Germany. It used the concept of economic rent to explain a spatial organization where different agricultural activities are competing for the usage of land. The underlying principles of this model have been the foundation of many others where economic considerations, namely **land rent** and **distance-decay**, are incorporated. The core assumption of the model is that agricultural land use is patterned in the form of concentric circles around a market [Krumme, 2002]. Many concordances of this model with reality have been found, notably in North America.
- The Burgess concentric model was among the first attempts to investigate spatial patterns at the urban level (1925). Although the purpose of the model was to analyze social classes, it recognized that transportation and mobility were important factors behind the spatial organization of urban areas. The formal land use representation of this model is derived from commuting distance from the CBD, creating concentric circles. Each circle represents a specific socioeconomic

urban landscape. This model is conceptually a direct adaptation of the Von Thunen's model to urban land use since it deals with a concentric representation.

- Sector and multiple nuclei land use models were developed to take into account numerous factors overlooked by concentric models, namely the influence of transport axis (Hoyt, 1939) and multiple nuclei (Harris and Ullman, 1945) on land use and growth. Both representations consider the emerging impacts of motorization on the urban spatial structure.
- Hybrid models tried to include the concentric, sector and nuclei behavior of different processes in explaining urban land use. They are an attempt to integrate the strengths of each approach since none of these appear to provide a completely satisfactory explanation. Thus, hybrid models, such as that developed by Isard (1955), consider the concentric effect of nodes (CBDs and sub-centers) and the radial effect of transport axis, all overlain to form a land use pattern. Also, hybrid representations are suitable to explain the evolution of the urban spatial structure as they combine different spatial impacts of transportation on urban land use, let them be concentric or radial, and this at different points in times.
- Land rent theory was also developed to explain land use as a market where different urban activities are competing for land usage at a location. It is strongly based in the market principle of spatial competition. The more desirable the location, the higher its rent value. Transportation, through accessibility and distance-decay, is a strong explanatory factor on the land rent and its impacts on land use. However, conventional representations of land rent are being challenged by structural modifications of contemporary cities.

Most of these models are essentially static as they explain land use patterns. They do not explicitly consider the processes that are creating or changing them.

2.2.3. Transportation and Urban Dynamics

Both land use and transportation are part of a dynamic system that is subject to external influences. Each component of the system is constantly evolving due to changes in technology, policy, economics, demographics and even culture/values, among others. As a result, the interactions between land use and transportation are played out as the outcome of the many decisions made by residents, businesses and governments. The field of urban dynamics has expended the scope of conventional land use models, which tended to be descriptive, by trying to consider relationships behind the evolution of the urban spatial structure. This has led to a complex modeling framework including a wide variety of components. Among the concepts supporting urban dynamics representations are retroactions, where as one component influences others. The changes will influence the initial component back, either positively or negatively. The most significant components of urban dynamics are:

- **Land use**. This is the most stable component of urban dynamics, as changes are likely to modify the land use structure over a rather long period of time. This comes as little surprise since most real estate is built to last at least several decades. The main impact of land use on urban dynamics is its function of a generator and attractor of movements.
- **Transport network**. This is also considered to be a rather stable component of urban dynamics, as transport infrastructures are built for the long term. This is particularly the case for large transport terminals and subway systems that can operate for a very long period of time. For instance, many railway stations are more than one hundred years old. The main contribution of the transport network to urban dynamics is the provision of accessibility. Changes in the transport network will impact accessibility and movements.
- **Movements**. The most dynamic component of the system since movements of passengers or freight reflect almost immediately changes. Movements thus tend more to be an outcome of urban dynamics than a factor shaping them.
- **Employment and workplaces**. They account for significant inducement effects over urban dynamics since many models often consider employment as an exogenous factor. This is specifically the case for employment that is categorized as basic, or export oriented, which is linked with specific economic sectors such as manufacturing. Commuting is a direct outcome of the number of jobs and the location of workplaces.

- **Population and housing**. They act as the generators of movements, because residential areas are the sources of commuting. Since there are a wide array of incomes, standards of living, preferences and ethnicity, this diversity is reflected in the urban spatial structure.

2.3 Transportation and Urban Form

2.3.1. Global Urbanization

No discussion about the urban spatial structure can take place without an overview of urbanization, which has been one of the dominant trends of economic and social change of the 20th century, especially in the developing world.

Urbanization: The process of transition from a rural to a more urban society. Statistically, urbanization reflects an increasing proportion of the population living in settlements defined as urban, primarily through net rural to urban migration. The level of urbanization is the percentage of the total population living in towns and cities while the rate of urbanization is the rate at which it grows (UNFPA, 2007).

This transition will go on well into the second half of the 21st century. Urban mobility problems have increased proportionally with urbanization, a trend reflected in the growing size of cities and in the increasing proportion of the urbanized population. Since 1950, the world's urban population has more than doubled, to reach nearly 3.16 billion in 2005, about 48.7% of the global population. This is due to two main demographic trends:

- **Natural increase**. It is simply the outcome of more births than deaths in urban areas, a direct function of the fertility rate as well as the quality of healthcare systems.
- **Rural to urban migrations**. This has been a strong factor of urbanization, particularly in the developing world where migration accounted between 40 and 60% of the urban growth. Such a process has endured since the beginning of the industrial revolution in the 19th century but has become prevalent in the developing world. The reasons for urban migration are numerous and may involve the expectation to find employment, improved agricultural productivity which

frees rural labor or even political and environmental problems where populations are constrained to leave the countryside.

The outcome has been a fundamental change in the socio-economic environment of human activities as urbanization involves new forms of employment, economic activity and lifestyle. Thus, industrialization in the developing world is directly correlated with urbanization, the case of China being particularly eloquent. The industrialization of coastal China has led to the large rural to urban migration in history. According to the United Nations Population Fund, about 18 million people migrate from rural areas to cities each year in China alone. Current global trends indicate a growth of about 50 million urbanites each year, roughly a million a week. More than 90% of that growth occurs in developing countries which places intense pressures on urban infrastructures, particularly transportation, to cope. By 2050, 6.2 billion people, about two thirds of humanity, are likely to be urban residents.

2.3.2. The Urban Form

At the urban level, demographic and mobility growth have been shaped by the capacity and requirements of urban transport infrastructures, be they roads, transit systems or simply walkways. Consequently, there is a wide variety of urban forms, spatial structures and associated urban transportation systems.

Urban form: Refers to the spatial imprint of an urban transport system as well as the adjacent physical infrastructures. Jointly, they confer a level of spatial arrangement to cities.

Urban (spatial) structure: Refers to the set of relationships arising out of the urban form and its underlying interactions of people, freight and information.

Even if the geographical setting of each city varies considerably, the urban form and its spatial structure are articulated by two structural elements:

- **Nodes**. These are reflected in the centrality of urban activities, which can be related to the spatial accumulation of economic activities or to the accessibility to the transport system. Terminals, such as ports, rail yards, and airports, are important nodes around which activities agglomerate at the local or regional level. Nodes have a hierarchy related to their importance and contribution to urban functions, such as production, management, retailing and distribution.
- **Linkages**. These are the infrastructures supporting flows from, to and between nodes. The lowest level of linkages includes streets, which are the defining elements of the urban spatial structure. There is a hierarchy of linkages moving up to regional roads and railways and international connections by air and maritime transport systems.

Urban transportation is organized in three broad categories of collective, individual and freight transportation. In several instances, they are complementary to one another, but sometimes they may be competing for the usage of available land and/or transport infrastructures:

- **Collective Transportation (public transit)**. The purpose of collective transportation is to provide publicly accessible mobility over specific parts of a city. Its efficiency is based upon transporting large numbers of people and achieving economies of scale. It includes modes such as tramways, buses, trains, subways and ferryboats.
- **Individual Transportation**. Includes any mode where mobility is the outcome of a personal choice and means such as the automobile, walking, cycling and the motorcycle. The majority of people walk to satisfy their basic mobility, but this number varies according to the city considered. For instance, walking account for 88% of all movements inside Tokyo while this figure is only 3% for Los Angeles.
- **Freight Transportation**. As cities are dominant centers of production and consumption, urban activities are accompanied by large movements of freight. These movements are mostly characterized by delivery trucks moving between industries, distribution centers, warehouses and retail activities as well as from major terminals such as ports, rail yards, distribution centers and airports.

Historically, movements within cities tended to be restricted to walking, which made medium and long distance urban linkages rather inefficient and time-consuming. Thus, activity nodes tended to be **agglomerated** and urban forms **compact**. Many modern cities have inherited an urban form created under such circumstances, even though they are no longer prevailing. The dense urban cores of many European, Japanese and Chinese cities, for example, enable residents to make between one third and two thirds of all trips by walking and cycling. At the other end of the spectrum, the dispersed urban forms of most Australian, Canadian and American cities, which were built recently, encourages automobile dependency and are linked with high levels of mobility. Many major cities are also port cities with maritime accessibility playing an enduring role not only for the economic vitality but also in the urban spatial structure with the port district being an important node.

Urban transportation is thus associated with a spatial form, which varies according to the modes being used. What has not changed much is that cities tend to opt for a **grid street pattern**. This was the case for many Roman cities as it is for American cities. The reasons behind this permanence are relatively simple; a grid pattern jointly optimizes accessibility and available real estate. In an age of motorization and personal mobility, an increasing number of cities are developing a spatial structure that increases reliance on motorized transportation, particularly the privately owned automobile. **Dispersion,** or urban sprawl, is taking place in many different types of cities, from dense, centralized European metropolises such as Madrid, Paris, and London, to rapidly industrializing metropolises such as Seoul, Shanghai, and Buenos Aires, to those experiencing recent, fast and uncontrolled urban growth, such as Bombay and Lagos.

2.3.3. Evolution of Transportation and Urban Form

The evolution of transportation has generally led to changes in urban form. The more radical the change in transport technology, the more the urban form has been altered. Among the most fundamental changes in the urban form is the emergence of new clusters expressing new urban activities and new relationships between elements of the urban system. In many cities, the **central business district** (CBD), once the primary destination of commuters and serviced by public transportation, has been changed by new manufacturing, retailing and management practices. Whereas traditional manufacturing depended on centralized workplaces and transportation, technological and transportation developments rendered modern industry more flexible. In many cases, manufacturing relocated in a suburban setting, if not altogether to entirely new low costs locations. Retail and office activities are also suburbanizing, producing changes in the urban form. Concomitantly, many important transport terminals, namely port facilities and railyards, have emerged in suburban areas following new requirements in modern freight distribution brought in part by containerization. The urban spatial structure shifted from a nodal to a multi-nodal character.

Initially, suburban growth was mainly taking place adjacent to major road corridors, leaving a lot of vacant or farm land in between. Later, intermediate spaces were gradually filled up, more or less coherently. Highways and ring roads, which circled and radiated from cities, favored the development of suburbs and the emergence of important sub-centers that compete with the central business district for the attraction of economic activities. As a result, many new job opportunities have shifted to the suburbs (if not to entirely new locations abroad) and the activity system of cities has been considerably modified. Different parts of a city have different dynamism depending on its spatial pattern. These changes have occurred according to a variety of geographical and historical contexts, notably in North America and Europe [Muller, 1995]. In addition, North American and European cities have seen different changes in urban density. Two processes have a substantial impact on contemporary urban forms:

- **Dispersed urban land development patterns** have been dominant in North America over the last 50 years, where land is abundant, transportation costs were low, and where the economy became dominated by service and technology industries. Under such circumstances, it is not surprising to find that there is a strong relationship between urban density and automobile use. For many cities their built up areas have grown at a faster rate than their populations. In addition, commuting became relatively inexpensive compared with land costs, so households had an incentive to buy lower-priced housing at the urban periphery.

Similar patterns can be found in many European cities, but this change is occurring at a lower pace and involving a smaller range.

- **The decentralization of activities** resulted in two opposite effects. First, commuting time has remained relatively stable in duration. Second, commuting increasingly tends to be longer and made by using the automobile rather than by public transit. Most transit and road systems were developed to facilitate suburb-to-city, rather than suburb-to-suburb, commuting. As a result, suburban highways are often as congested as urban highways.

Although transportation systems and travel patterns have changed considerably over time, one enduring feature remains that most people travel between 30-40 minutes in one direction. Globally, people are spending about 1.2 hours per day commuting, wherever this takes place in a low or a high mobility setting [Schafer, 2000]. Different transport technologies, however, are associated with different travel speeds and capacity. As a result, cities that rely primarily on non-motorized transport tend to be different than auto-dependent cities. Transport technology thus plays a very important role in defining urban form and the spatial pattern of various activities.

2.3.4. The Spatial Imprint of Urban Transportation

The amount of urban land allocated to transportation is often correlated with the level of mobility. In the pre-automobile era, about 10% of the urban land was devoted to transportation which were simply roads for a traffic that was dominantly pedestrian. As the mobility of people and freight increased, a growing share of urban areas is allocated to transport and the infrastructures supporting it. Large variations in the spatial imprint of urban transportation are observed between different cities as well as between different parts of a city, such as between central and peripheral areas. The major components of the spatial imprint of urban transportation are:

- **Pedestrian areas**. Refer to the amount of space devoted to walking. This space is often shared with roads as sidewalks may use between 10% and 20% of a road's right of way. In central areas, pedestrian areas tend to use a greater share of the right of way and in some instances; whole areas are reserved for pedestrians. However, in a motorized context, most of pedestrian areas are for servicing people's access to transport modes such as parked automobiles.

- **Roads and parking areas**. Refer to the amount of space devoted to road transportation, which has two states of activity; moving or parked. In a motorized city, on average 30% of the surface is devoted to roads while another 20% is required for off-street parking. This implies for each car about 2 off-street and 2 on-street parking spaces. In North American cities, roads and parking lots account between 30 to 60% of the total surface.
- **Cycling areas**. In a disorganized form, cycling simply shares access to pedestrian and road space. However, many attempts have been made to create spaces specifically for bicycles in urban areas, with reserved lanes and parking facilities.
- **Transit systems**. Many transit systems, such as buses and tramways, share road space with automobiles, which often impairs their respective efficiency. Attempts to mitigate congestion have resulted in the creation of road lanes reserved to buses either on a permanent or temporary (during rush hour) basis. Other transport systems such as subways and rail have their own infrastructures and, consequently, their own rights of way.
- **Transport terminals**. Refer to the amount of space devoted to terminal facilities such as ports, airports, transit stations, rail yards and distribution centers. Globalization has increased the mobility of people and freight, both in relative and absolute terms, and consequently the amount of urban space required to support those activities. Many major terminals are located in the peripheral areas of cities, which are the only locations where sufficient amounts of land are available.

