Republic of Kenya
Nairobi City County Government

REPUBLIC OF KENYA

THE PROJECT ON DETAILED PLANNING OF INTEGRATED TRANSPORT SYSTEM AND LOOP LINE IN THE NAIROBI URBAN CORE

FINAL REPORT

MAY 2018

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
PADECO CO., LTD.
CENTRAL CONSULTANT INC.

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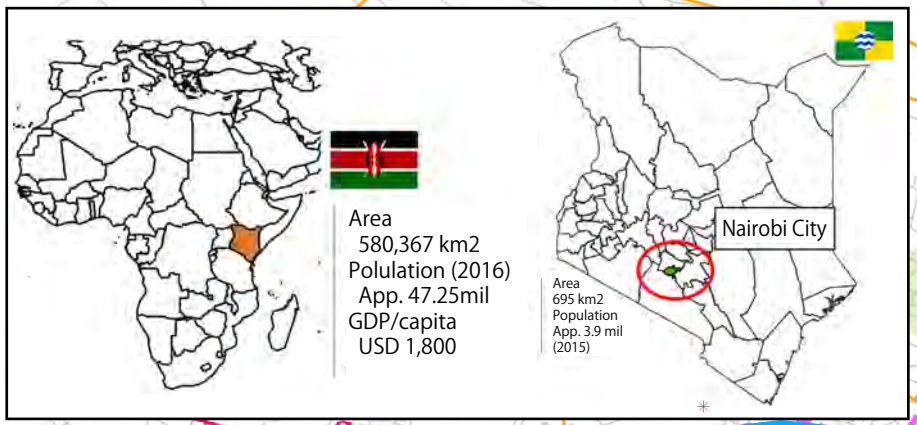
LOCATION MAP



Harmonization Study Proposed Line※
- BRT Line 1
- BRT Line 2
- BRT Line 3
- BRT Line 4
- BRT Line 5

Legend
- Loop Line (NIUPLAN)
- Road Widening/ /Improvement Works
- Land Development

- Existing Sta.
- Airport
- Street Name
- Railway Line
- Int'l Trunk Rd.
- Trunk Road
- Road
- City Area
- Green Area

Karura Forest
City Park
Waiyaki Way
Thika Rd.
Juja Rd.
Dandra
Outer Ring Rd.
Eastleigh
Kenyatta Av.
Landless Av.
Nairobi Sta
Railway City Dev.
BRT Line4(East)
Jogoo Rd.
Makadara Industrial Area
Ngong Rd
BRT Line3
BRT Line4(West)
Mbagathi Av.
Wilson Airport
Monbasa Rd.
BRT Line1
BRT Line2
BRT Line5
Embakasi Village
Imara Daima
Embakasi
JKIA
Langata Rd.

0 1 2 3 4 5 km

The Project on Detailed Planning of Intergrated Transport System and Loop Line in the Nairobi Urban Core

The Project on Detailed Planning of Integrated Transport System and Loop Line in the Nairobi Urban Core

Final Report

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ABBREVIATIONS

Abbreviation	Official Term
AIDS	Accrued Immune Deficiency Syndrome
AMP	Anominous MacAddress Probe
APRP	Annual Public Roads Programme
ARWPs	Annual Road Works Programme
ASCO	American Society of Clinical Oncology
AWSB	Athi Water Services Board
B/C	Benefit per Cost
BRT	Bus Rapid Transit
BT	Bus Terminal
CA	Communication Authority
CBD	Center of Business District
CBOs	Community Based Organizations
CBS	Central Bureau of Statistics
CCN	City Council of Nairobi
CO	Carbon Monoxide
CPS	County Partnership Strategy
CSUD	Centre of Sustainable Urban Development
DD	Detailed Design
DEO	District Environment Office
DMVI	Directorate of Motor Vehicle Inspection
DOE	Department of Environment
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Co-ordination Act
ESIA	Environmental and Social Impact Assessment
E-W	East - West
FIFA	Federation of International Football Association
FS	Feasibility Study
GDP	Gross Domestic Product
GIS	Geographic Information System(s)
GoK	Government of Kenya
GPO	General Post Office
GRDP	Gross Regional Domestic Product
HIV	Human Immunodeficiency Virus
HS	Haile Selassie
HTML	HyperText Markup Language
IAS	Invasive Alien Species
IBA	Important Bird Area
ICR	Inception Report
ICT	Information and Communication Technology
ILUT	Interdisciplinary Land-Use and Transport Metropolitan Analysis within the Nairobi Metropolitan Region
IPP	Independent Power Producers
ITDP	Institute for Transportation & Development Policy
ITS	Intelligent Transport Systems

Abbreviation	Official Term
JCC	Joint Coordination Committee
JICA	Japan International Cooperation Agency
JKIA	Jomo Kenyatta International Airport
JRISS	Japan Research Institute for Social Systems
JST	JICA Study Team
KAA	Kenya Airports Authority
KBS	Kenya Bus Services
KBSM	Kenya Bus Service Management
KCAA	Kenya Civil Aviation Authority
KEBS	Kenya Bureau of Standards
KEFRI	Kenya Forest Research Institute
KeNHA	Kenya National Highway Authority
KENSUP	Kenya Slum Upgrading Programme
KePSA	Kenya Private Sector Alliance
KeRRA	Kenya Rural Road Authority
KES	Kenya Shillings
KFS	Kenya Forest Service
KIHBS	Kenya Integrated Household Budget Survey
KNCHR	Kenya National Commission on Human Rights
KP	Kenya Power
KPA	Kenya Ports Authority
KPHC	Kenya Population and Housing Census
KR	Kenya Railways
KRB	Kenya Roads Board
KRBF	Kenya Roads Board Fund
KRC	Kenya Railways Cooperation
KURA	Kenya Urban Road Authority
KWS	Kenya Wildlife Service
KWTA	Kenya Water Towers Agency
LAPSSET	Lamu Port-South Sudan-Ethiopia-Transport
LCPDP	Least Cost Power Development Plan
LPG	Liquefied Petroleum Gas
MAC	Media Access Control
MENR	Ministry of Environment and Natural Resources
MEWNR	Ministry of Environment, Water and Natural Resource
MLPP	Ministry of Land and Physical Planning
MLSSS	Ministry of Labor, Security, Social and Services
MOE	Ministry of Energy
MOEP	Ministry of Energy and Petroleum
MoH	Ministry of Health
MOI	Ministry of Interior
MOICT	Ministry of ICT
MoLH&UD	Ministry of Land, Housing and Urban Development:
MoT	Ministry of Transport
MOTI	Ministry of Transport and Infrastructure
MoTIH&UD	Ministry of Transport, Infrastructure, Housing and Urban Development
MP	Master Plan

Abbreviation	Official Term
MRF	Material Recovery Facility
MRTS	Feasibility Study and Technical Assistance for Mass Rapid Transit System for Nairobi Metropolitan Region
MSM	Men having sex with men
MT	Motorized Transport
NACC	National AIDS Control Council
NaMATA	Nairobi Metropolitan Area Transport Authority
NaMSIP	Nairobi Metropolitan Service Improvement Program
NCCG	Nairobi City County Government
NCPD	Nairobi Council for Population and Development
NCWSC	Nairobi County the Nairobi City Water and Sewerage Company
NEC	National Environment Council
NEMA	National Environment Management Authority
NET	National Environment Tribunal
NETFUND	National Environment Trust Fund
NGO	Non-Governmental Organization
NHDP	Nairobi Housing Development Programme
NIUPLAN	Nairobi Integrated Urban Development Master Plan
NLC	National Land Commission
NMIMTs	Non-Motorized and Intermediate Means of Transport Policy
NMK	National Museums of Kenya
NMR	Nairobi Metropolitan Region
NMT	Non-Motorized Transport
NMTP	Non-Motorized Transport Policy
NMV	Non-Motorized Vehicle
NUTRANS	The Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area
Nox	Nitrogen Oxides
NRW	Non-Revenue Water
NSRDM	Nairobi Streets and Roads Design Manual
NTSA	National Transport and Safety Authority
NUC	Nairobi Urban Core
OSHA	Occupational Safety and Health
PCC	Public Complaints Committee
PDE	Provincial Director of Environment
PEC	Provincial Environment Committee
PEO	Provincial Environment Office
PLWHAs	People Living With HIV / AIDS
PM	Particulate Matter
PPHPD	Passenger Per Hour Per Direction
PPP	Public Private Partnership
PSPs	Private Service Providers
PSV	Public Service Vehicles
PTOD	Person Trip based Origin Destination
PubT	Public Transport
PWDs	Persons With Disabilities
RA	Round About
RAP	Resettle Action Plan
Rd	Road

Abbreviation	Official Term
RMLF	Road Maintenance Levy Fund
RVR	Rift Valley Railway Consortium
SACCO	SAvings and Credit Cooperative Organization
SEA	Strategic Environmental Assessment
SERC	Standards and Enforcement Review Committee
SGR	Standard Gauge Railway
SHM	Stakeholder Meeting
Sox	Sulfur Oxide
STAP	Short Term Action Plan
STIs	Sexually Transmitted Infections
STPs	Sewerage Treatment Plants
STRADA	System for TRAffic Demand Analysis
TAC	Technical Advisory Committee
TOR	Terms of Reference
TPS	Total Suspended Particulates
TT	Transit Talls
UfW	Unaccounted for Water
UNEP	United Nations Environment Programme
UNHABITIAT	United Nations Human Settlements Programme
UoN	University of Nairobi
VTOD	Vehicle Traffic Origin Destination
WHO	World Health Organizations
WRMA	Water Resources Management Authority
WSP	Water Service Provider

Executive Summary

Part I Current Conditions and the Analysis in the Nairobi Urban Core

1 Background

Transportation projects in Nairobi City are planned by various executing agencies and donors in the last decade, but these projects have not been coordinated each other. Because of that, there are some conflicts actualised between the on-going projects and no counter measures has been implemented, which should be discussed within the relevant institutions.

Nairobi City is in a transition period of urban core policy development of various fields based on the related master plan including NIUPLAN, after the 2012 devolution. However, NaMATA, the agency which was legalized to take an initiative and responsibility for any implementation of transport policy in Nairobi Metropolitan Area, is still on the way of activation.

Under these circumstances above, JICA and NCCG agreed to work on the mobility improvement in the Urban Core in 2016, to determine an appropriate integrated transport system without having pre-justification through an analysis of traffic demand utilising a latest technique as well as examination of all the relevant on-going transport projects.

2 Issues of Transport System in Nairobi Urban Core

Through the analysis by JICA study team, several controversial issues described below are found regarding future transport system based on the on-going plan in Nairobi Urban Core.

1) Consideration of Related Transport Service (Matatu, Ordinary Bus and Commuter Rail Service)

BRT plan is one of the flagship project for transport system in Nairobi City. Despite the fact, the public does not know thoroughly how the Matatu, ordinary bus, and commuter rail service will be affected by the BRT project. Since people who belong to these industries will be key stakeholders for BRT project, detailed analysis of business impact associated with their transport service as well as counter measures of some negative operational impacts will be expected would be critical to achieve the BRT plan.

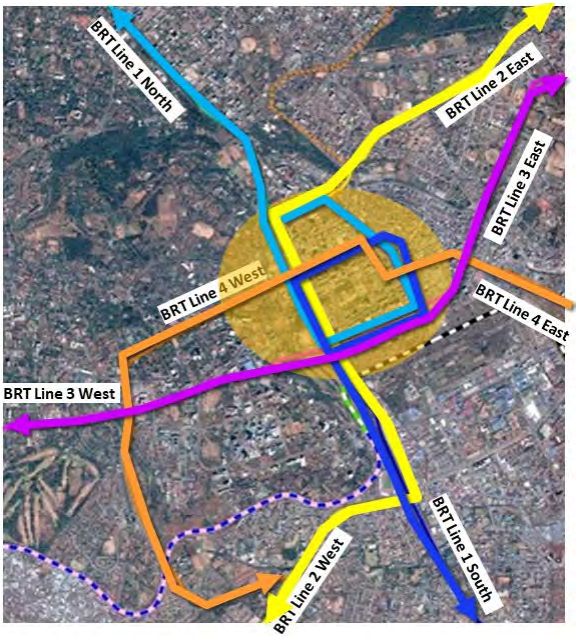
2) Concentration and Difficulty of Terminal Operation of BRT in CBD

Concentration of traffic volume in the CBD has to be avoided to ease traffic congestion as much as possible. However, according to the current plan for BRT Line 1, a circulated alignment plan for BRT Line 1 in the CBD is applied without mentioning any measures for controlling other traffic industries as shown in Figure 0.1. Additionally, this circulated alignment in the CBD will be reflected with increase of terminal operation in CBD. It is obvious that the more BRT in the CBD, the more difficult terminal operation to be committed.

3) No Coordination between BRT Lines (Line 1 and Line 3, 4)

There are several overlapping alignments with BRT Line 1, 3, 4 in the CBD found in the current BRT plan, and no analytical study has been carried out for the physical impact of this overlapping and accumulation of BRT vehicles, which could bring about paralysation of BRT as well as other vehicles including private cars and other transport services. It is clear that there would be less coordination between the BRT plans, and complication of the BRT system has to be avoided and simplification of integrated transport system would rather be necessary.

Additionally, on BRT Line 3 and 4 there are relevant transport projects initiated by JICA and Brazil Exim Bank. The former is viaduct project over the railway city and the latter is Jogoo road intersection improvement project. Coordinating BRT with those projects as integrated transport system will amplify public benefits from both characteristics of the projects.

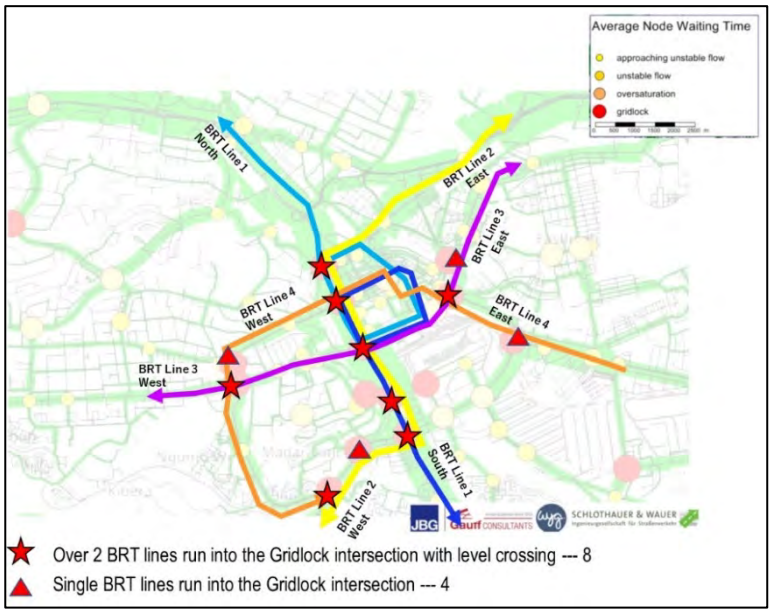


Source: JICA Study Team
Figure S. 1 Current Planning Alignment of BRT

4) Difficulty of Level Crossing of BRT in CBD

There are eight level crossing points into the gridlock intersection for BRT alignments which has dynamic confliction with other traffics including private vehicles and other bus services as shown on Figure 0.2. Without resolving the conflict of transports, it would be quite difficult to achieve smooth and sound operation of BRT.

Particularly, East-West crossing points along the Uhuru highway will be critical unless viaducts will be constructed from Haile Selassie Avenue to Jomo Kenyatta Avenue.

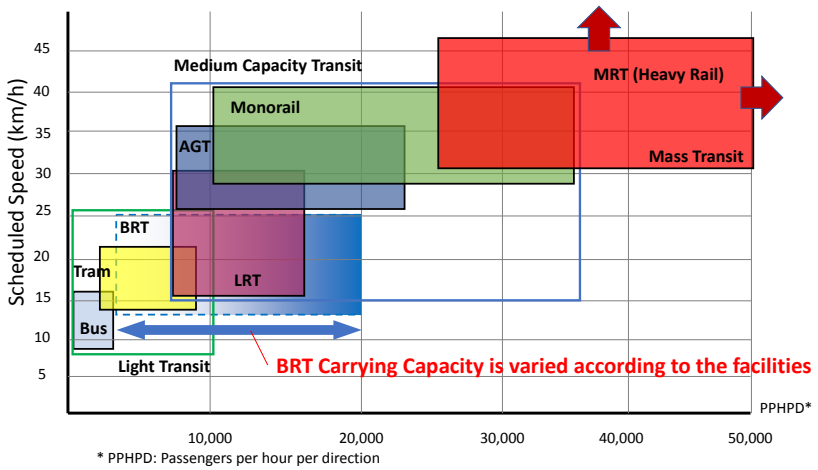


Source: JICA Study Team
Figure S. 2 Level Crossing Point and U-turn lane of Current BRT Plan

5) Over Estimation of BRT's Passenger Carrying Capacity

According to the report 'BRT Design Framework' issued by NaMATA on June 2017, it is mentioned that capacity (PPHPD) of BRT would be from 5,000 to 45,000 at maximum.

However, considering physical road condition in Nairobi City, it is difficult to meet maximum condition for BRT such as ensuring dedicated BRT lane and overpass lane as well as bus stop space due to current land availability. Therefore, considering normal capacity for BRT, from 5,000 to 10,000 would be more practical. Otherwise, it is critical to examine whether or not this capacity can meet the future traffic demand for future transport system in Nairobi.



Source: JICA Study Team

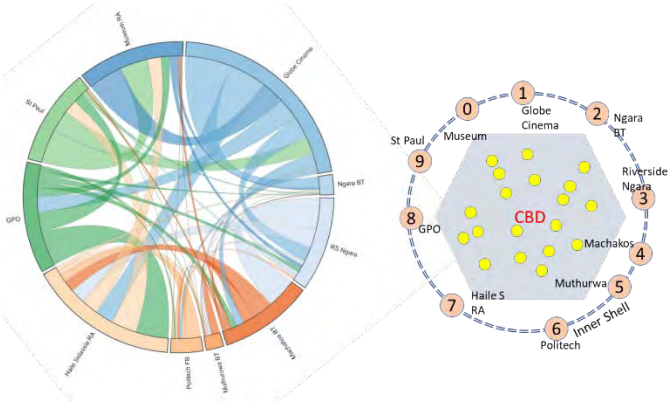
Figure S. 3 Transport Capacity for Various Urban Transport System

6) Difficulty of Land Acquisition

Development of new transport systems would require possible involuntary resettlement and land acquisition by widening existing road width on the transport alignment. Increase of volume of involuntary resettlement and land acquisition reflects to negative social impact to the residents as well as negative budgetary impact to NCCG to proceed the relevant project. It would be very critical to understand approximate intension of the negative impact on in the beginning stage.

7) Necessity of Transport Demand Oriented Plan

Justification of passenger distribution in NUC shall be made based on future transport demand analysis through an innovative transport survey technique such as AMP collectors carried out by JICA Study Team. The analysis can convey appropriate way of transport distribution to avoid lack of transport capacity as well as over capacity of future demand.



Source: JICA Study Team

Figure S. 4 Typical Traverse Movement – Inner Shell

Part II Future Urban Transportation Plan in Nairobi

There are three main policies proposed by the JST summarised below. These policies are determined through and reinforced by the analysis of current condition and relationship of all the planning and designs associated with transport in Nairobi Urban Core as well as the relevant mobility survey leading to the transport demand forecast. Details of the proposed integrated transport policy can be referred in Chapter 5 and 6.

1 Policy I: Comprehensive Mobility Management

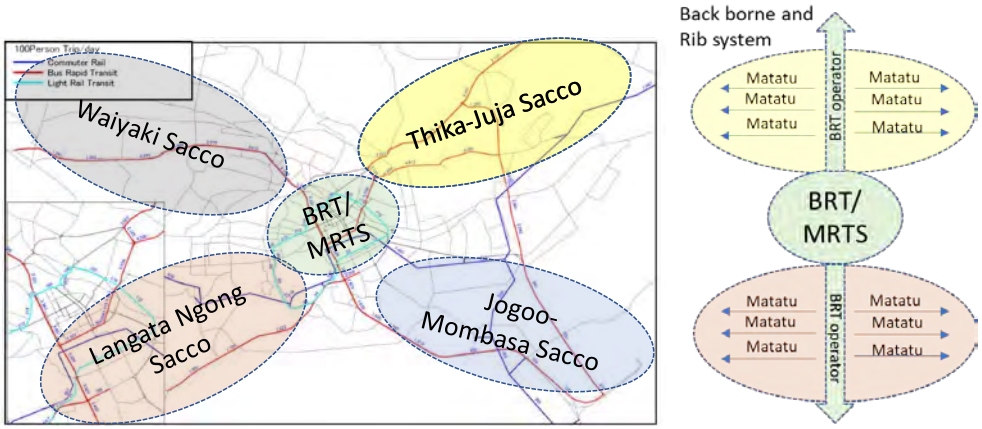
The policy of comprehensive mobility management consists of five items, which can be categorised as 1) bus, road network and pedestrian service for improvement, 2) development of intermodal facility correlated with newly proposed policy about re-organization of BRT and application of rail-based transport system, and 3) transport demand management (TDM) measures as soft component policy. Details of the policy are summarised below.

1) Improvement of Bus Service

There are 4 items for the improvement of bus service proposed for the policy for integrated transport system described below.

(i) Re-organization of Matatu and other ordinary bus service route

Demarcation of BRT/Metro and other bus service is proposed by managing the former exclusively in the CBD and other bus service will be allocated as a feeder service from suburban area to stops of BRT/Metro. To do so, traffic volume in the CBD can be controlled without having traffic congestion partly caused by disorganised bus volume in current condition.



Source: JICA Study Team

Figure S. 5 Area License and Back-borne and Rib service structure for Nairobi

(ii) Application of new bus fleet standard

Application of a Pan-Afric urban bus standard is proposed to carry bigger volume of passengers, to create easy and safe way of on-/off board, to provide comfortable on-board environment for passengers and environmentally friendly fleet by electric power unit.

(iii) Renovation of bus service system

Bus approaching notification system by utilizing smart phone application for example can be applied for better service to passengers. As one of the integrated aspects, this system can be correlated with BRT/Metro service to provide seamless connection with other transport modes Additionally, installation of commuter payment card system is proposed to ensure 100% of bus fare collection as well as to minimise loading time for passengers.

(iv) Revision of regulation for bus service

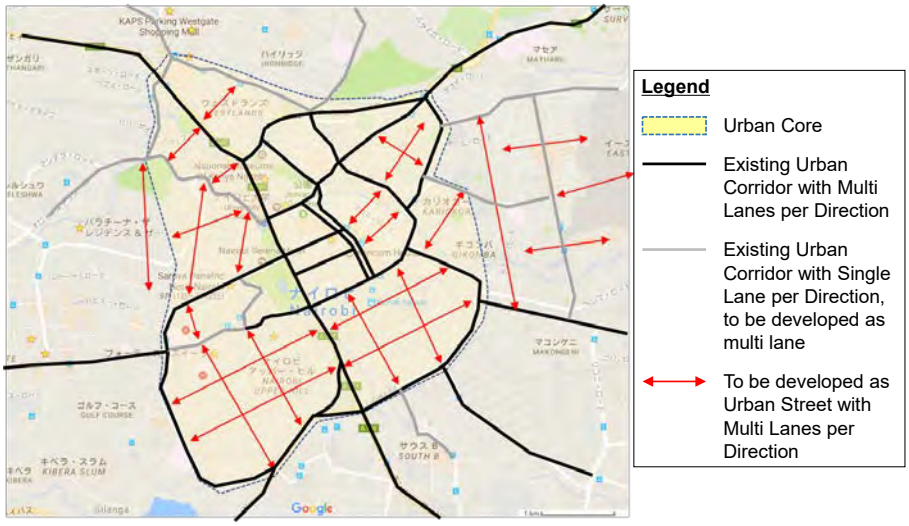
Currently, NCCG has seat regulation for bus operation service of both Matatu and ordinary bus service. The seat regulation requires operators ensure passengers to take their seat during operation. In spite of securing safety for passengers during operation, it is difficult to carry a large volume of passengers at a time. Providing other safety measures, revision of standing seat regulation can resolve having limitation of carrying volume of passengers.

2) Improvement of Road Networks

Two items for improvement of road network are proposed as stated below.

(i) Missing link improvement

Establishment of grid road network structure can provide practical alternative routes in Nairobi Urban Core as well as Westlands and Eastleigh possibly with installation of viaduct at the primary section.



Source: JICA Study Team

Figure S. 6 Missing link proposals for the Urban Core

(ii) Promotion of road space management

Open space development by utilizing part of road space would be critical to provide comfortable space for pedestrians by closing some of the lanes in the CBD, which could lead to establishment of pedestrian city and will be accommodated with integrated transport as well as land use management in urban district.

3) Improvement of Pedestrian Space

Improvement of pedestrian accessibility in the CBD has to be in cooperated with the integrated transport system by facilitating signs and clearing access route to the point of modal

intersections of relevant transport systems.

Source: Urb-i

Figure S. 7 Implications of Lane Closing – Before and After

4) Application of Intermodal Facility

Appropriate location, quantity and quality of intermodal facility such as stations for BRT and Metro will be necessary for better service of integrated transport system in Nairobi Urban Core. Additionally, minimisation of park and ride system without development of appropriate access to the station for vehicles and pedestrians is proposed.

5) Application of Transport Demand Management Measure

Three main items are noted for application of transport demand management measure and policy as below.

(i) Promotion of off-peak measure

It would be difficult to reduce traffic congestion in Nairobi Urban Core, unless the total volume of vehicles in Nairobi will decrease and people working in CBD. Changing work style for people working in CBD can reflects to off-peak measure which can control part of traffic volume by avoiding vehicle in peak time.

(ii) Reinforcement of parking policy

Minimisation of on-street parking in CBD could provide open space which could increase business opportunity and ensure easy and safe pedestrian access in CBD. Development of off-street parking lot in the fringe or out skirt of Nairobi Urban Core with cheaper tariff would be compromised for minimisation of on-street parking.

(iii) Establishment of pricing policy

Charging road price for private vehicle in designated district in Nairobi Urban Core and encouraging drivers to use public transport such as BRT/Metro could help traffic congestion.

2 Policy II: Proposal for Future Re-alignment of BRT

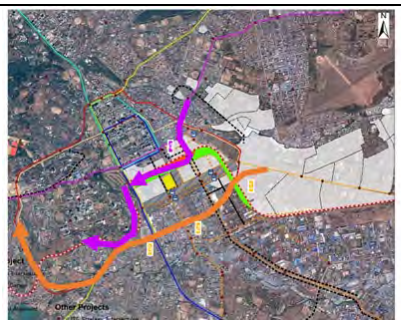
Regarding the policy of proposal for future re-alignment of BRT, three ideas of re-alignment are proposed to resolve the examined conflicts which has not been clarified in the current BRT plan.

1) Re-organisation of Current Alignment of BRT Line 3 and 4

Proposed alignment of BRT Line 3 or 4, Juja-Ngong road, is traversed in part of commuter rail alignment side by side to resolve difficulty of interference with BRT Line 1 south and other regular traffics on Uhuru Highway by utilizing the existing viaduct under Uhulu Highway. By applying the re-organized alignment, the BRT Line 3 will be able to pass Uhulu highway without any conflict with other transports.

Additionally, one of the proposed option is proposed as utilization of viaduct over the railway connecting with enterprise road for BRT Line 3 to coordinate with other project and aligning BRT line 4 in the middle of railway city connecting with Nyayo Stadium and Upper Hill in order to integrate with other on-going project in the future.

Current Proposed Alignment of BRT Line 3 and 4



Option 1 Proposed Re-alignment of BRT 3 and 4 (Integrated Plan)

Option 2 Proposed Re-alignment of BRT 3 and 4 (Integrated Plan)

Source: JICA Study Team

Figure S. 8 Re-alignment Plan of BRT Line 3 and 4

2) Re-organisation of Current Alignment of BRT Line 1

Simplification of BRT alignment is proposed for BRT Line 1, Mombasa, Uhuru, and Waiyaki Highway, by having a dedicated linear movement on that highways to avoid any conflict with other transport as well as to project less traffic in the CBD, whereas original alignment is traversed in the CBD as circulated way.

Current Proposed Alignment of BRT Line 1

Option 2 Proposed Re-alignment of BRT 1 (Simplified Plan)

Source: JICA Study Team

Figure S. 9 Re-alignment Plan of BRT Line 1

3) Re-organization of Current Alignment of BRT Line 2

Replacement of BRT Line 2 to rail-based transport system, Metro, is proposed to enhance transport demand capacity on Thika highway and traffic on eastern part of Nairobi, as well as to reduce social impact of land acquisition. Application of rail-based transport as one of the proposed policies will be stated as Policy II afterwards.

3 Policy III: Application of Rail-based Transport System

For principal idea of the policy can be pointed out as a connection of mass mobility volume in east and west by Metro on Thika and Ngong road through CBD underground with underground property development such as underground mall. Details of the policy are overviewed below.

1) Development of Metro Connecting Thika and Ngong Roads

In the NMRTS study, 3 Metro lines were selected for MRT corridors, namely, Thika, Juja and Ngong roads based on the demand forecast. Since the priority routes have not been changed, and BRT plan is on-going at Juja and Ngong roads, Thika road is selected as a metro corridor of east side for the study. A metro corridor of west side will be selected from candidates such as Ngong road and Langata Road by considering the mature degree of the BRT projects.

The selected route is able to have 4 or more junctions with KRC line and planned BRT lines as marked by pink stars on the map.

Source: JICA Study Team

Figure S. 10 Planned Route of the First Metro Line

4 Summary of Proposed Policy of Integrated Transport

The integrated transport policy proposed by the JST can be summarised as shown on Table below.

Table S. 1 Summary of Proposed Policy for Integrated Transport System

#	Name	Description
Policy I: Establishment of Comprehensive Mobility Management		
P-I-1	Improvement of Bus Service	(i) Re-organization of Matatu and other ordinary bus service route Replace Matatu and ordinary bus service to feeder transport service to avoid concentration of traffic volume in the CBD. (ii) Application of new bus fleet standard Applying bigger fleet, wider entrance door and electric power unit. (iii) Renovation of bus service system Applying approaching notification system integrated with other transport system. (iv) Revision of regulation for bus service Revision of standing seat regulation can resolve having limitation of carrying volume of passengers.
P-I-2	Improvement of Road Networks	(i) Missing link improvement Establishment of grid road network structure in Nairobi Urban Core as well as Westlands and Eastleigh. (ii) Promotion of road space management Open space development by utilising part of road space.
P-I-3	Improvement of Pedestrian Service	Improvement of pedestrian accessibility in CBD by facilitating signs and clearing access route to nodal point of other transport system.
P-I-4	Application of Intermodal Facility	Development of intermodal facility such as station for BRT and Metro
P-I-5	Application of Transport Demand Management Measure and Policy	(i) Promotion of off-peak measure Off-peak measure can control part of traffic volume by avoiding vehicle in peak time. (ii) Reinforcement of parking policy Minimisation of on-street parking in CBD. Development of off-street parking lot in the fringe or out skirt of Nairobi Urban Core. (iii) Establishment of pricing policy Charging road price for private vehicle in designated district in Nairobi Urban Core.
Policy II: Proposal for Future Re-alignment of BRT		
P-II-1	Re-organisation of Current Alignment of BRT Line 3 and 4	Re-alignment of BRT Line 3 and 4 utilising existing viaduct of commuter rail as well as part of ROW of commuter rail. Coordinating BRT with viaduct project to utilise future viaduct route. Re-alignment of BRT 4 running adjacent to railway city for future demand.
P-II-2	Re-organisation of Current Alignment of BRT Line 1	Simplification of BRT alignment for BRT Line 1, Mombasa, Uhuru and Waiyaki Highway, to traverse the line as the dedicated linear alignment.
P-II-3	Re-organization of Current Alignment of BRT Line 2	Modifying the BRT line to Metro to meet future transport demand from West and East part of Nairobi City County.
Policy III: Application of Rail-based Transport System		
P-III-1	Development of Metro Connecting Thika and Ngong Roads	Development of Metro on Thika and Ngong road connecting in the CBD underground. Construction of subway station in CBD would be associated with possible underground property development

Source: JICA Study Team

Part-I

Current Conditions and the Analysis in the Nairobi Urban Core

Chapter 1 Introduction

1.1 Background

Nairobi, the biggest city in east Africa and capital city of the Republic of Kenya (hereinafter referred as Kenya), is the political and economic center of the country with a population of 3.77 million (2014, UN estimate). Traffic condition in Nairobi is getting worse due to unsystematic development and high inflow of population. Traffic condition in Nairobi is getting worse due to unsystematic development and high inflow of population, which may influence to urban function, accessibility to social and economic services and livelihood.

Japan International Cooperation Agency (JICA) conducted "Nairobi Integrated Urban Development Master Plan (NIUPLAN)" study from 2013 to 2014 to formulate a Master Plan aiming to year 2030. In order to ease the concentration of political, economic and transportation services into the city business district (CBD), the master plan (M/P) formulates sub-centers and the provision of an urban transportation network; including as one of the priority projects, the construction of a loop line circulating the CBD. Based on the results of NIUPLAN, Nairobi City County Government (NCCG) requested to JICA on August 2014, to implement a further study of Technical Cooperation for Development Planning including a feasibility study of the loop line.

After receiving NCCG's request, JICA implemented "the Detailed Planning Survey on the Project with Technical Cooperation for Development Planning for Mass Rapid Transit System (Loop Line) in Nairobi" from November to December 2015. It was found through the survey that there was no clear vision about the project implementation body in Kenya and no prospect of urban transportation system which shall be connected to the loop line. Then, it was confirmed that a structure for project implementation shall be examined prior to implement a feasibility study.

Several studies on urban development and urban transport planning had been prepared to Nairobi and generate positive impact to Nairobi nowadays. JICA conducted the Nairobi Urban Transportation Masterplan Study (NUTRANS) in 2006, which proposed major urban road structure for Nairobi, including the Southern Bypass, Northern Bypass and Eastern Bypass, as well as urban transport development strategy. The proposed bypass system by NUTRANS has been developed and succeeded to divert the heavy vehicles from the Northern Corridor running along the CBD. Nairobi Metropolitan Services Improvement Project (NaMSIP) and National Urban Transport Improvement Project (NUTRIP) supported and funded by the World Bank have brought the large amount of investment opportunities. Several urban development projects by the NIUPLAN comes to be implemented by the NaMSIP funding.

1.2 Objectives

According to the Record of Discussion, the project title was decided as "The Project on Detailed Planning of Integrated Transport System and Loop Line". The aim of the study is to formulate an integrated transport system which will provide seamless connection between various transportation modes in the urban core, by reviewing on-going short term urban transportation policies and existing urban transportation improvement projects; such as BRT, road improvement and commuter rail project, and thus the mobility of passengers will be improved. This study is composed of 2 stages; the first stage reviews short term urban transport policies inside the urban core (BRT development, road improvement and existing railway improvement projects); analyzes the traffic movement; formulates measures for mobility

improvement and also when is the optimum time for introducing a rail based urban transportation system for mobility improvement. The second stage, materializes the framework of rail based urban transportation system as an additional scope of work.

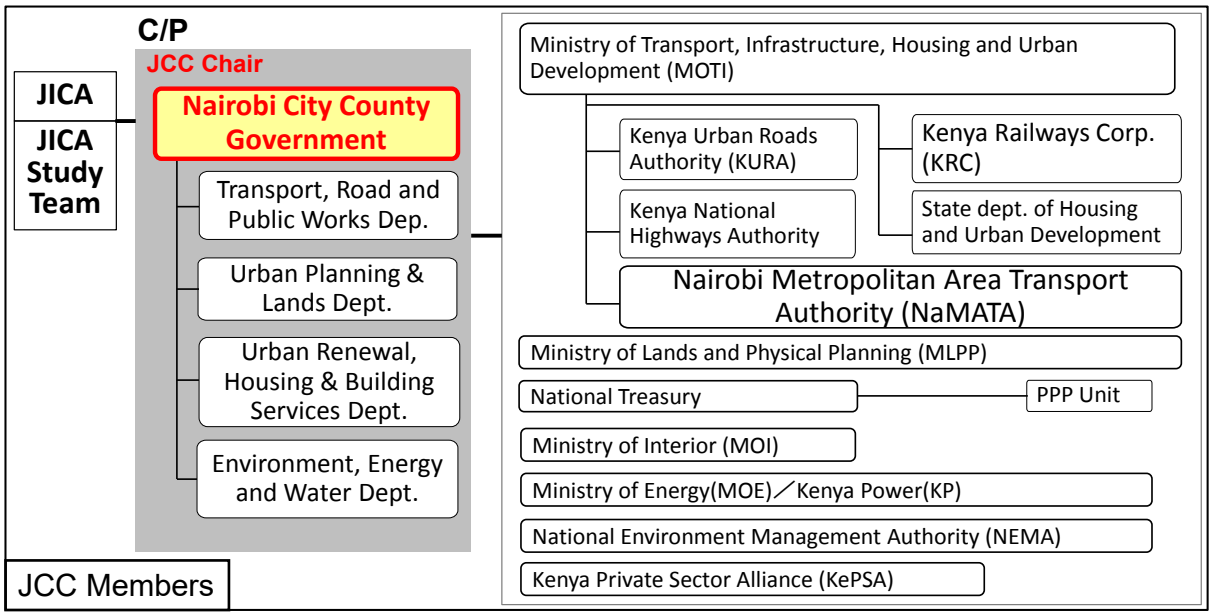
It should be noted about the two keywords of this study, "Urban Core" and "Loop Line". There is no clear definition of the Urban Core of Nairobi. The project concept of the Loop Line was proposed by the NIUPLAN and the Assembly of NCCG has designated the feasibly study of the Loop Line as a short term priority project (see chapter 2.3.1). However, priority of the Loop Line in the NIUPLAN was not so high, and it was proposed that the Loop Line development should follow after the radial Metro corridors development.

The study team and C/P team had discussion on this matter and detail definition on the two keywords are to be defined clearly through this report. Initially, it can be noted that the Urban Core function of Nairobi is expanding due to its rapid growth and the border of the Urban Core will require transport function in circular directions to alleviate the high traffic concentration to Nairobi, which could be translated as necessity of the Loop Line.

1.3 Counterparts

The counterparts from Kenya are the Transport, Road and Public Works Department; the Lands, Housing and Urban Planning Department and the Environment Department of Nairobi City County Government.

Also, the stakeholders involved in the Joint Coordination Committee (JCC) are shown in Figure 1.1.

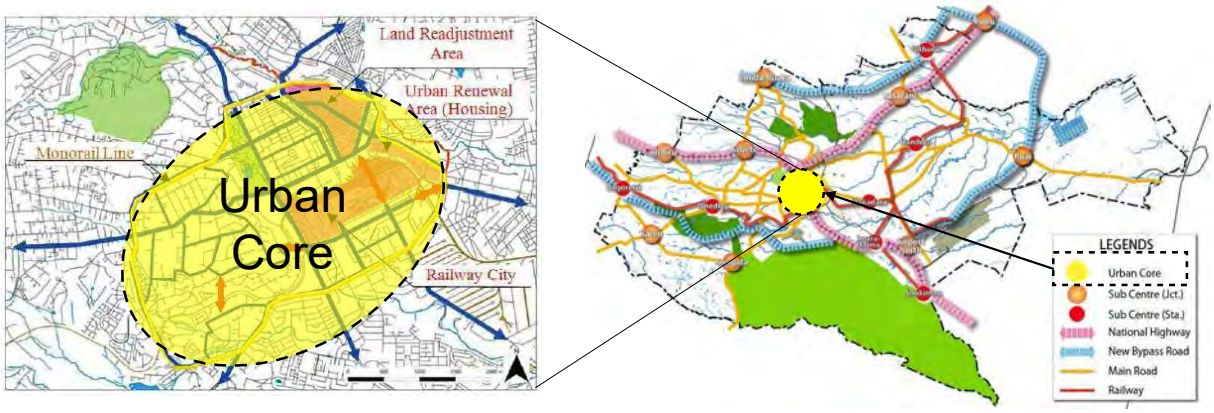


Source: JICA Study Team

Figure 1.1 Project Organization Chart

1.4 Scope of the Study

Nairobi City center: Greater CBD (Central Business District) is defined as Urban Core in the Study. The site is shown in Figure 1.2 as agreed between JICA and NCCG.



Source: Record of Discussions on the Project on Detailed Planning of Integrated Transport System and Loop Line in the Nairobi Urban Core, edited by JICA Study Team.

Figure 1.2 Project Site (the Nairobi Urban Core)

1.5 Contents of the Final Report

It summarizes current collected information in the Final Report.

- Chapter 1 summarized the background, objectives, counterparts and the project site.
- Chapter 2 describes the current situation from the point of view of urban development and transport in the Urban Core and Nairobi Metropolitan area; i.e., social and economic situation, infrastructure, organization for mobility improvement.
- Chapter 3 summarizes the project status concerning urban development sector and transportation and environment subsectors including project database. And then issues by sector are listed.
- Chapter 4 also summarizes the characteristics including AMP counter survey methodology and identification of travel pattern in Nairobi Urban Core.
- Chapter 5 proposes future urban transportation plan in Nairobi according to said transport surveys to cover expected demand as explained in Chapter 7.
- Chapter 6 proposes rail based Metro system at busiest corridor in Nairobi.
- Chapter 7 explains detail of the methodology of the demand forecasting in the project and justifies the transportation plan proposed in Chapter 5 and Chapter 6.
- Chapter 8 reports the status of the strategic environmental assessment survey in the project.
- Chapter 9 proposes the action plan of the projects in policy I, which can be implemented immediately with high effectiveness.

Chapter 2 Present Situation of Urban Development and Transportation

2.1 Social and Economic Situation

2.1.1 Population

Kenya's long-term development plan, known as Vision 2030, recognizes that rapid population growth could severely disrupt progress for reaching its primary goal: To achieve a sustainable high quality of life for all Kenyans with available resources.

In 2012, the government of Kenya launched a new policy on population and national development. The principal objective of the policy is to provide a framework to guide national population programs and activities for the next two decades (National Council for Population and Development [NCPD], 2012). The policy aims to reduce the natural growth rate of the population from 2.5% in 2009 to 1.5% by 2030.

However, to achieve Vision 2030, this policy seems ambitious. Counterparts and Study Team will discuss how to apply this challenging target growth rate to demand forecast.

Table 2.1 Targets for Key Demographic Indicators 2015-2050

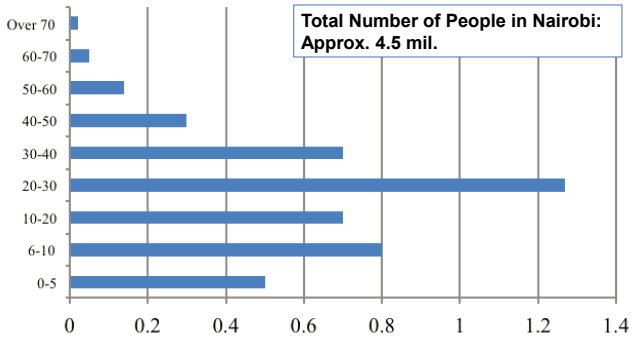
Indicator	Base year 2009	2010	2015	2020	2025	2030	2050
Population (millions)	38.6	39.6	44.6	49.7	54.7	59.5	77.3
Labour force (Millions)	20.7	21.4	25.5	29.9	34.1	38.6	53.1
Dependency Ratio	86.8	84.9	75	66.2	60.3	54.3	44.6
Crude Birth Rate (per 1000)	38	37	34	30	26	23	17
Crude Death Rate (per 1000)	13	13	11	10	9	8	7
Natural growth rate (%)	2.5	2.4	2.3	2.0	1.7	1.5	1.0
Median Age (years)	17	17	18	20	27	28	30
IMR (per 1000 live births)	52	51	45	38	31	25	11
U5MR (per 1000 live births)	74	73	67	62	55	48	34
MMR (per 100,000 live births)	488	473	400	350	250	200	120
Life Expectancy (years)	57	57	59	61	62	64	72
TFR	4.6	4.5	4.0	3.4	3.0	2.6	2.1

Source: Kenyan Population Policy

In Nairobi County, the population was 3.1 million in 2009 and it will be exceeding over 5.2 million people by 2030[1] with 166% growth rate. The increasing ratio in Kenya is predicted 154% between base year 2009 and 2030 as shown in the Table 2., and it is still lower than the prediction in Nairobi.

On the other hand, the current population has reached at 4.3 million, and 3.3 million people are below the age of 35 shared 76.7% as shown the Figure 2.. The population in Nairobi has rapidly increased and the average age is young.

[1] Nairobi County Manifesto 2017

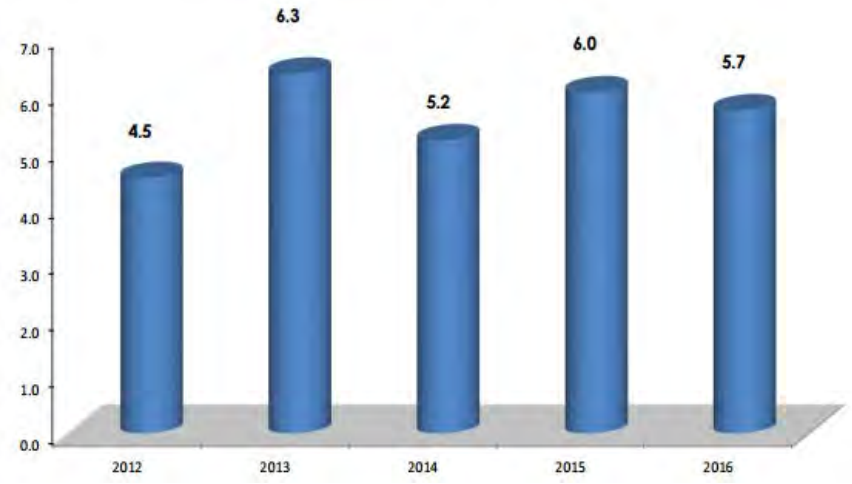


Source: Nairobi County Manifesto 2017

Figure 2.1 Population Number in Million in Nairobi

2.1.2 Economic Index

The Economic Recovery Strategy of 2003 and the Vision 2030 have driven exponential economic growth of Kenya in a decade, while the economy was challenged by several socio-economic shocks in the domestic and global levels. According to Quarterly Gross Domestic Product Report of the Third Quarter 2016 released by the Kenya National Bureau of Statistics, the economy grew by 5.7% in the third quarter of 2016 compared with a growth of 6.0% in the same period in the year 2015. Growth was largely supported by performance in the sectors of agriculture, transport and storage, electricity and water supply, wholesale and retail trade, and accommodation and restaurants.



Unit: %

Source: Quarterly Gross Domestic Product Report, Third Quarter 2016, Kenya National Statistic Bureau

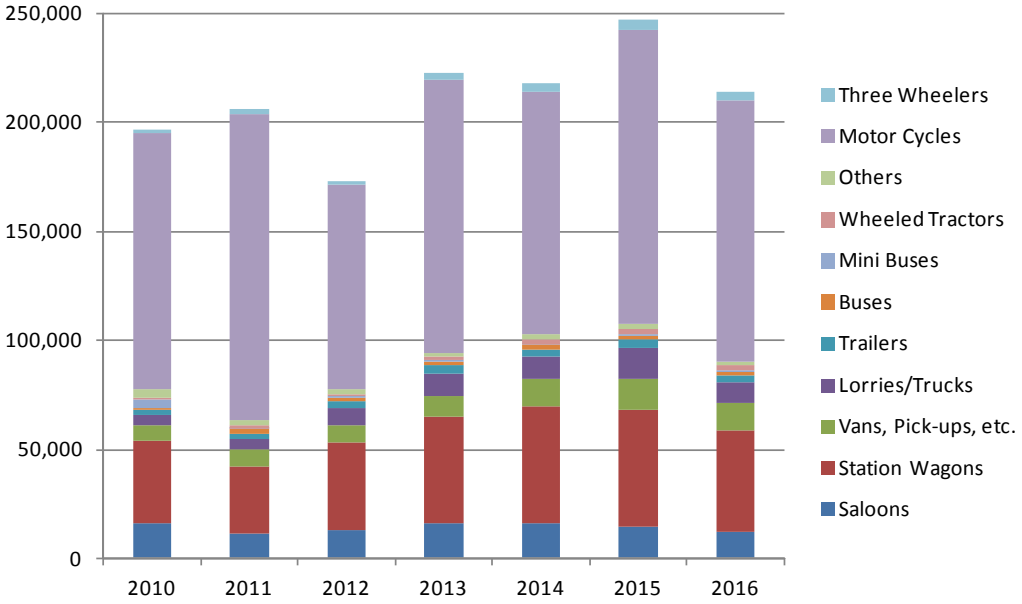
Figure 2.2 Third Quarter GDP Growth Rates

Nairobi plays a leading role in the economy of Kenya and East Africa as a hub for business and technology since it became the national capital. Although county or city level statistics are not well organized and there is variance by source, it is assumed that Nairobi City accounts for approximately 50% of formal employment in Kenya and generates over 50% of the country's GDP.[2] In 2013, it was reported that the Nairobi's Gross National Income per capita was estimated to be $1,160 while the economic growth rate was at 4.7%. Nairobi is a home of 48.4% of industrial establishments of the country and a contributor to 17.6% of exports. In

[2] According to the NIUPLAN, GDP per capita of Kenya is estimated at KSh73,988 at current prices while the GRDP (gross regional domestic product) of Nairobi City is estimated at KSh221,965 as of 2011.

addition, the city attracts a number of service and financial activities including foreign investments, while informal economic activities are also active.

Rapid economic growth boosts increase of vehicle ownership in Kenya and Nairobi. The number of newly registered vehicles per year exceeds 200,000 in recent years and it shows similar pattern with the annual growth rate of GDP. It implies continuing trend of growing vehicle ownership along with economic growth. Except for motorcycles, station wagons account for the large part of increase followed by vans and saloons. The total number of vehicles registered was recorded approximately 2.2 Million in 2014. Although the exact number of vehicle ownership by county or city is not available, an estimate indicates that approximately 500,000 private cars are registered in Nairobi[3].



Note: This is national statistics, not mentioning the vehicle growth of the Nairobi Urban Core
Unit: number of vehicle
Source: Kenya Revenue Authority

Figure 2.3 New Vehicle Registration

2.1.3 Land Use

2.1.3.1 Land hold and land tenure

Land hold (land ownership) and land tenure are clearly distinguished in Kenya. Before 1995, approximately 80% of the land within Nairobi was owned by the Government and these were divided into different categories as described in the Statistics Abstract 2005.

Based on table 2.1, about 41.0% of government Lands (32.9% of total land) are alienated[4] to private or other parties. This means that government owned land has been reduced from 80.3% to 47.3% for urban development to cope with development pressure from rapid population growth in Nairobi.

[3] JICA, Nairobi Viaduct and Road Construction Project in the Republic of Kenya; Draft Final Report 1, Sep 2016

[4] Aliened land means the land which ownership of property rights be transferred to others.

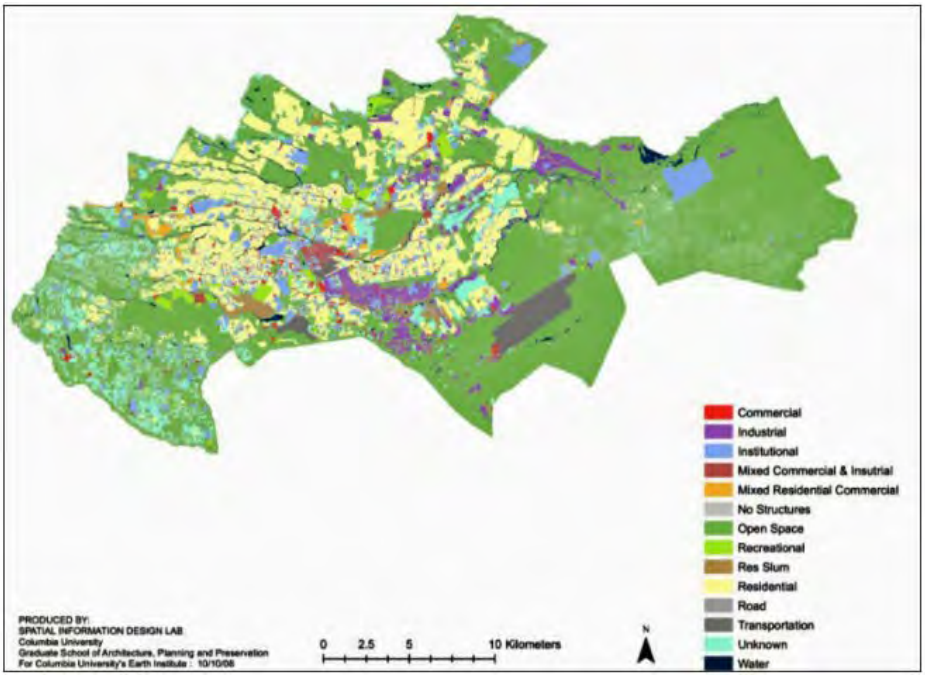
Table 2.2 Land Hold by Land Categories in Nairobi City

Category	Subcategory	Area(sq.km)	%
Government land	1) Forest reserve	21	3.1
	2) Other government reserve	77	11.3
	3) Township	93	13.6
	4) Alienated land	225	32.9
	5) Un-alienated land	16	2.3
	6) National parks	117	17.1
	7) Open water	-	-
	Subtotal	549	80.3
Freehold land	8) Smallholder schemes	-	-
	9) Other	135	19.7
	Subtotal	135	19.7
Grand Total		684	100.0

Source: Statistics Abstract 2005

2.1.3.2 Land Use

The land use map of Nairobi City in NIUPLAN was made based on the map developed by Columbia University, and then updated with satellite images.



Source: NIUPLAN

Figure 2.4 Existing Land Use Map of Nairobi City

The percentage of Open space had a large share of the area in Nairobi City, almost half of its area. However, it can be observed through satellite images that large parts of open spaces has been developed to residential plots.

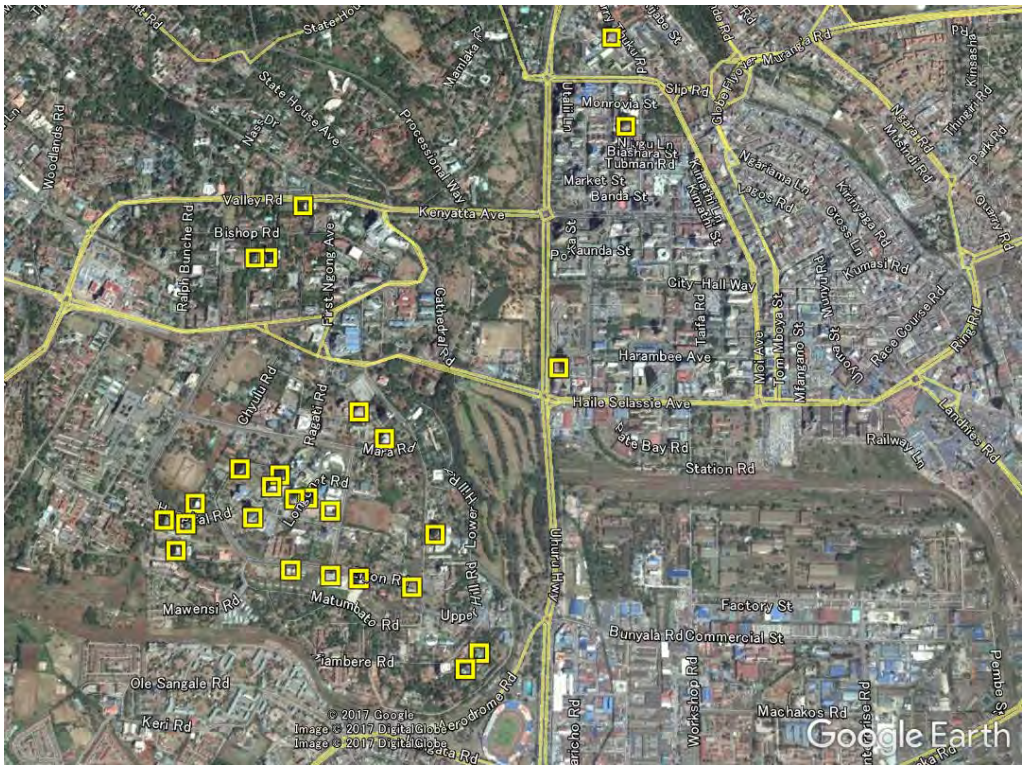
Table 2.3 Land Use in Nairobi City

Land Use	Area (sq. km)	
Residential	105.2	15.1%
Commercial	5.9	0.8%
Industrial	22.2	3.2%
Mixed commercial and industry	3.6	0.5%
Mixed residential and commercial	4.2	0.6%
Institutional	39.8	5.7%
No structures	0.3	0.0%
Open space	332.0	47.8%
Recreational	8.7	1.3%
Res slum	7.8	1.1%
Transportation	15.5	2.2%
Unknown	42.3	6.1%
Water	10.9	1.6%
Total	598.2	86.1%
National Park	96.9	13.9%
Grand Total	695.1	100.0%

Source: JICA Study Team

2.1.3.3 Land Use Change

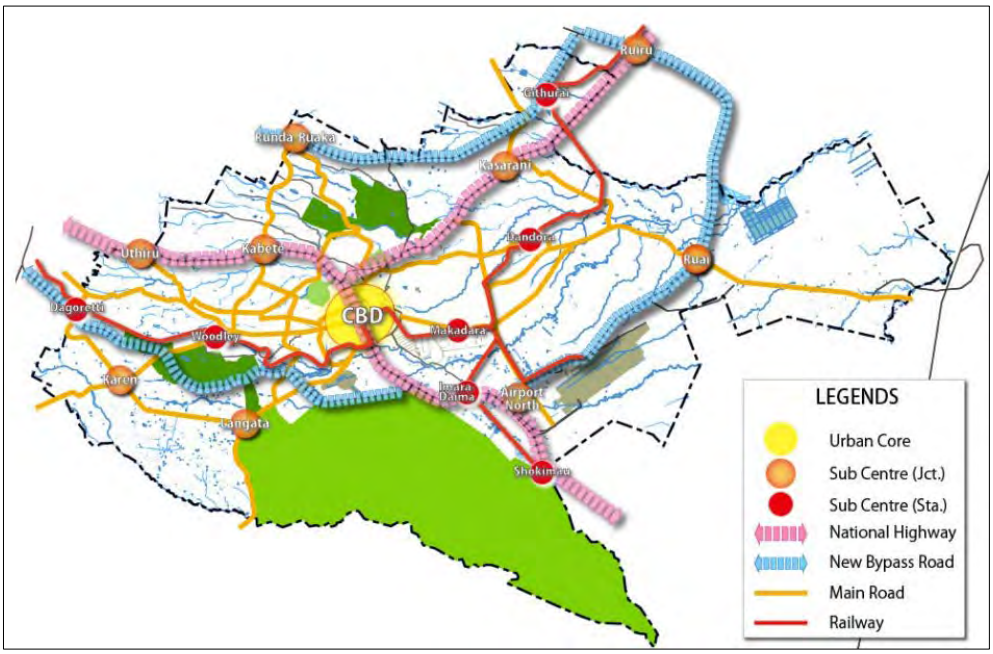
Recent years, development activities in and around CBD area have been growing rapidly, especially the western side, such as Upper Hill, Waiyaki Way, Westlands, Hurlingham estate and Kilimani estate. Most of the development activities changed from low density residential to commercial, high rise office building or high rise apartment.



Source: Google Earth (Image © Digital Globe)

Figure 2.5 Urban Development Activities in CBD and Upper Hill in Last Decade

Moreover, after the completion of the construction work Thika Super Highway and a series of bypass roads, development activities in suburban centres, designated as Sub-Centre in NIUPLAN; have been active especially in Karen, Lang'ata, Runda, Ruaka and Kasarani.



Source: NIUPLAN

Figure 2.6 Proposed Structure Plan for Nairobi City

2.2 Infrastructure

2.2.1 Roads

2.2.1.1 Fund Allocation

1) National Government Authorities (KeNHA and KURA)

As per the Kenya Roads Board Act No. 7 of 1999, Kenya Roads Board (KRB) has a mandate to oversee the road network in Kenya and coordinate the maintenance, rehabilitation and development funded by Road Maintenance Levy Fund (RMLF) and to advise the Minister on all matters related thereto. Section 19 (4) of the KRB Act requires KRB to review, individually, the Annual Road Works Programmes (ARWPs) submitted by Road Agencies and consolidate these ARWPs into an Annual Public Roads Programme (APRP).

The APRP presents the consolidated Annual Road Work Programme from the designated road agencies and provides detailed allocations for all the funds accruing from Kenya Roads Board Fund (KRBF) in the Financial Year 2017/2018.

The estimated projected collections of the Road Maintenance Levy Fund (RMLF) during the Financial Year 2017/2018 is Sixty-Three billion shillings (KSh 63,000,000,000). Similarly, the estimated collections of the Transit Tolls (TT) during the same period is Four Hundred Seventy-Three million and Six Hundred thousand shillings (KSh 473,600,000.00). These two primary sources of funds will contribute to the funds deposited into the KRBF.

The disbursement of the fuel levy funds is based on a legislated formula of 40% to KeNHA, 32% to KeRRA, 15% to KURA, and 1% to Kenya Wildlife Services (KWS). KRB retains the difference of 10%, which it allocates to road agencies on a "case-by-case" basis, and another 2% for its operations. The Annual Funds in 2017/2018 estimates is summarized in the table below.

Table 2.4 Annual Public Roads Programme Funds Allocation for FY 2017/2018

Road Maintenance Levy Fund (RMLF)	FY 2017/2018 Estimates
RECEIPTS	
Fuel levy	63,000,000,000
Transit tolls	473,600,000
Total funds available	**63,473,600,000**
DISBURSEMENTS	
KRB - Operations	1,260,000,000
KRB – 2 % Transit tolls	9,472,000
KRB Total	**1,269,472,000**
KeNHA - Maintenance	21,000,000,000
KeNHA – Development	0
KeNHA – Transit tolls	464,128,000
KeNHA Total	**21,464,128,000**
KeRRA – Rural roads	**11,438,297,872**
KURA – Urban roads	**5,361,702,128**
KWS – National park roads	**525,000,000**
KRB Board / CS Allocation	**5,250,000,000**
SUB-TOTAL	**45,308,600,000**
County Governments	7,875,000,000
Road Annuity Fund	10,290,000,000
TOTAL RMLF FY 2017/2018	**63,473,600,000**

Source: Kenya Roads Board

The main road agencies maintaining roads in Nairobi Area is covered by KeNHA and KURA. The annual fund of KeNHA and KURA are yearly increased from 2015-2016 until 2017-2018. The road budget allocated by Kenya Roads Board is summarized in the table below. The road maintenance and construction costs approx. 2 billion KSh in 2017-2018 in Nairobi by KeNHA and KURA.

Table 2.5 Funds Allocation for Nairobi Region and overall fund by Key Road Agencies in current 3 years

Agency	Year	2015-2016	2016-2017	2017-2018
KeNHA	Annual Fund Total in KSh	11,940,279,898	20,459,228,000	21,464,128,000
	Nairobi Region Allocated in KSh	**797,356,000**	**1,060,386,507**	**1,202,437,696**
	Maintained or Constructed in km	N/A	749.28 km	812.08 km
KURA	Annual Fund Total	4,307,231,962	5,106,382,979	5,361,702,128
	Nairobi Region Allocated	**1,350,574,275**	**994,927,267**	**807,701,423**
	Maintained or Constructed in km	N/A	620.9 km	423.9 km

Source: Annual Public Roads Programme for the Financial Year 2015-2016 ~ 2017-2018

According to the Road Sector Investment Plan, which was concluded in 2010 by KRB, the amount of backlog of road maintenance was estimated as KES 400 billion. And the annual maintenance budget for KeNHA, KURA, KeRRA and road related county government and organization was estimated as KES 400 billion[5]. The detail of the program is explained in Clause 2.3.

2) Nairobi City County

The estimated budget of road in NCCG is estimated 3,682,396,505 KSh in 2017-2018. The budget of road section shares 75% from 2017 until 2020 out of overall budget in Public Works, Transport & Infrastructure department in NCCG and the total yearly budget expected to be increased until 2020 with 5~6% rate growth a year. Also, the projected budget for road section also will be increasing year by year according to routine maintenance, construction of roads, access roads and bridges works increased with 5~7% rate growth a year.

Table 2.6 Budget for Public Works, Transport & Infrastructure in NCCG (2018/2019 – 2019/2020)

Item	2017-2018 (Estimated)	2018-2019 (Projected)	2019-2020 (Projected)
Roads (Growth rate in % from previous year budget)	**3,682,396,505 (N/A)**	**3,952,466,330 (+7%)**	**4,143,089,648 (+5%)**
(Share % of Public Works, Transport & Infra. Total)	**(75%)**	**(75%)**	**(75%)**
Transport	438,374,503	459,793,228	482,582,890
Electrical	700,000,000	714,000,000	749,700,000
Garage/ Transportation	60,000,000	63,000,000	66,150,000
Building works	60,000,000	63,000,000	66,150,000
Budget Total in Public Works, Transport & Infra. Dept. (Growth rate in % from previous year budget)	4,940,771,008 (N/A)	5,252,259,558 (+6%)	5,507,672,538 (+5%)

Source: NCCG

2.2.1.2 Road Classification

Roads in Kenya are classified under the Kenya Road Classification Manual (July 2009, Ministry of Roads). The manual classifies rural roads into four categories (S-C) and urban roads into seven categories (H-P). The classification of the Road network in Kenya is shown in Table 2..

[5] Annual Public Roads Programme for the Financial Year 2015/2016

Table 2.7 Road Class and the Description in Kenya

Category	Functional Class	Responsible Road Agency as of NIUPLAN	Road Class	Functional Class	Description
Rural Road	Arterial or Trunk	KeNHA	S	Super Highway	Highways connecting two or more cities and designed to carry safely large volumes of motor vehicle traffic at high speeds
			A	Major Arterial	Roads forming strategic routes and corridors, connecting international boundaries, and international terminals
			B	Minor Arterial	Roads forming important national routes, linking province headquarters or other important centres to the capital, to each other or to class A roads
	Collector		C	Major Collector	Roads linking district headquarters and other major designated towns to the higher level network or to each other
Urban Road	Arterial	KURA/ NCCG*	H	Major Arterial	Major arterials provide for through traffic and for relatively long distance movements between widely separated parts of the town or city
			J	Minor Arterial	Minor arterials provide the main means of moving between different zones of the urban area
	Collector		K	Major Collector	Major collectors provide the link between arterials and local roads, distributing traffic to residential and other defined zones
			L	District Distributor	These perform a similar function to major collectors, but generally serve a smaller area, with lower traffic levels
	Local		M	Shopping/ Local Street	These roads include the main shopping and business streets in the urban CBD or suburbs of larger towns and cities
			N	Non-residential Access	Roads providing direct access to individual or groups of properties, other than residential areas
			P	Residential Access	Roads providing direct access to groups of residential properties

* Urban roads are under jurisdiction of KURA and are currently in the process of devolution to the municipality.
Source: "Kenya Road Classification Manual" July 2009, Ministry of Roads and JICA Study Team

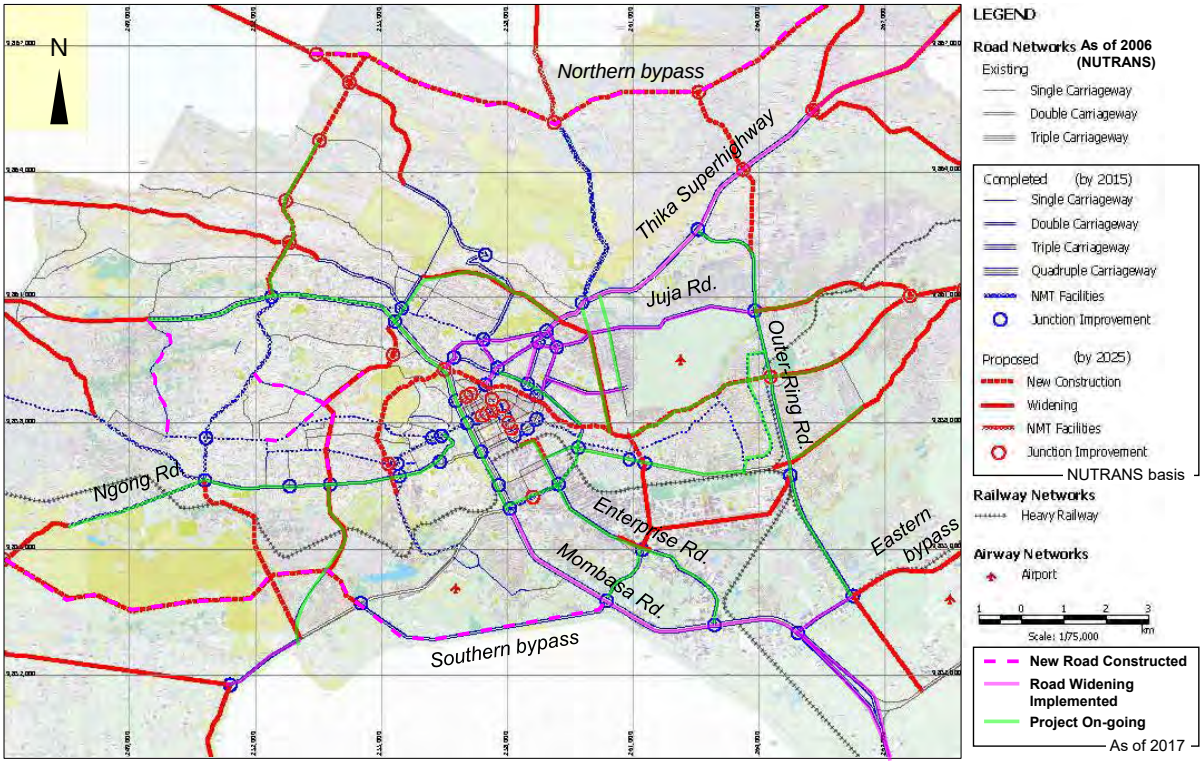
Amongst the classified rural roads, class S, A, B and C are national roads under the jurisdiction of KeNHA. Other rural roads are mainly under the jurisdiction of Kenya Rural Roads Authority (KeRRA). Urban roads are under jurisdiction of KURA and are currently in the process of devolution to the municipality.

According to the Kenya Roads Bill 2015, GOK has introduced three classes of roads. They are primary national trunk roads, secondary national trunk roads and county roads. Along with this, roads authorities will be reorganized into the Kenya National Highways Authority, Kenya National Secondary Roads Authority and the County Roads Agency. However, as of August 2016, reorganization of road sector has not been implemented and the jurisdiction of road has not fixed until the authority set. Whereas according to the Construction of Kenya 2010, the function of the county empowered for road management. All the counties shall be responsible for national roads and rural road as well in future.

2.2.1.3 Road Network in Nairobi Metropolitan Area

In 2006, JICA dispatched "The Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area" (hereinafter NUTRANS) in response to a request from Ministry of Roads and Public Works (consolidated in MoTIH&UD as of 2017) et al. The proposed road network

in NUTRANS and actual progress as of 2017 is illustrated in the figure below.

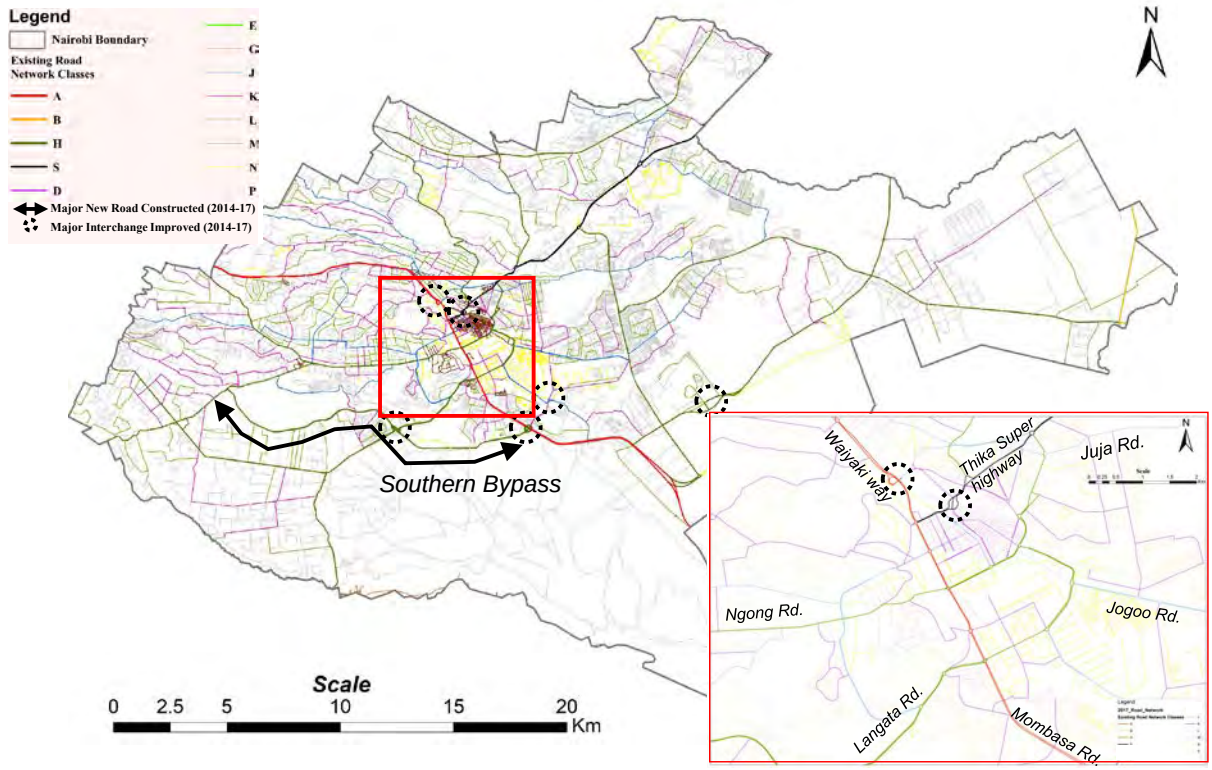


Source: JICA Study Team, NUTRANS

Figure 2.7 The Road Network Difference between NUTRANS and Current Situation

Compared with the road network in 2006, Northern and Southern bypasses were constructed and the Outer ring bypass is under construction, thus the backbone of the outer ring road network 10 to 20km away from CBD have been built in accordance with the NUTRANS. Furthermore, the trunk road network has been strengthened in northeastern and southeastern directions from CBD (Thika road and Mombasa road, respectively) meanwhile the western direction has also improved (Ngong road) and the trunk roads consisting of Nairobi area have also improved.

Figure 2. shows the road network in Nairobi Metropolitan Area in 2017 by road type and the location of the road developed between 2014 (NIUPLAN) and 2017. Southern bypass has been constructed and 6 intersections were improved during the period. The Southern bypass mitigated freight through-traffic in the Nairobi Urban Core.



Source: JICA Study Team

Figure 2.8 Road Network in Nairobi Metropolitan Area

Table 2.8 Road Length in Nairobi Metropolitan Area by Road Class

Category	Class	Road Length (km) 2014	Road Length (km) 2017	Difference (km)
Rural Road	S	33.6	33.8	0.2
	A	54.0	55.1	1.1
	B	5.7	5.7	0.0
Urban Road	H	149.8	179.4	29.7
	J	121.7	121.9	0.2
	K	276.9	279.2	2.3
	L	340.7	345.4	4.7
	M	62.1	62.1	0.0
	N	145.0	144.2	-0.8
	P	1,549.1	1,544.6	-4.5
Not Classified		196.6	196.6	0.0
Grand Total		2,935.2	2,968.1	**32.9**

Source: JICA Study Team

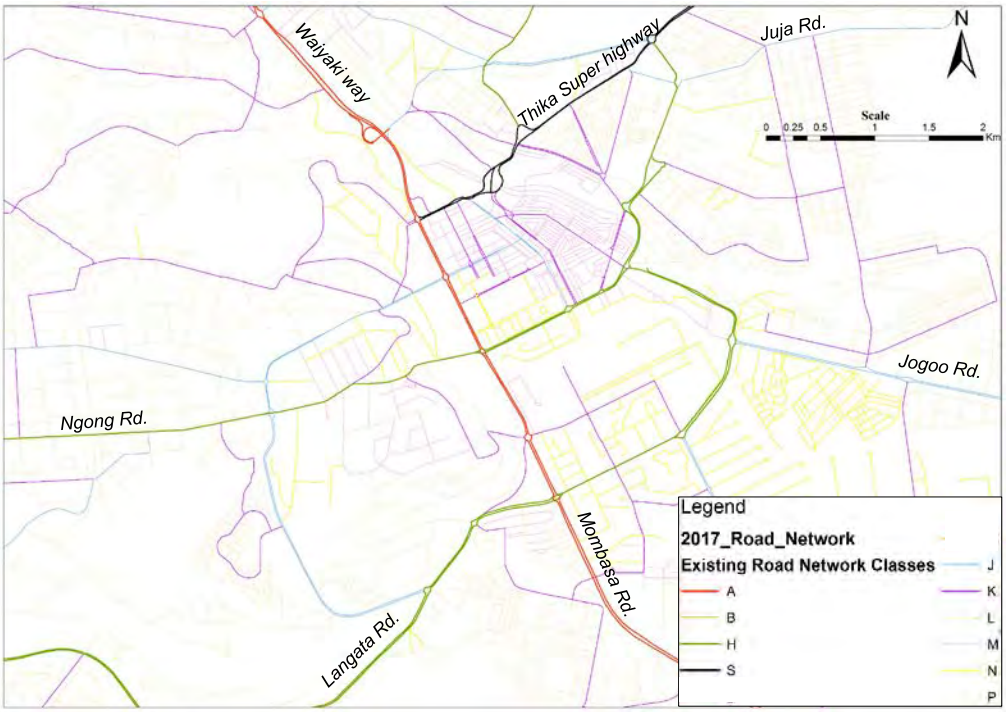
Bechtel Corporation, U.S. based engineering company has won and signed a KSh 230 billion commercial agreement with KeNHA[6]. This is Kenya's first expressway between Mombasa and Nairobi with four-lane, 473-kilometer expressway with 19 interchanges and will commence by 2023. The expressway connects southern bypass directly and enhance the motorization, the surrounding area i.e., Wilson Airport, along Lang'ata~Karen area and the outer ring road has the potential for future development.

2.2.1.4 Road Network in the Nairobi Urban Core

The current road network is illustrated as of 2017 in the figure below. Trunk roads consists

[6] Construction Business Review, Thursday, 9 November 2017

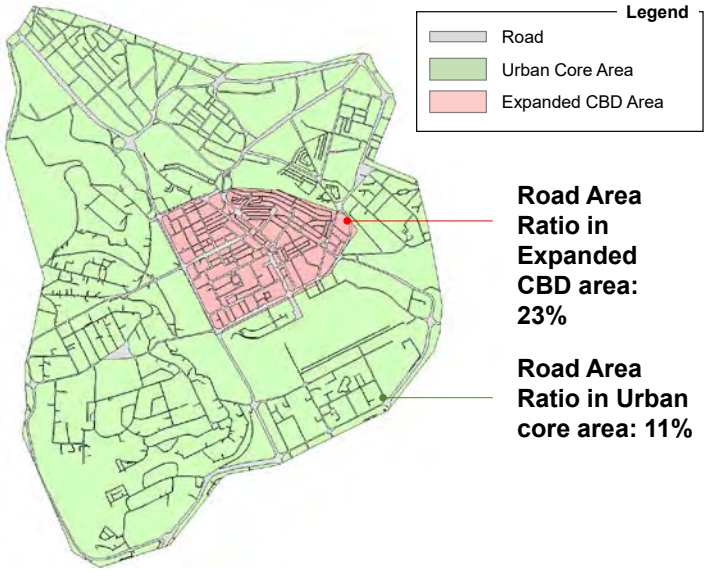
urban road network namely, Waiyaki way, Thika super highway, Juja road, Jogoo road, Mombasa road, Lang'ata road and Ngong road spread outskirt area from CBD.



Source: JICA Study Team

Figure 2.9 Road Network in the Nairobi Urban Core by Road Type as of 2017

The road area ratio, defined as the area divided by road area, is the index which represents the development level of the road network. The ratio in the Nairobi Urban Core and the expanded CBD area is summarized in the Figure 2.. The road area ratio reached 23% in expanded CBD area, however the one in Nairobi Urban Core is low.



Source: JICA Study Team

Figure 2.10 Road Area Ratio in the Nairobi Urban Core and the Expanded CBD Area

The cases of the road area ratio are listed in the table below. According the list, the value in the Nairobi expanded CBD i.e., 23% shows that the road is well developed same as developed

countries e.g., London. Therefore, the developed road network shall be utilized for mobility improvement in Nairobi Urban Core. However, the area widened until Nairobi Urban Area decreased the rate by 11%. The value shall be improved in view of the mobility improvement.

Table 2.9 Road Area Ratio Comparison in the Developed Countries and Nairobi

Item	Road Area Ratio (%)
Tokyo (Overall), JAPAN	15.6
Tokyo (Urban Core; Chiyoda-ku), JAPAN	21.8
New York (Manhattan Ward), USA	29.0
London (Urban Core; 4 wards), British	23.6
Nairobi (Expanded CBD), Kenya	23.0
Nairobi (Urban Core), Kenya	11.0

Source: New York: Community District Profile, NYC Department of City Planning (2004)
London: Generalised Land Use Database Statistics for England, the Office of the Deputy Prime Minister(OPDM) (2001)
Tokyo: Chiyoda-ku Website https://www.city.chiyoda.lg.jp/koho/machizukuri/kotsu/shuyodoro/doro.html , accessed in 1st Nov
Nairobi: JICA Study Team

2.2.2 Transport Service

2.2.2.1 Bus and Matatu

There is no clear demarcation in planning and management in infrastructure development among bus and matatu, and those infrastructures are commonly used by the both modes at present. The infrastructure for bus services can be classified as follows; i) terminals and routes allocation in CBD, and ii) bus stop facilities along the routes. Also, the state of practice for iii) transport operators (Sacco's and bus companies), iv) service regulators, v) route regulation and vi) fare regulation are discussed. In the end, the general review for bus market (as soft infrastructure) are assessed.

1) Terminals and routes allocation in CBD

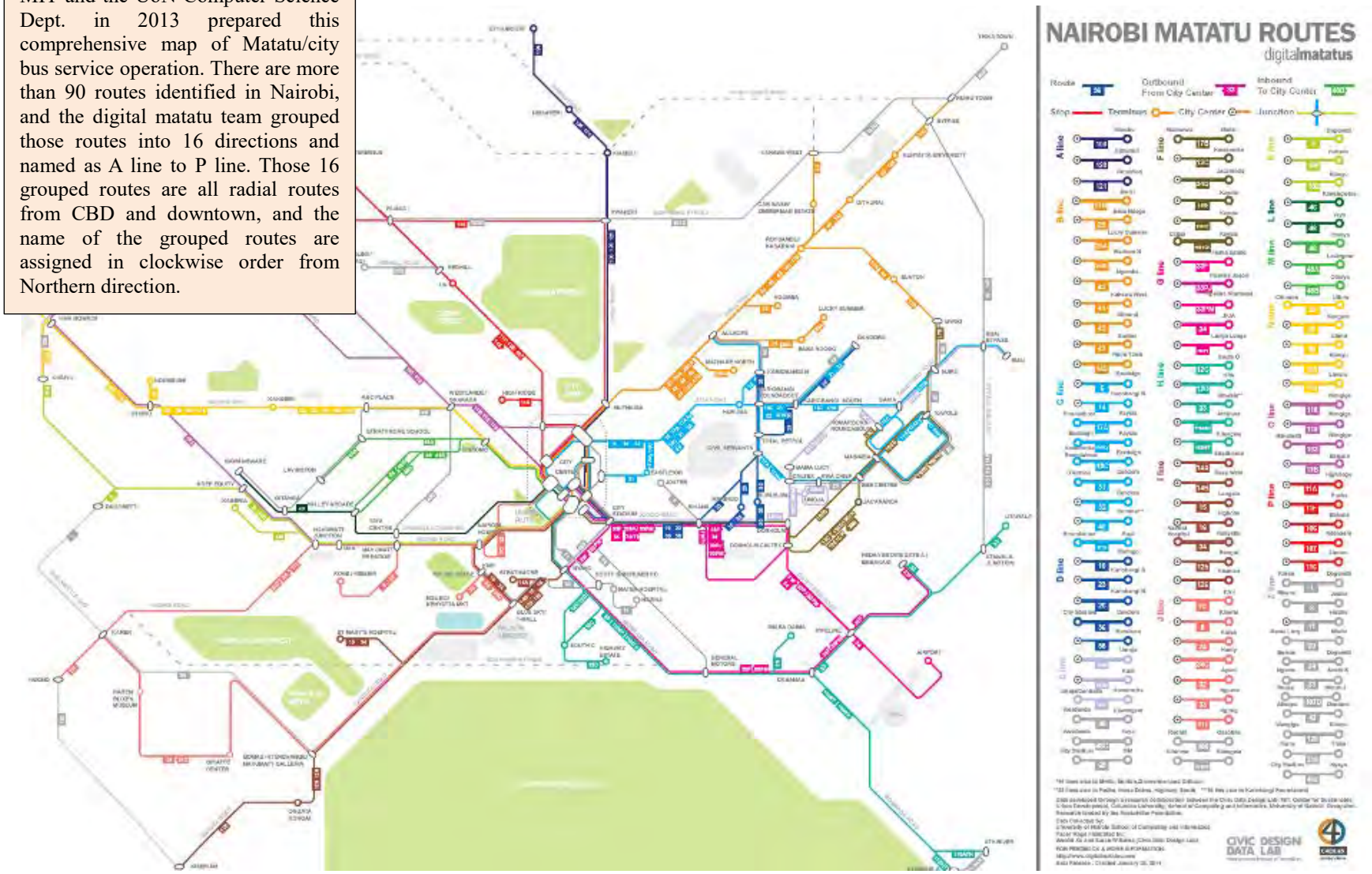
Figure 2. shows the general view of the bus terminal route allocations in the CBD, including matatu terminals and on-street parking which is a summary of the inventory surveys conducted by the Study team in June 2017.

As the figure shows, the number of the bus terminal owned and managed by NCCG are 10 in CBD. Each terminal facility has been assigned to specific routes, which has been gazetted by the Nairobi City County Government (NCCG) in the Kenya Gazette[7]. The Transport Unit of the NCCG manages the bus terminal usage, lease parking spaces in the terminals to bus and matatu operators for a renewable period of either one or three months and collect the specific fee from bus and matatu operators. The Transport Unit has developed 5 terminal facilities in the last four years namely (Murang'a Road, Desai Road, Park Road and Ngara Road. They have also rehabilitated 3 facilities namely Country Bus (Machakos Bus) Terminal, Railways Terminal and one section of Central Bus Terminal (Hakati).

There are other on-street unauthorized bus stops that matatus also operate from.

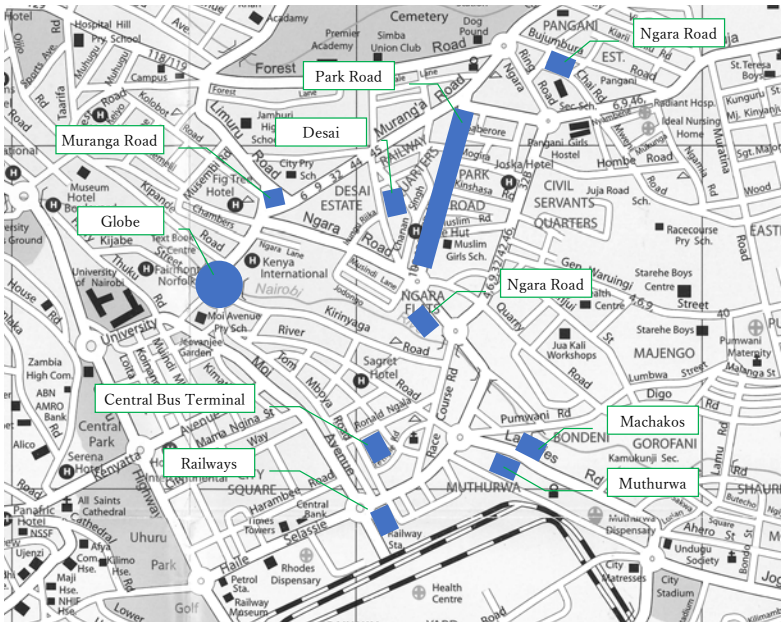
[7] For example, the Kenya Gazette Notice (Vol CXIX-61) published 12th May 2017, Gazette Notice No. 4479 on page 2116 outlines the matatu Termini by route as published by NCCG.

The digital matatus study done by the MIT and the UoN Computer Science Dept. in 2013 prepared this comprehensive map of Matatu/city bus service operation. There are more than 90 routes identified in Nairobi, and the digital matatu team grouped those routes into 16 directions and named as A line to P line. Those 16 grouped routes are all radial routes from CBD and downtown, and the name of the grouped routes are assigned in clockwise order from Northern direction.



Source: Digital Matatus

Figure 2.11 Matatu Network in Nairobi



Source: JICA Study Team, NCCG

Figure 2.12 Bus and Matatu Terminals in CBD and Downtown

2) Bus/Matatu Stop Facilities along the Routes

The on-street bus stops and related bus shelters are developed by the NCCG or private companies. During road construction, NCCG works with KeNHA and KURA to develop bus stops that may have been overlooked by the road agencies. Advertising companies also put up bus shelters at the designated bus stops for the purposes of generating advertisement revenue.

3) SACCOs and Bus Management Companies

Matatus in Kenya have to be part of a SACCO (Savings and Credit Co-operative), regulated by the National Transport and Safety Authority (NTSA). The purpose of this was to help facilitate a simplified system of safety inspections, instead of the original "one owner one vehicle" system, which made it impossible to trace liability or to enforce regulations. In Nairobi, 119 SACCOs[8] are in operation, with some of them owning as many as 100 vehicles.

On the other hand, there are 13 bus management companies in Nairobi, with the 5 major ones branded as KBS Management, Double-M (2M Connections), Citi Hoppa, City Shuttle, Compliant Management Company Limited, etc. KBS Management is same to the brand name of public bus operator Kenya Bus Services that has been in operation since the 1960s. However, the old public company KBS was reorganized and sold in 2000s and now the brand was succeeded by a private company, Kenya Bus Service Management. The present KBS is the one of the biggest management companies in Kenya running a franchise for bus operation, and its total fleet is approximately 600 vehicles. KBS owns its maintenance factory for safety inspection. KBS Management also publishes its own magazine highlighting various issues related to transport every month and quarterly.

[8] In addition to the SACCOs, there is a further level of organization amongst owners: many belong to either the Matatu Welfare Association (MWA, formed in 2001), or the Matatu Owners Association (MOA, formed in 2003). A merger was proposed in 2007, but it never came to fruition: the two organizations have competing interests in operations as well as historical differences. In terms of operations, the two organizations are often competing for the same routes. In terms of historical differences, it is important to note that the MOA was formed in response to certain owners having been excluded, for competitive/personal reasons, from the MWA.

4) Service regulations of transport service

The National Transport Safety Authority (NTSA) is in-charge of the regulation of Bus and Matatu operations. Its major concern is vehicle operational safety, On the other hand, it can be observed that NTSA has very little concern on bus operation. Specific regulation of the Bus and matatu are listed below as example;

- ensuring that all PSV (public service vehicles) are installed with speed governors to limit the running speed to 80 kph
- regulation of passenger seating; all passenger must be seated in the matatu and buses
- promotion of installation of larger sized matatu (more than 30 seats)

In Kenya, there are two levels of inspections for matatu and buses. The first level is the standard vehicle inspection that is required of all vehicles in the country. Every year, the road worthiness of a vehicle is examined, by the NTSA's Directorate of Motor Vehicle Inspection (DMVI). The second level of inspection is by bus companies or SACCOs, with their own technical specifications.

5) Bus and Matatu Routes

A Bus company or SACCO seeking to run on a new route applies to NTSA. A committee within the NTSA meets every Thursday to review/approve the routes, depending on their "sense" of demand – there is no detailed or quantified analysis of demand. Despite the overall decentralization in Kenya, the NTSA still makes decisions with local implications, an occasional source of tension.

Despite being responsible for managing routes of minibuses in Kenya, in practice, the NTSA does not have an inventory of the number of vehicles per any given route, nor any maps of routes.

It is noteworthy that earlier this year (2017) the KBS presented to NTSA a proposal for two new bus service routes crossing CBD, but not terminated in CBD, to NTSA, and NTSA approved one of two as new routes. However, there is no service yet on the new route.

6) Bus and Matatu Fares

Fares for matatus and buses are fixed as by the bus company or matatu sacco plying the route and charged by the conductors. Buses are generally cheaper than Matatus, by 1/3 to 1/2 of Matatu fare. The Kenya Government proposed a cashless payment system for fare collection in all PSV since 2013-14, and some matatu operators complied with the order and installed their own system, however, this was not successful as there was slow uptake of the prepaid cards by the commuters and resistance from the PSV operators. The ticketing technology was meant to ensure accountability and safety in the transport sector by removing the need for passengers to carry cash. Additionally, with proper records on how much money the PSVs collected, the Government would be able to tax the income earned from public transport more efficiently. Streamlining the payment collection system would also protect customers from price shocks, as matatu operators have been known to double or even triple their fares in the event of heavy traffic or heavy downpour. Currently, bus fare transaction are still cash based.

For matatu, despite the poor conditions of the vehicles themselves and the associated ride experience, matatu fares are rather high as compared to other international examples – not just in the developing world, but even in the rest of the world. A ride from the CBD to Umoja

(15km from the CBD) costs KES 80 during the peak hours and can increase to KES 150 in some instances e.g. heavy rains, congestion on the roads, matatu strike, etc.

As a comparison, minibuses in Dar es Salaam ("dala dalas") charge a flat fare of TSH 400 (KES 20), and minibuses in Hong Kong, a highly-developed city, generally cost HKD 2-10 (KES 30-150). It is a good motivation for commuters to walk long distances, even 10 km in any direction. To put these matatu prices in further perspective, food from street vendors can range from KES 10-50 for a snack, and up to KES 300 for a proper meal.

2.2.2.2 General Review

The photos below are the comparison of the Central Bus Terminal in downtown in 2005 (NIUTRANS) and 2017. These "before and now" tell many changes in the market.

- The previous time, 10-12m length buses were used, but now 8-10m minibus modified small truck fleets,
- There were only blue-colored-buses (KBS public company) in before, but now several brands (blue, yellow, green) are competing in the same bus terminals
- Quantity of services have become full now, and seems not well organized.
- Stalls surrounding the bus terminal increased, with lower quality. The bus exits are narrowed due to the construction of these stalls.

Source: JICA Study Team, NIUTRANS

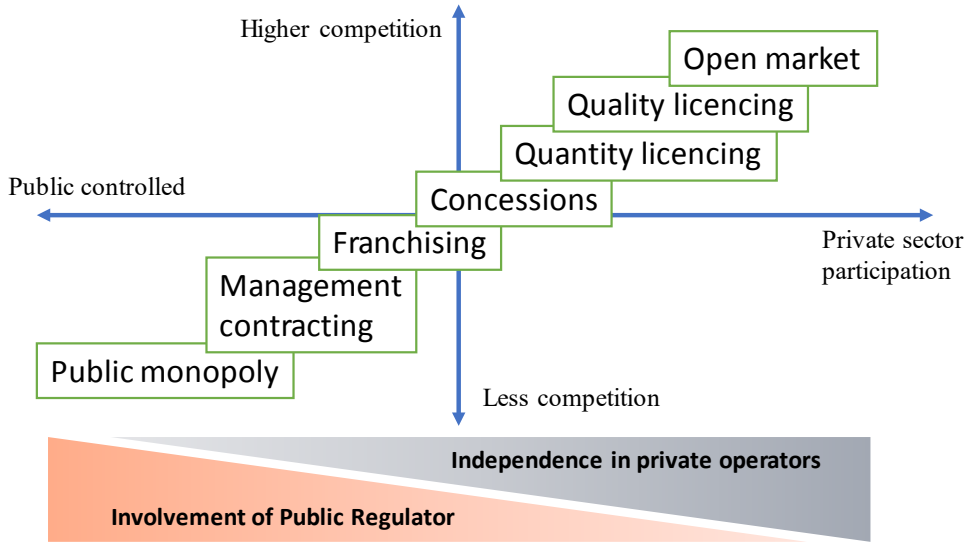
Figure 2.13 Situation of Central Bus terminal in 2005(left) and 2017(right)

As shown before, Nairobi's bus service was owned by a public transport operator, KBS, however, invasion[9] of matatu service with political support and low enforcement capacity by the industry regulators have thus damaged the fair market structure.

Figure 2. shows the variety of transport market control, and the present market in Nairobi can be classified as "Quality licensing" status, with close to uncontrolled open market. The

[9] According to a reference from NCCG transport office (not clear the origin, but written in 2004), the bus service operations in Nairobi were managed by KBS (Kenya Bus Service, a public bus operator monopolizing the market at that time, and different from the present KBSM, Kenya Bus Service Management, a private company for bus operation management) up to 1980s, with routes passing through the CBD, not terminating at CBD, which was appreciated a modernized case of bus operation in developing countries as like Curitiba and Singapore. After 1980s, however, matatu operators who had served for intercity market joined and invaded into the intracity route operation, and matatu influenced to the intracity bus service market also, and the bus routes were modified to terminate in the CBD to compete with matatus. The NUTRANS in 2006 describes that the some of KBS bus routes passed through the CBD, however, some in bus industry operators claim that most bus and matatu routes started and stopped in CBD since 1980s

enforcement capacity of NTSA is critical to expand and harmonize further development of new transport service with bus operation.