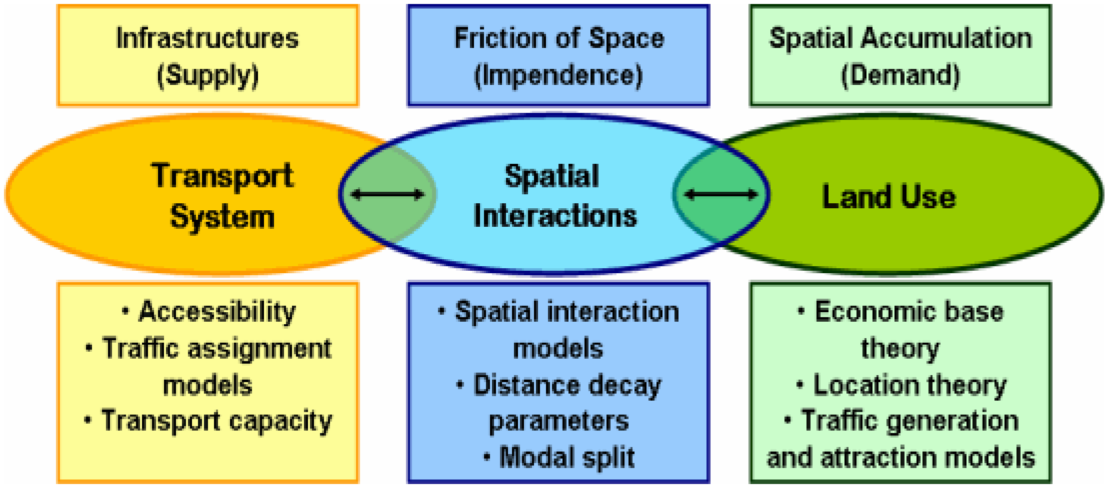
The spatial importance of each transport mode varies according to a number of factors, density being the most important. If density is considered as a gradient, rings of mobility represent variations in the spatial importance of each mode at providing urban mobility. Further, each transport mode has unique performance and space consumption characteristics. The most relevant example is the automobile. It requires space to move around (roads) but it also spends 98% of its existence stationary in a parking space. Consequently, a significant amount of urban space must be allocated to accommodate the automobile, especially when it does not move and is thus economically and socially useless. At an aggregate level, measures reveal a significant spatial imprint of road transportation among developed countries. In the United States, more land is thus used by the automobile than for housing [Kauffman, 2001]. In Western Europe, roads account for between 15% and 20% of the urban surface while for developing countries, this figure is about 10% (6% on average for Chinese cities).

2.3.5 Transportation / Land Use Relationships

Transportation and economic systems have a reciprocal relationship. In other words, **transport supply and demand are mutually interdependent**. For instance, the construction of an highway interchange favors the concentration of commercial and service activities, which will generate additional transport demand, which in turn will favor the location of new activities and a reorganization of the regional spatial structure. This interdependence can be conceptualized with three major elements:

- **Transport system**. Is mainly composed of infrastructures conferring a level of supply, from which can be derived levels of accessibility as well as transportation networks. For instance, traffic assignment models take an existing spatial interaction structure and infer flows within a transportation network. Conceptual flows consequently become a physical reality.
- **Spatial interactions**. Assume flows between locations mainly through a function of spatial impendence, which reflect the friction of the urban space. They have a long tradition in geography and many spatial interaction models were developed. They rely on distance decay parameters as well as the modes involved in urban trips.
- **Land use**. Represents a level of spatial accumulation from which transport demand is derived. There is a wide base of spatial economic models aiming at estimating transport demand, mainly through the generation and attraction of traffic by different land use zones.

Figure 1: Spatial interaction model



- *Source; Kauffman, 2001).*

2.4 Urban Transit

Transit is dominantly an urban transportation mode, particularly in large urban agglomerations. The urban environment is particularly suitable for transit because it provides conditions fundamental to its efficiency, namely **high density** and significant **short distance mobility demands**. Since transit is a **shared public service**, it potentially benefits from economies of agglomeration related to high densities and from economies of scale related to high mobility demands. The lower the density in which a transit system is operating, the lower the demand, with the greater likelihood that it will be run at a loss. In fact, the great majorities of public transit systems are not financially sound and have to be subsidized. Transit systems are made up of many types of services, each suitable to a specific set of market and spatial context. Different modes are used to provide complementarily services within the transit system and in some cases between the transit system and other transport systems.

Contemporary transit systems tend to be **publicly owned**, implying that many decisions related to their development and operation are politically motivated. This is a sharp contrast of the past as most transit systems were private and profit driven initiatives. With the fast diffusion of the automobile in the 1950s, many transit companies faced financial difficulties, and the quality of their service declined as in a declining market there were limited incentives to invest. Gradually, they were purchased by public interests and incorporated into large agencies, mainly for the sake of providing mobility. As such, public transit often serves more a social function of public service and a tool of social equity than having any sound economic role. Transit has become dependent on government subsidies, with little if any competition permitted as wages and fares are regulated. As a result, they tend to be disconnected from market forces and subsidies are constantly required to keep a level of service. With suburbanization transit systems tend to have even less relationships with economic activities.

Reliance on urban transit as a mode of urban transportation tends to be high in Asia, intermediate in Europe and low in North America. Since their inception in the early 19th century, comprehensive urban transit systems had significant impacts on the urban form and spatial structure, but this influence is receding. Three major classes of cities can be found in terms of the relationships they have with their transit systems [Cervero, 1998]:

- **Adaptive cities**. Represent true transit-oriented cities where urban form and urban land use developments are coordinated with transit developments. While central areas are adequately serviced by a metro system and are pedestrian friendly, peripheral areas are oriented along transit rail lines.
- **Adaptive transit**. Represent cities where transit plays a marginal and residual role and where the automobile accounts for the dominant share of movements. The urban form is decentralized and of low density.
- **Hybrids**. Represent cities that have sought a balance between transit development and automobile dependency. While central areas have an adequate level of service, peripheral areas are automobile-oriented.

Contemporary **land development tends to precede the introduction of urban transit services**, as opposed to concomitant developments in earlier phases of urban growth. Thus, new services are established once a demand is deemed to be sufficient, often the subject of public pressures. Transit authorities operate under a service warrant and are often running a recurring deficit as services are becoming more expensive to provide. This has led to a set of considerations aimed at a higher integration of transit in the urban planning process, especially in North America, where such a tradition is not well established. Still, in spite of decades of investment, North American public transit ridership has roughly remained the same.

From a transportation perspective, the potential benefits of a better integration between transit and local land uses are reduced trip frequency and increased use of alternative modes of travel (i.e. walking, biking and transit). Evidence is often lacking to support such expectations has the relative share of public transit ridership is declining across the board. Community design can consequently have a significant influence on travel patterns. Local land use impacts can be categorized in three dimensions of relationships and are influenced by levels of use. Land use initiatives should be coordinated with other planning and policy initiatives to cope with automobile dependence. However, there is a strong bias against transit in the general population because of negative perceptions, especially in North America, but increasingly globally. As personal mobility is a symbol of status and economic success, the users of public transit are perceived as the least successful segment of the population. This bias may undermine the image of transit use within the general population (Cervero 98).

2.5 The Rail Transport

2.5.1 Overview

Rail has come into favor by regional and national governments because of its capabilities of increasing attractiveness and quality of urban public transport (Du &Malley, 2006), thereby contributing to a sustainable and efficient transport network. Rail is still the most energy efficient mode for the movement of freight and passengers (Ministry of Transport, 2005b), and is capable of transporting large numbers of people at high speeds. Rail systems are generally implemented when urban populations and car dependence levels congest transport networks and decrease standards of living. Implementing new rail systems into dispersed urban environments can initially be difficult; however the long-term benefits are permanent.

The benefits of rail are in the fixed nature of the mode. Rail systems have been shown to increase land value around train stations due to the increased levels of accessibility to the area (Du and Malley, 2006) and are highly visible and capable of high speeds. It is stated in transport literature that one of the benefits of suburban rail is that it is a radical, high profile alternative to the private motor-vehicle (Newman &Kenworthy, 1996; Mees, 2000). Other benefits of rail travel include comfort and reliability (Jefferson, 1996). Electrified rail systems can provide increased environmental benefits such as low emissions, noise and vibrations while the fixed nature of rail has been shown to increase pedestrian and passenger safety due to its high visibility and predictable travel path (Jefferson, 1996). Rail platforms also provide the opportunity for level access to the train carriages, which when combined with automated ticketing, decreases the time-spent stationary and increases average travel speeds (Jefferson, 1996). The separation of rail and guided Bus-ways from the road network negates delays caused by congestion or negotiating in and out of traffic at stops. Average travel speeds by bus without the availability of priority space will average travel speeds.

Research has shown railway stations are capable of attracting residential and commercial development resulting in high-density nodes (Edwards &Mackett, 1996; Gibbons &Machin, 2005). Urban development can be planned around the location of stations. Suburban rail can also co-operate with the movement of regional and national freight and increasing rail transport capacities can be achieved through additional carriages. If, as is proposed, public transport increases its proportional share of all travel, increasing capacities should be an important future consideration in the development of any service. The formation of railway station hubs is important as it represents less dependence on private motor vehicles in the area.

Importantly, rail is renowned for being a potentially reliable form of transport. Reliabilities an important consideration in ensuring the success of any public transport system (Anable&Gatersleben, 2005). People enjoy driving because they feel they are in control of their travel. Therefore the accuracy of transport timetables is important in allowing people to control their travel by not having to wait stationary for long periods of time or be subject to in-travel delays on the system.

2.6 Global Trends in Rail Transport Development

2.6.1 Ancient world

The earliest evidence of a railway found thus far was the 6 to 8.5 km long *Diolkos*wagonway, which transported boats across the Isthmus of Corinth in Greece since around 600 BC (Drijvers, J.W, 1992). Wheeled vehicles pulled by men and animals ran in grooves in limestone, which provided the track element, preventing the wagons from leaving the intended route. The Diolkos was in use for over 650 years, until at least the 1st century AD (Lewis, M. J. T, 2001). The first horse-drawn wagonways also appeared in ancient Greece, with others to be found on Malta and various parts of the Roman Empire, using cut-stone tracks.

2.6.2 Early railways

Wagonways or tramways are thought to have developed in Germany in the 1550s to facilitate the transport of ore tubs to and from mines, utilising primitive wooden rails. Such an operation was illustrated in 1556 by Georgius Agricola (Georgius. A, 1913).

The technology spread across Europe and had certainly arrived in Britain by the early 1600s. The WollatonWagonway was probably the earliest British installation, completed in 1604, and recorded as running from Strelley to Wollaton near Nottingham. Another early wagonway is noted at Broseley in Shropshire from 1605 onwards. Huntingdon Beaumont (who was concerned with mining at Strelley) also laid down broad wooden rails near Newcastle upon Tyne, on which a single horse could haul fifty or sixty bushels (130-150 kg) of coal (Pacey. A, (1990).

By the eighteenth century, such wagonways and tramways existed in a number of areas. Ralph Allen, for example, constructed a tramway to transport stone from a local quarry to supply the needs of the builders of the Georgian terraces of Bath. The Battle of Prestonpans, in the Jacobite Rebellion, was fought astride a wagonway. This type of transport spread rapidly through the whole Tyneside coal-field, and the greatest number of lines were to be found in the coalfield near Newcastle upon Tyne, where they were known locally as wagonways. Their function in most cases was to facilitate the transport of coal in chaldron wagons from the coalpits to a staithe (a wooden pier) on the river bank, whence coal could be shipped to London by collier brigs. The wagonways were engineered so that trains of coal wagons could descend to the staith by gravity, being braked by a brakesman who would "sprag" the wheels by jamming them. Wagonways on less steep gradients could be retarded by allowing the wheels to bind on curves (Pacey A, (1990). As the work became more wearing on the horses, a vehicle known as a dandy wagon was introduced, in which the horse could rest on downhill stretches.

Because rails were smoother than roads, a greater quantity and tonnage of bulk goods such as coal and minerals could be carried, and without damage to highways. Naturally, a great deal of inventiveness was focused upon improving the rails and reducing the degree of friction between wheel and rail. In the late 1760s, the Coalbrookdale Company began to fix plates of cast iron to the wooden rails. These (and earlier railways) had flanged wheels as on modern railways, but another system was introduced, in which unflanged wheels ran on L-shaped metal plates - these became known as plateways. John Curr, a Sheffield colliery manager, invented this flanged rail, though the exact date of this is disputed. The plate rail was taken up by Benjamin Outram for wagonways serving his canals, manufacturing them at his Butterley ironworks. Meanwhile William Jessop, a civil engineer, had used a form of edge rail successfully for an extension to the Charnwood Forest Canal at Nanpantan, Loughborough, and Leicestershire in 1789. Jessop became a partner in the Butterley Company in 1790.

As the colliery and quarry tramways and wagonways grew longer, the possibility of using the technology for the public conveyance of goods suggested itself. On 26 July 1803, Jessop opened the Surrey Iron Railway in south London - arguably, the world's first public railway, albeit a horse-drawn one. It was not a railway in the modern sense of the word, as it functioned like a turnpike road. There were no official services, as anyone could bring a vehicle on the railway by paying a toll.

It was not until 1825 that the success of the Stockton and Darlington Railway proved that the railways could be made as useful to the general shipping public as to the colliery owner. This railway broke new ground by using rails made of rolled wrought iron, produced at Bedlington Ironworks in Northumberland (Pacey A, 1990). Such rails were stronger. This railway linked the town of Darlington with the port of Stockton-on-Tees, and was intended to enable local collieries (which were connected to the line by short branches) to transport their coal to the docks. As this would constitute the bulk of the traffic, the company took the important step of offering to haul the colliery wagons or chaldrons by locomotive power, something that required a scheduled or timetabled service of trains. However, the line also functioned as a toll railway, where private horse drawn wagons could be operated upon it. This curious hybrid of a system (which also included, at one stage, a horse drawn passenger wagon) could not last, and within a few years, traffic was restricted to timetabled trains. (However, the tradition of private owned wagons continued on railways in Britain until the 1960s.)

2.6.3 Steam power introduced

James Watt, a Scottish inventor and mechanical engineer, was responsible for improvements to the steam engine of Thomas Newcomen, hitherto used to pump water out of mines. Watt developed a reciprocating engine, capable of powering a wheel. Although the Watt engine powered cotton mills and a variety of machinery, it was a large stationary engine. It could not be otherwise; the state of boiler technology necessitated the use of low pressure steam acting upon a vacuum in the cylinder, and this mode of operation needed a separate condenser and an air pump. Nevertheless, as the construction of boilers improved, he investigated the use of high pressure steam acting directly upon a piston. This raised the possibility of a smaller engine, that might be used to power a vehicle, and he actually patented a design for a steam locomotive in 1784. His employee William Murdoch produced a working model of a self propelled steam carriage in that year (Gordon, W.J. (1910).

The first railway steam locomotive was built in 1804 by Richard Trevithick, an English engineer born in Cornwall. (The story goes that it was constructed to satisfy a bet by Samuel Homfray, the local iron master.) This used high pressure steam to drive the engine by one power stroke. (The transmission system employed a large fly-wheel to even out the action of the piston rod.) His locomotive had no name, and was used on the MerthyrTydfilTramroad in South Wales (sometimes - but incorrectly - called the PenydarrenTramroad).Trevithick later demonstrated a locomotive operating upon a piece of circular rail track in Bloomsbury, London, the "Catch-Me-Who-Can", but never got beyond the experimental stage with railway locomotives, not least because his engines were too heavy for the cast-iron plateway track then in use. Despite his inventive talents, Richard Trevithick died in poverty, with his achievement being largely unrecognized.[11]

The impact of the Napoleonic Wars resulted in (amongst other things) a dramatic rise in the price of fodder. This was the imperative that made the locomotive an economic proposition, if it could be perfected.

The first commercially successful steam locomotive was Matthew Murray's rack locomotive *The Salamanca* built for the narrow gauge Middleton Railway in 1812. This twin cylinder locomotive was not heavy enough to break the edge-rails track, and solved the problem of adhesion by a cog-wheel utilising slots cast in one of the rails. It was the first rack railway.

This was followed in 1813 by the *Puffing Billy* built by Christopher Blackett and William Hedley for the Wylam Colliery Railway, the first successful locomotive running by adhesion only. This was accomplished by the distribution of weight by a number of wheels. Puffing Billy is now on display in the Science Museum in London, the oldest locomotive in existence (Hamilton Ellis (1968).

Figure 2: A replica of the Planet, an early steam locomotive from 1830

Source: Hamilton Ellis 1968

In 1814 George Stephenson, inspired by the early locomotives of Trevithick, Murray and Hedley, persuaded the manager of the Killingworth colliery where he worked to allow him to build a steam-powered machine. He built the *Blücher,* one of the first successful flanged-wheel adhesion locomotives. Stephenson played a pivotal role in the development and widespread adoption of the steam locomotive. His designs considerably improved on the work of the earlier pioneers. In 1825 he built the *Locomotion* for the Stockton and Darlington Railway which became the first public steam railway in the world (Hamilton Ellis (1968).