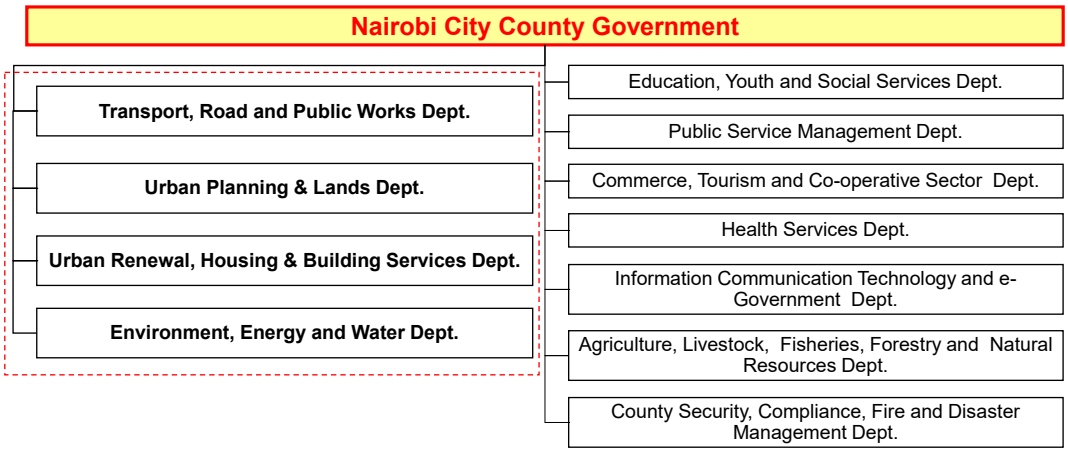
Source: Prepared by JICA Study Team, referring to the World Bank, "Review of Urban Public Transport Competition – Draft Final Report", prepared by Halcrow Fox, Washington, 2000

Figure 2.14 Variety of Transport Market Governance

2.3 Organization for Mobility Improvement in the Nairobi Urban Core

2.3.1 Capacity for Project Implementation (NCCG)

In 1984 the Nairobi City Council was dissolved to pave way for the Nairobi City Commission which governed the city up to 1992 when the Nairobi City Council was reconstituted. With the promulgation of the constitution of Kenya 2010, Nairobi City County (NCCG) was established as the successor to the defunct Nairobi City Council. It operates under the auspices of the Cities and Urban Areas Act, The Devolved Governments Act and a host of other Acts. NCCG is charged with the responsibility of providing a variety of services to residents within its area of jurisdiction including transport planning. These include the services that were hitherto provided by the defunct City Council and the ones that have been transferred from the national government. The NCCG consist 11 departments as shown the chart below.



Source: NCCG

Figure 2.15 NCCG Organization

The departments related with transportation projects are following four departments;

- Transport, Roads and Public Works Department:
  The department is responsible for policy formulation and leadership with regards to storm water management systems in built up areas, county roads repair, rehabilitation and construction, street lighting, traffic management, bus terminals and parking lots within the county.
- Urban Planning and Lands Department:
  The department is responsible for City Planning and policy direction on matters related to city development. These include regularization of development, approval of building plans, approval of application for development permissions and outdoor advertising.
- Urban Renewal, Housing and Building Services Department:
  The department is responsible for policy formulation and leadership in matters related to urban renewal and regeneration of old county houses.
- Environment, Water, Energy & Natural Resources Department:
  The department is responsible for policy formulation and leadership in areas related to solid waste management, soil and water conservation, forestry, water and sanitation policy (including sewerage), energy regulation, Nairobi City Water and Sewerage Company.

Article 186, of the Constitution of Kenya 2010, makes clarifications on functions and powers of county governments. The Fourth Schedule of the Constitution contains the division of functions between the national and the county governments in Kenya. These functions include, but are not limited to; County transport, including County roads, street lighting, traffic and parking, public road transport, and ferries and harbors.

In these circumstances, Nairobi Integrated Urban Development Master Plan (NIUPLAN) was approved by the County Assembly in August 2016. There are 38 priority projects in the NIUPLAN; 4 projects in Urban Development, 9 projects in Urban Transport, 12 projects in Infrastructure Development, 11 projects in Environment and 2 projects in Urban Development Management. NCCG has set the project three terms of action timeline, namely;

- First Medium Term: 2017-2021;
- Second Medium Term: 2022-2026; and
- Third Medium Term: 2027-2031

The priority project is listed as below;

Table 2.10 Projects Proposed in NIUPLAN by Sector

No.	Sector	Project Name	Responsible Agency	Timing of Implementation*
1	Urban Development	Railway City Development	NCCG, KRC	Short
2	Urban Development	East of Tom Mboya St. Development	NCCG, Private Developers	Mid
3	Urban Development	Dandora Sub-Centre Development	NCCG. KRC	Short
4	Urban Development	Eastlands Urban Renewal Project	NCCG, National Housing Corporation	Short
5	Urban Transport (Road)	Flyover in CBD for Railway City	KURA, NCCG	Short
6	Urban Transport (Road)	Widening of Enterprise Road	KURA, NCCG	Short
7	Urban Transport (Road)	Construction of Northern Part of Circumferential Road C-2	KURA, NCCG	Short
8	Urban Transport (Bus)	Development of New Bus & Matatu Terminal in Railway City	KURA, NCCG	Short
9	Urban Transport	Formulation of Public Transport System Policy and Guideline		Mid
10	Urban Transport (Railway)	Vitalization of Commuter Train Operation	KRC	Short
11	Urban Transport (Railway)	Feasibility Study for the East-West Corridor MRT Line		Mid
12	Urban Transport (Railway)	Feasibility Study on Nairobi Loop Line	NCCG	Short
13	Urban Transport (Road)	Formulation of ITS City Master Plan	NCCG, Police MoDP	Short
14	Infrastructure Development	Master Plan of Distribution Network in Nairobi City	NCCG	Mid
15	Infrastructure Development	Equipment of collecting rainwater for Building	NCCG	Mid
16	Infrastructure Development	Priority Project operated by AWSB (Athi Water Services Board)		Mid
17	Infrastructure Development	Amendment for technical criteria of overhead line	Kenya Power	Long
18	Infrastructure Development	Reviewing the LCPDP (Least Cost Power Development Plan)	Energy Regulatory Commission	Mid
19	Infrastructure Development	Development of Underground Cable in Dandora Area	NCCG	Long
20	Infrastructure Development	Power Supply for Dandora Industry Area		Long
21	Infrastructure Development	Fiber optic trunk communication network in Nairobi city	Telecommunication operators, MOICT	Short
22	Infrastructure Development	Common Infrastructure for Operators	NCCG, Operator	Long
23	Infrastructure Development	Introduction of Dedicated Government Network among Government Offices	NCCG, MOICT	Long
24	Infrastructure Development	Disaster Information Gathering and Dissemination System	NCCG	Long
25	Infrastructure Development	Infrastructure Sharing Policy	NCCG, Operator	Long
26	Environment	River Improvement Project	WRMA, NCCG	Mid

No.	Sector	Project Name	Responsible Agency	Timing of Implementation*
27	Environment	Sewerage Improvement Project	AWSB, NCCG	Mid
28	Environment	Capacity development for storm water drainage system in Nairobi city	NCCG, NCWSC	Mid
29	Environment	Capacity development for storm water drainage system in Nairobi city	NCCG, NCWSC	Mid
30	Environment	Development of New Landfill Site	NCCG	Mid
31	Environment	Safe closure of existing landfill site	NCCG	Long
32	Environment	Nairobi solid waste management	NCCG, KAA, NEMA, KCAA	Short
33	Environment	Development of MRFs	NCCG	Long
34	Environment	Improvement of Collection and Transportation System	NCCG	Long
35	Environment	Establishment and improvement of laws, regulations and guidelines for effective solid waste management	NCCG	Long
36	Environment	City-wide Air Quality Management Program	NCCG, NTSA, MoT	Short
37	Urban Development Management	Installation of Integrated GIS for NCCG Data Management System	NCCG	Long
38	Urban Development Management	Urban development management strengthening	NCCG	Short

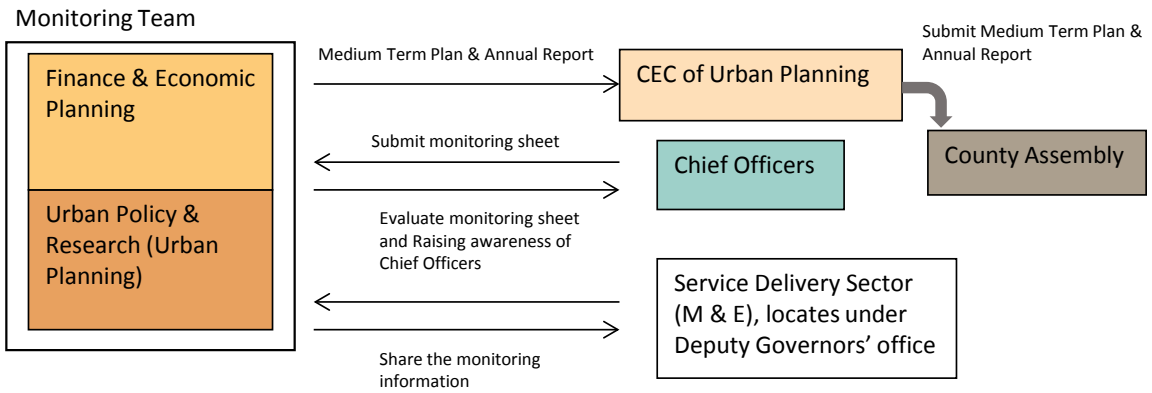
Note: *Short, Mid and Long indicate the project expect to be completed in 2017-2021, 2022-2026 and 2027-2031, respectively.
Source: NIUPLAN, JICA Study Team

After authorization of NIUPLAN in 2016 and NCCG is preparing the first medium term plan (2017-2021). The project monitoring sheet is prepared to all concerned agency and NCCG will monitor the project status periodically. The monitoring sheet is as shown in Table 2.. The table will be updated as collected the status from counterparts in the Progress Report by project planned in NIUPLAN. The monitoring system is summarized in Figure 2..

Table 2.11 Project Monitoring Sheet

No.	1-1)	Date		
Sector	Urban Planning	Responsible Agency		• NCC • KRC
Project Tittle	Railway City Development		Name	Please write the responsible person's information
Location			Tel	
Target			E-mail	
Source of fund	World bank	US Million	Budget from NCC	KES
Background	Nairobi central station area is one of obstacles for CBD expansion toward south. KRC is planning to develop this area as "Railway City". However, their first master plan is not adequately considered current CBD situation.			
Objectives	To revise master plan for the area to strengthen traffic and pedestrian network, and utilize development potential of the expanded CBD area			
Components	(1) Survey of current situation (2) Revision of KRC's master plan (3) Priority project design (4) Urban management Scheme (5) Project implementation			
(1)Status	Please describe current status			
(2) Problems or issues	Please describe the problem or issues for implementation			
(3) Action program for implementation	Please describe action plan for this year specifically			
(4) Next 5 year's Plan including timeline	Please show Next 5 year's plan for this project			
(5) Estimated Budget including timeline	How much the cost for this year, and how to get the budget or expectation?			
(6) Expected Output	Please describe the output after 5 years			
(7) Expected Outcome/ Materials	Please describe the outcome when the project finishes			
(8) Remarks				

Source: JICA Study Team



Source: Medium Term Action Plan (Draft), NCCG

Figure 2.16 NIUPLAN Project Monitoring System

Metropolitan Ministry has planned the strategic policies until 2012 but the authority of the Ministry has been transferred to counties under the revised constitution 2010. Therefore, NCCG's capacity shall be improved during this transition period accordingly to lead the planning in Nairobi. National agencies e.g., MoTIH&UD have experience to plan thus NCCG also shall coordinate with them to improve the capacity.

2.3.2 Organizatin of Nairobi Urban Core

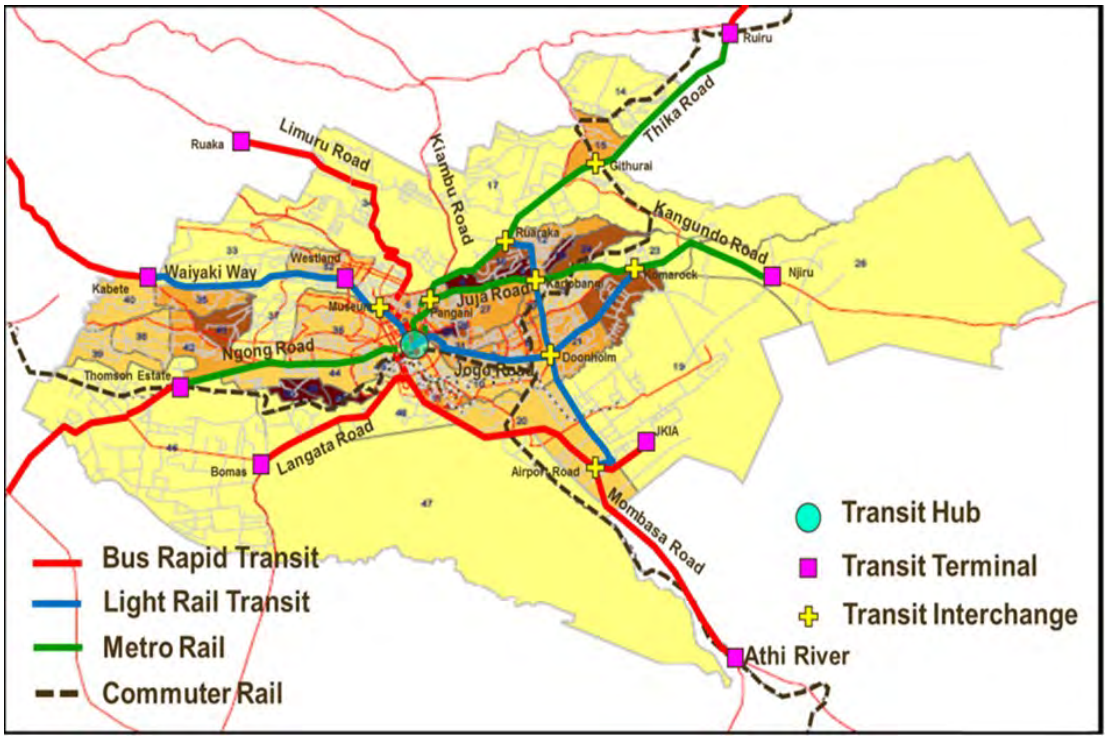
2.3.2.1 Ministry of Transport, Infrastructure, Housing and Urban Development (MoTIH&UD)

Ministry of Transport, Infrastructure, Housing and Urban Development (MoTIH&UD) was established as the successor to the Ministry of Transport and Infrastructure. It has five State Departments namely, State Department of Transport, State Department of Infrastructure, State Department of Housing and Urban Development, State Department of Maritime and Shipping Affairs and State Department of Public Works.

The vision and mission for the ministry is as follows;

- Vision: *To be global leader in provision of transport infrastructure, maritime economy, the built environment and sustainable urban development.*
- Mission: *To develop and sustain world class transport infrastructure, maritime economy, public works and housing for sustainable socio-economic development*

Former Ministry of Transport dispatched the Feasibility Study and Technical Assistance for Mass Rapid Transit System for Nairobi Metropolitan Region (MRTS) in 2009 and the plan was finalized in 2011. In the MRTS, three MRT lines and three LRT lines and three BRT lines are proposed as shown the figure below. However, the plan was replaced by Harmonization Study (2016).



Source: Feasibility Study Technical Assistance for Mass Rapid System for Nairobi Metropolitan Region (MOTI, 2011)

Figure 2.17 NMRTS Network for Nairobi Metropolitan Region

2.3.2.2 Nairobi Metropolitan Area Transport Authority (NaMATA)

The Nairobi Metropolitan Area Transport Authority (NaMATA) was established in February 2017 through an Executive Order signed by the President. This agency was formed so as to

oversee the establishment of an integrated, efficient, effective and sustainable planning system within the Nairobi Metropolitan Area which also comprises of Nairobi, Kiambu, Machakos, Kajiado and Murang'a. As a key function as per the executive order, NaMATA shall also be incharge of the formulation and oversight of a sustainable, evidentially based, integrated mass rapid transit strategy.

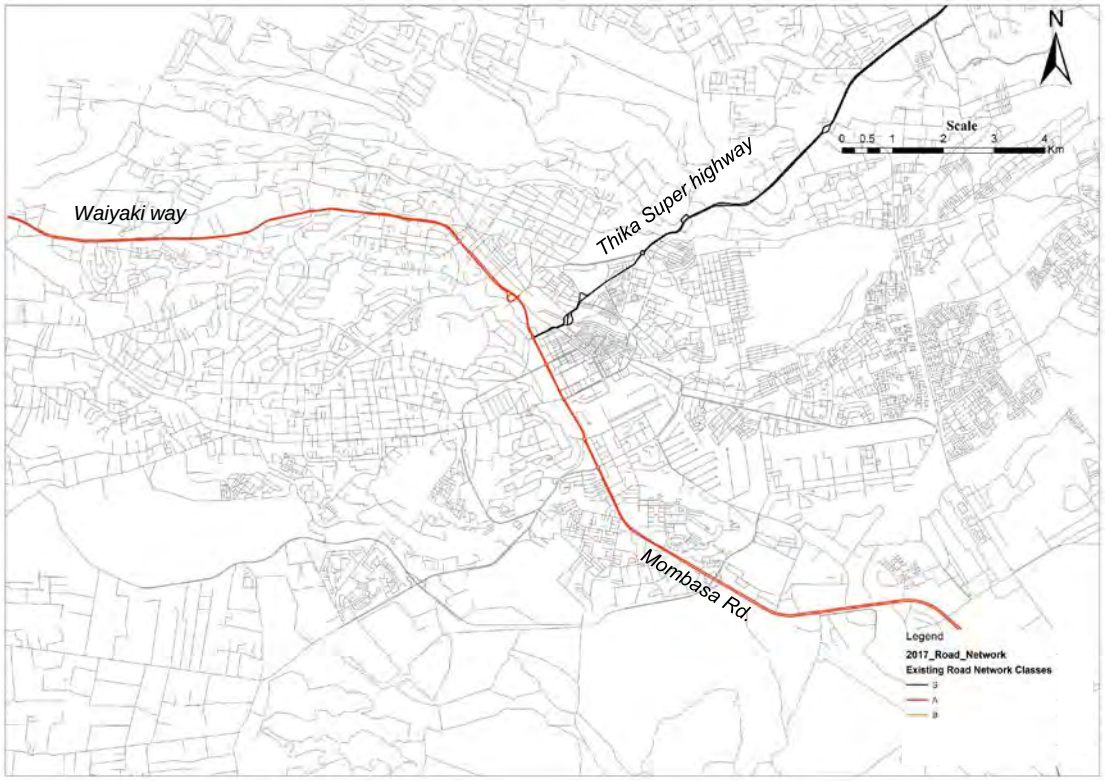
NaMATA shall also be in charge of the development of and MRTS system which includes both BRT and the commuter rail. These provisions thus place the BRT projects under the jurisdiction of NaMATA. Therefore, once properly constituted, the BRT projects shall be under the jurisdiction of NaMATA. However, the current proposed BRT projects were initiated by the Ministry of Transport and Infrastructure in partnership with various international partners who were interested in the project with regards to financing and approval.

As per the executive order, KURA and KeNHA shall be in charge of the provision of the necessary infrastructure in terms of road development. The proposed BRT routes are currently running along corridors that are under the jurisdiction of the two agencies. Therefore, in conjunction with NaMATA, the agencies shall ensure that the development and operation of transport infrastructure necessary for the smooth operation of the BRT services is attained.

However, the authority has just established in February 2017 and is not fully operational properly under the act so far.

2.3.2.3 Kenya National Highway Authority (KeNHA)

Kenya National Highways Authority (KeNHA), established by Sections 3, 4, and 5 of the Kenya Roads Act (2007), is an autonomous road agency, responsible for the management, development, rehabilitation and maintenance of Super highway and major arterial road (Class S and A) The road network which maintained by KeNHA is Waiyaki way, Mombasa road and Thika Superhighway as shown the figure below.



Source: JICA Study Team

Figure 2.18 Road Network in Nairobi Metropolitan Area (Class S, A)

The functions that KeNHA is mandated to perform are:

(a) Constructing, upgrading, rehabilitating, and maintaining roads under its control;

(b) Controlling national roads and road reserves and access to roadside development;

(c) Implementing road policies in relation to national roads;

(d) Ensuring adherence to the rules and guidelines on axle load control prescribed under the Traffic Act (Cap. 403) and under any regulations under this act;

(e) Ensuring that the quality of road works is in accordance with such standards as may be prescribed by the Minister responsible for roads;

(f) In collaboration with the ministry responsible for transport and the Police Department, overseeing the management of traffic and road safety on national roads;

(g) Collecting and collating all such data related to the use of national roads as may be necessary for efficient forward planning under this act;

(h) Monitoring and evaluating the use of national roads;

(i) Planning the development and maintenance of national roads;

(j) Advising the Minister on all issues relating to national roads;

(k) Preparing the road works programmes for all national roads;

(l) Liaising and coordinating with other road authorities in planning and on operations in respect of roads; and

(m) Performing such other functions related to the implementation of this act as may be directed by the Minister.

2.3.2.4 Kenya Urban Roads Authority (KURA)

Kenya Urban Roads Authority (KURA), established by Sections 9, 10 and 11 of the Kenya Roads Act (2007), is an autonomous road agency, responsible for the management, development, rehabilitation and maintenance of all public roads in the cities and municipalities in Kenya except if these roads are national roads.

The functions that KURA is mandated to perform are:

(a) Constructing, upgrading, rehabilitating, and maintaining roads under its control;

(b) Controlling urban road reserves and access to roadside development;

(c) Implementing roads policies in relation to urban roads;

(d) Ensuring adherence of motorists to the rules and guidelines on axle load control prescribed under the Traffic Act (Cap. 403) and under any regulations under this act;

(e) Ensuring that the quality of road works is in accordance with such standards as may be defined by the minister;

(f) In collaboration with the ministry responsible for transport and the Police Department, overseeing the management of traffic and road safety on urban roads;

(g) Monitoring and evaluating the use of urban roads;

(h) Planning the development and maintenance of urban roads;

(i) Collecting and collating all such data related to the use of urban roads as may be necessary for efficient forward planning under this act;

(j) Preparing the road works programmes for all urban roads;

(k) Liaising and coordinating with other road authorities in planning and on operations in respect of roads;

(l) Advising the Minister on all issues related to urban roads; and

(m) Performing such other functions related to the implementation of this act as may be directed by the Minister.

2.3.2.5 Kenya Railway Corporation (KRC)

The Kenya Railways Corporation Act provides for the powers of Kenya Railways Corporation (KRC) being generally, without prejudice, to construct railways, develop roads to access the railways, develop parking, provide train services, and determine tariffs and train fares. The other roles include responsibilities to buy and sell property, provide housing to its employees, and all such related services. KRC is mandated to promote, facilitate and participate in the National and Metropolitan Railway development.

The Act was amended through the Kenya Railways (Amendment) Act 2005 to make it possible for the Board of Directors to enter into concession agreements or other forms of management for the provision of rail transport services. Following this Amendment, KRC conceded railway operations to Rift Valley Railways Ltd (RVR) from November 1, 2006 for 25 years for freight services and 1 year for passenger services.

However, KRC has canceled the concession agreement and the commuter railway is directly operated by KRC since August 2017. The available land owned by KRC in the Nairobi Urban Core and its surrounding have the potential to be developed as part of the integrated Transport system. The land example is shown the figure below.

Source: JICA Study Team, Google Earth (Image © Digital Globe)

Figure 2.19 Available Land Owned by KRC in the Nairobi Urban Core and the Surroundings (Example)

2.3.2.6 National Transport and Safety Authority (NTSA)

Currently, NTSA is in-charge of routing and licencing of all public transport vehicles in operation Nationally. The task of licencing shall remain under the jurisdiction of NTSA however, routing and regulation of BRT operations shall be the mandate of NaMATA. NTSA shall however still continue enforcement of the safety laws on the roads. NTSA shall also still be in charge of the licensing and training of the crew (drivers and conductors) as per the current law.

2.3.2.7 Police

The Kenya Police Service, Traffic Department shall also be very keen as currently, they are in charge of traffic management. This function is shared with the county as it is supposed to be a devolved function as per the Constitution of Kenya 2010.

1) Kenya Police Service

The Kenya Police Traffic Unit was established to support the following functions of the Kenya Police Service in accordance with Section 24 of the National Police Service Act, 2011.

a) Ensuring of free flow of traffic
b) Prevention of Road Accidents
c) Investigation of Accidents
d) Enforcement of all Laws, Rules and Regulations with which the department is charged.
e) Initiate road safety sensitization to the members of the public.

They are also supposed to undertake the enforcement of all Laws, Rules and Regulations with which the department is charged and initiate road safety sensitization to the members of the public.

In 2016, in accordance with the Kenya Constitution 2010, the traffic police command operations were devolved and were now no longer centralized at National Headquarters located along Thika Road, Nairobi. These were placed under the County Commanders leaving the headquarters only being in charge of research, government vehicle unit, and check unit, highway patrol, driving schools, and National Transport and Safety Authority officers, formulation of policies and organization of courses for officers at various levels.

This move was also greatly appreciated as it was perceived as being aimed at curtailing corruption within the police service as well as improve efficiency.

2) Nairobi City County Traffic Marshals

Devolution as envisaged in the Constitution of Kenya 2010 required newly established County Governments shall take up specific roles that were previously under the jurisdiction of the Central Government. Traffic management was one such devolved function was traffic management in the Counties. However, under the laws relating to Traffic, The Traffic Act (Cap 403) and The National Transport and Safety Authority Act 2012, the marshals are not recognized. They are however a creation of the county governments for the purposes of undertaking the mandate of traffic management as part of devolution as prescribed in the Kenyan Constitution 2010. This thus reflects itself as the overlaps in the traffic duties they undertake with the police

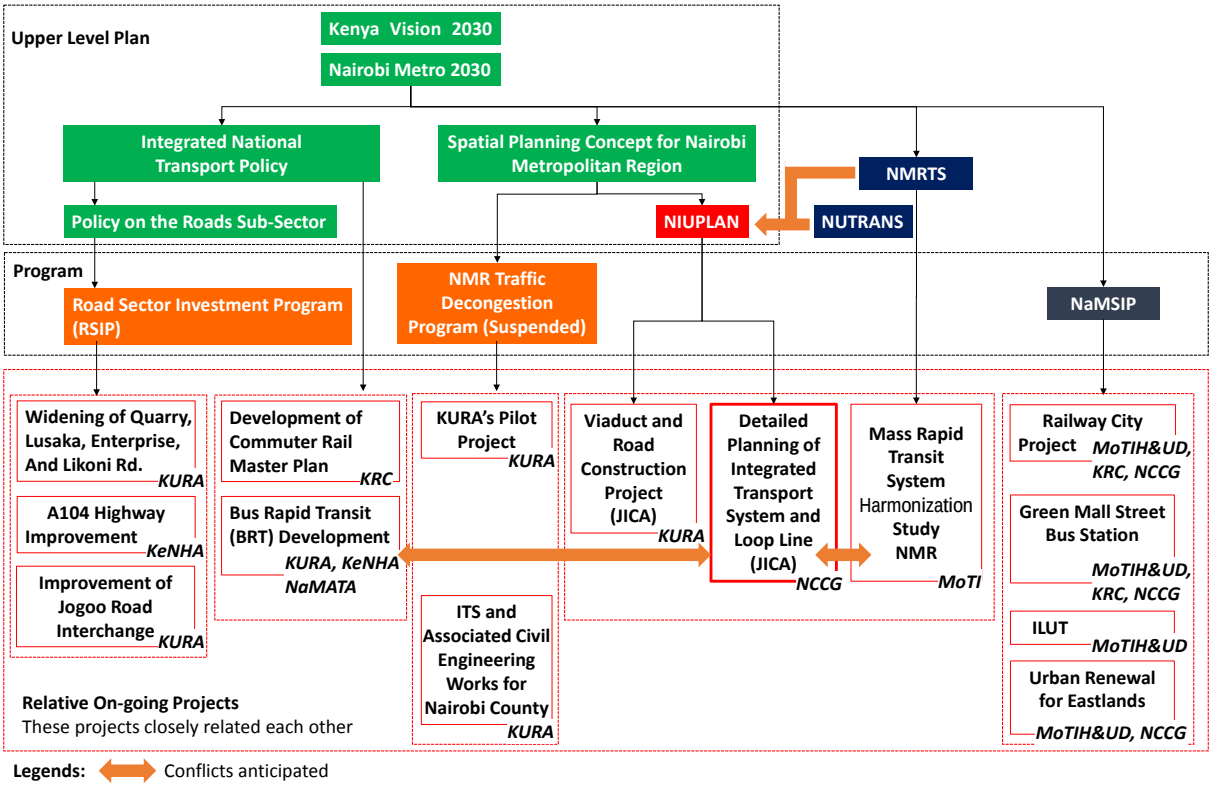
In Nairobi, the Nairobi City County Traffic Marshalls have been actively engaged in working in conjunction with the Traffic Police since March 1, 2014. The marshals were deployed to intersections and select roads within the city to monitor the adherence to the digitized traffic signals. They were also to support the police in controlling traffic movement. These marshals had powers to arrest motorists found contravening traffic laws on the city roads.

Notably, there is a great disconnect in the training that they receive as there is need for a standardised manual and training curriculum to be developed so as to be able to churn out qualified personnel who help support traffic management in the counties.

Chapter 3 Ongoing and Planning Projects Review

In Nairobi, various transportation projects have been planned/ implemented without coordinator(s) so far. It is essential to review the on-going projects in Nairobi Urban Core to analyze the influence of the planned/ implemented projects. In addition to that, all the reviewed projects to be included in Project Database in GIS would be visualized by the system. It will aid in locating all the projects easily.

The relative projects are planned under upper level plan and the program approved by the cabinet. The structure of the road focused project is summarized in Figure 3.1.



Note: Agencies indicated in *Italic* is the executing organization
Source: The Preparatory Survey on Nairobi Viaduct and Road Construction Project, JICA Study Team edited

Figure 3.1 Plan and Project Hierarchy

- Kenya Vision 2030 was formed 2008 and it is understood to be the highest development policy in Kenya.
- NIUPLAN was formed by JICA in 2014 in referece to Kenya Vision 2030, Nairobi Metro 2030 (2008) and The Spatial Planning Concept for Nairobi Metropolitan Region (2013). As well as this, NUTRANS (2006, JICA) and NMRTS (2011) have been studied and integrated. Detailed Planning of Integrated Transport System and Loop Line (the project) has listed as a priority project in NIUPLAN.
- Although Harmonization Study(HS) had referred to NMRTS, it replaced all the transport system in Nairobi to BRT and the Bus Rapid Transit (BRT) Development is about to be planned Harmonization Study basis. In the project, transport policies shall deeply be coordinated especially BRT projects as well as other on-going projects.
- RSIP covers the road improvement projects in Nairobi Metropolitan Area and three major on-going projects are listed.

- In the Nairobi Urban Core, urban development projects are also on-going planned by NaMSIP funded by World Bank in 2012.
- The intersection improvement in Nairobi is currently being handled by KURA, which has transferred from NMR Traffic Decongestion Program planned by NCCG and two ITS projects are on-going.
- As well as BRT development, Development of Commuter Rail Master Plan is also being studied as of September 2017.

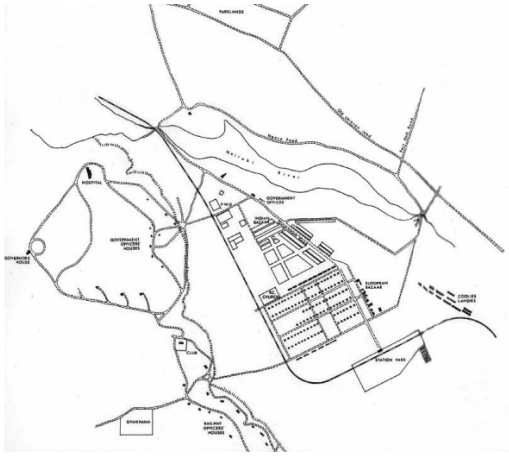
As shown the Figure 3.1, many projects are on-going in road, urban development and transportation sectors in Nairobi and each project shall be coordinated by executing organizations.

3.1 Urban Development Sector

3.1.1 Brief History of Nairobi Urban Planning

3.1.1.1 Past Nairobi City Plan

The history of Nairobi City traces back to the last decade of the 19th century, when the British started the Mombasa Uganda Railway. When the laying of the railways tracks began, a camp for workers depot for construction materials and equipment were established in an elevated land, which later became Nairobi.

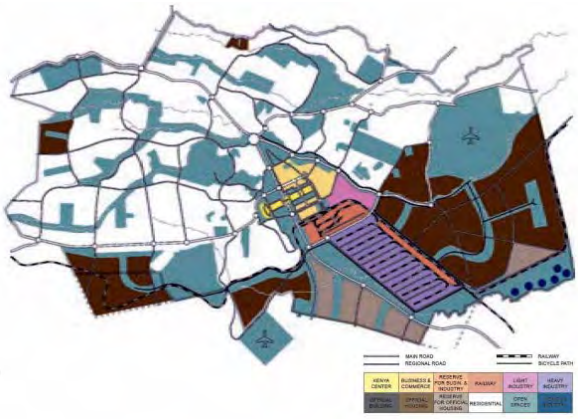


Source: S. Mills, Railway to Nowhere

First Plan by A. F. Church in 1898

Source: ETH Studio Basel, History of Urban Planning in Nairobi City, 2008

Plan for Settler Capital in 1927



Source: ETH Studio Basel, History of Urban Planning in Nairobi, 2008

Master Plan for a Colonial Capital in 1948

Source: ETH Studio Basel, History of Urban Planning in Nairobi, 2008

Nairobi Metropolitan Growth Strategy 1973

Figure 3.2 History of Nairobi Master Plan

Table 3.1 Historical population Change of Nairobi City and Its Plans

Year	Population (1,000)	Average Annual Growth Rate (%)	Remark
1906	11		1st Master Plan (1898) 2nd Plan for Settler Capital (1927)
1948	119	6.84	3rd Master Plan (1948)
1963	342	7.29	Independence (1963), Capital of Kenya
1969	509	6.85	1st Census
1979	828	4.99	4th Master Plan (1973), 2nd Census
1989	1,325	4.81	3rd Census
1999	2,143	4.93	4th Census
2009	3,138	3.89	5th Census, New Constitution (2010)

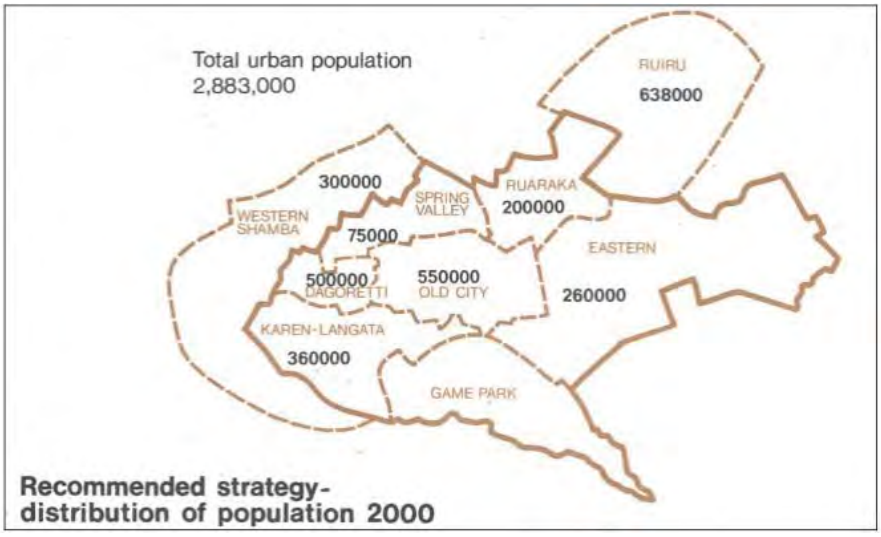
Source: Nairobi City County

The first plan of Nairobi was made in 1898 as a layout for the railway depot. In 1905, Nairobi replaced Mombasa as capital of the British protectorate. And the city grew as an administration and safari tourism destination, and the population reached 11,000 in 1906. Nairobi became base city for the British occupier to explore the region.

The second Plan for Settler Capital was drawn in 1927 under the British East African rule. The city administrative area was expanded to 77 km^2 to accommodate growing population. The residential area was generally segregated by racial groups.

In 1948, shortly after the World War II, a new plan for Nairobi as a colonial town was prepared. The population at that time was 119,000. In this plan, a zoning scheme was introduced. Also the plan was expected to make Nairobi more attractive for industrial investments. It is noteworthy that the alignment of the railway had been changed to the present one along the western part of the town, which gave way for the expansion of the Uhuru Highway today. The area to the south of the railway station was converted to an extensive industrial zone.

Then, Nairobi grew as a regional economic center, and when Kenya achieved her independence in 1963, Nairobi became the capital city of the Republic of Kenya. The population of Nairobi City at the time of independence was 342,000. After independence, Nairobi grew rapidly and this growth put pressure on the city's infrastructure. Power cuts and water shortages were a common occurrence.



Source: Nairobi City County

Figure 3.3 Recommended Distribution of Population 2000 in the 1973 Strategy

In 1973, Nairobi Metropolitan Growth Strategy was published. The Metropolitan Strategy set the ultimate target year of 2000. The population of Nairobi City was about 590,000 in 1971, and projected to be 2.88 million in 2000, which was composed of 1.94 million for NCC and the remaining balance in adjoining areas outside of NCC, including Ruiru and Western Shamba, which shown in Figure 3.3 above. The actual population of NCC was 2.20 million in 2000, so the target was slightly surpassed.

3.1.1.2 Nairobi Metropolitan and Decentralized County Government

1) No Master Plan after 1973 Strategy

After Nairobi Metropolitan Growth Strategy 1973, no master plan was set up for Nairobi for more than three decades. Actually, the Strategy 1973 was not urban development master plan. It was a just strategy and it recommended to draw up master plan following this strategy. Unfortunately, no plan was made after this strategy.

During that period, population of Nairobi had been rapidly grown from approx. 0.6 million to 3 million without proper plan. This population explosion caused huge expansion of slums in Nairobi and surrounding counties.

2) Nairobi Metro 2030 Strategy & Nairobi Metropolitan Region (NMR) Spatial Plan

During Kibaki Administration, Nairobi Metro 2030 was edited in 2008 and was part of the overall national development agenda for Kenya which is encapsulated in Kenya Vison 2030 and the Grand Coalition Government Policy Agenda. These two documents were the country's response to dealing with five key development issues, 1) rapid economic growth, 2) employment and balanced wealth creation, 3) poverty alleviation, 4) meaningful youth engagement, and 5) a vigorous pursuit of regional equity in all its manifestations.

The Nairobi Metro 2030 Strategy document aims at optimizing the role of the NMR in the national development effort. It will be targeted at ensuring that it facilitates the effective and efficient utilization of the NMR's resource endowments as well as effectively integrating the region into the national fabric.

Spatial Planning Concept for Nairobi Metropolitan Region was drafted in 2010 by Indian Consultant firm

3) Establishment of Ministry of Nairobi Metropolitan Development in 2008

New ministry was established to implement the Nairobi Metro 2030 Strategy and NMR Spatial Plan.

4) 2010 Constitution of Kenya and Decentralized County Government

The 2010 Constitution of Kenya is the current constitution of the Republic of Kenya, which is now in force, replacing the 1969 Constitution. The constitution provides that there shall be a county government for each county, consisting of a county governor, a county assembly and county executives.

It also provides for formulation of not more than 22 ministries at the central level. Ministry of Nairobi Metropolitan Development was merged into Ministry of Urban Development as one department.

5) Difference between NaMSIP and NIUPLAN

NaMSIP program was prepared by the World Bank based on the request from the Ministry of Metropolitan Development to realize the Strategy "Nairobi Metro 2030" for Nairobi Metropolitan region. After the Constitution, the Ministry was reorganized to a section under the Ministry of Lands, Housing and Urban Development. After this, establishment of NaMATA was planned to coordinate transportation issues among the Counties in Nairobi metropolitan area.

After the decentralization process in Kenya by the new Constitution 2010 and the County Government Act 2012, the Nairobi City County Government was established which should have its own county integrated development plan (CIDP). NCCG requested JICA to implement the study for their CIDP. JICA dispatched the Study Team from 2013 to 2014. During this study period, NCCG completed the SEA process and sent the draft Plan to the County Assembly for approval and ratification. The Plan was approved by the County Assembly and adopted as the County's Official Plan.

3.1.2 Ueban Development Project related NaMSIP Projects

3.1.2.1 Introduction of NaMSIP (Nairobi Metropolitan Services Improvement Project)

1) Introduction

In May 2012, the World Bank approved USD 330 million in funding for the Nairobi Metropolitan Services Improvement Project (NaMSIP). This project aims to strengthen urban services and infrastructure in the Nairobi Metropolitan Region. The project was developed to help steer Kenya towards the path of becoming a middle-income country – one of the goals of Nairobi Metro 2030.

2) NaMSIP Components

NaMSIP has been structured into four components with distinct areas of coverage as outlines below,

Table 3.2 NaMSIP Components

Component	Sub-Projects Clusters
Component 1 **Institutional Reform and Development**	▪ Selection of physical support location ▪ Construction and installation of offices and facilities ▪ Establish capacity on Environment and social management
Component 2 **Other Critical Public Services**	▪ Installation of street lighting in pre-identified road junctions ▪ Markets development in collaboration with respective County Councils ▪ Development and improvement of drainage systems in selected urban zones (commercial and residential areas ▪ Development OR rehabilitation of sanitation facilities in collaboration with County Councils, Athi Water Services Board and Water Services Providers ▪ Establishment of public parks and green spaces in collaboration with County Council
Component 3A **Integrated Solid Waste Management**	▪ Waste management Audits by Local Authorities ▪ Development of waste transfer stations in towns ▪ Development of engineered sanitary solid waste disposal sites ▪ Decommissioning of unsanitary disposal sites ▪ Capacity building initiatives (skills, institutional equipment, waste collectors welfare
Component 3B **Transport Management**	▪ Construction of new link roads, upgrading and improvement of existing roads and associated facilities (bridges, etc) within Local authority jurisdiction. ▪ Construction of NMT facilities (foot bridges, under passes, footpaths, cycle tracks, hand cart passages, Bodaboda" parking areas, etc.) ▪ Rehabilitation of existing railway corridors for commuter train and associated rail

	stations. ▪ Installation of road provisions (traffic lights, speed bumps, signage etc. ▪ Capacity building including establishment of a transport master plan
Component 3C **Water and wastewater management**	▪ Improvement of wastewater collection (drainage, sewer systems, etc, ▪ Provision of waste water treatment facilities for towns (stabilization lagoons), ▪ Appropriate discharge systems for wastewater
Component 4 **Project management, monitoring and Evaluation**	▪ Selection of physical requirements ▪ Installation of necessary support facilities (offices, water supply, sanitation, communication and security installations)

Source: NaMSIP

3.1.2.2 Railway City

1) Background

MoTIH&UD main stakeholders are Kenya Railways and Nairobi City County. They intend to redevelop the Nairobi Central Railway Station and its surroundings areas into "Nairobi Railway City" through the Consulting Services for Preparation of Urban Plans, Urban Designs, Economic/Finance and Implementation Study, as one of NaMSIP projects, funded by the World Bank.

The project has goals to prepare a participatory, economically feasible and socially/environmentally sustainable urban plan and design; to complete and expand Nairobi CBD by filling in the missing gaps in development and integrating with CBD spatial structure, and to promote the global competitiveness of the Kenya's capital city Nairobi.

2) Project Outline

Project area is 149 ha which consists 118 ha of KRC Land and 31 ha of surrounding private lands showing in the figure below.

Source: Inception Report of Railway City

Figure 3.4 Location Map of Railway City project

3.1.2.3 Green Mall Project

1) Background

GoK has received financing from the World Bank for NaMSIP. GoK intends to apply part of the proceeds for consulting services for the projects regarding development of selected roads and the Green Mall street bus station in Nairobi Railway Station and its surroundings. KRC, together with NCCG and the Directorate of Nairobi Metropolitan Development in Ministry of Lands and Physical Planning will jointly carry out feasibility studies, detailed design, preparation of tender documents and construction supervision for the project. It shall be noted that these projects are components of the proposed Nairobi Railway City and its Surroundings. The consulting service for feasibility study has commenced as of May 2016. After the completion of the official contract for consulting services, the tentative period for its feasibility studies is expected to be twelve months.

2) Project Outline

Selected roads totals 15.8km in length and details of each road are described below.

Source: JICA, Nairobi Viaduct and Road Construction Project in the Republic of Kenya, Draft Final Report 1

Figure 3.5 Location Map of Green Mall project

1. Road No. 1: Begins at Haile Selassie Avenue and cuts through the railway yard ending up at Workshop Road. The termination point of the road corridor is on Mombasa Road and the alignment will follow Dunga and Mukenia roads from Workshop Road. The length of this corridor is approximately 3.2 Km. Preliminary design for a section of this road (Haile Selassie Avenue to Workshop/Lusaka Roads Roundabout) dubbed Railway Toll Bridge, has already been carried out by KRC.

2. Road No. 2: Begins at Haile Selassie Avenue/Race Course Roads Roundabout and proceeds southwards through Nairobi railway yard and workshops to end up on Enterprise Road. The scope of works will require a consultant to carry out design of the entire Enterprise Road all the way to Mombasa Road. The length of this corridor is about 7.0 Km.

3. Road No. 3: Begins at Haile Selassie Avenue at Wakulima Market and traverses present-day Muthurwa Market. The alignment will be parallel to Factory Stand and will join the Nairobi- Makadara railway corridor at Muthurwa, from which the alignment is expected to run parallel to the existing railway corridor up to Makongeni area where it is expected to pass through the built-up area and end up at the Likoni/Lunga Lunga Roads Junction. The length is approximately 3.9Km.

4. The Proposed Green Mall Street Bus Station: It will be a high capacity bus station. Its length is approximately 1.7 Km - This will be part of a multi-use wide-ranging green corridor beginning at Uhuru Highway and ending at proposed Road No. 3 and will be situated on Nairobi Railway Station marshalling yard.

3.1.2.4 Interdisciplinary Land-Use and Transport Metropolitan Analysis within the Nairobi Metropolitan Region (ILUT)

Final report on Phase I and Phase II was submitted in September 2015.

1) Background

The Nairobi Metropolitan Region (NMR) requires efficient and coordinated urban spatial/land-use and transport planning in order to accommodate the expected population and travel growth. By 2030 the regional population is expected to be more than double reaching 13 million and the vehicle fleet to quintuple to approximately 2.6 million.

It will be needed to serve the high travel demand development of a strong public transport system. Current planning aims to introduce mass transit systems to the existing bus operations, and to greatly upgrade and expand the existing commuter rail services as the backbone of the system.

The World Bank-assisted NaMSIP providing support to various elements of Nairobi's urban development, including support for the Interdisciplinary Land-Use and Transportation Metropolitan Analysis with the Nairobi Metropolitan Region Study (ILUT). ILUT is the first effort in Nairobi for integrating land use planning with the development of major transportation facilities and considering urban design.

2) Project Outline

Important concepts of ILUT are the consideration of intermodal station access for transit users and the potential to develop high density, value, amenity and efficiency in land uses around station areas. Land use concept plans have been produced for areas within 1 km of the 30 KRC commuter rail stations. Engineering designs and bidding documents will be produced for selected early action infrastructure facilities, such as access roads, foot and bike paths and parking lots.

The main objectives of the ILUT study are as follows:

(i) Analyzing the missing links among the different existing transport plans (MRTS and commuter rail plan) and proposing the integration of intermodal transfers among the modes of transport;

(ii) Analyzing the land use development around the main intermodal nodes, the commuter rail stations, aiming to coordinate land use and transport in these centralities, and

(iii) Providing detailed engineering designs for selected infrastructures around designated

commuter rail stations.

3.1.2.5 Urban Renewal for Eastlands

Inception report was submitted in September 2016. Progress report is being prepared by the consultant.

1) Background

The Urban Renewal Plan is one of the projects forming part of the Nairobi Metropolitan Service Improvement Project (NaMSIP), which is an initiative of the Government of Kenya with the support of the World Bank under the Country Partnership Strategy (CPS). The plan falls under component (iii) Metropolitan infrastructure and services.

The project covers a large area of approximately 11.54 Km^2 of the Eastlands area, one of the key neighborhoods in Nairobi. This is a fully settled area and it is predicted that a successful Urban Renewal Program would further increase the area's population to not less than 300,000 people, which is equivalent to a city according to the new classification under the Urban Areas and Cities Act. Therefore, it is expected that the program will come up with adequate proposals to supply for a new city. It is also expected that the project will greatly improve the lifestyles of many people. It will also make Eastlands more attractive to people, unlike the present scenario where many people do not want to be associated with the area.

2) Project Outline

The main purpose of the Urban Renewal study is to prepare Action Area Plans which will guide development of the area under consideration. Others include the following:

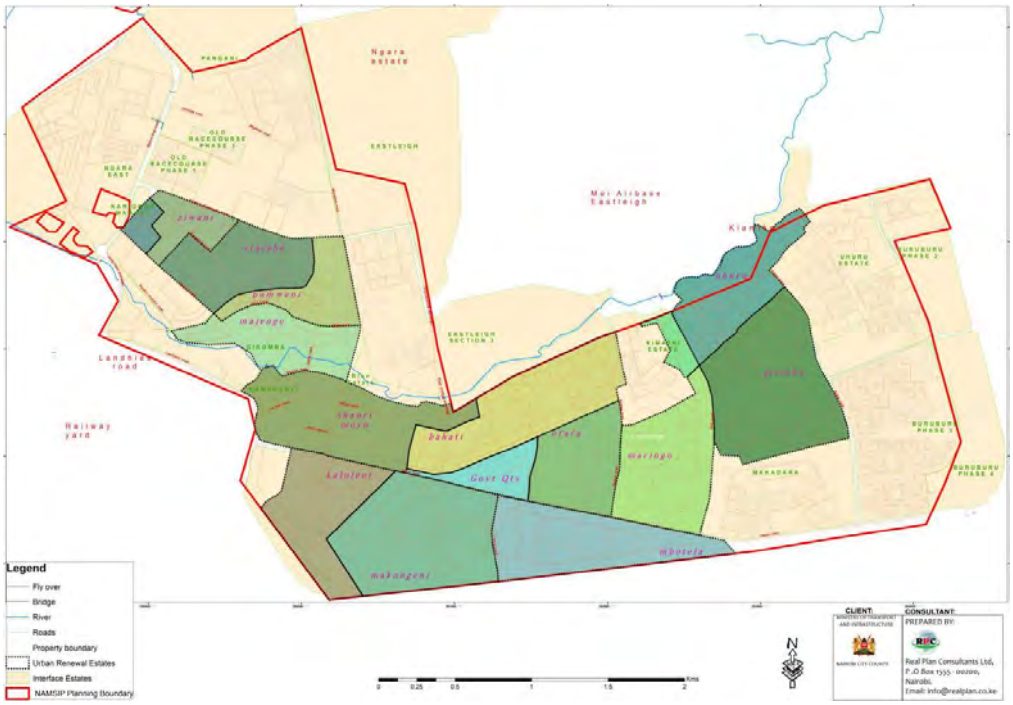
a. Articulation of National and County Government Aims for Eastlands
b. Provision of Development Framework
c. Provision of a Basis for Coordinated Development
d. Provision of Public Transport Solutions
e. Guiding Framework for House Sitting Tenants
f. Identification of Land Tenure Issues
g. Promoting Synergies between Study Area and Surrounding
h. Development of Financing Models

The study is aimed to achieve the following objectives:

a. Providing a Development Framework for over 20 years
b. Delineation a Functional Urban Renewal Area
c. Preparation of an Urban Renewal Framework
d. Preparation of Urban Development Model
e. Determination of Land Ownership Patterns

The focus area targets an 11.54 Km 2 area covering the following;

- Old Nairobi City County housing estates
- Old Government/Railways housing estates
- Other estates owned by companies and private individuals (interface estates)



Source: Inception Report of Urban Renewal for Eastlands

Figure 3.6 Planning Area of the Project

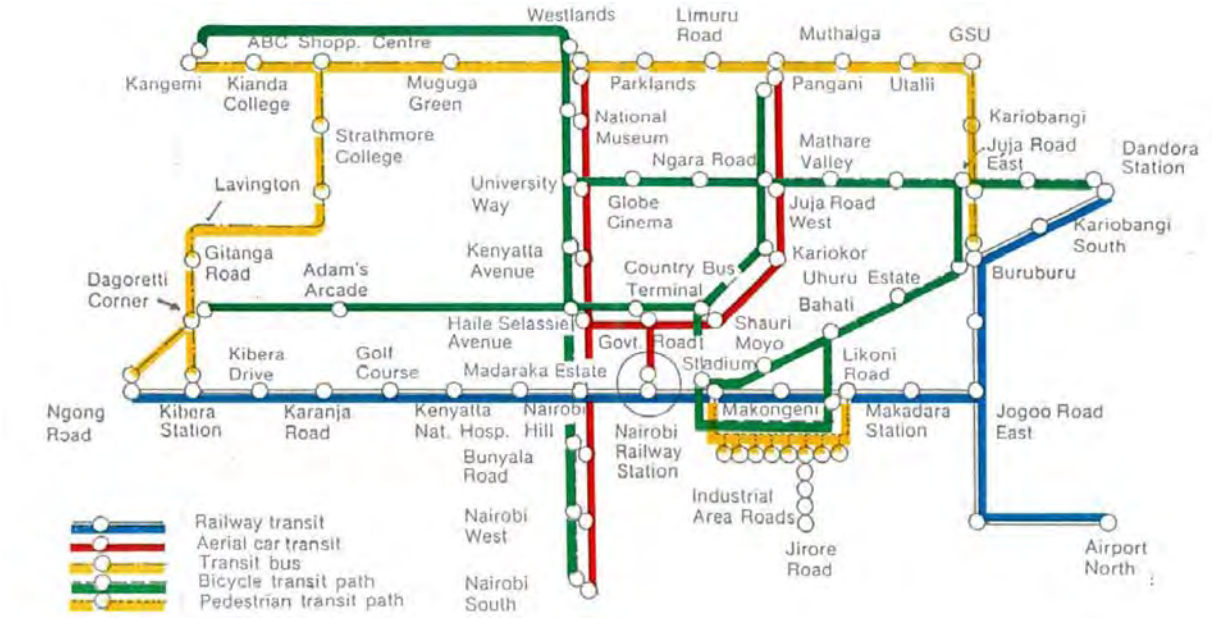
3.2 Transportation Subsector

3.2.1 History of Mass Rapid Transit System Plan Formulation

This section gives a review on the full history of rail based Mass Rapid Transit (MRT) and BRT proposals since 1990s for Nairobi as first step. Then, a comparison of the recent comprehensive achievements in MRT planning, NIUPLAN and Harmonization Study in 2014, is presented. The recent two BRT feasibility study for Line 1 and Line3&4 are summarized. In the end, remaining planning issues are clarified.

1) Historical Background of MRT and BRT Project Development

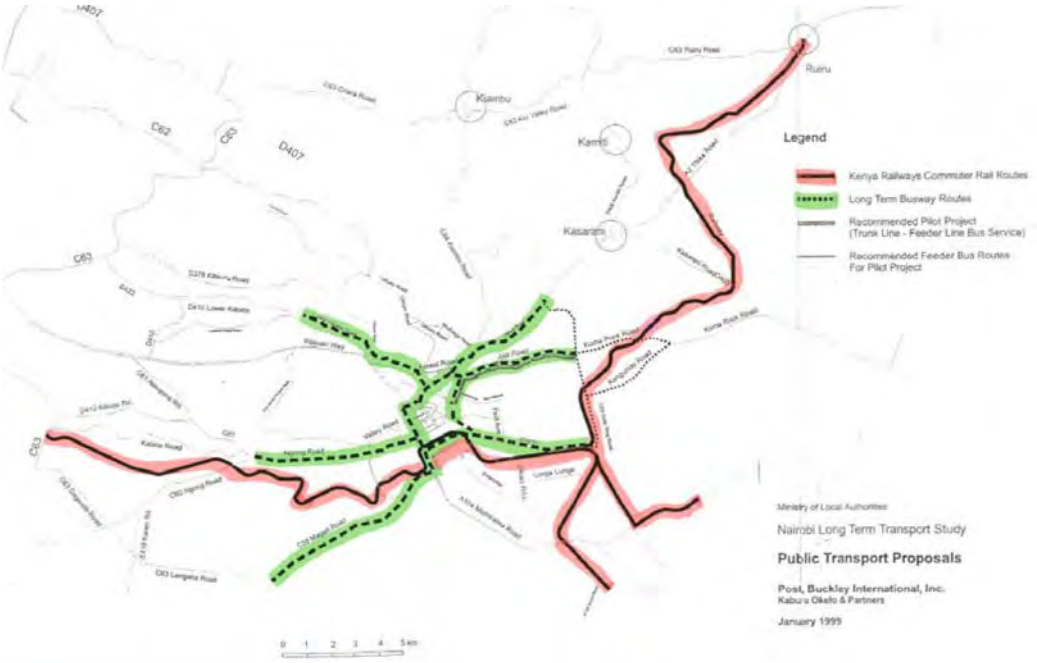
The public transit and transport service plan with modernized system had been initiated by the "Action Towards a Better Nairobi, the Nairobi City Convention", prepared in 1993, as far as possible we reviewed, which proposed a combined transit system with railway (Blue), elevated MRT (red), and transit bus (yellow), as shown in the Figure 3.7.



Source: Action Towards a Better Nairobi, the Nairobi City Convention (1993)

Figure 3.7 Proposed Transit Network by Action Towards a Better Nairobi, the Nairobi City Convention

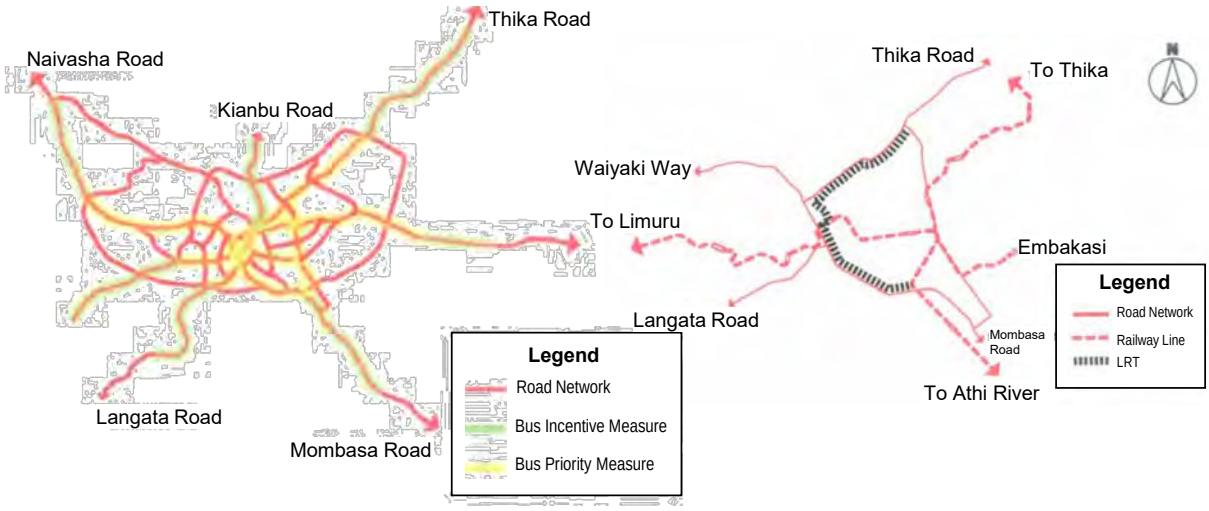
The following plan for Nairobi transport study funded by the World Bank, proposed combination of the KRC (red) and bus prioritized services (green), as shown in Figure 3.8



Source: Nairobi Long Term Transport Study, Stage-1 Report, World Bank, 1999

Figure 3.8 Proposed combination of KRC and Bus in 1999

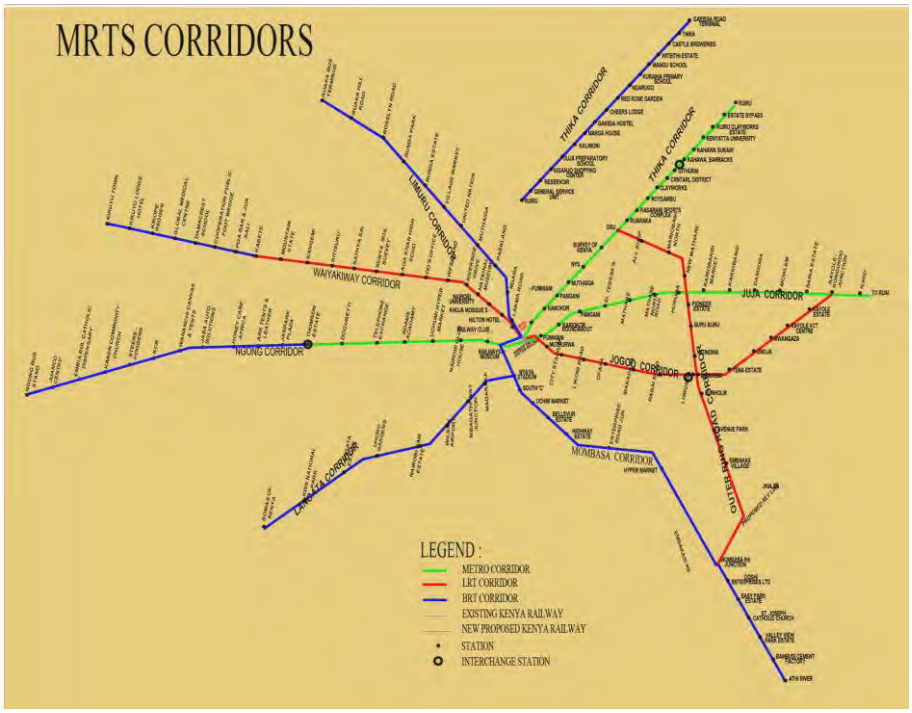
The NUTRANS in 2006 proposed comprehensive transport facilitation planning including road network, transport services and improvement for NMV. For the public transport services, presented in the Figure 3.9, it suggested construction of the elevated Light Rail Transit (LRT) connecting Mombasa Road, Uhuru Highway and Thika Road, and multi-layered bus services and phased implementation plan for prioritized bus service installation with exclusive lanes development.



Source: NUTRANS (2006)

Figure 3.9 Proposed road network integrated with Bus priority policies (left), Elevated LRT, railway network with major road corridors (right)

The Feasibility Study & Technical Assistance for Mass Rapid Transit System for the Nairobi Metropolitan Region in 2011 prepared by MoTI suggested a combined transport services with metro, KRC services, elevated LRT, and BRT. The travel demand for the public transport were forecasted under two population distribution scenarios,

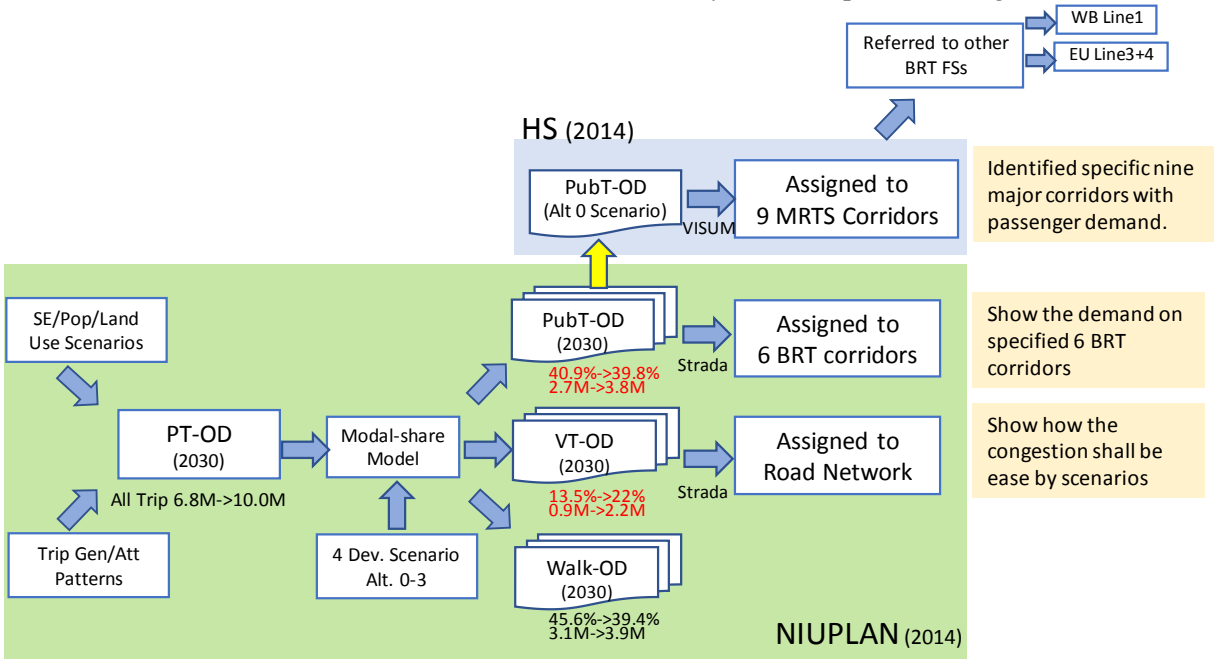


Source: Feasibility Study & Technical Assistance for Mass Rapid Transit System for the Nairobi Metropolitan Region

Figure 3.10 Proposed Network with Metro, KRC Services, Elevated LRT and BRT by MoT in 2009

2) Review of NIUPLAN and Harmonization Study

The NIUPLAN funded by JICA and the Harmonization Study funded by AfDB were implemented during 2013-14, referring to the previous studies for MRT and BRT development as aforementioned. The difference between NIUPLAN and Harmonization Study can be explained in Figure 3.11.

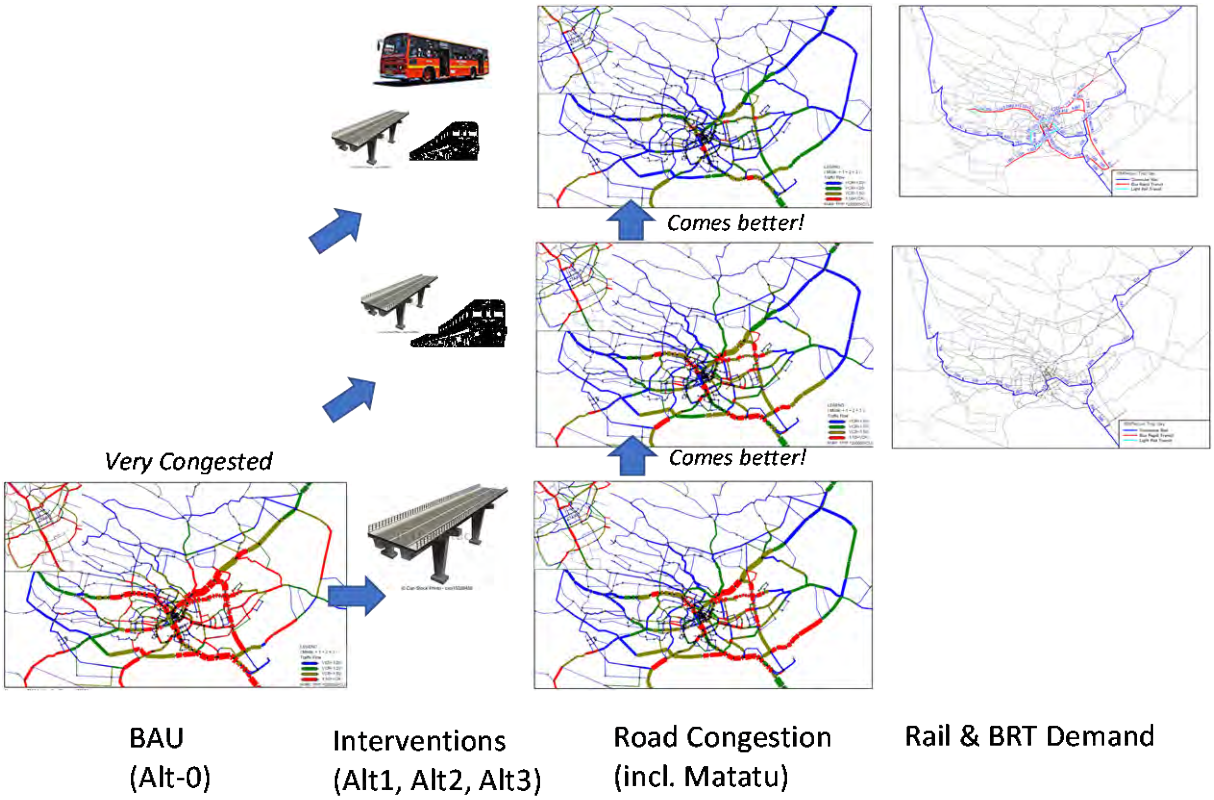


Source: JICA Study Team

Figure 3.11 Comparison of NIUPLAN and Harmonization Study in Analysis

The NIUPLAN achievements in transport planning can be presented as area painted with green.

NIUPLAN prepared the Person Trip OD for 2030 with socio-economic, population and land use scenario, and trip generation patterns, and applied modal share model to estimate the Public Transport OD, Vehicle Trip OD and Walk OD for 4 development scenarios (named as Alt-0 to Alt-3). Those ODs were assigned to BRT/Rail corridors or road network by JICA STRADA model, and estimated expected demands on MRTs and congestion in road network. (Figure 3.12)



Source: JICA Study Team and NIUPLAN (2014)

Figure 3.12 Achievement of NIUPLAN Transport Demand Analysis

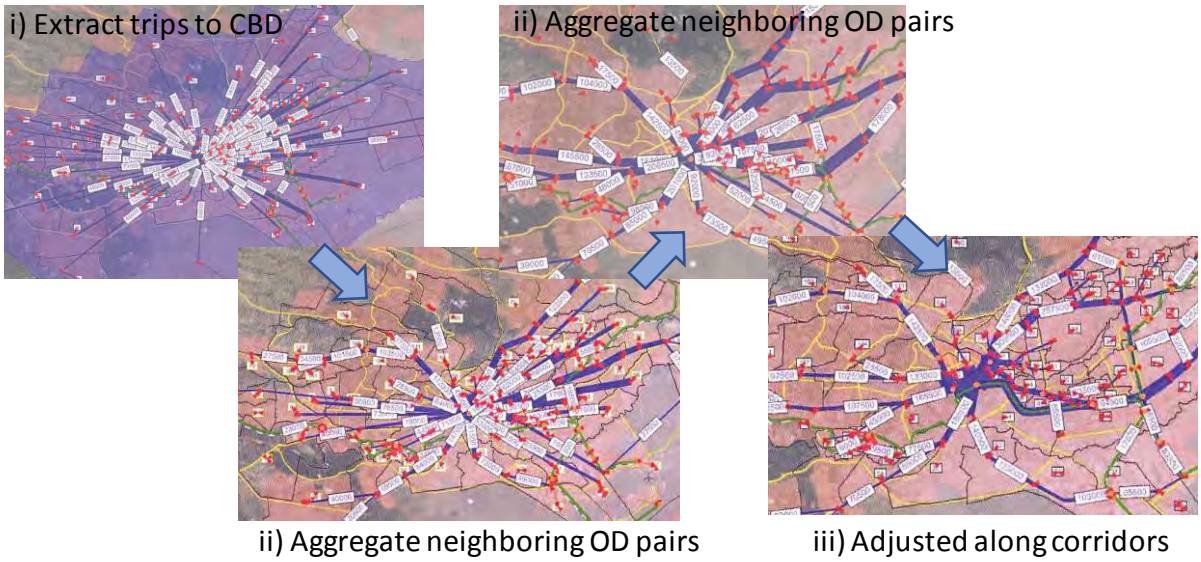
The Harmonization Study (HS) achievement can be presented as the area shaded with blue in Figure 3.12. HS adopted base case scenario (Alt-0 scenario) of the Public Transport OD prepared by the NIUPLAN, and identified 9 MRTS corridors with passenger estimation in the following procedures;

i) Extracted the trips connected to the CBD (30% of the whole Public Transport OD only),

ii) Aggregate the OD pairs with neighboring OD pairs to achieve adequate threshold (more than 100 thousand), and

iii) Adjusted the aggregated OD pairs along the existing road corridors

The procedure above are depicted with scans of the HS (Figure 3.13).



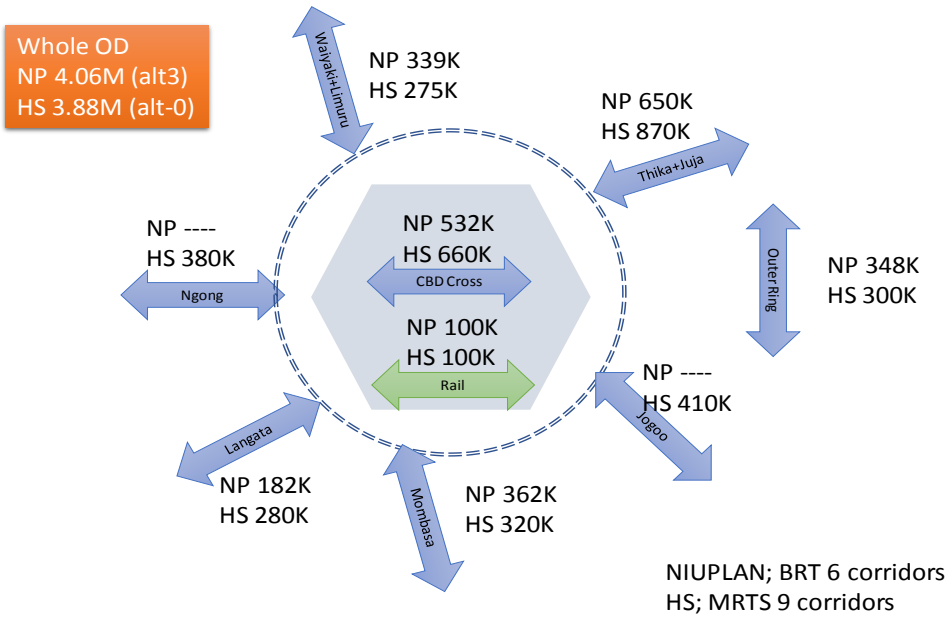
Source: JICA Study Team and Harmonization Study (2014)

Figure 3.13 MRTS Corridor Identification Procedure in HS

The comparison of NIUPLAN and HS can suggest the following;

i) NIUPLAN is more complicated, but wider variation of transport modes and infrastructure, harmonizing road traffic and other modes. NIUPLAN shows the road investment can alleviate the congestion, moreover BRT/Rail investment shall improve the traffic situation. On the other hands, HS is very simple but does not discuss anything about vehicle traffic, ordinary bus services.

ii) As both plans used same ODs for demand projection, the major trends in corridor based traffic were similar, as shown in Figure 3.14, although NIUPLAN did not propose BRT services in all major corridor.



Source: JICA Study team

Figure 3.14 Comparison of NIUPLAN/HS for Maximum MRTS Sectional Loading Estimation (2030)

iii) The both plans assess the maximum sectional loading of the commuter rail services will be

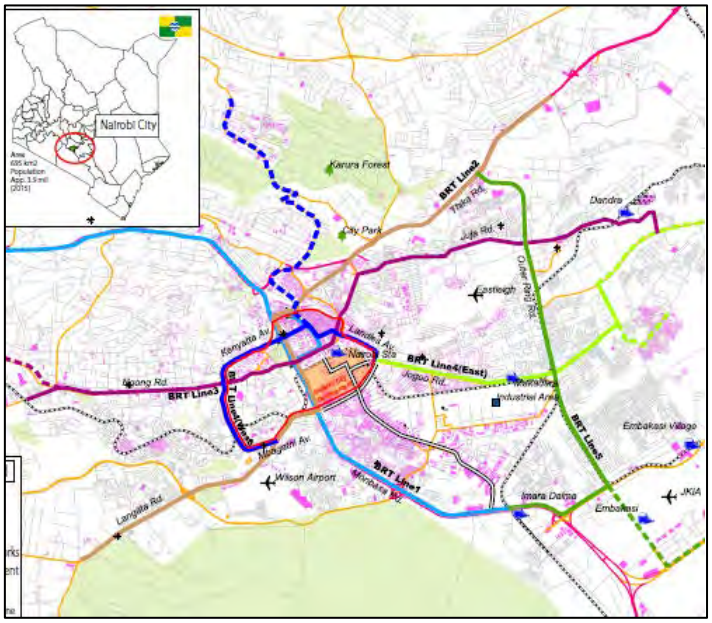
100 thousand passengers per day, although those of BRT services exceeds 300 thousand passengers. Moreover, the both plans do not mention such low utilization of railway service capacity. Usually, urban rail service can provide more capacity than BRT services, however there are no comments on low expected quantity of the commuter rail.

iv) The influence in surface traffic flow of BRT installation into CBD are not well assessed in both plans, particularly in the HS. NIUPLAN assessed the flow capacity in major traffic link in 2030, however, necessary space for the BRT in CBD are not well considered.

v) The multi-cored urban development scenario is not properly reflected to the daytime population scenario of NIUPLAN in 2030, which also influenced to the HS. The net daytime population[1] were specified as 714 thousand in the downtown, and 110 thousand in the CBD in 2030, and this is the reason why the large amount of traffic (500-600K per day) is concentrated into the CBD, pass through the CBD, and such large BRT investment were proposed.

3) BRT Proposals

Based on the Harmonization Study, the 5 BRT lines are proposed as shown in Figure 3.15. Table 3.3 explains the present status of the BRT planning by routes.



Source: JICA Study Team

Figure 3.15 Proposed BRT 5 Lines - Summary

Table 3.3 Status of BRT Project (As of July 2017)

Line No.	BRT Route	Section	Existing Status of BRT Project	Remarks
1	Waiyaki way - Uhuru Highway - Mombasa road	Lot 1 (Mombasa raod) Imara Daima - Nyayo Stadium	DD completed including operation plan	Financed by WB. Implementation agency is KeNHA.
		Lot 2 (Uhulu highway) Nyayo Stadium - Univ. way RA	No activity	Information was not available on BRT Line 1 Lot 2
		Lot 3 (Waiyaki way) Univ. way RA - Kangami	Study re-started by new consultant	Supported by WB.
2	Langata road - Uhuru Highway - Thika road	Line 2 East (Thika road) CBD - Ruiru	No activity	Road widening has been completed. However, there is no room for BRT at Thika road.

[1] Daytime population minus nighttime population

Line No.	BRT Route	Section	Existing Status of BRT Project	Remarks
		Line 2 West (Langata road) Bomas Kenya - CBD	No activity	Road widening has been completed between Langata cemetery and Bomas. There is no space for BRT.
3	Ngong road - Haile Selassie ave - Juja road	Line 3 East (Juja road) CBD - Njiru	DD has been completed between KNH to Dandra	Supported by EU. Implementing agency is KURA. Consultant is Ingerop.
		Line 3 West (Ugong road) Show ground - CBD	DD is on-going.	Supported by EU. Implementing agency is KURA. Consultant is Ingerop. There will be reserved space for bus lane (9m width) after the road widening project by JICA. However, BRT plan requires demolish of the on-going new road.
4	Mbagath way - Kenyatta ave - Landhies road - Jogoo road - Mayanja road - Kayole Spine road	Line 4 East City Stadium - Mama Lucy	DD is on-going.	Supported by AfDB. Implementing agency is KURA. Consultant is Gauff.
		Line 4 West T Mall - City Stadium	No information.	Supported by EU. Implementation agency is KURA. Consultant is Ingerop.
5	Outer Ring road - Airport North road	Balozi - Imara	Basic design is on-going.	Supported by AfDB. Implementing agency is KURA. Road expansion project is on-going.

Source: JICA Study Team

As shown on the table, the existing status of each BRT lines are different. There is no information of activity on BRT Line 1 Lot 2, Line 2 East and West, and Line 4 West.

4) Review on Feasibility Study on BRT Line 1 (The World Bank funded[2])

This feasibility study covers the BRT Line 1 mainly passing the Waiyaki way to Mombasa Road. This route is one of prioritized section and desired to be completed by the year 2023. This road section is classified as A class therefore this study was initiated by KeNHA. This study proposed the following;

i) Proposed 5 BRT routes options including feeder service expansion, and variety of operational option "trunk-only" and "direct access". The trunk only operation is to set the BRT service will follow along the fixed trunk road, and may force passengers transferring to other feeder services. The direct access operation shall accept BRT to run both trunk road and branched feeder routes. The proposed length of trunk road varies from 16.7 km to 20.9 km, due to the options.

ii) Assessed passenger demand for the 5 options, by creating simplified models for passenger in the catchment areas, particularly provided analysis for the AM peak period

iii) Assessed rough physical development cost, including vehicle purchasing, and time saving benefit, and cost benefit ratio. It assumes that the trunk-only cases require to build transfer stations, but the direct access cases will not require those.

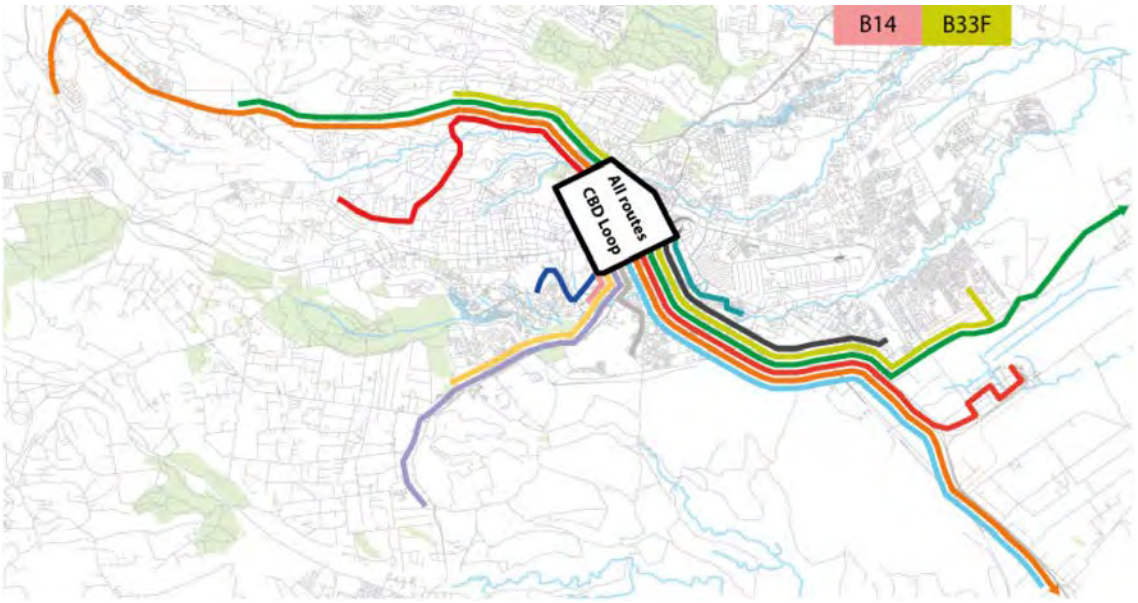
Major recommendations are the following;

i) The route option 5 is best to be implemented, shown in Figure 3.12, which provide "direct access" services. In CBD, it proposed a loop route for BRT exclusive service along the University Way, Moi Avenue, Jomo Kenyatta Avenue, Haile Selassie road, and Uhuru highway to distribute the BRT traffic.

ii) The estimated daily passenger is 450 thousand per day and 49 thousand in the morning peak hour. It does not provide PPHPD estimation.

iii) The direct cost for options varies 200 to 262 million USD. For the option 5, the direct cost will be 239 million USD, and cost benefit ratio will be 0.92.

[2] *Nairobi Ndovu/A104 BRT Service Plan,* ITDP, UN-Habitat, 26 Feb 2015



Source: Nairobi Ndovu/A104 BRT Service Plan, ITDP, UN-Habitat, 26 Feb 2015

Figure 3.16 ITDP's Proposed BRT Service Network, Option 5, Direct Access Services

This study is rough assessment as pre-feasibility study level, and ITDP is still working with KeNHA and NaMATA for full feasibility study. According to the presentation of the ITDP[3], the maximum PPHPD in the route would be 10 -12 thousand in 2020, although we have not yet received any details of the feasibility study and implementation schedules.

5) Review on Feasibility Study on BRT Line 3-4W[4] (EU funded)

This full feasibility study provides comprehensive analysis for passenger demand, related institutional arrangement, physical design, cost estimation and project feasibility analysis. It also implemented substantive traffic surveys along the target area in September 2015, and developed a multimodal transport model for the targeted BRT sections, named as NaBRaT.

The BRT Line 3 will run along the Juja road, Ring Road Ngara, Haile Selassie Avenue and Ngong road. Additionally, the Line 4W west section will be branched from the Line 3 at the Moi-Haile Selassie intersection, run along Moi avenue, Jomo Kenyatta Avenue, Valley Road and Mbagathi Way. The Line 4E is the section connected to 4W running into the Jogoo road.

This study did not show any figure of PPHPD, the important criteria for mode selection in planning stage, even though its comprehensive scope of work. However, this study provided detail demand projections and line loading profile therefore the PPHPD could be estimated.

First, this study estimated the daily and peak hourly passenger demand for 2020 and 2045 as shown in Table 3.4. These cover demands for both direction. Compared among the passenger demands in 2020 and 2045, there are not much difference although there are 25 years gap, because this study accounts the other BRT services (Line 2 along the Thika road, and Line 5 along the Outer Ring Road will be opened in 2035) will absorb the passenger demand, and private car growth are also accounted.

[3] NUTRIP/WB/ITDP, Presentation of working paper 3 on service plan and infrastructure options report on feasibility study and conceptual design for BRT Line 1 – JKIA to Rironi, Date: March 23, 2017, Crown Plaza Nairobi

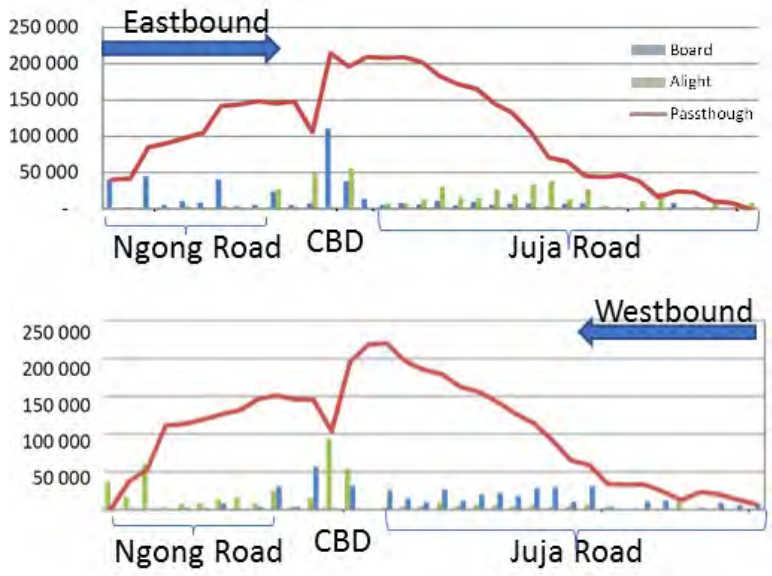
[4] Nairobi Bus Rapid Transit Network Feasibility and Detailed Design of Lines 3 and 4w, Feasibility Report, Volume 3. Transport Demand Report, 3&4W-FEA-GEN-LUX-003-A

Table 3.4 Passenger Demand for BRT (Medium growth scenario)

	2020		2045	
	Peak	Daily	Peak	Daily
3W (Ngong)	29,000	494,000	31,000	514,000
3E (Juja)	34,000	416,000	40,000	530,000
4W* (Valley - Jogoo)	12,000 (27,000)*	210,000 (372,000)*	14,000 (30,000)*	263,000 (440,000)*

Note: * includes for Line 4E (Jogoo road) passengers as in 2020 it has been assumed that Line 4E will be opened
Source: Nairobi Bus Rapid Transit Network Feasibility and Detailed Design of Lines 3 and 4w, Feasibility Report, Volume 3. Transport Demand Report

Secondly, the study produces the line loading profile as shown in Figure 3.17. The top chart shows eastbound passenger loading and the bottom one shows westbound. The both charts show passengers on board are accumulated gradually, peaked in CBD, and decreased gradually up to the terminal.



Source: Nairobi Bus Rapid Transit Network Feasibility and Detailed Design of Lines 3 and 4w, Feasibility Report, Volume 3. Transport Demand Report
Note: the study team modified the figures in the source for better understanding

Figure 3.17 Daily Line Loading Profile for Whole Line 3, 2020, medium growth scenario

The maximum loaded section can be seen at the eastern sections in CBD, and it would be 220 thousand per day. Therefore, the maximum PPHPD could be estimated by applying peak hour ratio to the figure. Assuming the peak hour ratio as 9-12%, the PPHPD for the Line 3 for 2020 can be estimated. The PPHPD for the other target years and those of the Line 4 are estimated in the same manner as follows;

Table 3.5 PPHPD estimation for Line 3 and Line 4

PPHPD (in thousand)	2020	2025	2035	2045
Line 3	19.8 – 26.4	22-29	14-19	15-21
Line 3 without other BRT lines after 2035*	19.8 – 26.4	22-29	24-32	26-34
Line 4W**	16.2 – 21.6	16-21	10-14	10-14
Line 4W with 4E available***	28-38	--	--	---

Source: JICA Study Team
Note: *) just extrapolated the case of Line 3 after 2035
**) for Line 4W, the maximum daily loading in 2020 was seen at Ronald Ngara BT in eastbound, approx. 180K per day.
***) figures in 2025 and 2035 could not be estimated due to little reference.

As shown in table, it is estimated that the Line 3 maximum PPHPD will be 22-29 thousand in 2025, and will be decreased to 14-19 thousand in 2035, due to the other BRT service opens. Considering the difficulty of opening BRT services along the Thika road, the Line 3 PPHPD would be expanded to 24-32 thousand in 2035 and 26-34thousand in 2045. For 4W, the estimated value will be around 16 to 21 thousand up to 2025 and 10-14 thousand after 2035, however, if the 4E section will be opened simultaneously with 4W, it would be 28-38 thousand in 2020.

It should be noted that this study also conducted cost estimation and feasibility analysis, and the economic viability of Line 3 was high enough to show its B/C as 1.57 to 1.64, although its financial B/C was 0.76, which requires subsidization. For Line 4 west, the both economic and financial viability were 0.4-0.57 and 0.39-0.41 in B/C respectively, saying low feasibility.

3.2.2 Railway Projects

1) Commuter Rail Master Plan

In order to utilize the rail network, KRC has planned to modernize and expand the Nairobi commuter rail system in April 2009 by entering into a Joint Development Agreement (JDA) with InfraCo Limited to jointly develop the new commuter rail system on the basis of a Public-Private Partnership. InfraCo is a company owned by the Private Infrastructure Development Group Trust (PIDG), which comprises of several development partners including: SIDA (Sweden), DfID (UK), SECE (Switzerland), DGIS (Netherlands), ADA (Austria) and the World Bank.

The project was planned to be undertaken in two phases. The purpose of Phase 1 was to create the Project Development Plan, which included a proposed funding and commercial structure. Phase 2 was planned to include i) detailed market forecast, ii) engineering design, iii) development of bankable project document, iv) competitive procurement of contractors, suppliers and operators, and v) identification and procurement of debt and equity financing through to financial close and the start of construction. However, as the result, this PPP project was not successful.

In the Feasibility Study and Technical Assistance for Mass Rapid Transit System for the Nairobi Metropolitan Region (NMRTS, 2011), 4 KRC lines were planned to be improved as Kenya Railway Commuter Services Improvement Program (Phase 1), namely, 1) Nairobi – Limuru, 2) Nairobi – Ruiru, 3) Nairobi – JKIA, and 4) Nairobi – Embakasi Village. Although new MRT plans were changed to BRT lines in the Harmonization plan, the improvement project of KRC lines have been on-going. However, the progress has been very slow.

One of the reasons of the failure of railway modernization may be the concession contract with Rift Valley Railways (RVR) for the operation and maintenance of railway in Kenya and Uganda since 1992. Passenger train operation was not in the scope of contract for Uganda, however RVR was obliged to operate passenger trains in Kenya. Since passenger train operation is not profitable, RVR was reluctant to improve the passenger train operation. The concession agreement was terminated on July 31, 2017.

Under the financial assistance from the World Bank, the Government of Kenya has decided to develop a Nairobi Metropolitan Commuter Rail Master Plan as a part of the Nairobi Urban Transport Improvement Project (NUTRIP). The selection of the consultant was completed and the consulting services commenced since September 2017.

Commuter Rail Master Plan project is scheduled to complete within 9 months. The services include carrying out feasibility studies, preliminary design and development of technical specifications of railway track infrastructure, stations, fencing and other barriers, footbridges, signaling, ICT systems, fueling depot, rolling stock and other associated facilities, and development of an implementation plan for the commuter railway lines and evaluation of Kenya Railways as well as an organization structure and capacity requirements. Figure 3.18 indicates KRC's future commuter rail network.

Source: KRC

Figure 3.18 Planned KRC Commuter Rail Network Extension of SGR to Nairobi Central Station

The SGR project connecting Mombasa and Nairobi was completed in May 2017 and is scheduled to be extended up to Uganda by 2021. However, the track will not pass through the Nairobi Central Station. In order to transport passengers from Mombasa arriving at Nairobi South Station, KRC is planning to extend SGR track from Nairobi South Station to Nairobi Central Station in Running in parallel to the existing Meter Gauge Track.

KRC's intension is to operate EC (electric car) between two stations, and not to operate long distance train to Nairobi Central Station because the existing Meter Gauge track is not electrified and number of commuter train on the meter Gauge track is very limited.

According to KRC, the section will be electrified and the power will be supplied through third rail. Power supply by third rail has an advantage to reduce the height of the rolling stock gauge. However, since the track is laying at grade and the track area is accessible by people living nearby the railway track, accidents caused by electric shock will be difficult to avoid.

Source: JICA Study Team

Figure 3.19 Power Supply by Third Rail and Overhead Catenary

Considering the safety operation, OHC (overhead catenary) system is recommended.

2) Loop Line

After the NMRTS plan was prepared by MOT, in order to develop a holistic approach to address intense urban issues arising, NCCG formulated the Nairobi Integrated Urban Development Master Plan (NIUPLAN) in 2014 supported by JICA. One of the priority projects in the public transport sector was development of a loop Line which circulating the Nairobi Urban Core to distribute traffic going into the CBD and to ease anticipated traffic congestion. Considering future passenger demands and, in order to minimize the land acquisition, a straddle type monorail having large transport capacity was suggested to apply for the Loop Line.

However, the NMRTS plan has been modified by the Harmonization Study which replacing all MRT and LRT lines into BRT lines in 2014. Harmonization Plan is suggesting to postpone the timing of introduction of MRT/LRT line after 2030. Since transporting capacity of BRT is much less than MRT, timing of the construction of Loop Line was reconsidered because the planned function of the Loop Line can be fulfilled by BRT. In fact, BRT Line 4 west will cover the northern half of the Loop Line route. Thus, it is recommended to postpone the construction of the Loop Line, and instead of the plan, construction of one MRT line on the busiest corridor is recommended.

As shown in Table 2.10, the NCCG authorized that the feasibility study of the Nairobi Loop Line is designated as a project for short term.

3.2.3 Road Project

The existing road situation is shown in 2.2.1 and this section describes the investment strategy in the Road Sector Investment Programme and Strategy (2010-2024) (hereinafter "RSIP") and the review of the road projects in the Nairobi Urban Core surroundings.

3.2.3.1 Road Sector Investment Programme and Strategy (2010-2024)

This is the program which is prepared by former Ministry of Roads and the main purpose of this RSIP is "to provide good roads for a globally competitive and prosperous Kenya". Its specific objective is to detail the country's road network infrastructure development and maintenance needs for the medium and the long term in order to facilitate guided, secure, aggressive, timely and quality investment for maximum benefits to the overall economy.

The RSIP is based on the assessment of the needs of the economy, and complies with Government policies and in particular Sessional Paper No. 5 of 2006 on *the Development and Management of the Road Sub-sector for Sustainable Economic Growth and Kenya Vision 2030.*

The RSIP includes: -

(i) An outline 15-year investment plan; and

(ii) A detailed 5-year implementation programme.

The RSIP covers all road works from construction of new roads to rehabilitation and maintenance utilizing all resources that are expected to be made available.