2.6.4 The Birth of the Railway

In 1812 Oliver Evans, a United States engineer and inventor, published his vision of what steam railways could become, with cities and towns linked by a network of long distance railways plied by speedy locomotives, greatly reducing the time required for personal travel and for transport of goods. Evans specified that there should be separate sets of parallel tracks for trains going in different directions. Unfortunately, conditions in the infant United States did not enable his vision to take hold.

This vision had its counterpart in Britain, where it proved to be far more influential. William James, a rich and influential surveyor and land agent, was inspired by the development of the steam locomotive to suggest a national network of railways. He was responsible for proposing a number of projects that later came to fruition, and he is credited with carrying out a survey of the Liverpool and Manchester Railway. Unfortunately, he became bankrupt and his schemes were taken over by George Stephenson and others. However, he is credited by many historians with the title of "Father of the Railway" (Miles Macnair (2007).

The success of the Stockton and Darlington encouraged the rich investors of the rapidly industrialising North West of England to embark upon a project to link the rich cotton manufacturing town of Manchester with the thriving port of Liverpool. The Liverpool and Manchester Railway was the first modern railway, in that both the goods and passenger traffic was operated by scheduled or timetabled locomotive hauled trains. At the time of its construction, there was still a serious doubt that locomotives could maintain a regular service over the distance involved. A widely reported competition was held in 1829 called the Rainhill Trials, to find the most suitable steam engine to haul the trains. A number of locomotives were entered, including Novelty, Perseverance, and Sans Pareil. The winner was Stephenson's Rocket, which had superior steaming qualities as a consequence of the installation of a multi-tubular boiler (suggested by Henry Booth, a director of the railway company).

The promoters were mainly interested in goods traffic, but after the line opened on 15 September 1830, they found to their amazement that passenger traffic was just as remunerative. The success of the Liverpool and Manchester railway influenced the development of railways elsewhere in Britain and abroad. The company hosted many visiting deputations from other railway projects, and many railwaymen received their early training and experience upon this line.

It must be remembered that the Liverpool and Manchester line was still a short one, linking two towns within an English shire county. The world's first trunk line can be said to be the Grand Junction Railway, opening in 1837, and linking a mid point on the

Liverpool and Manchester Railway with Birmingham, by way of Crewe, Stafford, and Wolverhampton.

2.6.5 Further Development

The earliest locomotives in revenue service were small four-wheeled locos similar to the Rocket. However, the inclined cylinders caused the engine to rock, so they first became horizontal and then, in his "Planet" design, were mounted inside the frames. While this improved stability, the "crank axles" were extremely prone to breakage. Greater speed was achieved by larger driving wheels at expense of a tendency for wheel slip when starting. Greater tractive effort was obtained by smaller wheels coupled together, but speed was limited by the fragility of the cast iron connecting rods. Hence, from the beginning, there was a distinction between the light fast passenger loco and the slower more powerful goods engine. Edward Bury, in particular, refined this design and the so-called "Bury Pattern" was popular for a number of years, particularly on the London and Birmingham.

Meanwhile by 1840 Stephenson had produced larger, more stable, engines in the form of the 2-2-2 "patentee" and six-coupled goods engines. Locomotives were travelling longer distances and being worked more extensively. The North Midland Railway expressed their concern to Robert Stephenson who was, at that time, their general manager, about the effect of heat on their fireboxes. After some experiments, he patented his so-called Long Boiler design. These became a new standard and similar designs were produced by other manufacturers, particularly Sharp Brothers whose engines became known affectionately as "Sharpies"

The longer wheelbase for the longer boiler produced problems in cornering. For his six-coupled engines, Stephenson removed the flanges from the centre pair of wheels. For his express engines, he shifted the trailing wheel to the front in the 4-2-0 formation, as in his "Great A." There were other problems. One was that the firebox was restricted in size, or had to be mounted behind the wheels. The other was that, the generally held opinion arose that, to improve stability, the centre of gravity should be kept low.

The most extreme outcome of this was the Crampton locomotive which mounted the driving wheels behind the firebox and could be made very large in diameter. These achieved the hitherto unheard of speed of 70mph but were very prone to wheelslip. With their long wheelbase, they were unsuccessful on Britain's winding tracks, but became popular in the USA and France, where the popular expression became to "prendre le Crampton".

John Gray of the London and Brighton Railway was one who disbelieved the necessity for a low centre of gravity and produced a series of locos that were much admired by David Joy who developed the design at the firm of E. B. Wilson and Company to produce the 2-2-2 Jenny Lind locomotive, one of the most successful passenger locomotives of its day. Meanwhile the Stephenson 0-6-0 Long Boiler locomotive with inside cylinders became the archetypical goods engine

2.6.6 Expanding network

Railways quickly became essential to the swift movement of goods and labour that was needed for industrialization. In the beginning, canals were in competition with the railroads, but the railroads quickly gained ground as steam and rail technology improved, and railroads were built in places where canals were not practical.By the 1850s, many steam-powered railways had reached the fringes of built-up London. But the new lines were not permitted to demolish enough property to penetrate the City or the West End, so passengers had to disembark at Paddington, Euston, Kings Cross, Fenchurch Street, Charing Cross, Waterloo or Victoria and then make their own way via hackney carriage or on foot into the centre, thereby massively increasing congestion in the city. A Metropolitan Railway was built under the ground to connect several of these separate railway terminals, and thus became the world's first "Metro."

2.6.7 The first Russian railway

Russia was in need of improved transportation and geographically suited to railroads, with long flat stretches of land and comparatively simple land acquisition. It was hampered, however, by its outmoded political situation and a shortage of capital. Yefim and MironCherepanovs, Russian factory engineers, actually invented and built successful working locomotives for a mine tramway between 1832 and 1835, but their inventiveness was not pursued. Foreign initiative and capital were required. The first major public railroad was the Saint Petersburg-TsarskoyeSelo Railway, proposed and built by an Austrian engineer, Franz Anton von Gerstner, in 1836.

2.6.8 Railroad growth in the United States 1830-1890

In 1830, there were only 23 miles of railroad track laid in America. After this, railroad lines grew rapidly. Ten years later, in 1840, the railways had grown to over 2,818 miles. Two decades after that, the number had surpassed 30,000 miles, and 20 years after that, the number had tripled once more to over 90,000 miles (Miles Macnair (2007).

Table 1: Railroad growth in the US 1830-1890

RAILROAD MILEAGE BY REGION					
	1850	**1860**	**1870**	**1880**	**1890**
New England	2,507	3,660	4,494	5,982	6,831
Middle States	3,202	6,705	10,964	15,872	21,536
Southern States	2,036	8,838	11,192	14,778	29,209
Western States and Territories	1,276	11,400	24,587	52,589	62,394
Pacific States and Territories		23	1,677	4,080	9,804
TOTAL USA	9,021	30,626	52,914	93,301	129,774

Source: (Depew. C. M, 1895)

In 1869, the symbolically important trans-continental railroad was completed in the United States with the driving of a golden spike.

2.7 Diesel and electric engines

2.7.1 Electric railways revolutionize urban transport

Prior to the development of electric railways, most overland transport aside from the railways had consisted primarily of horse powered vehicles. Placing a horse car on rails had enabled a horse to move twice as many people, and so street railways were born. In January of 1888, Richmond, Virginia served as proving grounds for electric railways as Frank Sprague built the first working electric streetcar system there. By the 1890s, electric power became practical and more widespread, allowing extensive underground railways. Large cities such as London, New York, and Paris built subway systems. When electric propulsion became practical, most street railways were electrified. These then became known as "streetcars," "trolleys," "trams" and "Strassenbahn."

In many countries, these electric street railways grew beyond the metropolitan areas to connect with other urban centers. In the USA, "electric interurban" railroad networks connected most urban areas in the states of Illinois, Indiana, Ohio, Pennsylvania and New York. In Southern California, the Pacific Electric Railway connected most cities in Los Angeles and Orange Counties, and the Inland Empire. There were similar systems in Europe. One of the more notable rail systems connected every town and city in Belgium. One of the more notable tramway systems in Asia is the Hong Kong Tramways, which started operation in 1904 and run exclusively on double-decker trams.

The remnants of these systems still exist, and in many places they have been modernized to become part of the urban "rapid transit" system in their respective areas. In the past thirty years increasing numbers of cities have restored electric rail service by building "light rail" systems to replace the tram system they removed during the mid-20th century.

2.7.2 Diesel power

Diesel-electric locomotives could be described as electric locomotives with an on-board generator powered by a diesel engine. The first diesel locomotives were low-powered machines, diesel-mechanical types used in switching yards. Diesel and electric locomotives are cleaner, more efficient, and require less maintenance than steam locomotives. They also required less specialized skills in operation and their introduction diminished the power of railway unions in the USA (one of the earliest countries to adopt diesel power on a wide scale). By the 1970s, diesel and electric power had replaced steam power on most of the world's railroads.

In the 20th century, road transport and air travel replaced railroads for most long-distance passenger travel in the United States, but railroads remain important for hauling freight in the United States, and for passenger transport in many other countries.

2.8 High-speed rail

The late 20th century saw high-speed rail systems such as the Shinkansen, the TGV and the Eurostar. Maglev trains are being introduced today.

2.8.1 Definition of High-speed rail

There is no globally accepted standard separating high-speed rail from conventional railroads; however a number of widely accepted variables have been acknowledged by the industry in recent years. Generally high-speed is defined as greater than 200 km/h- applying to both the train's maximum speed and the track's dimensions. Most modern high-speed trains do not exceed 350 km/h and trains exceeding this speed encounter several physical and electrical challenges; in the future this may lead to a separate designation for these even higher-speed trains. One of the most defining aspects of high-speed rail is the tracks on which the train travels, which must have high turn radii, and be welded together, and extremely well supported and anchored to avoid vibrations and other damage. The track itself in most cases is un-interrupted, with roads and other tracks crossing over bridges. Although almost every form of high-speed rail is electrically driven via overhead cables, this is not necessarily a defining aspect and other forms of propulsion, such as diesel locomotives, may be used. Magnetic levitation trains fall under the category of high-speed rail due to their association with track oriented vehicles; however their inability to operate on conventional railroads often leads to their classification in a separate category.

2.8.2 Rationale

Figure 3: German designed 3rd generation Intercity Express

Source: California High Speed Rail Authority

In both Japan and France the initial impetus for the introduction of high speed rail was the need for additional capacity to meet increasing demand for passenger rail travel. By the mid-1950s, the Tōkaidō Main Line in Japan was operating at full capacity, and construction of the first segment of the TōkaidōShinkansen between Tokyo and Osaka started in 1959. The TōkaidōShinkansen opened on October 1, 1964, in time for the Tokyo Olympics. The situation for the first line in Japan was different than the subsequent lines. The route was already so densely populated and rail oriented that highway development would be extremely costly, and that one single line between Tokyo and Osaka could bring service to over half the nation's population, in 1959 that was nearly 45 million people, today well over 65 million. The TokaidoShinkansen line is the most heavily traveled high speed line in the world, and still transports more passengers than all other high speed rail lines in the world combined, including in Japan. The subsequent lines in Japan had rationale more similar to situations in Europe.

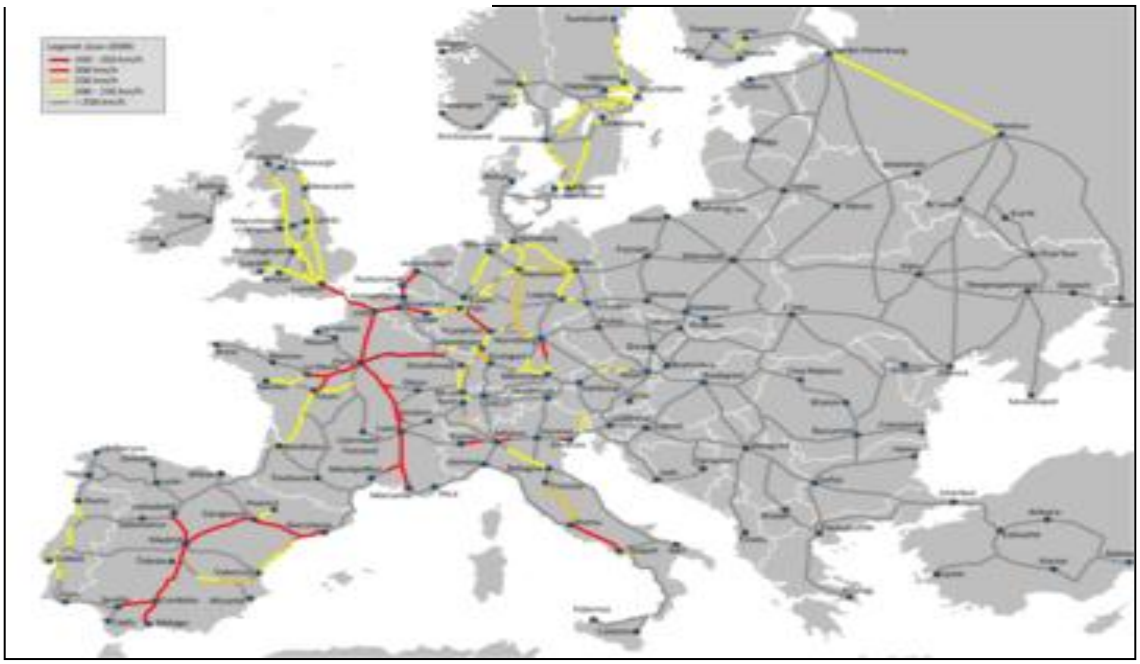
In France the main line between Paris and Lyon was projected to run out of capacity by 1970, so it was decided to build a new line. In both cases the choice to build a completely separate passenger-only line allowed for the much straighter higher speed lines. This dramatically reduced travel times on both lines bringing cities within three hours of one another caused explosions in ridership (Miles Macnair (2007). It was the commercial success of both lines that inspired those countries and their economies to expand or start high speed rail networks.

In the United States the decades after World War II, improvements in automobiles and aircraft, severe antitrust restrictions on railroads, and government subsidization of highways and airports made those means practical for a greater portion of the population than previously. In Europe and Japan, emphasis was given to rebuilding the railways after the war. In the United States, emphasis was given to building a huge national interstate highway system and airports. Urban mass transport systems in the United States were largely eschewed in favor of road expansion. The U.S. railways have been less competitive partly because the government has tended to favour road and air transportation more than in Japan and European countries and partly because of lower population density in the United States, but as energy costs increase, rail ridership is increasing across the country (Miles Macnair (2007).

Travel by rail becomes more competitive in areas of higher population density or where gasoline is expensive, because conventional trains are more fuel efficient than cars. Very few high-speed trains consume diesel or other fossil fuels but the power stations that provide electric trains with power can consume fossil fuels. In Japan and France, where the most extensive high speed rail networks exist, a large proportion of electricity comes from nuclear power. Even using electricity generated from coal or oil, trains are more fuel efficient per passenger per kilometer travelled than the typical automobile because of efficiencies of scale in generator technology. Rail networks, like highways, require large fixed capital investments and thus require a blend of high density and government investment to be competitive against existing capital infrastructure for aircraft and automobiles. Urban density and mass transit have been key factors in the success of European and Japanese railway transport, especially in countries such as the Netherlands, Belgium, Germany, Switzerland, Spain and France.

2.8.3 High-speed rail by country

Map 1: High speed rail by country



High-speed lines in Europe. 320–350 km/h 300 km/h 250–280 km/h 200–230 km/h

High speed lines in Asia.The early target areas, identified by France, Japan, and the U.S., were connections between pairs of large cities. In France this was Paris–Lyon, in Japan Tokyo–Osaka, and in the U.S. the proposals are in high-density areas. The only high-speed rail service at present in the U.S. is the Acela Express, in the Northeast Corridor between Boston, New York and Washington, D.C.; it uses tilting trains to achieve speeds of up to 240 km/h (150 mph) on existing tracks.