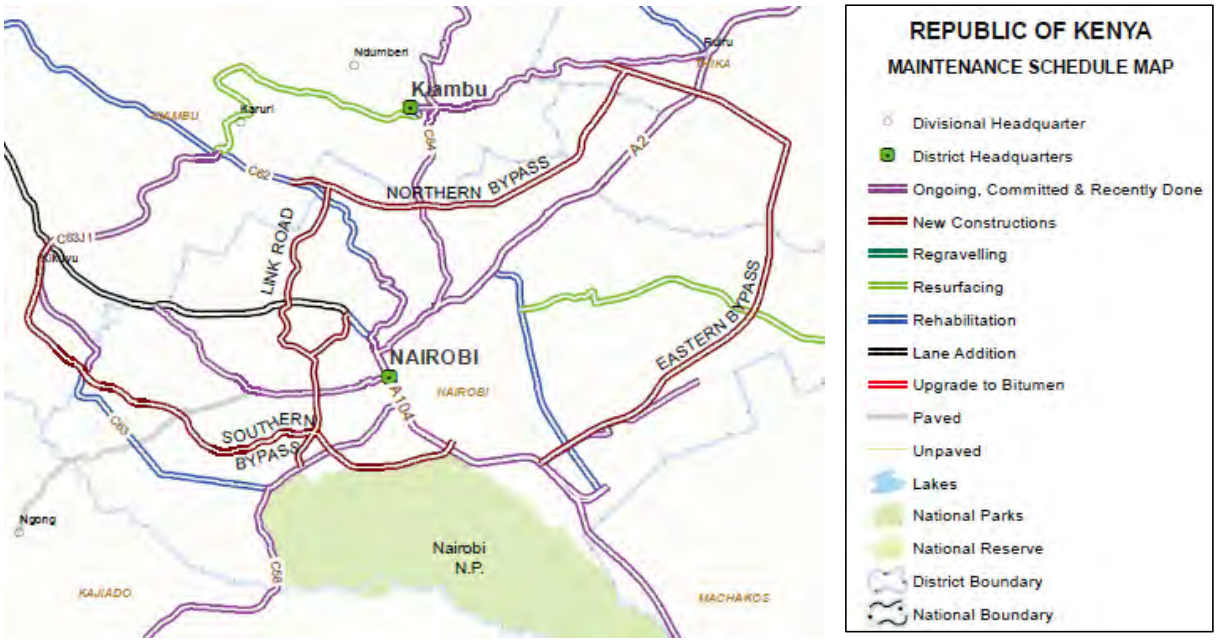
The projected expenditure for the first five years (2010-2014) of the RSIP is Kshs 604.6 billion. Of this amount, committed and ongoing projects will cost Kshs 263 billion. The detailed development menu is summarized the table below. As shown in the figure below, some newly constructed roads have been completed.

Table 3.6 Action Plan and the Planned Budget by Term in RSIP

Short Term (2010-2014)	Short Term (2010-2014)	Long Term (2020-2024)
•4,800km paved road resealed/ recarpeted • 3,900km of paved roads rehabilitated • 3,900km upgraded to bitumen standards • Completion of the 8 lane Nairobi – Thika Highway • Completion of bypasses and missing links in Nairobi totalling 207km new roads construction, increasing the total paved road network to 16,525km • Construction of Kisumu By-pass Roads • Construction of Isiolo – Merille River • Outering Road (C59) Dualling • Ngong Road (C60) Dualling – Uhuru Highway – Ngong Town • Langata Road Dualling – Karen – KWS Gate • Construction of Dongo Kundu By-pass (alternative route for Likoni Crossing) • Construction of Nairobi Urban Toll Road	• 10,200km paved road resealed/ recarpeted • 270km of paved urban roads rehabilitated • 9,900km upgraded to bitumen standards, increasing the total paved road network to 27,000km • All class A roads bituminised • 190km capacity improvement • 600km new roads construction • Bitumenisation of Merrille River – Moyale, • Machakos Turn-off – Athi River Dualling • Mombasa – Mtwapa Dualling • Construction of Lamu Port – Southern Sudan – Ethiopia Transport corridor (LAPSSET) • Construction of Kibera – Langata Link • Construction of Kibwezi – Kitui – Mwingi – Isiolo road • Upgrading to bitumen standards of rural roads • Upgrading of Game Park Roads	• 17,000km paved road resealed/ recarpeted • 13,000km of bitumen roads upgraded, • All class B, C and 50% D roads bituminised • 240km capacity improvement • 700km new construction, increasing the paved network to 41,000km. • Dualling – Limuru - Lanet • Construction of Circumferential and Radial Roads in Nairobi • Upgrading to bitumen standards of rural roads • Paving of roads in urban centres • Construction of Bridges and other major structures • Upgrading of Moyale – Mandera Road
Budget: 604,579 mil. Ksh (177,102 km development)	Budget: 809,046 mil. Ksh (203,194 km development)	Budget: 1,055,626 mil. Ksh (225,452 km development)

Source: Road Sector Investment Programme and Strategy 2010-2014, JICA Stuey Team Edited

Proposed road maintenance in Nairobi Metropolitan Area is illustrated in the figure below.



Source: Road Sector Investment Programme and Strategy 2010-2014, JICA Stuey Team Edited

Figure 3.20 National Roads Road Works on Road Sector Investment Program (2010-2014) in NMA

The proposed network in NUTRANS has integrated in the RSIP. The findings as of September 2017 are;

- On-going, Committed & Recently done: It has mostly developed already
- New Construction Roads: Some parts e.g., Southern bypass, Northern bypass and have been newly constructed accordingly as of September 2017 and key network Nairobi Area surroundings are about to be formed. The Eastern bypass and Link road shall be developed
- Rehabilitation (including Regravelling, Resurfacing) shall be developed
- Lane addition: Waiyaki Way is proposed for lane addition but it has not developed yet

The New Constitution, under the Fourth Schedule, has provisions for distribution of functions between the National and County Governments. The National Government has the responsibility for the construction and operation of national trunk roads and development of standards for the construction and maintenance. The County Governments are responsible for county roads, street lighting, traffic and parking, and public road transport.

3.2.3.2 Nairobi Metropolitan Region Traffic Decongestion Program

This is the program to mitigate traffic congestion by improvement of intersection from round about to signalized interchange in CBD area. Although the client of the program was NCCG and planned in 2015, the program was suspended since world bank has dispatched another ITS project, named “Consultancy services for the design, tender documentation and implementation supervision of an intelligent transport system (ITS) and in associated with civil engineering works for Nairobi County” (see 3-34)).

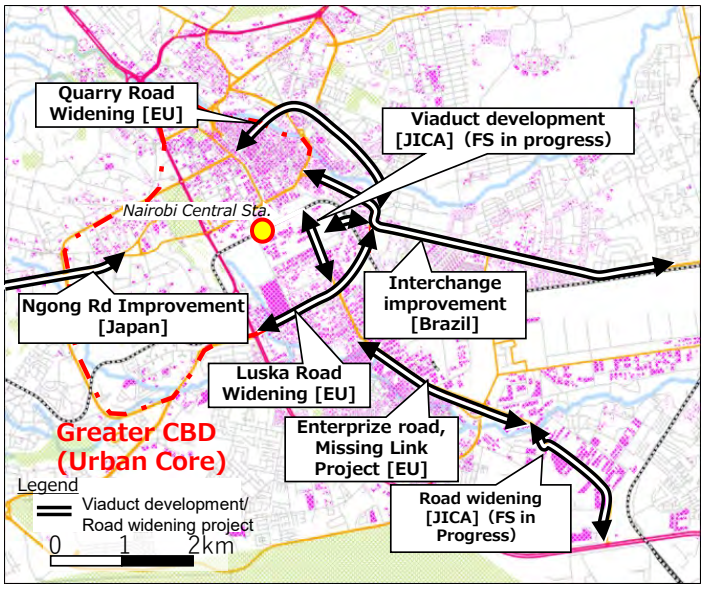
3.2.3.3 On-going Projects

The reviewed road project in the study area is listed in Table 3.7 and shown the area in Figure 3.21, respectively.

Table 3.7 Major Related Plans and On-going Projects

No.	Project Title
1)	Viaduct and Road Construction Project
2)	A104 Highway Improvement
3)	Widening of Quarry, Lusaka, Enterprise and Likoni roads
4)	Improvement of Jogoo Road Interchanges with Future Implementation of BRT
5)	Ngong Road Widening Project (The Project for Dualling Nairobi Dagoretti Corner Road C60/ C61)
6)	Pilot Project ITS
7)	Consultancy services for the design, tender documentation and implementation supervision of an intelligent transport system (ITS) and associated civil engineering works for Nairobi County

Source: JICA Study Team



Source: JICA Study Team

Figure 3.21 Reviewed Road Project Location around Study Area

1) Viaduct and Road Construction Project

Background of the Project

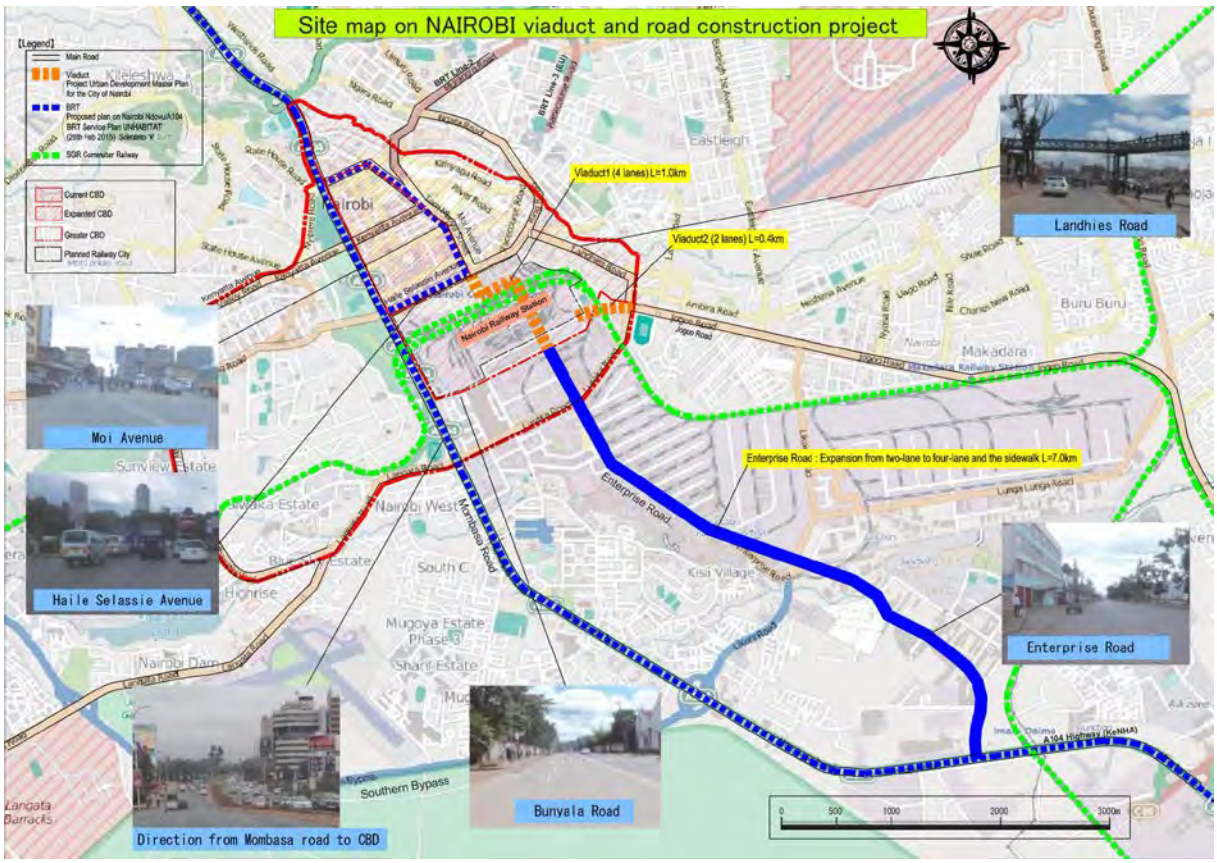
GoK submitted a request for financing from JICA to construct viaducts over the railroad yard at Nairobi Railway Station and widening of Enterprise Road that connects the eastern part of Nairobi with CBD, which are listed as priority projects in the "Nairobi Integrated Urban Development Master Plan 2030 (NIUPLAN), JICA, 2014" considering urban plan, transport network and urban infrastructures. After approval by the Government of Japan, JICA and GoK came to a mutual understanding that this Project was vital for traffic improvement in Nairobi CBD. They therefore agreed for the preparatory survey as per the minutes of the meeting held on 16 July 2015.

Scope of the Study

The scope of the survey consists of the following components, which are prioritized in NIUPLAN:

- Viaduct-1: 1,000m x 4 lanes (connecting Moi Avenue and Enterprise Road: North-South Axis)
- Viaduct-2: 400m x 2 lanes (connecting Jogoo Road and Railway City: East-West Axis)
- Widening of Enterprise Road: From existing 2 lanes to 4 lanes and sidewalks construction (length: 7.0 km)

The location map of the project is shown in Figure 3.22.



Note: the scope of the project is three sections i.e., Viaduct 1 (4 lanes) L=1.0km, Viaduct 2 (2 lanes) L=0.4km and Enterprise Road: Expansion from two-lanes to four lanes and the sidewalk L=7.0km, indicated yellow box in the figure.
Source: The Preparatory Survey on Nairobi Viaduct and Road Construction Project

Figure 3.22 Location Map of Nairobi Viaduct and Road Construction Project

The study originally planned to be finalized in August 2016 but it has been extended the contract until the latter of 2017 due to the alignment discussion between GoK and JICA.

2) A104 Highway Improvement

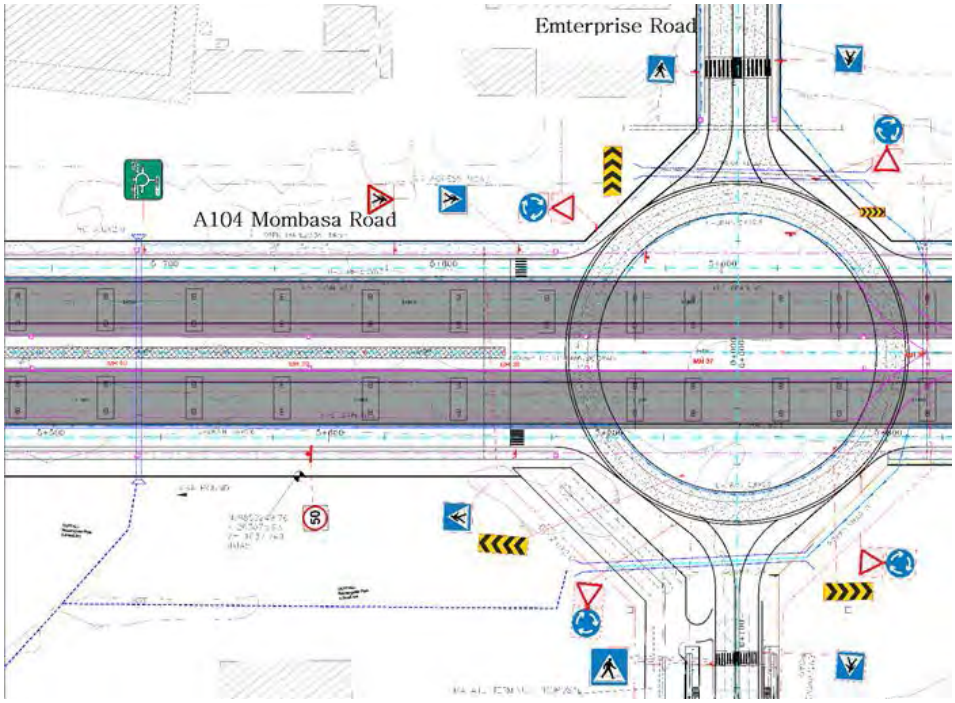
GoK intends to apply part of NUTRIP fund to improve A104 Highway from Jomo Kenyatta International Airport (JKIA) to Rironi dividing the section into the following three lots:

- Lot 1. JKIA to Likoni Road (8km + 4km adjoining road),
- Lot 2. Likoni Road to James Gichuru Road (12km), and
- Lot 3. James Gichuru Road to Rironi (25km).

Detailed Design has been completed for Lot.1 considering BRT facilities as a part of the BRT Line 5. The implementing agency, KeNHA, intends to announce the tender for the construction work as soon as the authority obtains a no-objection letter on the tender documents from the World Bank. It was expected that the construction work for Lot 1 works has already started as of June 2017.

Under Lot 1, Mombasa Rd / Enterprise Rd Roundabout shall be improved to a grade separated junction as shown in Figure 3.23. Furthermore, in accordance with this improvement,

Enterprise Rd shall be widened from the section up to Road C. The section to be widened is 500m long from the Roundabout.



Source: KeNHA

Figure 3.23 Improvement Plan for Mombasa Rd and Enterprise Road Roundabout

The project progress of Lot 1 as of January 2018 is summarized in Table 3.8.

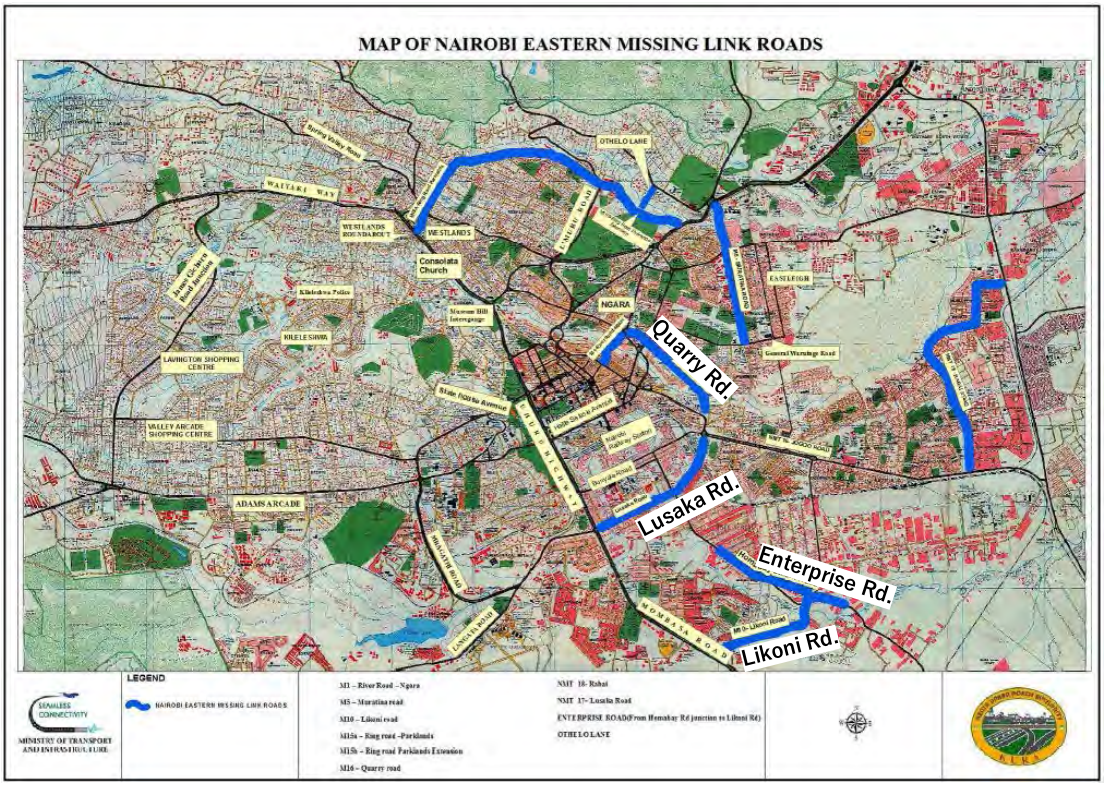
Table 3.8 Summary of A104 Highway Improvement Project (Lot 1)

PROJECT	NAIROBI URBAN ROAD DEVELOPMENT PROJECT : LOT 1
Project Extents	Sub- Lot 1A: JKIA Turnoff – Likoni Road Junction & New Access to ICD Sub- Lot 1B: JKIA Terminal – JKIA Turnoff & Airport South Road
Length (Km)	Sub- Lot 1A: 7.9Km Sub- Lot 1B: 6.7Km
Period when design was undertaken	Initial design: - June 2012 to December 2015 Updating of Designs: - Ongoing
Design Consultant	Gibb Africa Ltd
Current Status of Design	Updating of Final design reports and tender documents, anticipated completion in 28th February 2018.
Highlights of design	Sub-Lot 1A: 80m cross-section with 4x2 normal traffic lanes; 2x2 service lanes; BRT lanes 1 x 2 off-station and 2x2 at stations 5.9km of median-aligned BRT Interchange at intersection with Enterprise Road 0.9km dual carriageway new direct access to ICD Interchange at airport turnoff and access to the Nairobi South SGR station Sub-Lot 1B: 82m cross-section for B10 with 4x2 lanes 60m cross-section for Airport South Road with 2x2 lanes Interchange at existing elephant roundabout
Status of Implementation	Pending; The Identification mission of the AfDB was carried out in August 2016.
Safeguards	ESIA already submitted to NEMA RAP (2015) , updating of report in progress
Estimated cost of construction (USD)	200 MILLION (KSH 20B)

Source: KeNHA

3) Widening of Quarry, Lusaka, Enterprise and Likoni roads

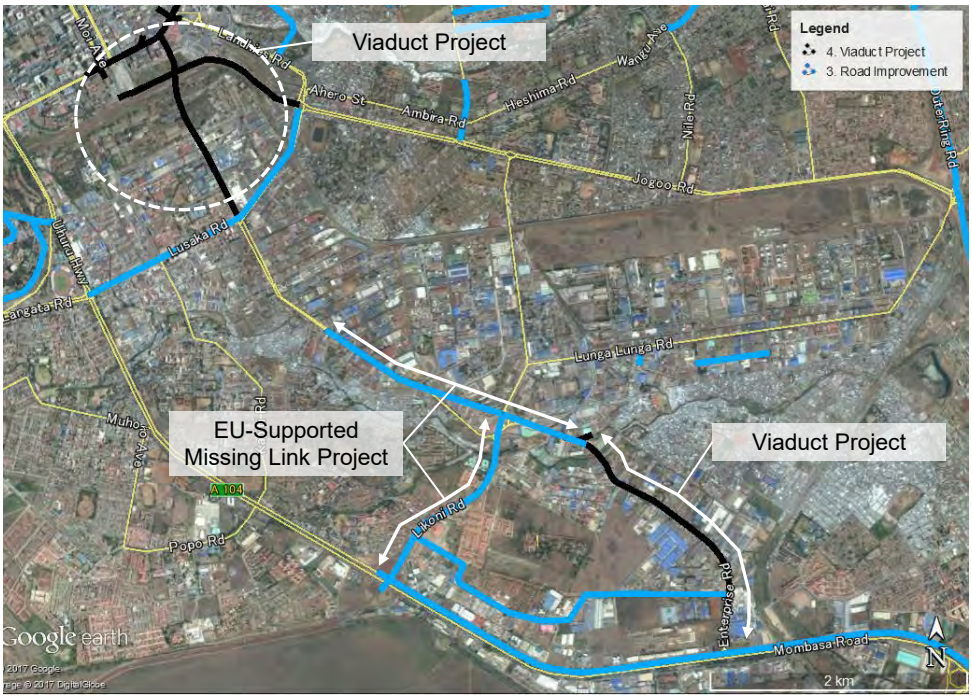
KURA is currently implementing the widening of Quarry, Lusaka, Enterprise and Likoni roads as part of the EU-supported missing link project of which the location map is shown in Figure 3.24. Those projects are on-going but the resettlement shall be required for the widening works and the issue is not settled yet. The timeline for the project is yet to be seen as of September 2017.



Source: KURA

Figure 3.24 Location Map of EU-Supported Missing Link Project

The Nairobi Viaduct project also covers the improvement of a section of Enterprise Road and the remaining section improved by other projects. The demarcation between viaduct project and EU-supported Missing Link Project along Enterprise road as shown in the figure below.



Source: Google Earth (Image © Digital Globe), JICA Study Team

Figure 3.25 Demarcation between Viaduct Project and EU-Supported Missing Link Project

4) Improvement of Jogoo Road Interchanges

KURA is preparing the preliminary design for improvement of Jogoo Road interchanges with future implementation of BRT Line 4 East receiving the support of Brazilian Exim Bank. The selected intersections for improvement are located along Landhies and Jogoo roads, which constitute a major arterial corridor serving the predominantly Residential Districts of Eastern Nairobi from the Central Business District (CBD). These intersections include following sections:

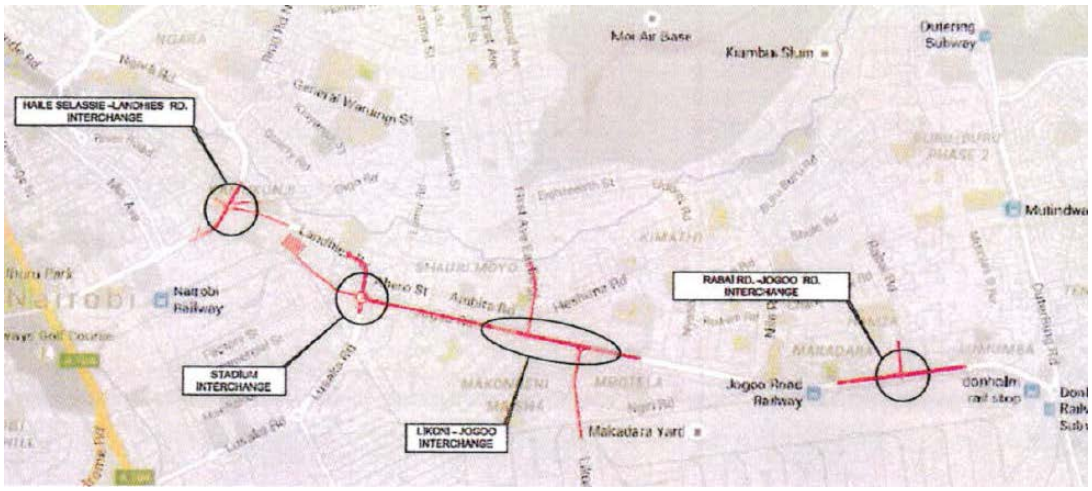
a) Haile Selassie Avenue-Landhies -Rd-Ring Road Ngara Roundabout

b) City Stadium Roundabout

c) Jogoo Road-First Avenue Eastleigh-Likoni Road Intersections

d) Rabai Road-Likoni Road Intersection

However, the project has not yet started as of September 2017 due to the shortage of fund from Brazilian Exim Bank.



Source: KURA

Figure 3.26 Location Map of Brazil-Supported Jogoo Rd Interchanges Project

5) Ngong Road Widening Project (The Project for Dualling Nairobi Dagoretti Corner Road C60/ C61)

This is the grant road improvement project having approx. 2.57km long to widen the road from two (2) lanes to four (4) lanes to ease the traffic congestion in the Ngong Road. The project has been requested by Government of Kenya (GoK) since 2008 and signed on the exchange of note in 2nd of June 2012 between GoK and Government of Japan, named "The Project for Dualling Nairobi Dagoretti Corner Road C60/ C61" (Ngong Road Widening Project). The project includes followings three components;

(1) Approx.2.57km long road widening works from two (2) lanes to four (4) lanes

(2) Bottlenecked intersection improvement works

(3) Other necessary road facilities along component (1), such as dredging, pedestrian road and so on.

The project is being constructed and the project outline is summarized in the Table below;

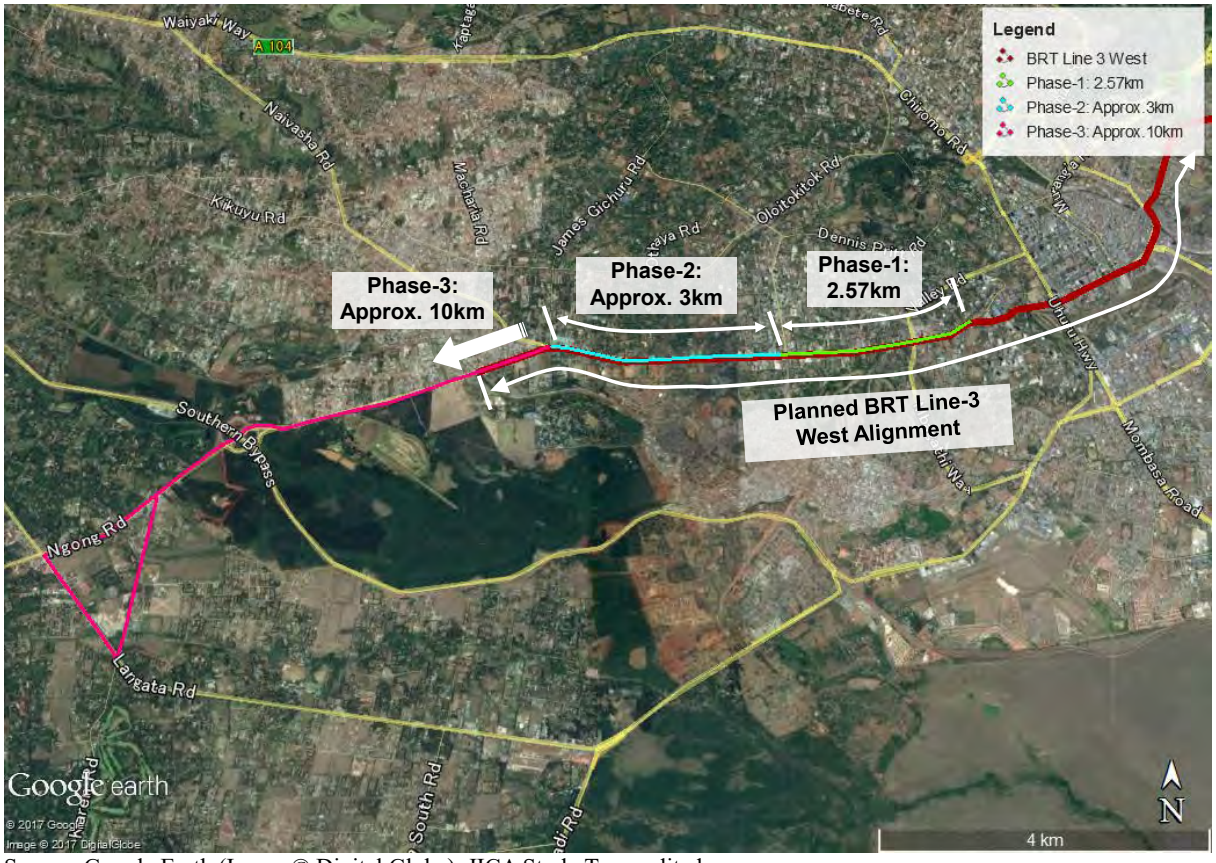
Table 3.9 Project Summary of Ngong Road Widening Project (Phase-1)

Project Outline		
1.1	Fund Source	Japan International Cooperation Agency (JICA)
1.2	Implementing Agency	Kenya Urban Roads Authority of The Republic of KENYA
1.3	Project Name	The Project for Dualling of Nairobi - Degoretti Coner road C60/61
1.4	Contract of Consultant	
	a) Consultant's Name	Katahira & Engineers International
	b) Signed Date	2015. Dec. 7.
	c) Work Period	To end of 2017
	d) Contract Price	JPY 110,930,000.
1.5	Contract of Construction	
	a) Contractor's Name	World Kaihatsu Kogyo Co., Ltd
	b) Signed Date	2016. Jan. 21.
	c) Work Commencement Date	2016. Fed. 18.
	d) Work Period	To 2017.July 31 (530Days)
	d) Contract Price	JPY 1,454,900,000.
Project Progress Brief		
1.1	Progress on Day	377Days/530Days (71.1%) From Feb. 18, 2016
1.2	Progress on Accomplishment	Original / Modification (Oct. 2016)
	a) Contract Amount	JPY 1,454,900,000. / JPY 1,454,900,000.
	b) Plan Progress Amount	JPY 1,020,030,000 (70.11%) / JPY 768,330,000 (52.81%)

c) Actual Progress Amount	JPY 535,400,000 (36.80%)	JPY 535,400,000 (36.80%)
d) Difference c) Actual - b) Plan	JPY -484,630,000 (-33.31%)	JPY -232,930,000 (-16.01%)
Project Progress Payment		
1.1 Contract of Consultant		
a) Contract Amount	JPY 110,930,000.	
b) 1st payment Amount	JPY 33,792,000.	Received on June 19, 2014
c) 2st payment Amount	JPY 38,569,000.	Received on April 21, 2016
d) 3rd payment Amount	JPY 25,713,000.	Not yet Received (85%) June 2017
e) Final payment Amount	JPY 12,856,000.	Not yet Received (Completion) August 2
1.2 Contract of Construction		
a) Contract Amount	JPY 1,454,900,000.	
b) 1st payment Amount	JPY 581,960,000. (40%)	Received May 13th 2016
c) 2st payment Amount	JPY 436,470,000. (30%)	Not yet Received (50%) Feb,2017
d) 3rd payment Amount	JPY 290,980,000. (20%)	Not yet Received (85%) June,2017
e) Final payment Amount	JPY 145,490,000. (10%)	Not yet Received (Completion) August 2

Source: JICA Study Team

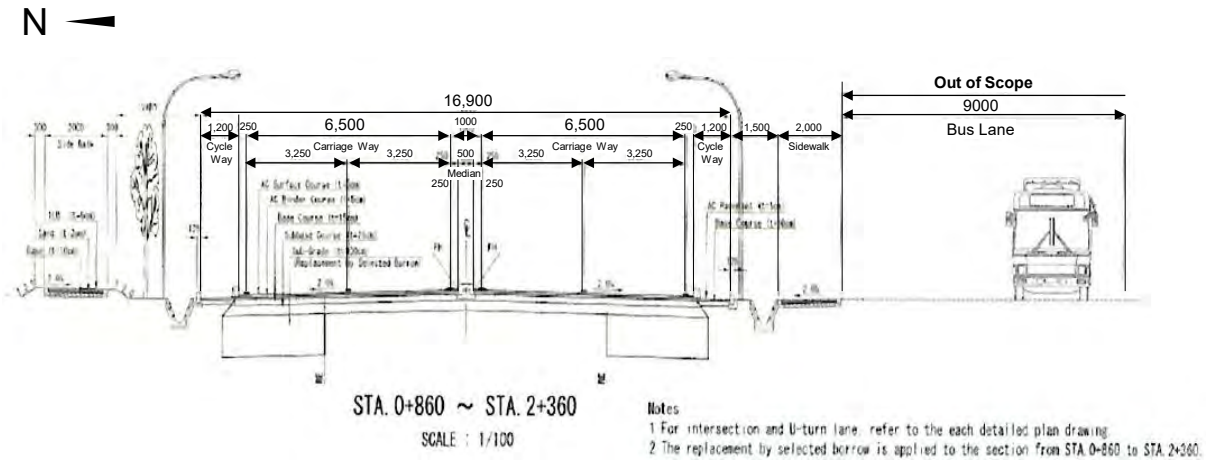
The project includes two phases as shown the Figure 3.27. This project is being implemented for phase-1 and it scheduled to complete by the end of the year 2017. The project for phase-2 is under designing stage and phase-3 funded by KURA is under procurement stage.



Source: Google Earth (Image © Digital Globe), JICA Study Team edited

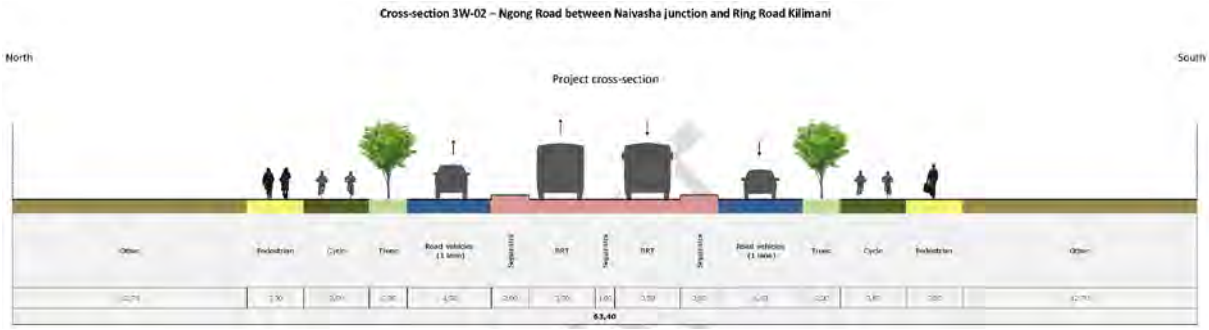
Figure 3.27 Location Map of The Ngong Road Widening Project

The section is overlapped with planned BRT Line 3 route. Although the road is designed considering the BRT, the alignment designed by EU does not match actual road construction design. The typical drawing of the section in phase-1 is shown in Figure 3.29. The BRT route goes center of the route according to the Feasibility Study as shown the Figure 3.29. The construction works is ongoing based on Figure 3.29 thus if the BRT lanes are planned at center of the road, the improved road on the project shall be demolished.



Source: Katahira & Engineers International, JICA Study Team edited

Figure 3.28 Typical Cross Section of Ngong Road Widening Project (Phase-1)



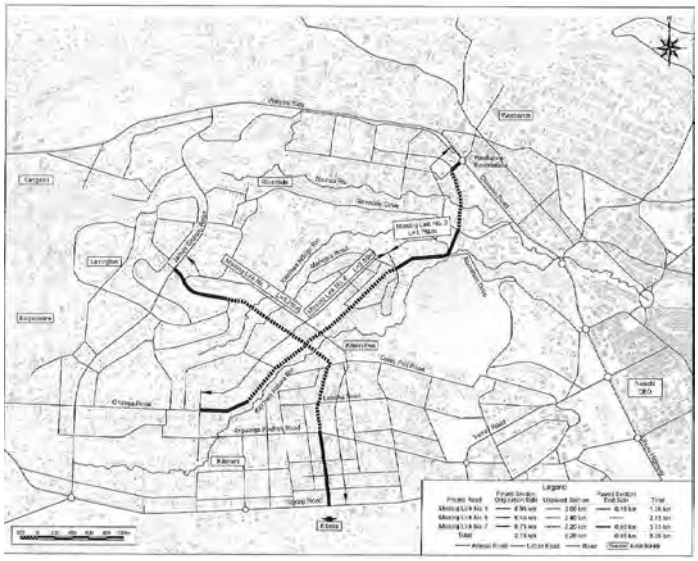
Source: Nairobi Bus Rapid Transit Network Feasibility and Detailed Design of Lines 3 and 4w, EU (February 2016)

Figure 3.29 Typical Section of Ngong Road Widening Project (Phase-1)

6) Pilot Project for ITS

Project Overview

In this project, ITS-based signaling system will be installed at seven interchanges along the Western Ring Road between Ngong road and Westlands which was developed by Government of Japan, as shown the figure below. It should be noted that the improvement of interchanges is not included of the project.



Source: KURA

Figure 3.30 Location of Pilot Project for ITS

- Current Progress

Currently, a consortium by a Chinese firm and a local engineering firm was awarded the contract for the installation of an ITS based signaling system, to be developed on a design-build basis. The project is currently ongoing and will be completed by the end of 2018.

7) Nairobi ITS Project

- Project Overview

The Government of the Republic of Kenya (GoK), through its Agencies, the Ministry of Transport and Infrastructure (MoTI) and KURA has set funds funded by the World Bank (WB) for use in the engagement of the services of a Consultancy Firm in order to undertake the provision of an ITS for Nairobi, named Consultancy services for the design, tender documentation and implementation supervision of an intelligent transport system (ITS) and is associated with civil engineering works for Nairobi County (hereinafter "Nairobi ITS"). The scope covers the area of Nairobi City County to develop a modern ITS.

As per the Terms of Reference the Nairobi ITS shall include the following;

- Traffic signal systems, vehicle detectors and a surveillance system comprising multiple Closed Circuit TV (CCTV) cameras and a communication network.
- A traffic management centre (TMC) to house the equipment and staff to operate the system. Nairobi City County (NCC) has recently acquired a new TMC. This facility will be assessed in terms of its ability to fulfil the requirements of the ITS system being designed under this consultancy assignment.
- Incorporate as required those components and devices that are associated with the upcoming Bus Rapid Transit (BRT).
- A Traffic Management Plan (TMP) that will form a basis for the identification of locations and intersections to be fitted with Traffic Signals and other ITS devices. In accordance with the TMP, junction capacity improvements and other safety enhancements will be quantified.

The project is phased in two phases i.e., Design and Tender Documentation as phase-1 and Implementation Supervision as phase-2. The breakdown the project is summarized in the table below;

Table 3.10 Project Phases on ITS Project

Phases	Duration (Month)	Progress as of May 2017
Phase-I- Design and Tender Documentation	15	Ongoing
Task 1: Development of ITS Plan	11	Ongoing
Task 2: Development of ITS and Civil Works Bidding Documents		Planned
Task 3: Assistance of Client during the Bid Process	4	Planned
Phase-II: Implementation Supervision	66	Planned
Task 4: Supervision of Contractors	24	Planned
Task 5: Training, Oversight and Monitoring	42	Planned

Source: Nairobi ITS (2017) Progress report-1, KURA, JICA Study Team edited.

- Current Progress

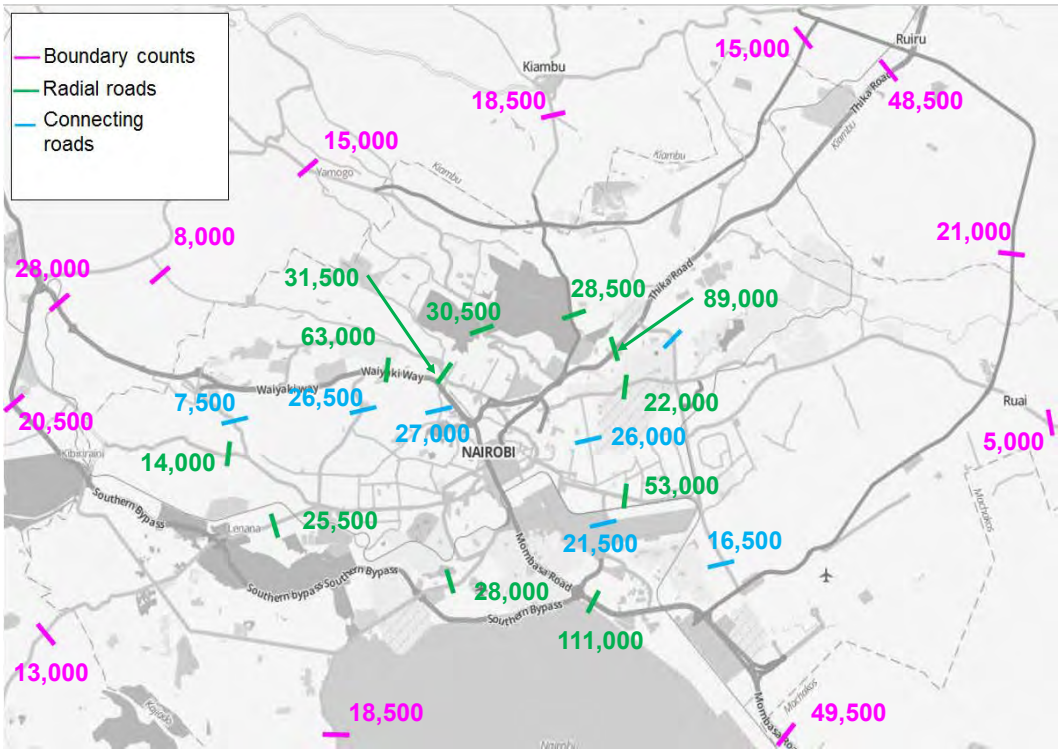
As listed Task 1, the network analysis, namely detailed urban transport network assessment for Nairobi County to understand the current transport patterns and address congestion and safety problems, has examined.

a) Traffic Surveys

In the task, following traffic surveys has conducted;

- Classified direction wise traffic volume counts for selected cross sections

16 hours count was conducted from 6 am to 10 pm in typical working day (Tuesday to Thursday) and 30 section has selected by road location i.e., Boundary counts (12 sections), Radial roads (11 sections) and Connecting roads (7 sections). The counting result is illustrated in the figure below;

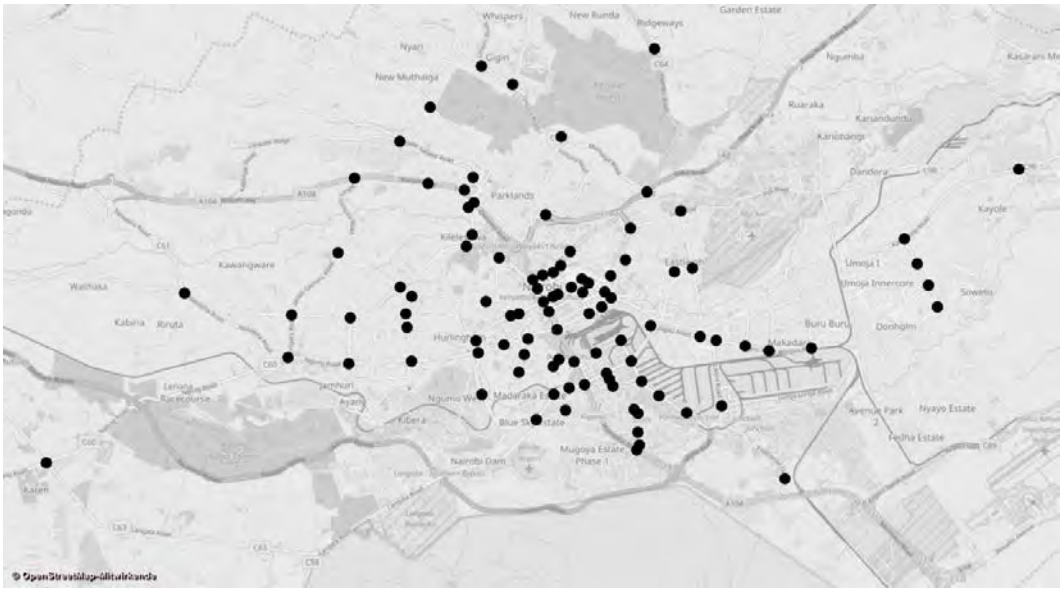


Source: Nairobi ITS (2017) Progress report-1, KURA, JICA Study Team edited.

Figure 3.31 Traffic Survey Result in Nairobi ITS Project

- Turning movement survey

The oversaturated junctions were surveyed by counting peak periods for 4 hours. The locations of the turning movement counts are depicted in the figure below:



Source: Nairobi ITS (2017) Progress report-1, KURA

Figure 3.32 Location of turning movement counts

b) Macroscopic Modeling and the Calibration

The 24 hour Transport Model of Nairobi County for the base year of 2017 has been finalized.

Based on the traffic volumes from the counts, site visits and studying of ongoing relevant projects following steps have been undertaken:

- Traffic Zone Refinement from 119 zones (BRT Study, 2014) to 153 zones
- Adaption of link in the model
- Adaption of node impedance based of site visits with observations and measurements
- Node categorization and setting of capacities

c) Junction Capacity Assessment

The junction capacity assessment is aimed at identifying bottlenecks on the street network and suggesting traffic management solutions. Based on the counts and site visits, with a detailed analysis of all relevant nodes, following approach for the categorization and capacity setting was determined:

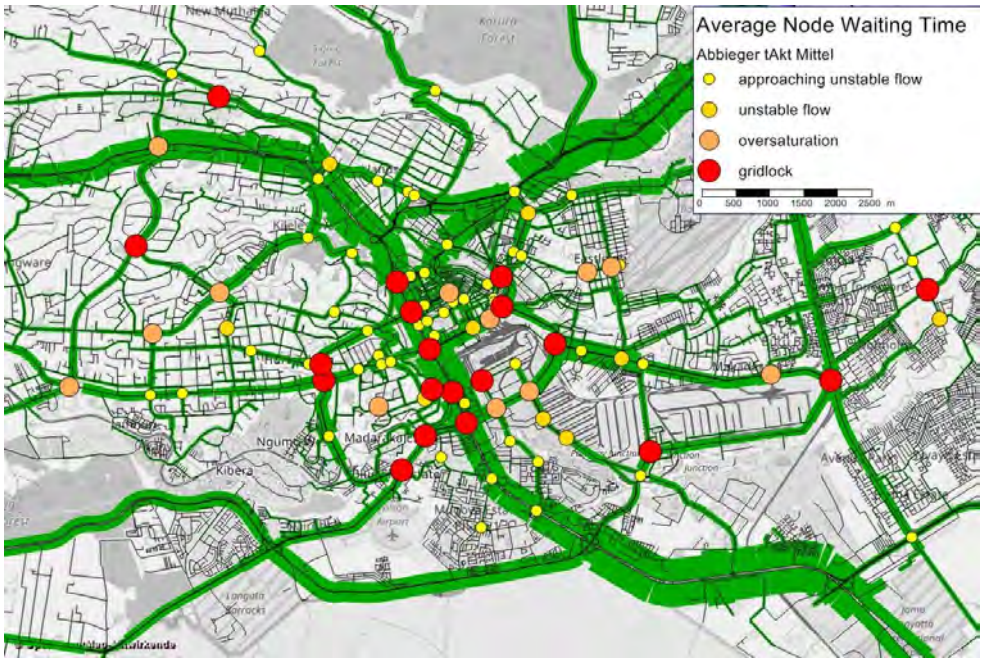
- Classification of junctions into four main types: T-junction, X-junction, Roundabout and complex junction
- Setting maximum capacity and traffic volume of junction and concerned parameters such as turning time

d) Selection of Junctions

The objective of the junction selection is to obtain a stable network with a clear hierarchy and a capacity enlargement on crucial network elements. The selection of junctions was undertaken iteratively based on four criteria's:

- Road hierarchy, which determines the main nodes
- Prior control of main nodes
- Weak-points analysis
- Integration of future projects

According to the calibration and the junction capacity analysis, junctions in NMA are categorized in four types by severity of congestion.



Source: Nairobi ITS (2017) Progress report-1, KURA

Figure 3.33 Nodes with Critical Waiting Times

The selected junctions (98 nodes) were presented and accepted without objections from the Client in the workshop 1 meeting held in 12th April 2017.

Further Steps

Task 1: Development of ITS Plan is ongoing but the other tasks are yet to be conducted. The commencement date is yet to be given. Although the planned project period is unknown, phase 1 shall be finalized in 2018.

3.2.4 Non-Motorized Transport

In May 2009, "Non-Motorized and Intermediate Means of Transport Policy" (NMIMTs) was established as a part of the policy paper on "Integrated National Transport Policy for Kenya" implemented by Ministry of Transport. This policy paper identifies a number of challenges inhibiting the transport sector from performing its role in respect to national, regional and international economics.

After 6 years of NMIMTs, the Non-motorized transport (NMT) policy was established as a joint initiative of UNEP and the Nairobi City County to improve the transport sector performance by promoting the Non-motorized transport mode.

The former policy covers both of urban and rural areas in Kenya and the latter policy covers Nairobi urban area.

3.2.4.1 Non-Motorized and Intermediate Means of Transport Policy

In this policy, NMT is including walking, wheelbarrows, hand-carts, animal transport (horses, camels, donkeys, mules and oxen as beasts of burden), animal-drawn carriages (such as sledges), bicycles and tricycles to transport passenger and freight.

This policy paper described the critical issues and policies of NMIMTs and expressed about the background of urban area that;

"In the urban areas, public transport is unaffordable to many members of working households, and indeed to many workers and their families, leading to low productivity and the drudgery of walking for most of them. Distances that can be covered on foot are also short, averaging about 5 km on each trip.", "In Nairobi, for instance, 60 per cent of the residents meet their daily travel needs by walking while 35 percent travel by public transport (mostly matatus and buses) and only 5percent use private cars."

3.2.4.2 Non Motorized Transport Policy

1) Vison and Objective

"Non Motorized Transport Policy" (NMTP) which is mainly focusing on the walking and the cycling in Nairobi urban area was established by NCCG in March 2015. The vision, objective and expected outputs and outcomes of this policy are mentioned in Chapter 4, clause 4.2 of NMTP as transcribed below.

"This NMT policy aims to develop and maintain a transport system that fully integrates NMT as part of the Nairobi transport system. This Policy will help in creating a safe, cohesive and comfortable network of footpaths, cycling lanes and tracks, green areas, and other support amenities. Further, it will put in place laws and regulations to ensure that NMT facilities and areas are not encroached by the MT[5] modes and other street users.

The Vision of the NCCG with this policy is: to be a County where NMT is the mode of choice for short and medium trips[6]."

[5] Motorized means of transport

[6] Pedestrian trips up to 5km; and cycling trips up to 15 km. Basically trips that can be made within one hour.

Table 3.11 Outputs and Outcomes of the Policy

Objective	*Output*	*Outcome*
1. Increase mobility and accessibility;	*Safe and cohesive pedestrian facilities (footpaths, etc.) from 500. km to 1,500 km by 2020*	*Increased modal share of walking from 47. to 50for trips up to 5km by 2025;*
	Cohesive cycle network of lanes, tracks and destination facilities from 50km to 1,000km by 2020.	*Increased modal share of cyclists from 2% to 10% for trips up to 15km by 2025;*
	NMT facilities along and at major PT routes and terminals from 500 to 1,500By 2020.	*Increased modal share of public transport from 32 to 35for all trips by 2025;*
	Nairobi Streets and Roads Design Manual (NSRDM) is developed by 2017.	*All roads within the County shall fully comply with the specifications of the NSRDM by 2025.*
2. Improve transport safety and security;	*Safe NMT crossings:* *Pedestrian signals from 185 to 500.* *Footbridges and underpasses from 27 to 50.* *Marked and visible crossings from 150 to 500 by 2020;* *Working street lights from 30,000 to 65,000 by 2020.*	*Reduced pedestrian fatalities from 500 to 50 or less by 2025.* *Reduced cyclist fatalities from 20 to 5 by 2025.*
3. Improve amenities for NMT;	*No of benches, No of repair shops; No of stores; etc.*	*Level of Service (LOS) rating of streets improves from D to B by 2025.*
4. Increase recognition and image of NMT in Nairobi	*Percentage of road users considering NMT as a mode for the poor reduces by 40% by 2020.*	*Diverse income groups using NMT as a mode of choice.*

Source: Non Motorized Transport Policy (NCCG, March 2015)

In addition to the vision, objective and expected outputs and outcomes of NMTP, Chapter 4 includes the explanation about the categories of policies and the plan which the NCCG will do on each policies.

Table 3.12 Categories of Policies

Category	Description
Enabling policies	Funding policy Planning policy Engineering and design policy Maintenances policy
Supporting policies	Motor vehicle parking and restrictions policy Traffic calming measures policy Convenience facilities to support NMT policy Integration of NMT with other means of transport policy Education and promotional activities policy Regulation and enforcement policy Monitoring and evaluation of the policy.

Source: Non Motorized Transport Policy (NCCG, March 2015)

2) Implementation Action Plan

Implementation action plan is described in Chapter 5. In clause 5.1 introduction, the following six requirements to improve and sustain the long term travel condition and for NMT are described.

i. Better transport planning, construction and maintenance of infrastructure and facilities that meet the five NMT user requirements ((1) Safety (and security); (2) Directness, (3) Coherency; and (4) Comfort; and (5) Attractiveness) as much as possible

ii. Improving traffic safety through traffic calming

iii. Enforcement of traffic laws and regulations

iv. Other interventions include providing NMT users with information on how to safely use the roads

v. Integration with motorised means of transport

vi. Management of mortised vehicles to release space for NMT in selected areas

Detailed implementation action plan is planned as its summary is described in the table below.

Table 3.13 Implementation Action Plan

Action	Description
Implementation Committee	After the launch of the Policy, the NCCG should immediately take up the responsibility of setting up a "Steering Committee" to implement the policy.
Funding arrangement	It is proposed that a special NMT Fund should be created to address the backlog until such time that NMT becomes an integrated part of the Nairobi transport system.
Priority Policy Actions	After adoption of the Policy, and formal launch of the Steering Committee, implementation of the following policy actions is considered to be of priority as they are essential to the overall implementation of the Policy. a. Development of a Nairobi Streets and Roads Design Manual (NSRDM) b. Data collection to help in identifying problems, designing interventions, prioritizing projects and monitoring progress c. Development of master plans for pedestrian, cyclists and human-drawn carts d. Development of the Highway Code and other materials for education and publicity campaigns e. Passing the necessary by-laws to enable proper planning, effective enforcement, adequate funding and effective land use planning and control. Implementation of a "Quick Wins" package and pilot infrastructure projects should also be part of the Short Term Action Plan (STAP) and undertaken in parallel with the actions above.
"Quick Wins" Package	The "Quick Wins" package may be described as interventions that can be implemented in a short time using existing general information, using small investments at many locations, and having high easily measurable immediate impacts. For Nairobi, the package should include interventions that address safety of NMT users (especially pedestrians and school children); security along the routes; and elimination of missing links (detours) and barriers.
Pilot Projects Package	Two NMT route pilot project packages are proposed. In addition, pedestrianization of the CBD should be in the priority package.
Investment Matrix for the STAP	The time frame for implementation of the STAP is 2 years starting in 2015.

Source: Non Motorized Transport Policy (NCCG, March 2015)

3) Present condition and issues of NMT

The present condition and the main issues of NMT as well as the road traffic and public transportation in Nairobi are described in Chapter 1 in NMTP. Chapter 2 of which title is "Non Motorized Transport survey findings and main challenges in Nairobi" provides the findings from a survey of NMT issues along Jogoo road and Juja road corridors and the consultation between NMT users and stakeholders. Furthermore, In Chapter 3 "Non Motorized Transport User Characteristics and Supplier Requirement", the requirements from the NMT user and supplier are described.

Since chapter 1, 2 and 3 will help with the for understanding of the situation of NMT in Nairobi, the main points of these chapters are described below.

Chapter 1

(a) Situation of road traffic and NMT
- Walking and public transport are the main means of transport in Nairobi. The private car only accounted for about 15% of all trips, but dominates in numbers on Nairobi roads and streets. Traffic congestion is mainly due to rapid increase in car ownership and use.
- The public passenger transport is operated by the private sector, mainly low-capacity minibus vehicles (matatus). The matatus were estimated to be more than 60,000 in number and moved about 3 million passengers per day in 2004.
- NMT is the dominant transport mode in Nairobi accounting for over 40 % of the total trips made per day.
- High accident rates among pedestrians may be a good indicator of how it is unsafe to use NMT in Nairobi. Road accidents data for 2014 shows that out of 723 fatalities, some 507 (70%) were pedestrians, followed by passengers at 101 fatalities (14%).

(b) Issues of road traffic and public transport
- There is poor network coverage and no dedicated facilities for public transport so they compete for the same congested road space with other vehicles.
- Public transport travel times are long and unpredictable.
- Control of traffic is mainly manual, and where traffic signals are operational, they are interrupted by the traffic police. Many roads still have the same layouts while the existing traffic volumes now call for a change in their shape to ensure their function in the network is performed.

(c) Issue of land use plan
- Land use planning and development control is weak and do not encourage compact land use.

(d) NMT issues caused by the issues of road traffic, public transport and land use plan.
- Stiff competition among public transport operators creates unsafe and aggressive driving behaviour. NMT users are exposed to fast, aggressive and high MT volumes with the consequences of high traffic accidents.
- Encroachment of NMT spaces by MT and public transport is rampant.
- Vulnerable road users, women and children have difficulties travelling without assistance.
- The current land use encourages increasing trip distances making the use of NMT and public transport less attractive.

Chapter 2

(a) Characteristics of main NMT users in Jogoo road and Juja road corridors (Abstract)
- Most pedestrians (70 %) were male and most trips were home-work trips. Reasons for being attracted to NMT modes were noted mainly as cost (52.9%) and convenience (32.2%).
- Majority (58.8 %) of the pedestrians earned less than KSh. 20,000 (US$225) per month, and walking seemed to decline sharply with increased income.
- The majority of the cyclists were male (96.9%) and a large number of them were within the age brackets of 18-45 years. A majority (92.3%) of the cyclists interviewed owned a bicycle. Most of those who owned bicycles or tricycles (61.5%) used them to run personal errands, although an equally significant number (32.3%) used them for commercial purposes.
- The major motivations for cycling were: low cost/cheaper (47.4%), convenience (28.4%) and speed/faster (17.9%).

(b) Characteristics of Trips using NMT mode in Jogoo road and Juja road corridors (Abstract)
- Trip purposes among pedestrians were listed as going to: work (71.5%), home (12.7%), school (7.6%), shop (4.4%) and for recreational purposes (2.5%).
- Among the most common purposes for cycling included attending personal business (28%), going to work (28%), and taking children to school (8%). The results also showed very limited use of cycling to the central business area.

- Nearly all those who cycled to their destinations (98.5%) covered the entire distance cycling without shifting to any other mode of transport.
- Cycling routes: 81.5% observed that the main criterion for selecting a route was its directness to the destination. Only 4.6% considered the safety of the route, while another 6.2% considered the existence of cycling-friendly infrastructure.

(c) NMT issues caused by insufficient infrastructure and not being respected by MT users (Abstract)

- Pedestrians and NMT infrastructure seemed to be not respected by motorists. The motorists do not give way along pedestrian crossings, do not respect traffic lights and often encroached on pedestrian facilities.
- Usage of existing NMT facilities were found to be fairly low as only 27.2 % were using pedestrian crossing regularly, 23.5 % using overpass regularly and only 13.2 % were using assisted crossing regularly. The reasons for not using the facilities were listed as unmarked (42.6%), indirect (30.1%), non-existence of the facility (19.1%) and the unsafe status of the facilities (5.9%).
- Other factors making walking unpleasant were noted as motorist and human traffic congestion (21.3%), insecurity (22.9%), air and noise pollution from vehicles (15.4%), insecurity (13.6 %), poorly maintained roads (11.8 %) and obstruction of walkways (7.1 %).
- Up to 89.2% of the respondents observed that there was no supportive infrastructure for cycling along the respective corridors that they used. A small number of the respondents indicated that the cycling infrastructure they used was either tarmacked (26.2%) or paved (17.5%). The rest complained of cycling infrastructure that is congested (11.7%), rugged (7.8%), narrow (13.6%) and unfriendly for physically challenged people (7.8%).
- A large number of cyclists (78.5%) felt that motor vehicle drivers did not respect them on the road and 73.8% of cyclists felt that available NMT facilities were not maintained.

(d) NMT Problems and Challenges from the perspective of stakeholders (Abstract)

- Motorcycles providing public transport and cyclists have no training; flout traffic rules.
- Driver training is poor and spot checks on competence required.
- Demarcation of lanes for NMT disappears quickly due to poor quality materials and lack of maintenance.
- Poor transport planning: No plans for NMT or NMT considered last in planning & design stages
- Roads are congested and there are no spaces for NMT users: spaces taken up by kiosks sanctioned by NCCG. Therefore, MT and NMT using the same space resulting into many accidents.
- Dust and pollution are also problems.
- Walkways may be there but not cleared like MT lanes: walkways should be attractive.
- NCCG may not be able to cope with NMT in future as the volumes are growing very fast.
- Foot bridges do not cater for the elderly and MT do not stop/give way to the elderly.
- Tolerance for pedestrians is lacking: capacity building of MT drivers required.
- Street lighting not functional.

Chapter 3

(a) NMT User Requirement (Abstract)

- It can be concluded that there are five main requirements that NMT users would like met: (1) Safety (and security); (2) Directness (3) Coherency; and (4) Comfort; and (5) Attractiveness is considered as the fifth requirement by those who have other modal choices, like private car users.
- It refers to conducive surrounding environment such as shades; landscaping; clean streets; and parks along routes.
- Safety is a key requirement to the use of any transport mode, especially for pedestrians in Nairobi who have to share the same space with fast moving motor vehicles at crossings.
- Directness means that the route or crossing provides the NMT user with the shortest and less

cumbersome link between his/her origin and destination. Delay at signalized and un-signalized crossings due to waiting for pedestrian green phase/adequate gaps in the MT traffic stream are elements of directness.

- Coherency means that the NMT route/lane must have no gaps or missing links between the origin and destination. Missing links can be unpaved and muddy sections; lack of a bridge; dug up lanes due construction works; and lack of facilities along the route (repair chops, convenience facilities).
- Comfortable NMT movement means minimal hindrance by other users (less congestion); smooth and stable and clean road surface; fair gradients; proper waiting areas at bus stops and crossings; and convenience facilities along the route.

(b) Supplier Requirement(Abstract)

- NMT infrastructure should be designed using accepted standards and should require low maintenance. A national NMT design manual is urgently required.
- Kenya has no long historical tradition of providing and maintaining NMT facilities (at national level), It is therefore necessary to progressively build the required confidence and capacity through pilot NMT projects.
- Like other public investments, NMT infrastructure should be subjected to basic economic analysis to determine its feasibility and help in ranking the projects in terms of internationally accepted economic indicators.

3.2.4.3 The subject of NMT in on-going projects in Nairobi

1) BRT Projects

According to the Feasibility and Detailed Design of Line 3 and 4W (February 2016, Ingerop), the preferred location for the BRT dedicated lane is at the centre of the carriageway and the low-floor articulated bus will operate with high frequency.

Improvement of public transport is vital for NMT users.

Meanwhile, according to Share of the Road: Design Guidelines for Non Motorized Transport in Africa (UNEP, 2010), it is said that "Raised crosswalks or elevated zebra crossings make the pedestrian surface continuously and obstacle free. This type of crossing also necessitates motor vehicles to go up a ramp above the roadway, which reduces their speed."

Raised crosswalk will influence the operation speed of BRT, and damage the comfort of the passengers of BRT.

2) ITS Projects

The roundabout with multi-lane approached create problems for NMT user as vehicles turn continuously without reducing speed. According to the consultant who conducts ITS Project under KURA, some roundabouts will be changed to the signalized intersection as a consequence of the Weak-Points analysis and junction capacity assessment. The signalized intersection will mitigate the problems of NMT user at crossing the street. ITS projects will contribute to NMT user, too.

3) Green Mall Projects

According to the consultant who is conducting the Green Mall Project under KRC, the pedestrian walkway connecting the developing area to CBD is proposed. NMT is being taken into account in this project.

3.3 Environmental Sector

The projects of the transport sector in the Nairobi Urban Core include construction of the loop line as well as road improvement projects related with BRT, commuter rail plan, and construction of viaducts and road expansion related with NIUPLAN. Of these, some projects are in the process of Environmental Impact Assessment (EIA) studies and some have already obtained EIA licenses. According to the hearings with relevant donors and project executing agencies, however, NIUPLAN is the only master plan that carried out the Strategic Environmental Assessment at its planning stage. NEMA approves that SEA of NIUPLAN applies to projects on infrastructures within the Nairobi Metropolitan area, thus allowing transition to initiate the process of EIA without conducting a new set of SEA.

The implementation status of the studies for environmental and social considerations for the transport sector in the Nairobi Urban Core is as follows.

Table 3.14 Implementation Status of the Environmental and Social Consideration Studies for the Transport Sector Projects

Transport Sector		Project	Master Plan	Implementing Institution	Assisting Institution	Environmental and Social Studies			Remarks
						SEA	EIA	RAP	
Mass Transit System	Public Transport	BRT Line-1(Lot 1)	NUITRIP	KeNHA	WB	×	N/A	○	Design Stage
		BRT Line-1(Lot 2)	NUITRIP	KeNHA	WB	×	N/A	N/A	Design Stage
		BRT Line-1(Lot 3)	NUITRIP	KeNHA	WB	×	○	○	Design Stage
		BRT Line-2	—	—	—	×	N/A	N/A	
		BRT Line-3	—	—	EU	×	△	△	F/S Stage
		BRT Line-4	—	—	EU	×	△	△	F/S Stage
		BRT Line-5	—	—	AfDB	×	○	○	
		Loop Line	NIUPLAN	NCCG	JICA	○	–	–	NIUPLAN SEA
	Railway	SGR Project	—	KRC	China	×	○	○	EIA Pending
		Commuter Railway Master Plan	NUITRIP	KRC	WB	×	–	–	Planning Stage
Road Improvement		A104 Highway	NUITRIP	KeNHA	WB	×	△	△	Procurement
		Lukasa Road turning into dual carriageway	—	KURA	EU	×	N/A	N/A	Under Construction
		Enterprise Road turning into carriageway	—	KURA	EU	×	N/A	N/A	Under Construction
		Likoni road turning into dual carriageway	—	KURA	EU	×	N/A	N/A	Under Construction
		Muratina street upgrading and enhancement	—	KURA	EU	×	N/A	N/A	
Road Improvement		Quarry road turning into dual carriageway and extension road and Acca road extension	—	KURA	EU	×	N/A	N/A	
		Footpath/cycleway alongside Rabai and Muimas South Road	—	KURA	EU	×	N/A	N/A	
		Dualing of Ngong Road	—	KURA	JICA	×	N/A	N/A	
		Nairobi Viaduct & Road Construction	NIUPLAN	KURA	JICA	○	△	△	NIUPLAN SEA
		Selected Road and Green Mall Street Bus Station	NaMSIP	MoLH&UD NCCG, KRC	WB	×	△	△	
		Jogoo Road Interchange with future Implementation of BRT	—	KURA	Brasil	×	N/A	N/A	
		Intelligent Transport System and Civil Engineering Works in NCCG	NaMSIP	KURA	WB	×	N/A	N/A	
		Decongestion of CBD in Nairobi	—	NCCG	GoK	×	–	–	Planning Stage

NOTE: ×=will not implemented, ○=implemented, △=being implemented or plan to be implemented, N/A=Not Available
Source: JICA material reorganized by JICA Study Team

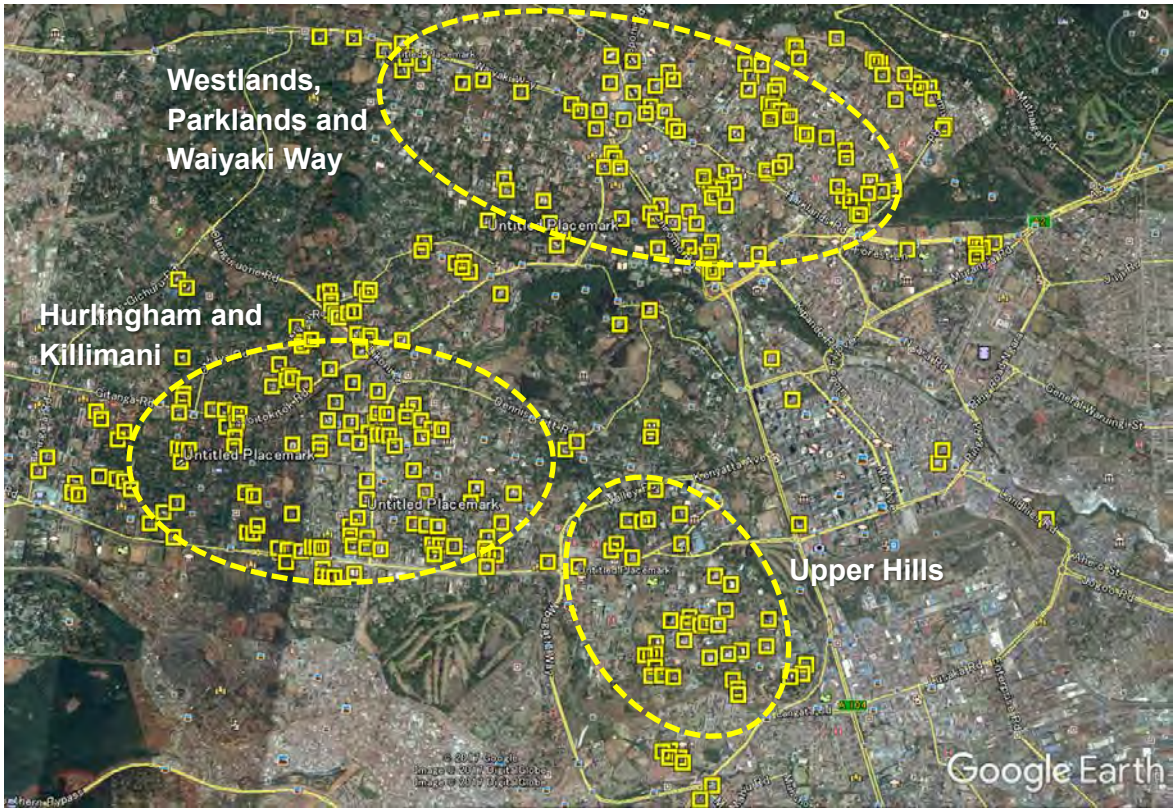
3.4 Sector Issues

3.4.1 Urban Development

1) Mushrooming Development Activities without Detailed District Plan

During last decade, Development activities in Nairobi were mushrooming especially in three areas such as i) Upper Hill, ii) Westlands, Parklands and Waiyaki Way, and iii) Hurlingham and Killimani.

In Upper Hill, many high-rise offices and commercial buildings have been constructed changing the skyline of Nairobi. Hurlingham and Killimani estates were detached low-rise and low density residential area with half to one acre of plot area, and now it has been changing to mid-rise apartment and office buildings. Westlands and Parklands area were historically for Indian-African residents' estates. Now mid-rise apartment and office buildings have sprung up especially along the Waiyaki Way.



Source: JICA Study Team Google Earth (Image © Digital Globe),

Figure 3.34 Location Map of Urban Development Activities in Past 10 Years

According to a series of interviews with realty dealers, development planners and consultants, recent skyrocketing land price has been affecting real estate market to make more high-rise building necessary to recover its extremely high land cost. This situation has been causing high demand for more FAR (floor area ratio) does not fit existing development ordinance. County government has been facing high pressure from developers and landlords to have more FAR for their buildings.

2) Necessity of Updated Development Ordinance as soon as possible

Before year 2000, the realty market in Nairobi yielded very low due to African economic slump in the 1990s. However, with sustained economic recovery and progressive growth in year 2000, western area of Nairobi has experienced catapulted development. [7]

NCCG have a development guideline and zoning so called "A Guide of Nairobi City Development Ordinance and Zones" which was effected in 2004.

3) Necessity of Detailed Spatial Plans

Under the County Integrated Development Plan, County Sectoral Plans and County Spatial Plans were developed. However, more detailed spatial plan shall be necessary to harmonize transportation plan and urban development to avoid future conflict among related sectors.

3.4.2 Transportation

The long history of MRT proposals since 1990s substantiates the importance of MRT installation in Nairobi and its corridors, and the basic structure of the MRT network is similar among the proposals. It can be said the major 5 alignments proposed by the Harmonization Study was done with simple (rather primitive) analysis than NIUPLAN, however, the proposed alignments by the Harmonization Study are comprehensive, and there are no major differences in passenger traffic estimation from NIUPLAN, and the 5 alignments are already approved by the administrative process. The two feasibility-analyses for BRT Line 1, and 3+4W did not show any PPHPD, however, the estimated PPHPD for Line 3 and 4W seems too high to be handled by BRT. The both studies shows its detail planning on the traffic arrangement in CBD how to maintain the traffic flow in peak hours, however, each study have analyzed based on its own BRT loading in the CBD, there is no analysis how the CBD will be paralyzed by accumulated BRTs of both the Line 1 and the Line 3 as well as private cars.

The followings are lessons to be considered in this study in later stage.

- Little Concern to Matatu Industry in Feasibility Studies

People do not understand how the matatu service invaded the existing bus services and changed the life of commuters. Background of Matatu services are strong, politically connected with police industry, and its population can influence to politics. The BRT system can strike back to the matatu invasion, but it may produce another confusion.

The affiliate industry of Matatu, e.g., bus body mounting services, seat production, painting, safety compliance are also large economy in Nairobi, and ignored in the feasibility analysis.

- Little compliance with the Poly-Nuclear Development Policy in NIUPLAN

All BRT alignments and all rail alignments are connected in the CBD and downtown, other than BRT Line 5. It can be said the assumption of day time population biased to CBD in the NIUPLAN has influenced to such high concentration of transport service planning in CBD. The assumption can be amended based on recent development in Upper Hills, Westlands and Railway Cities.

- Traffic control in CBD, Line 1 and Line 3+4 crossing

[7] A. Mwaura 2006, Policy Review for Zones 3, 4 and 5, Nairobi, Kenya

Repeating, there is no analysis how the CBD will be paralyzed by accumulated BRT of both the Line 1 and the Line 3 as well as private cars. Particularly, E-W crossing points along the Uhuru highway will be critical unless flyovers will be constructed from Haile Selassie Avenue to Kenyatta Avenue.

- Little Concern to Commuter Railway Services

This can be commonly pointed to the NIUPLAN and Harmonization study. Compared of the estimated sectional loadings of the rail and buses, rail carries only 100 thousand passengers instead bus carries more than 300 thousand passengers. If the planners expect much possibility on the buses on surface, why don't we make the existing rail modified to BRT to carry 300 thousand passengers? At least, the rail is existing, rail has land, and more potential for further improvement.

- Little Concern to Ordinary Bus Services

The Harmonization Study tells that 70% of the public transport demand in Nairobi in 2030 should be handled by services other than BRT, i.e., buses, matatus, or taxis. However, there are no studies for Nairobi transport suggesting any improvement program of the ordinary buses and matatu. There are several potential aspects for improvement of buses as follows;

- vehicle location; real-time bus location services could be installed for buses, to inform operation status to passengers.
- cashless payment; Kenyan Government tried to install but failed before, but can realize efficient passenger loading and farebox management
- vehicle design and facility design; another design to realize efficient passenger loading and unloading could be adopted to some routes, and
- timetable-based operation;

- NaMATA roles and the challenges

NaMATA was established in February 2017 to manage and coordinate the overall urban transport projects within the Nairobi Metropolitan Area (NMA). As of September 2017, the authority has not filled all the positions, and the number of staff is less than ten. As a result, it has not been able to perform the duties specified in the NaMATA order. Whilst NCCG is responsible for the area of Nairobi City only, NaMATA is playing a role in managing all the entire area of NMA. In order to provide an integrated transport system in the Nairobi Urban Core, the capacity of NaMATA needs to be improved through the provision of technical assistance by transport planning experts.

3.4.3 Environment

Various issues related to the projects are prescribed from the aspects of three categories, socio-economic, political and environmental.

a) Socio-economic and Cultural Issues

This project is listed as part of the Priority Program in the NIUPLAN and its targets include improving the economic and social situation of the stakeholders such as residence and business persons in Nairobi City County. Specifically, it involves:

- Improving the transport conditions for commuters and business persons in NUC and

surrounding district

- Promoting the development of the area associated with residential, commercial, industrial and agricultural sectors
- Revitalizing regional agriculture, commerce and industry
- Contributing to challenges for poverty
- Improving hygiene, sanitation and safety conditions for regional society

The project can be expected to contribute to indirect positive impacts on the quality of life for the local by boosting regional economy with an effective transport system in Nairobi City County.

b) Political Issues

The key political issues to be considered when executing this project are:

- Reinforcement of government policy to development and rehabilitation of road networks
- Reinforcement of decentralization of traffics by promoting the mobility of people and products
- Establishment of definite demarcation for political commitments between National and County Government relevant to transport systems in NUC
- Reinforcement of environmental regulation to protect natural resources

c) Environmental Issues

The environmental issues are as follows:

- Emission of dust and noise nuisance
- Discharge of hydrocarbons and other products on rivers and ground water
- Land acquisition and resettlement requirement
- Destruction of flora and fauna triggered by expansion of areal development
- Development disorder of land use
- Deterioration of solid waste management

3.5 Project Database

1) General

As discussed until Sub clause 3.4, not all the projects are monitored with one platform so far and that is one of the reason why various projects are on-going with little coordination with each other by various donors. In this study, the project database namely, project monitoring platform in other word, will be created by using GIS system.

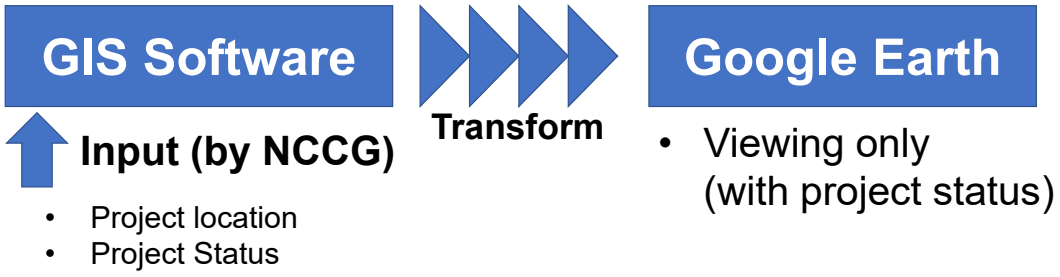
Project progress shall be shared with concerned stakeholders and JST proposed to monitor on-going project by Google earth. The software is free of charge however, it is difficult to input project information. It is easy to input project information by GIS software, instead. The comparison of the software is summarized the table below;

Table 3.15 Comparison between Google Earth and GIS Software

	Google Earth	GIS Software
Advantage	-Free software -Easy to use -Built-in Satellite image	-Easy ways to input detailed information -Variety of accepted format (shp, kmz…) -Spatial analysis (next slide)
Dis-advantage	-Difficult to input detailed data	-Expensive -No satellite image built-in

Source: JICA Study Team

Therefore, JST proposed separated system the data input and the monitoring. Proposed structure to utilize the database is illustrated as the figure below.



Source: JICA Study Team

Figure 3.35 Proposed Structure of Project Database Operation

Projects included in the database are listed in Table 3.16.

Table 3.16 Projects in GIS Database

No	Project Title	Organization
1_	Mass Transit System: Public Transport	
1-1_	Lot 1 (Mombasa raod) Imara Daima - Nyayo Stadium	KeNHA
1-2_	Lot 2 (Uhulu highway) Nyayo Stadium - Univ. way RA	KeNHA
1-3_	Lot 3 (Waiyaki way) Univ. way RA - Kangami	KeNHA
1-4_	Line 2 East (Thika road): CBD - Ruiru	KeNHA
1-5_	Line 2 West (Langata road): Bomas Kenya - CBD	KeNHA
1-6_	Line 3 East (Juja road): CBD - Njiru	KURA
1-7_	Line 3 West (Ngong road): Show ground - CBD	KURA
1-8_	Line 4 West: T Mall - City Stadium	KURA
1-9_	Line 4 East: City Stadium - Mama Lucy	KURA
1-10_	BRT Line-5: Balozi - Imara	KURA
1-11_	Loop Line Project	NCCG
2_	Mass Transit System: Railway	

No	Project Title	Organization
2-1_	SGR Project	KRC
2-2_	JKIA Project	KRC
2-3_	Construction of stations	KRC
2-4_	Meter Gauge Track Improvement	KRC
2-5_	Commuter Railway Master Plan	KRC
3_	Road Improvement	
3-1_	A104 Highway	KeNHA
3-2_	Lusaka Road turning into dual carriageway	KURA
3-3_	Enterprise Road turning into dual carriageway	KURA
3-4_	Likoni Road turning into dual carriageway	KURA
3-5_	Muratina street upgrading and extention	KURA
3-6_	Quarry Road turning into dual carriageway and extension Road and Accra road extension	KURA
3-7_	Footpath/cycleway alongside Rabai and Mumias South Road	KURA
3-8_	M-15 Road Constsuction	KURA
3-9_	The Project for Dualling of Ngong Road (Phase-1)	KURA
3-10_	The Project for Dualling of Ngong Road (Phase-2)	KURA
3-11_	The Project for Dualling of Ngong Road (Phase-3)	KURA
3-12_	Nairobi Viaduct and Road Construction Project	KURA
3-13_	Selected Roads and a Green Mall Street Bus Station in the Nairobi Railway Station and its Surroundings	MoLH & UD, KRC, NCC
3-14_	Jogoo Road Interchanges with a future Implementation of a BRT	KURA
3-15_	Intelligent Transportation System (ITS) and associated Civil Engineering Works in Nairobi County	KURA
3-16_	Decongestion of CBD in Nairobi	NCC
3-17_	Rehabilitation and Upgrading of Upperhill Roads Phase 1	KURA
3-18_	Construction of Missing Link roads and Non Motorized Transport (NMT) facilities in Nairobi	KURA
3-19_	Nairobi Outering Road Improvement Project	KURA
3-20_	Construction to Bitumen Standards of Ngong Road-Kibera-Kungu Karuma-Langata Road (Missing Link no.12)	KURA
3-21_	Construction to Bitumen Standard of Waiyaki way-Redhill link road	KURA
3-22_	Upgrading to Bitumen Satndards of Githurai-Kimbo Road (phase 2)	KURA
3-23_	Rehabilitation and Upgrading of Eastleigh Roads phase 2	KURA
3-24_	Construction of access to Embakasi (infinity) Industrial park	KURA
3-25_	Construction of Access Road to Ruai Police Station	KURA
3-26_	Rehabilitation and Upgrading of Upperhill Roads Phase 2	KURA
3-27_	Upgrading to Bitumen Standards of Lenana - Muchugia-Dagoretti Market Link Road	KURA
3-28_	Nairobi Roads Rapid Decongestion Programme (LOT 5); improvement of Junctions: Mbagathi Way/Mbagathi Road Mbagathi Way/access to Montezuma Funeral Home Lang'ata Road/Mai Mahiu Road Junction Langata Road/Access to Carnivore Langata Road/Access to Langata estate. Rehabilitation of Nyumba Moja and Muiri Road	KURA
3-29_	Nairobi Roads Rapid Decongestion Programme (Lot 6); Improvement of junctions; Argwings Kodhek,Ralph Bunche and Woodlands roads)	KURA
3-30_	Nairobi Roads Rapid Decongestion Programme phase 2-(Lot 7) Improvement of Dagoretti Corner Junction	KURA
3-31_	Nairobi Roads Rapid Decongestion programme phase 2-(Lot 9)	KURA
3-32_	Improvement of Kigwa Close	KURA
3-33_	Improvement of Kanyagia Drive	KURA
3-34_	Improvement of Forest View (Part)/Farah(Part)/Begonia(Part) and Lower Plains Road	KURA
3-35_	Improvement of Road C	KURA
3-36_	Improvement of Pepo Lane	KURA
3-37_	Missing Link Project (Ring Road Parklands)	KURA
3-38_	Missing Link Project (Eastleigh First Ave.)	KURA
4_	Land Development	
4-1_	Nairobi Viaduct and Road Construction Project	KURA
4-2_	Redevelopment of the Nairobi Central Railway Station and its Surroundings	MoLH & UD, KRC, NCC
4-3_	Selected Roads and a Green Mall Street Bus Station in the Nairobi Railway Station and its Surroundings	MoLH & UD, KRC, NCC
4-4_	Multi-storied car park at the Sunken Car Park land	NCC
4-5_	Wakulima market relocation to Eastlands	NCC
4-6_	Eastland Urban Renewal Project	MoLH&UD, NCC
4-7_	Interdisciplinary Land-Use and Transport Metropolitan Analysis within the Nairobi Metropolitan Region (ILUT)	MoLH&UD

Source: JICA Study Team

The data shall be as simple as possible, since it will be updated by counterparts after completion of the project. The format of the project is shown the Table 3.17. The detail of the project list by the form is summarized in Appendix 3.

Table 3.17 Project Database Format

Mode and/or Project Type	No	Project Title	Superordinate Project	Organization	Fund	Status	Description & Remarks
1. Mass Transit System: Public Transport							
2. Mass Transit System: Railway							
3. Road Improvement							
4. Land Development							

Source: JICA Study Team

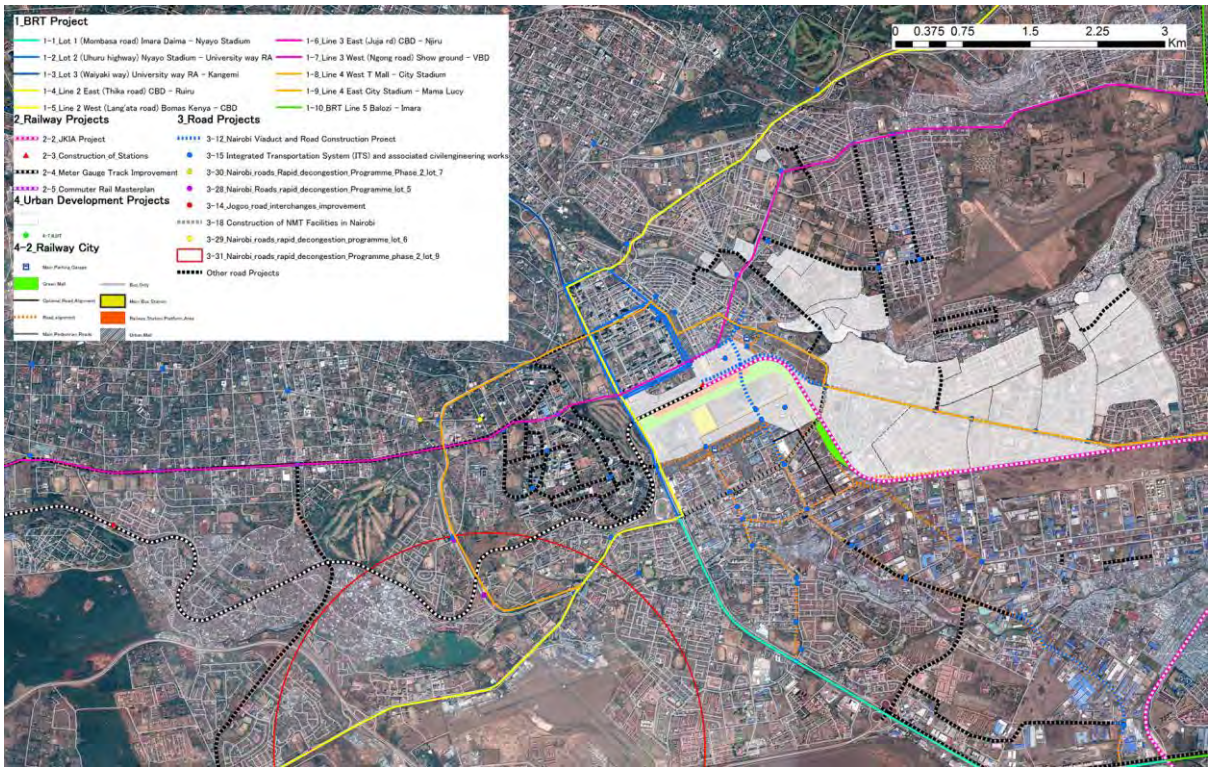
The project status shall be updated in the study period by JST and it shall be continuously updated by NCCG. In 19th December 2017, a workshop on how to update project database was held and the entire system was transferred to NCCG with the manual. However, it is essential to train an officer on how to update continuously so that it can be used after the completion of this project. The manual is attached as the Appendix 4 in the report.

Source: JICA Study Team

Figure 3.36 Snapshot in the Workshop of Project Database held in 19th December 2017

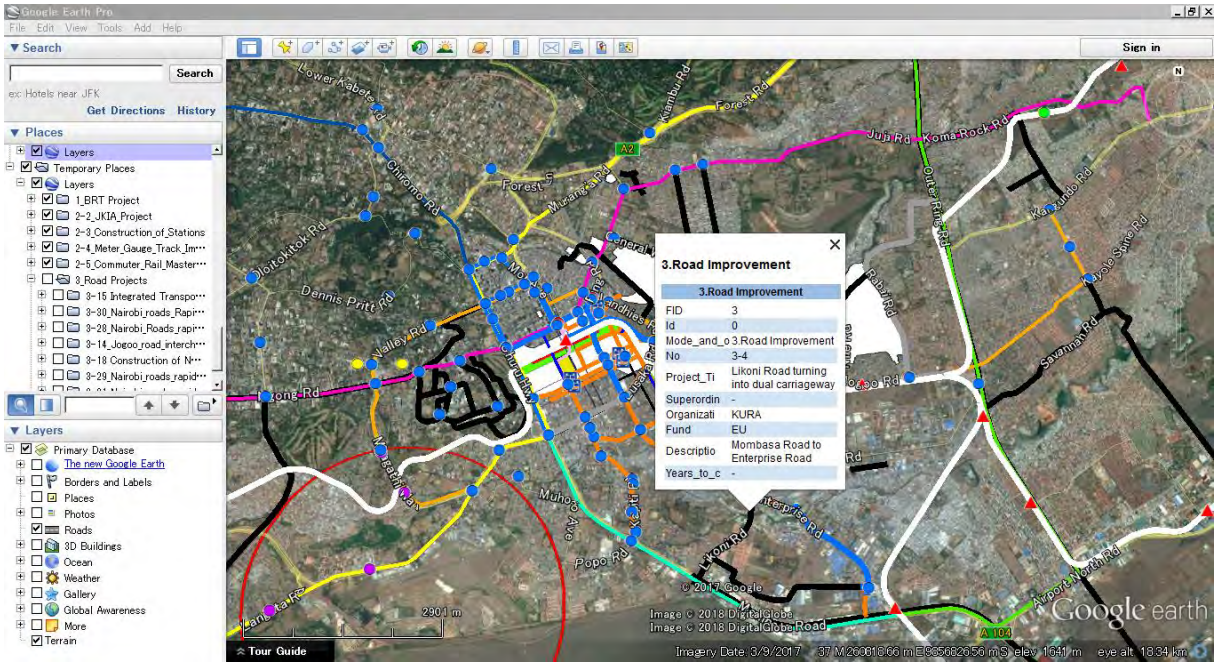
2) Output Image

The sample of the GIS database is shown as follows;



Source: JICA Study Team

Figure 3.37 Image of Project Database (GIS Software)



Source: Google Earth (Image © Digital Globe), JICA Study Team

Figure 3.38 Image of Project Database (Google Earth)

3) Further Steps for Sustainable Project Database Use

- Assign System Update Person in Charge

Although the GIS system has established in the Project, the database should be utilized for

project monitoring, missing projects analysis even after the Project demobilized. For this purpose, the database shall be kept updating.

- Coordinate System Update Organization in Charge

The projects in the database are not only handled by NCCG, but by other agencies such as KURA, KeNHA or KRC. NaMATA shall be empowered to handle transport projects in NMA according to NaMATA bill thus the capacity building will still be needed to handle projects in NMA for NCCG and NaMATA. The Agency in charge will have to assign an officer that will assist with coordination.

- Necessity of Technical Assistance Supported by JICA

For capacity improvement continuous training with assigned officers and technical assistance for GIS shall be coordinated in view of cross-sector and cross donor project monitoring, since the monitoring shall be operated by counterparts in future.

Chapter 4 Travel Characteristics of the Nairobi Urban Core

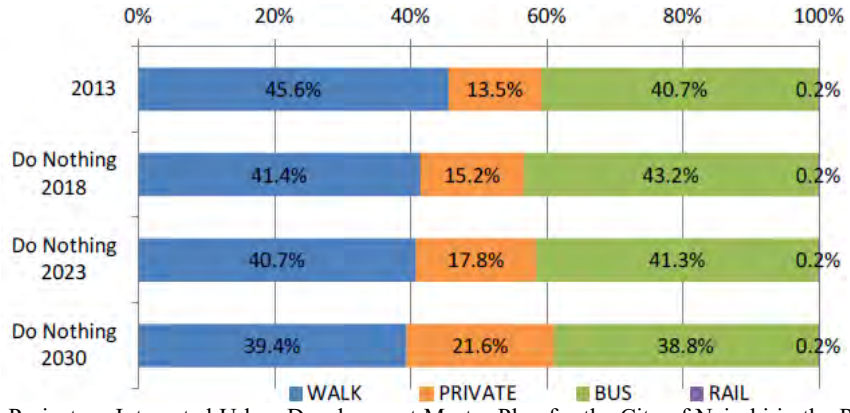
This chapter will give the proper idea of the travel characteristics of the Nairobi Urban Core with various methods of analysis. To date, a number of urban development and transport studies have been conducted in the Nairobi Metropolitan Area. Many of these studies have carried out traffic surveys. Section 4.1 will outline the major characteristics related to the transport planning in the center of Nairobi, identified mainly through a review of existing studies.

Section 4.2 and 4.3 will give the microscale travel patterns in the urban core, adopting an innovative approach of utilizing an anonymous MAC address probe (AMP) counter to observe detailed travel patterns in the urban core.

4.1 Overview

1) Heavy Dependence on Walking

Heavy dependence on walking is evident from the modal split in the city of Nairobi. Walking is the dominant mode of transport in the city, accounting for 45.6%, compared to 40.7% by bus, 13.5% by private mode, and 0.2% by rail (see the 2013 data in Figure 4.1).[1] This high dependence on walking resembles that of the other East African cities: Dar es Salaam and Maputo, where walking accounts for 36.4% and 45.6% respectively.[2] In addition, Nairobi's average walking trip length was 6.04 km.[3] This long walking distance, coupled with the heavy reliance on walking, highlights the need for monitoring travel patterns in the city center.



Source: JICA, The Project on Integrated Urban Development Master Plan for the City of Nairobi in the Republic of Kenya, Final Report, December 2014

Figure 4.1 Existing and Forecasted Modal Split in Nairobi City

[1] These are 2013 data. Source: JICA, *The Project on Integrated Urban Development Master Plan for the City of Nairobi in the Republic of Kenya*, Final Report, Part III: Appendix, December 2014. Note that this study is also referred to as the Nairobi Integrated Urban Development Master Plan (NIUPLAN).

[2] These data are obtained from the following: JICA, *Dar es Salaam Transport Policy and System Development Master Plan*, Technical Report, June 2008 (for Dar es Salaam); and JICA, *Comprehensive Urban Transport Master Plan for the Greater Maputo*, Final Report, Volume 1 Master Plan Report, March 2014 (for Maputo).

[3] Source: EU and the Ministry of Transport and Infrastructure, *Nairobi Bus Rapid Transit Network Feasibility and Detailed Design of Line 3 and 4W*, Feasibility Report, Volume 3. Transport Demand Report, February 2016.

2) Highly Concentrated Transport Services in the CBD

There are highly concentrated transport services in the center of Nairobi. Almost all of the matatu and bus routes (both intercity and intracity) start from and finish at the congested city center that covers approximately one-square km due to the current market. Figure 4.3 presents all of Nairobi's matatu routes, showing that there is a total of 97 routes, 70 of them are designated to provide services to terminals in the city center. Passengers traveling from Waiyaki Way to Jogoo Road, for example, must transfer within the CBD, which leads to an increase of traffic flow to the CBD.

As per the current laws on road safety, no standing passengers are allowed in Public Service Vehicles (PSV); therefore, some people must walk to terminals located within the CBD from the surrounding areas to catch their buses during the evening peak hours.

3) Unorganized Traffic Management

While some traffic management measures are being developed in the center of Nairobi (e.g., installation of an automated signal system, the improvement of intersections), there is an insufficient long-term traffic management plan and enforcement. This leads to unorganized parking, where matatus and other vehicles obstruct traffic when stopping, causing congestion and safety issues. In addition, Nairobi suffers from a lack of parking space. The Central Business District (CBD) has a total of 14,864 parking spaces, of which 3,941 are on-street parking, 3,834 are off-street parking, and 7,089 are building parking.[4] Using the average occupancy rate of 1.96 persons per car,[5] it is considered that the CBD has limited parking for about 30,000 people.

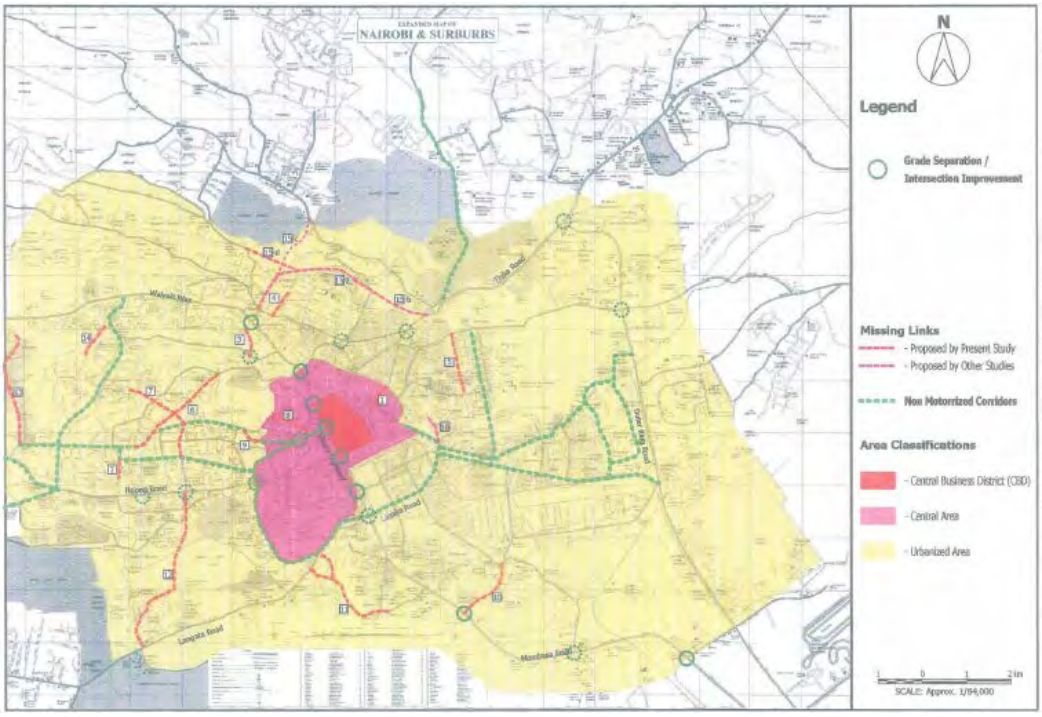
4) Road Provision

With future road transport demand growth, an additional burden will be placed on the road infrastructure, which already has several constrains including (i) many missing links (see Figure 4.2. There is a need to develop multilane streets at least every 500-1,000 m in the urban core.), (ii) inappropriate land use that discourages the development of the city center, and (iii) encroachment of parking vehicles on the roads. Whilst the development of Northern, Southern, and Eastern Bypasses has contributed to alleviating traffic in the center of Nairobi by diverting through traffic (mostly large vehicles) from Uhuru Highway to the bypasses, more needs to be undertaken to address this issue.[6]

[4] This is based on the facility inventory survey undertaken as part of this Study.

[5] This was obtained from the NIUPLAN.

[6] The Northern, Southern, and Eastern Bypass Development follows the recommendations of the JICA-funded Nairobi Urban Transport Study (NUTRAN) undertaken in 2005-2006.



Source: NUTRIP

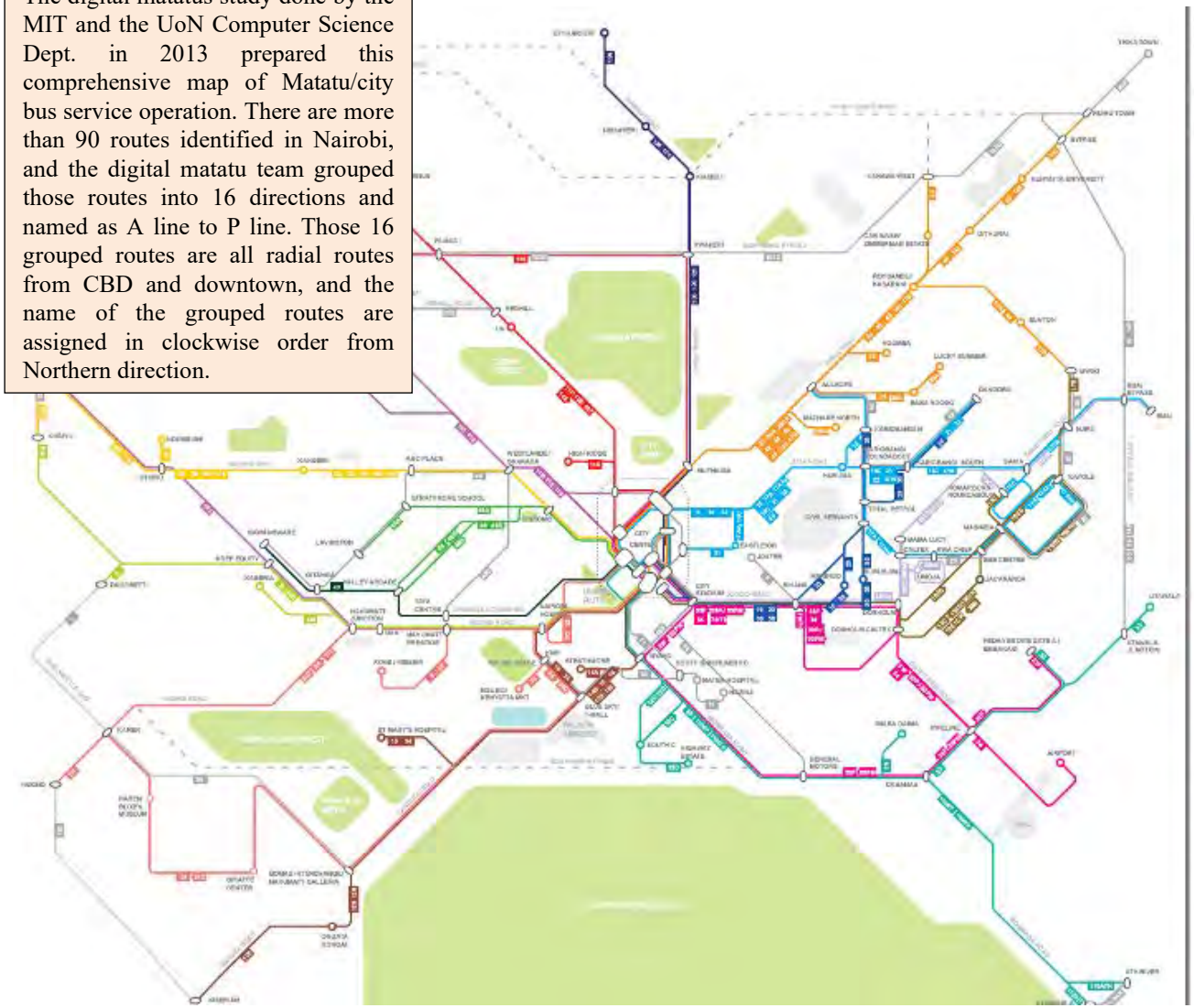
Figure 4.2 Missing Links in Nairobi

5) App-Based Ride-Sharing Service

Furthermore, it is important to point out that an app-based ride-sharing service has been gaining popularity in Nairobi. Since its launch in January 2015, Uber has provided a level of service that is different from conventional modes of transport: car, bus, matatu, and taxi.[7] According to Uber, there are 2,600 drivers in Nairobi and Mombasa as of January 2017, and every month over 100,000 people are using the service in the two cities. The minimum fare in Nairobi was increased from KSh 200 to KSh 300 in March 2017; however, as far as the JICA Study Team is concerned, the service was available at KSh 200 in September 2017 because of the promotion period.

[7] The other ride-hailing apps available in Nairobi include (i) Safaricom-backed Little Cab, (ii) Estonia-based Taxify, and (iii) Dubai-based Modo Ride. Little Cab and Taxify began operations in Nairobi in in July 2016, while Modo Ride started in September 2016.

The digital matatus study done by the MIT and the UoN Computer Science Dept. in 2013 prepared this comprehensive map of Matatu/city bus service operation. There are more than 90 routes identified in Nairobi, and the digital matatu team grouped those routes into 16 directions and named as A line to P line. Those 16 grouped routes are all radial routes from CBD and downtown, and the name of the grouped routes are assigned in clockwise order from Northern direction.



This is the list of the Matatu/Bus routes, which shows 70 of 97 routes are terminated in the city center

Source: Digital Matatus

Figure 4.3 Matatu Network in Nairobi

4.2 Traffic Surveys

4.2.1 AMP Counter Survey

4.2.1.1 Methodology

An innovative approach was adopted in identifying the existing travel patterns in the center of Nairobi. Unlike a large-scale household interview survey, this approach (i) installs an AMP counter at various locations (a total of 42 locations under this Study), (ii) collects Wi-Fi packets transmitted from each Wi-Fi communication device, including smartphones, tablets, etc., (iii) analyzes detailed travel patterns based on real-time observations by comparing the collected data at multiple locations.

An AMP counter is a combination of Wi-Fi router, microserver, 3G modem, and power supply. It was developed by the Japan Research Institute of Social System (JRISS) in 2013, and has been applied to several cities both in Japan and elsewhere to monitor, among other things, trip behavior, tourist behavior, bus locations, and travel speed.[8] While these previous attempts focus mainly on observing traffic flows, this Study is the first attempt to utilize the AMP counter for passenger transport planning.

Once installed in fields, the AMP counter detects signals transmitted by Wi-Fi communication devices if their Wi-Fi is switched on. Although each signal contains a unique MAC address to distinguish one device from the others, this MAC address is anonymized (i.e., converted to another unique ID code) by cryptographic hash function; and then is sent to the main server through a 3G modem. The data in the main server are aggregated and analyzed to identify mass travel patterns in the AMP counter coverage area.

The key functions of the AMP counter and its system are summarized as follows:

- Count the Number of Wi-Fi Devices in the Coverage Area: the AMP counter can count the unique number of Wi-Fi devices including smartphones, tablets, etc. for a certain period. The range of detection can be 150-200 m radius depending on the signal strength of the devices, building environment, and circumstances.
- Count Waiting Hours of Travelers: the main server can aggregate the MAC address detection and can count the waiting hours in the range.
- Estimate Travel Speed: the collected MAC addresses with time stamps among multiple AMP counters can be used to estimate the travel speed between two districts.
- Prepare Origin-Destination (OD): the collected MAC addresses among AMP counters can be summarized by an OD table immediately, with a variety of chronological aggregation (e.g., real-time morning peak two-hour OD, weekday OD, weekend OD, seven days OD, etc.).

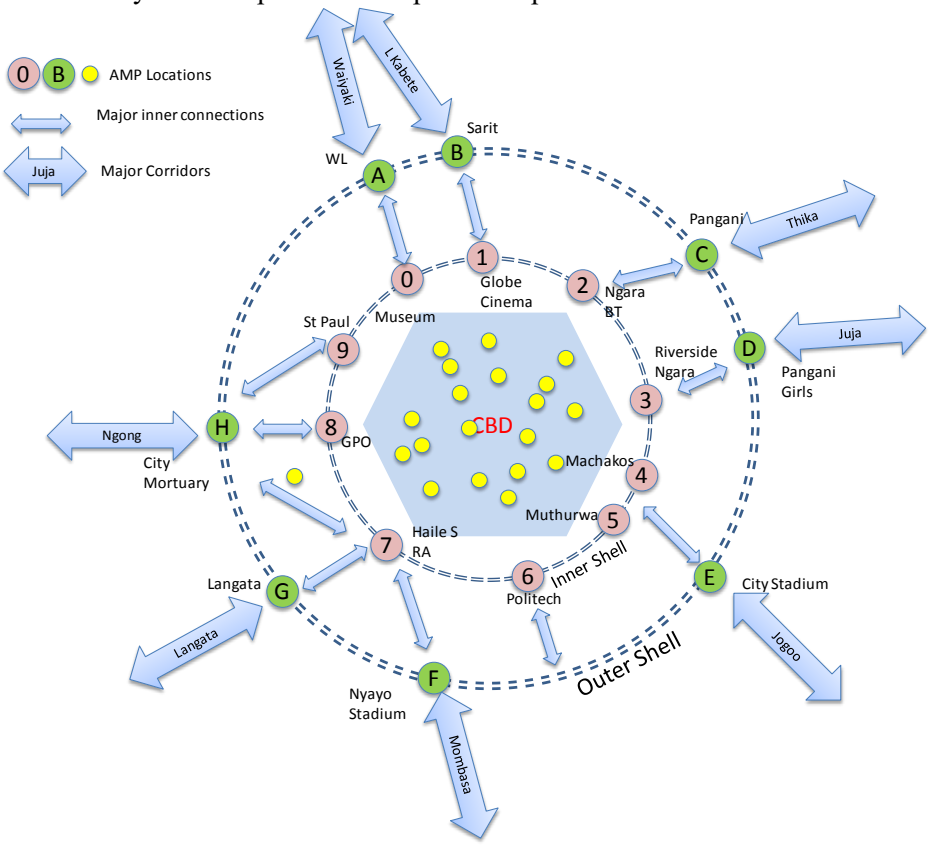
4.2.1.2 Design of AMP Counter Survey

1) Triple-Layered Monitoring Structure

A triple-layered structure was proposed to monitor the detailed travel patterns in the center of Nairobi. These three layers include (i) outer shell of the CBD, (ii) inner shell of the CBD, and

[8] The cities that have applied the AMP counter system include Hyogo, Japan; Makassar, Indonesia; Vientiane, Laos; Kyoto, Japan; and Osaka, Japan.

(iii) inside the CBD (Figure 4.4). It is anticipated that combined data of several AMP counters in the same layer would provide in-depth travel patterns to/from the CBD on a real-time basis.



Source: JICA Study Team

Figure 4.4 Triple-Layered Structure for AMP Counter Allocation

The key functions of each layer are as follows:

- Outer shell: a total of eight AMP counters are installed at the entry/exit points to identify inflow/outflow traffic to/from the CBD in macroscale. These identify the existing demands along Nairobi's major corridors,[9] as well as through traffic volume passing the CBD, its directions, peak period, and travel speed. One key point to examine includes major travel patterns between major OD pairs on the outer shell in terms of how to remove through traffic (see Subsection 4.3.2.2 for details).
- Inner shell: a total of ten AMP counters are installed along the peripheral border of the CBD and downtown to identify inflow/outflow traffic to/from the CBD on a meso-to-macro scale. One key point to examine is whether there is traffic movement between eastern downtown and western CBD. Note that bus terminals in eastern surroundings are connected to the low-income market, while western surroundings are connected to the middle-to-high income market (see Subsection 4.3.2.1 for details).
- Inside the CBD: a total of 24 AMP counters are installed at major office/shopping districts, transport facilities (including bus terminals), and major parking spaces. It is noted that 83% of the CBD and downtown (in terms of surface level) are covered by AMP counters, assuming the detection range of 200 m radius.

[9] These corridors include in clockwise from North: Thika Road, Juja Road, Jogoo Road, Mombasa Road, Langata Road, Ngong Road, Waiyaki Way, and Lower Kabete Road.

2) Physical Setting of the AMP Counters

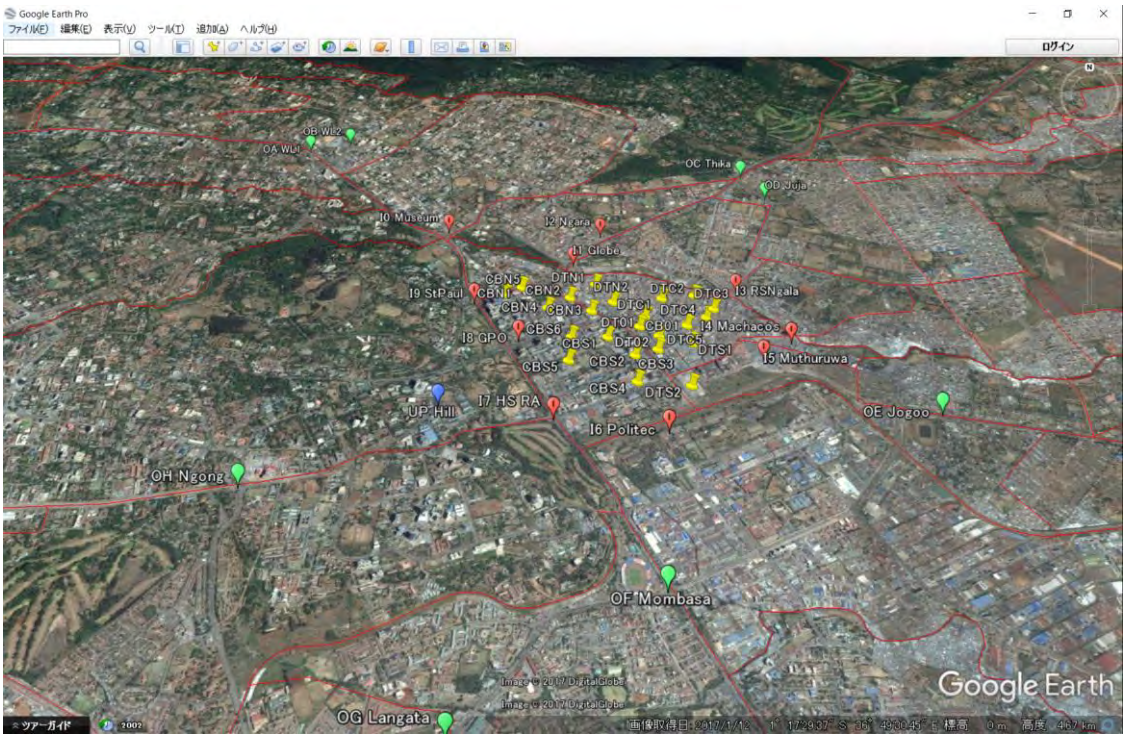
Table 4.1 categorizes the 42 AMP counters by ID, name, and code in KMP file.

Table 4.1 Location of AMP Counters

ID	Full AMP ID	Full name, Detail of Location	Name	Code in KMP
AMPs in Inside the CBD				
1	AMPM17-KN001	City Market	City Market	CBN4
2	AMPM17-KN002	Travel House/City Hall (Mount on City Hall Annex wall)	CityHall	CBS6
3	AMPM17-KN003	Kencom	Kencom BT	CB01
4	AMPM17-KN004	Nakumatt Lifestyle	Naku-LS	CBN1
5	AMPM17-KN005	Kimathi Street/Tubman Road Intersection (Jamia Mall)	Jamia Mall	CBN2
6	AMPM17-KN006	Kimathi Street/Kenyatta Avenue Intersection (New Stanley)	Stanley	CBN3
7	AMPM17-KN007	Anniversary Towers/View Park Towers/Car Park	Towers	CBN5
8	AMPM17-KN008	Koinange Car Park/Supreme Court (Locate along Taifa Road)	Supreme CP	CBS1
9	AMPM17-KN009	Sunken Car Park (Locate near public toilet)	Sunken CP	CBS2
10	AMPM17-KN010	Moi Avenue/Harambee Avenue Intersection (Tuskys Pioneer)	Tuskis Pioneer	CB02
11	AMPM17-KN011	Times Tower (Locate near Post Office)	Times tower	CBS4
12	AMPM17-KN012	KICC Car Park	KICC CP	CBS5
13	AMPM17-KN013	Accra Road/Tom Mboya Intersection	TMBY-ACR BT	DT01
14	AMPM17-KN014	Ambassadeur (Locate on Tom Mboya/Ronald Ngala Junction)	AMBSD BT	DT02
15	AMPM17-KN015	Accra Road/River Road Junction	ACR-Riv BT	DTC1
16	AMPM17-KN016	Kirinyaga Road/Kumasi Road Intersection (Abasa Tyres)	Kirinyaga Rd	DTC2
17	AMPM17-KN017	Nyama Kima (Near Molo Line)	Nyamakima	DTC3
18	AMPM17-KN018	Ronald Ngala/River Road Intersection	RN River BT	DTC4
19	AMPM17-KN019	Temple Road/Ronald Ngala	RN-TMPL BT	DTC5
20	AMPM17-KN020	Old Nation R/A (Locate towards Roast House)	Old Nation BT	DTN1
21	AMPM17-KN021	Posta (Tom Mboya)	TMBY Posta	DTN2
22	AMPM17-KN022	Central Bus Station/Hakati (on Magnate Ventures High Mast)	Central BT	DTS1
23	AMPM17-KN023	Railways	Railway BT	DTS2
AMPs on the Inner Shell				
24	AMPM17-KN024	Museum Hill R/A	Museum RA	I0 Museum
25	AMPM17-KN025	Globe Cinema R/A	Globe Cinema	I1 Globe
26	AMPM17-KN026	Ngara (on Magnate Ventures High Mast)	Ngara BT	I2 Ngara
27	AMPM17-KN027	Riverside Ngara	RS Ngara	I3 RSNgara
28	AMPM17-KN028	Country Bus Station (Machakos)	Machakos BT	I4 Machakos
29	AMPM17-KN029	Muthurwa (Near Embassava Stage)	Muthuruwa BT	I5 Muthuruwa
30	AMPM17-KN030	Railways footbridge (Landing near Railways Museum)	Politech FB	I6 Politec
31	AMPM17-KN031	Haile Selassie/Uhuru Highway R/A	Haile Selassie RA	I7 HS RA
32	AMPM17-KN032	Hazina/GPO Car Park (Combine with GPO)	GPO	I8 GPO
33	AMPM17-KN033	Uhuru Highway/University Way Roundabout	St Paul	I9 StPaul
AMPs on the Outer Shell				
34	AMPM17-KN034	Westlands Roundabout	WL1	OA WL1
35	AMPM17-KN035	Ring Road Parklands/Parklands Road Roundabout (Sarit Center)	WL2	OB WL2
36	AMPM17-KN036	Thika Rd Pangani	Thika Rd	OC Thika
37	AMPM17-KN037	Juja Rd Pangani Girls	Juja Rd	OD Juja
38	AMPM17-KN038	City Stadium R/A* (off Jogoo Road)	City Stadium	OE Jogoo
39	AMPM17-KN039	Nyayo Stadium R/A*	Nyayo Stadium	OF Nyayo Std
40	AMPM17-KN040	Langata R/A	Langata RA	OG Langata
41	AMPM17-KN041	City Mortuary R/A*	City Mortuary	OH Ngong
Other Category (for pedestrian movement observation)				
42	AMPM17-KN042	Community (footpath between Upper Hill and Uhuru park)	Community	UpHill

Source: JICA Study Team

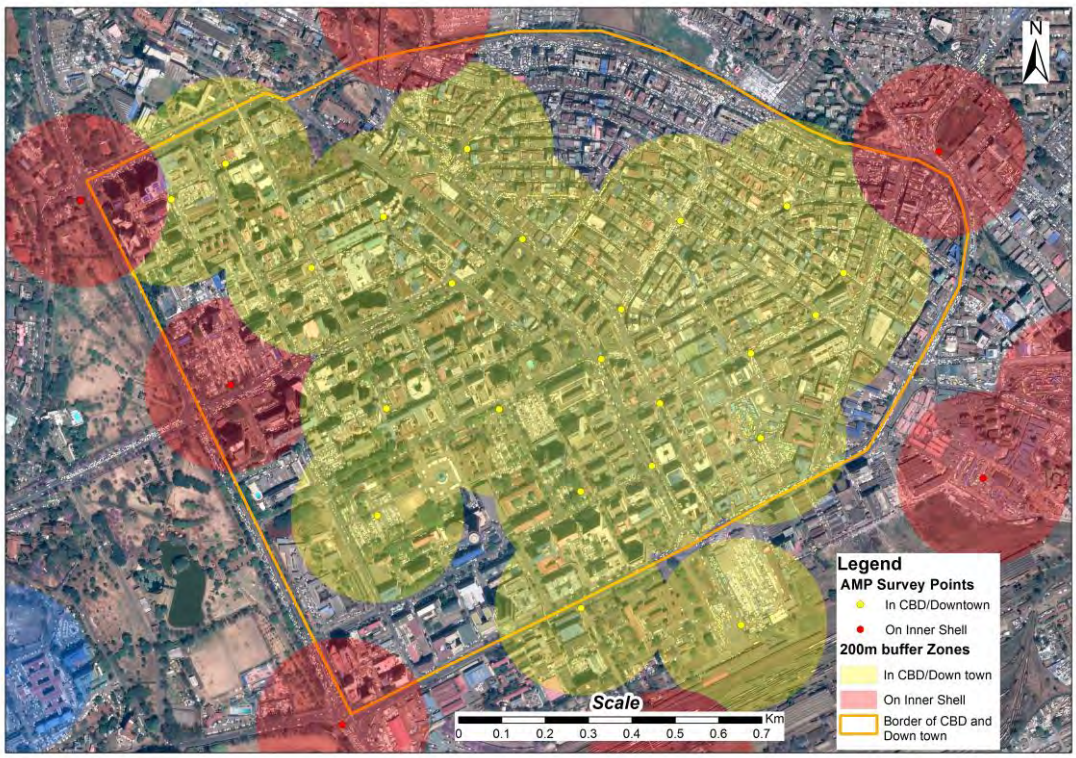
Figure 4.5 shows the locations of the AMP counters on the map.



Source: JICA Study Team, Google Earth (Image © Digital Globe)

Figure 4.5 Location of AMP Counters (yellow for inside the CBD, red for the inner shell and green for the outer shell)

Figure 4.6 shows the location of AMP counters around the CBD. Assuming the coverage of the Wi-Fi antennas of the AMP counters have a 200 m radius, 83% of the area can be observed by the set of the AMP counters.



Source: JICA Study Team

Figure 4.6 Location of AMP Counters in the CBD, showing expected coverage

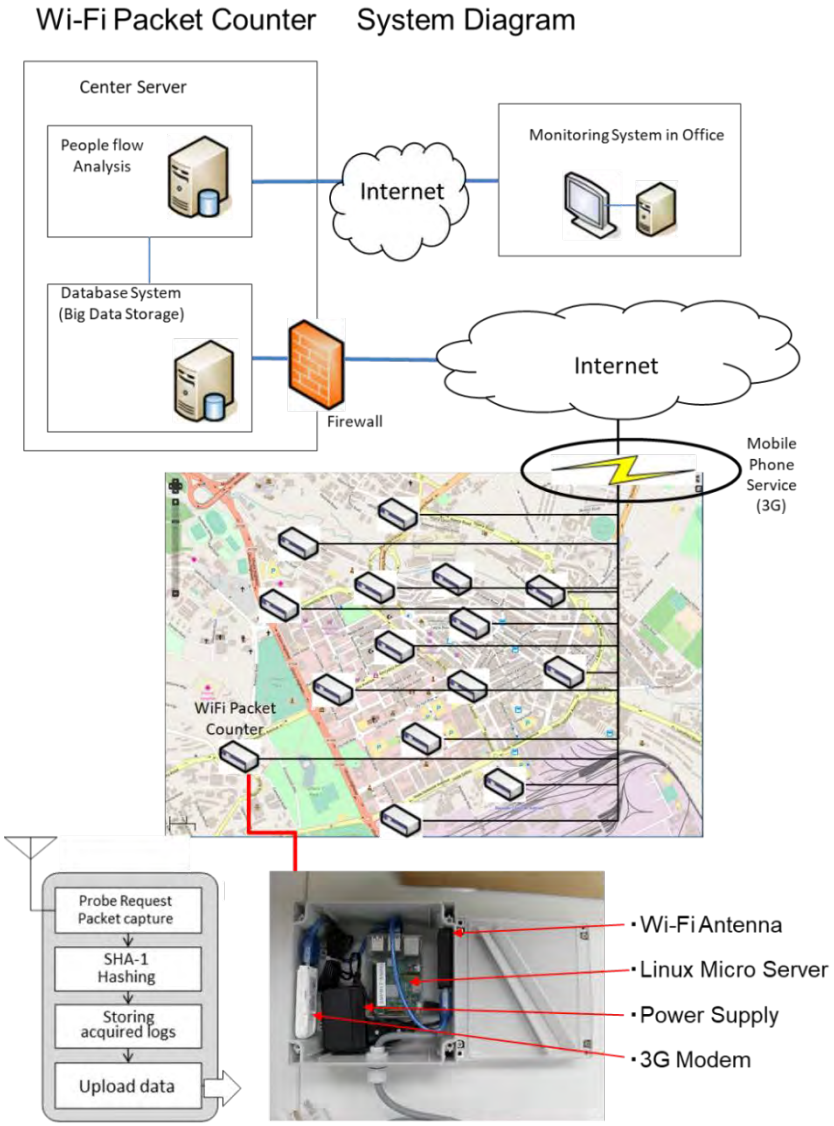
To set up the AMP counters in the city, 32 10-meter high poles were erected by the study team expenditure. Other AMPs were set on the wall of buildings or poles owned by the NCCG. All AMPs are connected to a permanent electricity supply of Keygens, with the cooperation of the NCCG. Figure 4.7 shows an AMP counter on a pole in a field and the interior and exterior of an AMP counter.

Source: JICA Study Team

Figure 4.7 AMP Counter on Pole, Interior and Exterior

3) Server and Data Processing

Figure 4.8 depicts the system diagram of the AMP counters. The AMP counters continuously collect the probe packet signals of smartphones (devices with Wi-Fi communication) in the field, including the unique MAC addresses belonging to each device. Each collected MAC address is modified by SHA-1 hash function into an anonymized MAC address to avoid immediate tracking by the micro server in the AMP collector. Then, the AMP counter sends the anonymized MAC address to the servers via 3G modem and internet. The servers are set in Japan, and the collected data is summarized into a visualization process.



Source: JICA Study Team

Figure 4.8 AMP Counter System Setting

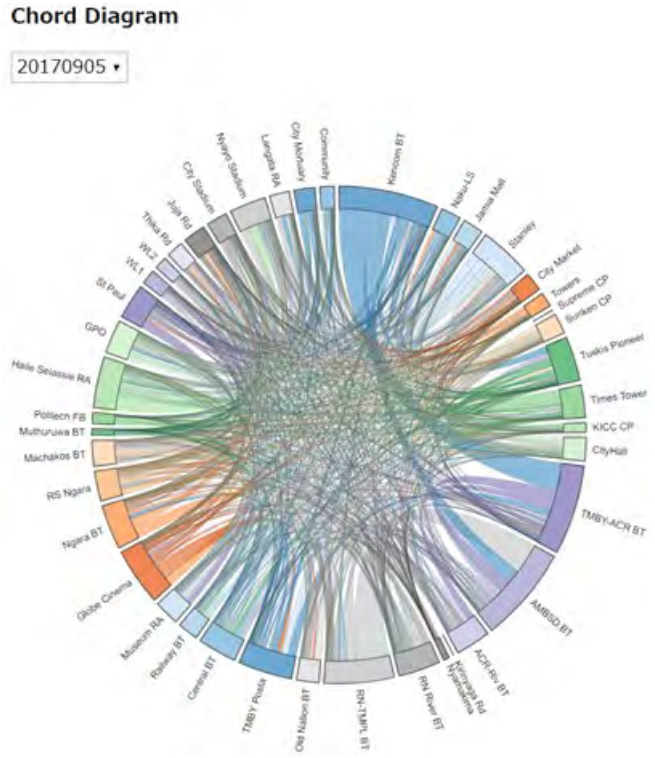
4) Big Data Visualization Approach

Considering the recent progress of big data real-time visualization technology, the Study Team has adopted a chord diagram that intuitively shows travel volume between a pair of OD, as presented in Figure 4.9. In the chord diagram, arc length, chord width, and chord combination indicate the following:

- Arc length: the relative ratio of trips generated from and attracted to one AMP counter to the entire trips;
- Chord width: travel volume between a pair of OD; and
- Chord combination: a pair of OD.

The exact figures also appear when clicking on each arc and chord in the system. Instead of OD tables, the Study Team will use this chord diagram hereinafter to visualize the movement characteristics in the urban core.

Figure 4.9 shows movement patterns between the 42 AMPs on September 5, 2017 for a whole day. The number of observed unique Wi-Fi packets at locations from No.1 to No. 42 are designated in Table 4.1 Location of AMP Counters are depicted as the length of arc, in clockwise order. The Kencom BT (AMP No.1), TMBY-ACR BT (AMP No.13) and AMBSD BT (AMP No.14) are shown with a longer arc length, as they are the traffic focal points among those 42 locations. The complicated chord combinations show the complexity of the passenger movement among the 42 locations. Some of the locations do not show their volume due to power failure at the sites.



Source: JICA Study Team

Figure 4.9 Sample of Chord Diagram, September 5, 2017

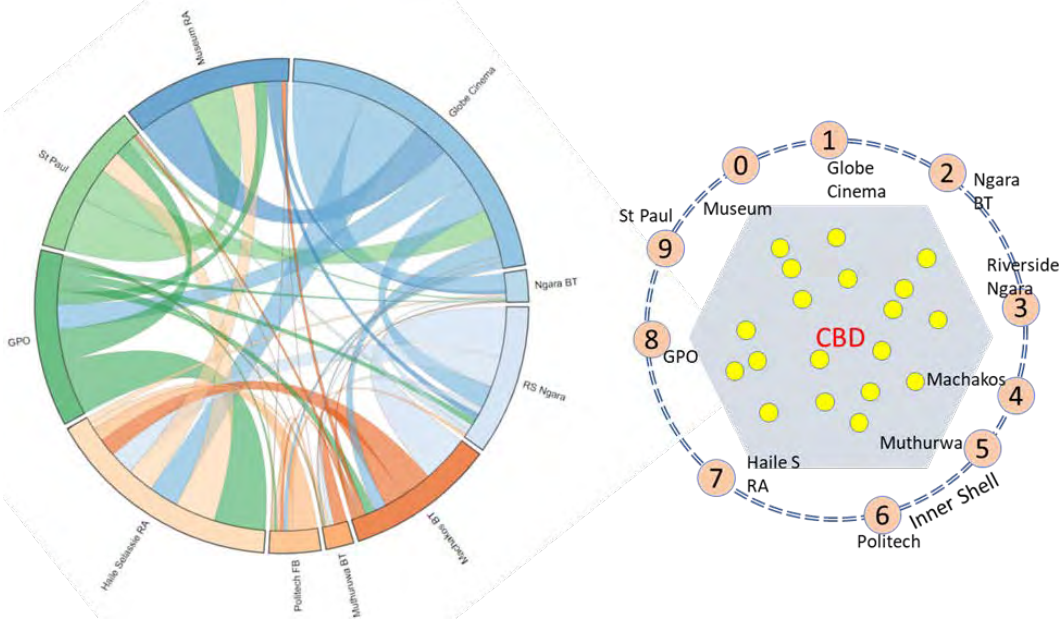
5) Traverse Movement in the Urban Core by Chord Diagram

Figure 4.9 above is too complex to understand the passenger movement in the CBD. The study team prepared several patterns of chord diagrams for grouped AMPs. For example, the Chord Diagram for AMPs on the inner shell shows the movement patterns on the edge of the CBD and the downtown area, and those on the outer shell show the travel pattern on the urban core border. As the locations of those AMPs on the inner shell and outer shell are designated at the crossing point of major corridors and circular cordon line in a clockwise order, the OD patterns on the inner shell and outer shell were visualized without any complexity.

The order of the chords from an origin connecting to several destinations are arranged by the amount of OD volume. In Figure 4.10, the biggest OD volume from Globe Cinema destined for Ngara BT, and the second biggest OD volume is to Haile Selassie RA.

The color of arc (location of origin/destination) are painted randomly just for visibility. Instead, the color of chord is attributed to the color of arc (location of origin/destination) having larger volume in origin. For example, the chord between Museum RA and Globe Cinema are painted with dark blue, which means the volume from Museum RA is larger than the volume in the other direction.

Also, the transport planner can share the traffic patterns with citizens without geographical background and local knowledge, as the shape of the chord diagram is adjusted with real geographic shape and relations.



Source: JICA Study Team

Figure 4.10 Sample of Chord Diagram for the Inner Shell

6) General Discussion

The original plan of this study was to collect detailed travel characteristics of passengers in the urban core by interview-based surveys (activity diary interview surveys). The study team used the AMPs instead of the interview-based surveys. There are pros and cons among the two survey methodologies, but the AMP has more advantages in reliability and economic aspects.

Table 4.2 Comparison of Survey Methodology, AMP Collector Application, and Ordinary Interview for Required Conditions to the Nairobi Study

AMP Collector	Conditions	Activity Diary Interview
The movement and behaviors can be collected in real- time basis and real quantity in the designated area. The system cannot identify trip purpose and trip mode; however, it could be estimated by location of AMP and velocity.	Movement in Peak hours	It requires time for aggregation, and the accuracy of data depends on literacy in trip survey of sampled passengers. Detail of trip characteristics including purpose and mode can be collected.
Can be collected with little additional cost (communication cost, electricity)	Movement in week, monthly, annually	Can be collected to the same samples (panel interview), which may increase dependence on the same sample. Repeating interviews requires more cost.
Can be collected in real-time basis. Sampling rate can be around 30%.	OD movement	Can be collected but accuracy will depend on the size of sample.
No requirements to passengers. Anonymization process is necessary.	Burdens to interviewees	Requires passengers to answer a lot of trip and behaviors, and his/her privacy.
It will be approx. 200,000 USD per 40 locations including personnel cost for analysis, development of software, dashboard, etc.	Price, Cost	Assuming 100,000 population in the CBD, 4 trips per day, 4 purposes, 4 modes, 20 zones in CBD, it requires 7.1% sampling rate. With 15 USD per passenger for interview survey cost, it will be 100,000 USD per one time.
The system can be utilized continuously.	Future sustainability	Requires additional cost for additional interview.
The reach of the Wi-Fi packet is 200m as maximum and depends on circumstances. AMP collectors can be moved if necessary.	Zone setting	Designated by statistics. The setting cannot be modified after the survey started.

Source: JICA Study Team

Detection of trip mode and purpose: The AMP cannot identify the mode and purpose of each trip, instead the interview-based survey can inquire about this. However, it is apparent the major movements in the morning period are commuting demands for work or school, and those in the afternoon are the trip home.

The AMP systems shall be handed over to the NCCG and the UoN computer science faculty.

4.2.1.3 Privacy Concerns

JST studied the legal requirements in Kenya and justified the AMP application as follows:

i) Article 31 (d) of the Constitution of Kenya 2010 protects every person not to have "the privacy of their communications infringed", and the AMP collectors do not infringe on communication; and

ii) The Kenya Information and Communications Act (2009), articles 31, 83 and 91 prohibits "interception and disclosure of the communication contents", and the AMP collectors do not intercept nor disclose personal communication itself.

As per NCCG's request, the authors consulted with the Communication Authority (CA) of Kenya in March 2017, and the CA instructed the following;

i) The Kenya Constitution requires broad consultations with the public before a new public system was installed. Therefore, the CA requested the NCCG and authors to conduct 1.) a public notice on in local newspaper with a wide circulation, 2.) one stakeholder meeting with special interest groups (SHM1), and 3.) one stakeholder meeting for the public (SHM2). The NCCG and authors conducted the SHM1 on April 20, a public announcement was made via the Standard Newspaper dated May 21, and the SHM2 was held on May 31, outlining the implementation, the public benefit, and addressing any privacy concerns. There was no concern raised or objection in either SHM, and nothing arose after the public notice appeared in the newspaper.

ii) The CA asked the authors to utilize equipment that are approved for technical conformity as per the regulations by the CA. The authors submitted the list of equipment in AMP collectors and the CA issued the letter of conformity for the AMP collectors in April 2017.

4.2.1.4 Setting Work and Local Concerns

The AMP collector itself is lunchbox sized, 20x20x10 cm, and weighs less than 800 g. It can be deployed anywhere as long as it is connected to a permanent electricity supply. The biggest mobile battery available in market for the AMP collector lasts 10-12 hours only. Concrete walls are barriers for signal detection, so the AMP collectors should be deployed in an open space.

The physical setting arrangement was done after a consultation with electrical engineers from NCCG's street lighting division. 31 locations of AMP required pole erection for set up, and the others utilized existing poles owned by the NCCG. The electricity supply was integrated with the existing contract between the NCCG and Kenya Power.

The Raspberry Pi was used for the micro server in the AMP collector. However, the authors adopted Raspberry Pi with higher specifications in heat capacity, which is essential for stable operations. All-weather housing units for the AMP collectors were used to hold this equipment, and they were mounted on plywood blocks with a sunshade in the field.

Vandalism was a key concern with regards to field location. The height of the erected mounting pole was 10 m, with a metal switch box.

The setting work began in the first week of June 2017, all poles were erected by the third week of June 2017, and all settings and electricity connections completed by the second week of July 2017.

The AMP system started to count the probe signals from mobile devices starting July 14, 2017, however, the system was always influenced by local power failures. The failure of the AMP was minimized by the maintenance contractor of the AMP, and the Study Team could achieve stable operations and data collection from July 14 to September 15 (two months). The behavior analysis in chapter 4.3 mainly uses the collected data during this period.

From the 15th to 25th of September, 30% of AMP could not function due to the delay of payment for the 3G modem communication cost. After October 2017, the system worked properly.

4.2.1.5 System Ownership and Technical Transfer

The main server for data storage and analysis is located in Japan, mainly for the stability of the system. However, the authors are considering handover of the system to NCCG at the end of the study itself. Also, the authors are considering a Hacker-son event to involve young planners and analysts for further thematic analysis of the data from AMP. The authors will prepare the procedure of how to publish the collected data with proper arrangements for personal security.

4.2.2 Sampling Rate Setting

A smartphone ownership survey was conducted on May 22, 2017 to identify (i) the average number of smartphones and/or tablets owned per person, (ii) whether the smartphones and/or tablets are turned on or off in the CBD, and (iii) whether the Wi-Fi switch is on or off in the district. It supplements the results of the AMP counting survey in terms of estimating the number of persons. Key points regarding the results of the smartphone ownership survey include the following:

- A total of 652 people with wide-ranging ages and occupations were interviewed as shown in Table 4.3.

Table 4.3 Age and Occupation of Smartphone Ownership Survey Respondents

Age			Occupation		
Range	**Sample**	**Share (%)**	**Category**	**Sample**	**Share (%)**
16-20	66	10.1	Employee	255	39.1
21-30	307	47.1	College/University student	161	24.7
31-40	163	25.0	Own account worker	142	21.8
41-50	84	12.9	Employer	56	8.6
51-60	27	4.1	Jobless/Jobseeker	18	2.8
61-70	5	0.8	Housewife	9	1.4
			Others	11	1.7
Total	**652**	**100.0**	**Total**	**652**	**100.0**

Source: JICA Study Team

- Table 4.4 summarizes the results of the smartphone ownership survey. Of the 652 interviewees, a total of 563 (=446+105+10+2) people carried one or more smartphones and/or tablets, 510 of these smartphone and/or tablet owners had their switches on, and 160 of these smartphone and/or tablet owners with their switches on also had Wi-Fi on at the interview.

Table 4.4 Results of Smartphone Ownership Survey

Number of Smartphone	Number of Interviewees (person)	Number of Turn On (person)	Number of Wi-Fi On (person)
0	89	…	…
1	446	431	149
2	105	85	30
3	10	9	2
4	2	2	1
Total	**652**	**527**	**182**

…= not applicable
Source: JICA Study Team

- The above results also revealed that the total number of smartphones and/or tablets with their Wi-Fi on amounted to 219 (=1*149+2*30+3*2+4*1). Together, with all the interviewees totaling 652 people, it is suggested that an expansion factor (i.e., the factor to convert the number of packets observed by AMP counters into the number of people) is 3.0 (≒652 / 219). However, this expansion factor is apparently conservative, as the smartphone ownership survey did not include children under the age of 16, which accounts for at least 30% of the Nairobi's total population.[10]
- Based on the above observation, it is recommended that an expansion factor of **3.0-3.3** be used to convert the number of packets observed by AMP counters into the number of persons.

4.3 Existing Travel Patterns Identified by AMP Counter Survey

Nairobi's travel routes largely fall along the several major road corridors, and Mass Rapid Transit System, for example, has been proposed along these corridors. In this Study, a total of 42 AMP counters were installed to identify inflow/outflow traffic to/from the CBD. Additionally, the Study geometrically overlapped chord diagram (that intuitively shows travel volume between major OD pairs) with AMP counter locations so that travel patterns could be visualized and understood without having in-depth knowledge of Nairobi's geography. Furthermore, the results of the AMP counter survey are coupled with those of the smartphone ownership survey. The actual amount of traffic is estimated by multiplying the number of packets observed by AMP counters with the expansion factor calculated above.

It should be noted that the behavior data of the AMP has been collected since July 14, 2017; however, in this chapter, Tuesday, September 5 was specified as a standard day of analysis in this study for simplification purpose. All the collected data can be observed on the system.

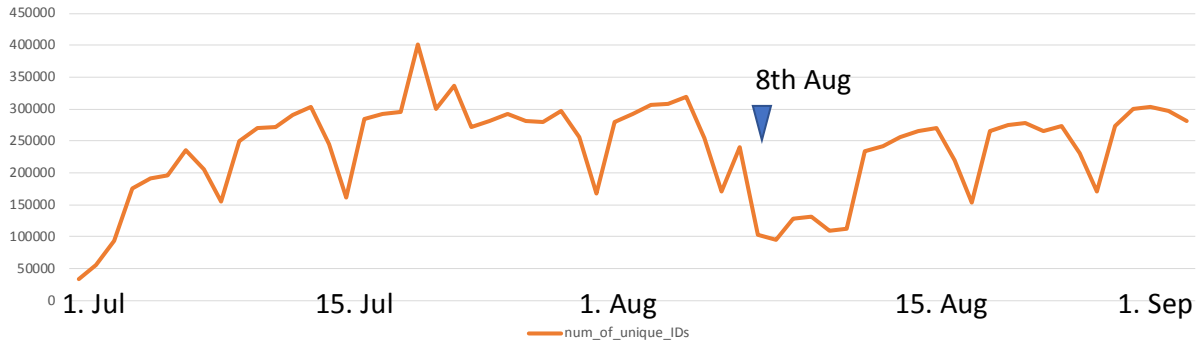
4.3.1 Macro-Scale Evaluation

4.3.1.1 Overall Passenger Traffic Volume

AMP counters were gradually installed starting in early July 2017, and all 42 AMP counters became active on July 14, 2017. Figure 4.11 shows the number of unique IDs observed by a total of 42 AMP counters from July 1, 2017 to September 1, 2017. Although some fluctuations are observed, it generally shows that the number of unique IDs increases in early July (as installation works are progressed), remains at a steady level of approximately 300,000 during

[10] According to the 2009 Kenya Population and Housing Census, Nairobi had a population of 3,138,369, of which 30.3% (951,003 people) were 0-14 years old. When the number of children whose age is 15 is included, the percentage would be higher (around 32%).

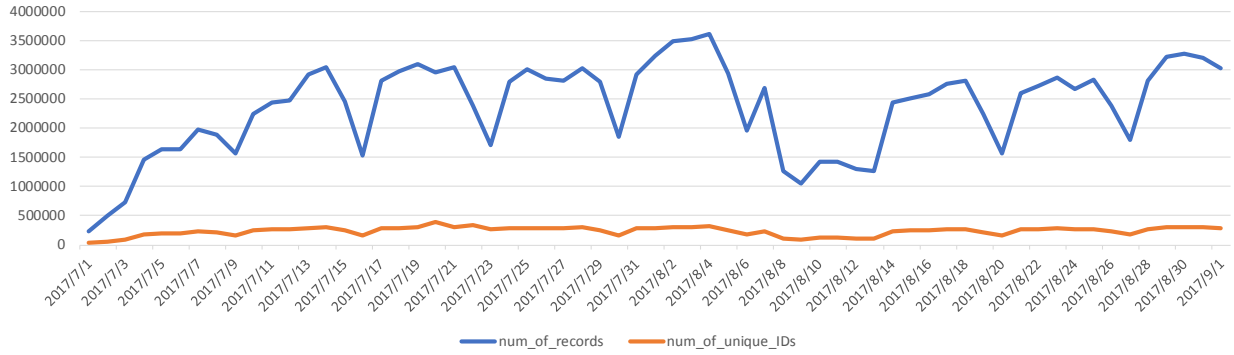
business days, before falling on Tuesday, August 8 (the sixth presidential election day), and finally returns to around 300,000 towards the end of August. Using the expansion factor of 3.0-3.3 obtained from the smartphone ownership survey, it is conservatively estimated that around 900,000 to 1 million people were moving around the city center daily on average during weekdays.[11]



Source: JICA Study Team

Figure 4.11 The Number of Unique IDs, July 1, 2017–September 1, 2017

Figure 4.12 shows the difference between the whole number of detected IDs (blue line) and the number of unique IDs (orange line) during the same period (i.e., July 1, 2017 to September 1, 2017). It means that the blue line counts a unique ID each time it is detected by any AMP counter, while the orange line counts a unique ID just once, even if detected by multiple AMP counters on the same day. The blue line remains at a steady level of around 3,000,000 during business days; while the orange line remains at a steady level of around 300,000 on the same days, indicating that the movement of one person is detected by an average of 10 AMP counters per day. Note that this is a rough average and that, for example, some are detected by 20 AMP counters (mostly by traveling within the CBD), while others are detected by just one AMP counter, possibly on the outer shell.



Source: JICA Study Team

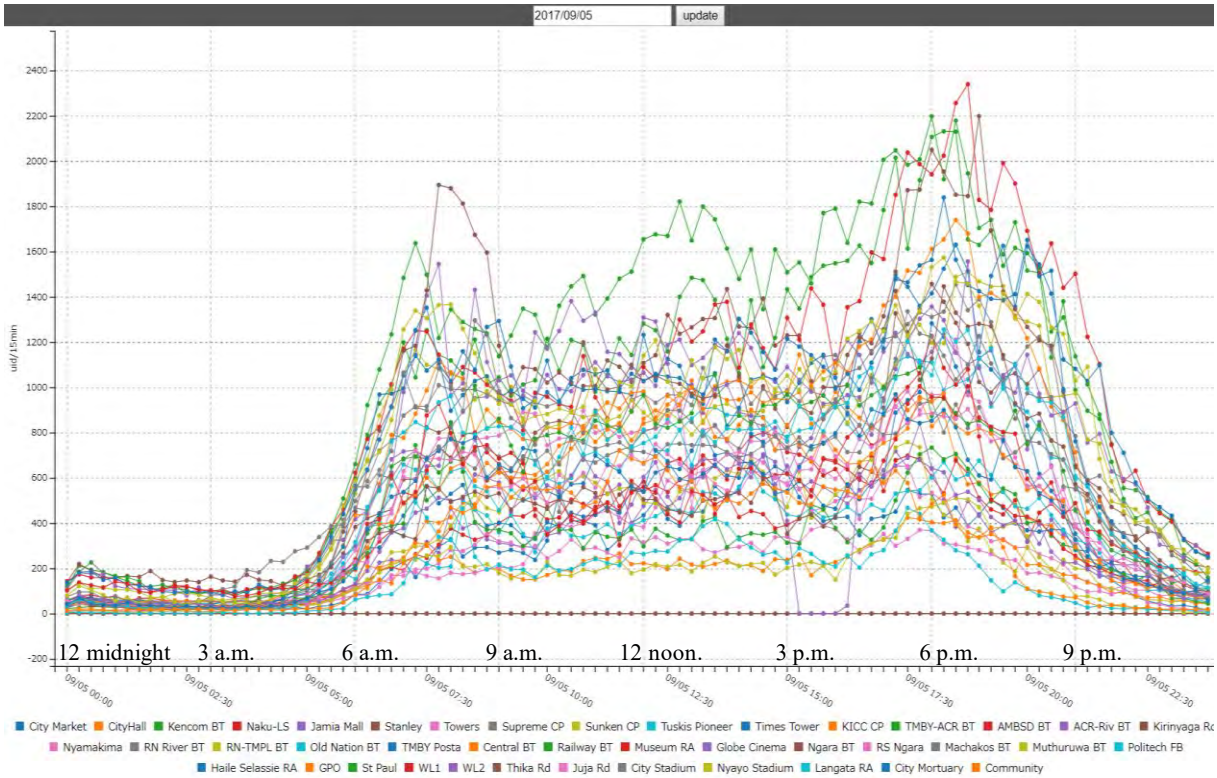
Figure 4.12 All Detected IDs (Blue) and Unique IDs (Orange), July 1–September 1, 2017

4.3.1.2 Daily Passenger Traffic Patterns

The daily travel pattern in Nairobi has been unusual in that the evening peak is higher than the morning peak. Figure 4.13 shows the number of packets observed by each 42 AMP counters on a typical weekday (Tuesday, September 5, 2017). Although some variations are found among the counters, the number of packets generally starts rising from around 5 a.m. with the

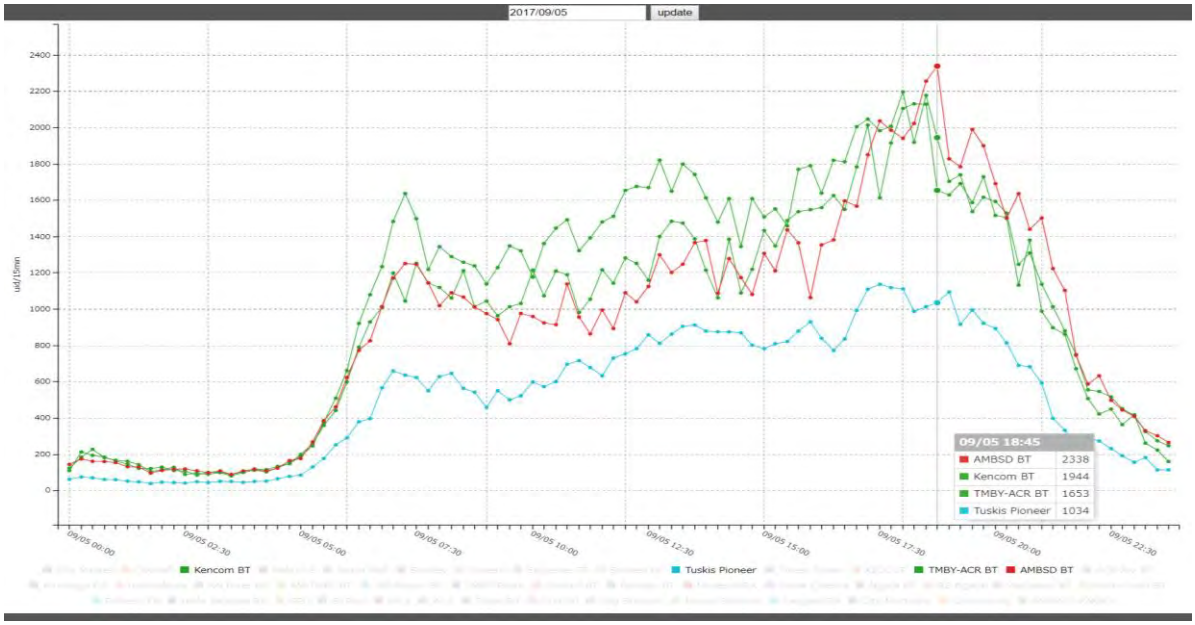
[11] A couple of AMP counters stopped working even after 14 July, which led to underestimate the number of unique ID observed by all the AMP counters.

morning peak of around 7-9 a.m., remains at a relatively steady level before having the evening peak at around 5-7 p.m., and falls drastically afterwards. It should be noted that business hours in Kenya are generally from 8:30 a.m. to 5:00 p.m. including a lunch break from 1:00 p.m. to 2:00 p.m.



Source: JICA Study Team

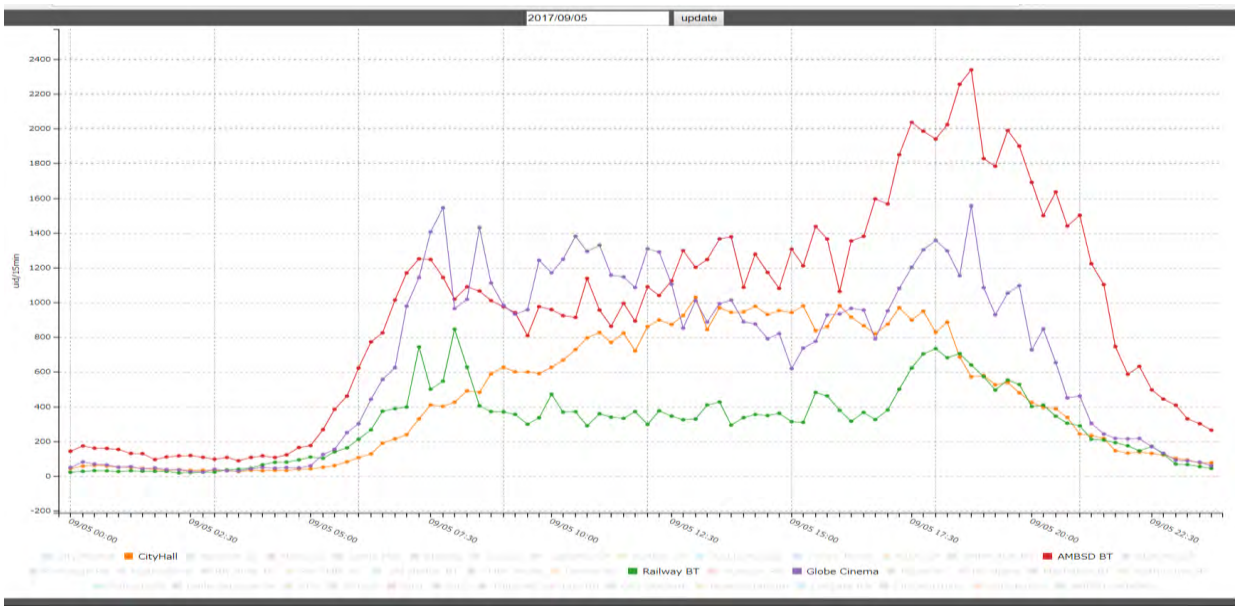
Figure 4.13 Number of Observed Packets on September 5, 2017



Source: JICA Study Team

Figure 4.14 Hourly traffic trends – high concentration in evening peak

Figure 4.15 shows the hourly trend in 4 AMP locations in the bus terminals in the CBD and Downtown on the same day, which presents commonly high traffic concentration in evening. As shown in the figure, 2,338 unique IDs observed in the Ambassador Bus Terminal from 18:45-19:00 was highest count on the day, which means that 7,000-8,000 passengers were observed around the place in 15 minutes.



Source: JICA Study Team

Figure 4.15 Hourly traffic trends – high concentration in evening peak

Figure 4.16 shows results with different patterns, i) the red line shows the typical trends of the terminals in the CBD, which peaks in the evening, ii) the purple line is observed in the Globe Cinema AMP, which is the only place where the passenger volume in the morning peak is bigger than the evening peak, iii) the orange line shows the typical trends of the business districts in the CBD, which is flat in the business hours between 10 a.m. and 4 p.m., and iv) the green line is the observation in front of the railway station, showing two peaks in the morning, which is the arrival of commuter train services in that period.

Source: JICA Study Team

Figure 4.16 Hourly Traffic Trends – Comparison among the CBD, the Inner Shell and the Outer Shell

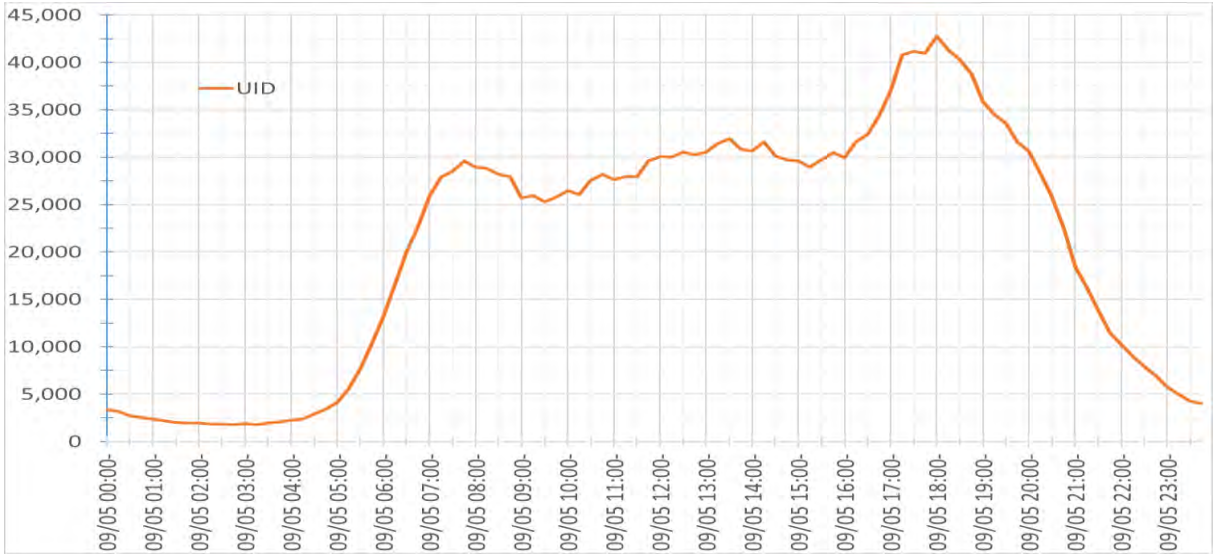
Figure 4.16 shows a comparison of trends in peak hours by AMP location along a corridor. The orange line is for the AMP in the Central Bus Station in the Downtown district, where its peak was from 17:45-18:00. The blue line is for Haile Selassie Intersection, in the inner shell, where its peak continues until 20:30. The green line is for Nyayo Stadium in the outer shell, where its peak continues until 21:00. The passenger movement to the southern Nairobi direction starting from the Central Bus Station to Nyayo Stadium are presented by the trends in the three locations.

4.3.1.3 Evening Peak Concentration

In order to see the overall trend in the CBD more precisely, each number of packets observed at different 42 AMP counters was aggregated as presented in Figure 4.17. The aggregate number of observed packets amounted to 29,607 in the morning peak (from 7:45-8:00 a.m.) and 42,724 in the evening peak (6:15-6:30 p.m.). It can be translated that**;**

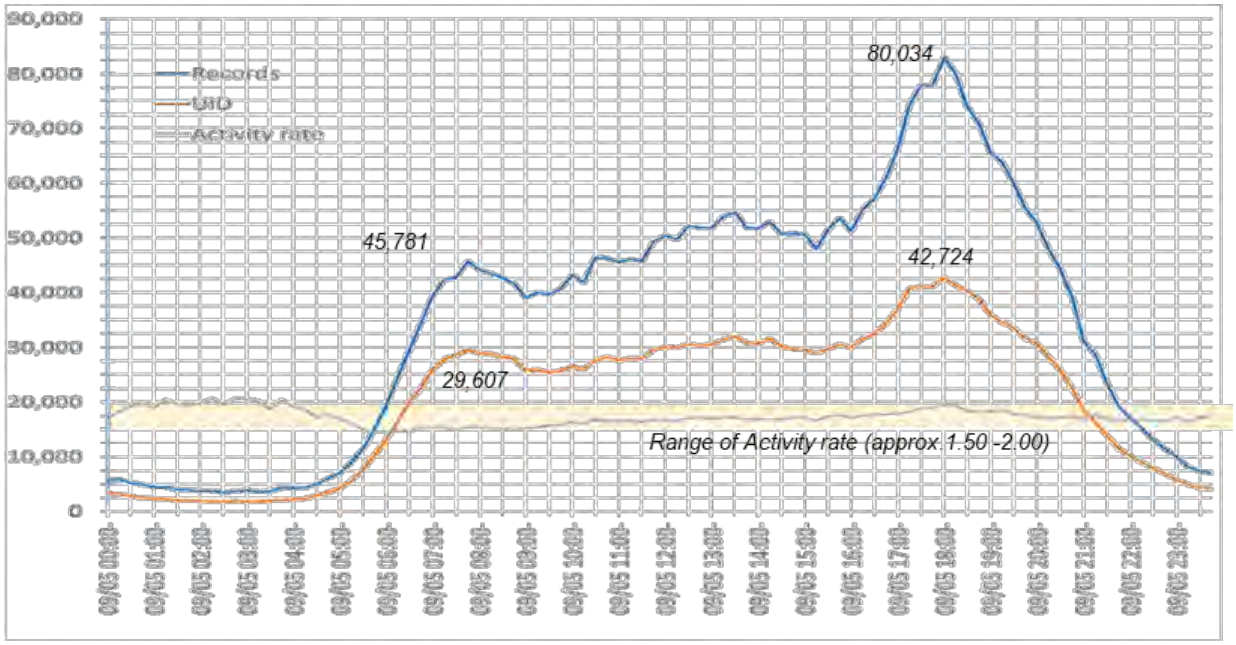
- Approx. 100-110 thousand passengers are on the streets around the CBD in a 15minute period in mornings, and 130-170 thousand passengers are there in the evenings.
- The peak period of passengers' movement in the CBD is in the evening around 6pm, and not in the morning.
- Considering the much higher peak packets in the evening than in the morning, staggered returning hours would be one of the traffic management measures to avoid congestion in the evening.[12]

[12] Instead of staggered returning hours, staggered commuting hours have been implemented in Japan, the United states, and others to avoid congestion in the morning.



Source: JICA Study Team

Figure 4.17 Aggregate Number of Observed Packets on September 5, 2017



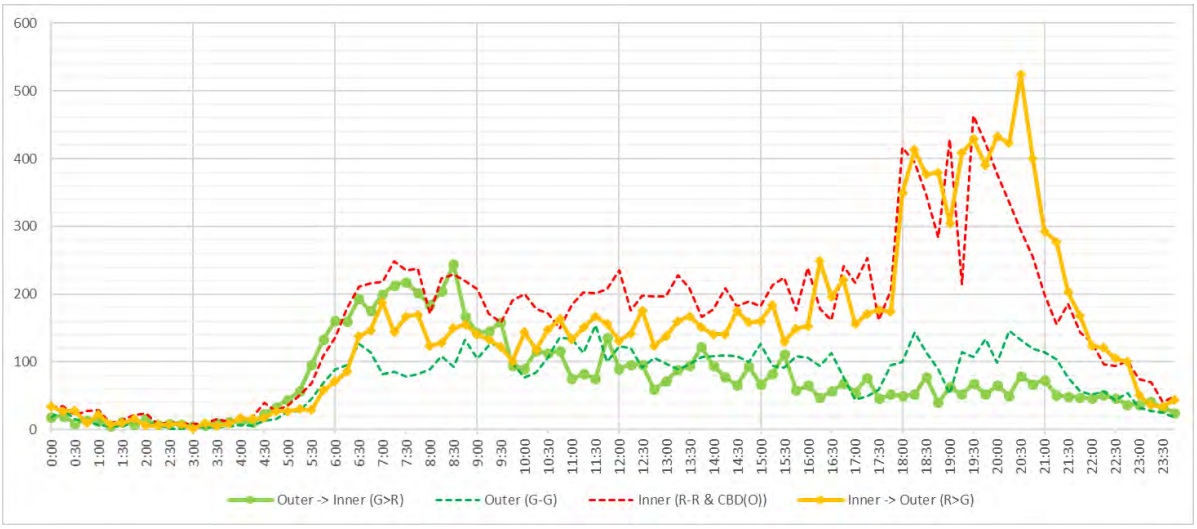
Source: JICA Study Team

Figure 4.18 Aggregate Number, Records, and Activity Ratio

Figure 4.18 gives another view of the observed number. The orange line is the same as the previous table, and the blue line shows the whole number of recorded IDs in the system. The line in gray is a value of quotient of entire IDs divided by unique IDs, which can be named as activity rate (per 15 minutes). JST suggests the activity rate can be translated as the following;

- Activity rate shows the number of AMPs that one person was detected by in a 15-minute period and it comes within 1.5 to 2.0 a day.
- In midnight, the activity rate is high, close to 2.0. The walking passengers detected inside the CBD are few, instead, passengers in cars are detected by more than two AMPs located in the outskirts of the CBD.

- During the morning peak, the activity rate is low. This means the passengers are not coming into the CBD, where AMPs were allocated in high density, and
- During the daytime to evening, the activity rate gradually increases. It shows the passengers come out onto the street for business and are exposed to AMP detection.
- In the evening peak period, the number of passengers increases and immediately decreases, and the activity ratio comes close to 2.0, which means the passengers come into the CBD from outside of the CBD, catch their buses, and immediately leave the CBD.



Source: JICA Study Team

Figure 4.19 Movement Trend Among the AMP Group

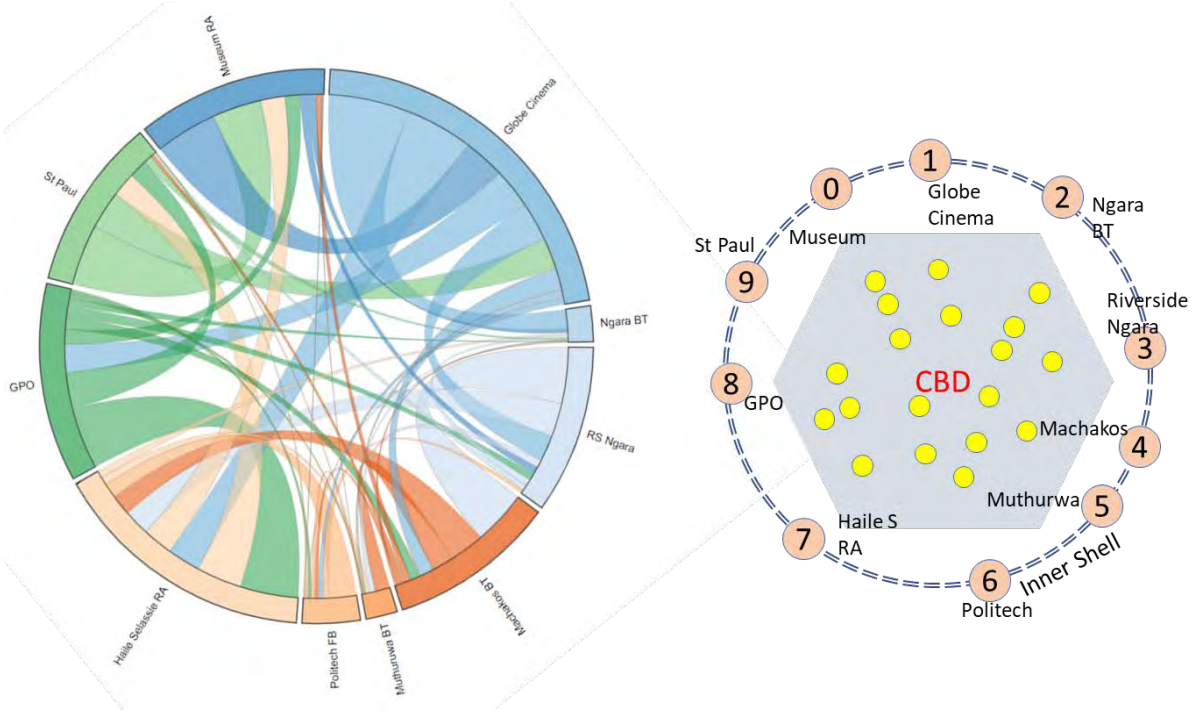
Figure 4.19 shows another summary in different aspects. This shows the amount of travel movement of among AMPs on the inner shell and AMPs on the outer shell. The thick green line is movement from the outer shell to the inner shell, which peaks in the morning period. The dotted red line is the going-out movement from the CBD-DT to the inner shell, and the thick orange line is the going-out movement from inner shell to the outer shell. Both movements show a sudden increase at 6 p.m., but the movement within the inner shell (red line) drops until 20:30, but the efflux to the outer shell remains until 21:30.

4.3.1.4 Summary: Chronological Trends of Passenger Movements in the Urban Core

- Around 1 million passengers can be counted on weekdays in the urban core, and less passengers on weekends. The passenger amount on Sundays is half of that on weekdays. The passenger amount fluctuated when political events happened.
- The hourly peak of the urban core is in the evening, not in the morning. The passenger volume at bus terminals in the CBD in the evening seems 1.5 to 2 times bigger than that in the morning.
- The passengers must come to the CBD to catch their bus with vacant sheets, therefore, the peak volume in evening comes higher than morning.
- The evening peak will continue from 5 p.m. to 9 p.m. The peak in the CBD remains until around 7 p.m., the peak in the outer shell remains until 9 p.m.

4.3.2 Travel Patterns Traversing the Urban Core

4.3.2.1 Traverse Traffic in the Inner Shell



Source: JICA Study Team

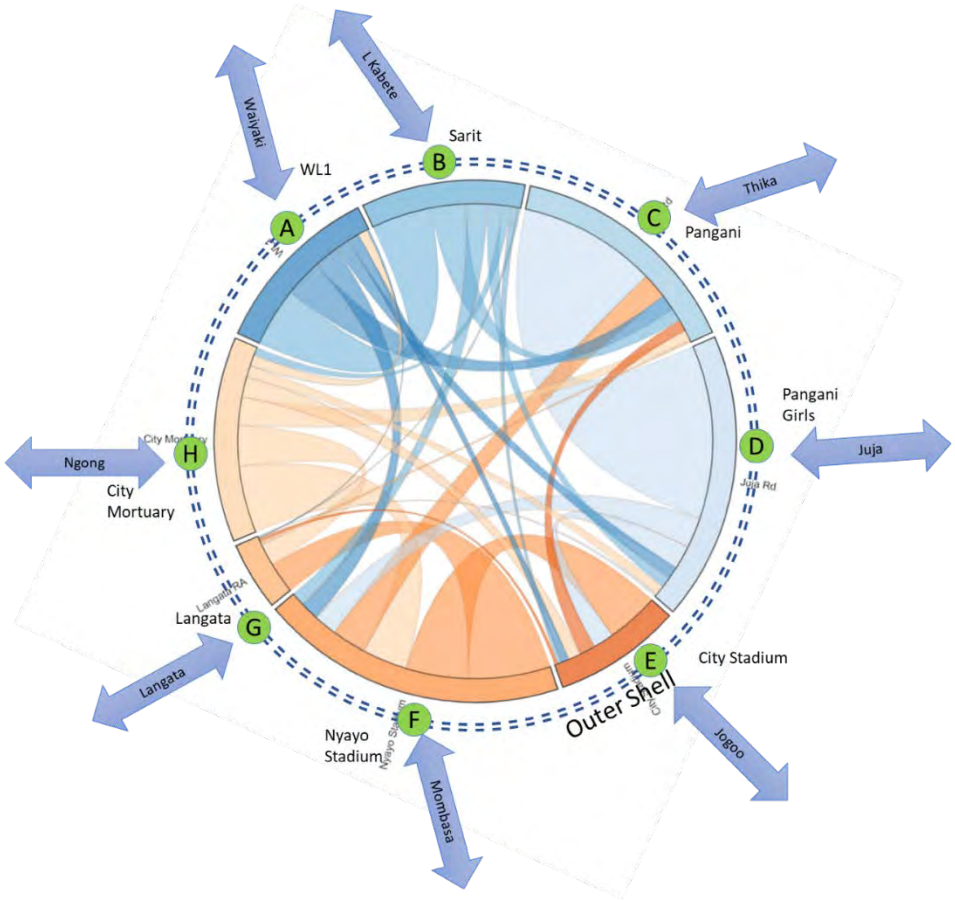
Figure 4.20 Typical Traverse Movement – Inner Shell

Figure 4.20 shows a traverse and circular movement among the AMPs on the inner shell, and it can be explained as follows;

- Traffic is concentrated in the Globe Cinema (GC), Haile Selassie roundabout (HS), and GPO.
  - The HS, GPO, St. Paul and Museum RA are located along the north-south Uhuru Highway, and the Globe Cinema is located on the Thika Highway.
- The traverse movement between northeast to west or southwest, GC-HS, GC-GPO, i.e., Thika-Juja corridors and Ngong-Langata corridor, are higher than others.
  - The biggest GC-HS travers traffic counted 5-6,000 UID both ways, which means 15,000-20,000 passengers are traversing the CBD per day. The GC-GPO has a similar amount.
- The circular movements are also big, which substantiate the importance of loop line services.
  - The movement along the Uhuru Highway, Machakos BT to HS RA, Museum RA to Globe Cinema shows a high volume, 6,000 to 7,000 counts for each OD, which means 20-25 thousand passengers are moving in each section in a circular direction.
- The passenger amount in Ngara BT and Muthurwa BT are small. Those two locations are always congested with pedestrians and passengers due to the chaos of the local market, however, the observed passenger amount is not so large.

- Traffic management is important in the areas surrounding Ngara BT and Muthurwa BT.

4.3.2.2 Traverse Traffic in the Outer Shell



Source: JICA Study Team

Figure 4.21 Typical Traverse Movement – Outer Shell

Figure 4.21 shows a traverse and circular movement among the AMPs on the outer shell, overlaying the location of AMP and the major corridors. This can be explained as follows;

- The high traffic concentration along Thika, Juja and Mombasa Corridors
- The high traverse movement between Thika/Juja and Ngong-Langata Corridors
  - The biggest Thika-Langata traverse traffic counted 3-4,000 UID in both directions, which means 10-12,000 passengers per day.
- The circular movements are also large, which substantiate the importance of loop line services.
  - The neighboring movements between A-B (WL1-WL2), and C-D (Pangani – Pangani Girls) are shown large, however, those observation locations are close to each other.
  - The passenger demand among City Stadium, Nyayo, Langata, and City Mortuary are well connected each other, due to the better connection of Lusaka, Langata, and Mbagathi road connection.
  - On the other hand, the connection between City Mortuary and Westlands (H to A) and the connection between the Pangani Girls School and City Stadium (D to E) are not

well connected. Between A to H, there are no proper road connections, and between D to E, passengers must pass through congested local markets.

4.3.2.3 Summary

This analysis is the main output of this study based on the traffic survey using the AMP system, and the results can suggest the following;

- There are traversing movements in the CBD and the Downtown district; however, there is no proper transport service to respond to such demand and no infrastructure to serve such demand. Those amounts can be expected 50,000 to 60,000 in total for Northeast to Southwest direction among the inner shell in this study.
  - ➢ This traffic volume can be handled by elevated services like Metro or elevated LRT.
- There are circulation movements around the CBD and the Downtown district; however, there is no proper transport service to respond to such demand. The Lusaka-Langata-Mbagathi road provides the proper connection now.
  - ➢ This traffic can be handled by combination of BRT, due to its low density in the outskirts of the CBD.

4.3.3 Travel Patterns in the CBD and Downtown

The detail traveled patterns in the CBD and Downtown can be described by the chord diagram of the AMPs. For simplification purposes, several AMPs were grouped into 6 city blocks, i.e.,

i) Bus terminals (BUSTNL), where major terminals are concentrated along Moi and Tom Mboya Avenue

ii) CBD south (CBS), where administrative offices and conference centers are located

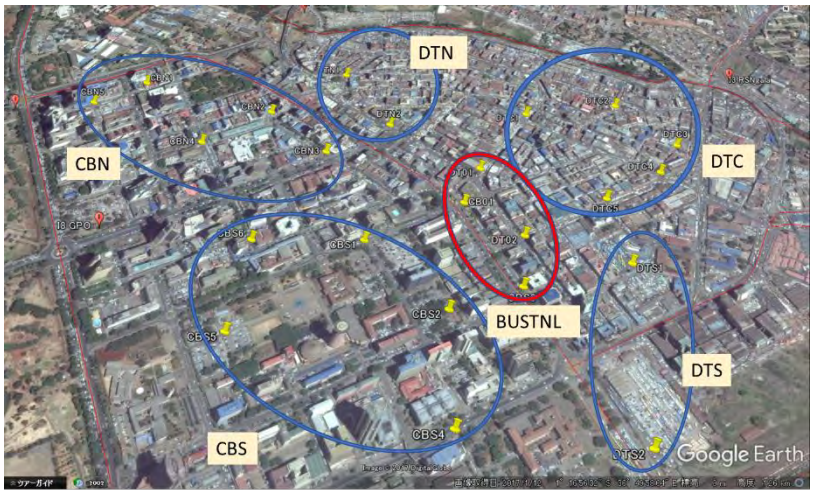
iii) CBD north (CBN), where private businesses and shopping areas are located

iv) Downtown Central (DTC), where matatu services and small-medium scale businesses are located

v) Downtown North (DTN), where matatu services and small-medium scale businesses are located

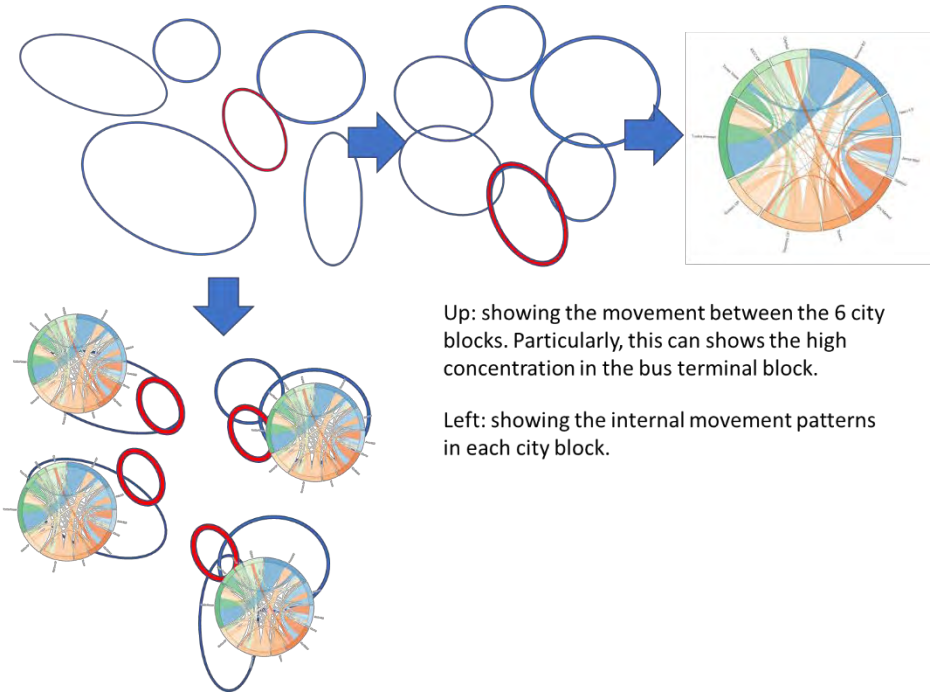
vi) Downtown South (DTS), where Central and Railway bus terminals are located

The 6 blocks are shown in Table 4.1 and Figure 4.22.



Source: JICA Study Team

Figure 4.22 Grouping of AMPs for Detailed Movement Analysis



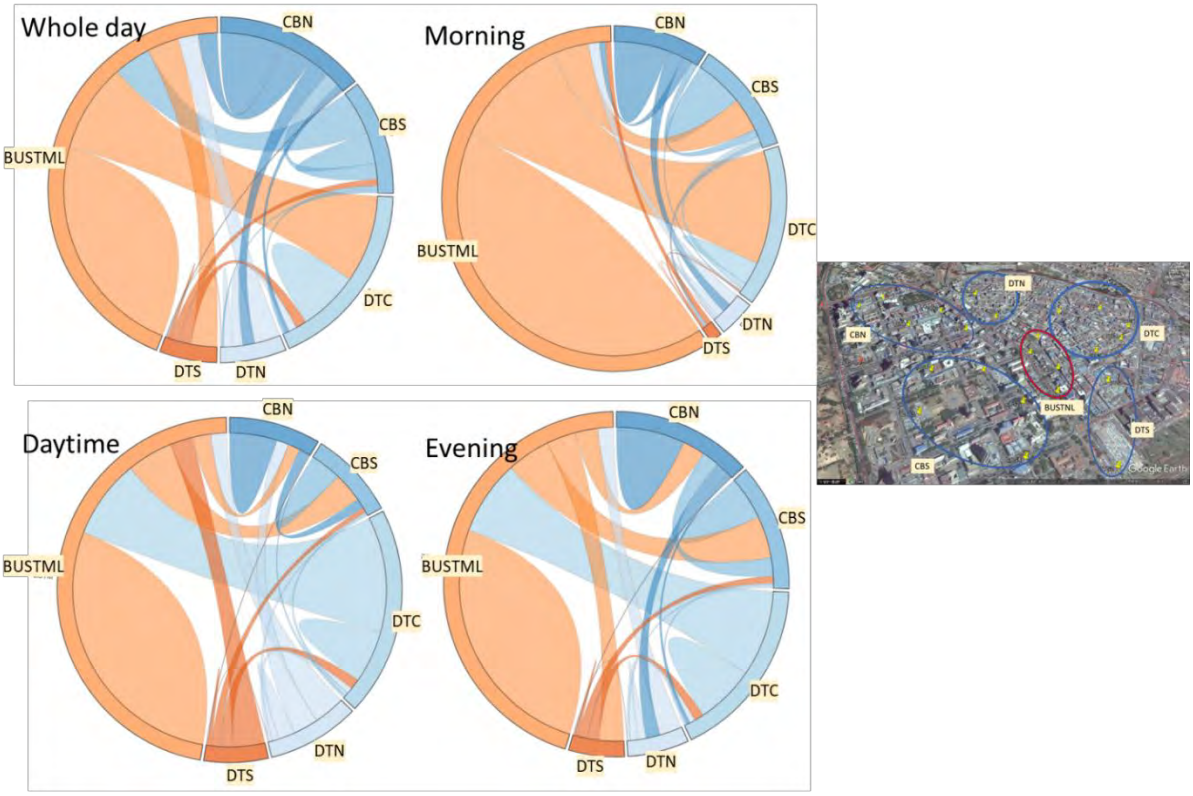
Source: JICA Study Team

Figure 4.23 Two Methodologies of Detailed Movement Analysis

Figure 4.23 shows the two methodologies of detailed movement analysis. The first one is the summary of the movement pattern among the 6 city blocks – Meso macro analysis. Particularly, the high concentration in the bus terminals and distribution patterns from the bus terminals can be shown. The second one will depict the passenger movement pattern in each city block with the bus terminal district. This will show how the passengers are connected to each of the AMPs in the city blocks from the major bus terminal.

The analysis of movement shall be shown in 4-time periods, (i) whole day, (ii) morning peak hours (6-9 a.m.), (iii) business hours (9 a.m.-3 p.m.) and (iv) evening peak (3-8 p.m.). These will show the difference in travel patterns in time.

4.3.3.1 Movement Among City Blocks -1, with Bus Terminal



Source: JICA Study Team

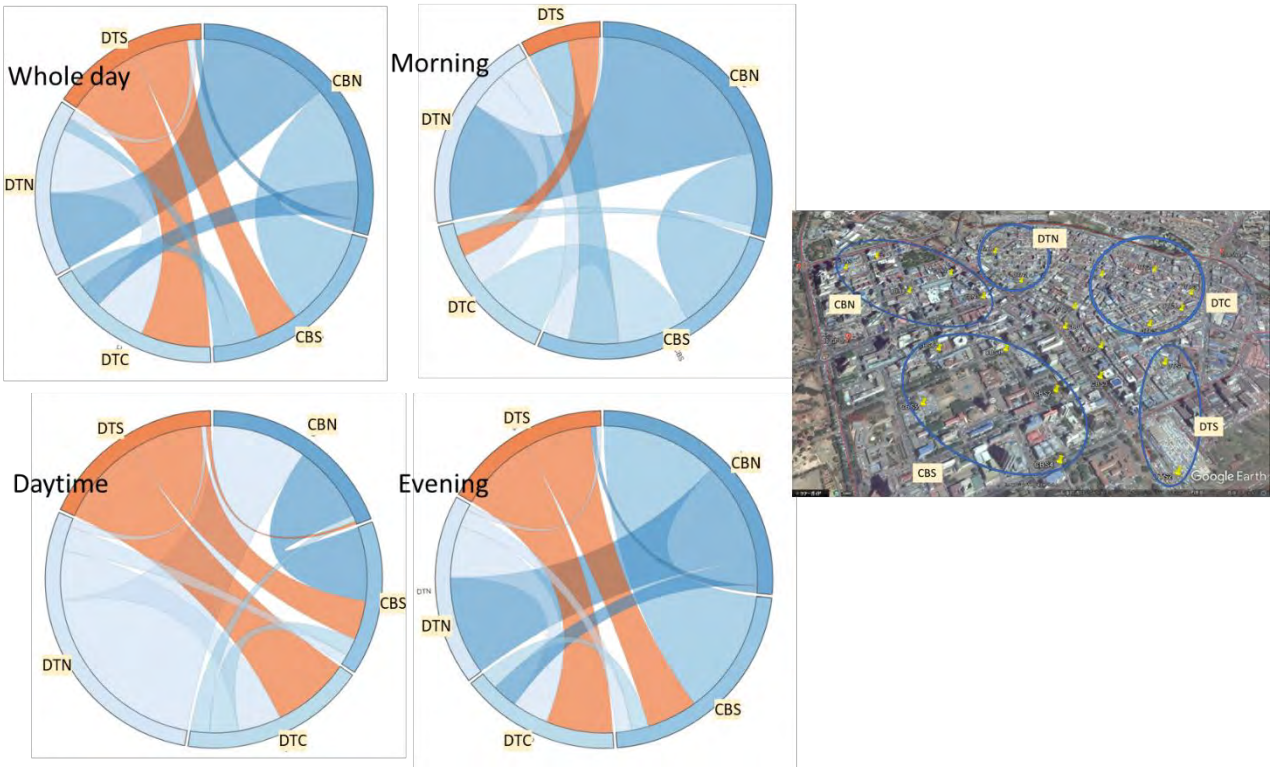
Figure 4.24 City Block Movement with Bus Terminal Block

Figure 4.24 shows the travel patterns by periods among the 5 blocks in the CBD and Downtown district, including the bus terminal district. The movement pattern among the blocks can be explained as follows;

- This chart shows the observed 274,000 unique IDs who made trips in the CBD and Downtown. This amount shares almost 90% of all unique IDs observed by the AMP system. The bus terminal district shares 44%, with 121,000 unique IDs. Out of the 121,000, 65,000 passengers made an internal trip within the bus terminal district.
  - Those figures above can be magnified by the 3.0-3.3 coefficient, this chart shows 900,000 passengers who made trips in the CBD and Downtown. The bus terminal district handles 360,000-380,000 passengers, and out of the 360-380 thousand, 200,000 to 210,000 passengers made an internal trip within the bus terminal district. (AMP cannot detect the mode of trip, therefore, all movement including bus, matatu, pedestrian, private cars are included.)
  - This substantiates how the passengers in Nairobi concentrate in the bus terminal district.
  - The CBN, CBS, DTC, DTN, and DTS share the trip as depicted, 5% to 15%. The major movement between the bus terminal and DTC is 50 thousand UID per day. This means 150,000 passengers go and return from the DTC and the bus terminals.
  - Considering the trip amount of each block to the bus terminal, the CBS, DTC, DTN, and DTS show the trip amount to bus terminal is biggest among 5 destinations, instead, the CBN shows the internal trip was biggest.

- For the morning period, the magnitude of trip share in the bus terminal district comes high. However, the total amount of observed UIDs between 6-9 a.m. is 14,000. Instead, in daytime (9 a.m.-3 p.m.) is 85,000, and the evening (3 p.m.-8 p.m.) is 98,000.
- For daytime and evening periods, the movement between DTC and the bus terminal is the biggest. In the morning period, the downstream movement from the bus terminal to DTC was major, instead, in the daytime and evening periods, the upstream movement from DTC to the bus terminal is the majority of movement.
- The movement among the 5 blocks shall be explained in the next section.

4.3.3.2 Movement among City Blocks -2, without Bus Terminal



Source: JICA Study Team

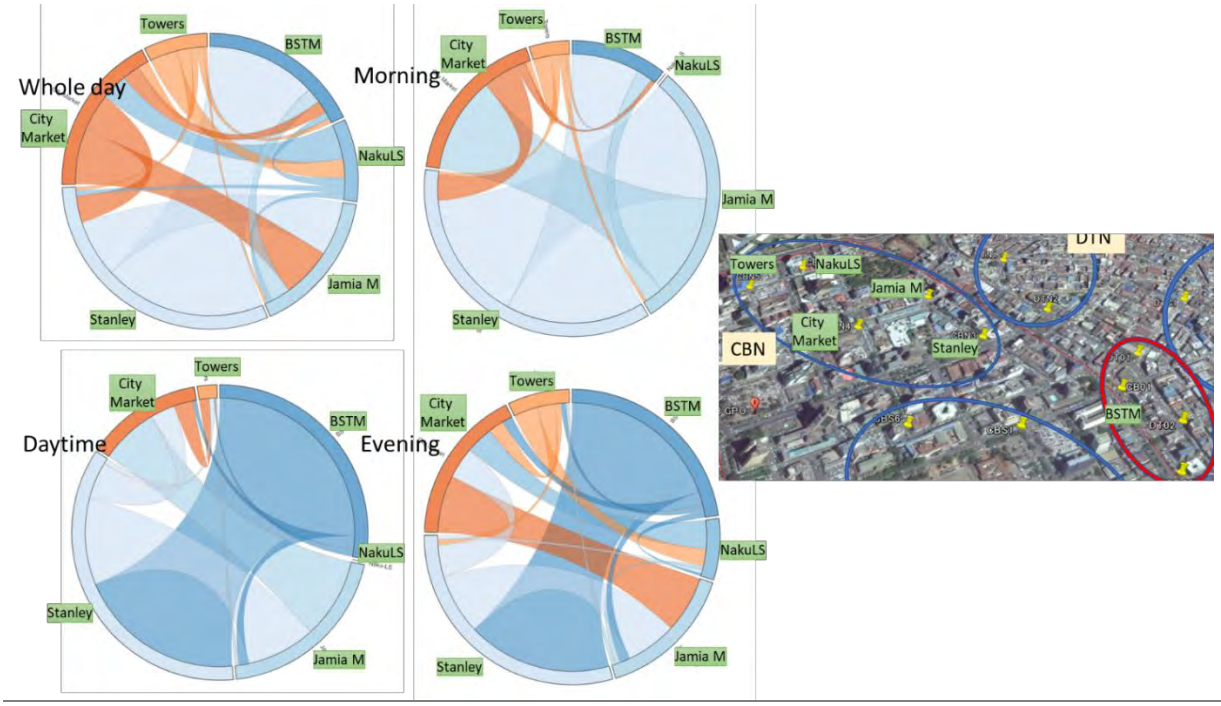
Figure 4.25 City Block Movement without the Bus Terminal Block

Figure 4.25 shows the travel patterns by periods among the 5 blocks in the CBD and the Downtown district, excluding the relation with the bus terminal district and the internal trip amount. The movement pattern among the blocks can be explained as follows;

This chart shows 42,000 unique IDs which were logged in an entire day, therefore, approx. 150,000 people traverse blocks in the CBD and Downtown.

- The major traverse movement is CBN-DTN, E-W crossing movement in the northern side, DTS-DTC, N-S movement between major bus terminals, and CBN-CBS, N-S movement between the CBD business blocks.
  - ➢ The high share of CBN-DTN movement may suggest that the Thika-Juja road-originated passengers arrive to DTN, and move into the business district in the CBN. The movement from DTN to CBN is high in the daytime, which suggests a high demand for shopping and business.