One notable fact is that in Europe, Korea, and Japan, dense networks of city subways and railways connect seamlessly with high speed rail lines. Despite efforts to create high speed rail in the USA, cities that lack dense intra-city rail infrastructure will find low ridership for high speed rail, as it is incompatible with existing automobile infrastructure. (People will want to drive when traveling in city, so they might as well drive the entire trip). Since in Japan intra-city rail daily usage per capita is the highest, it follows naturally that ridership of 6 billion passengers exceeds the French TGV of 1 billion (until 2003), the only other system to reach a billion cumulative passengers. [3] For comparison, the world's fleet of 22,685 aircraft carried 2.1 billion passengers in 2006, according to International Civil Aviation Organization.

The California High Speed Rail Authority is currently studying a San Francisco Bay Area and Sacramento to Los Angeles and San Diego line. The Texas High Speed Rail and Transportation Corporation strive to bring Texas an innovative high-speed rail and multimodal transportation corridor.

Figure 5: High speed LVG

Source: California High Speed Rail Authority

The Corporation developed the Brazos Express Corridor to link Central Texas. Later high speed rail lines, such as the LGV Atlantique, the LGV Est, and most high speed lines in Germany, were designed as feeder routes branching into conventional rail lines, serving a larger number of medium-sized cities.

A side effect of the first high-speed rail lines in France was the opening up of previously isolated regions to fast economic development. Some newer high-speed lines have been planned primarily for this purpose, such as the Madrid–Sevilla line and the proposed Amsterdam–Groningen line. Cities relatively close to a major city may see an increase in population, but those farther away may actually lose population (except for tourist spots), having a ripple effect on local economies.

Five years after construction began on the line, the first Japanese high-speed rail line opened on the eve of the 1964 Olympics in Tokyo, connecting the capital with Osaka. The first French high-speed rail line, or *Ligne à grandevitesse* (LGV), was opened in 1981 by SNCF, the French rail agency, planning starting in 1966 and construction in 1976.

Market segmentation has principally focused on the business travel market. The French original focus on business travelers is reflected by the early design of the TGV trains, including the bar car. Pleasure travel was to be a secondary market; now many of the French extensions connect with vacation beaches on the Atlantic and Mediterranean, as well as major amusement parks and also the very popullar Alpine ski resorts in France or Switzerland. Friday evenings are the peak time for TGVs (*train à grandevitesse*) (Metzler, 1992). The system has lowered prices on long distance travel to compete more effectively with air services, and as a result some cities within an hour of Paris by TGV have become commuter communities, thus increasing the market while restructuring land use.On the Paris - Lyon service, the number of passengers grew to impressive numbers justifying the introduction of double-decks coaches on the TGV trainsets.

Other target areas include freight lines, such as the Trans-Siberian Railway in Russia, which would be allow 3 day Far East to Europe service for freight as opposed to months by ship (but still slower than air), and allow just in time deliveries. High speed north-south freight lines in Switzerland are under construction, avoiding slow mountainous truck traffic, and lowering labour costs.

2.8.4 Technology

Figure 6: French High Speed Rail

Source: SNCF

France's TGV technology has been adapted for use in a number of different countries.Much of the technology behind high-speed rail is an improved application of mature standard gauge rail technology using overhead electrification. By building a new rail infrastructure with 20th century engineering, including elimination of constrictions such as roadway at-grade (level) crossings, frequent stops, a succession of curves and reverse curves, and not sharing the right-of-way with freight or slower passenger trains, higher speeds (250–320 km/h) are maintained. Total cost of ownership of HSR systems is generally lower than the total costs of competing alternatives (new highway or air capacity). Japanese systems are often more expensive than their counterparts but more comprehensive because they have their own dedicated elevated guideway, no traffic crossings, and disaster monitoring systems. Despite this, the lion's share of the Japanese system's cost is related to boring tunnels through mountains, as was in Taiwan. Recent advances in wheeled trains in the last few decades have pushed the speed limits past 400 km/h, among the advances being tilting trainsets, aerodynamic designs (to reduce drag, lift, and noise), air brakes, regenerative braking, stronger engines, dynamic weight shifting, etc. Some of the advances were to fix problems, like the Eschede disaster. The record speed for a wheeled electric train is 574.8 km/h is held by a shortened TGV train and long straight highly modified track. The record speed for an unmodified commercial trainset is 403.7 km/h, held by the Velaro E. European high-speed routes typically combine segments on new track, where the train runs at full commercial speed, with some sections of older track on the extremities of the route, near cities.

In France, the cost of construction (which was €10 million/km (US$15.1 million/km) for LGV Est) is minimised by adopting steeper grades rather than building tunnels and viaducts. However, in mountainous Switzerland, tunnels are inevitable. Because the lines are dedicated to passengers, gradients of 3.5%, rather than the previous maximum of 1–1.5% for mixed traffic, are used. Possibly more expensive land is acquired in order to build straighter lines which minimize line construction as well as operating and maintenance costs. In other countries high-speed rail was built without those economies so that the railway can also support other traffic, such as freight. Experience has shown however, that trains of significantly different speeds cause massive decreases of line capacity. As a result, mixed-traffic lines are usually reserved for high-speed passenger trains during the daytime, while freight trains go at night. In some cases, nighttime high-speed trains are even diverted to lower speed lines in favor of freight traffic.

2.9 Historical development of the railway transport in Kenya

The former Uganda Railway, was run by the company East African Railways jointly for the countries of Uganda, Tanzania and Kenya after World War I. Since the dissolution of the EAR Corporation in 1977 the national company Kenya Railways Corporation runs the former Uganda Railway and its branches in Kenya. The most important line in the country runs between the port of Mombasa and Nairobi, where sleeping car accommodation is offered for tourists.

In 2006, the Rift Valley Railways Consortium led by South African companies took operating control of the Kenya and Uganda railways as part of a contract lasting at least 25 years. After criticism from the Kenya Railways Corporation, RVR doubled the frequency of service, and also imposed restrictions to reduce derailments on the ageing infrastructure. RVR run passenger trains within Kenya only, primarily from Nairobi to Mombasa but also to local towns such as Kisumu. Passenger services on these lines are offered on peak periods only. Freight services are the bulk of RVR's operations.

2.10 Railway transport in Kenya

The railway system in Kenya comprises of a single-track main line from Mombasa to Malaba covering a distance of 1082 km. Its important branch lines are the Nakuru-Kisumu and Nairobi-Nanyuki railway lines, while the minor branch lines consist of VoiTaveta, Gilgil-Nyahururu, Rongai-Solai and Leseru-Kitale. These were built primarily to serve the former white highlands. KRC operates a meter gauge (1000 mm) system built in the late nineteenth and early twentieth centuries. The main branch lines and their lengths are shown in the table below.

Table 2: Kenya Railways Track Mileage

Line	**Line Length (km)**
Principal Lines	
Mombasa – Nairobi	483
Nairobi – Malaba	456
Nakuru – Kisumu	200
Minor Lines	
Voi – Taveta	119
Konza – Magadi	150
Nairobi – Nanyuki	262
Gilgil – Nyahururu	82
Eldoret – Kitale	90
Kisumu – Butere	69
Rongai – Solai	28

Source: Kenya Railways Corporation

The entire railway transport system consists of a total track network of 2,130 km. It also connects wagon ferry services at Kisumu. The main line from Mombasa to Malaba is 95 lb./m while major branch lines such as Kisumu and Nanyuki are 80 lb./m. Smaller branch lines have 50 lb./m rails.

2.11 Commuter railway network in Kenya

The headquarters of Kenya Railways (KR) is situated at Nairobi railway station, near the city centre. Kenyan Railways connect:

- Nairobi to Ruiru via Ruaraka, Githurai and Kahawa
- Nairobi to Athi River via Embakasi
- Nairobi to Kikuyu via Kibera and Riruta.

2.12 Commuter Trains Operations

Currently, there are four commuter trains operating in the Nairobi Metropolitan Area from the centre of Nairobi Central Station as under:

- Nairobi – Kahawa via Makadara (24 km)
- Nairobi – Embakasi Village via Makadara (12.6 km)
- Nairobi – Kikuyu via Kibera, Dagoretti (31 km)
- Nairobi – Ruiru (32 km)

The trains operating for commuter traffic are usual passenger trains hauled by locomotives.

The trains are stabled at Ruiru, Kahawa, Embakasi, & Kikuyu at night and operate from these stations to Nairobi in the morning. The trains are worked from Nairobi in the evening. The locomotives return light without train in the evening and travel back in the morning to pick up the trains.

Magadi Railway (MR) operates a siding between Konza and Magadi (150Km) – mainly for freight traffic, but there are regular overnight passenger trains operating between Nairobi, Mombasa and Kisumu. Commuter rail services are currently operated by the Rift Valley railways who are the concessionaires for the Kenyan Railways.

Most of urban commuters do not use the commuter rail due to the following:-

- Lack of safety
- Lack of comfort
- Limited number of routes and services
- Inadequate intermodal transfer facilities and
- Long walking distance between the railway station and places of work.

It is also, observed that the demand for train service is low, since, none of the important stations can be reached easily by a large number of passengers.

2.13 The Present System

Presently 3 rail lines of Kenyan Railways traverse the NMR. In addition there is a long industrial siding from Konza to Magadi via Kajiado, owned and operated by a private company. The track is of meter gauge (MG). The alignment is circuitous, geometrics poor, rakes obsolete and service dismal. It takes more than 1 hours from Nairobi to Ruiru. Though the fare is cheap, compared to bus and matatus, patronage is low due to poor quality of service. Overall the system is obsolete and requires scrapping and rebuilding on modern standards and technology.

The Kenya Railways is planning to develop the railway on modern lines. The process of planning and feasibility studies is under progress. In general the railway lines would run from Mombasa to Kampala (Uganda) and from North Kenya to South Kenya, both traversing through NMR. It is a good opportunity to re-align the rail lines in NMR along the proposed Regional Bypass Grid. The transport hub at Kajiado will contain the rail terminal and yards.

Extensive land for rail system could be allocated. With this re-alignment, the tracks, stations and yards of the railways within NMR, in particular within Nairobi, would be free for use for urban rail service within NMR and Nairobi City.

Map 2: Proposed and existing commuter rail network in NMR

Source: Kenya Railways Corporation

2.14 CASE STUDIES

2.14.1 RAIL TRANSPORT IN ASIA (MANILA-PHILIPINE)

The Manila Metro Rail Transit System, popularly known as the MRT, Metrostar Express or Metrostar, is part of the metropolitan rail system in the Metro Manila area of the Philippines, the Strong Republic Transit System (SRTS) (Philipine Star, 2003). It has a single line, MRT-3 or the Blue Line. Although it has characteristics of light rail, such as the type of rolling stock used, it is more akin to a rapid transit system. It is not related to the Manila Light Rail Transit System, a separate but linked system.

The MRT forms part of Metro Manila's rail transport infrastructure, known as the Strong Republic Transit System, and overall public transport system. One of its original purposes was to decongest Epifanio de los Santos Avenue (EDSA), one of Metro Manila's main thoroughfares and home to the MRT, and many commuters who ride the MRT also take road-based public transport, such as buses, to reach the intended destination from an MRT station. MRT has been only partially successful in decongesting EDSA, and congestion is further aggravated by the rising number of motor vehicles (LTO, 2006). The expansion of the system to cover the entire stretch of EDSA is expected to contribute to current attempts to decongest the thoroughfare and to cut travel times. The MRT is operated by the Metro Rail Transit Corporation (MRTC), a private company operating in partnership with the Department of Transportation and Communications (DOTC) under a Build-Operate-Transfer (BOT) agreement.

The single line (P.I, July, 2006) serves 13 stations on 16.95 kilometres (10.5 mi) of line. It is mostly elevated, with some sections at grade or underground. The line commences at Taft Avenue (*Taft* on the map) and ends at North Avenue, serving the cities that EDSA passes through: Makati, Mandaluyong, Pasay, Pasig, Quezon City, and San Juan.

Taft Avenue and Araneta Center-Cubao are interchanges with the LRT network, with Taft Avenue connected to EDSA station on the Yellow Line and Araneta Center-Cubao connected to its namesake station on the Purple Line. The line's termini have been designated as transport hubs, where commuters can change to and from take other forms of public transport.

Figure 7: An MRT train in-between the EDSA-Quezon Avenue Flyover.

Source: Metrostar Express

A metro line on EDSA was envisioned in the plan of Electrowatt Engineering Services of Zürich during the construction of the LRT. The plan consisted of a 150 kilometre network of rapid transit lines spanning all major corridors within 20 years, including a line on EDSA.

In the 1990s, the MRTC was awarded a Build-Operate-Transfer contract by the DOTC. The DOTC would have ownership of the system and assume all administrative functions, such as the regulation of fares and operations. The MRTC would have responsibility over construction and maintenance of the system and the procurement of spare parts for trains. In exchange, the DOTC would pay the MRTC monthly fees for a certain number of years to reimburse any incurred costs (MRTC, July, 2006).

Construction started on September 16, 1997 after the MRTC signed an amended turnkey agreement with a consortium of companies, which included Mitsubishi Heavy Industries and Sumitomo Corporation, and a local company, EEI Corporation, which was subcontracted for civil works. A separate agreement was signed with ČKD on rolling stock. MRTC also retained the services of ICF Kaiser Engineers and Constructors to provide program management and technical oversight of the services for the design, construction management and commissioning (MRTC, July, 2006)

Figure 8: Taft Avenue Station platform area

Figure 9: The entrance to Ayala station as seen from the Ayala Center

2.14.1.1 Station layout and accessibility

Stations have a standard layout, with a concourse level and a platform level. The concourse is usually above the platform, with stairs, escalators and elevators leading down to the platform level. The levels are separated by fare gates.

The concourse contains ticket booths. Some stations, such as Araneta Center-Cubao, are connected at concourse level to nearby buildings, such as shopping malls, for easier accessibility.

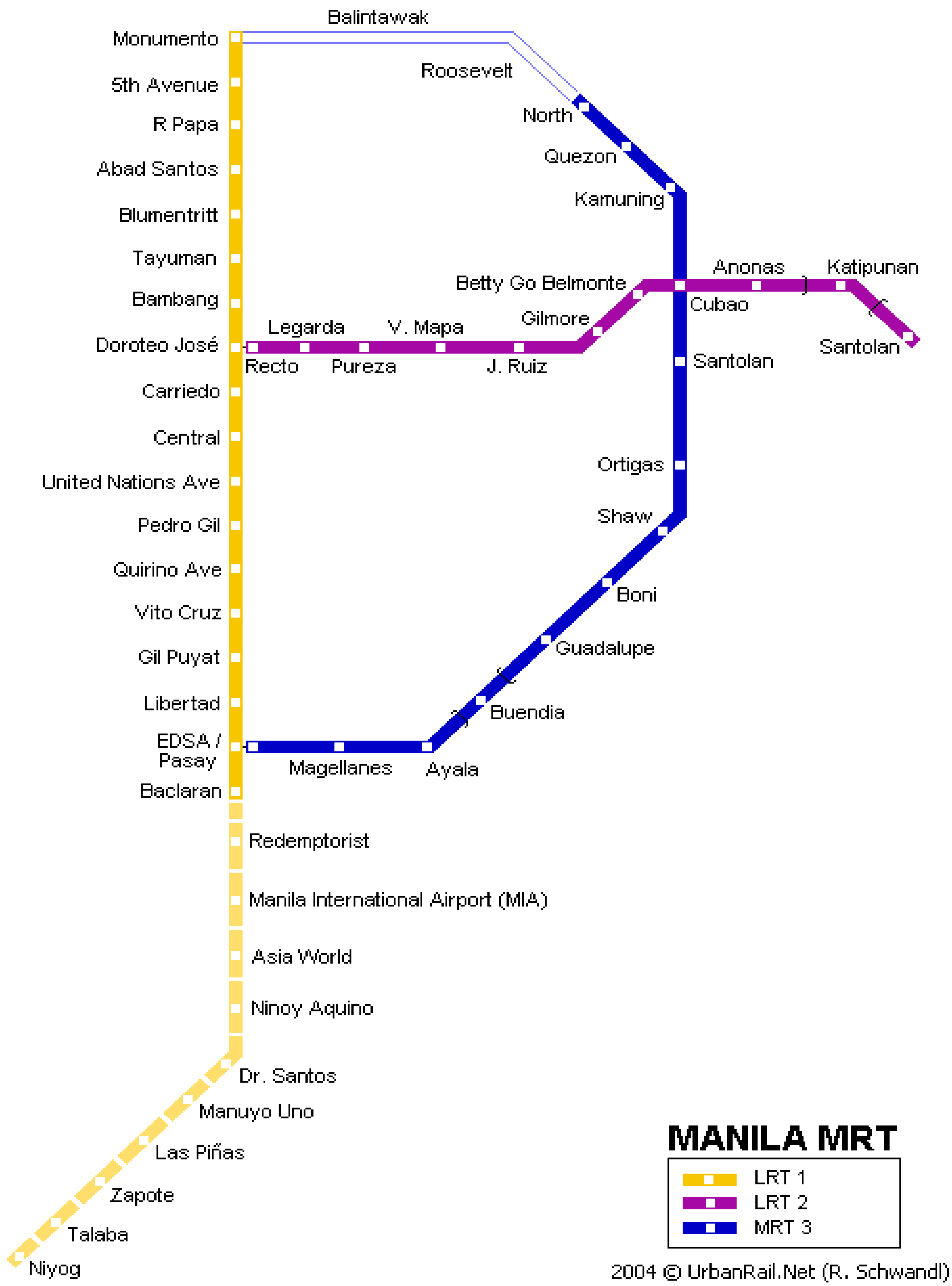
Stations either have island platforms, such as Taft Avenue and Shaw Boulevard, or side platforms, such as Ortigas and North Avenue. Part of the platform at the front of the train is cordoned off for the use of women, children, elderly and disabled passengers. At side-platform stations passengers may need to enter the concourse area to enter the other platform or go through bridges atop some stations, while passengers can easily switch sides at stations with island platforms. Stations have toilets at the concourse level.Most stations are barrier-free inside and outside the station, and trains have spaces for wheelchair-bound passengers.

2.14.1.2 Shops and services

Inside the concourse of all stations is at least one stall or stand where people can buy food or drinks. Stalls vary by station, and some have fast food stalls. The number of stalls also varies by station, and stations tend to have a wide variety, especially in stations such as Ayala and Shaw Boulevard.

Stations such as Taft Avenue and North Avenue are connected to or are near shopping malls and/or other large shopping areas, where commuters are offered more shopping varieties.In cooperation with the Philippine Daily Inquirer, passengers are offered a copy of the Inquirer Libre, a free, tabloid-size, Tagalog version of the Inquirer, which is available from 6 a.m. at Santolan, Ortigas, Buendia and Ayala stations.

Figure 10: The Manilla Metropolitan Rail System



Metro-Manila, the metropolitan area of the capital of the Philippines is home to some 10 million people. A light metro system (Mass Rail Transit - MRT), which runs mainly elevated, is being developed:

LRT 1 is a fully elevated north-south route opened 1 Dec. 1984 (7 km) and June 1985 (8 km). It runs along Rizal and Taft Avenues (15 km, 18 stations). The capacity of the line was increased in 1998. The line runs on a precast concrete structure 7 m above the street, designed to withstand earthquakes. It has 1435 mm gauge and 750 V overhead power supply. Average station distance is 825 m, stations are only accessible via stairs, there are no elevators or escalators. *Central*, *Monumento* (northern terminal) and *Baclaran* (southern terminal) function as transfer station to buses and jeepneys. Trains operate in 2-4 car units (one unit 29.3 m long, 2.5 m wide), which have roof ventilation. A 12 km southern extension will be built by SNC-Lavalin (Canada) (Oct.2000).

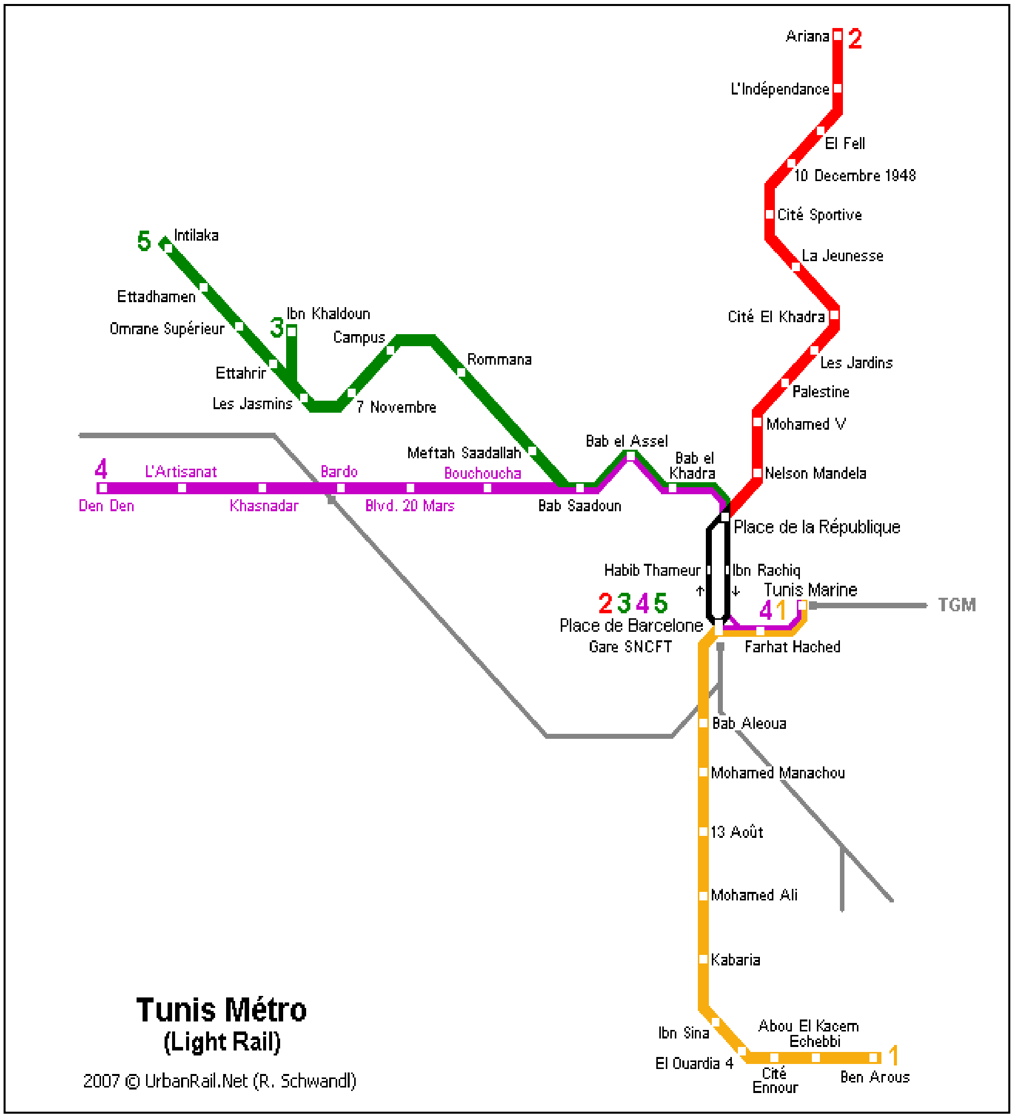
MRT 3 (popularly called **Metrostar**) runs elevated along EDSA (Epifanio de los Santos Ave.) ring road (except *Buendia* station which is underground). The central section opened on 16 Dec. 1999, the southern section, which connects to LRT 1 followed on 20 July 2000. The total length is now 16.8 km, once the northern section is built the line will be 24 km. After the first months of operation, ridership was far below expectations, mainly due to high fares compared to buses and long flights of stairs to access the elevated stations. Metrostar trains are air-conditioned.

LRT 2 (**Megatren** or **Purple Line**) runs from Manila in the west via Quezon City to Pasig in the east. The line is elevated except for *Katipunan* station, which is underground. Construction of this line started in 1998 and it runs along Recto Ave, Magsaysay Blvd and Aurora Blvd. The full length from *Santolan* to *Recto Ave*. is 13.8 km with 11 stations. Although called LRT, this line uses heavy rail metro vehicles. A footbridge linking the Purple Line to the Yellow Line eventually opened in March 2005.

2.14.2 RAIL TRANSPORT SYSTEM IN AFRICA (TUNIS-TUNISIA)

Tunis is the capital of Tunisia and has some 1.5 million inhabitants. In order to save costs and speed up implementation, a light rail system was chosen instead of an underground metro.

Figure 11: Tunis Metro Rail



After less than four years of construction, Line 1 opened in 1985. In 1989, Line 2 was inaugurated between the city centre and the northern districts, both lines serving the western suburbs were taken into service in 1990. Total length of the network is 30 km. The whole system was built as a turnkey project by a consortium led by Siemens. The "Métro Léger de Tunis" is so far the only one of its kind and apart from Cairo's subway the only urban mass transit system on the African continent. The bi-directional light rail vehicles are based on those running on several networks in Germany (Stuttgart, Cologne, etc.). They are prepared for low and high platforms. The 30/60 m long trains run mostly on separate right-of-way with level crossings along the route. Power supply is via a 750 V dc overhead wire. Track gauge is 1435 mm.

At *Tunis Marine*, the Métro links to the TGM suburban line and at *Place Barcelone* transfer is possible to Tunisian State Railways. The metro is operated by Société du Métro Léger de Tunis (SMLT).

2.15 Legal and institutional framework

2.15.1 Traffic Act Chapter 403

This Act consolidates the law relating to traffic on all public roads. The Act also prohibits encroachment on and damage of roads including land reserved for roads. The project is under the provision of the Act.

2.15.2 Kenya Railways Corporation Act (Cap. 397, 1979)

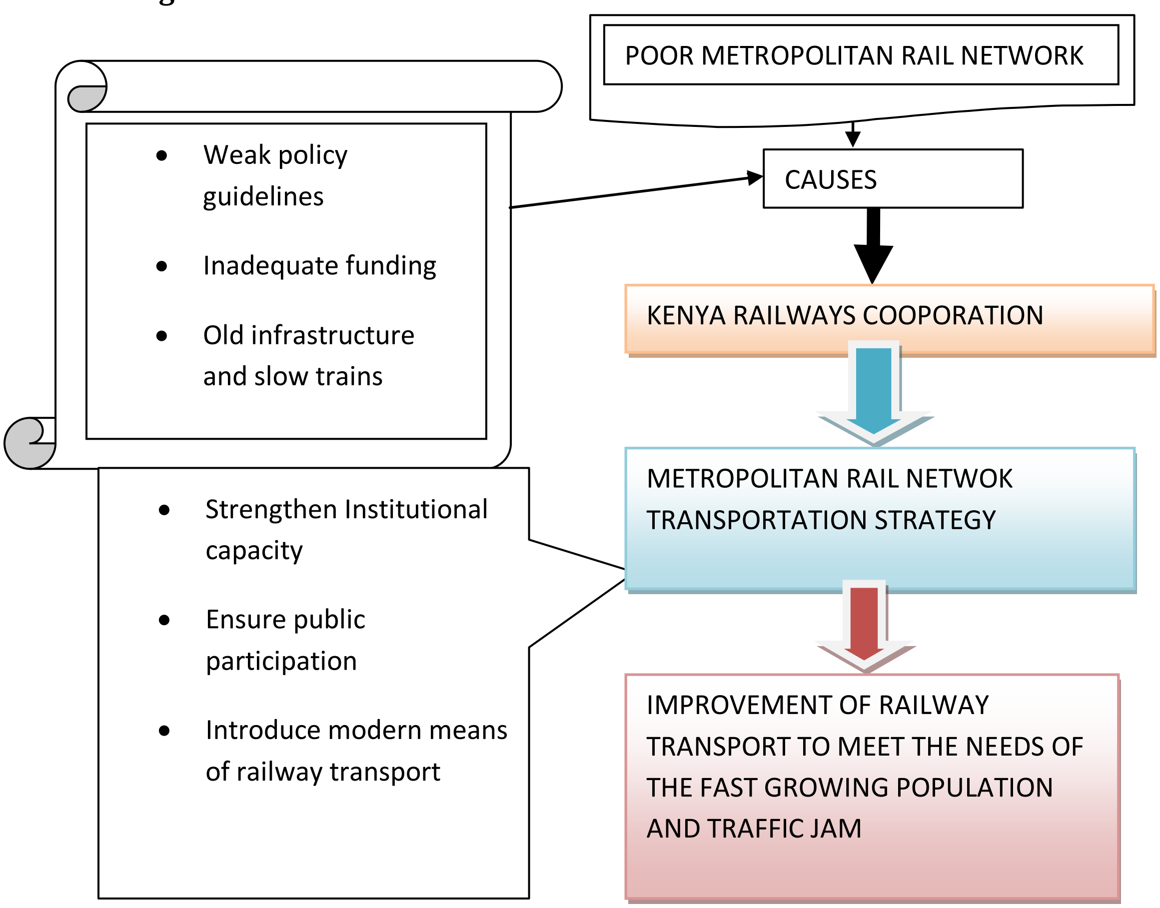
Rail transport is the second most important mode of transport in Kenya, after road transport. The nature of Kenya Railways, its operations and business are defined by this Act. (Kenya Government 1979)

Currently, operations of Kenya Railways lie on a national network of railway tracks covering a total distance of 2,778 km. The land corridor on which the rail tracks are laid belongs to Kenya Railways. Under the Vesting of Land Order of 1996 made under the Act, Kenya Railways owns the land extending 60 metres on either side of a main running line. The proposed project is located entirely within the land corridor of the Nairobi-Mombasa main railway line and will run for a distance of 2 km, and extend a further 200 metres on land leased by Kenya Railways. The Kenya Railways (Amendment Act of 2005) amends Cap 397 in so far as concession arrangements are concerned. Specifically this relates to facilitation of concession of railway operations and business only, otherwise the original statute is still operational in its aims, objectives and jurisdiction.

2.16 CONCEPTUAL FRAMEWORK

Railway development is never the business of the railway company alone. With the rising expectation and demand for liveable communities, the social impact of public investments like railway projects is coming under greater scrutiny. Support from stakeholders is not only a positive driving force for sustainable railway development, but is also necessary for ensuring a smooth project implementation process. To secure their support, sufficient communication between the railway company and the stakeholders in an open and proactive manner is needed. It would be beneficial to the rail project if stakeholders could obtain a better understanding of the projects and the constraints that have to be taken into account through the communications about the project-related issues, for example, introduction of the project programme and corresponding arrangements, like traffic diversion, explanation of possible disturbances during construction and discussions about alternative solutions to problems and objections, etc.

Figure 14:



2.17 Summary of the emerging issues

The various theories and concepts have been reviewed in order to set the foundation on which the aspects of the research were founded. A review of literature on earlier works was carried out with gaps in such studies identified. Some of the works and theories emphasized that the more accessible a location is the higher the value, and the better a location is connected in terms of network of access the higher the values of properties than a location that is in a disadvantaged location. Other works however found no direct impact of transport network on location of land use.