4.3.3.3 Internal Movement in CBD North



Naku-LS	CBN1	In front of Nakumatt Lifestyle, shopping, restaurants, but old-fashioned districts
Jamia Mall	CBN2	Kimathi Street/Tubman Road Intersection (Jamia Mall), shopping, restaurants, but old-fashioned districts
Stanley	CBN3	New Stanley, business district with busy intersection, in front of Sarova Stanley Hotel
City Market	CBN4	City Market, shopping, restaurants, and residential apartments
Towers	CBN5	Anniversary Towers/View Park Towers/Car Park, three high rise office buildings with car parking function

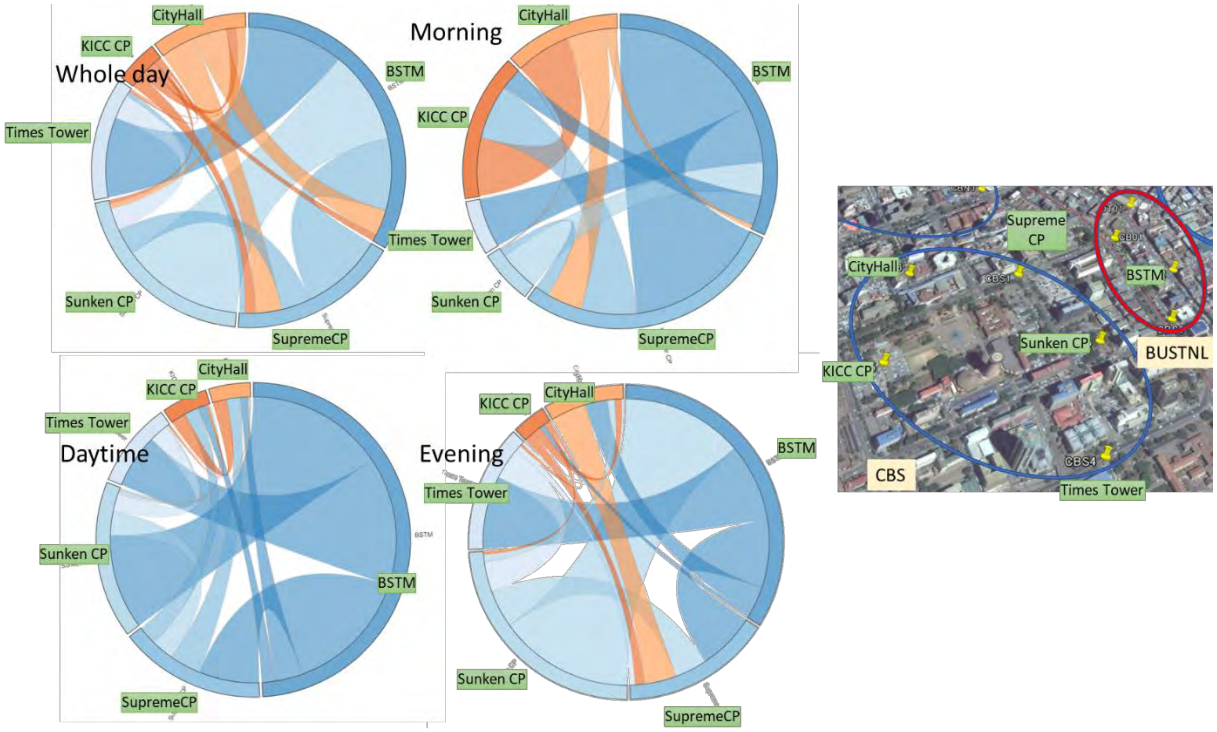
Source: JICA Study Team

Figure 4.26 Inner Block Movement – CBD North

Figure 4.26 shows the travel patterns by periods among the CBD northern block and the bus terminal district. There are 5 destinations in this block, the table in the figure shows characteristics of the destinations. The movement pattern in the CBD northern block can be explained as follows;

- For a whole day of movement, Stanley has the biggest passenger volume. The connection between BSTM and Stanley is biggest due to their close relation. The major bus route in the western direction runs in front of Stanley Junction. For traverse demand, the movement between Jamia Mall to City Market shows a high demand.
- For the morning period, Stanley and Jamia Mall show a large demand. This is attributed to the bus movement along Moi Avenue in the morning. The passengers between the bus terminal district and the CBD north block are few in the morning period.
- For the daytime movement, the BSTM and Stanley show a strong connection. The traverse movement between City Market and Jamia Mall cannot be ignored.
- For the evening period, Nakumatt LS and Towers presence is larger than at other periods.
- In the CBD north, the influence of the bus terminal district is not so strong, however, Stanley and Jamia Mall have a strong connection with the bus terminal district. The traverse demand between Jamia Mall and the city market district is stable during all periods.
  - ➢ The pedestrian environment can be enhanced for the movement above.

4.3.3.4 Internal Movement in the CBD South



Supreme CP	CBS1	Supreme Court (Located along Taifa Road), close to Supreme Court administrative district
Sunken CP	CBS2	Sunken Car Park (Locate near public toilet), in the center of major HQ buildings
Times tower	CBS4	Times Tower (Locate near Post Office), Bank HQs, Ministry of Finance
KICC CP	CBS5	KICC Car Park, close to the National assembly and high security area
CityHall	CBS6	Travel House/City Hall (Mount on City Hall Annex wall), in local business district

Source: JICA Study Team

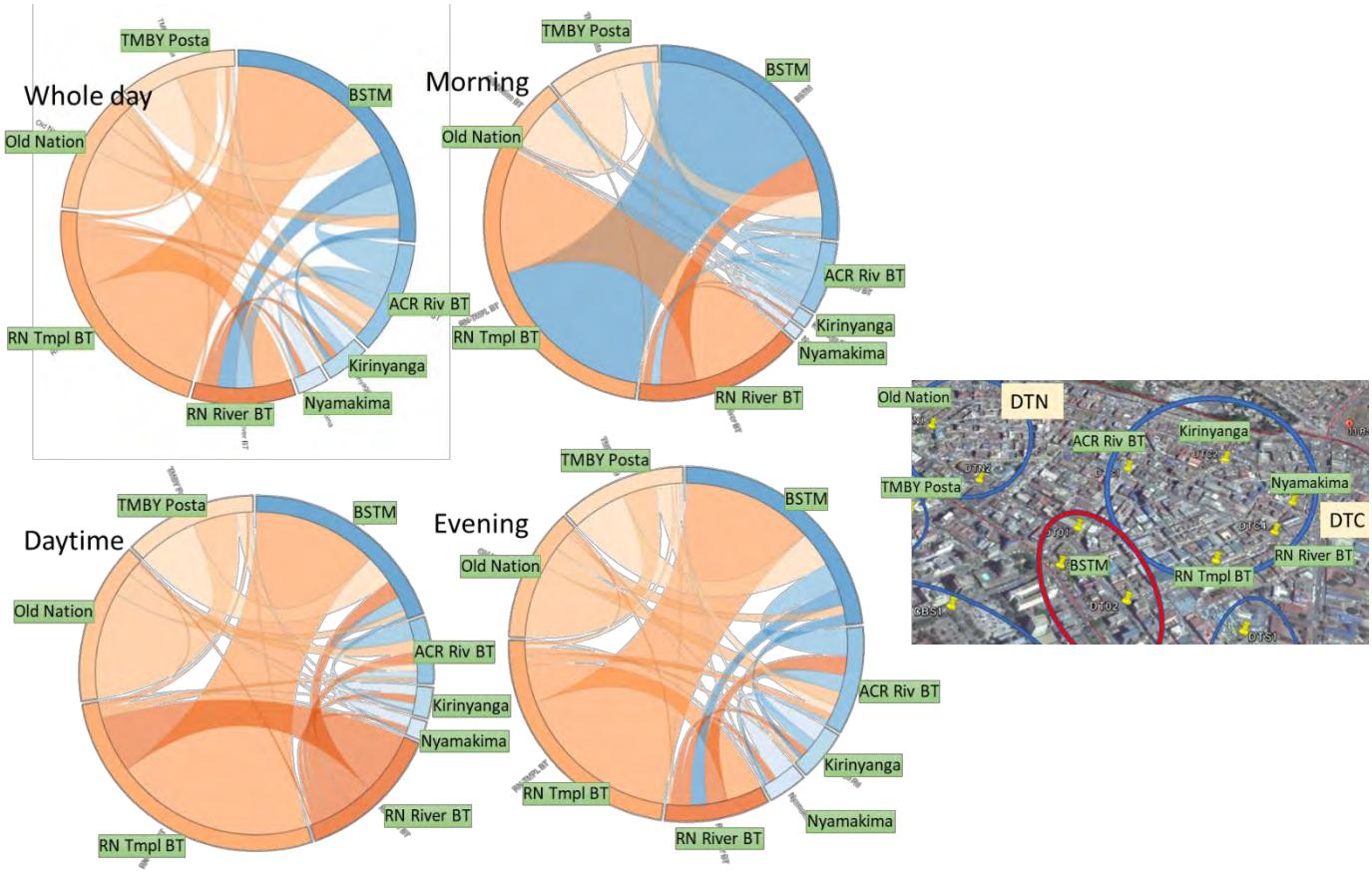
Figure 4.27 Inner Block Movement – CBD South

Figure 4.27 shows the travel patterns by periods among the CBD southern block and the bus terminal district. There are 5 destinations in this block, the table in the figure shows characteristics of the destinations. The movement pattern in the CBD south block can be explained as follows;

- For the whole day of movement, Sunken CP and Times Tower are major, where large office buildings and various company HQs are located. Though the Times Tower district is located 500 meters away from the bus terminal, the biggest passenger movement in total was counted here. The passenger volume to/from KICC CP is small, due to its low-density use. Passengers in the City Hall district show even distribution to their destinations.
- For the morning period, the movement between BSTM and Supreme Court was the biggest, due to their close relation. Most passengers for Times Tower district move from BSTM. The large share of the KICC CP and City Hall districts may include pedestrians as well as car users.
- For the daytime period, the high business movement concentrated in BSTM connecting the surrounding business districts are presented in the chart. The passenger amount of KICC and City Hall is small.

- In the evening peak, the demand between Sunken CP and BSTM is the biggest due to their close relation.
- The movements in the CBD southern block show highly concentrated characteristics with the bus terminal compared to the CBD north block. The results do not show much circulation among destinations in the block. This may suggest that **walkability improvement in radial directions** from the bus terminal district will be required in the CBD south block.

4.3.3.5 Internal Movement in Downtown Center and North



ACR-Riv BT	DTC1	Accra Road/River Road Junction, high matatu demand and long-haul large bus terminal
Kirinyaga Rd	DTC2	Kirinyaga/Kumasi Road Intersection, less matatu terminal function, small businesses
Nyamakima	DTC3	Nyama Kima (Near Molo Line), less matatu terminal function, small businesses
RN River BT	DTC4	Ronald Ngala/River Road Intersection, high concentration of matatu with small businesses
RN-TMPL BT	DTC5	Temple Road/Ronald Ngala, high concentration of matatu with small businesses
Old Nation BT	DTN1	Old Nation R/A (Located towards Roast House), matatu
TMBY Posta	DTN2	Posta (Tom Mboya)

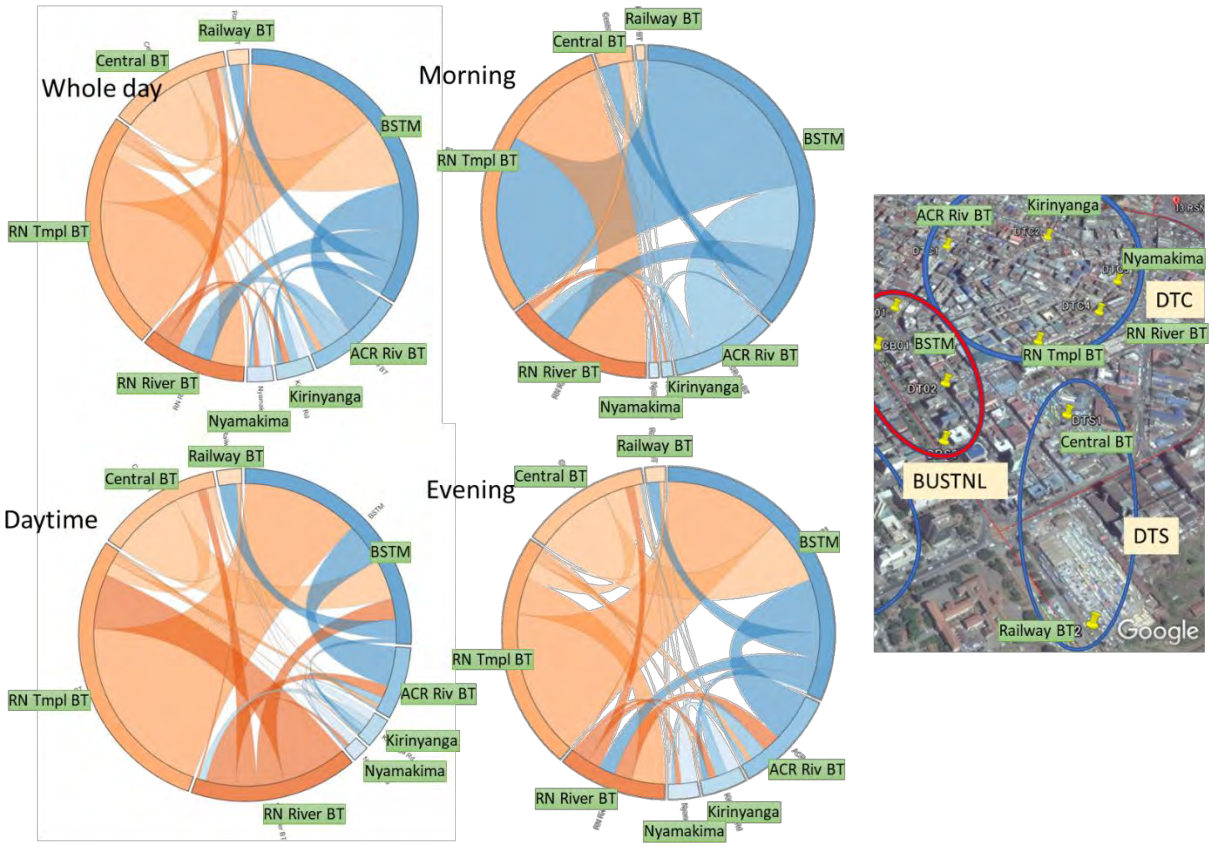
Source: JICA Study Team

Figure 4.28 Inner Block Movement in Downtown Central and North

Figure 4.28 shows the travel patterns by periods among the Downtown central and north blocks and the bus terminal district. There are 7 destinations in this block, and the table in the figure shows characteristics of the destinations. The movement pattern in the Downtown central and north block can be explained as follows;

- For the whole day of movement, the RN Tmpl BT presence is biggest due to its close relation with the bus terminal district, and its high concentration of matatus.
  - The circular movement from the bus terminal, RN Temple, RN River, and back to the bus terminal represents major movement around this block.
  - The traffic among ACR Riv, Kirinyanga, Nyamakima shows their close relation to each other.
  - The movement along Old Nation, Tmby Posta, and then the bus terminal represents major matatu influx movement from Globe Cinema.
- For the morning period, the movement from the bus terminal to RN (Ronald Ngala) district is major. Likewise, in daytime and evening period, the reverse movement becomes major.
  - The movement in a whole day comes to 53,000 total, which means 160-180 thousand passengers move in this area.
- For the daytime period, the volume of traffic generated at Old Nation and RN River is larger than other periods. It can be considered that the influx demand by matatu continues during the daytime for business and shopping purposes.
- In the evening peak, the demand pattern similar to the pattern of the whole day.
- The connection of Downtown north district and central blocks is weak. A strategy to enhance the circulation among the blocks should be considered.
- Walkability improvement along the Bus Terminal district and Ronald Ngala St. should be improved.
- Moreover, the diversion of matatu services from Ronald Ngala St. might be necessary to avoid a high concentration of traffic.

4.3.3.6 Internal Movement in Downtown Central and South



Central BT	DTS1	Central Bus Station/Hakati (on Magnate Ventures High Mast), large bus, with some small business.
Railway BT	DTS2	Railways, matatu and bus terminals. Little business and commercial services

Source: JICA Study Team

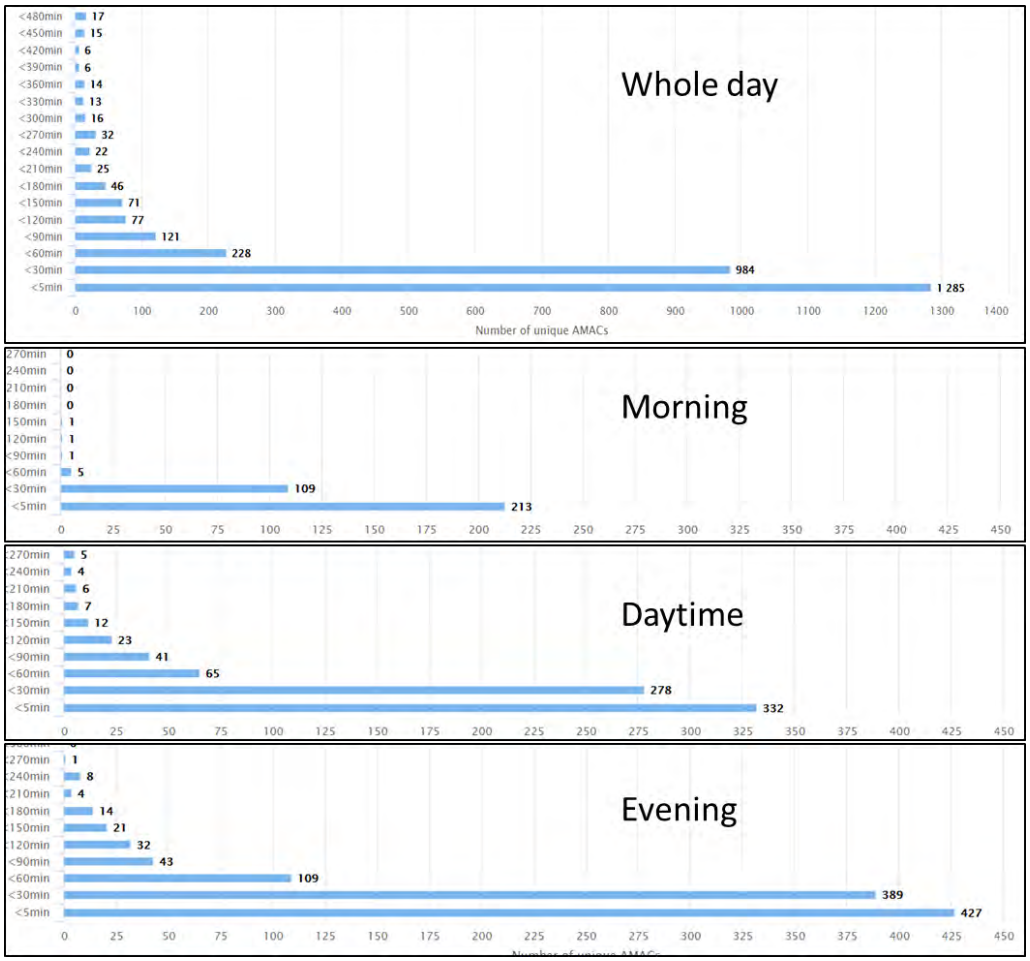
Figure 4.29 Inner Block Movement in Downtown Central and South

Figure 4.29 shows the travel patterns by periods among the Downtown central and south blocks and the Bus Terminal district. There are 7 destinations in this block, and the table in the figure shows characteristics of the destinations. The movement pattern can be explained as follows;

- The difference of the travel patterns from the previous section is not big. The movement between RN Temple Road and the Bus Terminal district is major.
- The connection between central BT and railway BT is little.

4.3.3.7 Staying Period

The AMP system can measure the staying time length of the Wi-Fi devices in a place or in a grouped place. Figure 4.30 Waiting Time in the Bus Terminal District shows the staying period in the Bus Terminal district (4 AMP collectors), summarized in 30-minute thresholds. For the daytime and evening period, the share of waiting time of more than 5 minutes and less than 60 minutes, is more than morning and whole day.



Source: JICA Study Team

Figure 4.30 Waiting Time in the Bus Terminal District

This can substantiate that the passengers must wait for their buses for longer times, particularly in the evening period, as all buses do not allow standing seats. This study may suggest revising the standing seat regulation for buses.

4.3.3.8 Summary

Those series of analysis in meso, macro, and micro level for internal movement among the city block in the urban core may suggests the following;

- High concentration of bus terminal districts. Nearly 50 % of passengers coming into the urban core need to be in the bus terminal district (Moi and Tom Mboya).
  - ➢ This is attributed to the design of matatu/bus services, all the services are terminated in this small district, and force passengers to exchange buses. This generates delay and lost time waiting.
  - ➢ Enforcement of standing seats for buses is also a reason of delay.
- Traverse movement and circular movement are revealed by AMP surveys, which should be supported by new infrastructure and new transport services.
  - ➢ This study suggests Metro and circular BRT network. Details are discussed in Chapter 5.

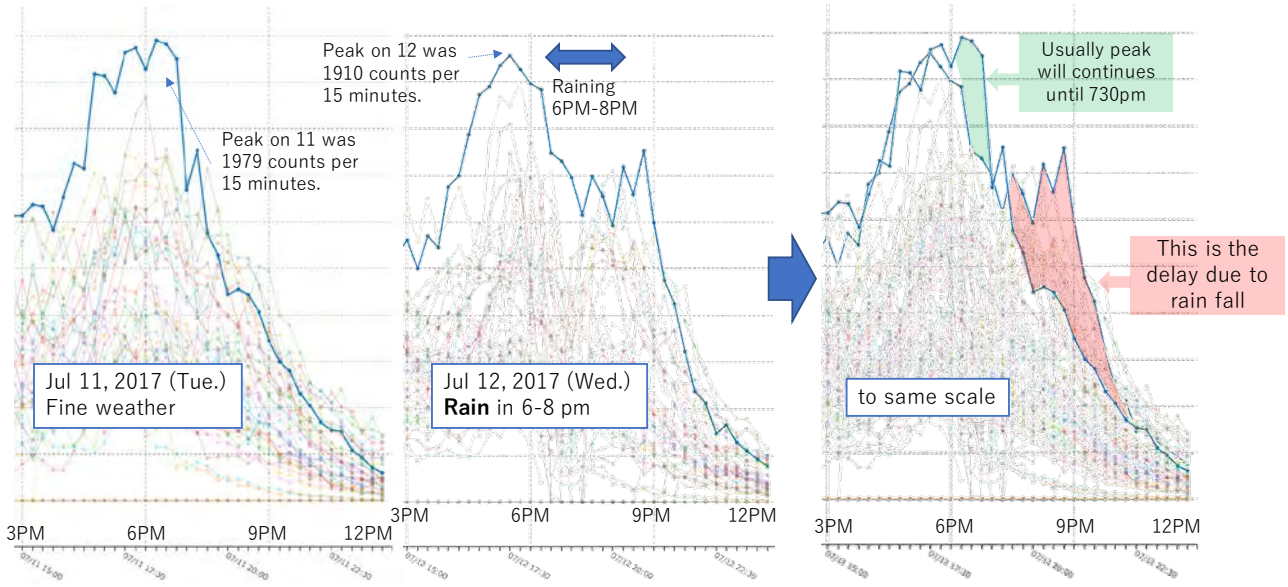
- Walkability improvement should be considered in the CBD and the Downtown district, this study visualized where large traffic demands are, which district the traffic moves to and returns from, and in which period the traffic changes direction.
  - ➢ This study suggests (i) the Bus Terminal district to Ronald Ngala corridor, (ii) CBN internal traffic, (iii) CBN-DTN crossing, and (iv) CBS-the bus terminal, are major areas to be improved.

4.3.4 Unique Travel Patterns

This section shows thematic analysis of the AMP results.

4.3.4.1 Heavy Rain and Delay in the Evening Peak

The CBD experienced heavy rain from 6 p.m. to 8 p.m. on Wednesday, July 12, 2017. It was the first rain in two weeks, which disrupted the movement of commuters returning home. The AMP counters clearly captured the change in travel patterns. Figure 4.31 compares the travel pattern of a sunny day on July 11, 2017 (left), to that of a rainy day on July 12, 2017 (middle), and the overlapping travel patterns of these two days (right) at the Haile Selassie Junction, one of the biggest intersections in Nairobi.



Source: JICA Study Team

Figure 4.31 Delay in the Evening Peak Due to Heavy Rain

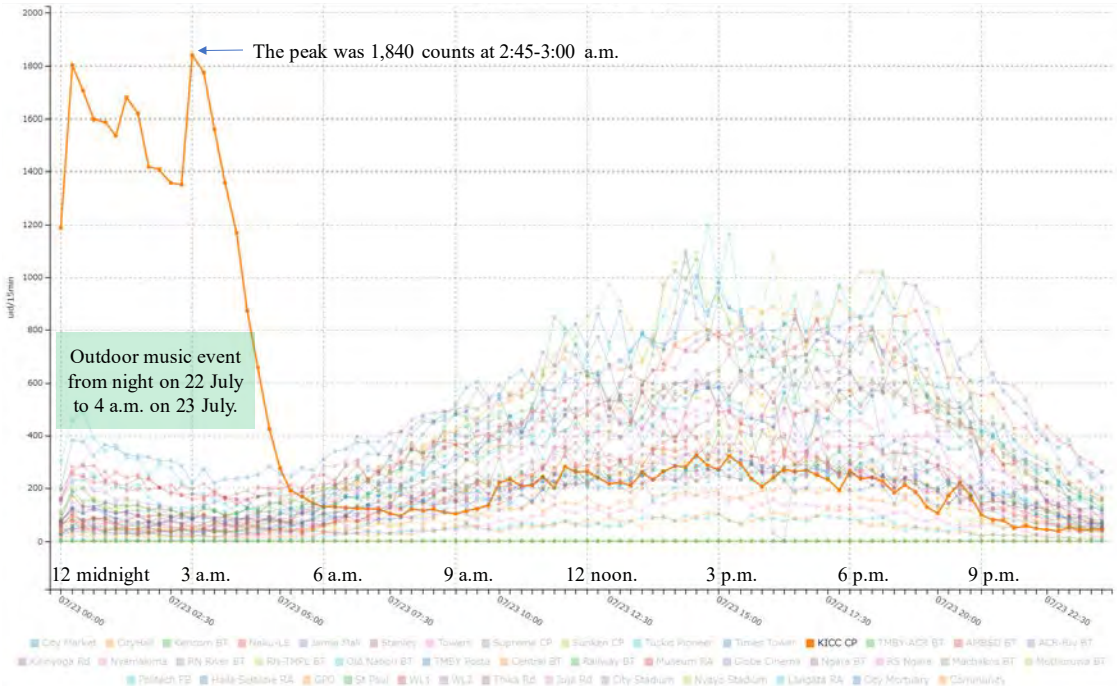
The comparison of the observed number of unique MAC address on July 11 and July 12 shows the following two gaps. The first gap colored in light green indicates that the peak duration is shorter on rainy days. The second gap colored in pink can be interpreted as a delay of the evening peak compared to a day earlier. This analysis of course can be criticized as follows:

- The counted packets are of passengers in all directions. Another AMP counter nearby could provide information on direction;
- The July 11 data does not represent the travel patterns on all sunny days;
- The counted packets represent bus and matatu passengers, pedestrians, and car users; and
- The AMP counter at this location does not seem affected by temporary blackout, although some AMP counters were affected and stopped in the same period due to heavy rain.

4.3.4.2 Music Event

The AMP counter at the Kenya International Conference Centre (KICC) car park recorded an abnormal trend on Saturday, July 22, 2017 at midnight (Figure 4.32). This was due to an outdoor music event that took place during 2:00 a.m.-4:00 a.m. on July 23 at the venue. The AMP counter collected 1,840 unique signals at the peak from 2:45 a.m.-3:00 a.m.

Assuming the expansion factor of 3.0, it is estimated that 5,520 people were at the venue. According to the KICC and the event owner, the venue capacity is 4,000 people. The event owner deployed 1,500 staff and police also deployed 200-300 officers. Comparing these two figures, it is considered reasonable to assume an expansion factor of 3.0.



Source: JICA Study Team

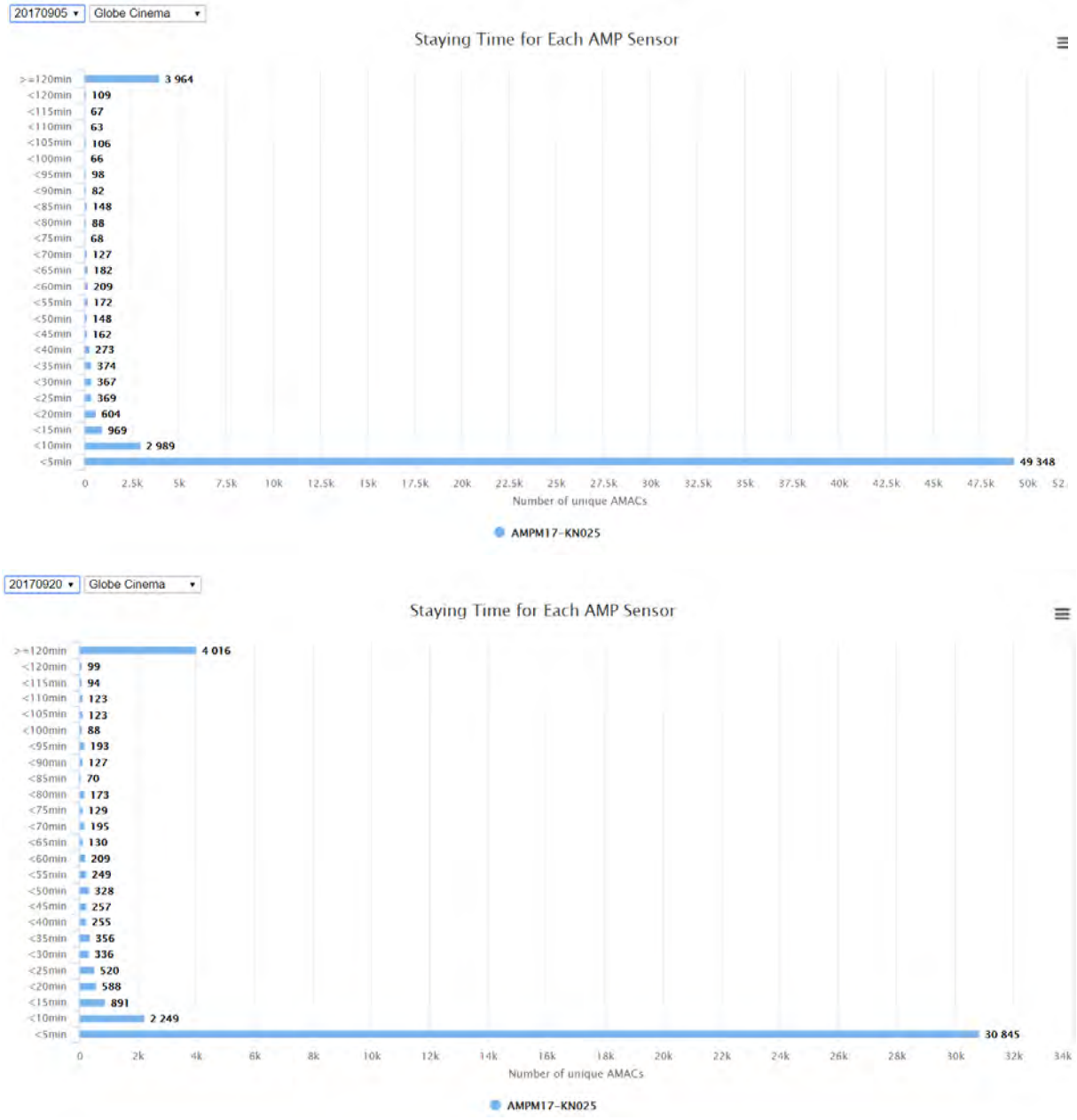
Figure 4.32 Abnormal Trend at KICC Car Park due to a Music Event, July 2017

4.3.4.3 Prohibition of Matatus' Double Parking

On September 20, 2017, a traffic management measure was undertaken mainly to prohibit matatus' double parking. The staying time at Ngara Bus Terminal and Globe Cinema, where double parking by matatus is occasionally observed, is compared between before and after the implementation.

Figure 4.33 presents the similar tendency: the unique IDs staying less than five minutes at Globe Cinema declined by 37% from 49,348 to 30,845, compared to the 30% reduction of total daily unique IDs from 61,152 to 42,643.

The significant reduction of total daily unique IDs is coupled with the slightly larger reduction percentage of the number of unique IDs staying less than five minutes at the two locations. This indicates that the traffic flow in the center of Nairobi was moderated before and after the implementation of the traffic management measure.



Source: JICA Study Team

Figure 4.33 Distribution of Staying Time at Globe Cinema, September 5, 2017 (up) and September 20, 2017 (down)

Part-II

Future Urban Transportation Plan in Nairobi

Chapter 5 Nairobi Urban Core and Its Future

5.1 Concept Notes and Strategic Approaches

5.1.1 Concept Notes

The following notes can be a base of strategic consideration for Nairobi urban core mobility development. This chapter explains the broader concept, not only transport engineering and urban planning, but also business, security, historical issue, ethnicity and economic disparity[1].

1) Overview – Necessity of City Branding Concept

Referring to various statistics and business reports[2], Nairobi is the top city in the Sub-Sahara Africa region. Nairobi is widely regarded as being predominantly fluent in English communication, housing offices for several multinational and diplomatic organizations, various branches of top international companies with extensive market reach, historical background and variety of ethnicities with international communities etc. On the other hand, the expansion of the market reach of Dubai and cities within the Republic of South Africa, the market growth of smaller countries in the region such as Uganda and Rwanda, increased security threats from Somalia, etc., have impacted Nairobi's reputation negatively. It should be noted that cities are competing against each other to keep their own position higher than others.

As an example, there is an initiative[3] by the local business community to have Nairobi host the Olympic Games in 2032. It is apparent that Nairobi would be shortlisted if the Olympic society wanted to be convened in the Sub Sahara region, however, the author doubts if Nairobi has an adequate grasp of city development to host the Olympic Games. There are many questions to be asked; Does Nairobi have sufficient infrastructure? Are social services adequate to host it? The authors propose the necessity of a city branding concept to develop Nairobi as a global city, by meeting the standard requirements to be accepted by the global community in the long term. The transport concept plan in the urban core must be in line with such context.

Like most other cities, Nairobi is also facing challenges related to motorization and urban development, which cities have fought with since the beginning of the twentieth century. For the most part, there are limitations with controlling this as many cities even in Europe and US still suffer from heavy traffic congestion. It is worth referring to the experiences of motorization in Asian cities, as the speed of motorization and urbanization are faster than cities in Europe and the US.

2) Outgrow the Old UK Shell

As mentioned in chapter 3, the present functions of the CBD and Downtown were designed in the UK colonial period to handle a planned population of 600,000 for the whole city, and this smallness in size creates various strains presently. First, a new Urban Core Concept should be created, and its function should be defined to serve the planned 6 to 12 million people of the

[1] On preparation of this section, The JICA Study Team has studied on the Manifesto of Mike Sonko – Polycarp Igathe (2017, General Election). The Manifesto proposes the vision for transport as "*A congestion-free Nairobi County where public transport is orderly and flows seamlessly, where private car use becomes less necessary and where pedestrians and especially children have safe walkways across the city"* and several 5 years target policy.

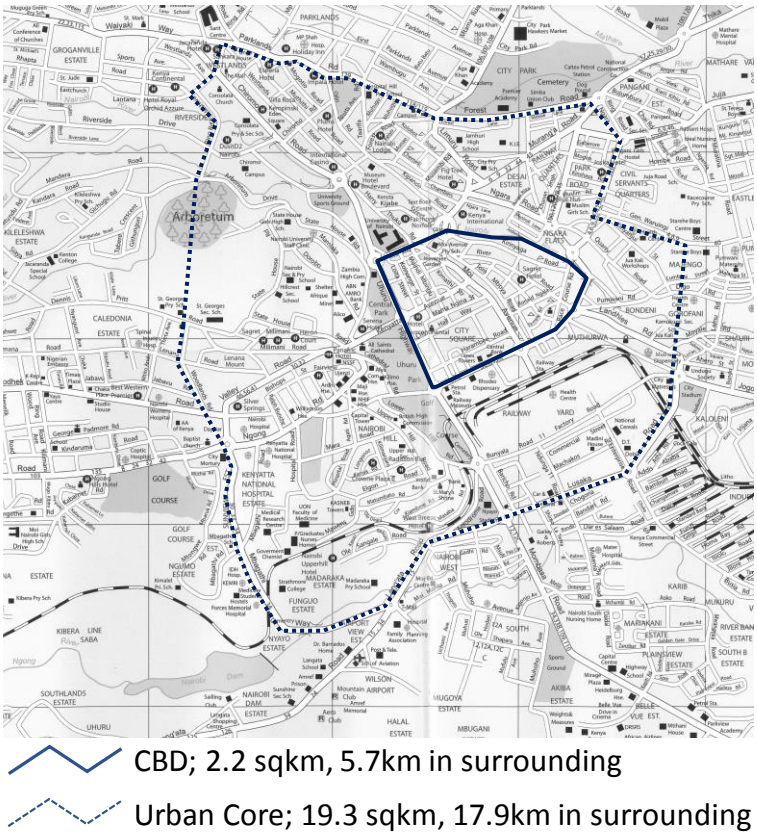
[2] https://www.standardmedia.co.ke/business/article/2000230390/nairobi-ranked-among-most-dynamic-cities-in-the-world

[3] https://arkafrica.com/article/nairobi-2032-olympics/ (now this link has been expired)

greater city area and NaMATA region.

The study team defines an initial Urban Core concept as follows;

- Define the Urban Core area. JICA Study Team provisionally suggests the urban core as Figure 5.1.



Source: JICA Study Team

Figure 5.1 Provisional defined Nairobi Urban Core

- The Loop Line service will be formulated around the peripheral of the urban core in conjunction with BRT services, instead of the initial monorail-based proposal in the NIUPLAN.
- In the old CBD area, the road ratio is 23%, which substantiates the road network has enough space, but the road ratio in the urban core is 11%, which requires more road and street investment. Ring road function and missing link development should be prioritized in the urban core area.
- There are several barriers in the Urban Core regarding missing link development, i.e., KRC underutilized railway land, KRC golf course, the State House, and the Eastleigh military airport. It is time to consider relocation of these to outgrow the old UK shell.

3) Integration of East-West

Referring to the old UK urban planning as explained in Chapter 3, it can be said that the urban development concept was influenced by colonization management and ethnicity control policy, e.g., CBD are for UK and its businesses, Downtown for Indians, Upper hills are estates for foreigners, Eastleigh are for Somali communities, etc.

However, from the early 2000s, estate development for the local middle class sprawled

outward from Nairobi settling beyond the Eastleigh districts (Donholm, Umoja, Kasarani, etc), which were traditionally recognized as predominantly residents from the Somali community. The development of the Thika Superhighway accelerated development in the eastern region of Nairobi. Another similar development can be depicted in the Upper Hill region. The new middle class settled in new estates around the Upper Hill districts, which was traditionally recognized as an area for upper income groups and foreigners. As shown in Chapter 4 and chord diagram, the biggest passenger movement in the urban core is East-West directions, which substantiates the movement of new middle-class residents.

Currently, the urban core can be said to be a hinderance to East-West connectivity. There is no infrastructure to handle through traffic in the East-West direction. There are no Bus and Matatu services connecting directly between East-West. It seems that there is an invisible wall between the CBD and Downtown, due to historical factors and the colonial UK urban planning.

Nairobi needs a strong corridor connecting the east-west direction with proper capacity, to enhance the middle-class economy exchanges. Moreover, such an east-west corridor should be designed to overcome the outdated UK urban structure, hidden cultural issues, etc.

4) Need to Harmonize with the "Harmonization Study" (reorganize the BRT plan)

The Harmonization Study undertaken in 2013 identified 5 priority corridors for Metro development. As explained in chapter 3, the proposed BRT network as per the Harmonization Study does not consider any harmonization with other urban planning aspects, such as land use, other competing modes, other development projects, etc. The initial design of BRT alignment cuts across grid-locked intersections with level crossing other BRT lines, which will aggravate the congestion in Nairobi.

As summarized in chapter 3, there are many planned projects within the Urban core and its environs, including the viaduct project, road widening, railway ROW development, and land readjustment. Also, Nairobi has a lot of unused public land which can be used for Metro network development. Metro network and BRT alignment should be integrated with new projects to assure its punctuality and rapidity.

The study team proposed a new harmonization study with a revised concept of the BRT network and design standard, to improve urban mobility of the urban core. It is summarized in Chapter 5.2

5) Improve the Ordinary Bus Services as Nairobi Local Industry

Ordinary bus services can be said to have been ignored for two decades by the public sector. These services are not suitable as feeder services. They must play the main role of transport service in lower demand corridors, e.g., Lower Kabete, etc.

The current operators of ordinary buses are private. They have to recoup their investment from the fare, however, public regulator NTSA requires that certain statutory requirements are met and this serves only to lower their profitability, e.g., standing regulations, larger bus fleet installation, non-standardization of payment method, etc. On the other hand, irregular Matatu operators rob the passengers of the ordinary buses.

Nairobi is in an interesting position as being the regional bus fleet supplier. A decade ago, the old 14-seater matatu were sold out to other cities within the EAC region, and when 31-seater minibuses started operations in Nairobi, local manufacturers in Nairobi expanded their capacity and conversions of Hino/Isuzu trucks to 31-seater minibuses. Currently, the 31-seater minibus are also exported to other small cities, and local manufacturers are also building 51-

seater minibus on Hino/Isuzu truck chassis. Some manufacturers partner with local bus operators who thus enjoy the economy of scale from large orders.

6) Utilize the KRC properties

KRC has an existing underutilized 60m reserve along the full length of the railway alignment. Even for the Kibera and Mukuru Slums, where the encroachment to the right of way was severe, the reserve is secured for 40m, which was proposed by the RAP study undertaken by KRC with support from the World Bank. In addition, KRC owns a lot of property and land around the stations which is also underutilized.

The existing underutilized resources could be leased out for use as an exclusive transport corridor shared with the current commuter train. This would ease congestion on the roads and also help in moving people to and from the CBD.

7) Define the Common Enemy of the Transport Service Promoters

The car ownership rate of Kenya nation-wide is around 15 vehicles per 1,000 people. For Nairobi, there are no reliable statistics available, but it can be estimated to be 50 to 60 per 1,000 people[4] in high income areas. It is quite low if compared with Bangkok (100-150), Nagoya (400-500), Los Angeles (600-700). Nairobi has not yet experienced actual motorization which will increase from now.

JICA Study Team observes that transport service promotors in Nairobi criticize proposed solutions proposed by each other, though more benefit would be drawn if they support each other in coming up with a comprehensive and all-inclusive solution for Nairobi as the city stands to get more benefit from such interventions. As it stands currently, there may be lack of expertise in the sector, and there is need for cooperation amongst the agencies involved to come up with a solution in the wake of increased motorization in the near future. It should be noted that the speed of motorization will accelerate according to experiences in Asian cities[5].

JICA Study Team suggests defining the motorization as the common enemy of the transport service promotors, in order to make their activities harmonized and cooperated.

8) Be the Top Runner within the Sub Sahara region

The United Nations' Global Innovation Index 2017 places Kenya third after South Africa and Mauritius amongst the most innovative nations in the Sub-Saharan Region. The index which is in its 10th edition surveys some 130 economies using dozens of metrics, from patent filings to education spending providing decision makers a high-level look at the innovative activities driving economic and social growth

In line with this, Nairobi can be on the forefront of innovation in public transport solutions for its residents. E.g., if Nairobi starts Metro operations, Nairobi can be a hub of human resources of Metro operation in Sub Sahara Region, Kenya can export such expertise to neighboring countries, and Nairobi can be the engineering base of the Metro services. Not only Metro, but also IT solutions for transport services, including payment system, bus location services, improvement of Matatu, and so on, are the targets of being the top runner.

[4] NIUPLAN's survey mentioned ownership was 45 to 50 vehicles in the Waiyaki way area of Nairobi.

[5] http://library.jsce.or.jp/jsce/open/00039/201105_no43/pdf/222.pdf

9) Transport Services Supporting Night Life

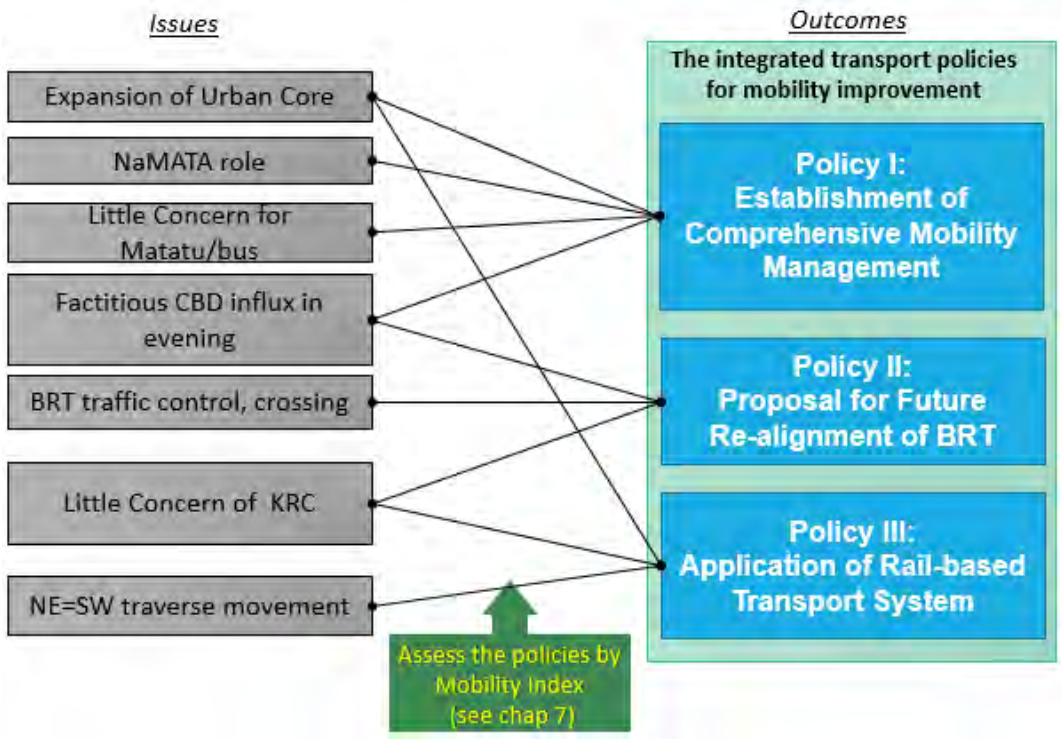
Chapter 4 introduced the specific characteristics of the passengers in Nairobi in the evening. Passengers come to CBD to catch their buses and tries to vacate the CBD before 8pm. Some may say the security situation plays a key role in this, however, it is more due to short operation hours of reliable transport service, which in turn influences the attractiveness of the night life of the Nairobi Urban Core.

Transport-planning-wise, the highly concentrated demand in evening can be staggered by extending the transport service hours of operation. Urban-planning-wise, the longer stay of passengers in the Urban Core will encourage traffic (as shoppers) and improve revenue for local businesses.

5.1.2 Strategic Approaches

Figure 5.2 shows the relationship between the issues and outcomes in Part 2, including chapter 5, 6 and 7. The listed issues are identified previously in chapters 2 to 4. This is regarding the land use, institutional issues, transport at the macro and micro level in the urban core. The strategies are generated from the concept notes above and summarized into three items. The outcomes of this study are also summarized into the three parts.

Regarding the issues, most are identified and discussed in section 3.4. The expansion of the urban core function with mushrooming development is creating new travel patterns in the Nairobi urban core. NaMATA's role is still unclear practically as it has not yet started with proper human resources. Some concerns regarding buses and matatu management, KRC improvement and BRT crossing and control in the urban core are identified as difficulties for transport service expansion. The CBD influx in the evening and NE-SW traverse movement are identified in Chapter 4, according to the AMP data analysis.



Source: JICA Study Team

Figure 5.2 Issues and Outcomes

The *outcomes* category suggests the urban core mobility concept to be created. As explained in the concept notes, the existing CBD is too small to accommodate the present travel pattern and demand. Therefore, a new concept of the "Urban Core" is suggested to realize city branding, which includes integration of city function and transport function, smooth traffic services, safe city with night life, etc. The comprehensive approach will include land use regulation, pricing, demand management as well as transport service interventions like BRT, road network, etc. This will be summarized as comprehensive approaches in Section 5.3, as Policy I.

The second outcome is the BRT reorganization, which resulted as the major proposal in this study, summarized in Section 5.2 as Policy II. A harmonized planning and proper coordination of BRT with new urban development is the urgent issue for BRT, therefore, the outcome is explained prior to the comprehensive approach.

The third outcome is a rail-based transport proposal. The study team proposes a rail-based transport system application to Nairobi along the identified NE-SW urban axis (explained in the Chapter 6).

As previously mentioned, this study focuses on Urban Core Mobility (not the whole city) for the metropolitan area of Nairobi, to strengthen the brand of City of Nairobi itself. Chapter 7 gives a numerical assessment of the proposed policy with the Urban Core context, applying transport network analysis.

5.2 BRT Re-organization Strategy

This section explains the mobility improvement strategy including the following planning aspects;

1) re-organization of the existing BRT (Metro) alignment and services integrated with existing planned projects, including a pros & cons evaluation of current and new network
2) affiliate services and projects other than the Metro network
3) Implementation strategy

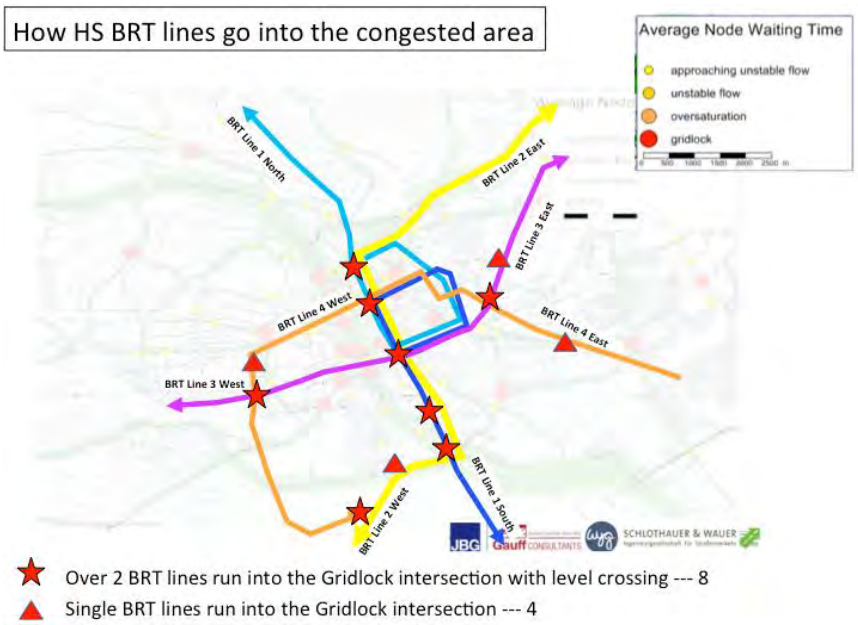
5.2.1 Necessity of Re-Organization

1) Target Lines

The targets are Line 1 to 4 of the proposed BRT network in the Harmonization Study. Line 5 is excluded as it is just running out of urban core. Line 1, 3 and 4 are prioritized for 2023 according to the present program, and Line 2 is expected to be built later (2030-35).

2) Micro Scale Reason

Figure 5.3 shows the geographical relation between the proposed BRT lines (HS), and KURA's ITS study for intersection improvement. It should be noted that both studies are funded by the World Bank (NUTRIP).



Source: JICA Study Team

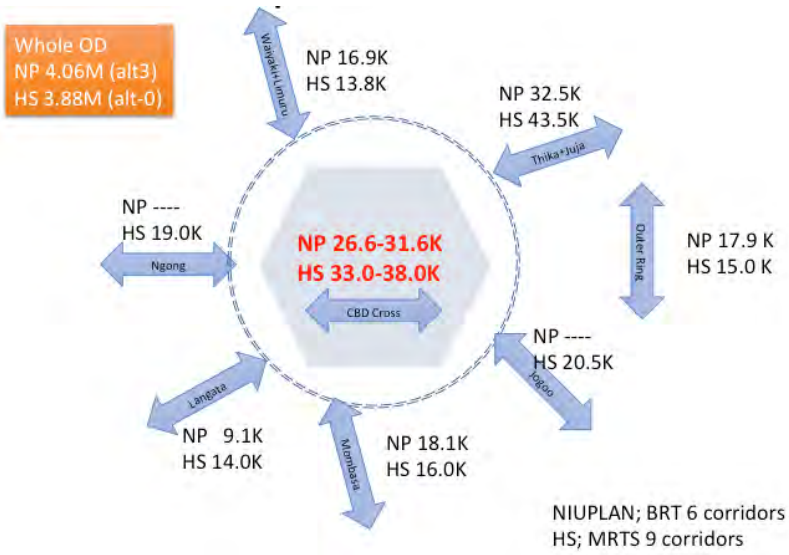
Figure 5.3 BRT Alignment within the Nairobi Urban Core

The figure shows there are 17 gridlocked status junctions in the city, and the BRT alignment is designed to go through 12 junctions of the 17; moreover, there are 8 junctions with 2 or more BRT alignments, and 4 with 1 BRT alignment. The study team considers that the grid-locked junctions do not have the capacity to handle BRT with level crossing.

3) Macro Scale Reason

Figure 5.4 shows the PPHPD[6] flow required for the BRT services along the major corridors in 2030, forecasted by the NIUPLAN and Harmonization Study. The PPHPD load exceeds ten thousand along the corridors, which makes the current BRT services saturated. For example, the Mombasa road has a 16-18 thousand PPHPD requirement, but the present plan only proposes one BRT service along the route, which can only provide 10 thousand PPHPD. The PPHPD of each mode are described in detail in Chapter 6. This requires increased BRT services for major corridors with higher demands, or proposal of alternates modes.

[6] The NIUPLAN and Harmonization Plan did not provide PPHPD for the BRT services along these corridors, but they estimated line loading volume by sections for both directions. The PPHPD here, can be estimated simply by applying peak hour ratio (assumed as 10%) and directional ratio (assumed as 50%).



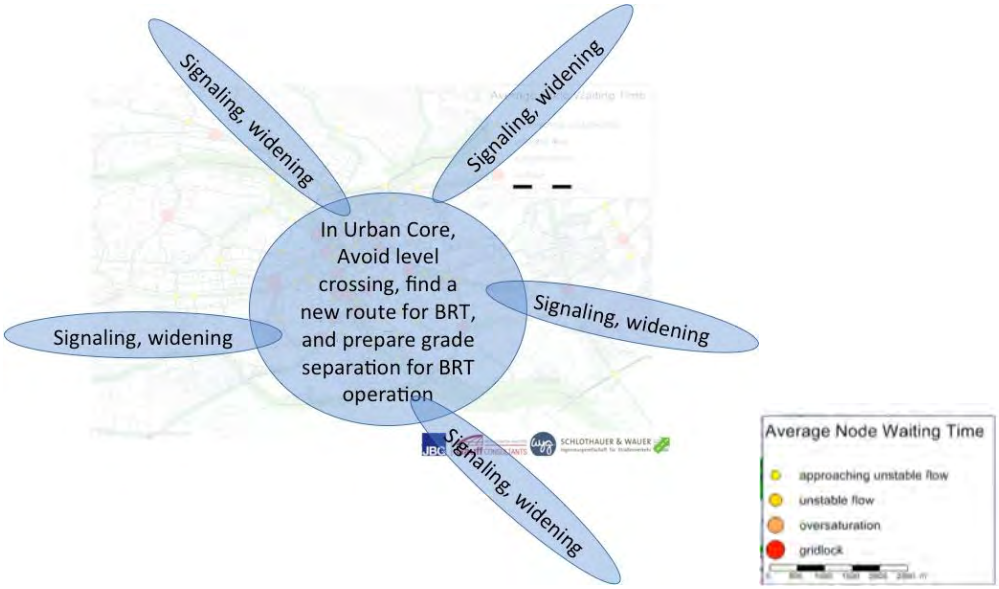
Source: JICA Study Team

Figure 5.4 Comparison of forecasted PPHPD from the NIUPLAN and Harmonization Study reports

5.2.2 Strategy for Re-Organization

The following concepts can be proposed for re-organizing the BRT alignment plans.

- Avoid CBD and level crossing of BRT within the Urban Core
  - Level crossing of BRT at crowded junctions is the biggest reason of delay. BRT must secure its operating timetable speed compete with LOS of passenger cars to harmonize with motorization. This is not a replacement of Matatu, but a new transport service. Outside of the Urban core, proper BRT operation can be maintained by utilizing exclusive lanes, as shown in Figure 5.5.
  - The CBD is too congested to accommodate the BRTs. The passenger demands are on the fringe of the CBD (as explained in chapter 4), so BRT can accommodate the demand in the outskirts of CBD, i.e., urban core.
- No need to run along the existing road
  - If KURA plans BRT, it will run along its KURA road. If NCCG (or NaMATA) plans BRT, BRT can run everywhere in the city. There are numerous land development plans to accommodate BRT corridors in the urban core.
- Consider operation of BRT operation
  - 18m-length BRTs cannot turn easily. So, it is best to keep them in the right turning lanes in the intersections and keep the alignments straight.
  - Transit (Exchange) Points should not be in one place. Do not keep the CBD as focal points for the new city design with 6 million people.
  - During peak hours or breakdowns, locations for stabling and turning around are required close to the urban core.



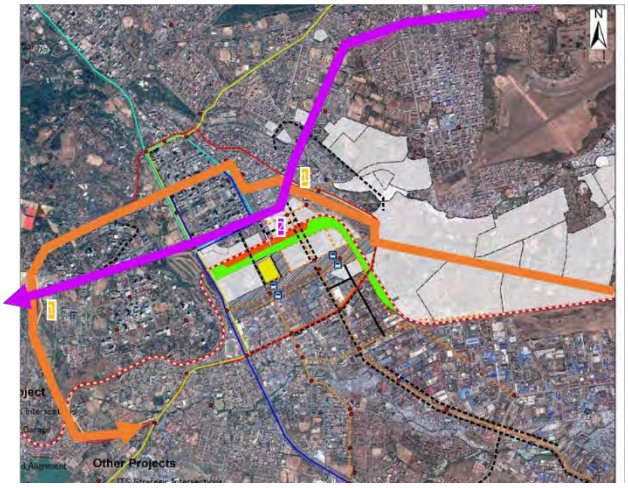
Source: JICA Study Team

Figure 5.5 Proposals on how to avert negative impacts of the convergence of the proposed BRT lines in the Urban Core

5.2.3 Review of Line 3 and Line 4 Combination

5.2.3.1 Present Alignment and KRC Viaduct Utilization

The Line 3 (Juja-Ngong; Purple) and Line 4 (Jogoo are Mbagathi, Orange) are designated as prioritized E-W corridor lines in the network, but they must cross the congested CBD and Uhuru highway. There will be significant obstacles at Racecourse and KNH junctions between Line 3 and 4, and Line 3 does not consider the viaduct development proposed by KURA and JICA at the Muthurwa market.



Present Idea;
Line 3 on Juja will run into Racecourse, Haile Selassie, and Ngong road.

Line 4 on Jogoo will run into Racecourse, Tom Mboya and Jomo Kenyatta Ave, and Mbagathi way

Source: JICA Study Team

Figure 5.6 Current proposed alignment of BRT Line 3 and 4

There is a viaduct along the Uhuru Highway on the KRC alignment. The study team will propose to utilize the un-used space of the KRC alignment for BRT crossing. It is very difficult to build a viaduct at Haile Selassie Jct., but this will require little additional cost, with paying a lease fee to KRC to use the area beneath the viaduct. Note that the KRC rail service is just one round trip per day (only on weekdays, with a few freight services on weekends)[7].

[7] It should be noted that the 60K vehicles on the Mombasa road need to climb the 8m-height-bridge and waste 780 Kl of gasoline per day. The viaduct itself cannot justify its necessity with the present operation of the KRC services.

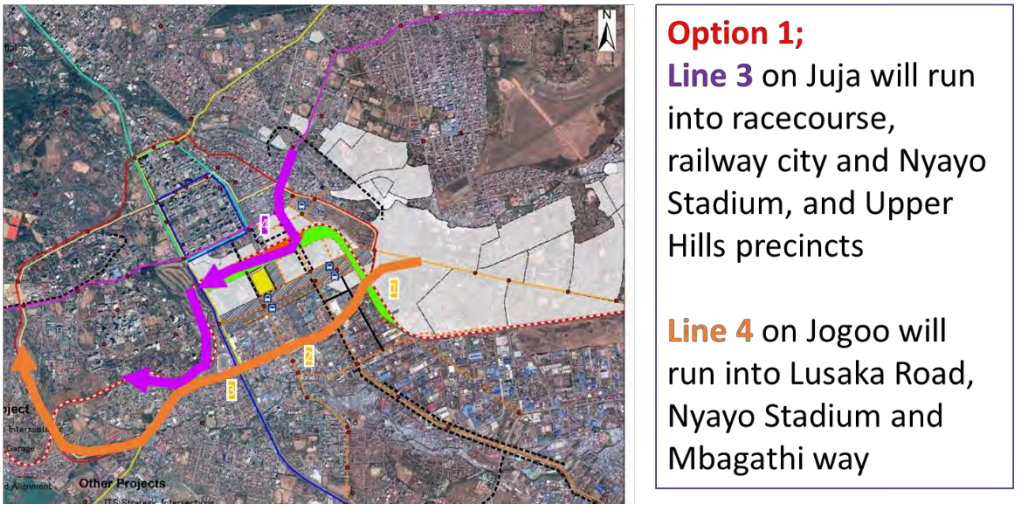
Source: JICA Study Team

Figure 5.7 Proposed realignment of BRT Line 3 with Railway City Concept

This idea is based on the recent Railway City Development concept. East end of this crossing will be connected to the main E-W corridor in the Railway City, which needs new transit services with new development. This can be coordinated with the Railway City design team. The Green Mall plan also proposes that the Green Mall Bus Station shall be located in this area.

5.2.3.2 Option 1 – L3&L4 Reorganization

Figure 5.8 shows the first option for reorganization utilizing the KRC viaduct.



Source: JICA Study Team

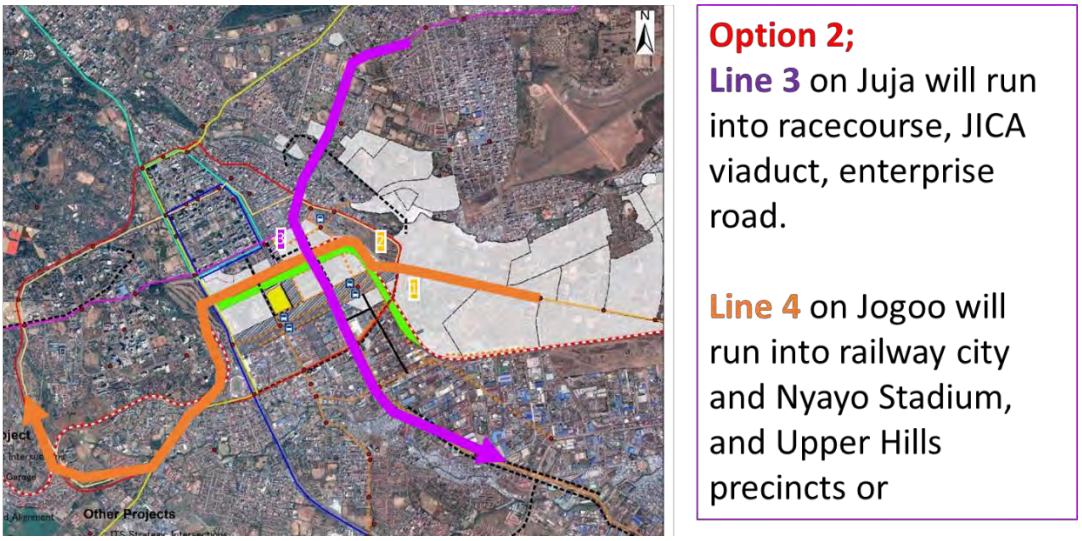
Figure 5.8 Option 1: Proposed realignment of BRT Line 3 and 4

This idea is based on the following integrations with the other on-going projects;

- The Urban renewal project of Eastlands (NaMSIP) should accommodate the Line 4 detour of the city stadium junction.
- The Lusaka road widening is under EU funding to accommodate Line 4.
- The Nyayo Intersection needs an E-W underpass, which should be covered by EU funding
- Line 3 will cross into the railway city at Muthuruwa Market (which may appear difficult).

5.2.3.3 Option 2 - L3&L4 Reorganization

Figure 5.9 shows the 2nd option for reorganization by utilizing the viaduct.



Source: JICA Study Team

Figure 5.9 Option 2: Proposed realignment of BRT Line 3 and 4

This idea is based on the following integrations with other on-going projects;

- For Line 4, a viaduct is necessary to avoid the ring road at city stadium (to get into railway city).

- For Line 3, JICA viaduct plan will build a 4-lane viaduct at Muthuruwa Market. Use this on a non-exclusive basis. Connect Juja to Enterprise.
- For Line 3, the enterprise road widening is on-going, led by EU or JICA
- This will form the Loop Line south-western part function.

5.2.3.4 Micro Arrangement to Avoid Junctions – Jogoo-Lusaka

Source: JICA Study Team

Figure 5.10 Proposed realignment of BRT

Connecting BRT Line 4 on Jogoo Rd. into Lusaka Rd: As an idea to avoid the city stadium junction utilizing the flyover of the KRC for Lusaka Rd, the BRT must run along the shoulder side. An underpass should be facilitated to realize this idea. A circulation route of BRT around city stadium can facilitate the operation of BRT for U-turn in peak hours.

5.2.3.5 Micro Arrangement to Avoid Junctions – Nyayo Stadium Surroundings

Source: JICA Study Team

Figure 5.11 Proposals for micromovements around currently congested intersections

To connect E-W BRT to Langata Rd, it needs to run along the KRC alignment and go into

Nyayo stadium, running into Langata rd. Branch out around Nyayo stadium to make a U-turn station. Possible to find a branch leading to Upper Hill.

The small bridge on the Bunyala Rd., not enough to accommodate the BRT alignment in both directions. Need to expand.

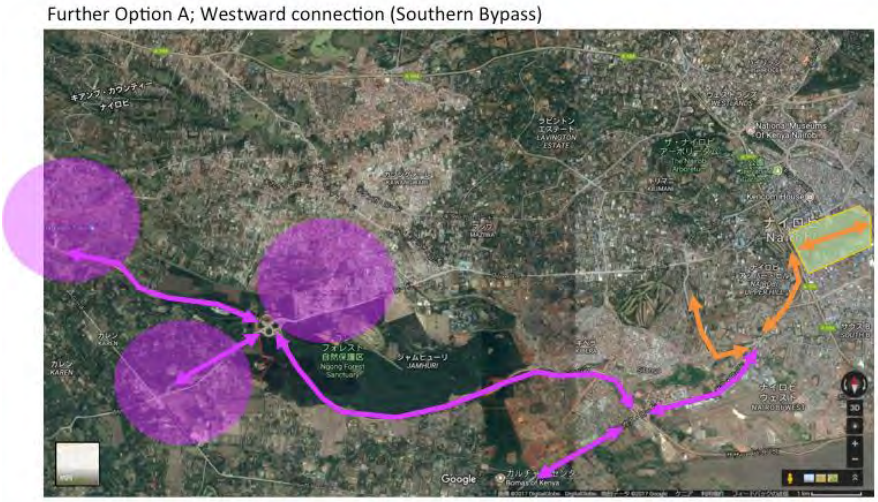
Behind the Nyayo Stadium. Enough space to accommodate dual lanes for BRT. Note that there is one round trip on KRC.

Source: JICA Study Team

Figure 5.12 Proposed BRT Line 3 realignment along existing railway reserve

5.2.3.6 Further Option for Line 3 Westbound (with Southern Bypass)

Figure 5.13 shows a further possibility of BRT alignment to go into the Southern Bypass. The southern bypass has stable capacity to accommodate the larger bus fleets and maintain punctuality without any physical investments. Some BRT services to Langata and Ngong directions can run into the Southern Bypass and connect to Ngong, Karen, and far west regions.



Source: JICA Study Team

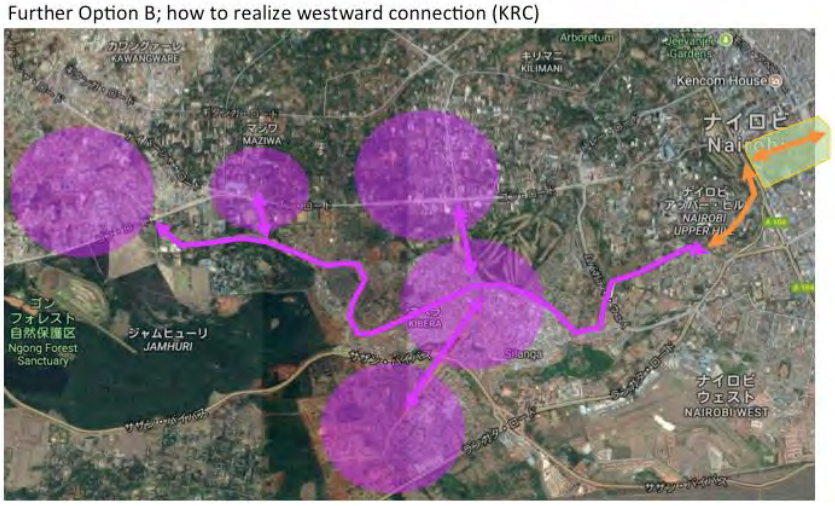
Figure 5.13 Proposed future expansion of BRT Line 3 along the Southern Bypass

5.2.3.7 Further Option for Line 3 Westbound (with KRC Alignment)

Figure 5.14 and Figure 5.15 shows another option of westbound BRT alignment, applying BRT exclusive lanes along the KRC alignment. The KRC alignment between Mbagati-Ngong section (approx. 10 km) is currently under housing relocation[8] (funded by World Bank 40%

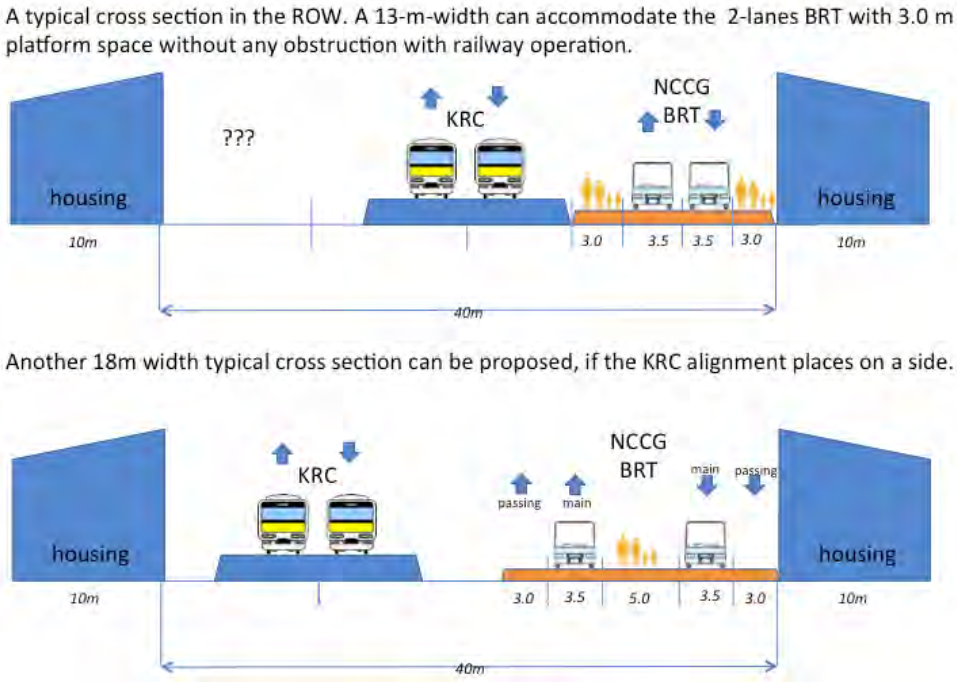
[8] The on-going relocation housing along the KRC alignment to Kikuyu (at Kibera station). Similar housing construction project shall be applied to Mukuru (Its study has been done. Implementation is waiting for completion of Kibera section – funded by the WB). The residents under local CBOs (Ngazi ya Chini and Muungano wa Wanavijiji) contributed saving under the Slum Dwellers Int'l savings model.

and Kenyan Government 60%, with 70% progress in September 2017 – Contractor H Young), and 20m (x2) right of ways will be secured soon. It can be proposed to use 10-15m width of the 40m ROW for BRT services. NCCG shall pay a lease fee to KRC. KRC can find funding for rail improvement.



Source: JICA Study Team

Figure 5.14 Proposed alaignment and expansion Westward along Ngong Road using the railway reserve



Source: Nairobi Railway Relocation Action Plan Design: Kibera
http://upfi.info/projects/nairobi-railway-relocation-action-plan-design-kibera/

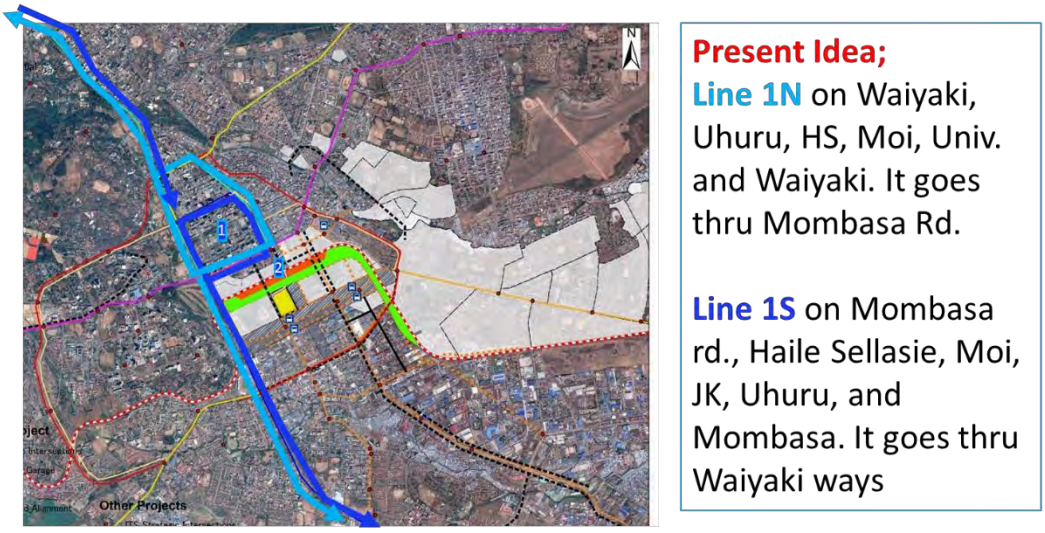
Figure 5.15 Cross-section of proposed alignment alternatives along the railway reserve

5.2.4 Review of Line 1

5.2.4.1 Present Alignment and Level of Services

Line 1 (Waiyaki-Mombasa) is also a prioritized alignment of BRT. Figure 5.16 shows the

present alignment. It is divided as Line 1N and 1S, and both lines circulate around the CBD. This will create conflicts everywhere in the CBD. The CBD network does not have capacity to accommodate such a loop. There will also be conflicts with a future viaduct program (JICA) along Moi Ave.

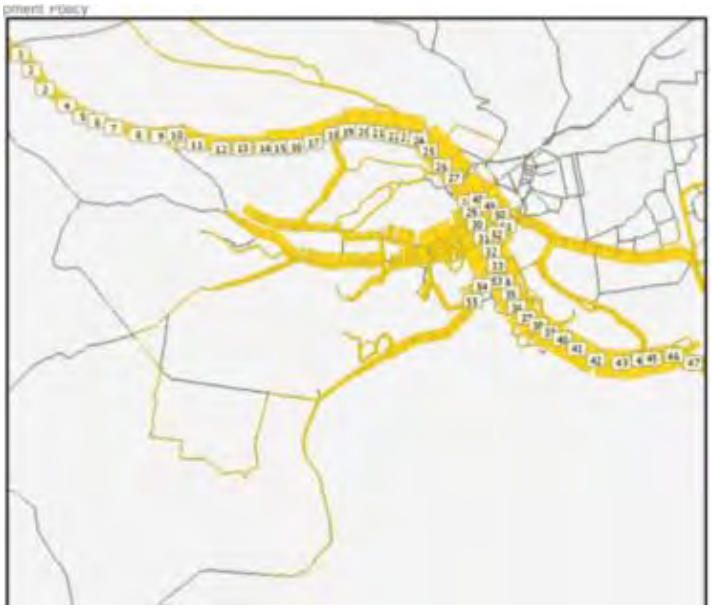


Source: JICA Study Team

Figure 5.16 Proposed BRT Line 1 alignments around the CBD

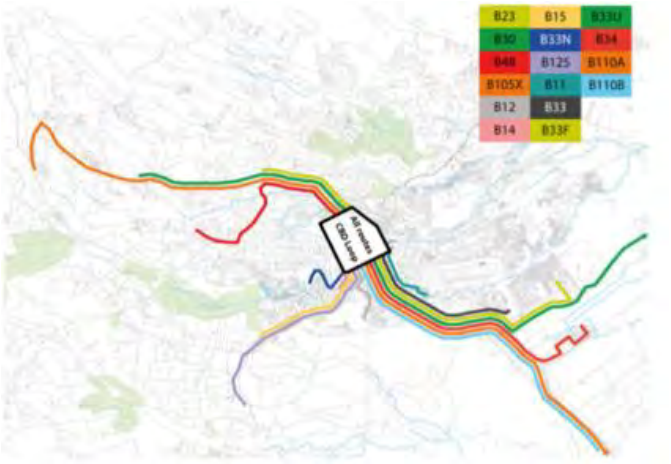
Figure 5.17 shows locations of proposed bus stops along the BRT Line 1N and 1S. There are 30 stations along the section between James Gichuru Rd. and Airport Rd (16.5km, average interval of 550m). BRT is not a replacement of ordinary bus service, and JICA Study Team proposes to make the interval at least 1.5 km, to maintain or improve operation speed. The 1.5 km is based on the acceptable access length for pedestrians (800m).

It should be noted that the Initial F/S for Line 1 proposed several branches to expand the catchment area of the BRT (as shown in Figure 5.18), in order to improve economic feasibility. The Branches to the airport and eastern bypass can be acceptable, however others will have conflicts with existing traffic, which will slow down BRT services. The long 18m articulated bus cannot turn around easily compared with ordinary bus. JICA Study Team recommends BRT to be focused on the main corridor, and not to improve EIRR via branches.



Source: ITDP, Nairobi Ndovu/A104 BRT Service Plan, P74

Figure 5.17 Proposed BRT Line 1 stops

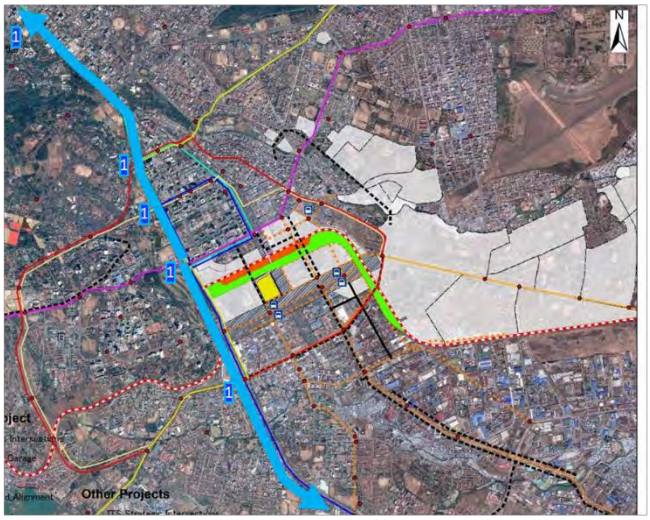


Source: ITDP, Nairobi Ndovu/A104 BRT Service Plan, P65

Figure 5.18 Proposed branches for the present BRT Line 1

5.2.4.2 Option 1 for Line 1

Figure 5.19 shows the rationalized proposal for Line 1. The study team proposes to simplify Line 1 as much as possible, remaining outside of CBD. To maintain sufficient travel speeds, grade separations at major intersections should be facilitated along the Uhuru Highway.

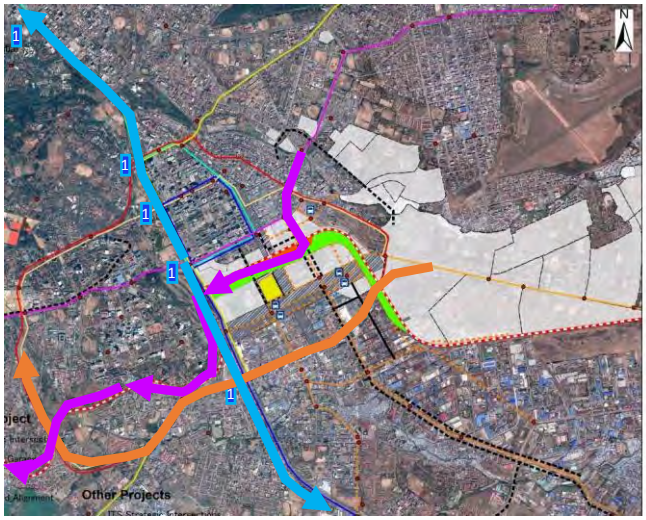


Option 1;
Line 1 on Waiyaki, Uhuru, Mombasa

Source: JICA Study Team

Figure 5.19 Option 1: Proposed realignment of BRT Line 1

5.2.4.3 Option 1 for Line 1 – with L3&L4 Option 1



Option 1;
Line 1 on Waiyaki, Uhuru, Mombasa

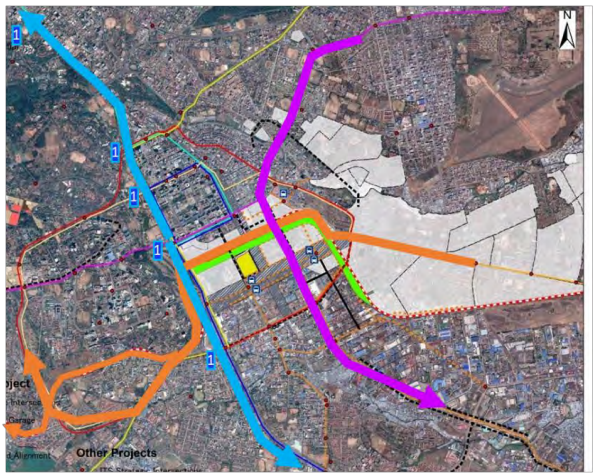
With Option 1;
Line 3 on Juja will run into railway city
Line 4 on Jogoo will run into Lusaka Road, Nyayo Stadium

Source: JICA Study Team

Figure 5.20 Realignments of BRT Line 1, 3 and 4 – Option 1

Figure 5.20 overlays the Line 1 alignment with the L3/L4 option 1. This can minimize the level crossing of BRTs, but all transit locations should be at Nyayo stadium, which may create another focal location along Moi avenue.

5.2.4.4 Option 2 for Line 1 – with L3&L4 Option 2



Option 1;
Line 1 on Waiyaki, Uhuru, Mombasa

Option 2;
Line 3 on Juja will run into enterprise road.
Line 4 on Jogoo will run into railway city.

Source: JICA Study Team

Figure 5.21 Realignments of BRT Line 1, 3 and 4 – Option 2

Figure 5.21 overlays the Line 1 alignment with the L3/L4 Option 2. This is better than the previous one as the transit location can be well distributed; i.e., Line 1 and Line 4 transit at the Nyayo Stadium, and Line 3 and Line 4 at Railway City.

5.2.4.5 Option 2+ - Additional Bypass of Line 1

Option 1+;
Line 1 on Waiyaki, Uhuru, Mombasa
Line 1+; Branch and run along enterprise road.

Option 2;
Line 3 on Juja will run into enterprise road.
Line 4 on Jogoo will run into railway city.

Source: JICA Study Team

Figure 5.22 BRT Line 1, 3 and 4 realignment with Bypass Line 1+

Figure 5.22 shows a further option for BRT Line 1, a branch development to use the Enterprise road connection can be proposed as Line 1+. Line 1+ can be integrated with Line 3 (Juja Rd). Railway City can be the transit location of Line 3, Line 4, Line 1+, while Nyayo Stadium can be the transit location of Line 1, Line 4.

BOX-1 Comment on Implementation of BRT Core Line 3 by EU

JICA Study Team prepared the conceptual plan of the BRT alignment reorganization to minimize the BRT conflicts in the CBD as noted above. The Team calculated the potential travel hours reduction in the urban core area (in Chapter 7) which substantiated positive benefits of the BRT reorganization concept.

On the other hand, we cannot ignore the progress of implementation and financial arrangement of ongoing BRTs, particularly, the EU's financial arrangement for the section of Dandora to Kenyatta National Hospital (12.5km), which is named "BRT Core Line 3" according to EU office in Nairobi, and it may be difficult to revise the alignment due to relation with investors.

JICA Study Team has already identified issues of high concentration of transport services in the CBD, and through observed data it was identified that geographical gaps in the transport services provision induced unnecessary pedestrian influx into CBD in evening peak time. Therefore, the proposal of the BRT reorganization can maximize the benefit of Nairobi and passengers in the metropolitan region, however, JICA Study Team also respects the implementation of the proposed projects by foreign investors. Nairobi's transport market deserves new transport mode interventions, in order to outgrow the old shell of Nairobi.

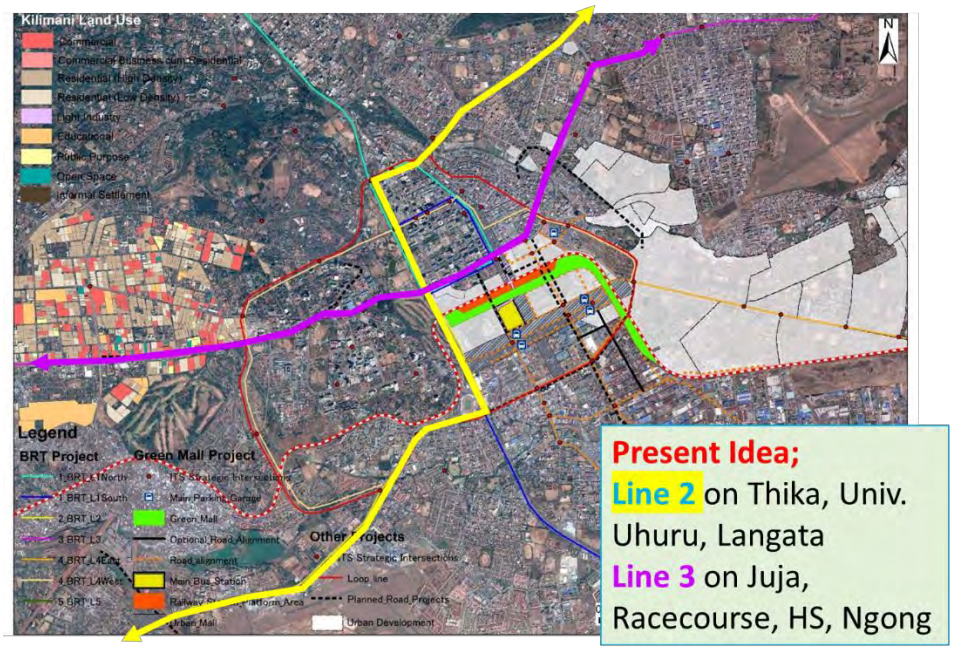
JICA Study Team suggests the following to justify the implementation of the BRT Core Line 3.

- Proper traffic management is necessary, particularly in the section of CBD, Racecourse Road intersection, Uhuru Highway Intersection, and KNH intersection.
- Consideration of creating a branch or bypass into the proposed Railway City Development area as it is not currently served by any mass transit services. It is noteworthy that according to the feasibility study for Line 3, by the third year of operations it shall reach the full capacity of BRT as per the shared demand forecast.
- If the EU report for further design of the BRT Core Line 3 were delivered to the JICA Study Team, the JICA Study Team will review the BRT reorganization concept in the Stage 2.

5.2.5 BRT Line 2 Reorganization

5.2.5.1 Present Proposal

Figure 5.23 shows the BRT Line 2, running from Thika to Langata, which is scheduled to be built in 2030-2035. The figure also shows Line 3 running between Juja and Ngong. As the Juja and Thika corridors has the biggest forecasted demands, and Ngong Rd has limited surface road capacity, JICA Study Team proposes reorganizing the BRTs of these corridors into Metro services.



Source: JICA Study Team

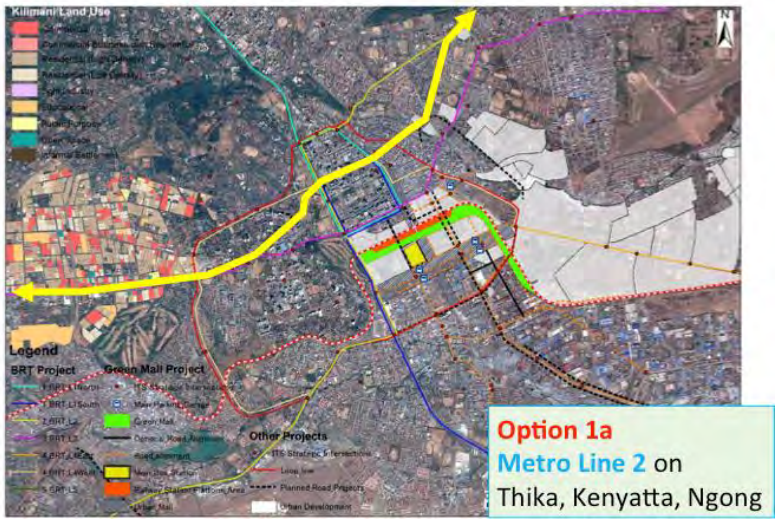
Figure 5.23 Current proposed alignment of BRT Line 2 and 3

5.2.5.2 Options for Line 2 and Relation with Other Lines

Figure 5.24 shows the first option (Option 1a) for Thika-Juja Metro alignment, passing the Kenyatta Avenue in the CBD. This may require land readjustment work in the downtown districts if the Metro were to be built as viaducts. Metro could be constructed as an underground line as another option.

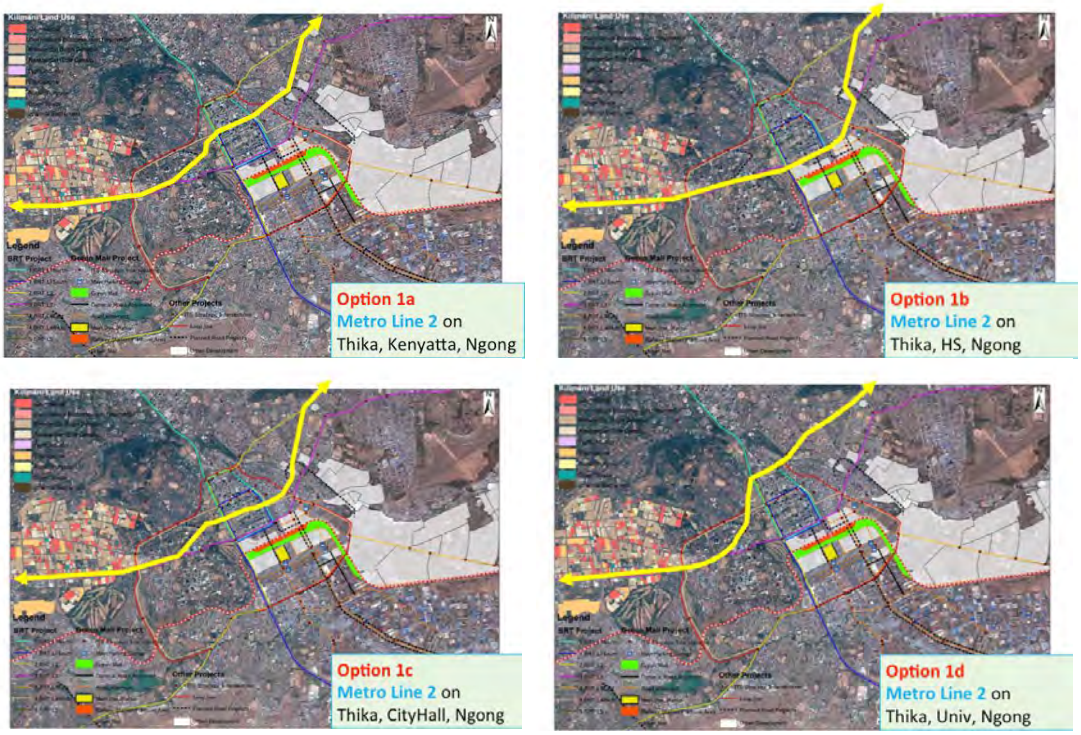
Figure 5.25 shows 4 options for Line 2 routes by Metro installation, with 4 alternatives of bypassing the CBD, i.e., Kenyatta Avenue, Haile Sellassie Rd, City Hall Rd., and University ways.

Figure 5.26 overlays the Line 2 alternatives with proposed Line 1, 3, and 4 alternatives. The combined BRT and Metro alignments will create a rectangular shape in the urban core, peripheral of CBD, and four transit locations among the services. In the case of Line 2 running along the Haile Sellassie Rd, the rectangular shape will be at a minimum size, and in the case of Line 2 running along the University way at maximum, but the transit points may not be created on the Thika and Juja Corridors.



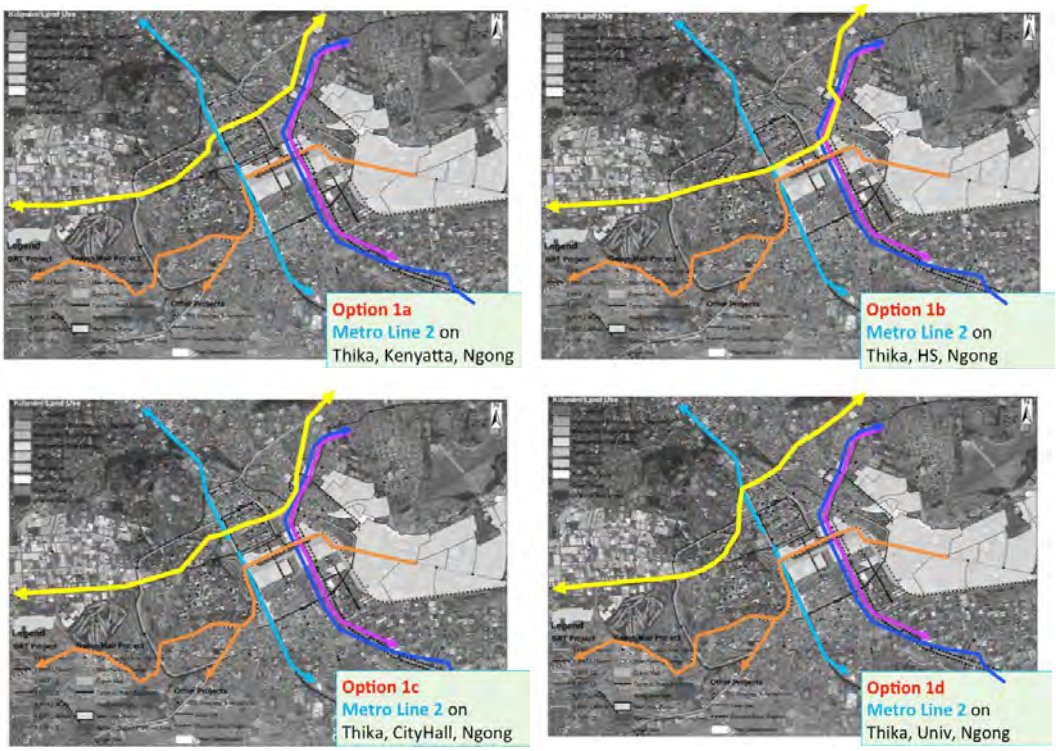
Source: JICA Study Team

Figure 5.24 Option 1a: Proposed BRT Line 2 realignment



Source: JICA Study Team

Figure 5.25 Proposed alternative alignments for BRT Line 2



Source: JICA Study Team

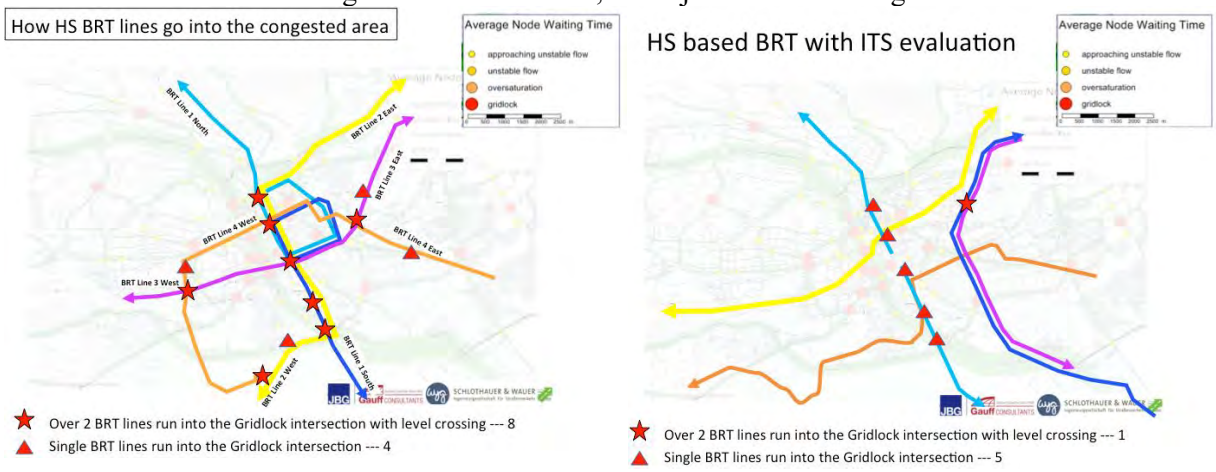
Figure 5.26 Interaction of BRT Line 2 with other BRT Lines

5.2.6 Evaluation on Urban Core Mobility with BRT Re-Organization

Hereafter, the proposed alternative shall be evaluated in terms of the Urban Core Mobility improvement.

5.2.6.1 Focal Points Avoidance

Figure 5.27 shows a comparison of the original and the alternative network with the criteria of avoiding congested junctions. With the original network, there are 8 junctions where more than 2 BRT lines run into gridlock intersections with level crossing, and 4 junctions with single BRT lines. On the other hand, with the alternative there is only 1 junction where more than 2 BRT lines run into gridlock intersections, and 4 junctions with single BRT lines.