Literature on transportation and commercial property values on Kenya are scanty, thus this study will fill the gap. The theoretical frameworks that are relevant and adopted for this study are the concepts of accessibility theory, pattern of rail network and location theory.

These theories and concepts are essential to guide the study towards attaining the stated aim and objectives and determine if the research findings confirm or contradict them.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This section describes the methodology used in the study and details out the study's sampling design, data sources, analysis and presentation. Research methodology employed in this study includes a reconnaissance survey of Kikuyu, Dagoretti, Dandora, Ruiru and Nairobi Railway stations, which was done to assist in the delimitation of the study area. For data collection, the study relied on secondary information as the primary data was collected through techniques such as questionnaire administration, informal interviews alongside direct participant observation and field photography of salient features. The survey was conducted with the help of two research assistants.

The spatial sample frame for the study was defined by the railway lines consisting of the Dandora-Nairobi, Kikuyu-Dagoretti-Town and Thika-Ruiru-Nairobi. The railway lines serve stations such as Nairobi Railway Station, Dagoretti station, Dandora station, Kikuyu station, Ruiru station and Thika Railway station. The railway lines are the major transportation hub linking the neighbiurhoods of Dandora, Kikuyu, Dagoretti, Ruru and Thika to the CBD and other neighbourhoods within the city council of Nairobi . The railway stations were systematically selected, where household survey was conducted in each of the stations. A maximum of 10 questions were administered in each station to gauge the residents opinion on the rail transport system within the Nairobi Metropolitan region.

3.2 Research design.

The research design is the conceptual structure within which research is conducted. It consists of blueprint for the collection, measurement and analysis of data. As such the design includes an outline of the framework of study, availability of various data, and observations. It means the exact nature of the research work in a systematic manner (Kothari, 2004).

This research study used descriptive research design. This design uses description as a tool to organize data into patterns that emerge during analysis.. There are two categories of descriptive designs: surveys and observational studies. This research was administered through the use of a structured questionnaire distributed among respondents to collect primary data.

3.2.1 Methods of data collection

This is the most fundamental feature of the research design. The data collection is done with participatory involvement of the Nairobi Metropolitan Residents who constitute the passengers and done by the research in conjunction with the stakeholders.

The methods of data collection that will be employed include.

i. Interview schedules with the key informants i.e. The Ministry of Transport and Kenya Railways.

ii. Structured questionnaires. These data instruments will source data and information from the passengers.

iii. Photographing.

iv. Observation- will be achieved by sketching.

v. Use of GPS to measure and establish both the elevation and area of the study area.

3.2.2 Preparation for data collection

Consent to carry out the research will be first obtained from university of Nairobi- department of urban regional planning through a formal written consent.

3.3 Population and sampling

The target population for this research study included private property developers, passengers (those who have used the railway network and those who have not), Kenya Railways staff, Rift valley Railways staff and government agencies such as the Ministry of Transport that have been involved in railway transport strategies.

3.3.1 Selection Criteria

3.3.1.1 Railway stations

The selected railway stations were the stations that serve the commuters making frequent trips to Nairobi for different purposes. The stations were within the distance that could support active daily commuting to and fro Nairobi city.

3.3.1.2 Target Population

The target population included those that make frequent trips to and fro the city using different modes of transport. The population had to be within the catchement of the railway station. To this end, only the population that resides where there is a railway station.

3.4 Sampling Design

A reconnaissance survey was first conducted in August 2008, the period when questionnaires and interview schedules were also formulated, units of observation and analysis identified and sampling procedures designed. To reduce costs and control the quality of data collected, 50 households within the spatial sample frame were randomly selected for the administration of household questionnaires.

3.5 Research Approach

The study focused on qualitative aspects of commuter rail transport situations, how effective it is, and how it can be planned to cover the larger Nairobi Metropolitan Region. The main strategy of this research was a combination of secondary data and case study of the various railway stations in Nairobi, Dagoretti, Kikuyu, Ruiru and Thika.

The multiple approaches helped me to avoid unexpected difficulties during fieldwork and increased the validity and reliability of the data. Besides, multiple sources of information improve the research by using data from other sources to support the cases.

3.6 Data Collection Tools

There is a wide range of research tools that researchers use to collect different kinds of data and information, (Shihembetsa, 1995). Tools range from analytic investigations, to multivariate studies using surveys and observational techniques, (Rubin and Elder, 1980) as cited in (Shihembetsa, 1995). Each of these tools has its strengths and weaknesses depending on the type of information that is being collected.

Due to wide range of issues to be investigated as highlighted in chapter one, there was need to use multiple research tools. This approach is otherwise called triangulation. Denzin, (1978) as cited in Shihembetsa, (1995) asserts that "the greater the triangulation the greater the confidence in the observed findings". It (in this context) refers to the use of more than one research tool to collect different data. Its adoption as a research approach was based on the "assumption that any bias inherent in particular data sources, investigator and method would be neutralized when used in conjunction with other data sources, investigators and methods," (Shihembetsa, 1995).

This research collected both primary and secondary data as follows:

3.6.1 Interview through questionnaires and observation

Direct field observation and recording by the researcher was done by use of a field notebook, base map and a camera. To verify all the information provided, the researcher made field observations. Some of the issues that were observed directly include the state of the railway lines and also the conditions of the existing coaches and engines.

The researcher conducted personal interviews of selected sample respondents using standard structured questionnaires. This gave the researcher the socio-economic background of the study area. Questionnaires also captured data that were informative about the modes of affecting the metropolitan commuter rail system in the Nairobi region, the problems the potential train users face in using the rail transport system and also the existing regulatory framework of the transport sector.

3.6.2 Qualitative interview with Key Informants

Guided interview were administered to selected Kenya Railway Corporation (KRC) officials and officials from the Ministry of Transport. Their contributions shed more light on the institutional framework and existing transport policies. This was important in understanding various roles of the two institutions vis-à-vis rail transport development in the country and more specifically in the Nairobi Metropolitan Region.

3.6.3 Mapping and photography

Not all the information could be obtained from the field; therefore the researcher looked at secondary data source from records, publications, and magazines among others. Relevant information, documents were extensively used to compliment information collected in the field.

Table 3: Summary of Information Sources

GENERAL	SECONDARY SOURCES	EMPIRICAL DATA
a) Books b) Magazines c) Newspapers d) Internet	a) Journal articles b) Papers to conferences c) Government publications d) Professionals e) Unpublished materials-minutes, reports, internal correspondences	a) Personal contact with researchers b) Field visits to ongoing projects c) Round table discussions

Source: Adapted from Shihembetsa L. 1995

3.7 Data Analysis

Data collected was analyzed using various appropriate techniques. For quantitative data, it was coded, entered in a well-designed data entry frame and soon after entry, was cleaned to check consistency, validity and reliability. Statistical Package for Social Scientists (SPSS) was used to analyze the data. With simple analytic and presentation procedures including frequencies, cross tabulations, charts, and others, the information generated was extracted for compilation of this final document.

The Geographical Information System (GIS) was used to do the analysis of the Nairobi railway network. The information was then presented in form of maps and charts.

3.8 Conclusion

Table 4: Summary of the Research Methods Used

METHOD USED	**TOOLS USED**	**VARIABLES**	**TECHNIQUE OF ANALYSIS**		
			Descriptive	**Frequencies X-tabs**	**Photos**
QUESTIONNAIRE INTERVIEWS	Structured Questionnaires	Commuters' characteristics a) social b) demographic c) economic d) nature and reasons for commuting		X	
OBSERVATIONAL TECHNIQUES	Notes	-Railway conditions -conditions of the coaches	X		X
DISCUSSIONS	Open ended	a) Legal b)Institutional dispensation	X		
INSTRUMENT TECHNIQUES	a) Cameras b) Maps c) Plans		X		X

Source: Adapted (But Modified) from Shihembetsa L. 1995

Table 3: Data Needs Matrix

RESEARCH OBJECTIVE	RESEARCH QUESTION	TYPE OF DATA REQUIRED	METHODS OF DATA COLLECTION	SOURCES OF DATA
To determine the factors affecting development of the Nairobi metropolitan rail system	What are the factors affecting development of an effective Nairobi metropolitan mass transit rail system?	Government strategy and incentives on railway transport	Questionnaires interviews	**Secondary data** Literature review **Primary data** interviews
To determine whether the existing rail transit network is adequate to provide the passenger services within the Nairobi City and its environs	Is the existing metropolitan rail network adequate to provide the necessary mass passenger transit within Nairobi and its environs?	Population size of the Nairobi Metropolitan	Questionnaires interviews	**Secondary data** Literature review **Primary data** interviews
To identify the limitations of the existing metro rail transit network in terms of accessibility to passengers, routing and	Is the existing network conveniently accessible to high passenger potential areas?	Route network of the current railway	Questionnaires interviews	**Secondary data** Literature review **Primary data** interviews

convenience.				
To propose a sustainable approach to delivery of an effective metropolitan mass transit rail network in Nairobi city and its environs in terms of spatial convenience and accessibility to passenger traffic	What is the possible effective approach to the development of an efficient sustainable mass transit rail system?	Legal and institutional framework of railway transport in Kenya	Questionnaires interviews	**Secondary data** Literature review **Primary data** interviews

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

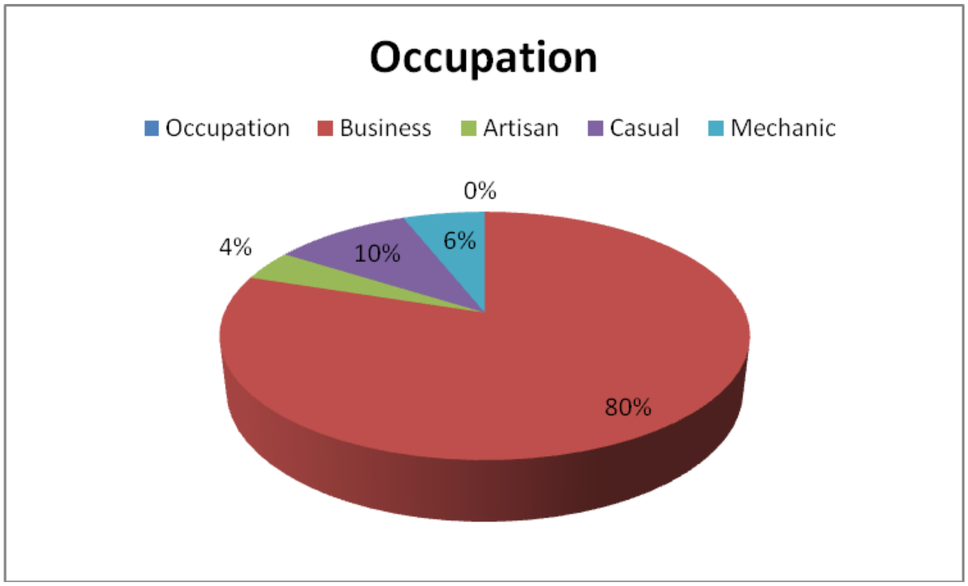
This chapter will provide the presentation, analysis and interpretation of all the data collected from the area of study during the research period. Data was collected through various research instruments which included questionnaires targeting households and water vendors, interview schedule with key informants, focus group discussions with various community members and through an observation schedule which included photography.

The quantitative data was analyzed using descriptive statistics and was presented in the form of tables, percentages, graphs and charts. The qualitative data was analyzed through the use of content analysis. Results of the data analysis provided information that formed the basis for discussion, conclusion, and interpretation of the findings and recommendations of the study. The Use of Statistical Package for the Social Science (SPSS) was extensively used by the researcher in statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation. Photographs were analyzed through subjective analysis as they were objective. Descriptive statistics was attained through cross tabulation, frequencies, and descriptive ratio statistics. Cross tabulation involved the process of creating a contingency table from the multivariate frequency distribution of statistical variables. Content analysis was used to analyze the qualitative data. This allowed for the classification, sorting and enabled the researcher to arrange information and examine the relationships in the data. The analyzed data was later exported to Microsoft Word where the researcher was able to come up with the conclusions of the analysis.

4.2 Occupation of the respondents

Most of the respondents were found to engage in business activities while the minority engaged in informal activities like artisans and mechanics.

Figure 12: Occupation of the respondents

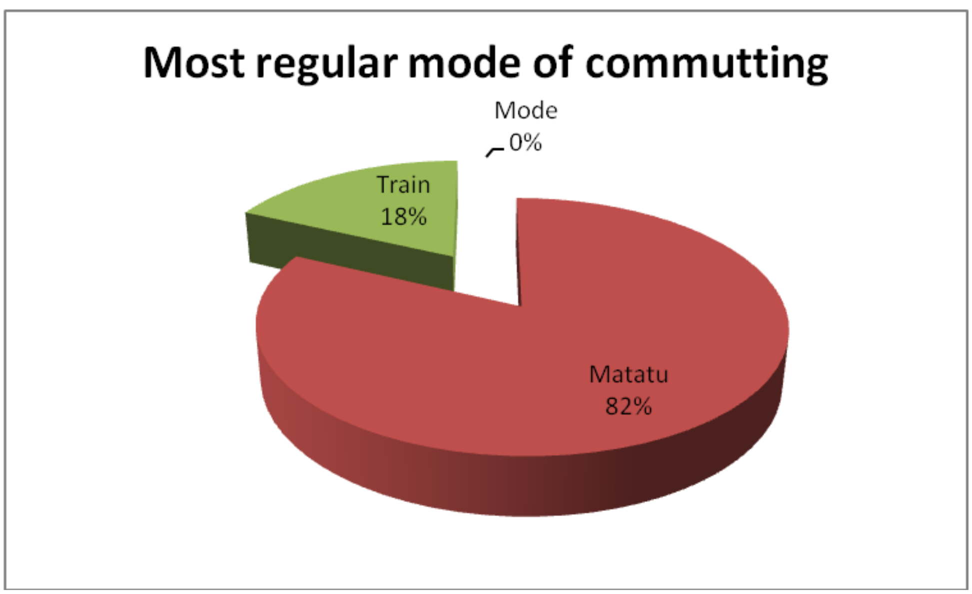


Source: Field survey 2011

4.3 Regular mode of commuting within the Nairobi Metropolitan

The study established that the most common mode of transport within the Nairobi Metropolitan was through matatu.

Figure 13: Mode of commuting within Nairobi Metropolitan

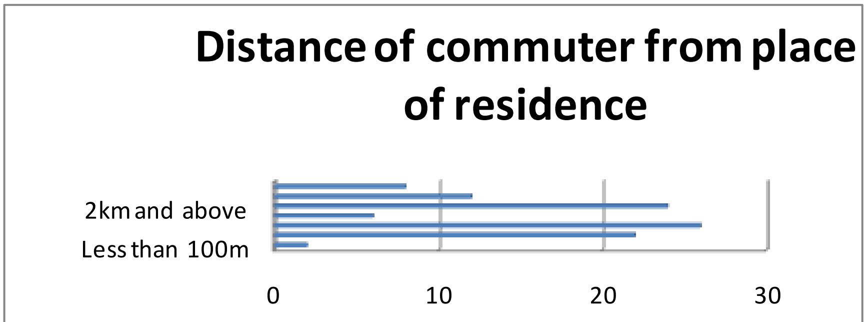


Source: Field survey 2011

4.4 Railway network link to place of work and residence

Majority of the respondents said that their places of work and residence were not connected to the railway network. Most of the residents were six hundred meters and above from the railway network.

Figure 14: commuter link to residence and place of work



	Less than 100m	100-500m	500-1km	1-2km	2km and above	N/A	No response
Series1	2	22	26	6	24	12	8

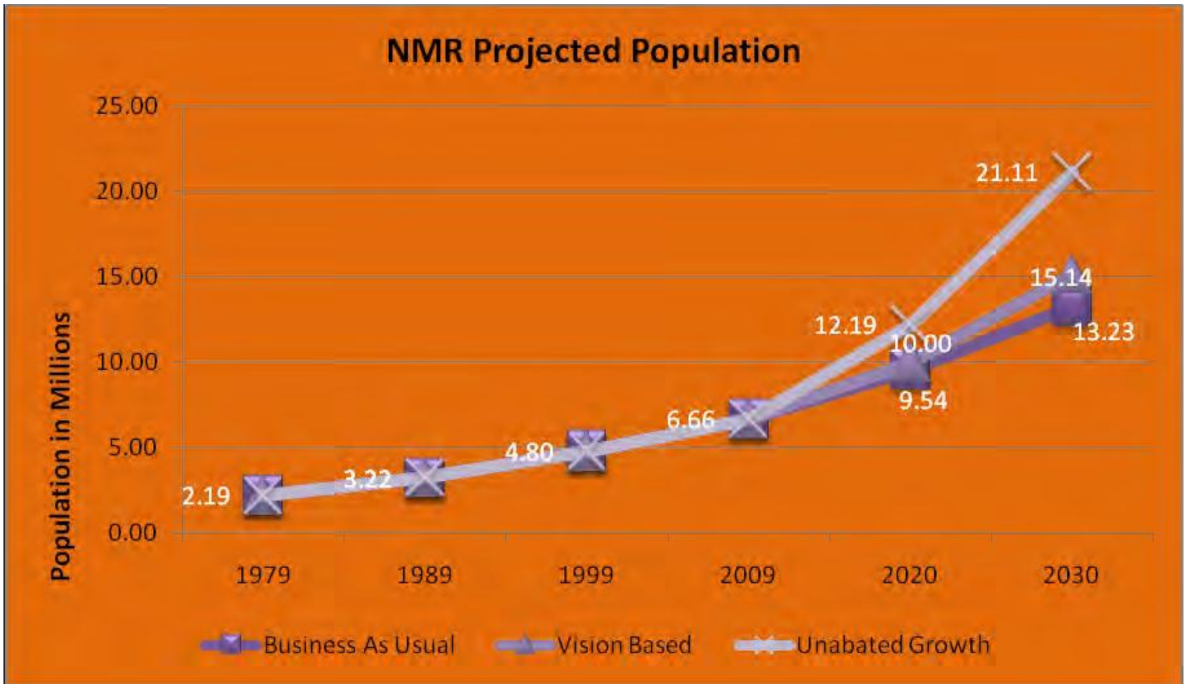
Source: Field survey 2011

4.5 The population of Nairobi Metropolitan Region

The population of NMR is growing rapidly. The forecast of population by 2030, fewer than three (3) scenarios of Business As usual, Vision Based and unabated Development – has been made. The range is 13.2 million to 20.1 million.

The forecast, of 15.1 million, under Vision Based scenario has been selected for further detailing.

Figure 15: Population Projection by Three Methods for NMR in 2020 And 2030



Source: Field survey 2011

4.6 Population distribution within Nairobi metropolitan region

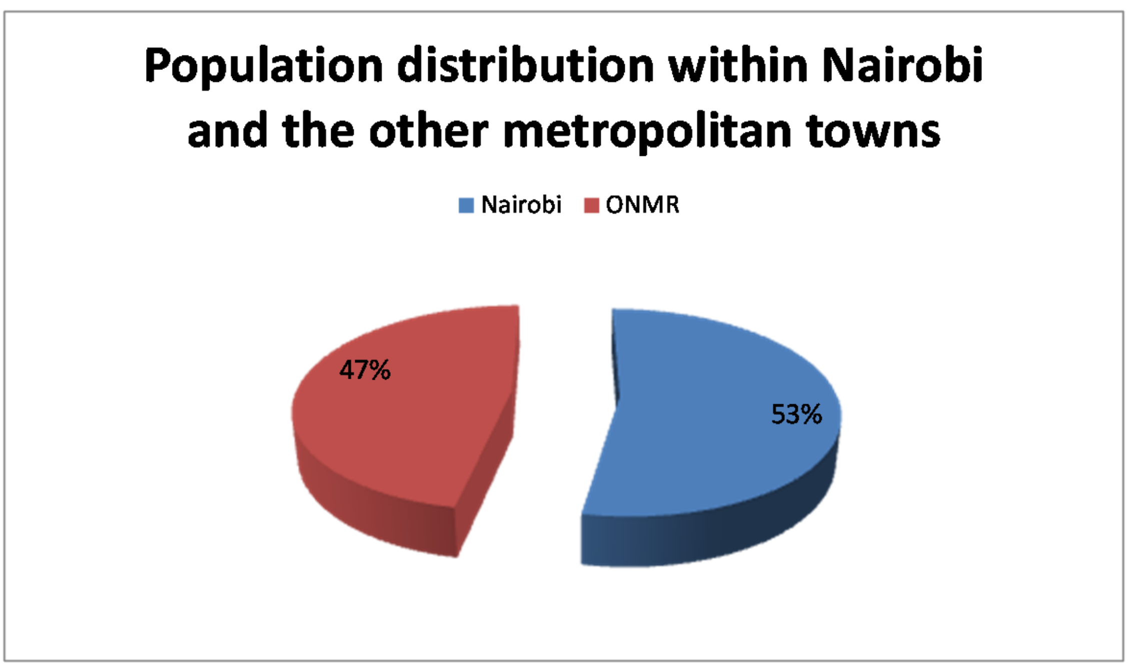


Figure 16: Population distribution within NMR

Source: Field survey 2011

Presently there is an inequitable distribution of people by the component sub-regions (4 counties). Nairobi city accounts for almost half of the region population (2009) and Northern Metro Region (Kiambu County) for half of the balance population. Some of the urban centres are experiencing runaway growth rates. There is a need for a more balanced growth and distribution.

With the expectation of growth of Kenya's GDP at 10% as envisaged in Kenya Vision 2030, NMR GDP would need to grow at about 15%. The per capita income would more than double. The economy is expected to become more formal. While agriculture will be the main occupation in the rural areas, manufacturing, transportation, construction and service sectors would be the major sectors contributing to the urban, and in general to the overall, economy of the region.

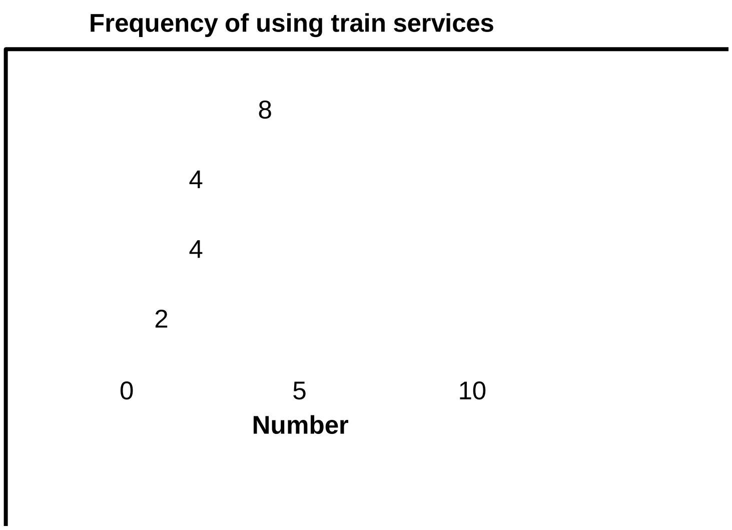
The large increase in employment size presents an opportunity to promote balanced spatial and inclusive development of NMR. However, it calls for comprehensive, coordinated and continuous planning and development process.

NMR is a highly urbanized region and will continue to be more urbanized in the decades to come. The urban share will be about 87%. The 18 urban centres (excluding Nairobi city) will grow at high rates and will increase their population size manifold. Care needs to be exercised in consuming land for urban use. Optimal densities, based on city size, have been recommended. About 173 sq. km of land would be under urban developed land which is about 5.4% of NMR area.

4.7 Frequency of using train services

It was found that most of the respondents rarely use the train for transport within the metropolitan.

Figure 17: Frequency of using train services

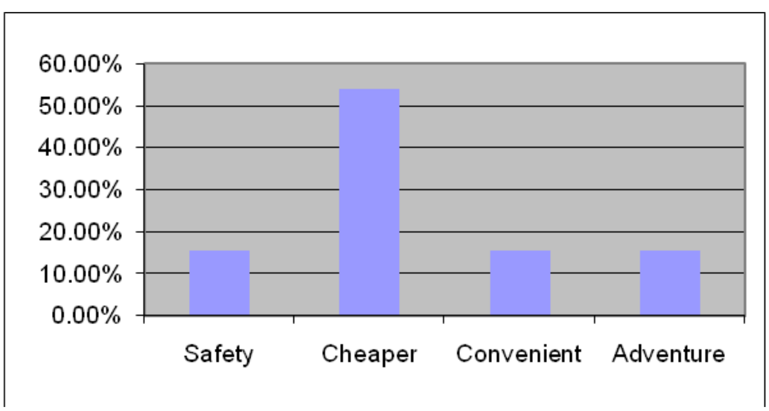


Source: Field survey 2011

4.8 Reasons for commuting with train

Rail commuter transport was found to be preferred because it was found to be cheap and safe.

Figure 18: Reasons for commuting with train



Source: Field survey 2011

4.9 Status of the Existing Commuter Rail Transport Network

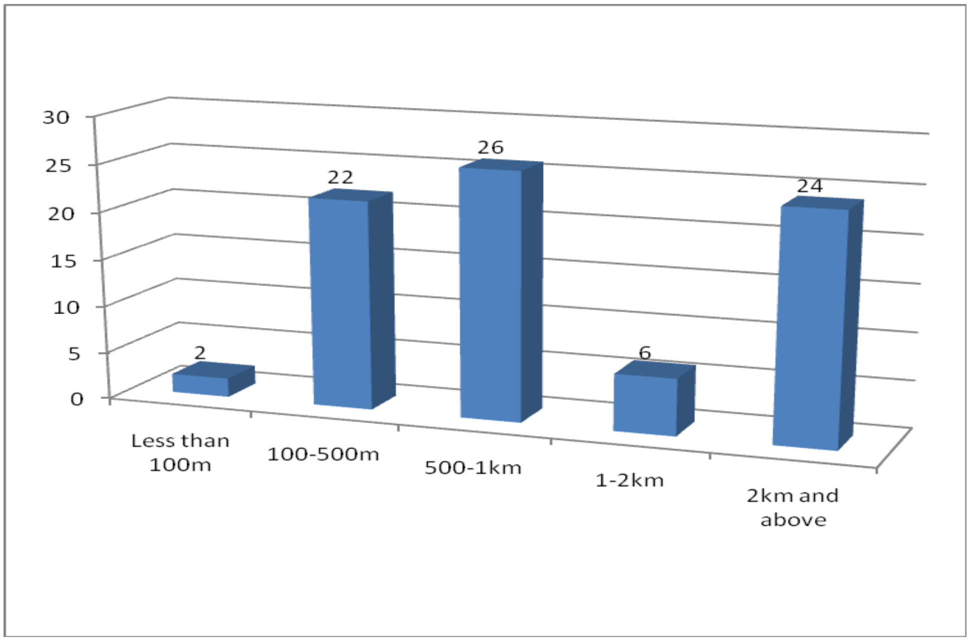
The Nairobi commuter rail line was first built with the intention of connecting Thika and Nairobi, mainly by channeling heavy and bulky manufactured goods to Nairobi.Thelinewasfirstmainlyusedforfreightpurposesbeforetheintroduction of heavy trunks on the road. When there was massive competition from road transport coupled with lack of political will, freight services became crippled to an extent that there was no container being ferried through the line. Because of this, the corporation introduced passenger rail services between Thika and Nairobi. To date the passenger service is the main service along the line. Most Nairobi residents prefer using this service because they consider rail transport cheaper and also faster. The main catchments in Nairobi are Kikuyu, Dagoretti and Dandora area.

4.10 The Rail Network within Nairobi Metropolitan Region

The Nairobi sub-urban commuter service only connects a small portion of Nairobi Eastland's sub-urban areas and west of Nairobi to the city centre. The train's run6 days in a week during the morning and evening peak hours and unlike road transport, the train service does not experience traffic jams.

The study found out that only14% of the respondents has railway connecting their residence and places of work. Out of this percentage, only 2% of the commuters are within100 meters of railway line as shown in figure below.

Figure 19: Proximity of railway to commuter's residence



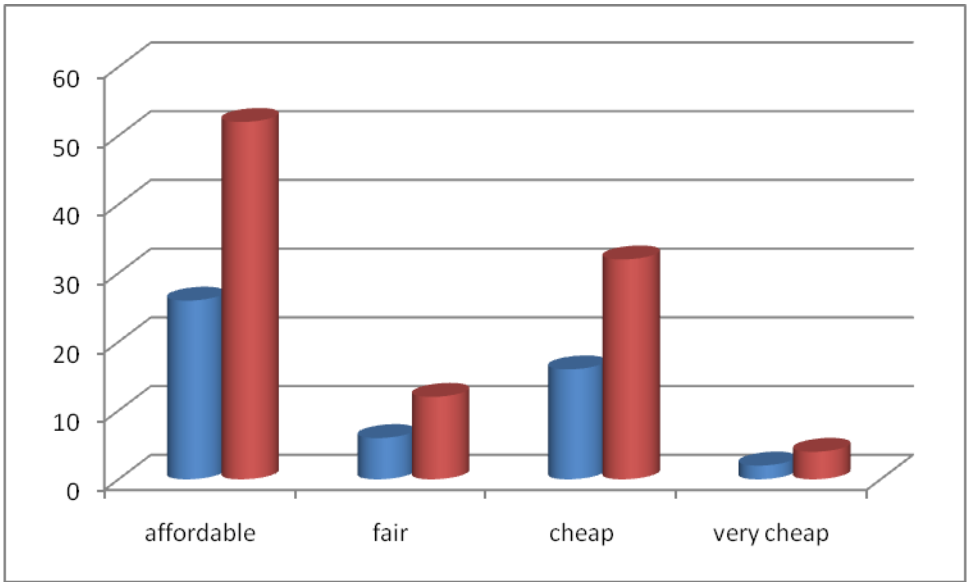
Source: Field Survey 2011

4.11 Utilizationof the Commuter Service

The commuter service is currently being utilized especially between Kikuyu and the citycenter. This line serves mostly low in-come earners who find train charges friendly to their pockets. They also prefer to use commuter service because the service is faster and very convenient compared to road transport, which frequently faces traffic congestion. The study found out that 58% of the respondents prefer to use the commuter rail service because they consider it affordable compared to road transport which charges high fares. Figure below shows the commuters' rating of the cost of commuter train services against other means of transport.

4.12 Commuters' rating of the cost of commuter train services against other modes of transport

Figure 20: Commuters' rating of the cost of commuter train services



Source: Field Survey 2011

Besides affordability of the train services, the commuters also prefer to use the service because it avoids delays as compared to road transport which faces congestion as a result of heavy traffic jam.

Table below provides a summary of the reasons given by commuters for their preference in using commuter train services.

Table 4: Summary of Commuters Preference for using Commuter train services

Reasons.	Percent of Cases
Trains carry many people at ago trains drop everybody at one central place if train network can be expanded to cover all the estates	50.0%
Trains have few accident rates trains will remove matatus from the CBD	12.5%
Train services are affordable	12.5%
Do not cause traffic jams train services will discourage the use of personal cars	12.5%
Trains can be faster	31.3%

Source: Field Survey 2011

4.13: Challenges Facing Commuter Train Services in Nairobi

4.13.1: Kenya Railways Corporation's Point of View

The Nairobi commuter train services face a number of challenges which has historical roots as was discovered during the interview with the Kenya Railways Corporation. In the early1970's the East African Railways Corporation (EARC), KRC's predecessor was the largest public sector enterprise and reputedly one of the best managed. It was the predominant carrier of freight traffic between Mombasa and Nairobi, and almost had a monopoly of long distance traffic into Uganda. In the mid1970's, political problems within East African Community (EAC) resulted in the split of EARC, finally leading to the creation of national railways. An Act of Parliament established KRC in 1978 following the collapse of the EAC in1977.It was formed to provide transport services to serve the country and the region. The total railway network consists of 2,778kmcomprising1083 kms of mainline, 346km of principle lines, 490 km of minor and branch lines and 859km of private lines and sidings. Over the, last ten years, the rail way has not been expanded, with the exception of 38km of private line.