Source: JICA Study Team

Figure 5.27 Current and proposed alternative for BRT Alignment to avoid currently congested intersections

5.2.6.2 Organization of Transit Functions

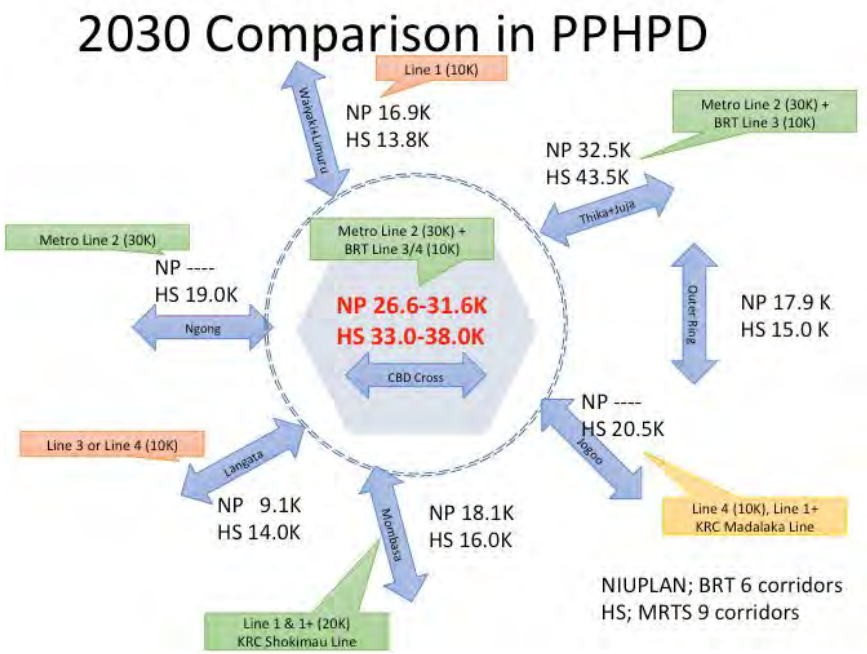
As shown in Figure 5.26, the alternative network develops 4 new transit places in the peripheral of the CBD, to expand the function of CBD and form the urban core structure. On the other hand, the original network creates transit function inside the present CBD, keeping it congested.

5.2.6.3 Formation of Loop Line Function

As suggested in the chapter 4.3.2, the loop demands from Northeast to southwest, via Lusaka, Langata, and Mbagati roads have potential demands. The alternative network can cover these demands with the combination of BRT Line 3 and 4, which the original network does not cover.

5.2.6.4 Balance of Demand and Capacity

Figure 5.28 shows the comparison of PPHPD demand and supply of the proposed alternative network. For CBD crossing demand, the expected 26-38 thousand PPHPD can be handled by one Metro (Line 2) and one BRT (Line 3/4). The biggest demand along the Thika-Juja corridor will be handled by the combination of one Metro (Line 2) and one BRT (Line 3). The Jogoo road will be handled by the combination of Line 4 and Line 1+ (Line 3) running along the Enterprise road. Additionally, the KRC commuter rail can take some load. For Mombasa road, the expected PPHPD can be handled by BRT Line 1, 1+ and KRC Shokimau line. For Langata road, the BRT Line 3/4 can cover, but demand may exceed the supply. The Ngong road demand can be handled by Metro Line 2. For Waiyaki, 13-16 thousand PPHPD will be handled by Line 1. Figure 5.28 shows the balance of demand and supply in three colors, i.e., green as balanced, yellow as a slight shortage, and red for significant shortage.



Source: JICA Study Team

Figure 5.28 Comparison of PPHPD in 2030 and proposed alternative network

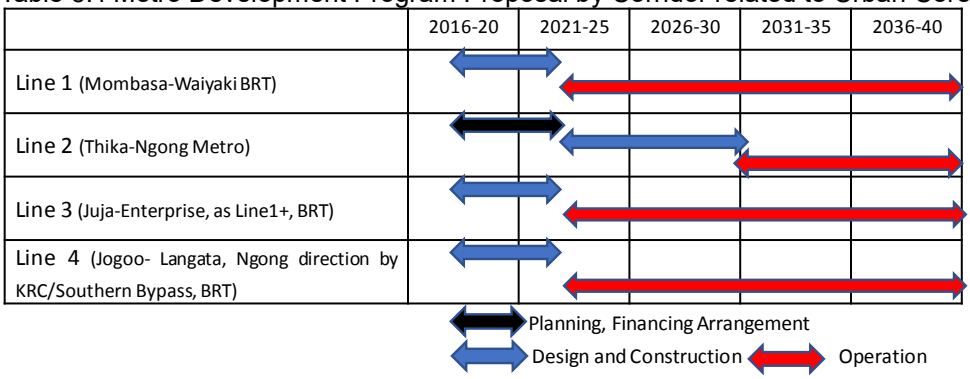
It should be noted that the shortage of supply in the North-South corridor (Waiyaki way – Mombasa Rd) should be considered as the next section for metro installation.

5.2.7 Implementation Strategy of the Alternative Metro Plan

5.2.7.1 Chronological View for Development

Table 5.1 shows the summary of Metro development in Chronological order. The prioritized BRT lines would be facilitated by 2023 and commence services, and the proposed Line 2 would be considered as Metro, which requires proper planning and financing arrangement in the initial stage, followed by design and construction phase, then operation will start after 2030, as the original BRT plan proposed.

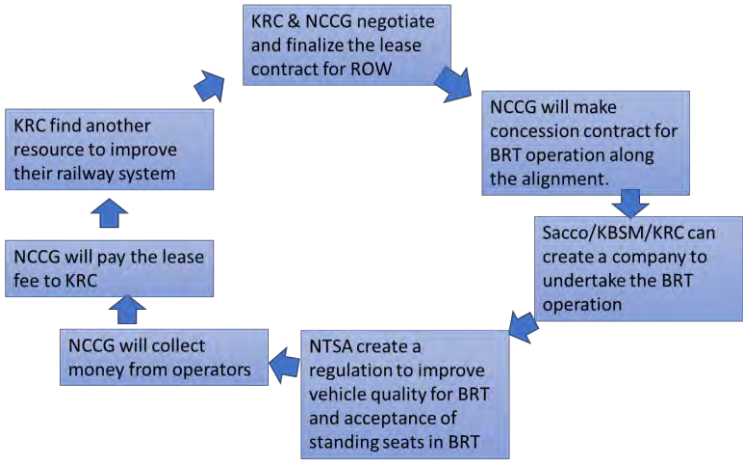
Table 5.1 Metro Development Program Proposal by Corridor related to Urban Core



Source: JICA Study Team

5.2.7.2 Implementation Scheme and Utilization of KRC Land and ROW

As mentioned in Section 5.2.3.7 there is a possible option to develop BRT lines within the ROW of KRC alignment, Figure 5.29 shows an initial concept of arrangement to obtain the ROW from KRC, i.e., the mechanism of lease payment of the BRT alignment will help to improve the railway operation. A win-win relation among KRC and BRT/Metro operations should be initiated by NCCG or NaMATA.



Source: JICA Study Team

Figure 5.29 An initial consideration of a Lease Scheme among the KRC and BRT/Metro

5.2.7.3 Coordination of Other Projects;

As suggested previously, the alternative plan requires coordination with other on-going projects in Nairobi. Table 5.2 summarizes the major requirements of the projects. JICA Study Team recommends that the coordination should be initiated by NCCG and arranged under NaMATA authority.

Table 5.2 Possible Coordination for the Alternative Plan Proposal for the Metro

Code	Issues, items to be coordinated	On-going Projects	Owner
BRT-L1-1	Revision of alignment, bus stop location, feasibility criteria, connection with Line 1+ (Line 3)	BRT Line 1 Basic Design	KeNHA-WB
BRT L1-2	Coordination with Enterprise road widening for installation for Line 1+	Enterprise road widening plan, BRT Line 3 Basic Design	KURA/EU, JICA
BRT L3-1	Revision of alignment, feasibility criteria, implementation program	BRT Line 3 Basic Design	KURA/EU
BRT L3-2	Utilize the planned viaduct for BRT operation	Viaduct Plan at the Muthuruwa Market	KURA/JICA
BRT L3-3	Coordination of transit scheme with Line 4 in the Railway City	Railway city	KRC/ WB-NaMSIP
BRT L4-1	Revision of alignment, feasibility criteria, implementation program	BRT Line 4 Basic Design	KURA/EU
BRT L4-2	Coordination of transit scheme with Line 3 in the Railway City	Railway city	KRC/ WB-NaMSIP
BRT L4-3	Installation of Line 4 in the Railway City	Railway city	KRC/ WB-NaMSIP
BRT L4-4	Installation of Line 4 in the KRC alignment, utilization of KRC ROW	Kibera relocation project	KRC
BRT L4-5	Line 4 exclusive lanes installation under the Eastland land readjustment program	Eastland land readjustment program	TBD
BRT L4-6	Line 4 installation along Lusaka Rd	Lusaka Rd widening project	KURA/EU
BRT L4-6	Line 4 installation along Southern Bypass	BRT Line 4 Basic Design	KeNHA
MRT2-1	Line 2 installation as Metro	Masterplan	NCCG
BRT-1	Entire BRT implementation project	Masterplan	NCCG/NaMATA

Source: JICA Study Team

5.2.7.4 Special Requirements for BRT operations

As mentioned in Section 5.1, the present regulation of standing prohibition in the bus fleets should be relaxed for BRT installation to secure the expected PPHPD capacity by the BRT. The Surveillance camera and recording system can contribute to personal security requirements.

As mentioned in Section 5.1, Nairobi has industrial resources for local production of BRT fleets, or necessary interior parts production with local resources. In the initial stage, completed BRT fleets can be imported from foreign producers, however, NaMATA and NCCG should prepare and negotiate with funding agencies to maximize local production content.

Arrangement with matatu and bus operators along the major corridors is an important issue, and NIUTRANS's study in 2006 suggested how it should be harmonized. See section 5.3.1 for further discussion.

5.2.7.5 Financing and Institutional Arrangement

The Metro will particularly require huge investment of infrastructure, rolling stock installation, and stable electric supply, as well as operation and maintenance capacity and authority. JICA Study Team propose a JICA Yen Credit Loan for its development. JICA has extensive experience of installation of Metro in mega cities in Asian countries that have little experience in urban railway operation. It is an advantage of JICA that both the yen credit for infrastructure development and TA grant for technical assistance and capacity building can be provided by a single financing institute. Further arrangement for financial and institutional issues should be considered in the next phase.

5.2.7.6 International Commitment Necessity

JICA Study Team recommends that an international commitment for international events by NCCG or GOK should be arranged in order to secure the Metro development of Nairobi. Generally, transport facility developments are always combined with political interests, and its implementation plans are always influenced by political interference and power games. International commitments for international events which require transport facility development can be a good chronological target of project implementation, and a good reason to avoid such power game interferences. International events can be sporting events like the Olympic games, world cup for track and field athletics, regional football tournament, EXPO, cultural events, etc.

5.3 Urban Core Mobility Improvement – Comprehensive Plan -

Re-organization of BRT and Metro was discussed in the previous section as it is an urgent and major issue in Nairobi, however, a comprehensive approach for urban mobility improvement is necessary to handle aggressive motorization. Table 5.3 shows a typical comprehensive list of urban transport interventions, and identifies which items are already discussed in section 5.2, and which items are discussed in this section with section-wise index. The right column indicates interventions analyzed in the macro network simulation (in chapter 7).

Table 5.3 Comprehensive Urban Mobility Improvement Interventions

PLANS AND PROJECTS	Sec 5.2	Sec 5.3	Chap 7
0. Public Transport Improvement Plan	✓		
0.1 Bus Service Improvement Plan	--	5.3.1	✓
0.2 Metro Development Plans	✓+Chap6		✓
0.3 Trunk and Feeder Public Transport Network	✓	5.3.1	✓
0.4 ITS Application	✓	5.3.1	--
1. Road Network Development Plan			
1.1 Hierarchical Road Network	--	5.3.2	✓
1.2 Arterial Road Construction/Improvement	--		✓
1.3 Secondary Road Construction/Improvement	--		✓
1.4 Intersections and Flyovers	✓		✓
1.5 Railway Crossing and Underpass	✓		✓
2. NMT Facility Improvement Plan			
2.1 Strategy for NMT Facility Improvement		---	--
2.2 Pedestrian Facility Improvement		5.3.3	--
2.3 NMV Facility Improvement (bicycles, rickshaws)		--	--
3 Intermodal Facilities			
3.1 Bus Terminals	✓		--
3.2 Bus-Rail Interchange	✓	5.3.4	✓
3.3 Park and Ride Facilities		5.3.4	--
3.4 Freight Terminals		--	--
4. Regulatory and Institutional Measures			
4.1 Unified Metropolitan Transport Authority		--	--
4.2 Traffic Impact Assessment Mechanism		--	--
4.3 Regulatory Changes Required for the Introduction of TDM Measures		5.3.5	--
4.4 Traffic Safety Regulations		--	--
4.5 Parking Regulations		5.3.5	✓
5. Fiscal Measures			
5.1 Fare Policy for Public Transportation, and Parking		5.3.1	--
5.2 Subsidy Policy for Public Transport Operators	✓	--	--
5.3 Taxation on Private Vehicles and Public Transport Vehicles		--	--
5.4 Potential for Road Congestion Charging		5.3.5	✓

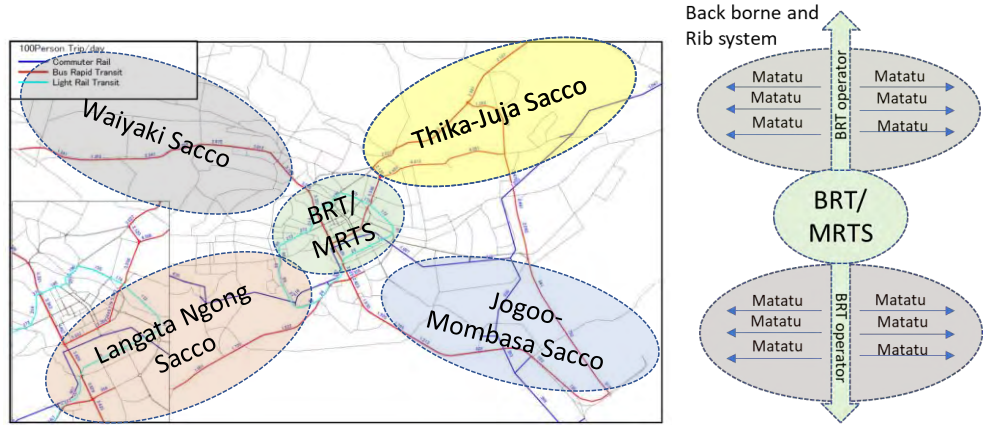
Source: Guidelines and Toolkits for Urban Transport Development in Medium Sized Cities in India Module 1: Comprehensive Mobility Plans (CMPs), 2008, ADB/PADECO

5.3.1 Ordinary Bus Services

As aforementioned in the section 5.1, ordinary bus service improvement is essential for Nairobi. A proper package of bus improvement and regulations should enhance the mobility improvement.

1) Bus-01 Reorganization of Matatu/Bus routes

On installation of BRT/Metro, the Matatu/Bus routes should be reorganized with Area Licensing concept and SACCOs should be modernized in the following steps.



Source: JICA Study Team

Figure 5.30 Area License and Back-borne and Rib service structure for Nairobi

- Demarcate the service area among BRT and Ordinary bus/matatu. The main corridor service connecting the Urban Core will be exclusively served by BRT only. Ordinary buses can operate along corridors with lower demand. Don't let Matatu operate in the CBD and downtown. (after 2023, when the BRT commences). BRT/Metro and matatu create such Back Born and Rib Structure.
- Those bus/matatu services shall survive with the growing demand in the city peripheral. In 2013, there were 2.7 million trips for Matatu, and in 2030, 0.7 million trips will be carried by MRTS/BRT and 3.1 million trips to be served by Ordinary bus or Matatu
- Matatu Saccos shall be amalgamated and gradually corporatized (by year 2025) to enhance their operations.
- The area license of Matatu shall be approved by the future amalgamated saccos company solely (by 2030).

It should be noted that NCCG and the BRT operators should create a suitable employment pool to absorb matatu drivers and conductors. Surplus matatu staff shall be hired as BRT staff via the employment pool. NCCG and the BRT operator should prepare a monetary pool for matatu business compensation.

2) Bus-02 New Bus Fleet Standard Development

The ordinary bus design should be improved to enhance the bus service quality and sustain the local vehicle industry.

The present major bus fleet in Nairobi (having 31 seats or 51 seats) is a modification of truck chassis, e.g. Isuzu N series Truck or Hino Dutro 500 series were used as a base, and local fleet

manufacturers customize the body, with several parts manufacturers providing passenger seats, glasses, frames, etc. JICA Study Team should not consider this is a bus. This is a freight carrier without any consideration of passenger service quality. E.g., the height of floor is high, passengers have difficulty boarding. The majority of bus service in Kenya is still intercity service, little interest is paid to frequent on-off loading of passengers, but the design of bus services within the urban core require wider doors and wide interior aisles for frequent loading.

JICA Study Team proposes the following as a new Pan-Africa urban bus fleet standard, which urban bus services will fall under, to boost urban transport demand in cities within the sub-Saharan region instead of old fashioned matatu and 31/51 seat buses, and which will further boost the Nairobi bus parts industry as well. NCCG or NaMATA can initiate this kind of structural change with assistance from Japanese firms, as currently the main fleet providers are Japanese manufacturers and resellers; Hino, Isuzu and Mitsubishi Fuso.

- **Chassis**: fleet producers can use existing truck designs to keep prices low, but should incorporate semi-lower floor design, suspension for passenger service quality, materials for high durability and low maintenance, integrated design for wide door and seat setting requirements, complete with third party bus interior fabrication. This can initially be produced abroad, but consider semi-knock down system that can be produced in Nairobi in the future.
- **Doors and steps**: double flapped doors for high passenger demand and quick passenger handling, minimize number of steps and height of the steps to passenger deck, safety hand-bars with bright color paints, anti-slip material on the steps etc.
- **Seat arrangement:** design standing seats, wide flat floor with anti-slip materials etc.
- **Power unit and safety:** preferably compatible with EV conversion, or low carbon emission sources, optimize for frequent stop-and-go style typical of urban settings etc.

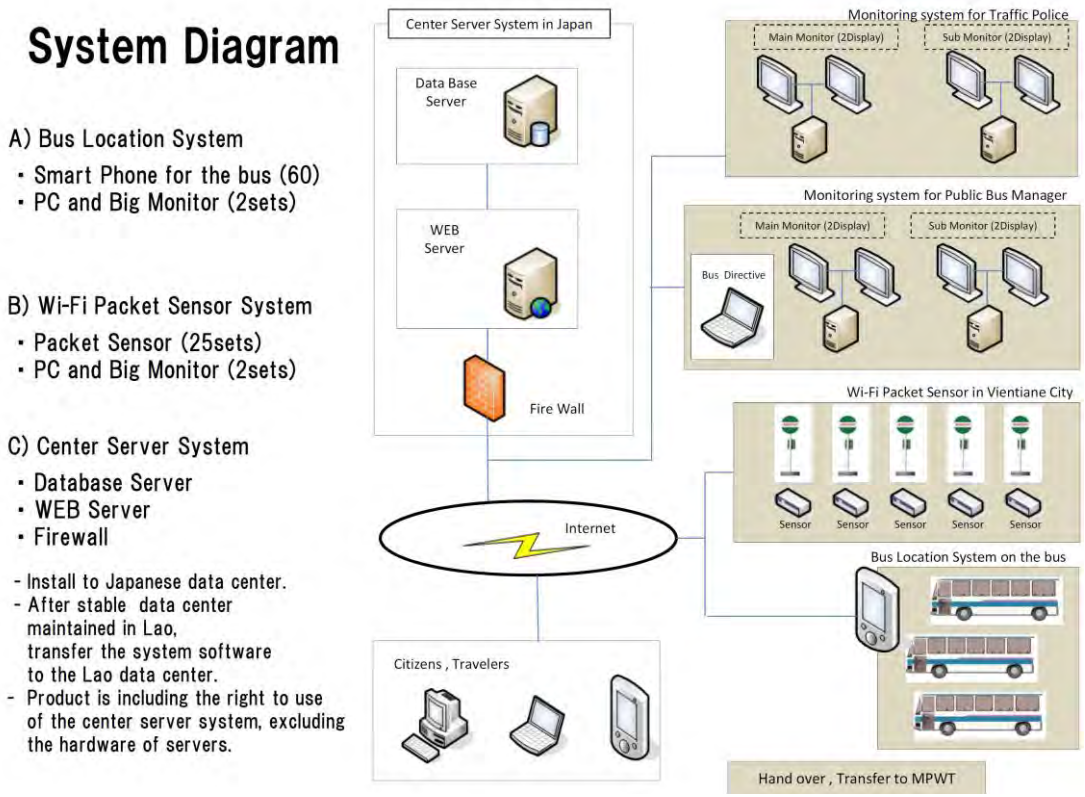
3) Bus-03 Bus approaching notification for passengers

In the Urban Core, the frequency of bus service is quite high, however, the bus approaching information is essential in corridors with lower bus service density. When the BRT and Metro networks are completed, real time approaching information of feeder services are required to improve BRT passenger services. Thanks to GPS, mobile internet services and smartphones, the approaching notification of bus fleets can be realized easily with lower cost. JICA Study Team proposes to go ahead and install this service as soon as possible in bus fleets, not waiting for BRT service commencement.

Phased and prioritized installation shall be considered. Operators with high levels of compliance with regulations should be prioritized for installation of bus services. Larger sized buses belonging to proper companies are the initial target for installation of bus approach information, which will give incentive to exclude low density bus fleets and low roadworthiness fleets from the market.

The system can be comprised of an on-board equipment with 3G-modem, data receiving server, and broadcasting server (as shown in Figure 5.31). The on-board equipment will cost 300 USD per unit, which has high outdoor durability. The operation of 3G modem and servers will require on-going operation costs. JICA Study Team propose to involve a web-media company to recover the O&M expenditure via advertisements.

It should be noted that JICA materialized the bus approaching system in Vientiane, Laos in 2015-16 with low cost.



Source: JRISS, JICA, Location Information System and Traffic Observation System for Urban Transport Improvement in Vientiane City, June 2016

Figure 5.31 System Diagram of Real time Bus approaching notification system

4) Bus-04 Bus standing seat regulation revision

This is NTSA's issue. In order to realize the expected PPHPD for bus and BRT, the present regulation on standing seating will be biggest barrier.

5) Bus-05 Commuter Payment Card Installation

Nairobi tried to install a commuter card installation in 2012 but it ended up failing. As a reference, Kigali, the capital of Rwanda, installed a payment card system in 2015 and 100% of fare collection of buses were realized by the payment card[9].

First off, it will require the leadership of the transport service regulator (NTSA or NCCG) to avoid unnecessary competition and over investments. JICA Study Team recommends procuring the service through international competition bidding, with proper monitoring services. JICA can provide such monitoring and procurement service as a technical assistance.

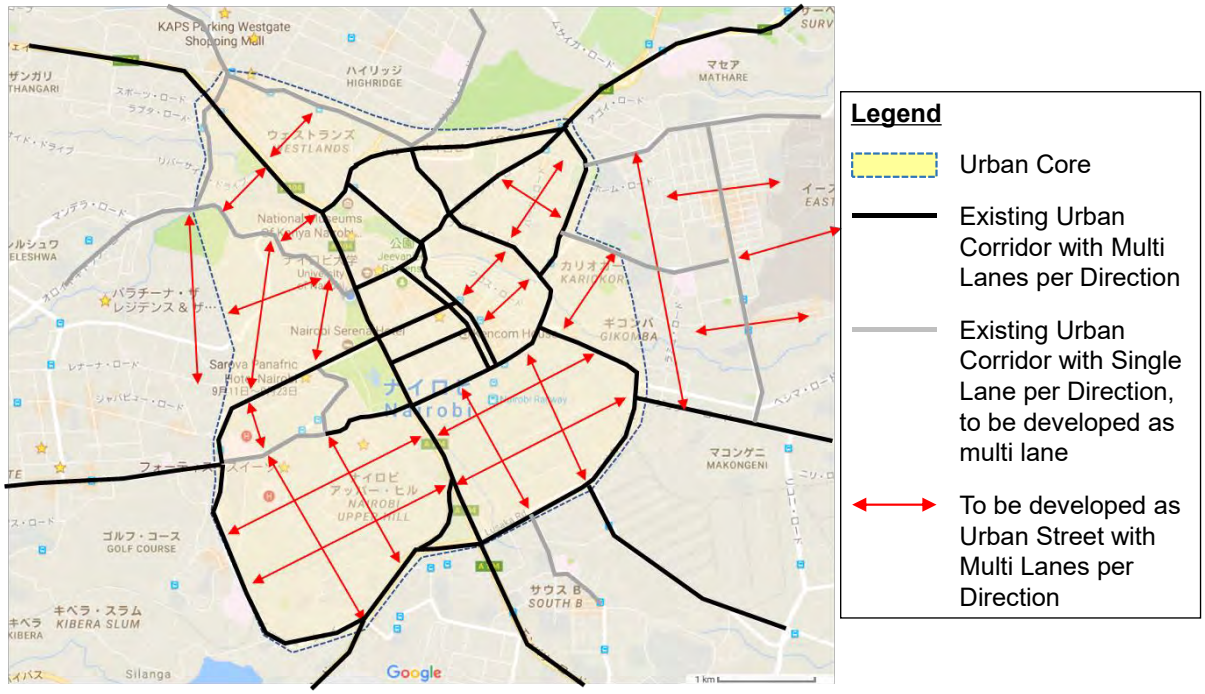
There are various benefits of a commuter card. For the urban core, the biggest benefit is minimization of passenger loading time. The M-pesa payment is Kenya's advantage, however, speed of clearance is too slow for payment on buses.

[9] http://ktpress.rw/2017/09/all-city-buses-to-adopt-electronic-payment-system/

5.3.2 Road Network

5.3.2.1 Road-1 Missing Link Improvement

As aforementioned, the road ratio of the urban core is 11%, not sufficient if compared with other international cities. JICA Study Team suggests the target should be more than 20% in the urban core. Missing link development is essential to achieve this target. JICA Study Team proposes Figure 5.32 as the proposed essential missing links in the urban core.



Source: JICA Study Team

Figure 5.32 Missing link proposals for the Urban Core

The missing link development concept is based on a grid network with 500-800m intervals with multilane corridors, which will realize the 15-20% road density. The following should be noted;

- The major areas of this proposal are roads in Westlands, Community and Upper hill. JICA Study Team recognizes the terrain will be a challenge in the road network development in these districts, however, a grid layout is required to build a proper urban structure, and outgrow the UK urban planning. A link overlapped with the Statehouse is seriously required, which can be developed as an underpass if necessary.
- The proposed sections of Eastleigh are also essential to divert the heavy Juja-Jogoo traffic demand. The military airport will be a barrier for urban planning, and a proper arterial link to be developed to alleviate high congestions on Juja-Jogoo corridors.
- The grid structure of urban road in the Railway City or Green Mall district should be proposed by the designer of the Railway City

5.3.2.2 Road-2 Traffic Calming, Lane Closing, Open Area Development

As aforementioned, the road ratio in the CBD district is more than 23%, which forces car traffic into the pedestrian oriented districts. JICA Study Team proposes that it is necessary to close some lanes, to enhance the walkability and accessibility in certain areas. The target

sections should incorporate the improvement of pedestrian accessibility policy proposed in the next section. Figure 5.33 shows implications of lane closing in European cities, which don't allow on-street parking and expand footpaths, then install café space, which will enhance the city branding concept of Nairobi. This could be implemented in CBD and even in Downtown, which could improve the security of the district.

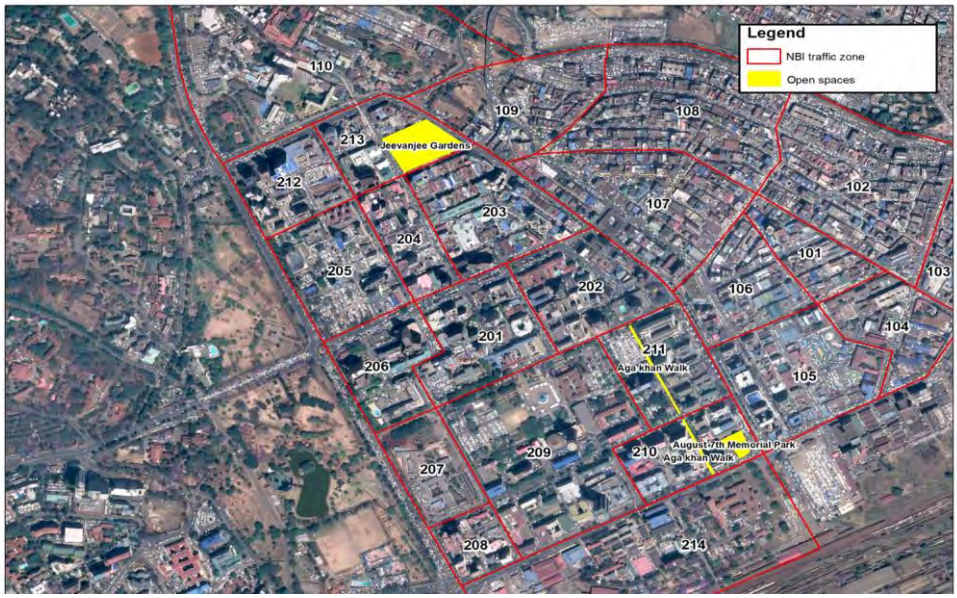
Source: Urb-i

Figure 5.33 Implications of Lane Closing – Before and After

Figure 5.34 shows the state of open space in Nairobi CBD and Downtown. Open spaces are limited in Nairobi. On-street parking regulation (see section 5.3.5), pedestrian corridor development (see section 5.3.3) should be combined with traffic calming implementation.

NCCG has already began place making activities with NGOs[10], however, such activities have not yet materialized as permanent areas. The sunken garden parking area in the CBD is open to teenagers for inline skating during weekends.

[10] https://web.facebook.com/SNINCCG/



Source: JICA Study Team (PARS)

Figure 5.34 Open Space in Nairobi

5.3.3 Pedestrian Services

5.3.3.1 Ped-01 CBD Accessibility Improvement

The analysis in section 4.3.3 identified the major travel patterns and focal points of the pedestrian movement in the CBD and Downtown. Accessibility improvement for the following locations should be proposed to improve the current travel patterns.

- The bus terminal district, including Moi avenue, Tom Mboya avenue, and connection to the Downtown central district have the most pedestrian movement. Based on the AMP counts, it is estimated that 360-380 thousand people were detected going through here per day, and most are pedestrian and matatu users.

- North-south has significant movement in Nairobi, but East-west has difficulty. The E-W movement between the Northern CBD and Northern downtown, surroundings of the Jamia mall, has not been identified as a major pedestrian movement in the urban core. Based on the AMP counts, it is estimated that 30 thousand passengers were detected in this crossing movement per day.

- There are two major pedestrian corridors in the urban core, i) community, Uhuru park and city hall avenue, and ii) the pedestrian footbridge crossing the railway yards connecting the workshop road.

  - The above former movement crosses the Uhuru highway which generates a conflict between pedestrians and vehicles. The AMP detects that the amount of passengers from/to the community district is 15 thousand per day. The NCCG considers the possibility of an exclusive foot bridge or other grade separated method, however, the bridge should be coordinated with the BRT Line 1 installation and expected road improvement plan proposed by the NUTRANS.

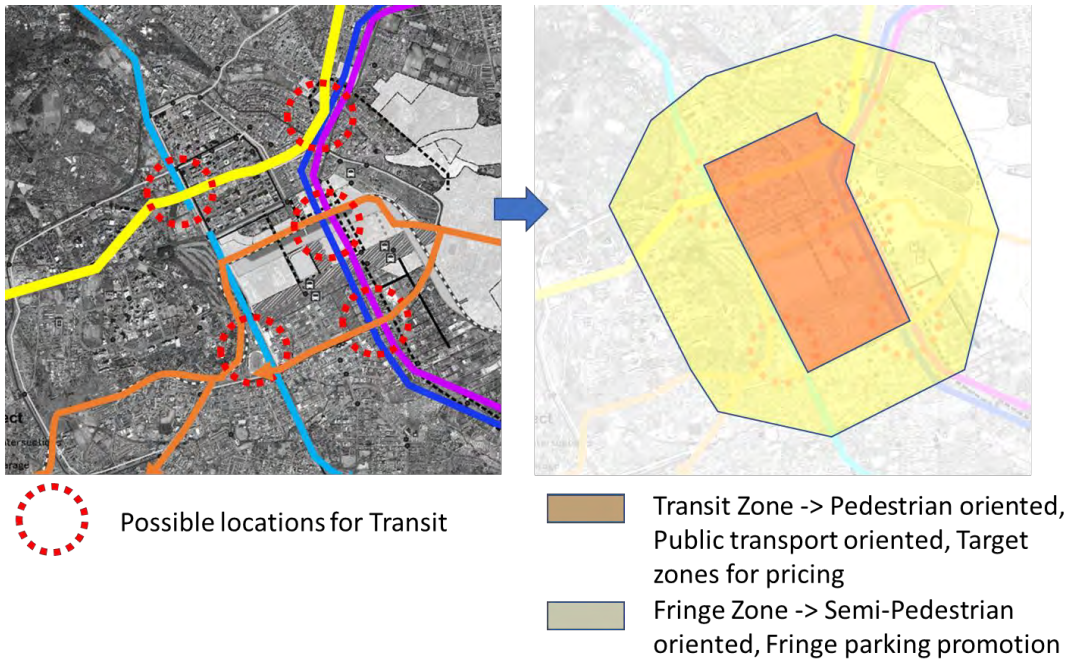
  - The latter movement needs improvement of the pedestrian bridge itself. The AMP detected the amount of passenger traffic from/to this bridge surrounding is 12-13 thousand per day.

5.3.4 Intermodal Facilities

The BRT, Metro service network structure and intermodal facilities were proposed in section 5.2, and intermodal concept between BRT and ordinary bus services are explained in section 5.3.1. In this chapter, intermodal connectivity with rail is explained.

5.3.4.1 IM-01 Transit Place Development

Based on the proposed reorganization plan, there are four transit points with the Metro and BRT, i) GPO, connecting Metro and Line 1, ii) Racecourse, connecting Metro and Line 3, iii) Railway city, connecting Line 3 and 4 with KRC railway lines, and iv) Nyayo stadium, connecting Line 1 and 4. As sections 2.2 and 5.1 mentioned, the present transit locations are all concentrated in CBD and Downtown, therefore, this proposal instead shifts transit points out of these areas. (The proposed transit points are provisional, which could be revised later)



Source: JICA Study Team

Figure 5.35 Transit Locations and Related Policies

Figure 5.35 shows possible transit locations connecting the re-organized BRTs, as discussed in Section 5.2. The multiple transit locations create a zone with high mobility services in the urban core, and formulates the Transit Zone (orange) and Fringe Zone (yellow) as shown on the right.

The following policies should be considered for the Transit Zone to enhance the mobility in the urban core; i) relaxing of height and volume restriction, ii) pedestrian and NMV oriented street development to enhance accessibility to transit locations, iii) implementation of pricing policy (see section 5.3.5.3), and iv) application of higher parking tariffs to control the private vehicle demand.

Additionally, the following policies should be considered for the Fringe Zone; i) relaxing of height and volume restriction, ii) pedestrian and NMV oriented street development, iii) application of lower price parking policy to absorb the parking demand in the Transit Zone (see 5.3.5.2).

5.3.4.2 IM-02 Park & Ride Minimization, Improve the Station Accessibility

JICA Study Team insists that the Park & Ride (P&R) development at present will not alleviate the congestion of Nairobi. P&R is a niche market policy for cities with high vehicle ownership. P&R requires a large parking space in front of space-strapped railway stations. Figure 5.36 shows the present situation of P&R implementation at Imara Daima Station, Shokimau Line, Nairobi.

Source: JICA Study Team, Google Earth (Image © Digital Globe)

Figure 5.36 State of Practice, P&R facility in Imara Daima Station

The Imara Daima station is located at a strategic point, as it is on the Mombasa road, and therefore seems suitable to develop a P&R facility. In Figure 5.36, the green triangle is the exact location of the station entrance. In front of the station, there are large P&R parking lots shown in the gray shaded rectangle, however, the accessibility of the P&R parking by car is poor, as there are no exclusive access roads to Imara Daima Station from Mombasa Road. Pedestrian accesses to the station (represented in yellow arrows) is also poor. The station and P&R parking are surrounded by high walls, which will not allow any pedestrian thru-traffic. Moreover, within the 500m radius from the station entrance, there is no housing.

Figure 5.37 illustrates the state of urban development practice in front of a railway station in a Tokyo suburb. Many apartments and residential districts with high density are attached to the railway station entrance (represented by a green triangle in the figure), and the exclusive pedestrian access corridor was developed in front of the station. This approach will minimize the car-oriented transport behavior and improve the KRC operability.

Source: JICA Study Team, Google Earth (Image © Digital Globe)

Figure 5.37 Rail & City Integration, Tama Center Station, Tama City, Tokyo

5.3.5 TDM Measures

5.3.5.1 TDM-01 Commuting Time Staggering and Operating Hours Extension

Commuting time staggering is a general TDM policy implemented in various cities to minimize the peak traffic demand inbound to the urban core in the morning period. As shown in Chapter 4.3.1, the peak period of the Nairobi Urban Core is in the evening period, however, the biased evening peak in the CBD is attributed to the existing bus regulation and route assignment. It should be improved by the re-organization of bus routes and deregulation of the bus standing seat.

One of the reasons of the high concentration of transport demand is the limited hours of service operation, as suggested in section 5.1.10).

5.3.5.2 TDM-02 On-Street Parking Restriction, Fringe Parking Development

There are 3,900 lots of on-street parking space in Nairobi CBD and Downtown, which should be minimized by the following ways:

i) minimize the on-street parking and convert to open space and pedestrian space. (see section 5.3.2.2)

ii) develop off-street parking to compensate the supply of the CBD on-street parking in the fringe or outskirts of the urban core, with cheaper tariffs from CBD off-street parking.

iii) for on-street parking control, m-pesa payment via SMS can be applied for efficient tariff collection and parking control.

5.3.5.3 TDM-03 Pricing Policy

A pricing policy on private vehicle use in the urban core should be proposed in this stage (although pricing policy is not a main focus of this study). Once the series of proposals on

transport services and infrastructure development in this chapter are completed, pricing policy can be applied to the Urban Core.

5.3.5.4 TDM-04 Statistics Improvement for Motorization Monitoring

As mentioned in section 2.1, there is no region-wide vehicle registration system in Kenya, and therefore, the government cannot get exact numbers of vehicle registration in the city/ metropolitan area, or growth trend of vehicle ownership in the city. Nairobi city or NaMATA can initiate its own statistics gathering for its motorization monitoring.

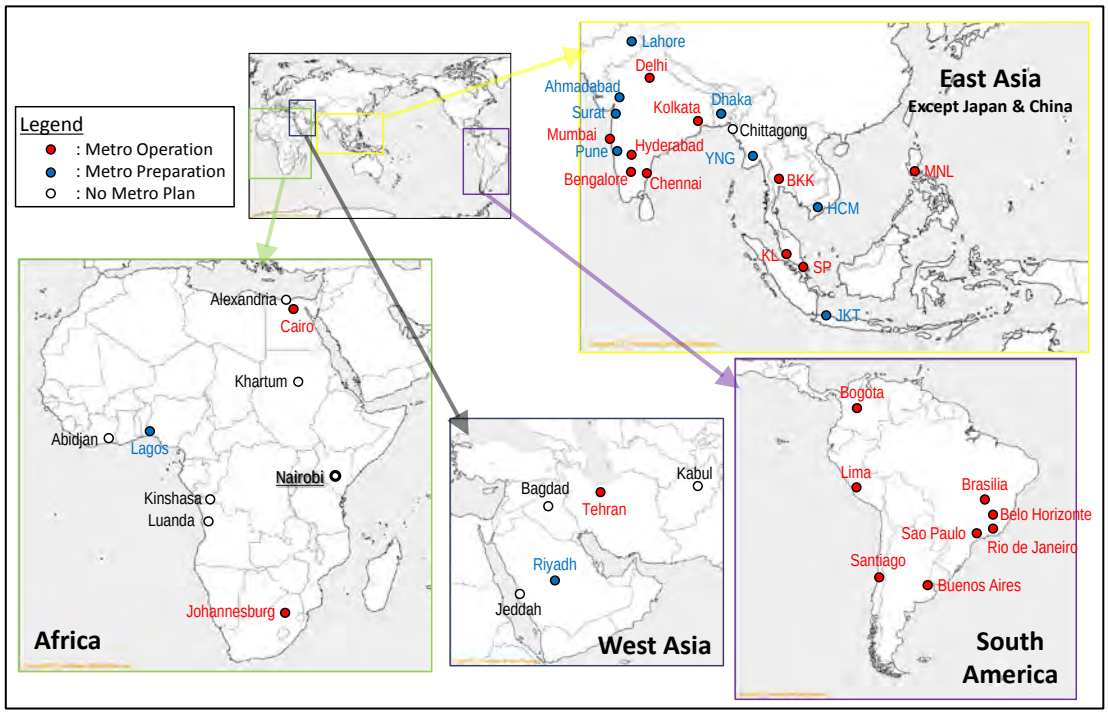
Chapter 6 Planning of the First Metro Line in Nairobi

6.1 Timing of the Metro Introduction in the World

6.1.1 Metro in the World

JICA has issued a Study Report entitled "The Research on Practical Approach for Urban Transport Planning" in December 2011. This study aimed to contribute the formulation of medium-to-long term development strategies for urban transport by reviewing available information on current socioeconomic urban development.

The following map indicates the location of mega cities (population over 4 million) in the world with indication of status of metro at present.



Source: JICA Study Team

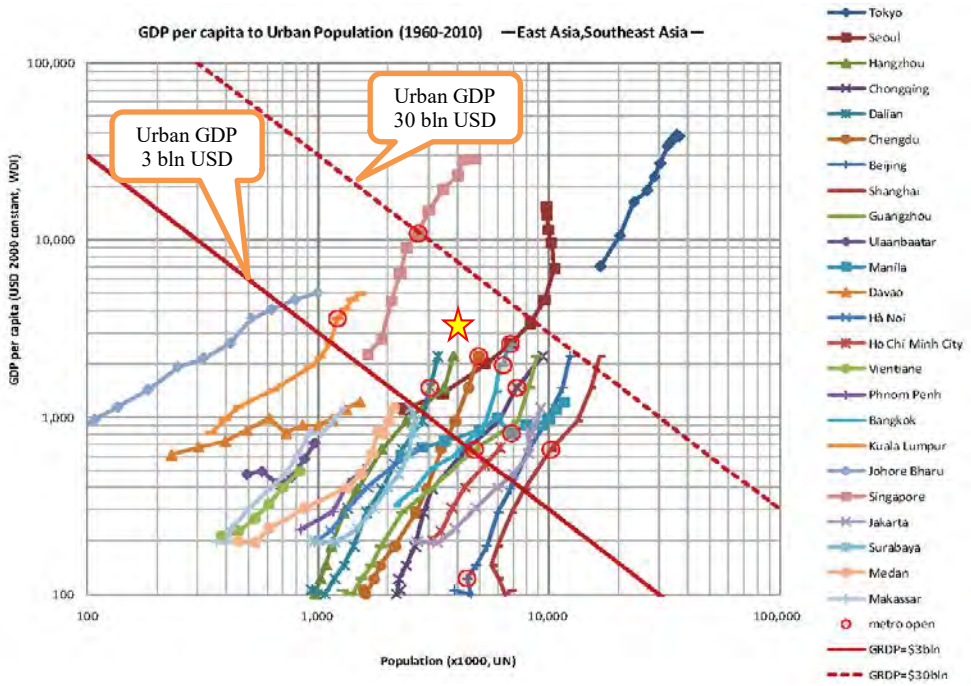
Figure 6.1 Mega Cities in the World with Status of Metro

6.1.2 Timing of Metro Introduction in Nairobi

It is noted that the timing for introducing a metro system is closely related to the level of socio-economic development a city has achieved. The larger the city population, the more likely the city can develop a metro system, even though the GDP per capita is not high enough. At the same time, cities with higher levels of GDP per capita started their metro systems when their population s were still small. Based on the figure below, it can be argued that the GDP range of USD 3 to 30 billion makes the opening of a metro system economically possible and its operation sustainable. The DGP of a city is calculated here by multiplying the city population by GDP per capita.

The following figure indicates the growth of urban population and GDP per capita of East Asia and Southeast Asian countries. Small circle (○) indicates the time when the first metro was opened at each country. The mark (☆) indicates the position of Nairobi in 2015.

(Population 4 million, and GDP per capita USD 1,133. This means that Nairobi should have had metro at present.



Source: The Research on Practical Approach for Urban Transport Planning (JICA, 2011)

Figure 6.2 Timing of Metro Opening in South East Asian Countries

The following Table 6.1 indicates the JICA's projection of metro opening as of 2011 with updates on 2017 by JICA Study Team.

Table 6.1 Projection of Metro Opening by JICA (2011) and Update (2017)

Area	Cities having Metro already (as of 2010)	Metro Opening (as of 2010)		
		Cities reached time to have Metro	Cities reaching time to have Metro by 2015	Cities not reaching time to have Metro by 2025
South East Asia	・ Bangkok ・ Manila ・ Kuala Lumpur ・ Singapore	・ Ho Chi Minh (U/C) ・ Jakarta (U/C) ・ Johor Bharu	・ Davao ・ Hanoi (U/C) ・ Surabaya, Medan	・ Ulaanbaatar ・ Vientiane ・ Phnom Penh ・ Makassar
Central and South Asia	・ Kolkata, Delhi ・ Baku	・ Dhaka (U/C) ・ Mumbai, Hyderabad, Pune ・ Jahor, Karachi	-	・ Kathmandu
Middle East	・ Tehran ・ Cairo	・ Baghdad ・ Damascus	-	-
Middle & South America	・ Mexico City ・ Caracas ・ Lima ・ Santiago ・ Sao Paulo, Rio de Janeiro ・ Buenos Aires	・ Guadarajara ・ Panama City ・ Barranquilla, Bogota ・ Guayaquil ・ Balem, Curitiba	・ Cartagena ・ Asuncion	・ Guatemara City ・ Managua
Africa	・ Johannesburg, Cape Town, Durban, Port Elizabeth	・ Lagos	・ Nairobi (2020) ・ Dar es Salam (2025)	・ Kampala ・ Lusaka ・ Lilongwe

Note: 1. (U/C) means Under Construction as of 2017.
2. City name shown in Red means already operated as of 2017

Source: The Research on Practical Approach for Urban Transport Planning (JICA, 2011) updated by JICA Study Team

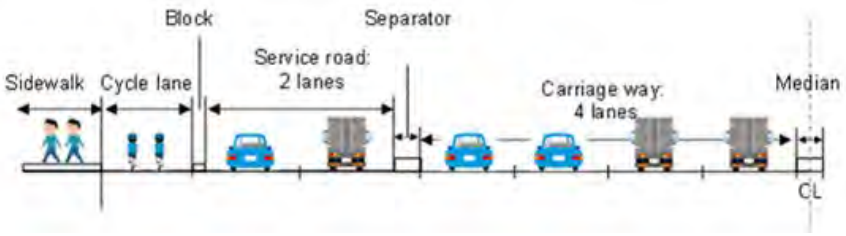
6.2 Concept of the First Metro in Nairobi

6.2.1 Background of the Metro Plan

The expansion of Thika road was completed at November 2012. After 5 years from the opening of Thika superhighway, the congestion of the road in the morning and evening is getting worse and worse because the traffic volume is much more than the forecasted demands.

There is a plan to introduce BRT as Line 2 on Thika road in future. However, it will be difficult to provide additional lanes and bus stops for BRT operation because there is no more space for additional land acquisition. Due to this reason, no study for BRT has been made on this corridor.

Structure of Thika road at one side consists of 3 to 4 lanes at main carriage way, 2 lanes service road, 1 lane of cycle road, and sidewalk. It is obvious that there is no space for BRT lanes. However, if one side of cycle lane can be utilized for the construction of elevated structure of metro, it will be possible to construct the first metro line along Thika road. Possibility of the construction of metro structure along Thika road is analyzed in this chapter.



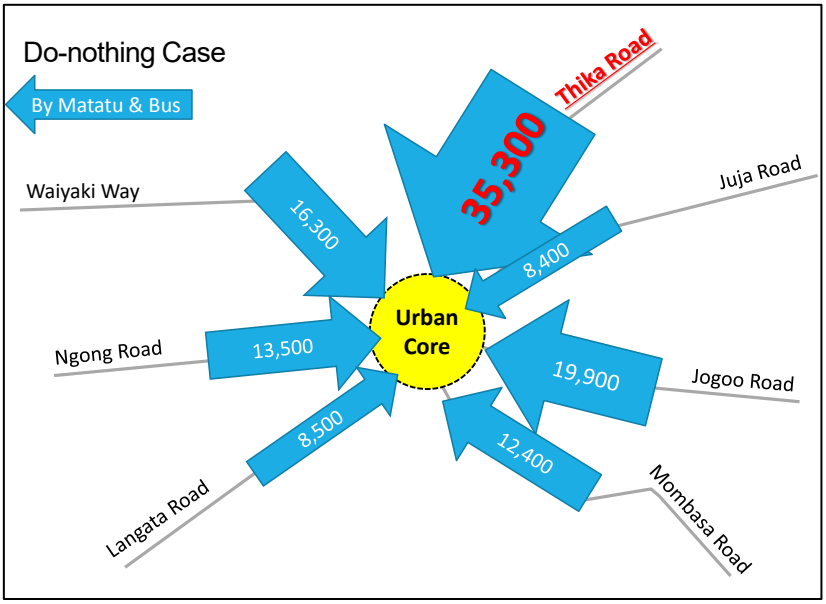
Source: JICA Study Team

Figure 6.3 Planned Route of the First Metro Line

6.2.2 Demand Forecast

According to the demand forecast on major corridors, i.e., inbound person trips in peak one hour by matatu and bus on 2030 (do nothing case), Thika road will have the highest demand as shown on the following figure;

It is obvious that matatu and bus are unable to carry 35,300 passengers to CBD at peak hour, and no BRT plan is on-going due to the abovementioned reason. Metro, LRT, Monorail, AGT, and BRT can carry such big demands. However, construction of a Metro system takes long time from planning, construction, and to passenger service. Even now, there is no construction of a Metro system is on-going in Nairobi. That is the reason why planning of a Metro system along Thika road is required at present.

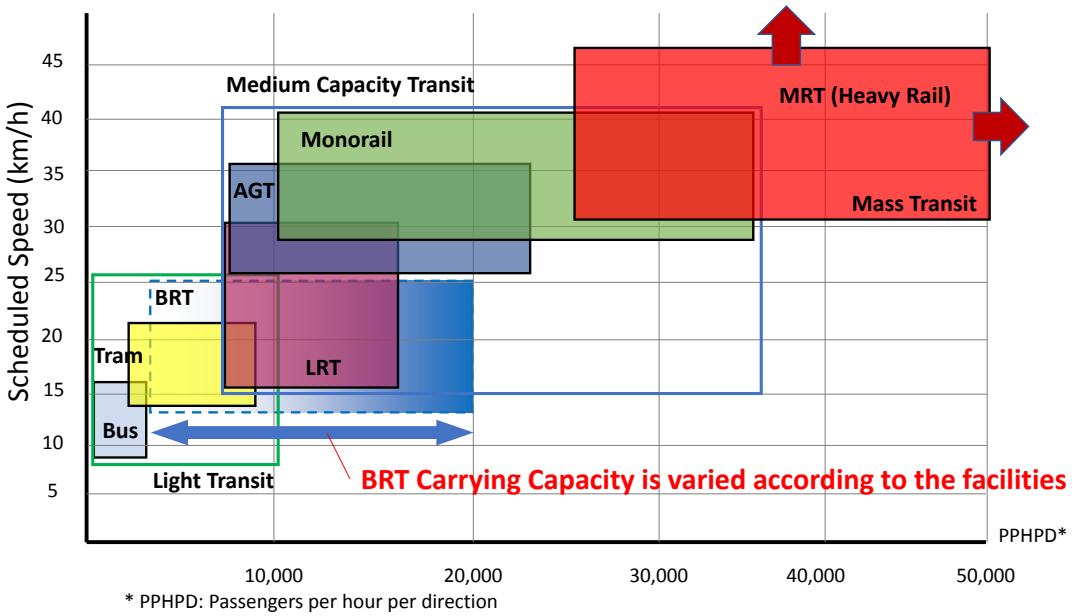


Source: JICA Study Team

Figure 6.4 Person trips by Matatu and Bus at Peak Hour (2030. Do nothing case)

6.2.3 System Selection

When planning a new urban transportation system, the most suitable system shall be selected by the future demand forecast of the corridor. The following kind of chart is commonly used for the purpose.



Source: JICA Study Team

Figure 6.5 Urban Transportation System Selection Chart

Each urban transportation system has a covering range of transportation capacity. If the future demand forecast is close to the maximum capacity of the system, that system shall not be selected providing margin of the capacity. When forecasted PPHPD of a part of the planned corridor exceeds 16,000 in future, BRT cannot be recommended.

Since future population of Nairobi will exceed 10 million, construction of Metro system is strongly recommended at major corridors.

6.2.4 Concept of the First Metro Plan

The following concepts are adopted for the planning of the First Metro Line in Nairobi:

- Connecting suburbs to CBD by one metro system which operates along the two major radial corridors.
- In order not to disturb transportation at ground surface, the metro line shall go underground within CBD.
- Minimizing land acquisition at the project sites.
- Fast access to CBD from suburbs.
- Achieving final status of urban transportation system.
- Intermodal integration facility shall be provided at each station to improve connectivity between trunk and feeder.

6.2.5 Planned Route

In the NMRTS study, 3 Metro lines were selected for MRT corridors, namely, Thika, Juja and Ngong roads based on the demand forecast. Since the priority routes have not been changed, and BRT plan is on-going at Juja and Ngong roads, Thika road is selected as a metro corridor of east side for the study. A metro corridor of west side will be selected from candidates such as Ngong road and Langata Road by considering the mature degree of the BRT projects.

Source: JICA Study Team

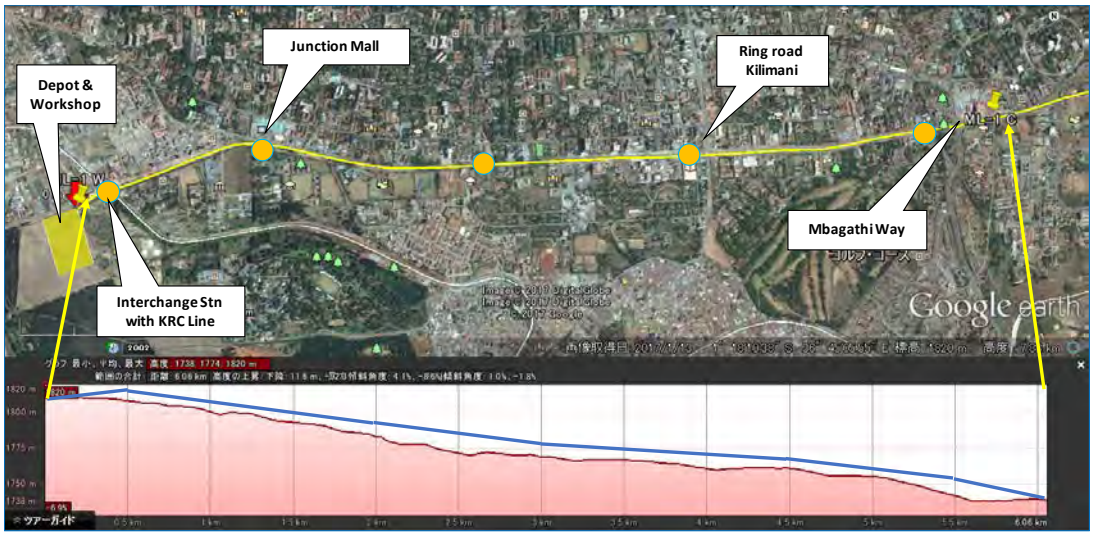
Figure 6.6 Planned Route of the First Metro Line

The selected route is able to have 4 or more junctions with KRC line and planned BRT lines as marked by pink stars on the map.

6.2.6 Topographic and Geological Condition

6.2.6.1 West Section – Ngong Road

If Ngong road is selected as the west side metro corridor, from the west end of the line to Upper Hill area, the ground elevation is declining at 2% in average as shown on Figure 6.7.

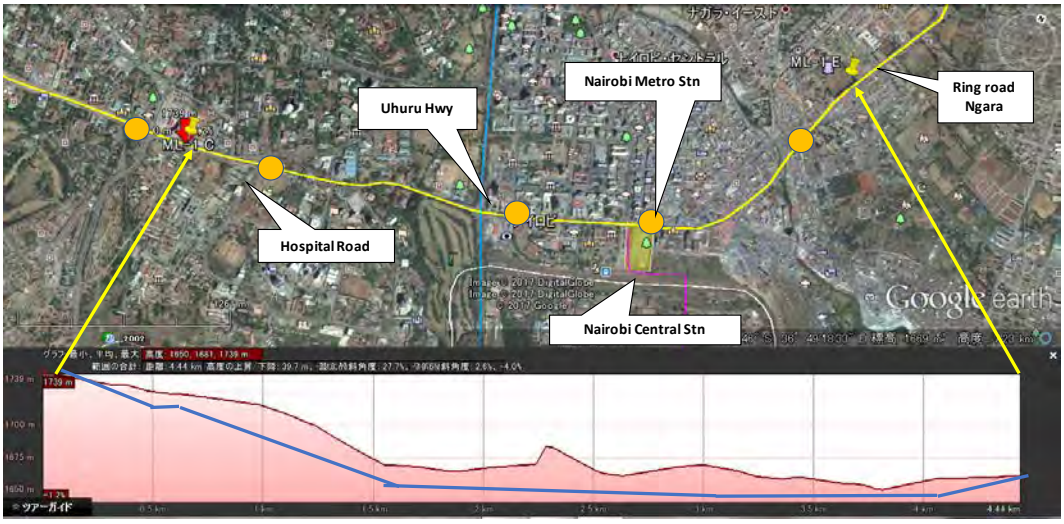


Source: Google Earth (Image © Digital Globe), JICA Study Team

Figure 6.7 Metro West Section

6.2.2.2 Central Section – CBD Area

There is a very steep slope between Upper Hill and CBD, in order to go to underground from Upper Hill area, a very long tunnel will be required if conventional type of Metro is adopted. In order to shorten the tunnel section, a special metro system will be required which can be applicable to climb 6% slope. The section of the area is shown on the Figure 6.8.



Source: Google Earth (Image © Digital Globe), JICA Study Team

Figure 6.8 Metro Central Section

6.2.2.3 East Section – Thika Road

After Passing CBD area, the alignment changed from the underground to the elevated section.

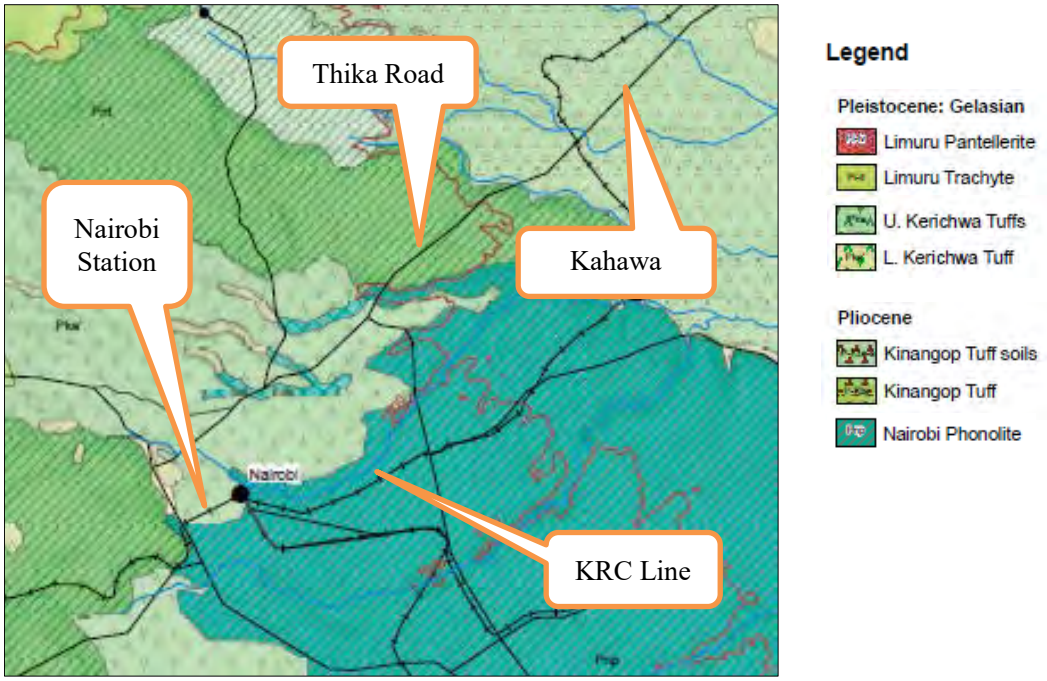
The elevated structure will follow the Thika highway as shown on the Figure 6.9.

Source: Google Earth (Image © Digital Globe), JICA Study Team

Figure 6.9 Metro East Section

This section consists of 2 (two) different base rock zones. Base rock next to the section after the CBD is Nairobi Trachyte, same rock as Upper Hill. The base rock next to Trachyte is Kinangop Tuff soils. This material is also derived from volcanic ash and not hardened yet. The boundary between 2 (two) base rocks can be seen in the difference of the ground elevation. Ground level of Trachyte zone is 1625m and that of Kinangop Tuff area is 1540m. This boundary zone is forming a gentle slope of 2% approx.

6.2.2.3 Geological Condition of the Area



Source: Geological Map of the Southern Kenya Lift (Michigan Tech. Univ.)

Figure 6.10 Geological Map of Planned Metro Alignment

According to the Geological Map, from Nairobi station is located on the Lower Kerichwa Tuff (Pka) which consists of hardened volcanic ash. Same material can be seen up to the starting

point of the Outer Ring Road.

Unconfined Compression Test of core samples of abovementioned material were carried out by the Nairobi Viaduct Project. Test results were ranging between 60,476 kN/m2 and 3,571 kN/m2. Generally, strength of samples taken from shallow depth were low and that from deep depth were high. Those strengths were ranging between very weak and moderately strong by the Classification of Rocks of BS5930.

Type of tunnel structure cannot be decided by the above data because number of sampling and testing was very limited. More detailed geotechnical investigation is required at feasibility study stage.

Nairobi Trachyte (Pnt) is indicated on the Geological Map around Kasarani area. If this material ihas same characteristics of Trachyte found at Upper Hill area, this roack can be classified as very strong – extremely strong. No pile foundation will be required at the area.

6.2.7 Design Concept of Nairobi Metro

It is difficult to find roads in CBD area having wide R.O.W. which allows the construction of viaduct structure for metro at median of the road. Many BRT lines are also planned to concentrate in CBD with long bus terminals. Therefore, it is recommended that the first metro to go underground within CBD. Considering easy access to metro station, it is recommended that the metro alignment shall follow the existing major roads.

Since there is no BRT plan accessing planned Railway City which will be developed at the KRC ex-cargo handling yard, the first metro is preferable to pass the Railway City. The metro station shall be connected with KRC Nairobi Central Station by underground passage.

The first metro line shall be constructed along Thika road, the corridor having the biggest traffic demands and suffering severe traffic congestion. As described in the clause 6.2.1, there is very limited space along the Thika road. However, if one side of the cycle lane can be utilized for the construction of an elevated viaduct structure, it is possible to build a metro structure along the road minimizing land acquisition.

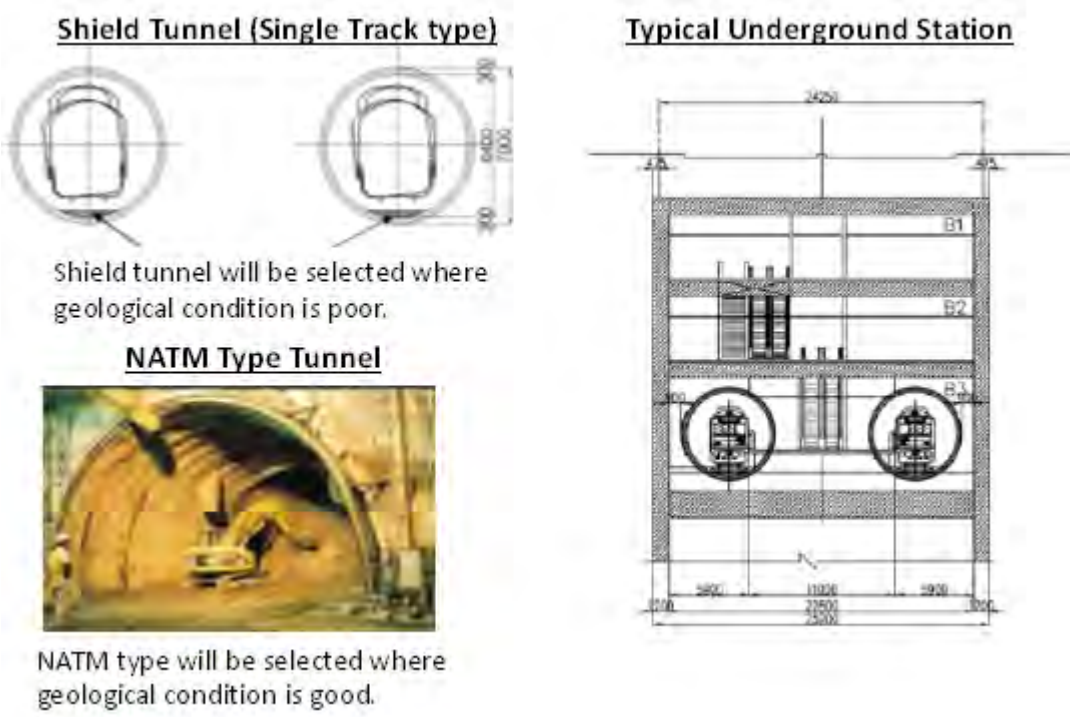
In order to provide smooth transfer from/to other transportation mode, such as, KRC commuter rail, BRT, bus and matatu, intermodal facilities shall be well considered at major stations.

6.2.8 Typical Metro Structures

6.2.4.1 Underground Section

By the “Geotechnical Investigations for the Preparatory Survey on Nairobi Viaduct and Road Construction Project in the Republic of Kenya” (May 2016), core borings were carried out at 5 locations nearby Nairobi station. According to the results, 3m to 6m thick top soil layers were found from the ground surface, and 14m to 19m thick weathered rock layers were found under the top soil. The thickness and degree of weathering of fractured rock layer were varied by boring location.

Abovementioned boring data were obtained at relatively narrow area nearby Nairobi station. All of the bore holes were drilled at 500m x 500m square. Since the planned underground section is 4km long, detailed geotechnical investigation will be required to determine tunnel structure.

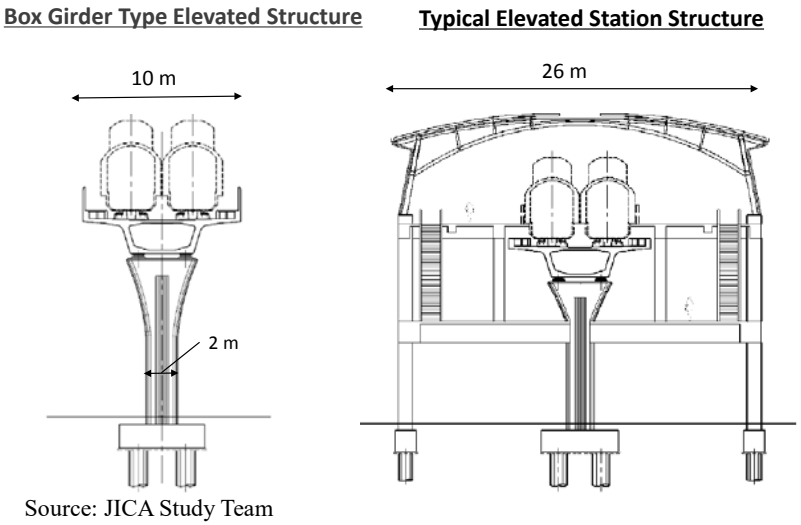


Source: JICA Study Team

Figure 6.11 Structure of Tunnel and Underground Station

6.2.4.2 Elevated Section

It is planned to construct an elevated metro structure along Thika road up to Kahawa. As shown on the following figure, an elevated double track metro can be constructed above 2m approx. diameter pier. Therefore, additional land acquisition can be minimized if one side of cycle lane can be used for pier construction.



Source: JICA Study Team

Figure 6.12 Typical Elevated Metro Structure

6.2.9 Intermodal Integration Facility at Station

In order to utilize the capability of metro effectively and maximize the benefit of the project, the station square which includes the bus and matatu bays shall be provided at each station.

Station square can facilitate intermodal integration between backbone (Metro) and rib (Matatu and ordinary bus) without disturbing road traffic as an intermodal integration facility.

Source: Yasu City, Uenohara City

Figure 6.13 Intermodal Facilities at Metro station

6.3 Salient Features of Nairobi Metro

Recommended salient features of the First Metro in Nairobi are as follows;

- Metro Line connecting west side of CBD and Kasarani stadium.
- Line length 120km approx. with 15 stations
- Underground section length: 4km with 4 stations
- Standard gauge track
- 6 cars to 8 cars train operation depending on the demand
- Distance between stations: 1.0 to 1.5 km
- Maximum train speed: 80 km/h
- Transportation capacity: PPHPD 30,000 to 60,000+
- Construction period: 4.5 to 5 years

Chapter 7 Evaluation of Traffic Situations in the Urban Core by Service Scenario of BRT/ Metro

This chapter evaluates the reorganization of Metro services and other interventions proposed in Chapter 5 & 6, and shows the pros and cons of the Metro reorganization and other interventions. This chapter starts with the methodology applying macro network analysis using JICA STRADA and updates of NIUPLAN model, then identifies the evaluation scenario and criteria of evaluation, and then shows the results.

7.1 Demand Forecasting Policy

The NIUPLAN study forecasted traffic demand in 2030. Its main objective was general transport masterplan preparation, and it covered the Nairobi metropolitan region including the surrounding 4 councils, evaluating the traffic demand and supply throughout an entire day. The objectives and framework of the Harmonized Study are similar to the NIUPLAN.

This study evaluates the Mobility conditions in Nairobi City, especially in the Urban Core, with mobility improvement objectives. First, the study proposed to evaluate the balance of traffic demand and supply on a peak hour basis. For this purpose, the study team prepared the new OD matrix for peak hour movement. The amount of the hourly traffic volume per direction in a peak period will give a proper image of Mobility. It should be noted to readers that the estimated traffic volume in this analysis is smaller than that in the NIUPLAN, which shows daily volume.

Secondly, the study team revised and developed the geographic framework of the demand forecasting policy. The traffic analysis zones in the CBD and downtown were divided to reflect the proper mobility status in the Urban Core, which is explained in section 7.2.3. The study team also prepared several new criteria explaining the mobility status in the Urban Core; i) corridor basis analysis: the balance of traffic demand and supply were evaluated by major influx corridors of the Nairobi Urban Core, which will show appropriateness of transport service supply by corridors. ii) network analysis for the Urban Core: for evaluation of the congestion status, the study team only focused on the road network in the urban core, as major interventions in this analysis are focused in the urban core region.

7.2 Methods for Traffic Demand Forecast

7.2.1 Selection of an OD Matrix for 2030

In the NIUPLAN study based on the PT, the below four OD matrices were developed for the "do-nothing" case and three alternative development cases as shown in Table 7.1.

Table 7.1 Future OD Matrices Prepared in the NIUPLAN Study

Alternative Case		Road Network	Public Transport Network	Remark
0	Ongoing Project Case	Existing network and ongoing road project	Existing network	
1	Road Development Oriented Case	Future road network	Existing network	
2	Utilization of Commuter Rail Case	Same as Alternative-1	Existing network and introduction of commuter rail	Three commuter rail lines
3	Introduction of Selective MRTS Case	Same as Alternative-1	Commuter rail and introduction of BRT, new transport system	Four BRT routes and one new transport system route.

Source: NIUPLAN

As it is necessary to forecast the future traffic demand at the time of introduction of the BRT and Metro, the OD matrix for Alternative-3, in which all on-going and planned road projects are or will be implemented, and Commuter Rail and BRT will be developed as the public transport modes, is applied in this study

7.2.2 Preparation of Peak Hour OD Matrices for 2030

In the NIUPLAN study, OD matrices were prepared to show daily volumes of person-trips. In this study, morning peak hour OD matrices are prepared by multiplying a peak hour factor and a heavy direction factor with the daily OD matrices. The peak hour factor and the heavy direction factor are estimated based on the analysis of traffic data of weekdays obtained through AMP counters. The heaviest traffic recorded is between 7 a.m. and 8 a.m., and the peak hour factor and the heavy direction factor in the peak hour are estimated at 8% and 55%, respectively.

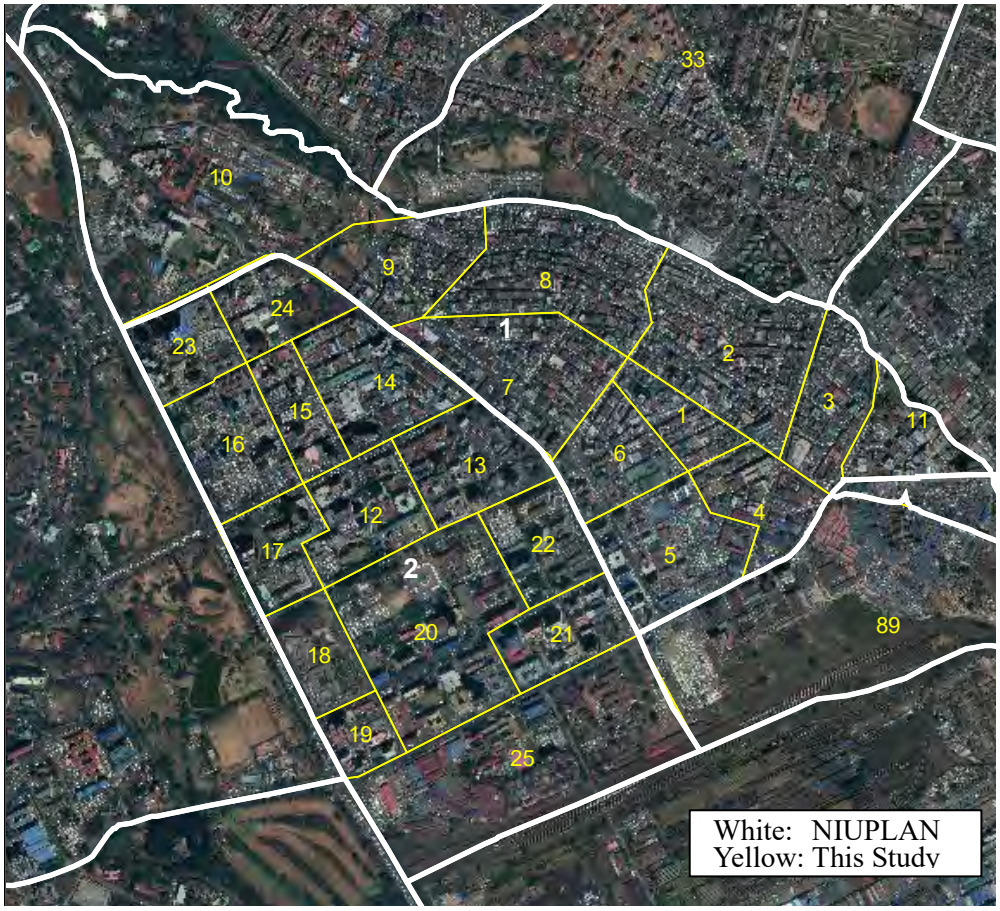
7.2.3 Zoning

In the NIUPLAN study, the urban core of Nairobi City is divided into two zones, namely 'City Center 1, 2, 3' and 'City Square 1, 2, 3', for the purpose of estimating traffic demands across the metropolitan area. As traffic flows within the urban core cannot be forecasted in detail with the zoning, the two zones are further divided into 25 zones by referring to the floor areas of the buildings based on the zoning of the NIUPLAN study. The total number of zones for this study has reached 173.

Table 7.2 Zoning for the NIUPLAN Study and this Study

New Zone seq.	NIUPLAN Zone seq.	Location
1-11	1	City Centre1, 2, 3
12-25	2	City Square1, 2, 3
26	3	Pangani
:	:	
173	150	Somali (Outside Kenya)

Source: NIUPLAN



Source: Prepared by JICA Study Team based on the zoning in NIUPLAN study

Figure 7.1 Update of Zoning for This Study from the NIUPLAN

7.2.4 Preparation of Network Data for Traffic Assignment

1) Future Road Network

The future road network data for the traffic assignment is prepared by adding roads that were constructed after 2013, are being constructed in 2017, and are planned to be constructed by 2030 to the network data collected in the NIUPLAN study.

Table 7.3 Roads Added to the Network for the Traffic Assignment in This Study

Completed	1	Nairobi Southern Bypass Road
	2	Construction of access to Embakasi (Infinity) Industrial Park
	3	Construction of Ayany - Otiende Link Road
	4	Improvement of Forest Line Road (Ushirika - Gatanga Link Road)
	5	Improvement of KISE - Sportsview Hotel
	6	Improvement of Kigwa Close
	7	Improvement of Kanyagia Drive
	8	Improvement of Forest View (Part)/Farah (Part)/Begonia (Part) and Lower Plains Road
Ongoing	1	Construction of Eastern Missing Link Roads and NMT in Nairobi
	2	Nairobi Outer Ring Road (C59) improvement project
	3	Dualing of Ngong Road (Phase 1) from Kenya National Library Services to junction with Ring Road Kilimani
	4	Construction of Waiyaki Way - Red Hill project
	5	Upgrading industrial area roads (Phase 1)
	6	Construction of Baraka Link Road (Kangundo Road - Komarock Road)
	7	Upgrading Lenana - Muchugia - Dagoretti Link Road
	8	Improvement of Eastleigh Roads (Phase 2)

	9	Piloting of Intelligent Transportation System on Western Ring Roads
	10	Upgrading Upper Hill - Mbagathi Link Road
	11	Rehabilitation and Upgrading Upper Hill Roads - Phase 2
	12	Construction of a flyover bridge across the Northern Bypass and approaches at Kahawa West
	13	Construction of Access Road to Ruai Police Station
	14	Rehabilitation of Mathare Roads
	15	Nairobi Roads Rapid Decongestion Programme (Lot 6) (Improvement of junctions: Argwings Kodhek, Ralph bunche and Woodlands Roads)
	16	Nairobi Roads Rapid Decongestion Programme Phase 2 (Lot 8)
	17	Nairobi Roads Rapid Decongestion Programme Phase 2 (Lot 9)
	18	Nairobi Roads Rapid Decongestion Programme Phase 2 (Lot 10)
	19	Nairobi Roads Rapid Decongestion Programme Phase 2 (Lot 11)
	20	Improvement of Road C
	21	Improvement of Pepo Lane
	22	Upgrading of Quarry Road
Future plan	1	Ngong Road Phase 2 (Prestige - Dagoretti Corner) - JICA
	2	Ngong Road Phase 3 (Dagoretti Corner - Karen Roundabout) - GoK
	3	Upgrading Industrial Area Roads Phase 2
	4	Design and construction of Missing Links in Nairobi Eastern Region
	5	Design and construction of Upper Hill Overpasses and Missing Links in Nairobi Western Region
	6	Design for implementation of Intelligent Transportation System on various junctions within Nairobi CBD
	7	Nairobi Roads Rapid Decongestion Programme (Lot 7) (Improvement of Dagoretti Corner Junction)

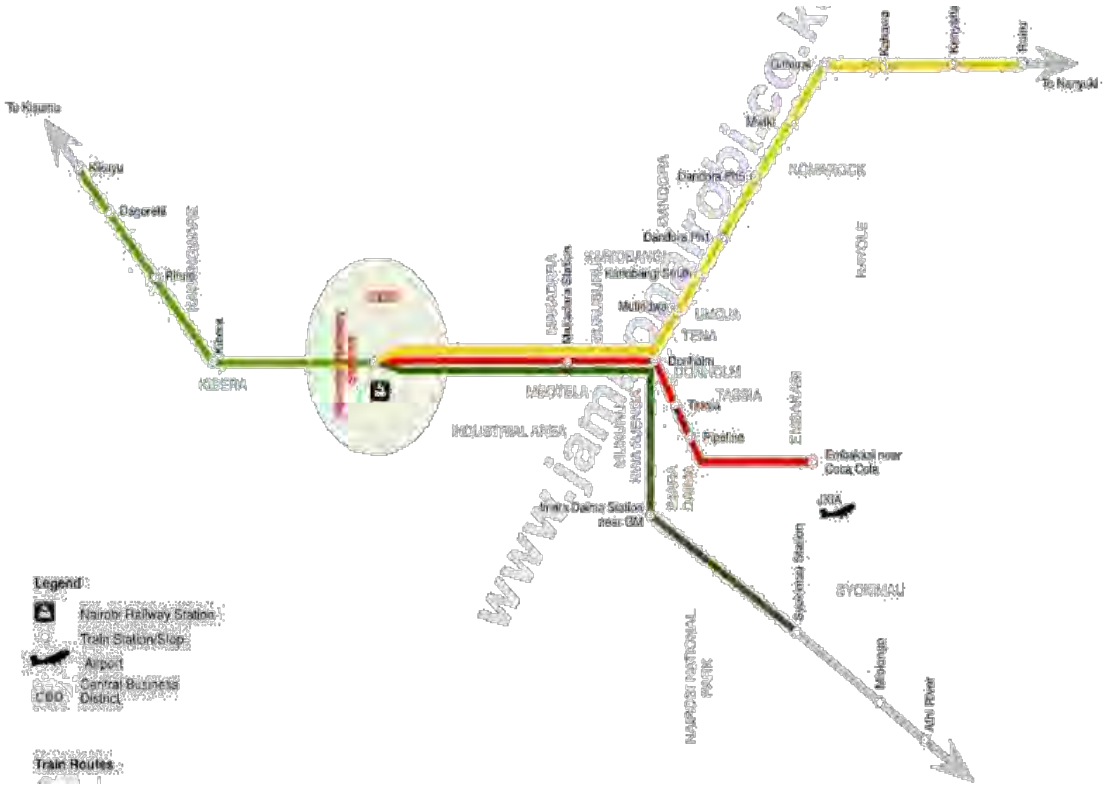
Source: JICA Study Team

2) Networks of Bus and Matatu

Operation of buses and matatu are prohibited in the urban core. For building the future transport network data for the traffic assignment, those vehicles are regarded as the ones allowed to run on roads in areas other than the urban core.

3) Railway Network

At present in Nairobi, there are railways that are not fully utilized. For building the network in this study, these railways are supposed to be rehabilitated and improved, and to be used as commuter lines by 2030. Transport capacity of these railways are set as 5,000 passengers/ per 1 hour/ per 1 direction with speed of 25km/h.



Source: KRC

Figure 7.2 Railway Network

4) BRT/Metro Network

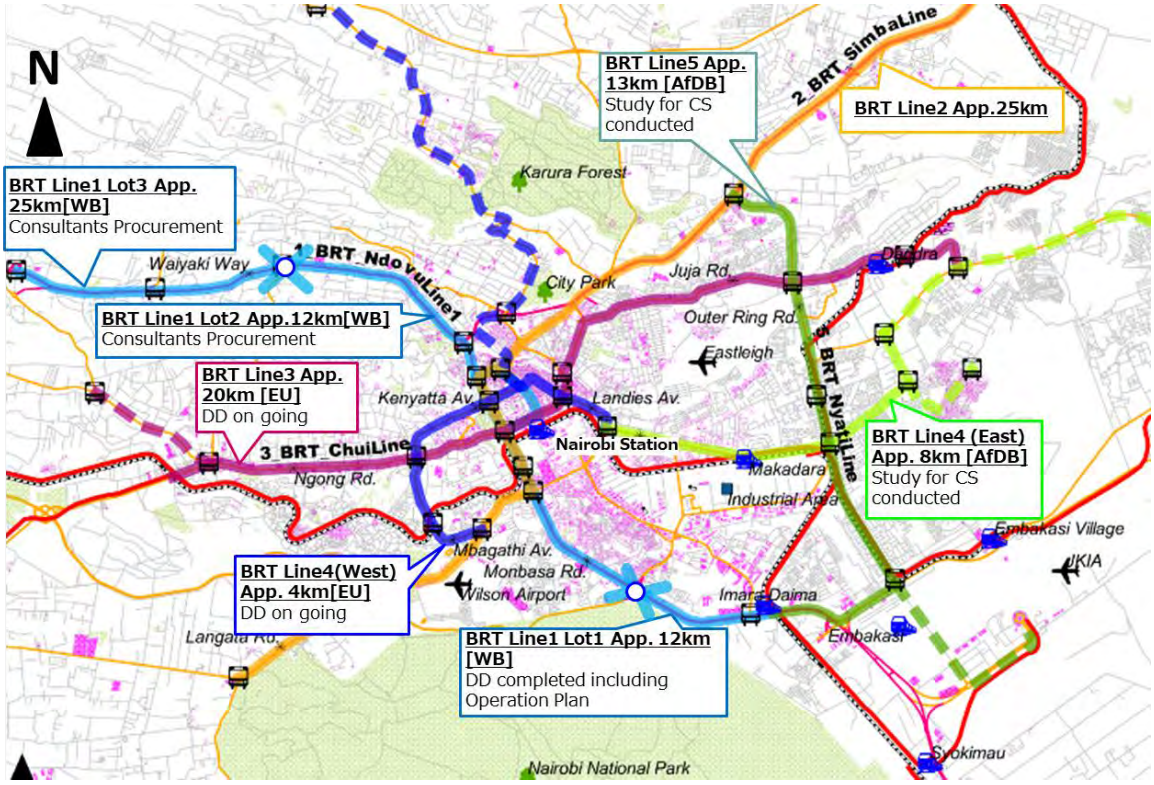
According to the Harmonization Study that was done by MOTI in 2015, there are five BRT route plans in Nairobi City, which are carried out from studies by the WB, EU and AfDB. (see Figure 7.3)

On the other hand, this study proposed to re-organize the present BRT proposal to a combination of BRT and Metro as stated in chapter 5. Figure 7.4 shows the outline of the BRT and Metro organization.

The Metro route proposed by the JICA Study Team is comprised of three sections; the western suburban section (elevated), the central urban core section (underground), and the eastern suburban section (elevated).

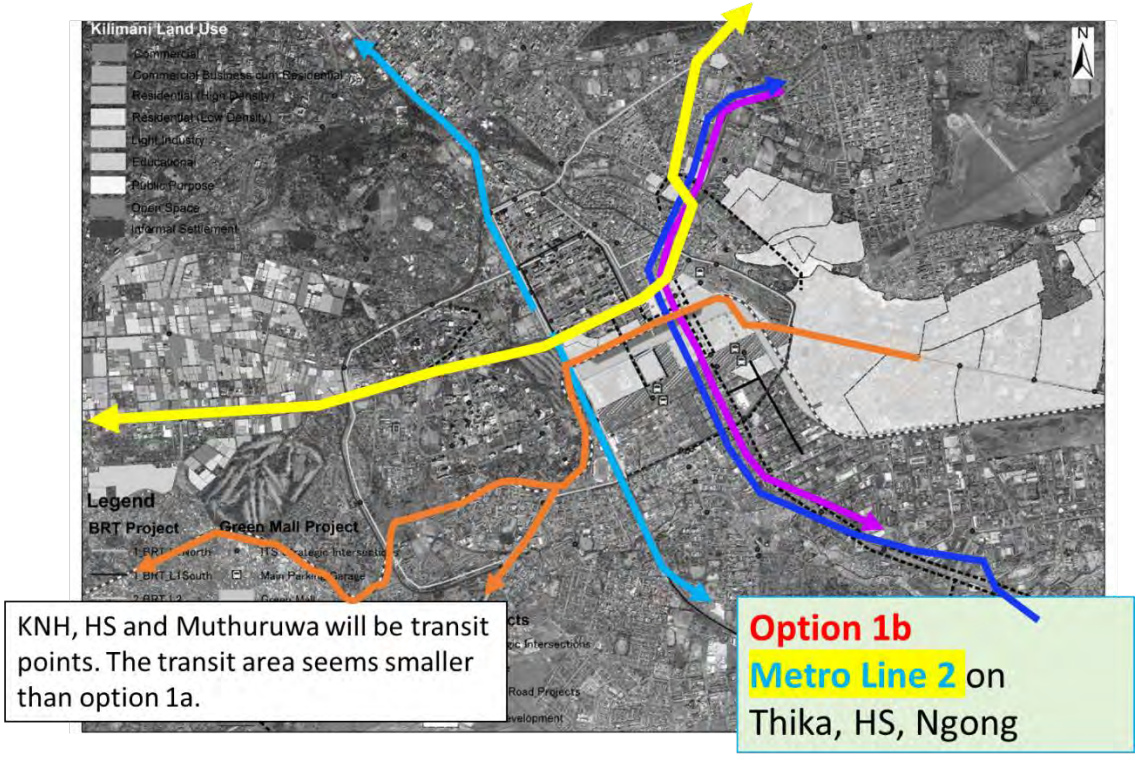
The transport capacities of BRT and Metro are planned as 10,000 and 30,000 passengers/ per hours/ per direction respectively, and the scheduled speeds of the vehicles is planned as 25km/h and 35km/h, respectively.

In the future, if BRT and Metro are to be developed, BRT will be operated on an exclusive BRT lane occupying two lanes of road space, and Metro is operated on an elevated Metro line that does not use road space.



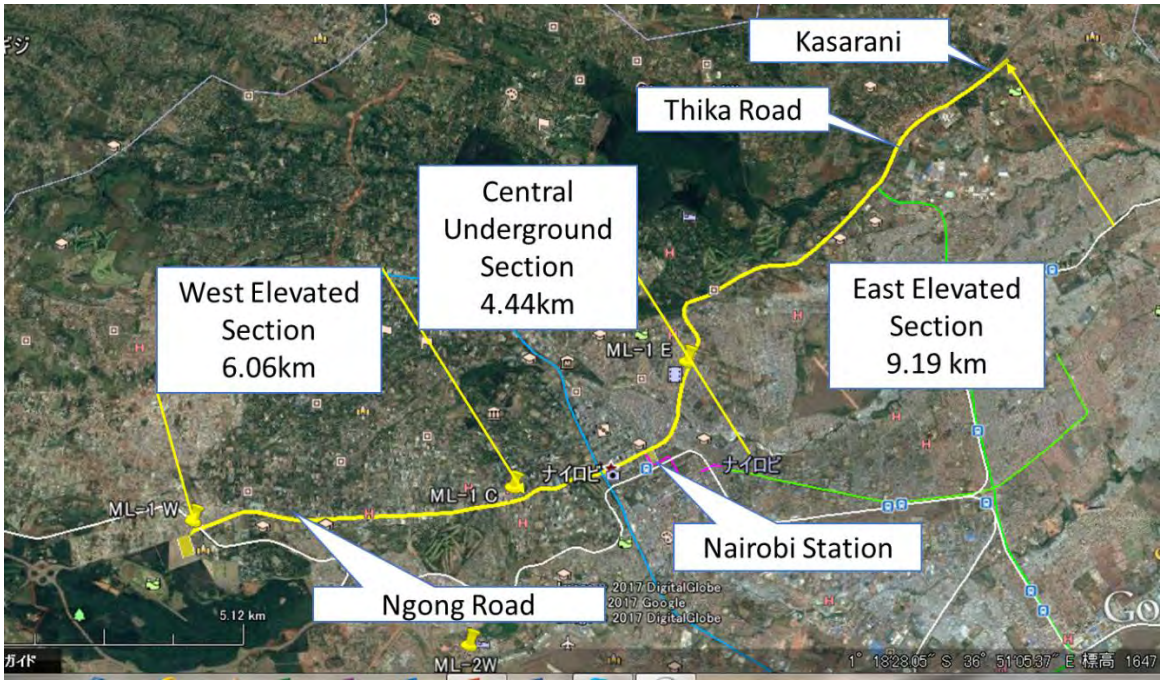
Source: JICA Study Team

Figure 7.3 BRT Routes (Existing Plan)



Source: JICA Study Team

Figure 7.4 BRT Routes (Revised by the JICA Study Team)



Source: Google Earth (Image © Digital Globe), JICA Study Team

Figure 7.5 Metro Routes (Planned by the JICA Study Team)

5) Setting of Network LOS

In order to assign the vehicle-base OD matrix to the future transport networks Level of Services (LOS), capacity (Qmax) and travel speed (Vmax) are set as the same as those set in the NIUPLAN study. For the peak hour passenger traffic, vehicle-based daily Qmax is converted to trip-based peak hour Qmax and 40 – 50% of daily Vmax is set as peak hour Vmax.

Table 7.4 Qmax and Vmax Applied in This Study

Rank	Divide	Location	Lane	For vehicle-based daily OD		For trip-based public transport hourly OD	
				Vmax (km/h)	Qmax (pcu/day)	Vmax (km/h)	Qmax (pax/h)
Trunk, Major Arterial	Divided	Suburban and Rural	8	80	120,000	40	166,000
		Suburban and Rural	6	80	90,000	40	124,000
		Urban	6	60	75,000	24	104,000
		Suburban and Rural	4	60	60,000	24	83,000
		Urban	4	50	50,000	20	69,000
	Undivided	Suburban and Rural	4	45	50,000	18	69,000
		Suburban and Rural	2	40	25,000	16	35,000
Minor Arterial, Major Collector	Divided	Urban	6	50	60,000	20	83,000
		Urban	4	45	40,000	18	55,000
	Undivided	Suburban and Rural	4	40	35,000	16	48,000
		Suburban and Rural	2	35	15,000	14	21,000
	Non-center	Suburban and Rural	2	30	10,000	12	14,000
Others	Ramp	--	2	30	20,000	12	28,000
		--	1	30	10,000	12	14,000
	Roundabout	--	4	30	60,000	12	83,000
		--	3	30	45,000	12	62,000
		--	2	30	30,000	12	41,000
		--	1	30	15,000	12	21,000
Railway (One direction)						25	5,000
BRT (One direction)						25	10,000
Metro (One direction)						35	30,000

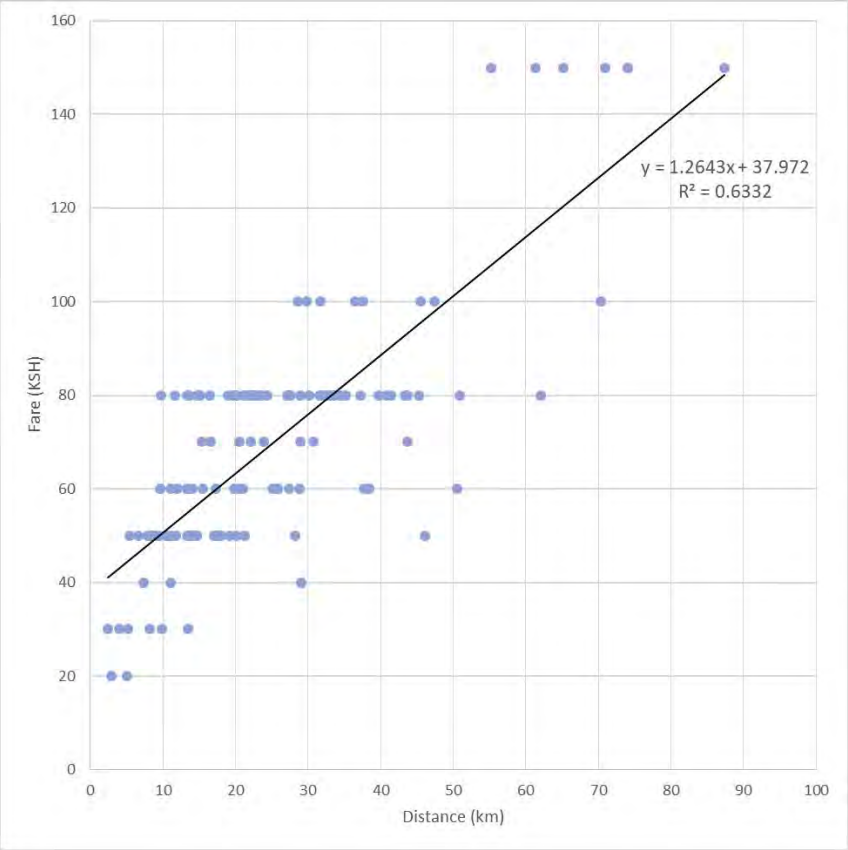
Source: Prepared by JICA Study Team based on the results of the NIUPLAN study

6) Setting Fares of Public Transport for the Traffic Assignment

Since various fares for the public transport services are presently set depending on routes and route lengths, and the exact fare for each route cannot be set in the traffic assignment model of this study, it is necessary to set a typical fare model for the assignment. A linear regression model is developed after plotting actual data on bus/matatu fares and riding distances in a graph as shown in Figure 7.6 The fares calculated with the following formula are used in the demand traffic assignment model.