KRC has overtime experienced financial, technical and operational problems arising from poor corporate governance and inadequate investment. Weaknesses in KRC management within a Government of Kenya-controlled environment became increasingly manifest in the1980s.Tariffs could not be increased in line with inflation, and asset renewal fell accordingly. Political interference in the appointment and tenure of senior management increased.

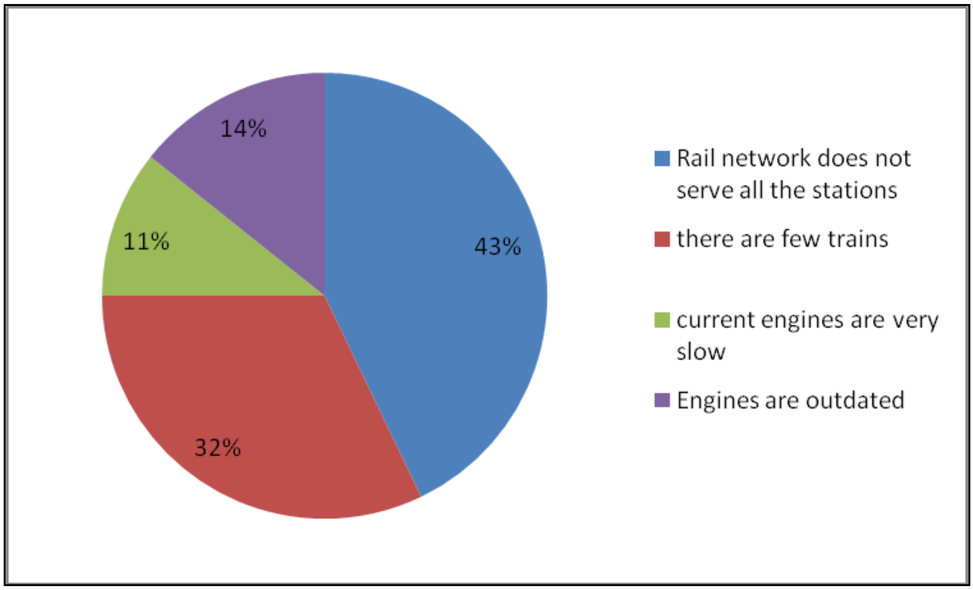
Salaries and benefits began to fall in real terms. In spite of substantial donor assistance it became very clear that, unless management and commercial autonomy was gained KRC would not be able to respond effectively to the increasing road competition. For example, total earnings from rail traffic (both passenger and freight) have grown at a slower pace as compared to those from roads. Rail earnings grew from around Kshs.10 million to only about Kshs.200 million in three decades. On the other hand, the road sector earnings witnessed a tremendous growth rate from around Kshs.10 million in 1978 to about Kshs. 1300 million in 2001.

The late 1980s and early 1990s witnessed donor assistance in the attempted commercialization of the management and operations of KRC. An attempt to implement a performance contract between KRC and the Government of Kenya never took off. While some measure of commercial autonomy was achieved, the effectiveness of KRC management to deliver efficient rail services had declined substantially. KRC's performance over the years has declined due to motive power and rolling stock capacity constraints caused by inadequate funding .As a result,KRC is unable to fully contribute to development of the country and to satisfy its customer's demands.

4.13.2: Commuters' Point of View

The commuters identified several challenges regarding commuter train services, which are given in the table below:

Figure 21: Commuters' opinions of the problems of Commuter train services in Nairobi



Source: Field Survey 2011

As depicted in table above, it is evident that despite the good will the commuter service is currently enjoying from Nairobi residents, there are a number of challenges facing the management. The current demand for the service is overwhelming but the supply is constrained due to inadequate rail network within the Nairobi region. This problem is also compounded by few engines, which is note enough to meet the ever-increasing demand. This has in most cases caused serious congestion and some of the passengers who do not find space usually hangout thereby endangering their lives. The engines are also old which make them move at a slower speed compared to modern commuter services.

4.14 Comments on the adequacy of the current commuter train services

The commuter train was found to be best preferred because it does not have traffic jams and is very cheap.

Table 5: Comments on the adequacy of the train services

Opinion	Responses	
	Number	**Percent**
Operates daily and adequately	2	16.7%
Cheap	4	33.3%
No traffic jams	4	33.3%
Safer	2	16.7%
Total	12	100.0%

Source: Field Survey 2011

4.15 Emerging issues

From the interviews of both the KRC and commuters, the following are emerging as the challenges facing metropolitan Commuter Rails services in Nairobi:-

i. **Lack of political good will**: in the past government, there was lack of political will, which nearly lead to collapse of the rail services. The introduction of heavy tracks on the road, which had political backing meant, that rail freight services was seriously affected. There was deliberate effort to convince the industrialists to transport their goods through the road as opposed to rail transport. The rail transport was also ignored in the development agenda. Because of this, there is no single line that has been added since the colonial period. The government has also not bought any new engine. The management of the rail services also suffered political interference, which has so far lead to the rail management being under concession.

ii. **Lack of appropriate technology**: Lack of appropriate technology has jeopardized the rapid expansion of the commuter services. This coupled with lack of enough funding by the government to invest in research and new technologies.

iii. **Government policies**: The existing transportation policies favor road transport at the expense of rail transport. More funding and investment is directed to building new roads while none is set aside for railway line expansion.

CHAPTER FIVE: SUSTAINABLE APPROACH TO DEVELOPMENT OF A METROPOLITAN RAIL TRANSIT SYSTEM IN NAIROBI

This chapter aims at answering questions such as: what can be done to build a system which is low in cost, high in performance and easy to maintain? What policy is required to activate Nairobi metropolitan commuter train services? How can we have a sustainable management of the commuter train system? What should be done to increase users of the commuter train service?

Apart from considering the integration with the urban form during planning, factors affecting the railway's sustainability should also be addressed in the project delivery processes, from design, procurement to construction. The sustainability benefits of railway projects should be maximized through community engagement, stakeholder management, environmental management and system optimization.

5.1: The Future Commuter Rail Services in Nairobi Metropolitan

5.1.2: Way forward

Metropolitan commuter rail service has a bright future within the Nairobi Metropolitan Area. This is evidenced by overwhelming demand for it by the Nairobi residents. What is needed is to increase supply to match the demand for the commuter services. There is need for investment in the expansion of the rail network within the metropolitan region to serve the entire region. Currently just a small section of Nairobi is being served by the commuter rail service. There is also need for investing on new and modern engines to keep pace with the modern technology. This will increase the passenger base thereby increasing the revenue base of the corporation. There is also need to improve on the information management by investing in modern communication technology.

5.1.2: Proposed Nairobi Metropolitan Commuter System

Introduction of a Light Rail Transport (LRT) connecting the city center with its suburbs would decongest the city and provide punctual urban transport. ALRT offers an adaptability to combine frequent services with variable length multiple unit trains and therefore cost effectively bridge the gap in passenger flows which exist between the traditional 'heavy' railways and buses because it is suitable for flows between 2,000and 20,000 passengers per direction/hour. The LRT is much cheaper than other railway type of transport such as sub way, mono rail and new transport system.

Long-term solution to de-congest Nairobi will be to construct urban rail transport along the radial trunk roads. As in Japan, railway construction and environmental concerns should be considered part of road development in abroad sense, and road funds should be utilized for these purposes. The construction of such a railway system would greatly change the modal share in Nairobi culminating in decongestion. Railway transport would gain more prominence over other transportation modes due to its punctuality and reasonable fare characteristics.

A viable option would be to construct railway lines through PPP. The private sector railway service providers should be allowed to augment therein come by engaging in businesses such as electric power supply, bus operation services, real estate development and management of department stores. This model of railway operation has been successful in Japan.

5.2: Sustainable Commuter Rail Management

5.2.1: Role of Kenya Government

It is important for the government to respect independent and self-motivated management conducted by agencies in charge of railway construction or operation from the view point of activating railway construction or operation. On the other hand, the government is required to play a role in protecting user benefit. Therefore, to enable the Nairobi Metropolitan commuter train network to function effectively in terms of securing user convenience, the government needs to act as a coordinator to take care of schemes such as those for mutual through operation and easy transfer at junctions between railways built or operated by different entities.

Considering the fact that urban railways cannot really earn profit during the construction term, the study believes that it is critical for the government to support construction or operational agencies e.g. Kenya Railways Corporation (KRC) by providing public funds to keep the KRC from being overburdened.

In addition, the government should consider measures to deal with traffic jams and environmental problems and provide support for Metropolitan commuter rail system operations using public funds. It is crucial to make people understand that the railway is not quite a profit-making entity but is rather a public utility. Further more, if public money is to be spent for sustainable operations of the metropolitan commuter rail system, it is imperative to gain the understanding and Support of taxpayers, policy planners, educators, consumers, and the public at large about the concept of value for money(value of Public service Obligation: PSO).

Government administration should secure user convenience and safety for the sake of user protection. Hence, the government is expected to establish a mechanism to ensure adequate standards of transport service (in terms of safety, stability, fares, security etc.).

5.2.2: The Role of the Ministry of Nairobi Metropolitan Development and Kenya Railway Corporation (KRC)

The ministry should co-operate with the Rift Valley Railways to improve the commuter rail service within the Nairobi metropolitan region. Its role should be to push for policies that will aid the rapid expansion of the rail network within the region. The ministry can also source for external funding from the development partners to support networking of the entire metropolitan region. The ministry should also support the Rift valley Company in acquiring new engines, which are modern and can keep pace with the modern technology. The ministry should also sponsor the spatial planning for the Metropolitan Commuter Rail service so as to come up with a spatial frame work to guide the development of rail services within the Nairobi metropolitan region. On the other the KRC should take regular maintenance of the commuter rail services to ensure that there are no problems arising.

5.3 Factors for Sustainable Railway Development in Design and Implementation

5.3.1 Stakeholder Management

Railway development is never the business of the railway company alone. With the rising expectation and demand for livable communities, the social impact of public investments like railway projects is coming under greater scrutiny. In the matter of developing ‘livable communities’, there are various stakeholders involved, such as political groups, concern groups, opinion formers, professional bodies, working partners, etc., whose expectations should be properly addressed *(MTR Corporation 2008)*.

Support from stakeholders is not only a positive driving force for sustainable railway development, but is also necessary for ensuring a smooth project implementation process. To secure their support, sufficient communication between the railway company and the stakeholders in an open and proactive manner is needed. It would be beneficial to the rail project if stakeholders could obtain a better understanding of the projects and the constraints that have to be taken into account through the communications about the project-related issues, for example, introduction of the project programme and corresponding arrangements, like traffic diversion, explanation of possible disturbances during construction and discussions about alternative solutions to problems and objections, etc.

5.3.2 Environmental Management

Among various public transport modes, railway is considered relatively efficient in its use of fuel, land and resources. However, despite its positive reputation in terms of environmental impact, railway is not free from environmental concerns, like energy consumption, disposal of materials and noise pollution, etc. Nowadays, as road vehicles are gradually improving in environmental performance by adopting cleaner fuels and more efficient engines, enhancement is needed in railway design for maintaining its competitive edge, as well as, to better protect the environment.

5.4 Conclusion

This study recognizes the fact that any attempt to establish a rail way system in an urbanized area will require a great deal of money and time, for factors such as the acquisition of land, coordination with existing facilities, and environmental measures. The study proposes that to ensure that the Nairobi metropolitan commuter train system could function adequately in terms of both the provision of services and operating costs, it is essential to get rid of the mindset that associates public transport systems with the poor and to enhance the systems so that these can be used safely by people of all classes.

Sustainable railway development is closely related to city planning and its interaction with the communities. With changing social environment and demand, new factors affecting the sustainability of railway development will evolve over time.

Throughout the railway planning and implementation process, governments and railway companies should be alert and take into account the wider social, economic and environmental and social effects in order to create ‘livable communities’ and facilitate the dynamics of the city.

Railway can be an effective tool for facilitating urban growth if planned and designed appropriately and properly tied in with urban development.

5.5 Recommendations

For changes in theoretical constructs the study found that most transportation theories are based on road transport thus need to develop more theories on rail transport especially on the new development concepts of sustainable developments.

Also, the study found that the existing transportation policies in Kenya favour road transport at the expense of rail transport. More funding and investment is directed in building new roads while none is set aside for railway expansion.

For changes in education practice, it recommended further studies on how best can the Government increase the supply of commuter rail transport without conflict in the industry. Also integration of modern communication technology with modern rail technology in Kenya should be explored so that it gains on its use.

Further, there is need to explore the economic benefits of provision of commuter rail transport services and its financial sustainability.

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APPENDICES: 1

UNIVERSITY OF NAIROBI

DEPARTMENT OF URBAN AND REGIONAL PLANNING

FACTORS AFFECTING THE PLANNING AND DEVELOPMENT OF NAIROBI METROPOLITAN RAIL NETWORK

QUESTIONNAIRE:

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1. Name of the respondent (optional)

……
……………………………………………

2. Gender

Male ☐ Female ☐

3. Age bracket

15-20 years ☐

21-25 years ☐

26-30 Years ☐

31-35 years ☐

36-40 years ☐

41-40 years ☐

Over 46 years ☐

4. Highest level of education

Primary ☐

Secondary ☐

Tertiary college ☐

☐

University

No education

5. Where do you live …………………………………………………………………?

6. Where do you work………………………………………………………………?

7. Do you travel frequently within Nairobi

Yes

No

8. How many trips do you make………………………………………………

9. What usually is the purpose of your commuting within Nairobi

Private

Business

10. What is your most regular mode of transport?

Matatu

Train

11. if commuter train, how often do you use it

……………………………………………..

12. If no, how far in kms if is the nearest railway

……………………………………………

13. Would you prefer having commuter train services as a mode of commuting within Nairobi?

Yes

No

14. If no which mode would you prefer?

……………………………………

15. Do you live and work within the greater Nairobi and its environs?

Yes ☐

No ☐

16. How do you earn a living

Self-employment ☐

Casual ☐

Odd jobs ☐

17. On average how much do you earn per month in Kshs?

6000 and below ☐

6001-12000 ☐

12001-24000 ☐

24001-48000 ☐

18. How much do you spend on commuting in Kshs?.........................

19. Do you consider the expenses on transport fair?

Yes ☐

No ☐

20. Do you commute using the commuter train within Nairobi?

Yes	
No	

21. if yes how much do you spend on the commuter train?....................

22. How would you rate the cost of commuter train services against other modes of transport?

affordable	

fair	
cheap	
very cheap	

23. Do you consider the current commuter train services adequate?

Yes	
No	

24. Do you consider train services as a solution to the current traffic congestion in Nairobi?

Yes	
No	

25. Who is responsible for development of a better Nairobi Metropolitan Commuter Train System?

Government	
Kenya Railways	
Rift Valley Railways	
Donors	

26. Do you think the KR through the government is capable of developing a better metropolitan commuter rail service?

Yes	
No	

27. Which of the following would you give priority as a solution to the current traffic jam in Nairobi?

Expansion of commuter rail system	
Light rail Transit system	

28. Do you think the ministry of Nairobi Metropolitan has a role in development of the metropolitan rail commuter services?

Yes	
No	