- *Fare of Bus/Matatu (KSH) = 1.26 (KSH/km) X Riding Distance (km) + 37.97 (KSH)*

Meanwhile, the flat rate of KSH 50 is set as the fare of BRT/Metro within the city.



Source: Prepared by JICA Study Team

Figure 7.6 Relationship between Fare of Bus/Matatu and Riding Distance

7) Estimation (Evaluation, Setting) Time Value

Average per capita salary per month is about KSH 32,000 (excluding tax) in Nairobi. Assuming 22 working days for a month and 8 working hours for a day, the average salary for a person for a minute is calculated at KSH 3.03. Since the survey in the NIUPLAN study says that 30% of the total trips were made for business purposes, the time value for a person is estimated at KSh 0.91/minute.

According to the survey in the NIUPLAN study, 30% and 70% of trips for business commuting are done by automobiles/taxis and buses, respectively. Assuming one third of the average salary of a car owner is that of a non-car owner, average time values for passengers of automobiles and busses are estimated at KSh 1.70/minute/person, and KSh 0.57/minute/person,

respectively. With an assumption that the average number of passengers for an automobile and for a bus are 1.96 persons and 30 persons, respectively, time values of passengers of an automobile and a bus are estimated at (evaluated as) KSh 3.33/minute and KSh 16.98/minute, respectively.

7.3 Assignment of Traffic Volume

The incremental assignment method is applied for the traffic volume assignment with assigned shares of 35%, 20%, 15%, 10%, 5%, 5%, 5% and 5 %.

7.3.1 Alternative Cases for Traffic Assignment

Assigned traffic volumes are estimated for the following cases:

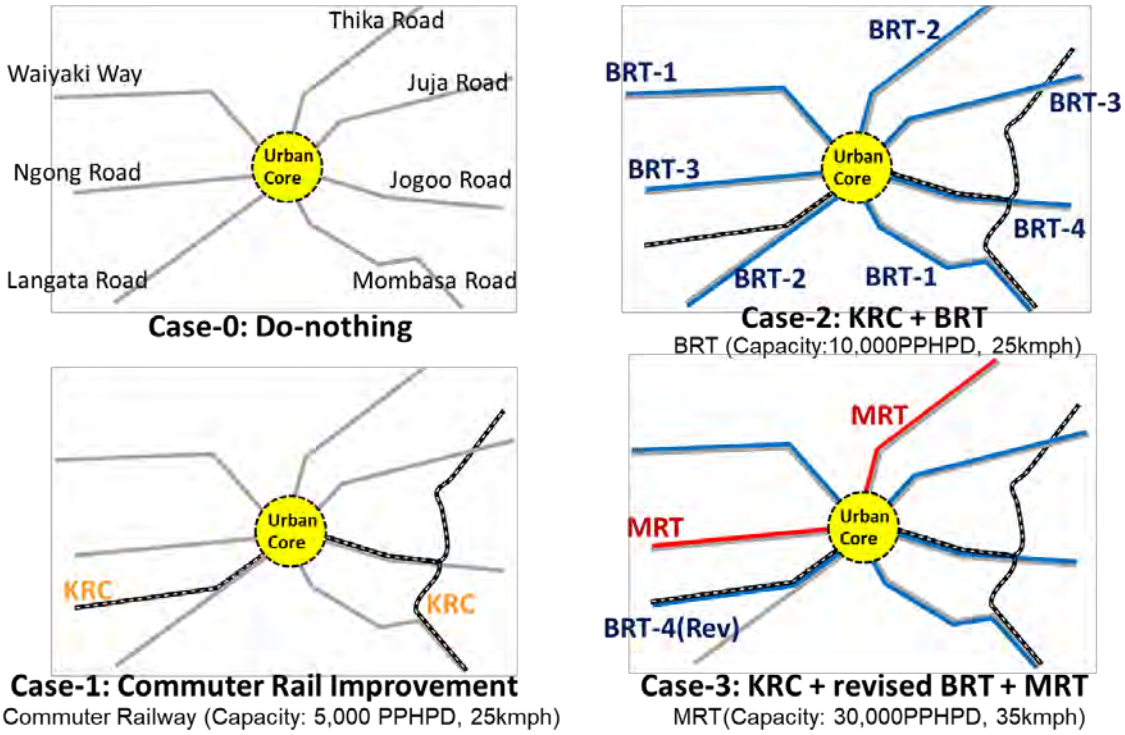
- Case-0: BAU, No new public transportation system development. Only bus and matatu services as public transport modes
- Case-1: Only railway improvement for commuting purposes
- Case-2: Railway improvement and Commissioning of planned BRT services
- Case-3: revised BRT, Railway improvement and Commissioning of Metro services planned by this study

Table 7.5 Alternative Cases for Traffic Assignment

Case No.	Improved Railway	BRT planned by WB, EU, AfDB	BRT planned by JICA Study Team	Metro planned by JICA Study Team
0	–	–	–	–
1	✓	–	–	–
2	✓	✓	–	–
3	✓	–	✓	✓

Source: Prepared by JICA Study Team

Figure 7.7 summarizes the major setting of interventions by scenario.



Source: Prepared by JICA Study Team

Figure 7.7 Scenario and Interventions

7.4 Mobility Assessment

7.4.1 Urban Core Evaluation

1) Results summary

Table 7.6 summarizes vehicle traffic and public transport during the peak hour in the urban core of Nairobi City.

Table 7.6 Evaluation Index of Vehicle Traffic and Public Transport Services

Case	Scenario					Vehicle Traffic			Public Transport	
	Improved Railway	BRT planned by WB, EU, AfDB	Metro	BRT planned by JST	Capacity-km	Vehicle-km	Vehicle-hour	Avg. speed (km/h)	Passenger-kilometer	Avg. speed (km/h)
Case-0	–	–	–	–	123,078	127,797	4,785	26.7	430,219	13.4
Case-1	✓	–	–	–	123,078	126,669	4,619	27.4	479,978	14.5
Case-2	✓	✓	–	–	103,964	101,877	4,316	23.6	546,182	19.1
Case-3	✓	–	✓	✓	112,360	107,354	4,285	25.1	661,445	20.9

Source: JICA Study Team

The table shows results of the 4 cases in vertical direction, and transport service elements of each scenario, and also shows 3 indices for vehicle traffic situation, and 2 indices of the public transport services.

The capacity-kilometer in the columns of Scenario tells the aggregated amount of the lane-km

in the target area. The case-0 is the base case of road traffic network in the Urban core. Case-1, rail improvement, will not add any impact to the road network. The capacity-km in Case-2 reduces capacity by 20% compared to Case-0 as the proposed BRT alignments deducts two lanes from the existing road network. Case-3 is less than Case-0, but more than Case-2, as the revised BRT alignment for Case-3 is designed to minimize lane deduction from the existing network.

The indices for the vehicle traffic shows travel status of vehicles in the urban core road network, including private cars, matatu, buses and freight. The indices for the public transport services shows the status of rail, matatu, bus and BRT and Metro users. The average speed tells quality of services, while vehicle-km, vehicle-hour, and passenger-km tells quantitative results.

On assessing the policies, the indices for Case-0 will be the reference of the analysis, and both travel speed for vehicle transport and public transport services are evaluated together.

Table 7.7 Vehicle Speed Improvement by Scenario

	Vehicle Ave. Speed	Vs Case-0	PT service Ave. Speed	Vs Case-0
Case-1	27.4	103%	14.5	108%
Case-2	23.6	88%	19.1	143%
Case-3	25.1	94%	20.9	156%

Source: JICA Study Team

For Case-1, some passengers will be carried by rail, therefore, vehicle traffic situation improves slightly for vehicle speed, and the travel speed of public transport services improves slightly.

For Case-2, the BRT intervention will improve the average speed of public transport by 43%, and the vehicle transport speed increases by 88% of the base case.

For Case-3, the BRT intervention will improve the average speed of public transport by 56%, and the vehicle transport speed increases by 94% of the base case.

2) Suggestions

The existing BRT Plan can improve the Public transport service, but its effect on the general road network is severe. The revised BRT plan with Metro can improve more than the existing plan, and alleviate the damage to the general road traffic.

The NUPLAN[1] in 2012 says, "*(On BRT system Installation) the identification of a strong leader or champion who can overcome resistance and reconcile various interests is very important is critical*". The JICA study team will not write about the political leadership, however, it is important to minimize the influence for road transport for smooth installation of the expected BRT system.

It can be said that BRT installation always has resistance from vehicle users. In Nairobi, Matatu operators who will be excluded from using bus lanes and loss of passengers by BRT may reject the BRT installation. Automobile Users Associations can reject the installation as taxpayers, who paid road tax to develop and maintain the road network, but some sections of the road network would be occupied by BRT passengers who never paid the road tax. The Nairobi City officials and NaMATA need to cope with resistance and optimize the demand among

[1] Project Appraisal Document, National Urban Transport Improvement Project (P126321), Report No: 67350-KE, Page 39

stakeholders.

Comparing Case-2 and Case-3, the following can be suggested;

- Case-2 (existing BRT proposals) achieves public transport improvement, however, it places increased stress on the vehicle traffic situation, as it occupies vehicle lanes in the urban core. This simulation does not reproduce the influence of BRT's level crossing and turning at several intersections perfectly, therefore, the actual result could be worse.

- Case-3 (revised BRT proposal with Metro) achieves better overall public transport service than Case-2, as it places less stress on the vehicle traffic situation.

It should be noted that the present BRT plan proposed by the Harmonization Study (Case-2) will not be able to improve the mobility of the Urban Core. The name "Harmonization Study" may mislead understanding of mobility improvement.

7.4.2 Urban Core Assessment with Sensitivity Analysis

This sensitivity analysis suggests the impact of interventions which will control the private car demand with TDM approach during peak hour, including parking control, area pricing, etc. It is difficult to estimate the impact of those interventions to traffic here, assuming that two scenarios for 5% and 10% of private car users shift to public transport users, then similar analyses were applied to Case-0 and Case-3, as shown in Table 7.8.

Table 7.8 Sensitivity Analysis for TDM Measures

	Case	Vehicle Traffic				Public Transport Users		
		Veh-km	Veh-hour	Congestion Ratio	Ave Speed	Person-km	Person-hour	Ave-speed
BAU	0	127,797	4,785	1.04	26.7	430,219	32,099	13.4
	1	126,669	4,619	1.03	27.4	479,978	33,179	14.5
	2	101,877	4,316	0.98	23.6	546,182	28,585	19.1
	3	107,354	4,285	0.96	25.1	661,455	31,670	20.9
5% shift	0	125,130	4,544	1.02	27.5	436,905	32,677	13.4
	1	123,975	4,392	1.01	28.2	486,944	33,825	14.4
	2	99,558	4,064	0.96	24.5	554,789	29,136	19.0
	3	104,454	4,052	0.93	25.8	670,799	32,217	20.8
10% shift	0	122,341	4,310	0.99	28.4	443,825	33,406	13.3
	1	121,070	4,153	0.98	29.2	494,210	34,483	14.3
	2	97,279	3,825	0.94	25.4	558,849	29,541	18.9
	3	101,467	3,823	0.90	26.5	680,205	32,831	20.7

Source: Prepared by JICA Study Team

The results show that a shift away from passenger cars can certainly improve the traffic situation. For example, a 10% shift in TDM measures with Case-2 may realize a similar level of impact with the Case-3 investment in BAU. The study team suggests a combination of TDM measures and physical interventions should be considered as to secure the impact of the development.

7.4.3 Corridor Basis Evaluation

The mobility assessment for the major influx corridors connecting to the Nairobi Urban Core follows below.

1) Thika and Juja Corridor

Table 7.9 shows the result of the corridor-based analysis for Thika and Juja roads. The table tells a variety of assessment results and suggestions for future traffic volume.

Table 7.9 Peak Hour Thika-Juja Corridor Situation

(Unit: 100 pax/h)

Dir.	Radial Road/ Mass transit	(section)	Case-0			Case-1			Case-2			Case-3		
			min		max	min		max	min		max	min		max
North East	Thika Rd	(Outer ring Rd-Ring Rd Ngara)	302	-	353	271	-	319	151	-	173	68	-	93
	BRT-2	(Outer ring Rd-Ring Rd Ngara)	-	-	-	-	-	-	96	-	101	-	-	-
	Metro	(Outer ring Rd-Ring Rd Ngara)	-	-	-	-	-	-	-	-	-	197	-	199
	Sub-total1		302	-	353	271	-	319	247	-	274	265	-	292
	Juja Rd	(Outer ring Rd-Ring Rd Ngara)	64	-	84	52	-	72	24	-	45	28	-	46
	BRT-3	(Outer ring Rd-Ring Rd Ngara)	-	-	-	-	-	-	122	-	132	125	-	135
	Sub-total2		64	-	84	52	-	72	146	-	177	153	-	181
	Sub-total1+2		366	-	437	323	-	391	393	-	451	418	-	473

Source: Prepared by JICA Study Team

This table shows the passenger amount using public transport in one hour in one direction. The readers can imagine the situation of the inbound traffic to the city in the peak morning period.

Case-0 tells the situation of a "No-improvement" case, for Thika Road, 30-35 thousand of public transport passengers can be observed in the section from the urban core to outer ring road. To carry such demands, it requires 500 large 70-seater buses per hour, and those buses need to operate every 8 seconds, which sounds impossible. It should be noted that the growing private passenger cars will add to this demand. The demand on the Juja road is five-times smaller than Thika.

Case-1 shows demand being alleviated slightly, as the demand from suburbs will be absorbed by the commuter rail. However, large demand still remains.

Case-2 shows the installation of the BRT (Line 2[2]) which can absorb around 10 thousand passengers from ordinary buses on Thika. Moreover, the BRT Line 3 on Juja will absorb 12-13 thousand passengers from Thika. The demand on Thika road becomes half, but ordinary buses still must operate every 15 seconds on Thika road, where one lane of four were deducted for the BRT services. The condition of Juja improves, and remaining demand can coincide with passenger car demands. The subtotal of public transport passengers on the northeast corridor (Thika-Juja) would increase from Case-0, as the attractiveness of the public transport service improves.

Case-3 shows that the Metro absorbs 20 thousand passengers from Thika road. The demand of ordinary bus service on the Thika road still remains about 7-9 thousand per hour, but can be managed better than Case-0 or Case-2. The situation of Juja is similar to Case-2.

As mentioned above, the Thika-Juja corridors run closely together and therefore, BRTs on Juja can influence the Thika transport business. However, the BRT on Thika is insufficient for the its demand amount. It is apparent that the combination of Metro and BRT is necessary to the Thika-Juja corridor.

[2] The target year of this analysis is 2030, and the BRT Line 2 is programmed to be installed during 2030-35. This analysis assumes the BRT Line 2 will be constructed earlier than expected.

2) Jogoo Corridor

Similar analysis has been applied to the Jogoo road, where railway and BRT Line 4 will be applied. Table 7.10 summarizes the results by scenarios.

Table 7.10 Peak Hour Jogoo Corridor Situation

(Unit: 100 pax/h)

Dir.	Radial Road/ Mass transit	(section)	Case-0			Case-1			Case-2			Case-3		
			min		max	min		max	min		max	min		max
South East	Jogoo Rd	(Outer ring Rd-Lusaka Rd)	127	-	199	117	-	186	45	-	93	44	-	113
	Railway	(Donholm Railway st.-Nairobi Railway st.)	-	-	-	82	-	82	52	-	52	51	-	51
	BRT-4	(Donholm Railway st.-Nairobi Railway st.)	-	-	-	-	-	-	91	-	96	71	-	76
	Sub-total		127	-	199	199	-	268	188	-	241	166	-	240

Source: Prepared by JICA Study Team

Case-0 tells the situation of a "No-improvement" case, for Jogoo Road, 12-20 thousand of public transport passengers can be observed in the section from the urban core to outer ring road. To carry such demands, it requires 280 large 70-seater buses per hour, and those buses need to operate every 15 seconds. It should be noted that the growing private passenger cars will add to this demand.

Case-1 shows demand is alleviated slightly, as the demand from suburbs will be absorbed by the commuter rail. However, the commuter rail will carry the demand of the Thika road corridor and Mombasa Road corridor, and won't have a major impact to the traffic on the Jogoo road. It should be noted that the rail carries 8 thousand passengers, although the capacity of the rail service was assumed as 5 thousand, which shows the passenger comfortability in rail being low.

Case-2 will bring BRT Line 4 in this corridor, which will absorb the passenger demands of the ordinary bus services. Case-3 has similar improvement but the BRT Line1+ on the Enterprise Road may absorb the demand of the BRT Line 4.

The Rail and BRT combination can manage the demand along the Jogoo road, however, rail capacity improvement can be expected.

3) Mombasa Road Corridor

Similar analysis has been applied to the Mombasa road, where Shokimau railway and BRT Line 1 will be applied. Table 7.11 summarizes the results by scenarios.

Table 7.11 Peak Hour Mombasa Road Corridor Situation

(Unit: 100 pax/h)

Dir.	Radial Road/ Mass transit	(section)	Case-0			Case-1			Case-2			Case-3		
			min		max	min		max	min		max	min		max
South	Mombasa Rd	(Airport North Rd-Lusaka Rd)	96	-	124	79	-	97	13	-	40	14	-	35
	Railway	(Imara Raima Railway st.-Donholm Railway st.)	-	-	-	18	-	37	14	-	36	19	-	35
	BRT-1	(Airport North Rd-Lusaka Rd)	-	-	-	-	-	-	80	-	90	49	-	107
	Sub-total		96	-	124	97	-	134	107	-	166	82	-	177

Source: Prepared by JICA Study Team

Case-0 tells the situation of a "No-improvement" case, for Mombasa Road, 9-12 thousand of public transport passengers can be observed in the section from the urban core to Airport road. To carry such demands, it requires 170 large 70-seater buses per hour, and those buses need to

operate every 30 seconds. It should be noted the growing private passenger cars will add to this demand.

Case-1 shows demand is alleviated slightly, as the demand from suburbs will be absorbed by the commuter rail. However, the commuter rail alignment does not cover the corridor fully and does not absorb the demand much.

Case-2 will bring BRT Line 1 to this corridor, which will absorb demand from the ordinary buses. Case-3 has similar improvement, but the BRT Line1+ on the Enterprise Road may absorb the demand of the BRT Line 1.

The Rail and BRT combination can manage the demand along the Mombasa road Corridor.

4) Langata Road Corridor

Similar analysis has been applied to the Langata road, where the Kikuyu Line railway and BRT Line 2 will be applied. Table 7.11 summarizes the results by scenarios.

Table 7.12 Peak Hour Langata Road Corridor Situation

(Unit: 100 pax/h)

Dir.	Radial Road/ Mass transit	(section)	Case-0			Case-1			Case-2			Case-3		
			min		max	min		max	min		max	min		max
South West	Langata Rd	(Magadi Rd-Mbagathi Way)	59	-	85	56	-	78	4	-	26	35	-	60
	Railway	(Showground(new) st.-Madaraka(new) st)	-	-	-	40	-	56	27	-	51	44	-	51
	BRT-2	(Magadi Rd-Mbagathi Way)	-	-	-	-	-	-	59	-	88	-	-	-
	BRT-4(REV)	(Showground-Ring Rd Kilimani)	-	-	-	-	-	-	-	-	-	8	-	67
	Sub-total		59	-	85	96	-	134	90	-	165	87	-	178

Source: Prepared by JICA Study Team

Case-0 tells the situation of a "No-improvement" case, for Mombasa Road, 6-8 thousand of public transport passengers can be observed in the section from the urban core to suburban area.

Case-1 the railway development will have a minor improvement to the ordinary bus service as this rail alignment does not cover fully of the Langata corridor. It should be noted that this line will cover the demand on Ngong road also.

Case 2 the BRT Line 2[3] extension will be applied, and Line 2 will absorb passenger demand well from ordinary services and alleviate the traffic condition. Case-3 is the application of BRT 4 extension as BRT reorganization, but the line does not run along the Langata road itself, therefore the absorption of ordinary bus traffic is modest.

The rail and BRT combination are required for the Langata road corridor.

5) Ngong Road Corridor

Similar analysis has been applied to the Ngong road, where BRT Line 3 or Metro will be applied. Table 7.13 summarizes the results by scenarios.

[3] The target year of this analysis is 2030, and the BRT Line 2 is programmed to be installed during 2030-35. This analysis assumes the BRT Line 2 will be constructed earlier than expected.

Table 7.13 Peak Hour Ngong Road Corridor Situation

(Unit: 100 pax/h)

Dir.	Radial Road/ Mass transit	(section)	Case-0			Case-1			Case-2			Case-3		
			min		max	min		max	min		max	min		max
West	Ngong Rd	(Kingara Rd-Mbagathi Way)	74	-	135	77	-	129	41	-	88	2	-	18
	BRT-3	(Kingara Rd-Mbagathi Way)	-	-	-	-	-	-	85	-	103	-	-	-
	Metro	(Kingara Rd-Mbagathi Way)	-	-	-	-	-	-	-	-	-	150	-	189
	Sub-total		74	-	135	77	-	129	126	-	191	152	-	207

Source: Prepared by JICA Study Team

Case-0 shows 7-13 thousand passenger traffic during the peak hour.

Case-1 does not show impact of the commuter rail installation, although the Kikuyu line may influence this corridor.

Case-2 shows the impact of the BRT installation of this corridor, and the BRT absorbs 8-10 thousand passengers, but 4-8 thousand passenger traffic on the ordinary corridor remains.

Case-3 installs the Metro, which will absorb the surface traffic perfectly, and attract more passengers from other corridors as total capacity increases from Case-0.

For Ngong corridor, the BRT is applicable but insufficient. Metro installation can develop Ngong as a main urban axis attracting surrounding traffic demands.

6) Waiyaki Road Corridor

Similar analysis has been applied to the Waiyaki road, where BRT Line 1 will be applied. Table 7.14 summarizes the results by scenarios.

Table 7.14 Peak Hour Waiyaki Road Corridor Situation

(Unit: 100 pax/h)

Dir.	Radial Road/ Mass transit	(section)	Case-0			Case-1			Case-2			Case-3		
			min		max	min		max	min		max	min		max
North West	Waiyaki Way	(Kapenguria-Meru Nairobi Hwy)	64	-	163	58	-	150	10	-	59	10	-	51
	BRT-1	(Kapenguria-Meru Nairobi Hwy)	-	-	-	-	-	-	61	-	103	49	-	88
	Sub-total		64	-	163	58	-	150	71	-	162	59	-	139

Source: Prepared by JICA Study Team

Case-0 shows 6-16 thousand passenger traffic during the peak hour.

Case-1 shows a small improvement from the commuter rail installation, as the Kikuyu line may influence this corridor.

Case-2 shows solid improvement of the BRT installation of this corridor, as the BRT absorbs 6-10 thousand passengers and the traffic on the ordinary corridor can be kept at an acceptable 1-6 thousand level.

The BRT installation for Case-3 has similar results of Case-2, however, it has influence of the Metro installation in Ngong corridor.

For Waiyaki corridor, the BRT is sufficient. Metro installation along the Ngong may alleviate the demand of the Waiyaki way.

7) Summary of Corridor Analysis

- It is apparent that the combination of Metro and BRT is necessary to the Thika-Juja corridor.
- The Rail and BRT combination can manage the demand along the Jogoo road, however, rail capacity improvement can be expected.
- The Rail and BRT combination can manage the demand along the Mombasa road Corridor.
- The rail and BRT combination are required for the Langata road corridor.
- For Ngong corridor, the BRT is applicable but insufficient. Metro installation can develop Ngong as a main urban axis attracting surrounding traffic demands.
- For Waiyaki corridor, the BRT is sufficient. Metro installation along the Ngong may alleviate the demand of the Waiyaki way.

The results for the whole city can be summarized as Table 7.15.

Table 7.15 Results of Traffic Assignment (PPHPD) by Radiation Direction (year 2030)

(Unit: 100 pax/h)

Dir.	Radial Road/ Mass transit	(section)	Case-0			Case-1			Case-2			Case-3		
			min		max	min		max	min		max	min		max
North East	Thika Rd	(Outer ring Rd-Ring Rd Ngara)	302	-	353	271	-	319	151	-	173	68	-	93
	BRT-2	(Outer ring Rd-Ring Rd Ngara)	-	-	-	-	-	-	96	-	101	-	-	-
	Metro	(Outer ring Rd-Ring Rd Ngara)	-	-	-	-	-	-	-	-	-	197	-	199
	Sub-total1		302	-	353	271	-	319	247	-	274	265	-	292
	Juja Rd	(Outer ring Rd-Ring Rd Ngara)	64	-	84	52	-	72	24	-	45	28	-	46
	BRT-3	(Outer ring Rd-Ring Rd Ngara)	-	-	-	-	-	-	122	-	132	125	-	135
	Sub-total2		64	-	84	52	-	72	146	-	177	153	-	181
	Sub-total1+2		366	-	437	323	-	391	393	-	451	418	-	473
South East	Jogoo Rd	(Outer ring Rd-Lusaka Rd)	127	-	199	117	-	186	45	-	93	44	-	113
	Railway	(Donholm Railway st.-Nairobi Railway st.)	-	-	-	82	-	82	52	-	52	51	-	51
	BRT-4	(Donholm Railway st.-Nairobi Railway st.)	-	-	-	-	-	-	91	-	96	71	-	76
	Sub-total		127	-	199	199	-	268	188	-	241	166	-	240
South	Mombasa Rd	(Airport North Rd-Lusaka Rd)	96	-	124	79	-	97	13	-	40	14	-	35
	Railway	(Imara Daima Railway st.-Donholm Railway st.)	-	-	-	18	-	37	14	-	36	19	-	35
	BRT-1	(Airport North Rd-Lusaka Rd)	-	-	-	-	-	-	80	-	90	49	-	107
	Sub-total		96	-	124	97	-	134	107	-	166	82	-	177
South West	Langata Rd	(Magadi Rd-Mbagathi Way)	59	-	85	56	-	78	4	-	26	35	-	60
	Railway	(Showground(new) st.-Madaraka(new) st)	-	-	-	40	-	56	27	-	51	44	-	51
	BRT-2	(Magadi Rd-Mbagathi Way)	-	-	-	-	-	-	59	-	88	-	-	-
	BRT-4(REV)	(Showground-Ring Rd Kilimani)	-	-	-	-	-	-	-	-	-	8	-	67
	Sub-total		59	-	85	96	-	134	90	-	165	87	-	178
West	Ngong Rd	(Kingara Rd-Mbagathi Way)	74	-	135	77	-	129	41	-	88	2	-	18
	BRT-3	(Kingara Rd-Mbagathi Way)	-	-	-	-	-	-	85	-	103	-	-	-
	Metro	(Kingara Rd-Mbagathi Way)	-	-	-	-	-	-	-	-	-	150	-	189
	Sub-total		74	-	135	77	-	129	126	-	191	152	-	207
North	Waiyaki Way	(Kapenguria-Meru Nairobi Hwy)	64	-	163	58	-	150	10	-	59	10	-	51
	BRT-1	(Kapenguria-Meru Nairobi Hwy)	-	-	-	-	-	-	61	-	103	49	-	88
	Sub-total		64	-	163	58	-	150	71	-	162	59	-	139

Source: Prepared by JICA Study Team

Chapter 8 Strategic Environmental Assessment

8.1 Background

The Project on Detailed Planning of Integrated Transport System and Loop Line in the Nairobi Urban Core (referred as the Project) is construed as a preparation study of the further feasibility study in order to clarify the mobility improvement policy through restructuring integrated transport system in the Nairobi Urban Core in the NIUPLAN. For that reason, the study associated with environment and social consideration for the project is considered as a supplemental study for NIUPLAN SEA, packaged as Environmental Assessment Study (referred as the EA study) to avoid confusion from the previous SEA.

With regard to the circumstances, the EA study has been carried out in line with Kenyan laws and policy relevant to environmental and social issues, especially National Guidelines for Strategic Environmental Assessment, 2012 (referred as the SEA Guideline), in order to establish harmonious consensus with other related organizations with assuring study items under the condition of category B in the JICA's Environmental and Social Consideration Guideline, April 2010 (referred as the JICA Guideline).

For the EA study, it is significant to integrate with other projects related with transport infrastructure, therefore sharing and feedback information shall be appropriately done with organizations directing other relevant projects. Additionally, it is necessary to consider that the study report will be attached to the NEMA Approval Letter for NIUPLAN SEA so that its procedure has to be followed by the SEA Guideline in Kenya through discussions with National Environmental Management Authority (referred as NEMA) about required reviews.

8.2 Methodology of the EA study (TOR)

8.2.1 Overview

Technically, analytical methodology of the EA study will be pursued by the one applied to the NIUPLAN SEA. Especially, for the stakeholder study, matrix analysis by examining relationship and weight of impact by the project will be applied and for the environmental scoping study, practical levels of impact will be studied through the multivariate analysis by allotting weight of determined criteria. Moreover, for the impact analysis, expectation and evaluation, the multi-criteria analysis using not only environmental and social aspects but also aspects of socio economic and workability of construction etc. will be applied.

For effective implementation of the EA study, utilizing same study contents of the NIUPLAN SEA to the extent possible will be encouraged to avoid redundancy. Particularly, Kenya's laws related with environment and social consideration and a part of baseline data can be utilized as directly available information and organization structures and monitoring plan can be referred as basic information. Furthermore, GIS technique can be applied for geographical analysis of the baseline data and stakeholder meetings can be simplified by selecting attendants as only representatives of relevant organizations and communities followed by the SEA Guideline in Kenya and also can be efficient by sufficient preparation time and works. Implementation flow and brief scope of works are shown on Table 8.1below.

Table 8.1 Implementation Flow and Scope of Works

Implementation Flow	Scope of Works
(a) PPP Brief Preparation ⇓ (b) Scoping Study ⇓ (c) TOR for the EA study ⇓ (d) Carrying out the EA study ⇓ (e) Stakeholder Meeting in Scoping Stage ⇓ (f) Preparation of Draft Final Report of the EA study ⇓ (g) Stakeholder Meeting in Draft Final Stage ⇓ (h) Validation Workshop (if needed) ⇓ (i) Preparation of Final Report of the EA study	(1) Establishment of Study Methodology (2) PPP Brief Preparation (3) Scoping Study ·General Outputs Expected from a Scoping Process ·EA Objective, Targets, Indicator, and Criteria ·Stakeholder Analysis (4) Establishment of TOR for the EA study (5) Carrying out the EA study ·Baseline Survey ·Situation Analysis ·Alternative or Scenario Analysis ·Identifying and Predicting Impacts and Evaluating Significance ·Identifying Mitigation Measures ·Identifying Recommended Programs or Prioritized Projects ·Establishment of Monitoring Program (6) Stakeholder Engagement ·Holding Stakeholder Meetings in Scoping Stage ·Holding Stakeholder Meetings in Policy Making Stage ·Holding Validation Workshop to Key Stakeholders (if necessary)

Source: JICA Study Team

8.2.2 Simplified Baseline Survey

Regarding the baseline survey, although necessary environmental and social data shall be collected in Nairobi City County, existing baseline data from the NIUPLAN SEA can be utilized to simplify the EA Study. Basic idea of necessary data corresponding with existing applicable data from NIUPLAN SEA will be shown in the table below. However, if availability of new references of the base line study is confirmed, the updated facts will be added to the previous study.

Table 8.2 Summary of Simplified Baseline Survey Items

Baseline Study Items	Descriptions in NIUPLAN SEA	Additional Study
Climate	Description of brief climatic elements in NCCG such as rainfall, temperature, humidity and winds in accordance with the KMD.	No
Climate change	List of Climate Change Risk from the overview of The National Climate Change Adaptation Strategy.	No
Topography, Geology and Soils	Description of topography and geology referring the Digital Elevation Model. Overview of pedorologic features referring soil samples from existing data in Dandora and Waithaka.	No
Ecosystems, flora and fauna	Description of parks, wetland, and forest coverage as well as avifauna.	No
Land use	Summary of land tenure, use and with land use map as well as land use trend between 2003 and 2012.	Updated data of land use trend shall be collected. Especially, current and ongoing industrial, commercial and housing development in Nairobi City.
Air quality	Description of results of air quality survey from EIA for Outer Ring Road Project carried out by KURA in 8 locations as well as major causes of mortality .in 1998, 1999 and 2000.	Updated data of mortality rate caused by air pollution shall be collected
Noise and vibrations	Description of results of air quality survey from EIA for Outer Ring Road Project carried out by KURA in 24 locations.	No

Baseline Study Items	Descriptions in NIUPLAN SEA	Additional Study
Water resources and waste water management	Overview of water resource condition in Nairobi with the figures and table of water resource capacity, distribution diagram, river water quality, demand and challenges. Current condition of waste water situation with the tables of facilities and challenges.	No
Solid waste	Description of solid waste management situation with management flow, facility location, and policies.	No
Energy	Overview of energy consumption condition in Nairobi with the figures and table of power generating composition, demand and blackout incidence.	Updated data about power generation and demand as well as current condition should be determined.
Population	Description of population distribution, growth, structure and trends in Nairobi referred from the KPHC.	No
Housing and informal settlements	Overview of conditions of housing and informal settlement in Nairobi with the figure of location of slum.	Updated and detailed survey shall be carried out.
Educational Service (Social and public infrastructure including quality of life)	Overview of educational condition with the tables of number of facilities and students, as well as the figure of distribution map of school in Nairobi.	No
Health Service (Social and public infrastructure including quality of life)	Overview of health condition of health service in Nairobi with the table of number of facilities as well as the figure of distribution map.	No
Cultural Service (Social and public infrastructure including quality of life)	No	Current number and location of religious facilities shall be identified through existing data collection.
Economy	Brief economic condition in Nairobi in accordance with AfDB's Economic Outlook.	Updated regional economic study shall be carried out including industrial structure. Data of current local market such as location and volume shall be organized. Trend of land value in Nairobi shall be determined.
Poverty Profile	Profiles of poverty incidence by sub county (1999).	Updated poverty profiles shall be studied.
Vulnerable Group	Description of condition of vulnerable group in Nairobi including the location of slums.	Updated condition of vulnerable group especially people in slum area shall be determined.
Urban agriculture	Brief situation of urban agriculture in Nairobi with clarification of environmental challenges.	Current conditions of urban agriculture in Nairobi including location, type and crop yields etc. shall be studied.
Transport infrastructure and modes	Overview of the items below -Road classes and function with road network map -Road lanes -Road density -Road traffic situation -Travel modes -Public Transportation in Nairobi -Non-Motorized Transport -Railway Transport -Airports -Pipelines -Transport issues in Nairobi	New survey data carried by JICA Study Team will be input to update.
Environmental and public health	Identification of environmental and public health as well as environmental hazards and disasters.	No

Baseline Study Items	Descriptions in NIUPLAN SEA	Additional Study
Environmental hazards, disasters and emergency response	This is categorized in the section, 'Environmental and Public Health'.	Baseline items shall be re-arranged as 'public health'. Updated records of disasters shall be collected.
Public spaces and Recreation Areas (Urban landscape)	Description of public parks, sports facilities and social halls in Nairobi	No
Landscape (Urban Landscape)	Description of elements of landscape such as road, open space, river as well as controversial issues such as powerlines and solid waste disposal in Nairobi.	Updated urban landscape shall be studied.
Current Environmental Planning and Management	Lists and description of current environmental planning and management.	Updated relevant environmental policy and planning as well as regulations shall be studied.
Traffic accidents	No	Volume and location as well as type of traffic accidents within a few years shall be determined through existing data of relevant authority.

Source: JICA Study Team

8.3 Condition Inventory

8.3.1 Overview of the Original Study

1) Study Objectives and Output

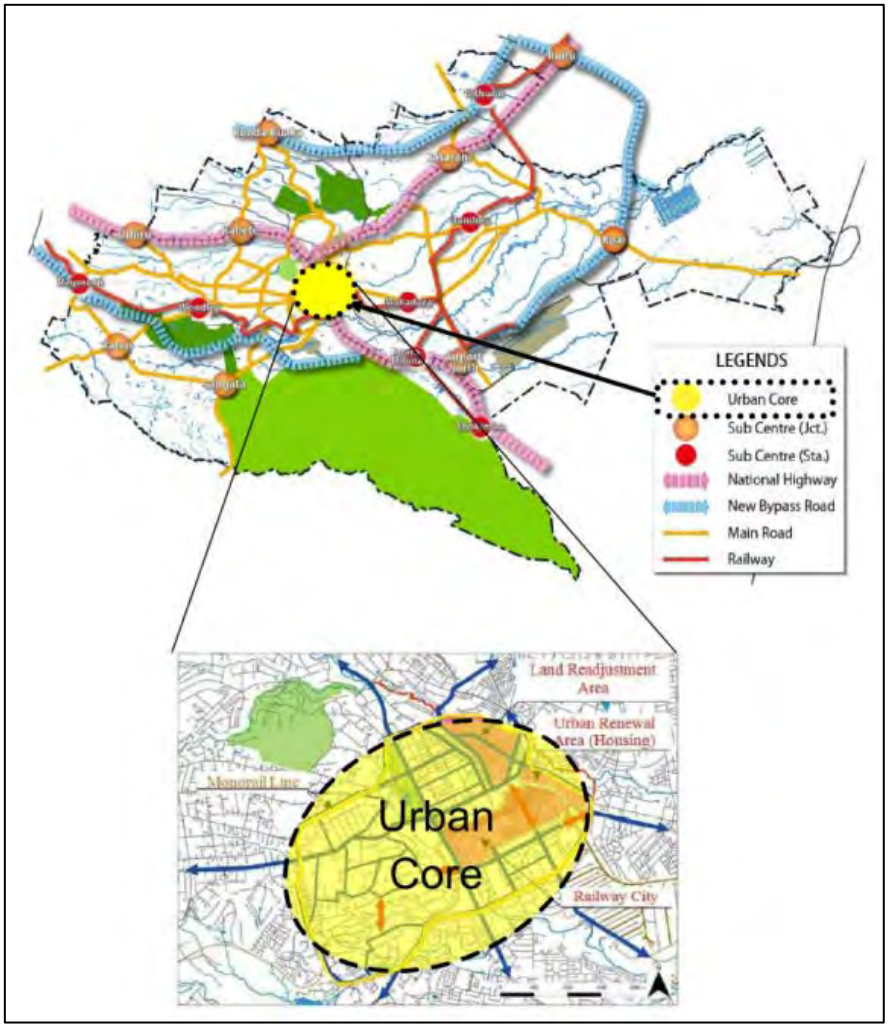
The objectives of the study for the project are as follows:

- To review the Urban Transport Policies (e.g. BRT, Road development, railway improvement projects)
- To grasp detailed traffic movement in Urban Core and
- To formulate measures for Mobility Improvement

And expected output of the study is the integrated transport policies for mobility improvement in Urban Core, Nairobi City County.

2) Study Area

The EA study should be carried out at the work sites covering the Nairobi City County and focusing on the area of Nairobi Urban Core (NUC) indicated in Figure 8.1.



Source: JICA Study Team

Figure 8.1 Location of Study Site

8.3.2 Law and Policy

Law and policy related to environmental and social consideration can be referred in the Appendix 2.

8.3.3 Institutional Structure

1) Environmental Consideration Related

a) Ministry of Environment, Water and Natural Resource: MEWNR

The mission of MEWNR is conservation, monitoring and sustainable management of the environment, water, and natural resources for development of the nation. Agencies under the Ministry include National Environment Management Authority (NEMA), Kenya Water Towers Agency (KWTA), Kenya Wildlife Service (KWS), Kenya Forest Service (KFS), and Kenya Forest Research Institute (KEFRI). MEWNR is responsible for policy formulation regarding environment and natural resources, sustainable management and conservation of natural resources, maintenance and management of information (database) required for management of natural resources and environment.

Aside from NEMA, EMCA established the following six institutions under MEWNR.

- National Environment Council (NEC)
- Technical Advisory Committee (TAC)
- Standards and Enforcement Review Committee (SERC)
- National Environment Tribunal (NET)
- Public Complaints Committee (PCC)
- National Environment Trust Fund (NETFUND)

Per the First Schedule of the EMCA, NEC consists of the Minister of MENR as its Chair, the Permanent Secretaries of 12 governmental agencies responsible for environmental matters, the representatives of public universities, specialized research institutions, the business community, and non-governmental organizations as other council members, and the Director General NEMA as its Secretary. NEC is responsible for policy formulation regarding EMCA, setting national goals and objectives for the protection of the environment, and promoting cooperation among the national government, district government, general public, and NGOs.

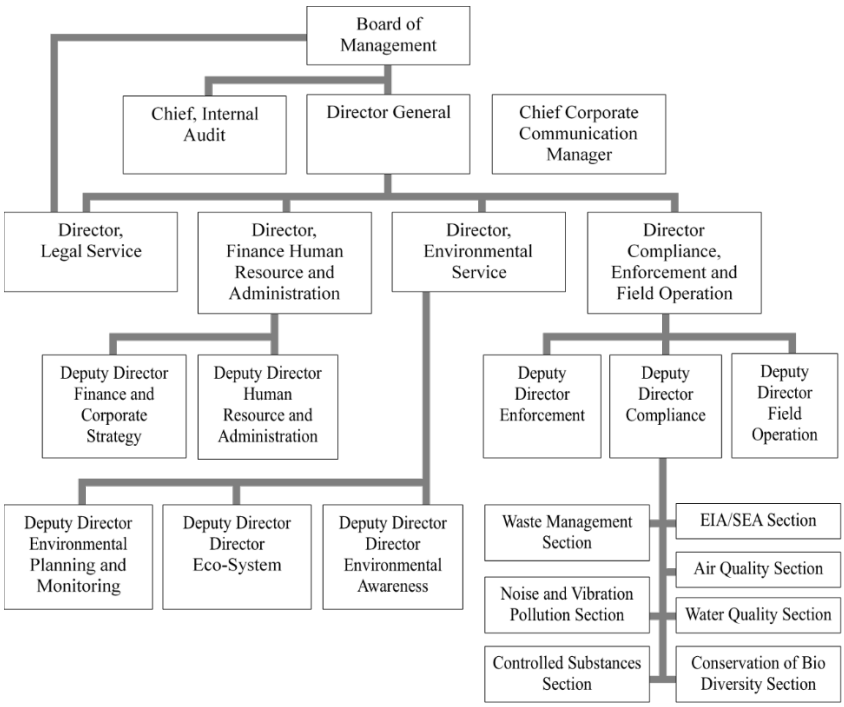
TAC and SERC carry out technical examinations of the environmental and emission standards related with air pollution, water pollution, noise and other aspects of pollution control, as well as the measurement procedures for each parameter, then provide advice and opinions to NEMA.

The principle function of NET is to determine appeals arising from decisions of the NEMA on EMCA and related rules such as issuance, denial, or revocation of licenses, and collateral conditions on licenses. Upon receiving a written appeal, NET hears and determines the case based on given evidence and oral proceedings, and provides necessary directions, orders, and decisions.

PCC provides mechanism to investigate complaints relating to environmental damage and degradation and to report periodically to NEC. NETFUND is provided to investigations, publications, capacity buildings deemed necessary for environmental management.

b) National Environment Management Authority: NEMA

NEMA, established under EMCA, is responsible for enforcing EMCA policies relating to the Environmental Impact Assessment, Strategic Environmental Assessment, and pollution control, as well as establishing required detailed regulations. As in the figure below, of four departments under the Board of Management and Director General, Director of Compliance, Enforcement and Field Operation undertake EIA/SEA audits, issuance of licenses, and pollution control. Under this department are Enforcement Division, Filed Operation Division, and Compliance Division consisting of sections, each of which deals with specific regulations. Within the current framework of local administration, NEMA established Provincial Environment Committee (PEC) in every province and district, chaired by the governor of each province/district. NEMA also established Provincial Environment Office (PEO) and District Environment Office (DEO). Each province has Provincial Director of Environment (PDE) appointed by NEMA.



Source: JICA Study Team

Figure 8.2 Organization Structure of NEMA

2) Social Consideration Related

a) Ministry of Land, Housing and Urban Development: MoLH&UD

MoLH&UD consists of Directorate of Land, Directorate of Housing, and Directorate of Urban Development, along with National Land Commission (NLC).

In Kenya, compulsory land acquisition for public purposes or in the public interest is undertaken by NLC under MoLH&UD, with the commission vested by the national and county governments (LAND ACT, 2012, Section 107). Resettlement Action Plan (RAP) with NEMA review is carried out under the supervision of Directorate of Land.

8.4 Scoping Analysis

Expected environmental and social impacts were determined as a scoping analysis in the early stage of the study. Since the policy items of the integrated transport systems are under study at this stage, this analysis will be carried out based on the programs stated on the NIUPLAN and other planned projects in NUC, including development of Bus Rapid Transport System, Railway System and Commuter Train System summarised in the previous section.

The results of scoping analysis and summary of scoping evaluation are shown in Table 8.3 and Table 8.4.

Table 8.3 Results of Scoping Analysis

Environmental Items	Description of Expected Impact
1) Air pollution	Exhaust gas from construction equipment and vehicles, and dusts caused by construction works may increase temporarily during construction period. Growth of traffic volume due to increase of flow of goods may generate more exhaust gas.
2) Water pollution	Discharge of mud, oil, etc. from the construction vehicles may cause water pollution during construction period. Development of a new transport system may create new employment opportunities and lead to population influx. Increase of inhabitants may cause sewage contamination.
3) Soil contamination	Infrastructure or facility development/rehabilitation may induce soil contamination during construction period.
4) Waste	Infrastructure or facility development/rehabilitation may generate a large volume of unmaintained wastes during construction period. Development of a new transport system may create new employment opportunities and lead to population influx. Increase of inhabitants may deteriorate solid waste management.
5) Noise and vibration	Construction noise and vibration from construction equipment and vehicles may disturb the residence and business environment during construction period. Growth of traffic volume due to increase of flow of goods may generate more noise and vibration from roads.
6) Ground subsidence	Excessive ground water use during the construction may cause ground subsidence in the city
7) Offensive odour	Some construction activities may produce offensive odour during operation.
8) Bottom sedimentation	This item is not direct relationship with transport development.
9) Protected areas	There is no protected area and national park in Nairobi Urban Core.
10) Ecosystem	There is no significant flora, fauna and biodiversity in Nairobi Urban Core.
11) Hydrological situation	This item is not direct relationship with transport development.
12)Topography and geographical features	Topographical modification may be required for development, which may affect to natural and social environment either directly or indirectly.
13) Climate Change	Growth of traffic volume may increase emission of carbon dioxide. Increase of concrete structures may surge heat island effect in the Nairobi Urban Core.
14) Involuntary resettlement	Development of a new transport system may requires a large amount of involuntary resettlements and land acquisition.
15) Local economy such as employment and livelihood, etc.	Development of a new transport system may lead to the creation of new employment opportunities, revitalization of local economy, and then improvement of people's quality of life. However, it is also probable that inequality of business opportunity and income may be induced.
16) Cultural heritage	There is no cultural heritage in Nairobi Urban Core.
17) Landscape	Three dimensional structure may negatively affect to urban landscape without any counter measures.
18) Ethnic minorities and indigenous people	There is no ethnic minority and indigenous people in Nairobi Urban Core.
19)Working condition	Well planned integrated transport system provides workers and business person effective time schedule without traffic congestion.
20) Water usage or water rights and communal rights	There are no significant and direct impacts on water usage and rights.
21) Poverty group	Living condition of the one suffering poverty may be improved by economic expansion with implementation of measures for poverty challenges.

Environmental Items	Description of Expected Impact
22) Existing social infrastructures and services	Existing social infrastructure and services such as water supply, electricity, waste disposal, education and health facilities, etc. could not be enough due to increasing inhabitants resulted from influx of population after the integrated transport system.
23) Misdistribution of benefit and damage	Without appropriate consideration and planning of the integrated transportation system for the public, misdistribution of benefit and wealth may become remarkable.
24) Local conflict of interests	This item is not direct relationship with transport development.
25) Land use and utilization of local resources	Land use modification by rearrangement of transport system may cause confusion of local resources.
26) Social institutions such as social infrastructure and local decision making institutions	Safe and easy access to social institutions may be provided through the sophisticated integrated transport system.
27) Sanitation	Increase of inhabitant influx may cause difficulty of sanitation management.
28) Hazards (risks), infectious diseases such as HIV/AIDS	Transport workers who often endure harsh working and living conditions, will be more in danger of damaging their health in general as well as at higher risk of contracting sexually transmitted infection such as HIV/AIDS.
29)Accident	The risk of accident may increase either during construction period or operation period with growth of traffic volume.

Source: JICA Study Team

Table 8.4 Summary of Scoping Evaluation

Category		Environmental Items	Stages			
			P	C	O	Z
Anti-pollution measures	1	Air quality	D	C-	D	D
	2	Water quality	D	C-	D	D
	3	Soil contamination	D	B-	D	D
	4	Waste	D	B-	D	D
	5	Noise and vibration	D	C-	C-	D
	6	Ground subsidence	D	D	D	D
	7	Odour	D	B-	D	D
	8	Bottom Sedimentation	D	C-	C-	D
Natural Environment	9	Protected areas	D	D	D	D
	10	Ecosystem	D	C-	D	D
	11	Hydrology	D	D	D	D
	12	Topography and geology	D	D	D	D
	13	Climate change	D	D	D	D
Social Environment	14	Involuntary resettlement	C-	C-	D	D
	15	Living and livelihood	C-	C-	B+	B-
	16	Cultural heritage	D	D	D	D
	17	Landscape	D	B-	D	D
	18	Ethnic minorities and indigenous peoples	D	D	D	D
	19	Working conditions	C-	B+	A+	A-
	20	Water use/rights	D	D	D	D
	21	Poverty group	C-	C+	B+	A-
	22	Existing social infrastructures and services	D	B+	B+	B-
	23	Misdistribution of benefits and damage	D	C-	C-	D
	24	Local confliction of interests	C-	C-	C-	D
	25	Land use and unification of local resources	C-	D	D	D
	26	Social institutions and local decision making institutions	D	D	A+	A-
	27	Sanitation	D	C-	D	B-
	28	Infectious diseases, HIV/AIDS	D	B-	B-	D
Other	29	Accidents prevention measure	D	B-	C-	A-

Notes: P: Planning stage, C: Construction stage, O: Operation stage, Z: Zero option

A+/-: Significant positive/negative impact is expected. B+/-: Some positive/negative impact is expected.

C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the study progresses.), D: No impact is expected.

Source: JICA Study Team

8.5 Environmental Assessment Study

8.5.1 Key Baseline Survey

Key baseline environmental and social information relevant to development of transport sector in Nairobi City County is collected from the existing reports including NIUPLAN SEA.

8.5.1.1 Climate

Although Nairobi is situated close to the equator, its altitude of about 1700 metres results in a modified climate as opposed to a tropical climate. The differences between the seasons are minimal and are generally described as the "wet" season and "dry" season and can be categorized as follows:

- Mid-December to Mid-March: Warm, sunny, dry.
- Mid- March to May: Main rain season.
- June to Mid-October: Cool, rather cloudy (especially July-August), dry.
- Mid-October to Mid-December: Secondary rain seasons.

According to the Kenya Meteorological Department the following is the description of specific weather elements in the County.

1) Rainfall

a) Annual rainfall

The Nairobi area enjoys one of the most reliable and best kept rainfall records in East Africa. Rainfall for the Nairobi Area has been described based on 5 stations with between 4 to 8 decades of data as shown in Table 8.34 below. Annual rainfall ranges from 762 mm at Nairobi JKIA and rises to over 900mm as one approaches the eastern slopes of the Rift Valley. The highest rainfall averaging 1049mm per annum is recorded at the Nairobi Observatory at Dagoretti Corner, in what is clearly an effect of its location on the lower eastern elevation of the Ngong Hills. The average annual rainfall in Nairobi is about 934.4 mm, but the actual amount in any one year may vary from less than 500 mm to more than 1500 mm.

Table 8.5 Mean annual rainfall for climatic station within Nairobi

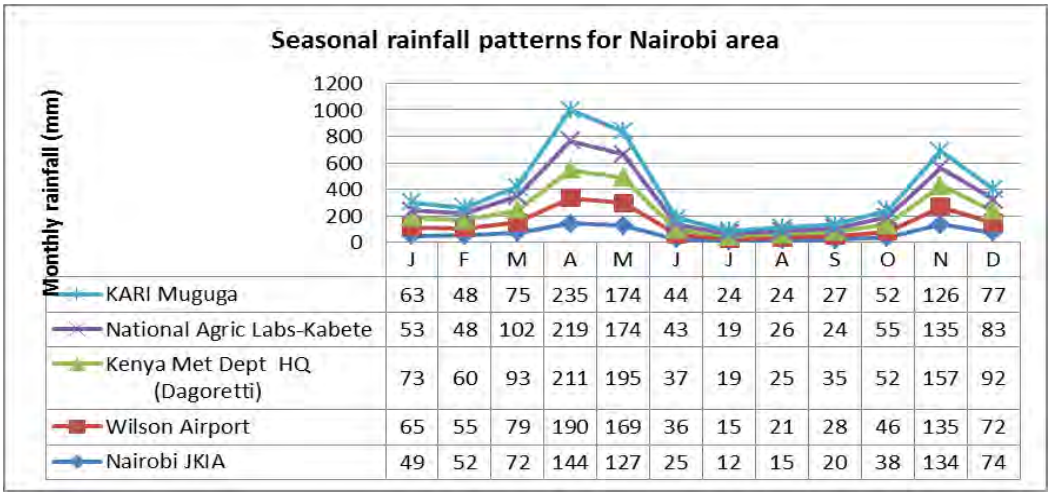
Station	KMD Reference	Length of record	Altitude (m asl)	Annual mean (mm)
Nairobi JKIA	9136168	Since 1958	1624	762
Nairobi Wilson Airport	91361430	Since 1961	1683	911
Nairobi Observatory at KMD HQ	91136164	Since 1955	1798	1049
National Agric Laboratories-Kabete	9136025	Since 1921	1737	981
KARI Muguga	9136121	Since 1953	2096	969
Rainfall for the Nairobi area				**934.4**

Source: JKIA Metrological Station

b) Seasonal rainfall

Figure 8.3 below provides data and charts for a seasonal rainfall distribution in Nairobi. The meso-g scale synoptic climatology of rainfall over Nairobi-area is tied in with the overall climate over Kenya, which is determined by the migratory trend of the inter-tropical convergence zone (ITCZ). The climatology consists of four seasons: The warm-dry season from January to February (JF), the "long rains" season between March and May (MAM) with a peak in April, the cool dry season spanning from July to September (JJAS) with a

peak in July, and the "short rains" season from October to December (OND) with a peak in November. The bulk of rainfall in Nairobi is therefore delivered within only three months, the wettest of which is April accounting for 22% of annual rainfall. April rainfall is also highly predictable with a clear direct relationship with altitude. The long rains season is most esteemed in agronomic terms as it promises better rainfall content and reliable onset dates compared to the short rains which are quite variable in terms of onset dates and rainfall content. Both wet seasons are separated by dry spells of which, the one lasting June to October is the main one.



	J	F	M	A	M	J	J	A	S	O	N	D
KARI Muguga	63	48	75	235	174	44	24	24	27	52	126	77
National Agric Labs-Kabete	53	48	102	219	174	43	19	26	24	55	135	83
Kenya Met Dept HQ (Dagoretti)	73	60	93	211	195	37	19	25	35	52	157	92
Wilson Airport	65	55	79	190	169	36	15	21	28	46	135	72
Nairobi JKIA	49	52	72	144	127	25	12	15	20	38	134	74

Source: JKIA Metrological Station

Figure 8.3 Seasonal Rainfall Patterns for Nairobi Area

c) Diurnal distribution

Daily rainfall is normally concentrated between late afternoon and early evening (JICA, 1994) with minimal rainfall occurring in the period between 8.00 am and 10.00 am. The late afternoon, early evening rainfall phenomenon is possibly a reflection of convective instability associated with intense isolation in the early morning and afternoon, resulting in intense rainfall in early evening late night period. The tendency for higher daily rainfall to be concentrated in the wet seasons especially in April when the ground is already saturated with moisture (Decurtins, 1992) has important implications for watershed management in areas targeted for development of bituminous road network which characteristically converts all rainfall into runoff which then has to be evacuated to natural water courses.

d) Climatic potential

Table 8.6 and Figure 8.4 present an analysis of the climatic potential of Nairobi rainfall. Annual rainfall averages 934.4 mm and is delivered in 2 distinct wet seasons lasting from March to April and November to December with the 1st season accounting for 47.6% of the annual rainfall. June to September marks a severe dry season with mean monthly rainfall generally below 10 mm. Climatic potential in Kenya is normally defined by the balance between rainfall and potential evaporation following the method of Sombroek et. al, 1982. 1 With a mean annual rainfall of 934.4mm and an equivalent potential evapotranspiration of 1721 mm, the Nairobi area has a climatic index (r/Eo ratio) of 0.54

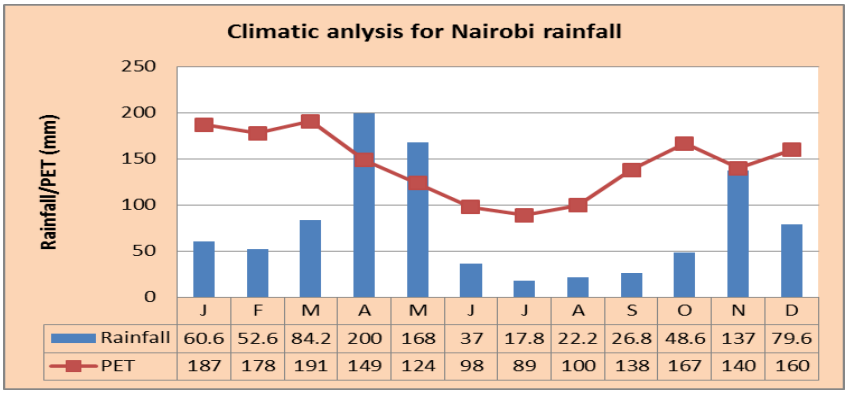
1

which translates to a semi-humid climate (Climatic Zone III) which is fairly hot. Monthly rainfall exceeds potential evapotranspiration demand only in April, May and November subsequent to which, a moisture deficit prevails during the rest of year.

Table 8.6 Analysis of the climatic potential of rainfall for the Nairobi area

Station	J	F	M	A	M	J	J	A	S	O	N	D	Annual mean
Rainfall	60.6	52.6	84.2	199.8	167.8	37	17.8	22.2	26.8	48.6	137.4	79.6	934.4
PET	187	178	191	149	124	98	89	100	138	167	140	160	1721
r/Eo Ratio	0.39	0.34	0.49	1.42	1.57	0.38	0.21	0.25	0.25	0.31	1.12	0.58	0.54
Climatic designation	Semiarid to semi-humid			Per humid		Semi-arid					Semi-humid to per-humid		Semi-humid

Source: JICA Study Team

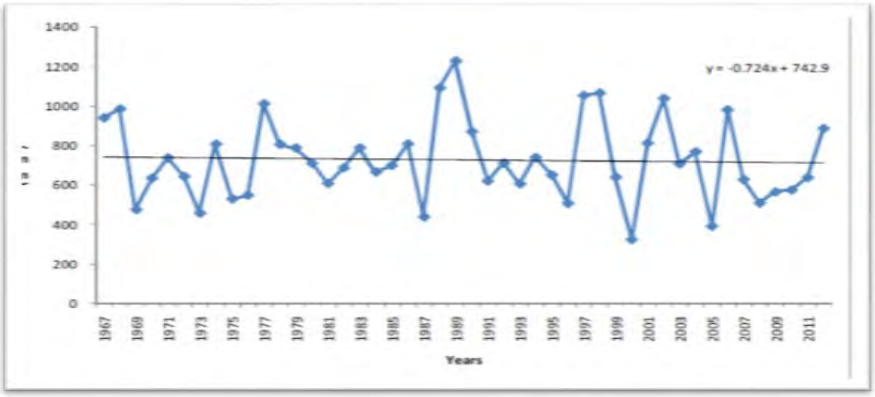


Source: JICA Study Team

Figure 8.4 Seasonal moisture balance for Nairobi Area

e) Long term rainfall patterns

Figure 8.5 shows the trend of annual rainfall amount over Nairobi (JKIA) area between 1967 and 2011. The graph shows that rainfall amount does not display any significant deviation from the long-term mean.



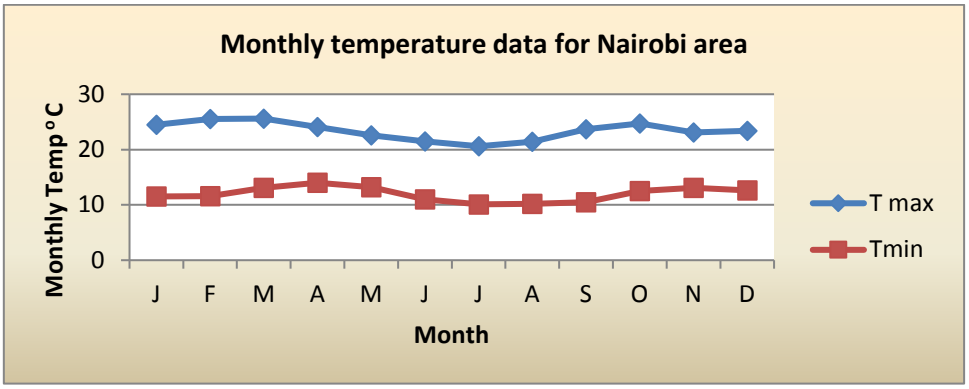
Source: JKIA Metrological Station

Figure 8.5 Long term rainfall trends in Nairobi (1961 - 2011)

2) Temperature

The county's mean annual temperature stands at 24°C. The warmest months are from January to April, where temperatures can hit 30°C and relative humidity can fall to below 10%. The coolest months are between June and August before it starts to warm up again in October.

Nairobi area remains generally hot throughout the year with a mean temperatures averaging 17.7° Centigrade with a range of 10.1 to 25.6° C. Temperatures are generally highest in February and March and lowest in July (Figure 8.6). Over the past 25 years the highest and lowest temperatures ever recorded by the meteorological department are 32.8°C and 3.9°C.

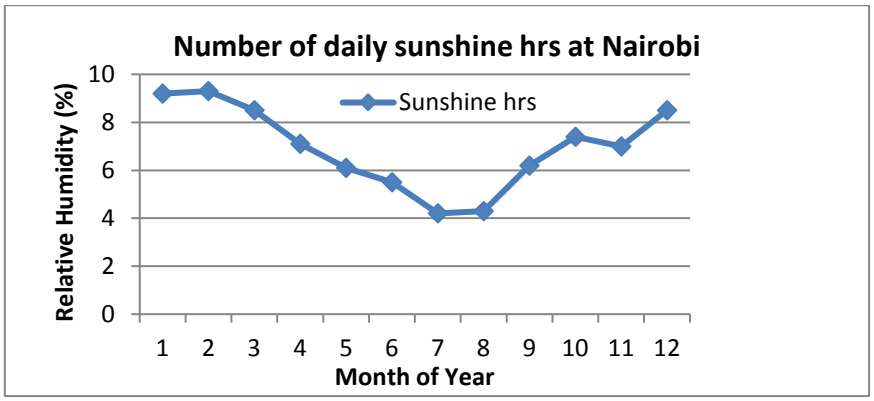


Source: JKIA Metrological Station

Figure 8.6 Seasonal variation of daily temperature in Nairobi

3) Sunshine hours

Figure 8.7 traces seasonal movement in insolation. Daily sunshine in Nairobi ranges from a low of 4.2 hrs to a high of 9.3 with an average of 6.9. The period December to February has the highest stretch of sunshine hours with July and August recording the lowest.

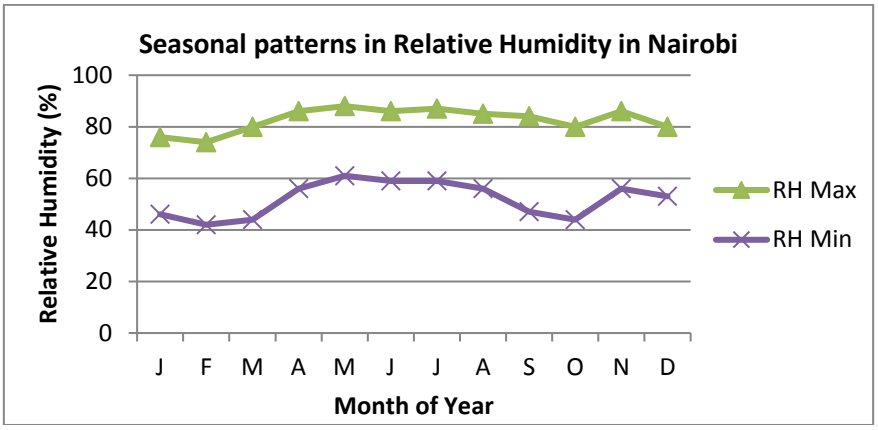


Source: JKIA Metrological Station

Figure 8.7 Seasonal variation of daily sunshine hours in Nairobi

4) Humidity

Figure 8.8 traces the seasonal movement of relative humidity in the Nairobi area. Nairobi is generally humid with a long-term average of 66% and a range of 42 to 88%. Relative humidity is lowest in December to March coinciding with the dry season and is highest between April and August.



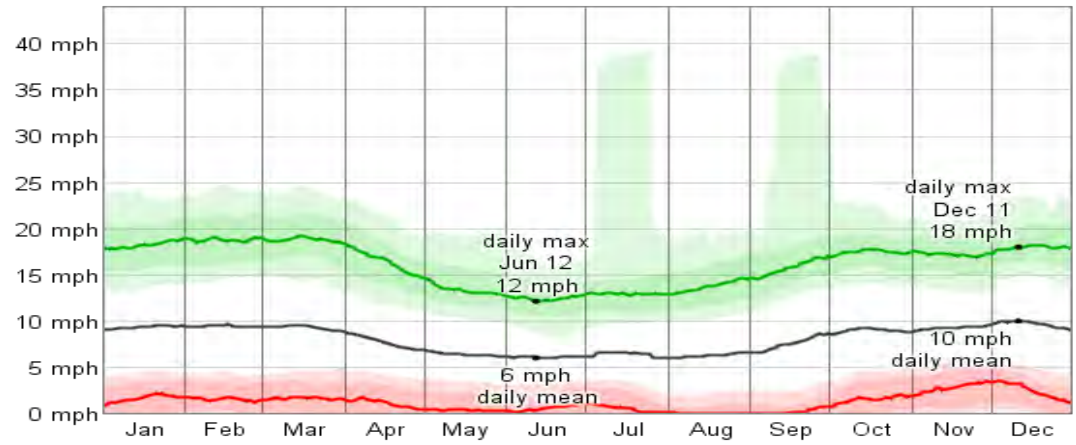
Source: JKIA Metrological Station

Figure 8.8 Seasonal variation of relative humidity in Nairobi

5) Winds

a) Average wind speed and direction

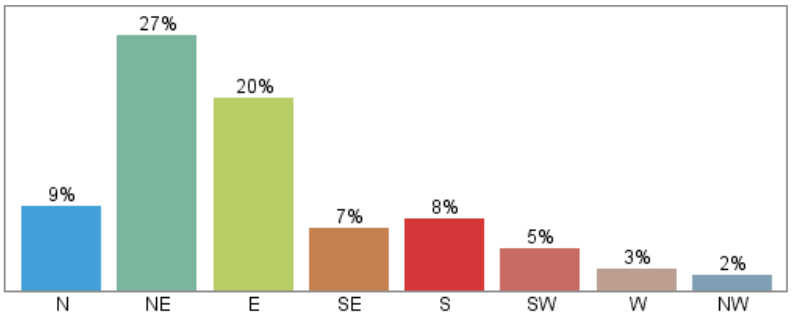
Long-term wind data for Nairobi (Figure 8.9, Figure 8.10 and (a & b) shows that mean wind speed is about 10 mph but with a range from 6 to 18mph. Wind-speeds in the Nairobi area is highest in March, November and December mainly associated with the South-easterly monsoon winds whose direction is predominantly from the south. The highest average wind speed of 10 mph (gentle breeze) occurs around December 11, at which time the average daily maximum wind speed is 18 mph (fresh breeze). The lowest average wind speed of 6 mph (light breeze) occurs around June 12, at which time the average daily maximum wind speed is 12 mph (moderate breeze).



Source: JKIA Metrological Station

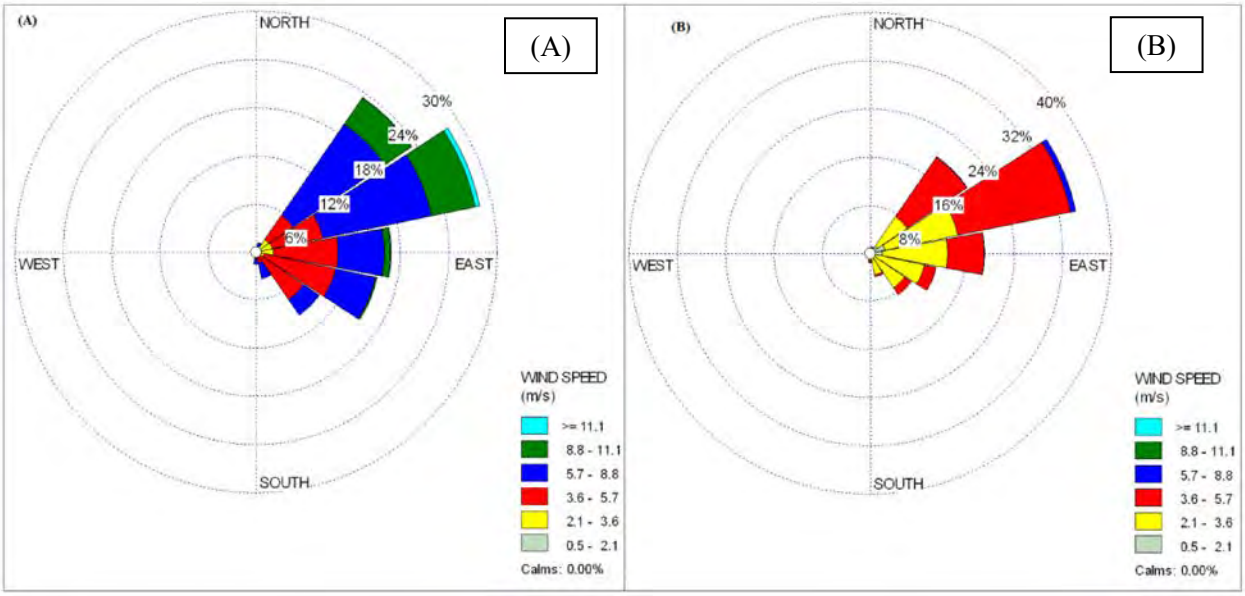
Figure 8.9 Long term average wind speed for Nairobi area

Long term wind speed and direction: The wind near the ground is very predominantly easterly throughout the year, generally between north-east and east from October to April, and between east and south-east from May to September. The strongest winds occur during the dry season just prior to the "Long Rains" when speeds of 20 to 25 meters per hour (m.p.h) are not uncommon from mid-morning to early afternoon. At other times of the year winds speeds reduce to 10 - 15 m.p.h. During the night the wind is usually light. In the squalls sometimes associated with thunderstorms, short-lived winds of up to 70 M.P.H. have been known to occur. It also can be noted that there is no change of wind direction within a decade, however wind speed has been weaker than a decade ago.



Source: ESIA Study for Ngong Road Phase II

Figure 8.10 Long term data on wind speed and direction in Nairobi area



Source: 'Investigation of the possible influence of Urbanization on Rainfall Variability over Nairobi City, Kenya'

Figure 8.11 Wind speed and direction in Nairobi area

8.5.1.2 Climate Change

1) Introduction

Climate variability refers to time scales ranging from months to decades, falling between the extremes of daily weather and the long-term trends associated with climate change. Climate variability thus refers to fluctuations of the climate about the 'mean average conditions', with some periods experiencing 'normal' climatic conditions, others experiencing below 'normal' conditions and still others experiencing above 'normal' conditions.

Climate Change is what we experience when the climatic conditions permanently shift either upwards or downwards of the average. Shifts in the start or end of the rainfall season, the length of the season, the number of rainy days, the number, length and intensity of dry spells, or changes in the total seasonal rainfall, among others, can also signify climate change.

Climate change is hence not always a shift in the mean climatic conditions, but can also exhibit itself as a change in the intensity and frequency of extreme climate events, such as drought, floods, storms, and strong winds, among others.

2) Climate change and the Aberdare Water Tower

The Aberdare Range is located in central Kenya, on the eastern edge of the Rift Valley. The forest belt of the Aberdare Range comprises a number of forest reserves, including Aberdare, Kikuyu Escarpment, Kijabe Hill, Kipipiri and Nyamweru, as well as some forest areas in the Aberdare National Park. The forests cover over 250,000 ha. These forests form part of the upper catchments of Tana River, Kenya's largest river, as well as Athi, Ewaso Nyiro (North) and Malewa rivers. They are also the main catchments for the Sasumua and Ndakaini dams, which provide most of the drinking water to Nairobi.

The forests are characterized by a high diversity of vegetation types, because of the wide altitudinal range (from 1,800 to 3,600 metres) and the climatic differences between the slopes.

In 2005, a total of 253,375.3 hectares of these forests were protected, of which 102,161.4 hectares was under the Aberdare's National Park. However, significant deforestation has occurred in the water tower in recent decades due to rising populations, conversion to agriculture, forest fires and illegal tree felling for fuel use and timber. The result has been "increased runoff, flash flooding, reduced infiltration, soil erosion, and siltation in the dams and other water reservoirs" (GoK, 2008).

Between 2005 and 2010, forest cover in the area increased by 20.6% in part due to establishment of the fenced in Aberdare Conservation Area (GoK, 2013).

The Government of Kenya is working on rehabilitation and protection of the Country's water towers. The project also aims at supporting the achievement of the target set in Kenya Vision 2030 of increasing forest cover in Kenya to 4% by 2012 (from less than 3 percent) and to 10 percent by 2030. One of the expected outcomes of this objective is to increase the volume of water flowing from these catchments.

To-date, the following progress has been made:

- ✓ Forest quality assessment for Aberdares Ranges has been completed.
- ✓ A climate risk assessment of the water towers and the related vulnerability reduction options;
- ✓ Determination of the estimated costs for the proposed interventions;

The government has also established the Water Towers Conservation Fund and a Kenya Water Towers Agency (Kenya Central, 2012). Current forest management policy promotes adopting an ecosystem based approach to forest management and the provision of incentives for sustainable use and management.

3) Climate Change Risks

The National Climate Change adaptation Strategy outlines the climate change risks facing Kenya's water towers. The climate change risks and proposed management strategies of relevance to NIUPLAN and the related impacts can be summarised as follows:

Table 8.7 Summary of Climate Change Risks

Key Climate Risk	Potential Direct Impact	Intervention Description
More frequent drought	Drying of the forest, leading to greater risk of fire	Increase availability of locally appropriate fire fighting capacity, equipment and practices: such as watch towers, rapid response units and fire-breaks
		Public education around forest fire prevention and response
		Improved training in fire prevention, early warning and fighting for KFS and forestry services
		Strengthen fire early warning planning and response systems
		Integrate climate change risks into fire management policies
Decrease in mean annual precipitation in highlands	Decline in the productivity of deciduous and semi-deciduous closed canopy forests	Re-forest with indigenous water efficient species
More frequent drought		Strengthen capacity of forest service to engage in sustainable forest management
		Integrate climate risk management into forest management planning
		Strengthen institutional capacity to engage in Payments for Ecosystem Services

Source: NIUPLAN

8.5.1.3 Topography and Geology

1) Topography

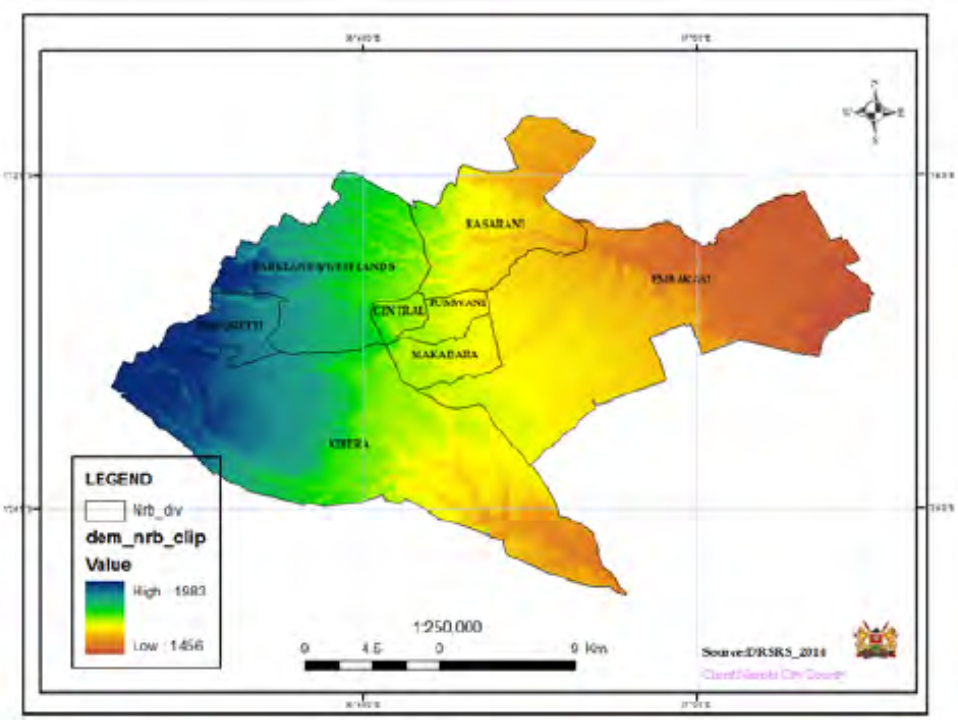
Nairobi lies at an average altitude of 1650 m asl (range 1500-1800 m). The city lies at the edge of the Athi Kapiti plain and the lower slopes of the Kikuyu and Aberdare escarpment. Land elevation increases from east to west.

The geology of the Nairobi area is dominated by volcanic rocks derived from volcanic activity associated with the formation of the Rift Valley. These are a thick succession of alkaline lavas and associated tuffs, the oldest of which is the Kapiti phonolite which lies directly on rocks of the Basement Complex, the oldest rocks in the East Africa region. The lavas thin out in an easterly direction.

The area is underlain by the Nairobi Trachyte that is separated from the Nairobi Phonolite by a narrow agglomeratic tuff. The Nairobi Phonolite is itself underlain by the Athi Series. The Athi Series is a sequence of sediments of volcanic origin deposited in a lacustrine environment the upper portion of which (the Upper Athi Series) form the most significant source of groundwater in the Nairobi area as a whole. The Athi Series lie atop the Kapiti Phonolite.

The main geologic formations in Nairobi area are, undifferentiated Ngong volcanic material (Tva3), Tva1 (Basanites), Tva2 (Tephrites), Tvp2 (Kandizi phenolites), Tvt2) Nairobi Trachytes), which covers most of the Karen area; Tvtf2 (middle and upper Kerichwa valley tuffs) which cover Wilson Airport area, Tvp3 (Nairobi phonolites – oflower Trachyte Division) which cover most of eastern parts of Nairobi, including Jomo Kenyatta International Airport (JKIA). The CBD and the rest of the city is covered in various form of Trachytes, (Saggerson, 1991).

As Nairobi is located close to the edges of the Rift Valley, it sometimes experiences tremors and minor earthquakes.



Source: NIUPLAN

Figure 8.12 Topography Map of Nairobi City County

2) Soils

The soils of the Nairobi area are products of weathering of mainly volcanic rocks. Weathering has produced red soils that reach more than 50 feet (15m) in thickness (Saggerson, 1991). A number of subdivisions are however recognized in the area according to drainage, climatic regions and slopes, and other soil categories include lithosols and regosols.

From available literature, there are cases of soil pollution in Nairobi mainly attributed to emissions from vehicles as well as improper management of industrial and domestic wastes. For instance, in various sources quoted in the Nairobi environmental outlook, analysis of lead concentrations in Nairobi revealed soil lead levels up to 265 g/kg in the city centre, and 44 g/kg in the residential areas (UNEP 2004). The World Health Organization (WHO) guidelines for lead levels in soil are in the range of 0.1– 0.12 g/kg. Up to 5 mg/kg of lead was also measured in kales, a common vegetable consumed in the county, exceeding the 0.3 mg/kg WHO limit nineteen-fold (UNEP 2004). Levels of lead in other food stuffs and water are all high. For instance, lead levels in maize have been found to be 20 times higher, water twice as high and milk 2.5 times higher than the WHO recommended levels (Mebratu, 2004).

A pilot study conducted in 2007 comparing elemental concentration in soils within and around Dandora dumping site and Waithaka, a peri-urban area in the outskirts of Nairobi established that soils adjacent and within the dumpsite had higher levels of heavy metals emanating from the site in particular lead, mercury, cadmium, copper and chromium (UNEP, 2007).The concentration levels of these heavy metals were higher that internationally acceptable limits as shown in Table 8.8.

Table 8.8 Soil Measurement Results and Sample Regulation

Elements	Mean elemental conc. Of soil samples adjacent to the dumpsite(ppm)	Mean elemental conc. of the soil samples within the dumpsite(ppm)	Mean elemental conc. Of Waithaka Soil samples (ppm)	Reference Values in Neths. Soil Standards	Reference Values in Taiwan Soil Standards
K	20758	19100	7835	-	-
Ca	14558	77000	4300	-	-
Ti	5433	6100	5650	-	-
Cr	157	689	118	100*/250**	100[a]/400[b]
Mn	4366	3500	2400	-	-
Fe	45800	84800	57100	-	-
Cu	105	507	BDL	50*/100**	120[a]/200[b]
Zn	462	2100	133	200*/500*	35[a]/500[b]
Hg	18.6	46.7	BDL	0.5*/2**	0.29[a]/2[b]
Pb	264	13500	34.5	50*/150**	50[a]/500[b]
Cd	40	1058	-	1*/5**	2[a]/5[b]

BDL: Below Detection Limit
*: Tentative soil quality standards for the (Neths.) Netherlands
**: Reference value for good soil quality
a: Taiwan's standard values to assess soil quality
b: The upper limit of the background concentration

Source: NIUPLAN

In addition to pollution, soils in Nairobi are subjected to loss of top layers which are mostly excavated to pave way for various infrastructural developments while new imports of soil is also common for landscaping. Deeper excavations are currently on the increase to lay foundation for the increasing number of high-rise buildings and accommodate underground parking lots. Further, there are numerous underground petroleum tanks installed in the city that can cause pollution from leakages.

8.5.1.4 Flora and Fauna

Nairobi has both terrestrial and aquatic ecosystems with various sub-types including forests, grasslands, wetlands and fresh water dams/ponds and rivers. These form important habitats for diverse wildlife and additionally play crucial social and economic functions within the city.

1) Nairobi National Park

Nairobi National Park (NNP) is unique, being the only game park in the world that lies within city boundaries. NNP has an area of 117km^2 and forms an open ecosystem, with its unfenced southern side allowing seasonal migration of wild animals. The Park is managed by Kenya Wildlife Service (KWS) and conserves samples of two major ecosystems; Highland dry forest & savannah. It has varied habitats including open, rolling grass plains, riverine woodland, man-made dams and ponds, rocky gorges and upland dry forest.

The park's predominant environment is open grass plain with scattered Acacia bushes. The western uplands of the park have highland dry forest with stands of *Olea africana, Croton dichogamus, Brachylaena hutchinsii*, and *Calodendrum*. The lower slopes of these areas are savanna grassland. *Themeda, Cypress, Digitaria,* and *Cynodon* species are found in these grassland areas. There are also scattered yellow-barked *Acacia xanthophloea.*

A riverine forest is found along the permanent river in the south of the park. There are areas of broken bush and deep rocky valleys and gorges within the park. The species in the valleys are predominantly *Acacia* and *Euphorbia candelabrum*. Other tree species include *Apodytes dimidiata, Canthium schimperiana, Elaeodendron buchananii, Ficus eriocarpa, Aspilia mossambicensis, Rhus natalensis,* and *Newtonia* species. Several plants that grow on the rocky hillsides are unique to the Nairobi area. These species include *Euphorbia brevitorta, Drimia calcarata*, and *Murdannia clarkeana*.

The park is inhabited by various wildlife ranging from different mammals to over 400 species

of birds. It is an Important Bird Area (IBA) and dry season refuge for a large population of plain game particularly wildebeest, plains zebra and eland. It is also the country's largest black rhino sanctuary and supplies rhinos to other rhino projects in the country. Other features connected to the park include: The Nairobi Safari Walk; Animal Orphanage; and Ivory Burning Site Monument.

The national park is however, regarded as an endangered ecosystem by KWS. Current pressures include:

- Rapid urbanization and urban sprawl e.g. growth of residential estates on the NNP dispersal areas in Athi Kapiti plains. This has increasingly reduced the size of dispersal area;
- Human – Wildlife conflicts: Poaching for commercial purposes; lions kill domestic animals and Herders kill lions to protect livestock
- Air and water pollution for vehicles and Industries; and
- Possible disturbance of current ecosystem in the NNP triggered by the proposed development plan of extended standard gauge railway passing through the NNP

Additionally, it is one of the wildlife areas that have been adversely affected by invasive alien species in the country. The most common invasive alien plants that pose the biggest threats to biodiversity conservation in Kenya include the Mathenge (*Prosopis juliflora*), *Lantana camara*, *Parthenium*, *Cactus* species, *Chromolaena* and the Water hyacinth. Threats posed by Invasive Alien Species (IAS) in Kenya's protected areas are expected to be managed following the launch of a national strategy and action plan 2013-2018 for the management of invasive species. The action plan was developed by KWS in collaboration with other government agencies and line ministries along with other conservation stakeholders.

2) Forests

Forests are land areas with tree more than 0.1 ha, crown cover of at least 30% and trees have a height of more than 2 m. Kenya currently has 3.456 million ha of forest cover constituting 5.9% of total land cover (KFS, 2009), having improved from less than 2% in 2002 (NEMA, 2009). Internationally, this makes Kenya a low forest cover country as it has less than 10% of its total land area classified as forest. Few forested areas are found within the City County of Nairobi. These are mainly gazetted and protected forests and include Karura, Ngong Road Forest Reserve and Nairobi Arboretum as discussed below.

a) Karura forest

Karura Forest Reserve is located in the northern part of Nairobi city. At 1,041 hectares, it is one of the largest urban gazetted forests in the world. The forest contains nearly all the 605 species of wildlife found in Nairobi. It is managed by Kenya Forest Service (KFS). Both plantation and indigenous trees are found within the forest. Plantations cover 632 hectares and the species include Araucaria *cunninghamii, Eucalyptus saligna, E. globula, Grevillea robusta, Cupressus torulosa* and *C. lusitanica*. Indigenous trees cover 260 hectares and the species include *Olea europeae subsp. auspidata*, *Croton megalocarpus, Warburgia ugandensis* (Muthiga), Silver Oak *Brachylea nahuillensis* (Muhugu), *Uvaridendrona nisatum*, *Markhamia lutea, Vepris nobilis, Juniperus procera* (Cedar), *Craebean brownii, Newtonia buchananii, Salvadora persica, Ficus thonningii, Trichilia emetica, Calondendrum capense* and *Dombeya goetzenii.*

Shrubs in the forest Include *Strychnoshen ningsii* (Muteta), *Erythrococca bongensis* (Muharangware), *Vangueria madagascariensis* (Mubiro), *Rhamnusprinoides* (Mukarakinga), *Caesalpiniavolkensii* (Mubuthi), *Elaeodendronbuchananii* (Mutanga) and *Rhusnatalensis*

(Muthigio).

Other plants are: groves of *Arudinaria alpina*, Kenya's native bamboo species along the riparian belts of Gitathuro and Ruaka Rivers; exotic giant bamboo *Dendrocalamus giganteus* along Karura River; and small wetlands that are important habitats for birds (KFS, 2014). The forest is also the water catchment for four major tributaries of the Nairobi River namely, the Thigiri, Karura, Rui-Ruaka and Gitathuru (Getathuru) rivers. In addition to ecological functions, the forest attracts tourists in nature trails.

Table 8.9 Karura forest is habitat to various wild animals.

Type	Species
Mammals	Harvey's Duiker, Grimm's Duiker, Bushbucks, Bush pigs, Genet Cats, Civets, Bush babies, Porcupines, Syke's Monkeys, Ground Squirrel, Hares and the Epauletted-bat.
Reptiles	Pythons, green snakes and monitor lizards
Birds	Around 200 species of birds including Ayres Hawk-eagle, the African Crowned Eagle, the Silvery-cheeked Hornbill, the Hartlaub'sTuraco, the Narina Trogon, Owls, Crested Cranes, Sparrows, Doves, Weavers and Vultures. Hartlaub'sTuraco, Tauraco hartlaubi is endemic to East Africa.
Butterflies	African Queen and Desmond's Green Banded Swallowtail

Source: NIUPLAN

The forest faced threats of excision for urban residential developments especially in the 1980s and 1990s. However, it has remained stable since the enactment of Forest Act in 2005 which made it difficult to excise forest land. The Nairobi Northern Bypass road passed through a wetland which is believed to feed Karura Forest, thus posing some threat to the forest.

b) Ngong Road Forest Reserve and Ngong Forest Sanctuary

Ngong Road Forest is located 6 km to the south of Nairobi's CBD and covers 1224.4 ha (KFS, 2014). The forest management approach is unique in that almost half (538 hectares) of the forest is managed by a charitable private trust named the Ngong Road Forest Trust through a memorandum of agreement between the Trust, KWS and Kenya Forest Service (KFS). The forest is densely inhabited by natural and agro forest trees composed of *Eucalyptus plantations, Croton, Cyprus, Grevillea*, Bamboo as well as shrubs of *Lantana camara* amongst others (UNEP, 2001).

Ngong road forest sanctuary, located within the larger Ngong Road Forest Reserve, comprises 538 hectares of forest, 80% indigenous forest and the rest exotic *Eucalyptus* plantations. It is rich in biodiversity as compared to other nearby forests and is home to over 120 bird species, over 35 mammals and numerous insects, reptiles, amphibians and fish.

c) Nairobi Arboretum

Nairobi Arboretum was established in 1907 and gazetted as a national reserve in 1932. The Arboretum occupies 30.4 hectares and holds over 350 tree species; it is home to over 100 species of resident and migrant birds, a multitude of insects, reptiles and small mammals, notably the playful Vervet and Sykes monkeys. The arboretum is a popular picnic spot for residents and is also known as a ground for social events such as music concerts and weddings.

d) Ololua Forest Reserve

The Ololua Forest reserve is located in the Karen suburb at a distance of 20km from the City Centre. The reserve covers 250 acres of indigenous trees and is home to the Institute of Primate Research under the National Museums of Kenya (NMK).It is managed by KFS under Kajiado Conservancy.

Other features in the forest include:

- The Mbagathi River course with swamps in some sections;
- Underground caverns reputed to have once been home to Mau Mau freedom fighters;
- Picnic and camp sites; and
- Nature trail for hikes by the public.

In addition to forests, substantial woody species among other landscaping vegetation covers are found planted by individuals on their residential plots, mainly in the high income neighbourhoods, as well as roadside trees planted by the NCCG. Apart from their ecological and water catchment functions, these urban forests play a crucial environmental role in carbon sequestration within an area characterised by relatively higher emission levels than other parts of the country.

Although most of the current forest covers have been protected, much of the natural vegetation surrounding Nairobi has been lost as the city's boundaries were extended numerous times to accommodate the growing population and the associated need for more land. Current threats to forests within the city include:

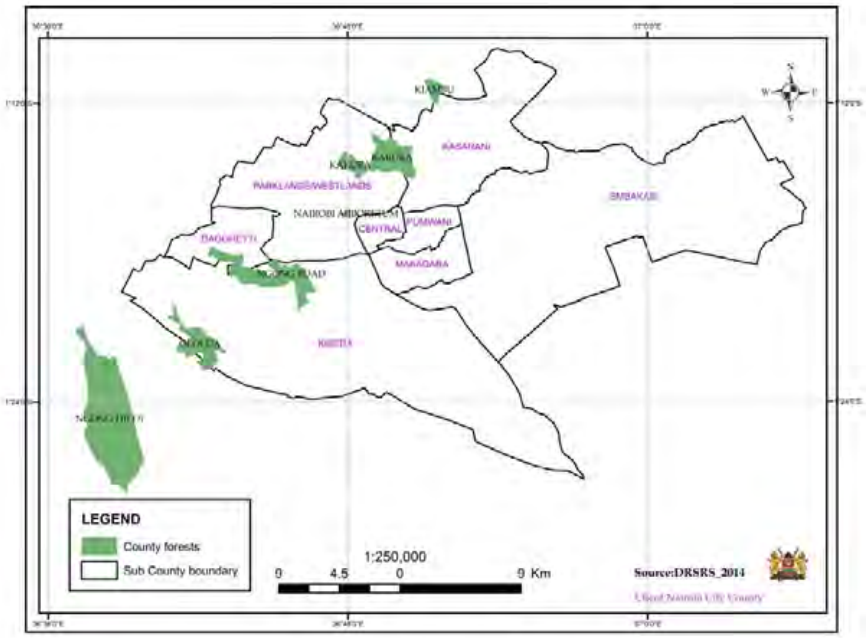
- Degradation and destruction from illegal harvesting activities;
- Loss of thousands of trees, especially the endangered Silver Oak species that happen to fall in the roads way to infrastructure developments e.g. in the southern by-pass construction. (See example in Figure 8.13, Figure 8.14);
- Insecurity within the forests, associated with theft and carjacking; and
- Forest ecosystem fragmentation.

Being a low forest cover country, the national vision is to attain 10% forest cover by 2030. A national forest policy was adopted in 2007 as Seasonal paper No. 1 of 2007. The forest policy requires that all existing indigenous forest reserves on public lands remain reserved and that forests in urban areas be sustainable managed to satisfy local forest-based needs, conserve biological diversity and be promoted for aesthetic and recreational values (GoK, 2007). As regards roadside tree planting, the forest policy requires responsible authorities in collaboration with landowners adjoining the road reserves to establish an amenity belt of appropriate tree species on both sides of the road reserves.

From the foregoing, it is important that the existing forests within the city county boundaries are accorded continuous conservation. An initiative to conserve the forests by working together with the neighbouring communities as indicated in the Forest Act 2005 has been successful especially with Karura forest.

Source: NIUPLAN

Figure 8.13 Loss of Part of Ngong Road Forest to Southern Bypass



Source: NIUPLAN

Figure 8.14 Protected/Gazette Forests in Nairobi

3) Wetlands

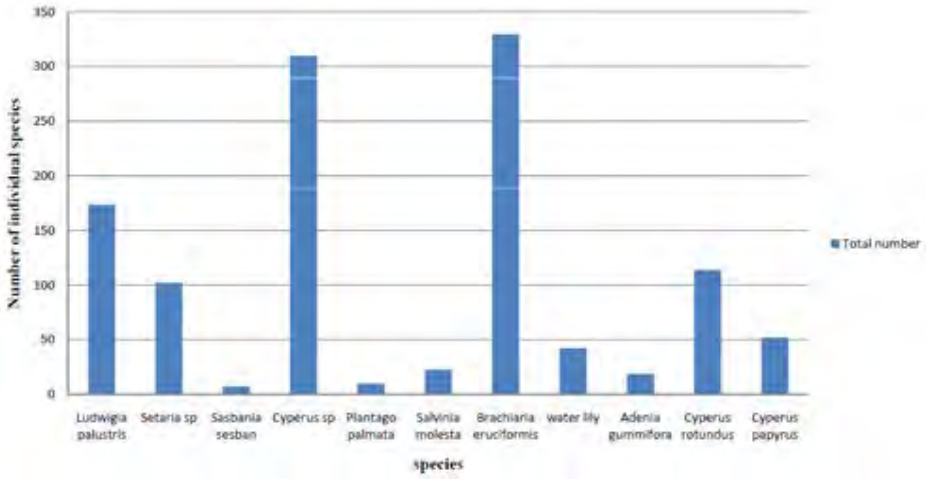
Wetlands are ecological sites of importance supporting bio-diversity, water purification, water storage, flow regulation, water provision, sequestering carbon and controlling floods. Nairobi lies within the Nairobi River basin in the greater Athi River Basin. A variety of internal wetlands consisting of both natural (riverine and palustrine) and artificial types are found in the basins of Rivers Mathare, Nairobi and Motoine. However, the only major natural wetlands that still exist in the Nairobi River's basin are the Ondiri swamp in the upper Kikuyu catchment which is the source of the Nairobi River (UNEP, 2005) and Nairobi River (Ministry of Environment and Mineral Resources, 2012).

The major artificial wetlands in the area include the Nairobi Dam and Dandora Sewage Treatment Works. Additionally, some seasonal and permanent wetlands are also found within Nairobi National Park and Karura Forest. These include: Hyena dam, Nalogomon dams, Oromanye dam, Eland hollow dam, Ruai dam, Embakasi reservoir and Athi basin in Nairobi National Park; and Water Lily Lake wetland in Karura forest.

The wetlands in the Nairobi Rivers Basin provide transitional habitats in form of riverine reservoirs, seasonal rock pools and marshes in Embakasi, and Kayole west plains and Dandora. The wetlands support substantial numbers of resident and of migratory birds. The Dandora oxygenation Ponds at Ruai, for instance, is inhabited by an average of 50 birds species and an average of 12,400 total water birds have been counted every year, majority being ducks and geeses (CCN, 2011). The treatment works was fully commissioned in 1992 and consist of 3 experimental ponds, eight facultation ponds and 24 maturation ponds.

The most common wetland plant species are *Cyperus dive*, *Typha domingensis* and *Hyparrhenia rufa*. However, natural riparian vegetation for most streams have been replaced and currently dominated by exotic trees, mainly Eucalyptus (*grandis*), *Gravellia*, whistling pines, Cyprus, *Sesbania* and *Lucena* sp. A closer picture of the natural remnant vegetation can be deduced from vegetation inventory for water lily lake wetland in the protected Karura forest which captured the following species in order of decreasing abundance: *Brachiaria*

eruciformis, *Cyperussp*, *Ludwigia palustris, Cyperus rotundus*, *Setaria* sp. *Cyperus papyrus*, Water lily, *Salvinia molesta*, *Adenia gummifora*, *Plantago palmat*e and *Sasbania sesban.* This presents one of the remnant pristine wetland environments within the city. Abundance of these species is shown in Figure 8.15.



Source: NIUPLAN

Figure 8.15 Abundance of Wetland Vegetation in Water Lily Lake Wetland in Karura Forest

4) Avifauna

Despite the built-up nature of the City of Nairobi, its green and open spaces and even some structures host numerous bird species. The major roosting and nesting sites for major birds' species in and around Nairobi are presented in Table 8.10 below.

Table 8.10 Major Roosting and Nesting Sites for Birds in Nairobi and its Neighbourhood

Sites	Major species
Nairobi National Park and surrounding natural habitats e.g. Ngong, Karura forests and Nairobi Arboretum	Large mixed colonies of a variety of birds
Dandora sewage treatment works	Ducks and Geeses
(CBD) and surrounding suburbs buildings	Little Swifts Apus affinis, Speckled Pigeon Columba guinea and Red-winged Starlings Onychognathus morio.
National Museums of Kenya botanical garden	Hadada ibis Bostrychia hagedash and Black kite Milvus migrans
University of Nairobi, Acacia and Eucalyptus trees	Eucalyptus trees Marabou Storks and black kites Milvus migrans
Nyayo Stadium	Marabou Storks Leptoptilus crumeniferus
Muthurwa	Black Kites
Mombasa Road at City Cabanas	Sacred Ibis Threskiornis aethiopicus and Cattle Egret Bubulcus ibis
Kwenia cliffs along Magadi road	White-backed (Gyps africanus) and Ruppells's Vultures (Gyps rueppelli)

Source: CCN, Aeronautical survey and Bird strike potential for JKIA, 2011

The Nairobi National Park, Ruai and Jomo Kenyatta International Airport (JKIA) lies within a major bird migratory pathway.

Nairobi National Park and Dandora ponds are Important Bird Areas (IBAs). Globally threatened species in NNP include Madagascar Squacco Heron, Corncrake Lesser Kestrel, Red-throated Tit and Jackson's Widowbird. Out of 611 species of birds in Nairobi area, 14 are globally threatened (Lepage Denis, 2014).

Apart from protection of their habitats, the above species have implication on siting for solid

waste management sites relative to locations of airports. A number of them have been involved in air strike. For instance, un-published data collected by different airlines in JKIA between June 2005 and November 2011 found over 54 bird strike incidences recorded by the airlines, with the Black Kite Milvus migrants being the major victim accounting for fifty-seven percent of the strikes (CCN, 2011).

5) Land use

About 80% of land in Nairobi is owned by the Government, but these lands are held by several types of users. About 41% of government lands (33% of total land) have been alienated to private and other parties. Table 8.11 shows the land use by land hold in Nairobi.

Table 8.11 Composition of Land Use in Nairobi City County

Category	Sub category	Area (sq.km)	%
Government land	1) Forest reserve	21	3.1
	2) Other government reserve	77	11.3
	3) Township	93	13.6
	4) Alienated land	225	32.9
	5) Un-alienated land	16	2.3
	6) National parks	117	17.1
	7) Open water	-	-
	Sub total	549	80.3
Freehold land	8) Smallholder schemes	-	-
	9) Other	135	19.7
	Sub total	138	19.7
Grand total		684	100.0

Source: Statistics Abstract 2005

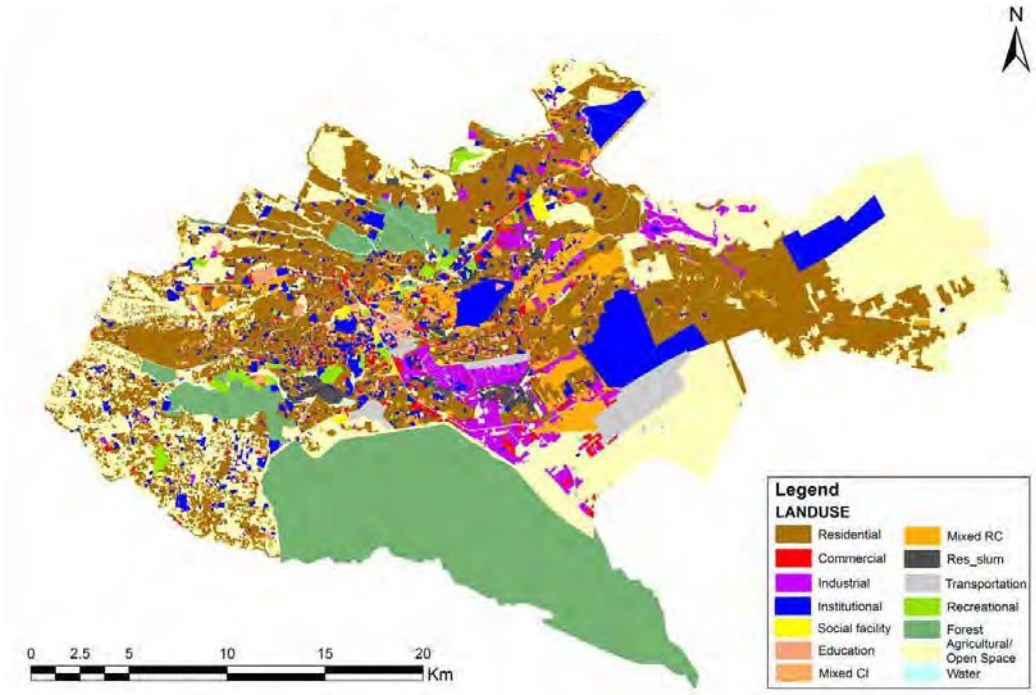
Available land use surveys for the whole area of Nairobi city were conducted by Centre of Sustainable Urban Development (CSUD) of Colombia University in collaboration with Nairobi University in 2005 and 2010. For the current study, the land use map was updated by the JICA study team from a combination of analysis of satellite images and ground surveys.

The composition of current land use is summarized in Table 8.11 and spatially depicted in Figure 8.16.

Table 8.12 Land Use Composition

Land Use	Area (sq.km)	Percentage
Residential	105.2	15.1%
Commercial	5.9	0.8%
Industrial	22.2	3.2%
Mixed Commercial & Industry	3.6	0.5%
Mixed Residential & Commercial	4.2	0.6%
Institutional	39.8	5.7%
No structures	0.3	0.0%
Open space	332.0	47.8%
Recreational	8.7	1.3%
Res slum	7.8	1.1%
Transportation	15.5	2.2%
Unknown	42.3	6.1%
Water	10.9	1.6%
Total	598.4	86.1%
National Park	96.9	13.9%
Grand total	695.1	100.0%

Source: NIUPLAN



Source: NIUPLAN

Figure 8.16 Land Use Map of Nairobi City County

Karen-Langata area which is located in south-western side of Nairobi still keeps low-rise and low density residential area with open space. Housing developments around Ruai is conducted by private developers without defined comprehensive development concept, it became to be high density and low open space area.

Regarding the land use trends, a lot of land changes have taken place between 2003 and 2012. Typical land use change in Nairobi is summarized as below.

- Soil rich farm land to residential area: Northern and eastern parts of Nairobi have rich red soil initially utilized for tea/coffee plantation or other agricultural activities. These plantations have been recently developed into residential areas.
- Grassland to residential area: Eastern part of Nairobi is mainly lower grassland and changed into residential areas.
- Detached house to apartment or office: Highland in western area of Nairobi was developed as estates for European settlers before the independence. Recently low rise detached houses for single families are converting into high rise apartments or offices.

8.5.1.5 Air Quality

Nairobi is faced with two major issues as far as the atmospheric environment is concerned: climate change and air quality. Air quality in Nairobi is mainly impacted by anthropogenic activities in the transport, energy and industrial sectors. The main sources of atmospheric pollution are emissions from vehicles, industries, the use of charcoal and firewood for energy, and other municipal sources such as suspended particulate matter from dust and the open burning of waste. Charcoal burning, a prevalent energy source in city, emits methane (CH_4) and carbon monoxide (CO) and sends tiny particulates into air. Vehicles emit significant levels of air pollutants, including greenhouse gases and precursors of smog.

Emissions from industry contribute to smog and haze over the city. The industrial area is

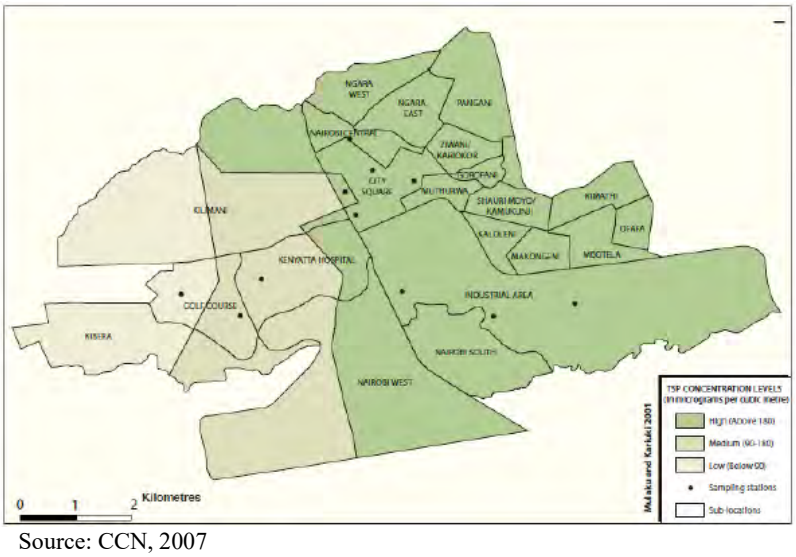
located to the east of the city; and the prevailing winds come from the east. Gaseous emissions from industries and vehicles are thus trapped against the western hills and sometimes form a cloud of smog over the city.

Areas with high vegetation cover and less traffic congestion are expected to have cleaner air. Some of these include Thika, Ruiru, Limuru and Kiambu. Limuru road and Kiambu road which share Karura forest Ngong as well as Karen area, which take advantage of the nearby forest covers. Kajiado, Machakos and Kangundo areas also has fresher air due to the high dispersal from windy conditions.

Kenya is yet to adopt any comprehensive air quality guidelines. However, there is currently a draft air quality regulation. Other frameworks exist for Quality Assurance of Imported Used cars which are applied by Kenya Bureau of Standards (KEBS) vide Legal Notice 78 of 15 July 2005. KEBS, through standards KS 1515 of 2000, has critical parameters of assessing imported used cars. These include radioactive contamination inspection, no emission of black or dense blue coloured smoke (by observation), less than 0.5 % of CO and less than 0.12 % of HC in vehicular emission. Others include Traffic Act, Cap 365, the Public Health Act, Cap 242 and OSHA of 2007.

Nairobi does not have any regular air quality management system and any measurements of air pollution have thus far been done on an ad hoc basis including studies conducted at the universities. The current air quality status is thus not fully understood. Studies have shown that there is a strong correlation between Particulate Matter (PM), Nitrogen Oxides (NOx) and motor vehicle density in Nairobi with vehicular emissions and mineral dust contributing most pollutants. Increasing number of cars in the city coupled with traffic snarl-up intensifies pollution problems. Given diversity of its urban landscape and land uses, the air quality in Nairobi is likely to vary across the different areas with the CBD, the major roads and the industrial area being the most affected.

In 1992, measurements of the concentration of suspended particulate matter in Nairobi revealed the highest concentrations in the industrial area (252 µg/m³), decreasing with distance from the industrial area. Other areas of the city had levels less than a third of this – 80 and 83µg/m³ in BuruBuru area and Woodley areas, respectively as depicted in Figure 8.17 (NCCG). Particulate matter is a major cause of respiratory diseases acting synergistically with other pollutants.



Source: CCN, 2007

Figure 8.17 Average Total Suspended Particulates (TPS) over a Section of Nairobi

Sampling conducted in July 2009 showed mean daytime concentrations of PM (2.5) ranging from 10.7 at the rural background site to 98.1 µg/m3 on a sidewalk in the central business district. Horizontal dispersion measurements demonstrated a decrease in PM (2.5) concentration from 128.7 to 18.7 µg/m3 over 100 meters downwind of a major intersection in Nairobi. A vertical dispersion experiment revealed a decrease from 119.5 µg/m3 at street level to 42.8 µg/m3 on a third-floor rooftop in the central business district. Though not directly comparable to air quality guidelines, which are based on 24-hour or annual averages, these concentrations raise concern with regard to public and environmental health. These suggest that many Nairobi residents are exposed on a regular basis to elevated concentrations of fine particle air pollution, with potentially serious long-term implications for health (Kinney PL et al, 2011).

Recent Spot air quality sampling and analysis undertaken along sections of Outer-Ring Road during ESIA study for the road improvement by KURA were also reviewed. Sampling sites were pre-determined such as to coincide with high population areas, junctions and economic activities.

Table 8.13 Pollution (Air Quality: Particulate Matter Level)

Sampling Location	Dust Concentration Levels (Mg/M³)	Tlv Mg/M³	Remarks
Outer-Ring-Thika Road Junction	3.25	10	Within the limit
Allsopps GSU Area	4.32	10	Within the limit
Kariobangi-Kiamaiko Area	6.15	10	Within the limit
Juja Road Outer-Ring Roundabout	7.59	10	Within the limit
Kariobangi South-Mumias Road Junction	5.45	10	Within the limit
Pipeline Estate Area	4.56	10	Within the limit
Outer-Ring Road-Eastern by-pass area	5.60	10	Within the limit

Source: KURA, ESIA report for Outer-Ring road

Table 8.14 Result of Ambient Air Quality Survey under Ngong Road Phase II Project

Pollutant	Unit	Measured value	Kenya*1	WHO*2	Time weighted average
Particulate Matter PM10	µg/m3	24	100	50	24 hours
			50	20	1 year
Sox (SO_2)	µg/m3	1.71	80	20	24 hours
			60	500	10 min
NOx (NO_2)	µg/m3	0.55	80	200	24 hours
			60	40	1 year
CO	µg/m3	0.67	4,000	30(mg)	1 hour
			2,000	10(mg)	8 hours
Lead	µg/m3	0.91	1	NV	24 hours
			0.75	0.5	1 year
Wind speed	m/s	1.5	-	-	-
Wind direction		SE	-	-	-

Source: ESIA Study for Ngong Road Phase II Project (SGS)
Note: NV- No Value given; ND- Not detected (less than the quantification limits);
*1: The Environmental Management and Coordination (Air Quality) Regulations, 2008 (Draft);
*2: WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide, Global Update 2005

Table 8.15 Pollution (Air Quality: Emission Levels)

Location	Carbon Monoxide (CO)	Sulphur Dioxide (SO_x) ppm	Carbon Dioxide(CO_2) %	Volatile Organic Compounds (VOC)	Nitrogen Dioxide (NO_x) ppm	Comments
Outer-Ring Road/Thika Road Junction(Top of the Bridge)	ND	<0.01	0.01%	ND	<0.05	Within the limit
Kariobangi/Kiamaiko Area	ND	<0.01	0.03%	ND	0.05	Within the limit
Juja Road/Outering Roundabout	ND	0.12	0.05%	ND	ND	Within the limit
Kariobangi South Mumias Road Junction	ND	0.02	0.05	ND	ND	Within the limit
Umoj/Buruburu Road Junction	ND	0.01	0.06%	ND	ND	Within the limit
Pipeline Easte	ND	0.01	0.05%	ND	ND	Within the limit
Outer-Ring Road/Bypass(under the Bridge)	ND	0.04	0.06%	ND	ND	Within the limit
TLV	10ppm	0.125mg /m^3	0.5%	70ppm	0.150mg/ m^3	

ND- Not Detected

Source: KURA, ESIA report for Outer-Ring road

Spot measurements tabulated above shows low or nil emissions levels of emissions and particulate matter in all the locations along the Outer Ring road. While it would be expected that the selected locations are characterized by high emissions due to the high populations and economic activities, this was not evident. The study observed that most of the corridor sections are characterized with high dispersal levels hence the display of low concentrations. This, therefore does not imply no emissions. From this spot analysis, locations with high emissions (including SOx and CO_2) were Juja Road junction, Eastern Bypass junction and Kariobangi/Kiamaiko area with between 0.01 – 0.4ppm SOx and 0.03 – 0.05% CO2. Particulate matter is reported as between 4 – 7ppm with high levels Juja Road junction and Kariobangi/Kiamaiko area. These scenarios are associated with the combination of traffic flows and economic activities (workshops, market activities, construction and open air burning of wastes).

From spot measurements undertaken as part of the ESIA Study for Ngong Road Phase II project, all the five pollutants monitored were detected. Patterns in prevalence were observed as follows:

a) Particulate matter

Particulate matter (PM_{10}) [2] was detected at concentrations way below the Kenyan specifications a for daily and annual mean, below the WHO limits for daily mean but in excess of the latter specification for annual mean. It will be noted that sampling took place when prevailing wing speed was very low (1.5m/s) and wind direction was from SW and thus opposite the direction of Nairobi City and its industrial area where most pollution is generated. Given that the dominant wind direction in Nairobi is from the E and NE, it is likely that, atmospheric pollution in the Ngong road area is more than actually observed in this study.

b) Sulphur dioxide

Sulphur dioxide was detected at but in insignificant levels possibly for the same reasons

2 PM10 represents the particle mass that enters the respiratory tract and it includes both the coarse (particle size between 2.5 and 10µm) and fine particles, those below 2.5µm in size.

advanced in respect of particulate matter. Given that sulphur oxides are generated from combustion mainly of fuel oil, low levels may be accounted for the prevailing wing direction from the relatively less polluted Ngong area.

c) Carbon monoxide

Carbon monoxide was detected as part of Volatile Organic Compounds (VOCs) but at concentrations much lower than the Kenyan and WHO thresholds.

d) Nitrogen oxides (NO_X)

Nitrogen oxides (NO_x) in the ambient air consist primarily of nitric oxide (NO) and nitrogen dioxide (NO_2). These two forms of gaseous nitrogen oxides are significant pollutants of the lower atmosphere. However, the level of NO_2 measured on Ngong Road is apparently quite low as annual mean concentrations of nitrogen dioxide in urban areas throughout the world in the range of 20–90 $\mu g/m^3$ have been reported (www.ifc.org). Maximum half-hour values and maximum 24- hour values of nitrogen dioxide can approach 850 $\mu g/m^3$ and 400 $\mu g/m^3$, respectively while hourly averages near very busy roads often exceed 1,000 $\mu g/m^3$. The 0.55 $\mu g/m^3$ measured for Ngong Road is thus low by international standards.

e) Atmospheric lead

Lead was detected at a concentration of 0.91 $\mu g/m^3$ which is quite close to the 1$\mu g/m^3$ stipulated by NEMA but way above the one year averages recommended by both Kenya and the WHO. Given that use of lead in fuel has been phased out, continued high prevalence of this element in the atmosphere requires closer monitoring.

f) Discussion of results

Diverse studies have documented that most of the City of Nairobi suffers from elevated levels of particulate matter. In a study of dispersal of airborne pollutants carried out at several sites in and around Nairobi ranging from high-traffic roadways to rural background, mean daytime concentrations of $PM_{2.5}$ ranged from 10.7 at the rural background site to 98.1 $\mu g/m^3$ on a sidewalk in the central business district while horizontal dispersion showed a decrease in $PM_{2.5}$ concentration from 128.7 to 18.7μgm^{-3} over 100 meters downwind of a major intersection in Nairobi. A vertical dispersion experiment revealed a decrease from 119.5 μgm^{-3} at street level, to 42.8 $\mu g\ m^{-3}$ on a third-floor rooftop in the central business district (Gichuru, et al, 2011).

The mapping study for TSP concentrations in Nairobi (Mulaku and Kariuki, 2001) based on analysis of data from 11 TSP air sampling stations (distributed in the commercial, industrial and residential areas of Nairobi) showed that that TSP levels in most of the City were above WHO recommended levels, with most of the City's eastern residential areas and the City Centre having concentrations in excess of 180 µg/m3). This finding was also collaborated by the works of Gatari, et al, 2009, who, in a study monitoring airborne aerosols in Nairobi City observed an average Pm_{10} concentration of 105 μgm^{-3} in samples taken at a site in the industrial area while similar studies by Odhiambo, et al (2010) documented PM_{10} levels of 66.7-444.5 $\mu g/m^3$) for a site along Uhuru Highway/ University way intersection.

With regard to other atmospheric pollutants, levels are largely within statutory limits. The study by Odhiambo, et al established that most pollutants for example, lead (0.051 to 1.11 $\mu g/m^3$), bromine (LLD to 0.43 $\mu g/m^3$), NO_2 (0.011-0.98 ppm), NO (0.001-0.26 ppm) and O_3 (LLD-0.13 ppm) are within the WHO guidelines.

The implication here is that, observed levels of particulate matter are indeed lower than both

the Kenyan and WHO guidelines. However, given that this study took place in May when the place was less windy (see table 4.12 below), it is possible that particulate matter may have been temporarily washed off the air by rain while prevailing humidity (weather was generally wet) mitigated against generation of airborne particles. Consequently therefore, it is possible that, particulate matter in the sites monitored for this study is seasonally elevated and could be much higher than currently reported depending on the prevailing weather conditions but even though, levels are likely to be below those observed by the Kenya Meteorological Department.

Air pollution adversely affects human health. Particulates are associated with respiratory and eye diseases such as asthma, lung cancer, and conjunctivitis, especially in the young and elderly who are more vulnerable. Respiratory diseases were the major causes of deaths in Nairobi in the period 1998 – 2000 (see Table 8.16).

Air pollution is also a major contributor to effects such as acid rain, which has been responsible for much damage to soil, fish resources, and vegetation, often very far from the emission sources.

Studies have indicated that vehicular emission loading can be reduced by mitigating chronic city-wide traffic congestion. For instance, improvement of city-wide vehicle moving speed such as from 15 km/hr to 30 km/hr can result 20 % – 25 % reduction of emission loading (NIUPLAN).

Table 8.16 Top Ten Major Causes of Mortality (%) in Nairobi (1998-2000)

	1998	1999	2000
Respiratory symptoms	37.0	27	35.5
Malaria	23.1	18.8	14.7
Accidents	-	14.2	10.0
Skin disease	14.4	6.6	7.7
Diarrhea	9.3	8.3	9.5
Urinary tract disease	4.6	Not indicated	6.0
Intestinal worms	4.1	Not indicated	Not indicated
Disease of puerperium& childbirth	3.9	7.3	Not indicated
Eye infections	3.2	7.9	6.7
Ear infections	-	9.4	0.8

Source: CCN, 2007

8.5.1.6 Noise and Vibration

Though not representative of the entire Nairobi County, spot noise level measurements taken during the ESIA study for improvement of Outer-Ring Road and Ngong Road Phase II were reviewed to give available indications of the current situation. The spot noise measurement locations coincided with high population areas and traffic volumes including junctions and results are presented in Table 8-12 below. These levels are higher than the stipulated noise levels under the NEMA Regulations (55dBA during the day). Noise level data expressed in the power average (LAeq) were computed using the formula

$$L_{Aeq} = 10\log_{10}\left[\frac{1}{n}\left(10^{\frac{L_{A,1}}{10}} + 10^{\frac{L_{A,2}}{10}} + \cdots + 10^{\frac{L_{A,n}}{10}}\right)\right] \quad \text{.....(i)}$$

where the LAeq is the measure of exposure to noise for the duration of a given time interval T (a 24-hour period, a night, a day, etc.) expressed as an equivalent sound pressure level (measured in decibels (dB(A) over the interval in question. According to the equal energy principle, the effect of a combination of noise events is related to the combined sound energy of those events. Thus, measures such as the equivalent continuous sound pressure level (LAeq, T) sum up the total energy over some time period (T) and give a level equivalent to the average

sound energy over that period- usually based on integration of A-weighted levels. Thus LAeq D is the average energy equivalent level of the A-weighted sound over the 14 hr daytime (D) or the 8 hr night-time (N) respectively.

Clearly, the Kenyan, WHO and IFC specifications for daytime and night time noise levels in commercial cum residential areas are exceeded at all measuring points in Nairobi while IFC standards for night noise level are all exceeded implying that Nairobi is apparently suffering elevated noise pollution especially at night when the low threshold is quite easily exceeded.

Excessive noise levels and vibrations reduce the quality of the living and working environment and have negative impacts human health. The noise and vibration in Nairobi is influenced by a collection of factors including transportation, commercial activities, domestic and industrial activities. The main sources of the noise and vibrations are the industrial factories, "jua kali" sector, loud speakers, Matatu touts, shouting, motor vehicle traffic and aircrafts.

Noise and excessive vibration thresholds for environmental health in Kenya are set in the environmental (Noise and Excessive Vibration Pollution Control) Regulations of 2003. Additionally, Occupational Safety and Health Act (OSHA) of 2007 set thresholds applicable for work places. However, just like air, there are no regular measurements of noise and vibration levels across the county for monitoring purposes. Though not representative of the entire Nairobi County, spot noise level measurements taken during the ESIA study for improvement of Outer-Ring Road were reviewed to give available indications of the current situation. The spot noise measurement locations coincided with high population areas and traffic volumes including junctions and results are presented in Table 8-12 below. These levels are higher than the stipulated noise levels under the NEMA Regulations (55dBA during the day).

Table 8.17 Spot Noise Levels Measurements along Outer-Ring road, Nairobi

		Noise levels (LAeq dBA) and standards			
Target Road	Monitoring point	Measured	NEMA [1]	IFC [2]	WHO[2]
Ngong Road	Dagoretti Corner	63	50res,60 comm	50 res 70 comm	55 (all)
Thika road /Outering road junction	Northern east (Thika Road)	67	50 res, 60 comm	50 res 70 comm	55 (all)
	Southern east (Thika Road)	63.8	50 res, 60 comm	50 res 70 comm	55 (all)
	Top of Thika road fly over	72.5	50 res, 60 comm	50 res 70 comm	55 (all)
	Eastern side (Thika road)	65.1	50 res, 60 comm	50 res 70 comm	55 (all)
Outering road	Outering road next to Thika Flyover	69.3	50 res, 60 comm	50 res 70 comm	55 (all)
	Outering road/Baba Dogo Junction	71	50 res, 60 comm	50 res 70 comm	55 (all)
	Kariobangi/Kiamaiko junction	76.5	50 res, 60 comm	50 res 70 comm	55 (all)
Outer-ring road-juja road junction	Outering road northern side	79.5	50 res, 60 comm	50 res 70 comm	55 (all)
	Outering road southern side	66.4	50 res, 60 comm	50 res 70 comm	55 (all)
	Juja road western side	71.8	50 res, 60 comm	50 res 70 comm	55 (all)
	Eastern side, Juja road	74.8	50 res, 60 comm	50 res 70 comm	55 (all)
	Round about Centre	70.9	50 res, 60 comm	50 res 70 comm	55 (all)
Outering road/ mumias road junction	Outer-ring road junction (south)	65.4	50 res, 60 comm	50 res 70 comm	55 (all)
	Outer-ring Road junction (north)	71.9	50 res, 60 comm	50 res 70 comm	55 (all)
	Mumias junction (western side)	66.2	50 res, 60 comm	50 res 70 comm	55 (all)
Outering road/ Kagundo road	Northern side	74.7	50 res, 60 comm	50 res 70 comm	55 (all)
	Southern side	75	50 res, 60 comm	50 res 70 comm	55 (all)
Buruburu Umoja	Road under construction junction	66.5	50 res, 60 comm	50 res 70 comm	55 (all)
Outering road/Jogoo road Donholm roundabout	Northern side	72.9	50 res, 60 comm	50 res 70 comm	55 (all)
	Southern side	75.8	50 res, 60 comm	50 res 70 comm	55 (all)
	Eastern side	75.2	50 res, 60 comm	50 res 70 comm	55 (all)
	Western side (Jogoo road side)	66.5	50 res, 60 comm	50 res 70 comm	55 (all)
	Round about Centre	63.2	50 res, 60 comm	50 res 70 comm	55 (all)
	Lungalunga road side	66.5	50 res, 60 comm	50 res 70 comm	55 (all)
Thika road /outering road junction	Northern east (Thika Road)	67	50 res, 60 comm	50 res 70 comm	55 (all)
	Southern east(Thika Road)	63.8	50 res, 60 comm	50 res 70 comm	55 (all)
	Top of Thika road fly over	72.5	50 res, 60 comm	50 res 70 comm	55 (all)
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	Outering road southern side	66.4	50 res, 60 comm	50 res 70 comm	55 (all)
	Juja road western side	71.8	50 res, 60 comm	50 res 70 comm	55 (all)

Source: SEA for NIUTRIP; ESIA for Ngong Road Phase II

Note: 1) The Environmental Management and Coordination (Noise and Excessive Vibration Pollution Control) Regulations, 2009. Time Frame: Day: 6.01 a.m. – 8.00 p.m.; Night: 8.01 p.m. – 6.00 a.m.

Note: 2) General EHS Guidelines; Environmental Noise Management, International Finance Corporation: IFC 2007.

Note 3) www.euro.who.int/document/e92845

8.5.1.7 Environmental Standards

Regarding environmental standards in Kenya, standards of air quality, discharged water quality, noise and vibration are regulated by NEMA. Table 8.18 shows comparison of environmental standards between Kenya, Japan and other international institutions.

Table 8.18 Comparison of Environmental Standards

Item	Unit	Standards					
		Kenya		Japan		IFC/WHO	
Air quality		Residential, rural & other area		-		-	
SO2	ppm µm/m3	<80µm/m3 (24-hour) <500µm/m3 (10 minute)		<0.04ppm (daily average) <0.1ppm (per hour)		<20µm/m3 (24-hour) <500µm/m3 (10 minute)	
NO2	ppm µm/m3	<0.05ppm(1-year) <0.1ppm(24-hour) <0.2ppm(1-hour)		<0.04-0.06 ppm(daily average)		<40µm/m3 (1-year) <200µm/m3 (1-hour)	
PM10(SPM)	mg/m3	<0.14 (1-year) <0.20 (24-hour)		<0.10(daily average) <0.20(per hour)		<0.02(1-year) <0.05(24-hour)	
CO	ppm mg/m3	<4.0mg/m3(1-hour)		<10(daily average) <20(1-hour of 8 hours average)		-	
Water quality		Effluent Discharge		Category B (agricultural use)	Category C (industrial use)	Effluent Discharge	
pH	pH	6.5-8.5		6-8.5	6-8.5	6-9	
SS	mg/l	<30		<25	<50	<50	
Turbidity	UNT	-		-	-	-	
BOD	mg/l	<30		<5	<8	<30	
COD	mg/l	<50		-	-	<125	
Noise		Residential zone	Industrial zone	Residential zone (B)	Industrial zone (C)	Residential zone	Industrial zone
dB(A)	dB(A)	<50(day) <35(night)	<70(day) <60(night)	<55(day) <45(night)	<60(day) <50(night)	<55(day) <45(night)	<70(day & night)
Vibrations							
dB	dB	-		55-65	75	-	

Source: JICA Study Team

8.5.1.8 Population

1) Population

According to the 2009 National population, Nairobi County had a population of about 3.14 million. This makes Nairobi County one of the most populous cities not only in Kenya but also in East Africa. The Nairobi's population accounts for 8.1% of the national population. Nairobi County constitutes nine (9) sub counties namely; Makadara, Kamukunji, Starehe, Lang'ata, Dagoretti, Westlands, Kasarani, Embakasi and Njiru.

The average population density excluding Nairobi National Park, which occupies 117km^2 or 16.8% of the city's total area, is 5,429 per km^2. The Central Division and Kamukunji Division located at the centre have a much higher density.

Table 8.19 Population Distribution by Sub-Counties

Division	Population	Area in km^2	Density per km^2
Nairobi City excluding Nairobi National Park (117 km^2)			
Central/Starehe	274,607	11	25,640
Kamukunji/Pumwani	261,855	12	21,623
Makadara	218,641	23	9,481
Dagoretti	329,577	39	8,532
Kasarani	525,624	86	6,081
Embakasi including Njiru	925,775	204	4,546
Langata/Kibera	355,188	106	3,346
Westlands	247,102	97	2,538
Nairobi City	3,138,369	578	5,429
Outside Niarobi City	1,877,652	4,206	446
Greater Nairobi	5,016,021	4,784	1,049
Kenya	38,610,097	581,313	66

Source: KNBS, 2009

2) Population Growth

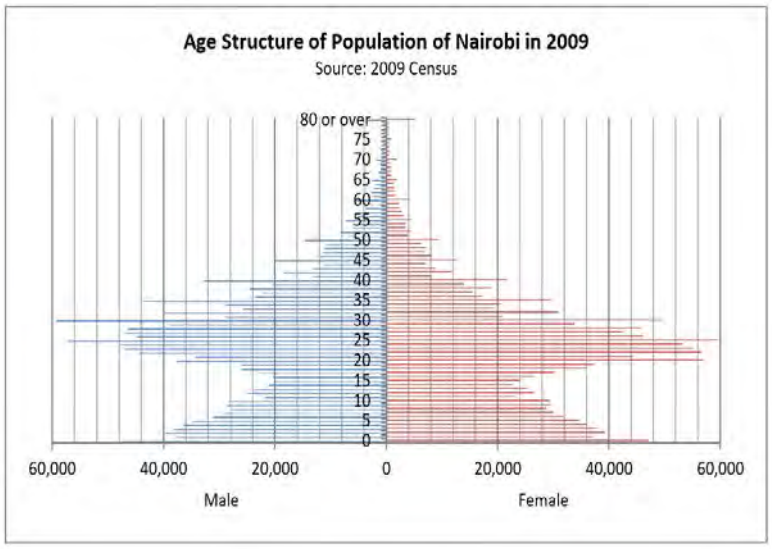
The 1989-99 inter-censal growth rate of the Greater Nairobi, the area consists of five counties including Nairobi County and surrounding counties, Kiambu, Murang'a, Kajiado and Machacos County, was 4.2% which reduced to 4.0% in the 1999 -2009 inter-census period. Kenya's population growth rate in both periods stands at 3.0%. This means that Nairobi's growth is much more than the national growth rate.

In the Greater Nairobi, Nairobi City had grown faster in the period from 1989 to 1999, when the city grew at 4.9% and the environs outside the city at 3.0%. But from 1999 to 2009, the environs grew faster as it grew at 4.1%and the city at 3.9%. Actually most of the people working in Nairobi today, come from outside the initial city boundary. The growth has attributed to urban expansion of Nairobi City. This growth has also led to the phenomenon of diurnal migration of people from the environs that commute daily into Nairobi for purposes of employment, education or trade.

In the city, Embakasi covers 35% of the total land area of Nairobi and has the highest rate of growth among all districts, while out of the city in the Greater Nairobi, Ruiru area to the north of the city and Mavoko and Kitengela areas to the south are fastest growing. It is in fact reported that those areas outside of Nairobi are dormitory areas for people working in Nairobi.

3) Population Structure

Unlike the age structure of the Kenyan population, the Nairobi City pyramid has a pair of wings with a large share of population around the twenties. This is an indication that the main contribution to Nairobi population increase is migration. As a result, the dependency ratio of Nairobi residents is lower than those of the overall Kenyan population. The forces motivating rural-urban migration to Nairobi include better economic prospects, opportunities for higher education and higher wage employment, and the attraction of Nairobi as a market for goods and services. The population structure for Nairobi is shown in Figure 8.18 below.



Source: NIUPLAN

Figure 8.18 Population Structure in Nairobi City County

Nairobi was established in 1899 as a railway supply depot, and by 1906, the population was estimated to be 11,500. By 1928 the number had increased by 159% to 29,864. Another significant increase in population was between 1936 and 1944 which saw a population increase by 119%. At independence in 1963, Nairobi's population stood at 342,764. Six years later at the 1969 census, there were 509,283 people in Nairobi. Ten years later, 1979, saw a population increase by 62.5% to 827,755. The trend is summarized in Table 8.20.

By 1989, Nairobi's population had hit over a million people. Population of the city reached 3.14 million people in 2009.

Table 8.20 Population Trend in Nairobi City County

YEAR	AREA (hectares)	Population	% Increase in Population	DENSITY (persons per hectare)
1906	1,813	11,512		6
1928	2,537	29,864	159.4	12
1931	2,537	47,919	60.5	19
1936	2,537	49,600	3.5	20
1944	2,537	108,900	119.6	43
1948	8,315	118,976	9.3	14
1963	68,945	342,764	188.1	5
1969	68,945	509,286	48.6	7
1979	68,945	827,755	62.5	12
1989	68,945	1,324,570	60.0	19
1999	68,945	2,143,254	61.8	31
2009	57,800	3,138,369	46.4	54

Source: Winnie Mitullah, as compiled from Olima 2001 and KNBS, 2011

8.5.1.9 Housing Condition

Housing has a central importance to quality of life with considerable economic, social, cultural and personal significance. Just as mentioned earlier those in informal settlement have a lower quality of life compared to those in formal settlements. In Nairobi, 60% of the population live in informal settlements squeezed into less than 6% of the city's land; in such conditions overcrowding and poor sanitary conditions is a cause of environmental health problems (UNHABITAT,2008).

Provision of shelter is a challenge in Nairobi. The National government, is unable to keep pace

with an annual housing shortfall of over 120 000 units (Kusienya 2004). Lack of investment in middle- and low-income housing has led to the mushrooming of informal settlements.

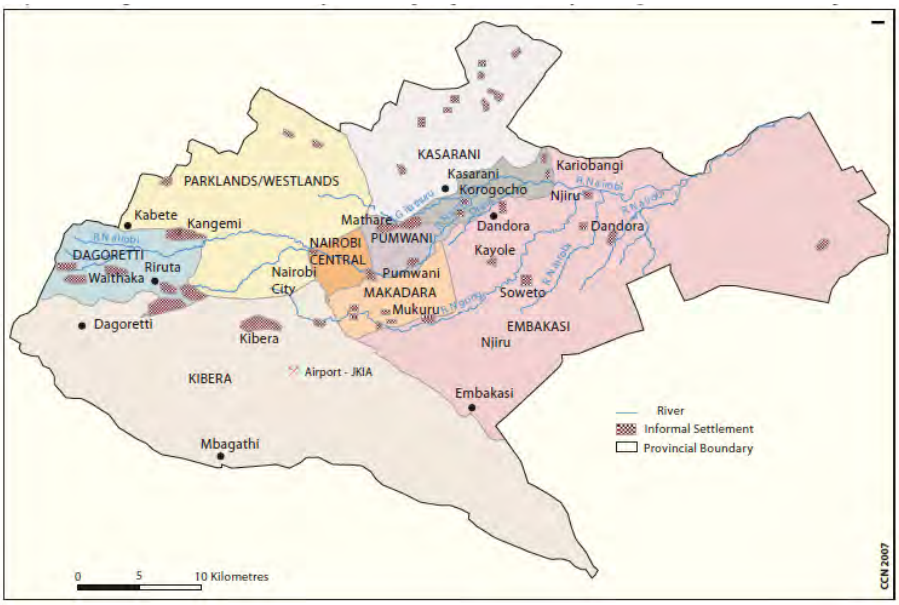
However, the government formulated a National Housing Policy in 2004 and a National Housing Development Programme (NHDP) 2003-2007 to operationalise the policy. Coupled with the Housing Act (2009) access to adequate housing is envisaged to be a reality. The housing act also establishes of a National Housing Fund to aid future housing development.

The urbanisation rate and population-related land pressures are two policy issues that the Nairobi City County needs to look at seriously. Land is a highly volatile and political in Kenya and its control continues to be a critical factor in the development. With limited land available for city expansion, it can be expected that this issue will assume growing importance in city politics, and the realisation of Master Plan Implementation.

Much of this population growth has resulted in rapidly expanding informal settlements, where people are living in conditions of extreme poverty and privation, without adequate shelter, infrastructure provision or security of tenure.

Some slum upgrading projects have been initiated within the city. These include: The Kenya Slum Upgrading Programme (KENSUP), run by the Ministry of Lands, Housing and urban development: Mathare IVA implemented by Amani Housing Trust; and Huruma upgrading by Pamoja Trust.

However, similar schemes in the past have been accompanied by gentrification problems. This is because beneficiaries of such projects usually end up renting out their houses to those who can afford to pay for services while they find their way back into the slums. The end result therefore is slum relocation as opposed to slum upgrading.



Source: NIUPLAN

Figure 8.19 Locations of Slums within Nairobi

8.5.1.10 Poverty Profile

Nairobi is the country's largest economic centre and generates 45% of the country's GDP, in the process employing 43% of all Kenya's urban workers (Oxfam, 2009). It is also the largest

industrial centre and food, beer, vehicles, soaps, textiles and chemicals are all produced or processed here. Due to numerous factors including global financial crisis the Kenyan economy.

Table 8.21 provides an aggregation of the overall proportion (44%) of those living below the absolute poverty line by the administrative divisions of the city 1999. It clearly indicates that in some areas overall poverty is considerably higher than others. The KIHBS calculated that Nairobi hosts nearly a third (29.5%) of the country's total urban food poor.

Table 8.21 Poverty Incidence by Sub County

District and Division	Poverty Incidence (%) of individuals below Poverty line (1999 Census)
Nairobi Overall	44
Central	45
Dagoretti	46
Embakasi	42
Kasarani	48
Langata	41
Makadara	59
Pumwani	46
Westlands	32

Source: Central Bureau of Statistics, 2003

8.5.1.11 Vulnerable Groups

1) General Information

The Constitution of Kenya recognises the need to address the needs of vulnerable groups within society, including women, older members of society, persons with disabilities, children, and youth, members of minority or marginalised communities, and members of particular ethnic, religious or cultural communities.

Vulnerability in the context of the SEA for NIUPLAN is defined by the risk faced by a certain member of society as a result of an environmental or social impact arising during the planning, operation or decommissioning of certain components of the master plan.

Vulnerability may also vary in its form within the same group. For example, the risk faced by vulnerable children in education sector may have a different face for vulnerable children in the health sector. In the first instant, the risk faced by teenagers in terms of lack of access to education facilities may arise from the economic resources available to their parents. However, the risk faced by teenagers in terms of lack of access to reproductive health services may arise from lack of adequate information and awareness on reproductive health.

2) Women

Inequalities arising from culture and social set up that makes women have less social, economic and legal rights than men and lack access to development resources, benefits and decision-making participation at all levels of society.

The socio-cultural attitudes held by both men and women, the socialization processes and women's perception of their own status, roles and rights are of particular significance in determining the status of women.

Women also face physical, economic and emotional gender based abuse particularly those in vulnerable situations such as young women, women with disabilities; refugees and internally displaced women. Factors contributing to violence against women include culture, substance

abuse and poverty.

According to a study on violence against women in Nairobi by UN-HABITAT, only 7% of physical abuse victims and 6% of sexual abuse victims report the incident. Studies also show that two in every five abused women believe there is nothing they can do to make Nairobi safer. In addition to the low rate of reporting, only 12% of reported cases result in actual arrest. Interventions are therefore needed to reduce incidences and impacts of violence against women.

3) Children and Youth

The term youth is often defined as those between the ages of 15 and 24; young people those of 10-24 years of age, adolescents 10-19 year-olds, and children as those under 10. Kenyan law however defines a child as someone below 18 years, while the constitution recognises the unborn child.

The world's population is becoming increasingly urban, and three-quarters of the urban population growth is occurring in developing countries. Existing urban areas are not equipped to accommodate such rapid population increases, and cities in the developing world are characterized by unplanned and overcrowded settlements without access to even the basic urban services. According to UN-HABITAT 60% of Nairobi's population live in informal settlements squeezed into less than 6% of the city's land. Most of these settlements have neither toilet nor water connections.

Based on the status of Nairobi's population pyramid, children and young people represent a very high percentage of this population.

Urban youth at risk include all those young girls and boys whose living conditions, health and circumstances or behaviours place them at risk of victimization and/or involvement in crime. In Nairobi this includes children living in slums, school drop outs, un-employed youth, street children and child beggars.

The development of these children is severely hampered yet when they join the work force; they are subjected to the same criteria as children who grew up in established homes with improved or high level access to all the basic needs. Nairobi's future work force is mainly made up of these vulnerable children.

Orphan children face additional inequality in their development in comparison with children with parents or guardians.

Child labour often places children at risk from impacts on their health and well-being due to unacceptable working conditions for people of their age and physical development. Such children are also cut off from an environment that would otherwise promote their physical, emotional and mental development. The children are also restricted from access to free time and play which is necessary for their present and future well-being.

Child labour in Nairobi usually stems from poverty and lack of access to basic needs. The hardest hit are children in Nairobi's slums as well as children and young people employed as domestic help (house-helps). The domestic help usually emigrate from other Counties to work in homes in the City. This group of workers usually lack the psycho-social support that they would otherwise enjoy if they were still at home or in school.

Child labour also increases the risks of exposure to illegal activities such as prostitution or drug trafficking, and increases the risk of AIDS especially among girls (AUMP-ROA, 2002).

Nairobi's youth are also exposed to crime and end up in the legal correctional system which includes our courts and reform schools. Interventions in these sectors are important to promote reform of such urban youth prior at the youngest age possible. Exposure of youth to hard core criminals in jail and in society is likely to hamper their growth into future responsible members of society.

A case study of Nairobi's youth by UN-HABITAT as part of the "Safer Cities Initiative" shows that the main issue confronting most youth in Nairobi is a breakdown in the transmission of social values and norms, which should take place through the family and the local community. The family and the school have ceased to operate as primary socializing agents, and many youth in Nairobi have opted for a life in street gangs or in social groups, which are similar to gangs. The street culture or gang has therefore become the primary socializing agent and friendship. The breakdown of traditional sanctions to combat the culture of violence enables the cycle of violence to continue.

4) Persons with Disabilities

Persons with disability (PWDs) in the context of NIUPLAN face reduced access to public and social utilities. The reduced access may be physical or economic. The vulnerability of a person with a disability is heightened when he or she is dependent upon a caregiver. The close personal contact involved with assisting persons with disabilities with daily living activities such as bathing, dressing and personal hygiene fosters dependence upon the caregiver.

Another root cause of lack of access may be due to poverty due to lack of access to education as children. The poorest of the poor are usually persons with disability due to lack of access to education earlier on in life. Vulnerable PWDs may also be found among households with better incomes due to isolation and lack of exposure due to stigmatization by parents or care givers.

Persons with disabilities may also have an impaired ability to utilize self-defence and avoidance of violence mechanisms.

Persons with disability may also face additional challenges in accessing information due to inability to hear or read information presented in the standard manner. For example, people with visual impairment may need access to Braille material or visual aids while those with hearing impairments require translations into sign language.

5) HIV / AIDS

The biological make-up of the female genital tract makes women more susceptible to HIV infection than men. Young girls are at an even higher risk than older women. Sexually transmitted infections (STIs) can also go un-diagnosed in women. This increases vulnerabilities faced by women as the presence of STIs in an individual increase the risk of infection by HIV. The risk of infection is higher in forced or coerced sex. It is reported that this risk is faced more by women than by men.

The subordination of women in African culture is said to increase their economic dependencies thus increasing their vulnerability to dependency and economic pressures. This is reported to expose them more to sexual exploitation, sexual violence and prostitution. Cultural sexual practices including inter-generational sex, promiscuity in marriage and polygamy leave also women more vulnerable to infection than men. The patriarchal system gives men dominance over women and restricts their ability to question their partners over their infidelity.

Recent studies show that though women in Nairobi are not highly affected by wife inheritance, the married couples do engage in "couple swapping". Due to their biological make-up, women

engaging in such activities are more susceptible to infections more than their male counterparts.

Men having sex with men (MSM) are considered a vulnerable group as the practice is illegal and considered immoral. This group therefore faces cultural restrictions in terms of access to information and services, specifically for management of HIV and AIDS. This vulnerability is higher for the unemployed, students and low income earners who would face additional economic challenges to accessing health services and facilities. In 2008, HIV prevalence among MSM was estimated at 25% in Nairobi (NACC, Population Council, 2009). Drug addicts also face additional risks as sharing of needles exposes them to infection and reinfection.

Reduced economic power makes the elderly less likely to access health services and facilities, which are critical in managing one's health after infection by HIV / AIDS. Nearly one in five (18%) Nairobi residents over age 50 report having been personally affected by AIDS, such as becoming infected, caring for an AIDS patients or orphaned child, or losing a loved one (Kyobutungi et al., 2009).

New-borns and babies are also vulnerable through transmission of the virus from mother to child at birth and in breast feeding. Abandoned babies due to their HIV status are also an issue in the City. Studies show that in the absence of treatment, In the absence of treatment, up to half of infants who contract HIV infection will die before age two (Marston et al., 2005; Newell et al., 2004).

Lastly, regardless of their age, gender, or economic standing, people living with HIV / AIDS (PLWHAs) face HIV related stigma that may lock them out of benefits enjoyed by other citizens due to social exclusion. Nearly half of all Kenyan women surveyed in 2008–2009 said they would want to keep a family member's HIV infection secret while one-third of individuals surveyed in the Eastleigh neighbourhood of Nairobi said it was reasonable to refuse to buy goods from a person living with HIV, and one in four respondents said it was appropriate to refuse to rent a room to someone who is HIV-positive (Pathfinder International, 2009).

However, there is support offered to PLWHAs. For example, in 2010, over 199,000 PLWHAs were registered in the County for support while more than 100 post-test clubs exist in Nairobi, operated by numerous grassroots organizations and networks, such as the Kenya Organisation of People Living with AIDS and the Kenya Organisation of Young People Living with AIDS.

6) Poverty

Poor people are more likely to live in places where they are exposed to hazards, but lack the resources to cope when disasters strike. Examples of such social groups in relation to NIUPLAN include:

- People living in informal settlements that are located on wayleaves for roads, railways, petroleum pipelines;
- People living in informal settlements located in the buffer zones for dangerous installations such as petroleum installations;
- People living in informal settlements located in riparian reserves.

These people are also likely to face greater challenges in finding alternative housing after resettlement as a result of development projects. This may also result in secondary impacts such as their ability to re-establish land based economic activities such as urban agriculture, hawking and other informal businesses. The relocation may also result in reduced access to formal and informal employment due to increased transportation costs or increased distances

to work places. This is especially critical for persons who live in informal settlements located next to Nairobi's industrial areas and the high income residential areas. The coping mechanism to lack of adequate incomes to cater for public transport is to live at a walking distance from their work places.

8.5.1.12 Social Facility

Table 8.22 shows the existing and planned urban public utility in the Nairobi City.

Table 8.22 Existing and Planned Urban Public Utility

Utility	Existing number	Current Deficit planned for	Number require by 2030 projection
Health Centres	79	47	101
Large Markets	20	126	209
Secondary schools	49	77	-
Primary schools	185	443	1043
Community facilities	25	603	1043
Fire stations	3	32	-

Source: NIUPLAN

1) Education Facility

According to the Nairobi City County Department of Education, the total number of enrolled primary schools pupils in 2011 was 336, 723 which increased to 408, 888 in 2012. This massive increment in a span of one year needs to be investigated.

Among public primary schools in Nairobi City, the Embakasi-Njiru district has the largest number of schools while Langata and Kamukunji districts have the lowest. Districts such as Starehe and Westlands have almost as many schools as Embakasi and Njiru, a district with almost 2.5 times more primary school students. In addition, there are almost as many nonformal schools as public schools in Nairobi, especially in the Embakasi district and in Kasarani, where there are more non-formal schools than public.

Table 8.23 Number of Schools and Students in Primary Schools in Nairobi, 2012

	District/ Sub county	Students in Primary School	No. of Schools
1	Dagoretti	46,181	25
2	Embakasi and Njiru	104,566	39
3	Kamukunji	18,825	16
4	Kasarani	87,791	25
5	Lang'ata	38,050	15
6	Makadara	26,489	30
7	Starehe	44,685	36
8	Westlands	42,301	30
Total		408,888	216

Source: NIUPLAN

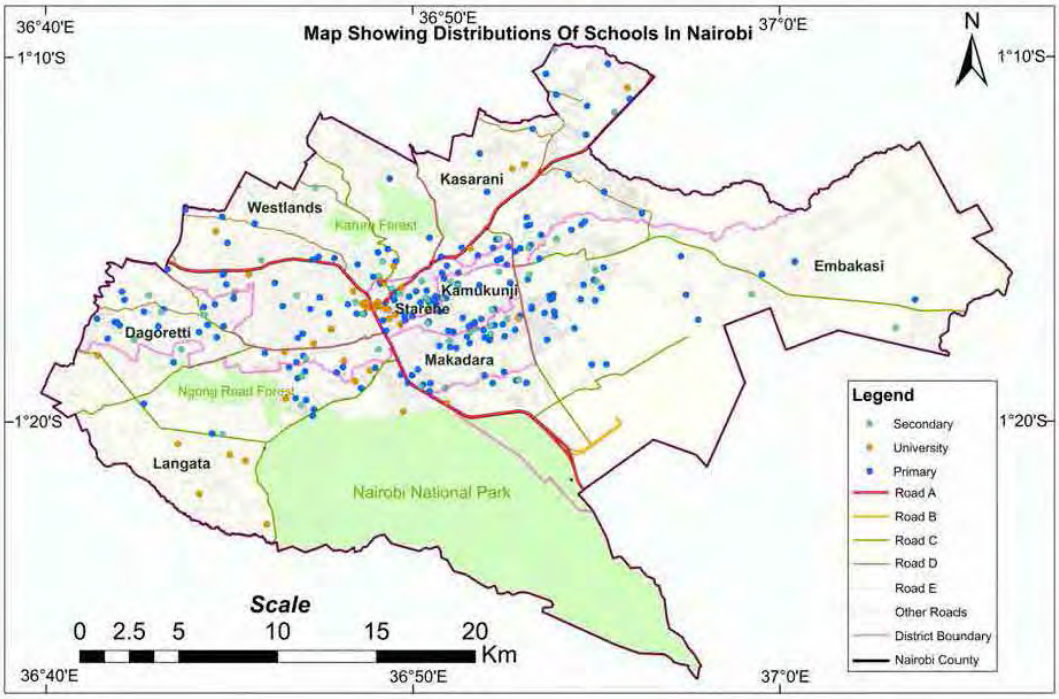
Table 8.24 Number of Public Schools in Nairobi City County

Sub County	Status of School		Grand Total
	Private	Public	
Dagoretti	110	23	133
Embakasi	204	40	244
Kasarani	341	31	372
Kibera	142	14	156
Makadara	33	28	61
Pumwani	28	15	43
Starehe	71	36	107
Westlands	77	50	127
Grand Total	1,006	237	1,243

Source: MoE, IMIS

As shown in Figure 8.20, although the number of public schools is equitable distributed in all the sub counties, there is a general discrepancy in terms of school capacity in some areas such as Nairobi East and Nairobi West, and an indication of possible overpopulation in Eastland schools. This gap has been filled by mushrooming of privately owned primary schools in these areas. Future planning of educational facilities should concentrate on increasing the number of schools in Nairobi East, in order to minimize overpopulation and align with population growth trends.

Spatial distribution of schools in Nairobi geographical area (Figure 8.20) shows that schools are concentrated in the central part of Nairobi. Areas such as Embakasi and Kasarani have very few schools compared to the population density of the area.



Source: NIUPLAN

Figure 8.20 Distribution of schools in Nairobi

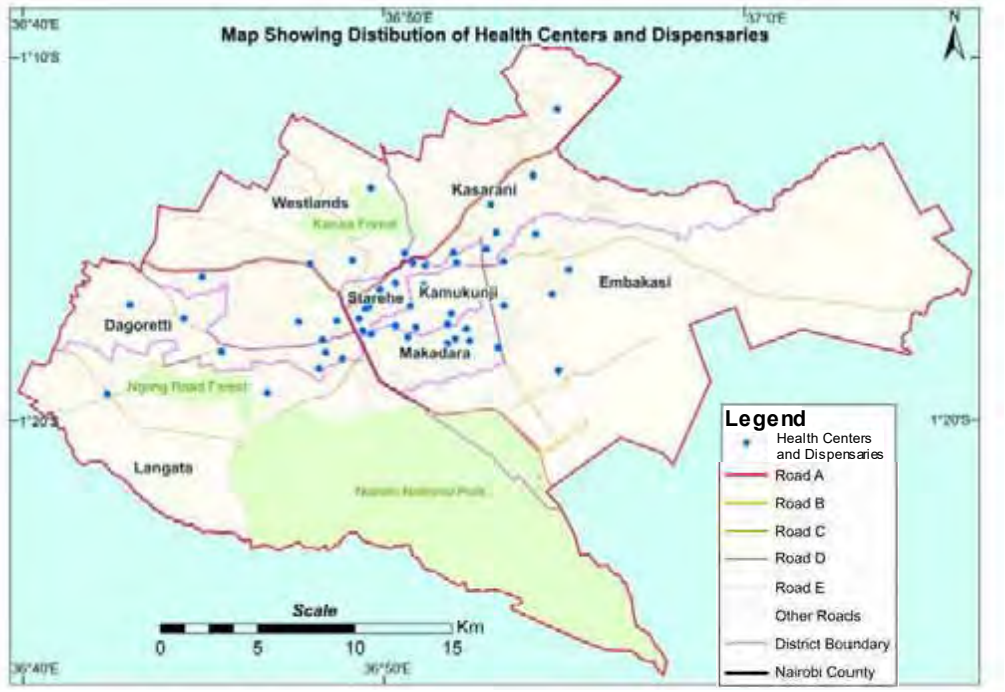
2) Medical Facility

Ministry of Health (MoH) e-health database list some of the health facilities in Nairobi. Table 8.25 shows the distribution of health facilities in Nairobi. It can be noted that Nairobi east which has the highest population density has the least number of facilities. Figure 8.21 demonstrates that health centres are predominant in the city centres leaving most of the people in other part of Nairobi with no access to such facilities.

Table 8.25 Number of Medical Facilities in Nairobi City County

Nairobi East		Nairobi North		Nairobi West	
Type	Total	Type	Total	Type	Total
Dispensary	23	Dispensary	69	Dispensary	64
District Hospital	1	District Hospital	1	District Hospital	1
Health Centre	23	Health Centre	21	Health Centre	27
Maternity Home	3	Maternity Home	3	Maternity Home	8
Medical Clinic	65	Medical Clinic	26	Medical Clinic	35
Nursing Home	6	Nursing Home	14	Nursing Home	1
Other Hospital	7	Other Hospital	12	Other Hospital	15
VCT Centre	2	VCT Centre	17	VCT Centre	15
Health Programme	1			Dental Clinic	1
				Funeral Home	2
				National Referral Hospital	2
Total	131		163		171

Source: MoH, eHealth, 2014



Source: NIUPLAN

Figure 8.21 Distribution of Health Centres and Dispensaries in Nairobi

There are great disparities in health care between informal settlements and the middle- and high-income areas, and the health problems are also different. Middle- and high-income groups access healthcare through private clinics or government hospitals whereas informal settlements are largely left out.

In Nairobi, just like in the other part of the country, privatisation and cost-sharing make healthcare costs unaffordable to the poor. Due to lack of access to clean water, poor hygiene, and the high densities in the informal settlements, illnesses, such as diarrhoea, malaria and tuberculosis affect a large number of slum dwellers. Poor living conditions due to high densities in informal settlements are also the reason for greater mortality rates compared to the middle- and high-income areas.

3) Public Spaces and Recreation Area

Public spaces and recreational areas provide spaces for people to relax and carry out certain social activities at a minimal cost or at no cost at all.

These areas are also important for the youth as they provide spaces for alternative recreation activities such as sports and performing arts. The low cost of accessing these spaces is important considering that the youth are likely to have limited financial means.

Public spaces and recreation areas in Nairobi include:

- Parks and gardens;
- Sports stadia;
- Social halls.

Public parks and gardens in Nairobi include the following:

- Uhuru Park;
- Central Park;
- Uhuru Gardens;
- City Park;
- Jevanjee Gardens.
- Jamuhuri Park

a) Uhuru Park

Uhuru Park is located in the City's CBD and is a famous spot for its public events ranging from state celebrations on national holidays to public protests on social issues such as those led by Wangari Maathai among others.

Uhuru Park is arguably the most famous green space in the city with its green lawns, artificial lake, commemorative monuments and amusement parks. Indeed it is considered a key land mark and a considerable number of photos of the City's skyline are taken from the Park.

Uhuru park recreation ponds have a drainage channel that joins the Motoine Ngong river system near Mater Hospital in South B area. During the rainy season the fish in the ponds escape with flood water thus acting as a restocking source of tilapia (UoN, ASCO 2005).

b) Central Park

Central Park is located within Nairobi's CBD and directly opposite Uhuru Park. The Nyayo monument (Fimbo ya Nyayo) is a key land mark within the Park in commemoration of the Country's second President's ten (10 no) year rule milestone.

The park has a lawn with shade trees which is popular with city residents as a picnic site. It also has a children's playground with facilities for games by children.

c) Uhuru Gardens

Uhuru Gardens is located in Langata Sub-County. This historical site was the location of the first Independence Day celebration known as Jamhuri Day as held on 12 December 1963. On this day, Kenya celebrated its first state function as a republic.

Today, the memorial gardens as managed by the National Museums of Kenya are also used as a picnic site.

d) City Park

City Park was established in 1921 as a zoological garden on a 91 hectare area, and formally declared a public park in 1925. Nairobi's Parkland's residential area gets its name due to the presence of this Park. Today the Park covers 60 acres and was gazetted in 2009 as a protected area.

Other features within this park include:

- Pio Gama Pinto Memorial;
- Joseph and Sheila Murumbi's memorial and its related sculpture garden. Joseph Murumbi passed on a very respectable collection of Kenyan art pieces that have been featured at the Kenya National Archives;
- Picnic sites;
- A community of Sykes monkeys.

e) Jevanjee Gardens

The five acre recreation park was donated in 1906 by the Late Alibhai Mullah Jevanjee. The park is located at the northern end of Nairobi's CBD and is one of the few protected green spaces in the City.

The park provides a picnic site and a relaxation site for visitors to the CBD and features some artistic sculptures and benches for revellers.

f) August 7 Memorial Park

This park was established in August 2001 in commemoration of the people who lost their lives on 7 August 1998 through bombings by terrorists targeting the former United States of America (USA) embassy.

The park consists of manicured gardens, memorial walls and sculptures made of debris from the blast. The park is open to the public at a nominal fee of twenty shillings (Kshs 20.00).

The park can arguably be considered as a physical memorial to the global war on terror whose repercussions were felt by the people of Nairobi County.

g) Nyayo National Stadium

The stadium was completed in 1983 seats 35,000 persons and its football field was completed to Federation of International Football Association (FIFA). The stadium was constructed in anticipation of Kenya hosting the 4th All Africa Games in 1987.

The stadium is managed by the Sports Stadia Management Board.

h) Moi International Sports Complex-Kasarani

The Sports complex is located 15km from the City Centre off the Thika Super-Highway and is also managed by the Sports Stadia Management Board. The complex was also constructed in anticipation of Kenya hosting the 4th All Africa Games in 1987. The complex has several facilities including a stadium with a capacity of 60,000 persons.

i) City Stadium

City stadium is located off Jogoo Road and was formerly named African Stadium; Donholm Road Stadium then renamed Jogoo Road Stadium in 1963 before it was finally named Nairobi City Stadium. The stadium is managed by the City County of Nairobi and has a capacity of 15,000 persons.

j) Social Halls

Nairobi has Social Halls located at Sub-County Level under the management of the City County. Social Halls are a critical public utility for use by communities living around them. They are especially important to youth who may not have access to a lot of funding for organised recreation activities.

From consultations during the SEA studies, the youth view social halls as areas where they can come together for various activities such as sports. However financial constraints block them from fully utilising such facilities. It was also reported that the city's social halls have as spaces to link urban youth with employment opportunities especially if ICT can be incorporated into the social halls.

4) Transport Infrastructure

a) Road classes and functions

Nairobi has two international roads (Class A) forming the major arterial road in the City. The first is the Northern Corridor (A109/104) that includes Mombassa Road, Uhuru Highway, Chiromo Road, Waiyaki Way and Naivasha Road as the trunk road A104 then extends from Nairobi City Centre to the south thorough Kajiado and Namanga towards the Tanzanian Border. Further, A109 extends to the south-east and connects to Mombasa, the second largest city in Kenya, and to the west to Busia-Malaba on the border with Uganda, and forms the logistic axis for the inland countries.

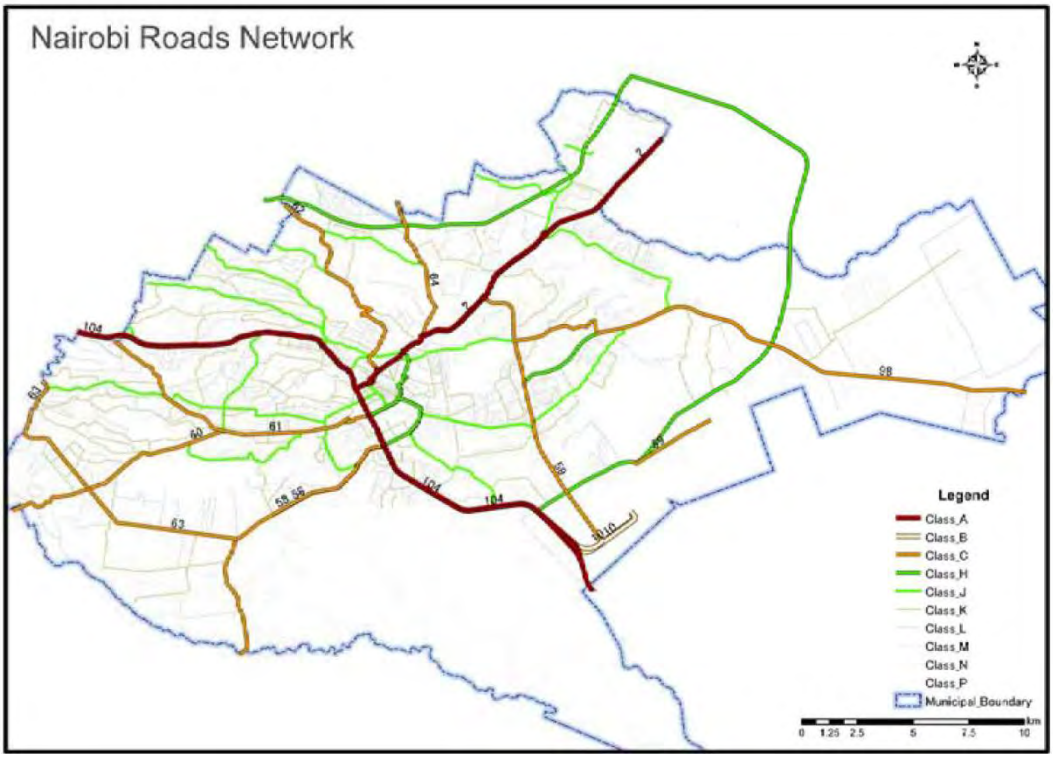
The second international trunk road is Thika Road (A2) that was constructed and improved currently with the assistance of AfDB and China. The road connects in the northeast direction from Nairobi City Centre to Thika then proceed North through Central Kenya, exiting at Nanyuki to proceed to the border with Ethiopia at Myale through Isiolo and Marsa bit.

Figure 8.22 shows the road network and road classification in Nairobi City County. Functions of major road of Class B, C and H are described in Table 8.26. Recently constructed Bypasses such as H6 and H7 are also included in the Table.

Table 8.26 Classified Roads in Nairobi and Their Function

Road No.	Name	Function	Covering Area
B10	Airport North Road	Principal Arterial	Airport north
C58	Magadi Road	Minor Arterial	Langata, Kajiado
C59	Outer Ring Road	Principal Arterial	Embasaki, Makadara, Kamukunji and Kasarani
C60	Ngong Road	Principal Arterial	Dagoretti, Langata to Kajido
C61	Naibasha Road	Minor Arterial	Dagoretti to Langata (Partly missing)
C62	Limuru Road	Principal Arter1al	Westlands
C63	Langata Road, Dugoretti Road, Kiambu Road and Ruiru Road	Principal Arterial	Langata, Kajiado, Kiambu
C64	Kiambu Road	Minor Arterial	Kassarani, Westlands
C98	Komarock Road	Principal Arterial	Embakasi, Kjiru, Kathiani
H6	Eastern Bypass	Principal Arterial	Embakasi, Njiru
H7	Northern Bypass	Principal Arterial	Klambu, Kasarani, Westlands

Source: JICA Study Team, Road functions are based on The Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area, JICA 2006



Source: NIUPLAN

Figure 8.22 Nairobi Roads Network Map

Issues for the road network structure are summarized as follows:

International trunk road traversed though the city from north to south known as the northern corridor, is the most crucial road for Nairobi City, however the corridor would be a barrier for the local traffic flow due to its traffic volume. Additionally, in the suburban area including densely populated area of east and west of the city, where housing development are in progress, access roads, collector roads and arterial roads which collect a large volume of traffics are insufficient. Therefore, roads of west-east direction across the northern corridor are always congested.

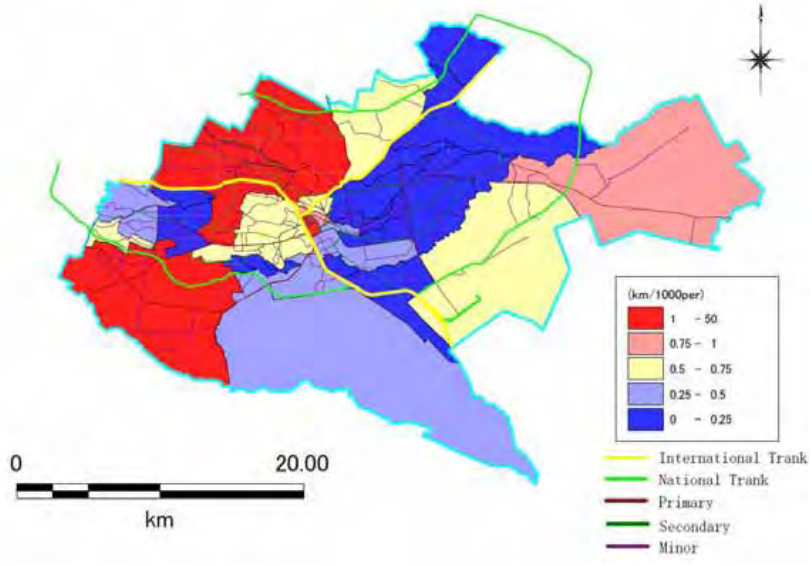
Number of lanes of existing road class A to J and roads more than 4 lanes are shown in Figure 8.23. Roads with more than 4 lanes are major trunk roads and roads in the city centre area.

Most of the roads with south-north direction are 2 lanes; consequently traffic demand concentrates to A 104. According to the traffic analysis by the NIUPLAN study team, traffic with east-west direction will increase in the future. Roads with east west direction will require to be strengthened.

Source: NIUPLAN

Figure 8.23 Number of Lanes on the Major Roads

The road length density by population is shown in Figure 8.25. The road length density by population of overall Nairobi City is 0.22km/1000 people. The western part of Nairobi City has a high road length density by population. However, the east side of Thika Road has low road length density; it indicates that there are not enough roads where the rapid increase in population is taking place.



Source: NIUPLAN

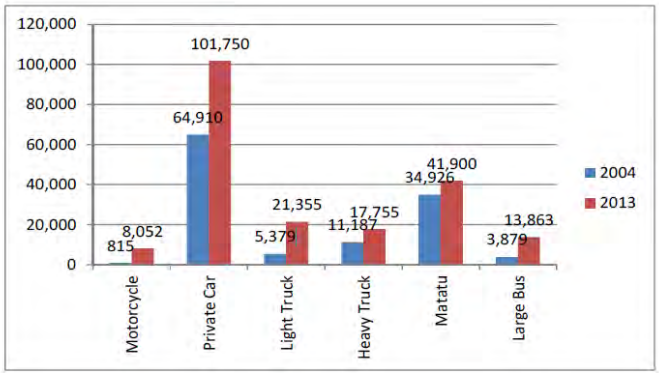
Figure 8.24 The Road Length Density by Population of the Target Road Network

In general, development/improvement of roads in Nairobi City concentrates to trunk roads, and development/improvement of small roads in residential area is left behind.

- Road traffic situation

For the road traffic, statistics from two different traffic surveys in Nairobi (2004 and 2013) were available for review allowing for comparison as follows.

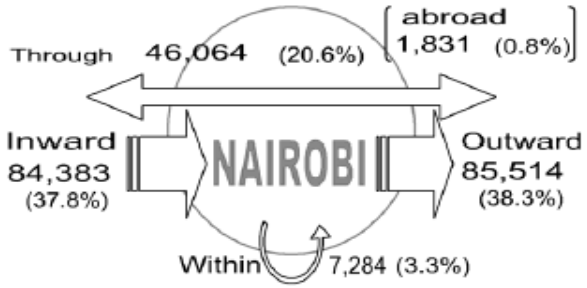
Compared with 2004 traffic survey, total traffic increased by 1.69 times in 2013 (almost doubled) as shown in the Figure 8.25 below.



Source: NIUPLAN

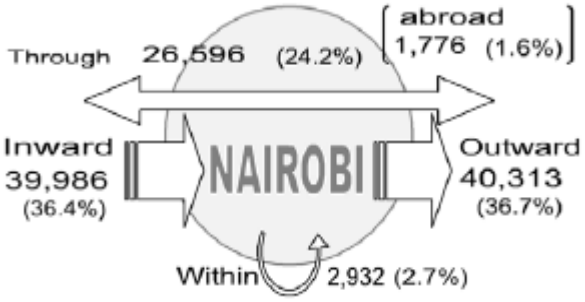
Figure 8.25 Comparison of Number of Vehicles in Nairobi by Type with 2004 Survey

Traffic survey conducted in 2013 indicate that in a day 46, 0000 vehicles are passing through city area, 84,000 vehicles are coming into the city and 86,000 vehicles are going out of the city. See Figure 8.26 and Figure 8.27.



Source: NIUPLAN

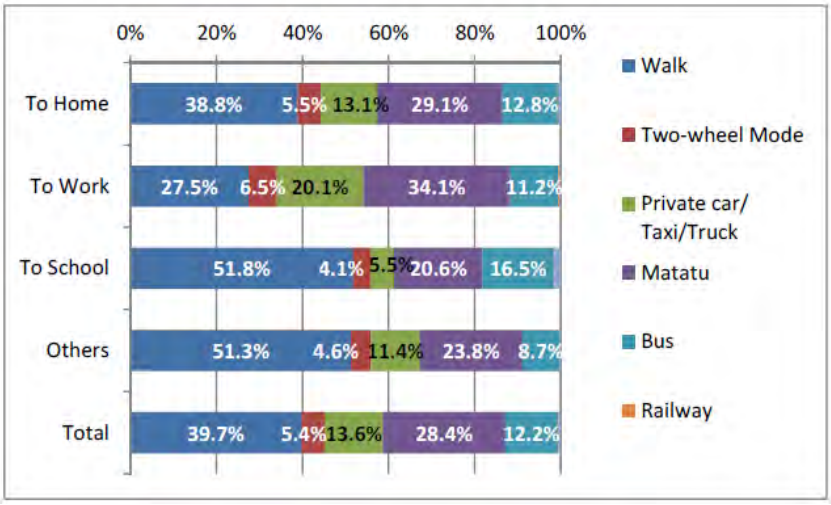
Figure 8.26 Total Traffic on All Cordon Line Survey Points.



Source: NIUPLAN

Figure 8.27 Total Traffic on A104 and A2.

Selection of travel mode has close relationship with trip purpose. Figure 8.28 shows the current travel mode composition by trip purpose. In every trip purpose except for "To Work", walking occupies largest share. Matatu occupies largest share in trip purpose "To Work", and is second largest in other trip purposes.



Source: NIUPLAN

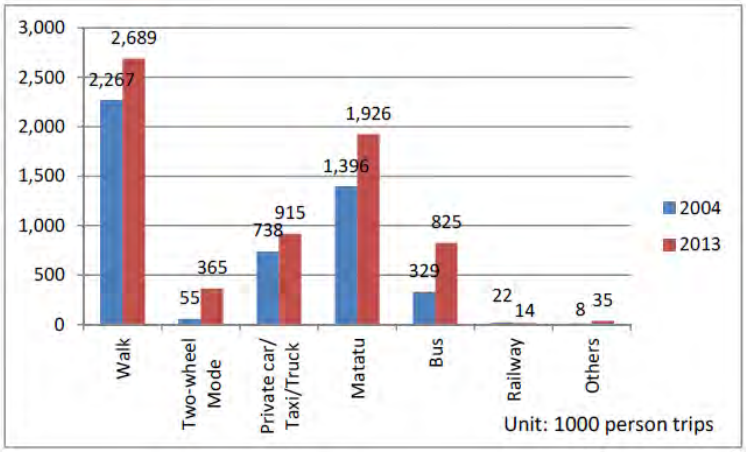
Figure 8.28 Travel Mode Comparison by Trip Purpose

Table 8.27 Number of Trips by Trip Purpose by Travel Mode.

	Walk	Two-wheel Mode	Private car/Taxi/Truck	Matatu	Bus	Railway	Others	TOTAL
To Home	1,170,560	165,266	392,633	878,839	383,876	5,512	17,349	3,014,035
To Work	479,317	112,098	347,084	591,842	195,493	6,708	2,313	1,734,855
To School	470,579	37,303	49,781	188,539	150,558	1,087	13,695	911,542
Others	568,351	50,332	125,901	266,587	95,424	699	2,135	1,109,429
Total	2,688,807	364,999	915,399	1,925,807	825,351	14,006	35,492	6,769,861

Source: NIUPLAN

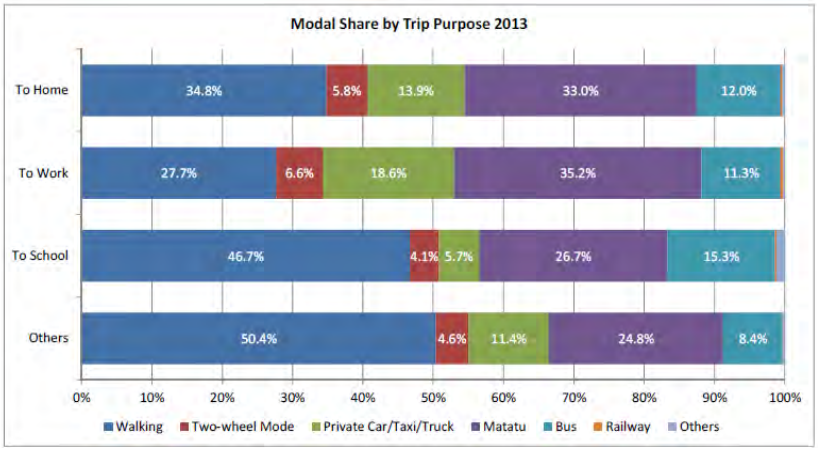
Figure 8.29 shows comparison of travel mode between 2013 and 2004. Compared with 2004, walking decreased and bus and Matatu increased. Among Matatu and bus, share of bus increased due to the promotion policy of the government which encouraged larger capacity public service vehicles.



Source: NIUPLAN

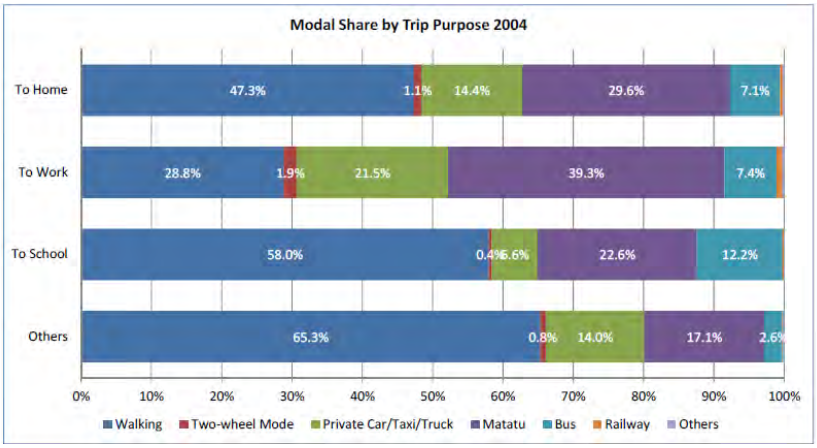
Figure 8.29 Comparison of Number of Trips by Travel Mode between 2004 and 2013.

Public Transport within Nairobi Public transport in Nairobi is mainly by bus and Matatu. Most of bus and Matatu terminals are located around the Nairobi railway station, but are not systematically located by direction or destination. Outside the city centre, lay-bys for bus stop are prepared on the trunk roads, but along minor roads, Matatus and buses often stop at roadsides or intersections for picking up passengers, which cause obstacle in traffic flow of the roads. According to the interview with the public transport passengers, three major requirements of bus/Matatu passengers were: 1) Improvement of bus stop facility/Information; 2) Improvement of accessibility; and 3) Improvement of regularity/punctuality. As a result of the screen line survey, total number of Matatu was 72,000 and large bus was 23,000. Applying the average number of passengers of 10 passengers per Matatu and 27 passengers per a large bus, the total number of passengers crossing the screen line by Matatu is 720 thousand and 620 thousand by bus. Figure 8.30 and Figure 8.31 show that modal shift to the public transport was not much in progress. Considering the traffic condition in Nairobi, use of public transport should be encouraged more. To this end, conditions and quality of public transport operation should be improved in such a way that there is higher operation speeds, punctuality, better accessibility to terminals and convenience for passengers.



Source: NIUPLAN

Figure 8.30 Modal Share by Trip Purpose 2013



Source: NIUPLAN

Figure 8.31 Modal Share by Trip Purpose 2004

From the traffic surveys, many people walk to work along the arterial roads and in the urban streets. Walking occupies a large proportion among the travel modes as shown in Figure 8.30 and Figure 8.31. Therefore, NMT facilities for safe, comfortable and easy movement is necessary especially in traffic congested areas. In this viewpoint, the followings are pointed out from current situation:

- Sideways are narrow; x Marking for pedestrian crossing is not sufficient;
- Pedestrian crossing signals are insufficient, sometimes not working and are neglected by drivers and passengers;
- Along some roads, sideways are provided, but still are not formulating pedestrian network; and
- There are no dedicated lanes for bicycles in urban area.

b) Railway Transport

The main line of the Kenya Railway Corporation (KRC) is the line from Mombasa to Uganda through Nairobi. It has some spurs serving the city. Many railway commuters are using this line from Athi River (South-East direction) to Nairobi, and from Kikuyu, (North-West direction) to Nairobi. Many passengers are also commuting from Ruiru, (North-East direction) to Nairobi, on a branch line towards Thika city. A short branch line towards Embakasi Village is also used for commuting purpose. Except for few stations, the existing station buildings are small and not well maintained and access roads to stations are generally in poor condition.

The existing commuter train service has been operated by KRC since July, 2017. The concessionaire of train operation by Rift Valley Railways (RVR) since 2006 was terminated due to its management difficulty. Table 8.28 shows operational sections.

Table 8.28 Operational Commuter Train Services in Nairobi

Section	Description
Ruiru Section (32km)	Operating 22 coaches train, 2 trains/day, total 6,900 passengers/day in 2010, total 7,450 passengers/day in 2011, and 5,350 passengers/day in 2012.
Kahawa Section	Operating 16 coaches train, 2 trains/day, total 6,900 passengers/day in 2010. From 2011, 8trains/day, 7,500 passengers/day in 2011, and 3,950 passengers/day in 2012.
Embakasi Section	Operating 10 coaches train, 2 trains/day, total 2,300 passengers/day in 2010. From 2011, 8 trains/day, 4,960 passengers/day in 2011 and 3,030 passengers/day in 2012.
Nairobi–Kikuyu Section	Operating 10 coaches train, 2 trains per day, total 4,200 passengers/day in 2010, 1,100 passengers/day in2011, and 1,910 passengers/day in 2012.

Source: NIUPLAN

KRC is planning to strengthen commuter train services by providing new lines as indicated in red lines on the following map. Recently, KRC launched the Nairobi-Syokimau commuter service.

Source: NIUPLAN

Figure 8.32 Existing and Planned Railway Lines

c) Airports

Air transport mode plays a significant role in economic growth of the country. In Kenya, it is the main transport mode for tourism, high value export and import and perishable good. Also Kenya occupies a strategic position as an Aviation centre in the Eastern and Central Africa region. In the last ten years air traffic through Kenya's airports has increased substantially from 4,748 thousand to 8,584 thousand annual passengers.

Nairobi has two civil airports: Jomo Kenyatta International Airport (JKIA); and Wilson Airport and a military airbase, Moi Air Base located in Eastleigh.

JKIA is located 18 km from city centre to serve as a domestic hub and International gateway in Kenya. JKIA is the 7th busiest airport in Africa and a major hub in East and Central Africa for tourist and cargo movement. Wilson Airport is located 5 km south of the city and neighbours Nairobi National Park.

Wilson Airport is used mostly for both domestic and international general aviation traffic. It lies approximately 18 kilometres west of JKIA.

Source: NIUPLAN

Figure 8.33 The Location of Civil Airports in Nairobi

JKIA is projected to grow with the growth of Kenya's economy, as well as increase in foreign currency income. In 2011, JKIA had more than 80 % of its total passenger traffic from international flights and around 40 % from domestic flights. Moreover, JKIA had 65 % of the total flights in Kenya in 2011.

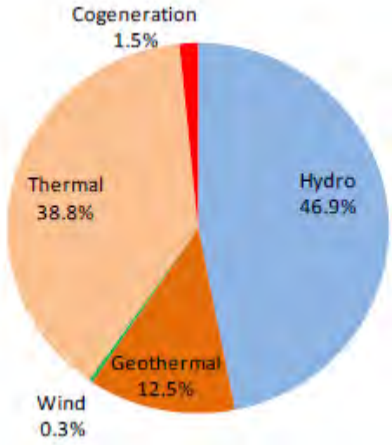
Key environmental issues associated with Airports in Nairobi are the land use compatibility with certain infrastructure e.g. solid waste sites, waste water treatment, sanitary landfills and national parks.

5) Energy

Energy is needed for cooking, heating and lighting of households, power for industry and transportation. Households, commerce and industry in Nairobi use a combination of fuels. Energy sources used include biomass, fossil fuels, hydro and geothermal energy.

Figure 8.34 shows the composition of power-generating facilities in Kenya. The ratio is for

installed capacity of the facilities and is composed of only total interconnected system. As shown in the figure below, hydro-power constitutes 46.9 % of total generation capacity for the main network system. Because of the large portion of hydro-power, seasonal variation of power generation occurs due to amount of rainfall. The total generation capacity of main network system is 1,680.4 MW as installed capacity and 1,253 MW as actual output capacity. Besides the interconnected system, there are isolated systems mainly in northern part of Kenya. The off-grid installed capacity is totally 10.1 MW.



Source: NIUPLAN

Figure 8.34 Composition of Power Generating Facilities in Kenya

The factors determining choice of energy use depend on its relative price and the appliances that it will use; income levels; the availability of the fuel and related appliances in the market; and cultural preferences. Biomass is by far the most predominant fuel, providing over 74 per cent of energy consumed in the country (NEMA 2003).

Baseline surveys reveal that Nairobi consumes approximately 91,250 tons of charcoal annually, equivalent to the destruction of over 900,000 tons of green wood each year (Barnett and Ndanyi 2003). According to Commission on Revenue Allocation (2011), 72.4 per cent of Nairobi households are connected to electricity. For cooking, however, 68.3 per cent of households use kerosene, 19.8 per cent liquefied petroleum gas (LPG), 7.4 per cent charcoal and only 1.8per cent electricity (CBS et al. 2004).

Available data on energy use disaggregated by gender show some differences with16 per cent of men using LPG or electricity compared to 3per cent of women (CCN, 2007).

Source: NIUPLAN

Figure 8.35 Energy Use by Gender

Renewable energy used includes solar, wind and hydropower. Other energy sources commonly used include power alcohol, biogas and municipal solid waste. These, however, have not been well developed.

Table 8.29 shows number of customers, total sales and maximum demand in Nairobi city. The number of customers in Nairobi increased by more than 100,000 annually from 2009/10 financial year. Moreover, according to Kenya Power's new connections report 2012 to 2013, the number of customers in Nairobi recorded 1,062,329 in April, 2013.

On the other hand, the latest data of total sales in Nairobi region experienced a slight decrease from the previous year. This is probably because poor rainfall resulted in a reduction in hydro generation in the first half of 2011/12 financial year, and thus suppressed the sales. Table 8.30 shows the sales by tariff type. From the Table, the sale for domestic in 2011/12 financial year decreased from previous year. Also the sales for small commercial and large commercial and industrial road (11 kV) decreased.

Table 8.29 Power Demand and Supply in Nairobi Region

Nairobi Region	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12
Number of Customers	445,595	505,414	595,010	669,128	814,251	921,548
Total Sales (GWh)	2,595	2,782	2,950	3,071	3,332	3,290
Maximum Demand (MW)	522	548	568	588	623	662

Source: Kenya Power Annual Report and financial Statements 2012

Table 8.30 Sales for Type of Customers Covered by Tariff

Tariff	Type of Customers Covered by Tariff (GWh)	2008/09	2009/10	2010/11	2011/12
DC	Domestic	800	804	888	841
SC	Small Commercial	400	402	435	426
CI1	Large Commercial and Industrial Load (415V)	757	752	760	760
CI2	Large Commercial and Industrial Load (11kV)	598	652	736	727
CI3	Large Commercial and Industrial Load (33kV)	0	3	4	3
CI4	Large Commercial and Industrial Load (66kV)	272	326	368	384
CI5	Large Commercial and Industrial Load (132kV)	20	31	30	34
IT	Off-peak	40	34	36	41
SL	Street Lighting	11	11	12	11
	R.E.P. Schemes	52	55	63	63
	TOTAL	2,950	3,071	3,332	3,290

Source: Kenya Power Annual Report and financial Statements 2012

Nairobi region has a problem of unreliable electricity. The current condition of power quality in Nairobi is the worst of all the regions in the country. In many cases, blackout occurs when a tree touches a distribution line or an uprooting of a tree makes disconnection.

Table 8.31 shows blackout incidence by sub region. The column of target as on 29th April, 2013 in the table shows objective number of incidences from 1st to 29th April, 2013. Incidences per 1000 customers as on 29th April, 2013, shows the comparison; Nairobi North and Nairobi West are particularly higher than other regions, as well as Nairobi South is high.

Table 8.31 Daily Monitoring of Blackout Incidence

Sub Region	Target	Actual (All Incidences)	Incidences per 1000	% Variance
Nairobi North	1,236	6,256	14.68	-406.1 %
Nairobi West	773	3,025	11.35	-291.3 %
Nairobi South	1,072	2,323	6.29	-116.8 %
Coast	700	1,023	4.24	-46.1 %
Central Rift	536	409	2.21	23.7 %
North Rift	369	541	4.25	-46.4 %
West Kenya	729	1,774	7.06	-143.4 %
Mt. Kenya North	610	764	3.63	-25.3 %
Mt. Kenya South	444	844	5.51	-90.0 %
TOTAL	6,469	16,959	7.60	-162.1 %

Source: Kenya Power (As on 29th April, 2013)

Based on this, Kenya Power has been making effort to deliver adequate and reliable power to Nairobi and other regions. During 2011/12 financial year, under the Energy Sector Recovery Project, Kenya Power installed modern equipment. Moreover, Kenya Power has undertaken to implement underground cabling project.

In NCCG, vandalism to the electricity system such as stealing electricity, stealing oil or copper from transformers and eventually stealing transformers themselves are also common problems. As countermeasures for vandalism, Kenya Power has been executing some preventive measures such as police patrols, spot-welding, reinforcement and relocation of transformers to safe areas, and installation of electronic burglar alarms.

Every type of energy generates varying degrees of environmental externalities that affect human health, ecological stability, and economic development. These effects can occur at the household community, regional, national or trans-national levels.

Environmental issues in energy sector in Nairobi include:

- Wayleave for power transmission and distribution lines. The land of transmission line needs to be utilized effectively;
- Safety and electromagnetic radiation issues associated with power lines and sub stations
- Inadequate power supply. There is need to investigate power supply capacity for railway development as proposed in the plan;
- The demand for charcoal in Nairobi is threatening the nearby Aberdares forest, which plays an important role in the city's water catchment system and at the same time, is home to endangered animal species such as the forest elephant (UNEP/UN-Habitat 2006);
- Air pollution and climate change. Studies in Kenya have indicated that charcoal production and consumption in Kenya could be emitting more greenhouse gases (mainly CO2, CH4 and NOx) into the local atmosphere than industry and transport sectors combined (ROK 2003); and
- Indoor air pollution and public health. Pollution from unvented cooking stoves is a major cause of respiratory illnesses

6) Sources of Water for Nairobi City

In line with the Water Act 2002, bulk water and sewerage services for the project area are provided by the Athi Water Services Board (AWSB) that serves Nairobi City as well as 13 towns in the Nairobi Metropolitan Area within the Athi water catchment area.

The Water Service Provider (WSP) for Nairobi County the Nairobi City Water and Sewerage Company (NCWSC). The water sources for the City are all located outside the Nairobi County administrative boundaries as follows:

- Kikuyu Springs-comprising of 3 springs located 18km west of the City, yielding a total of 4,800m3/d (0.056m3/s). The springs were the first source of potable water for Nairobi, developed between 1900 and 1906.
- Ruiru Dam on Ruiru River, located 25km north of the City. The Dam was constructed in 1950 and has a safe yield of 21,700m3/d (0.25m3/s)
- Sasumua Dam on Sasumua River, located 60km north of the City. The Dam was constructed in between 1956 and 1968. It has a safe yield of 68,400m3/d (0.79m3/s)

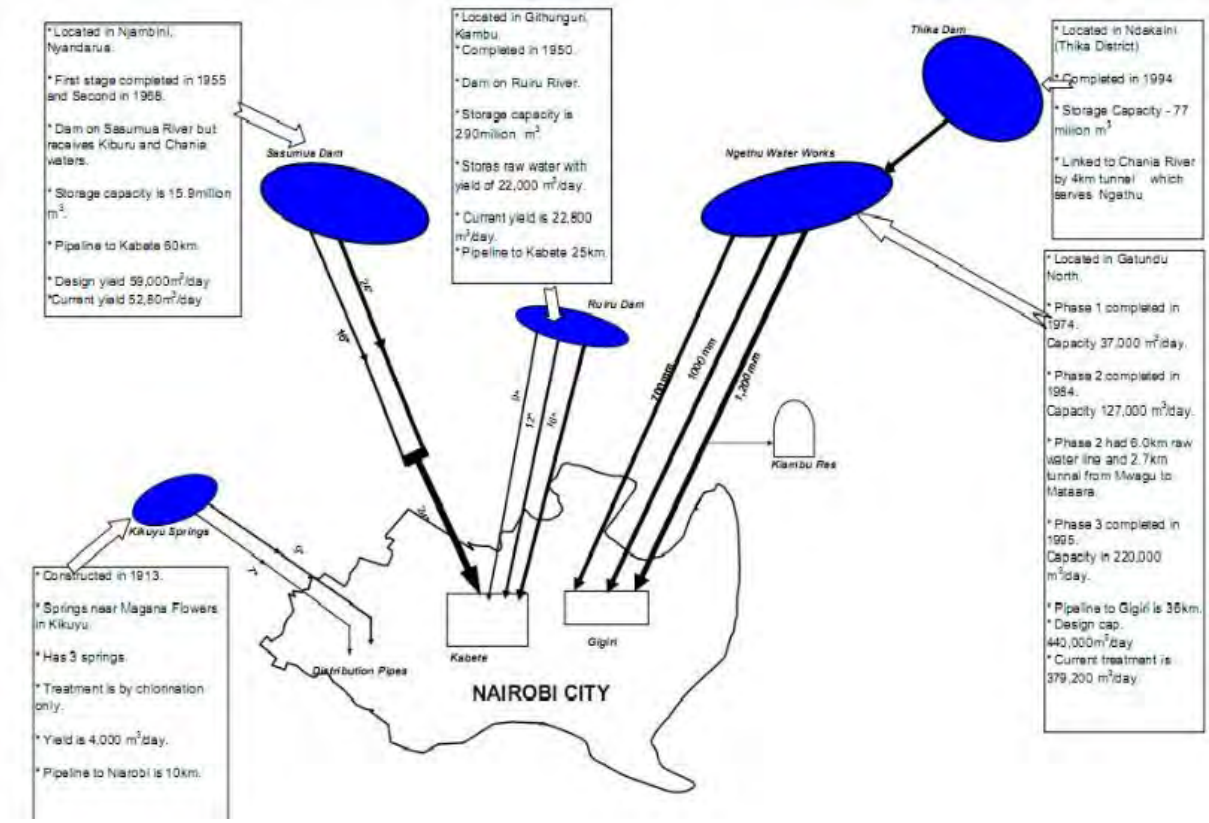
- Third Nairobi Water Project (Thika Dam-Mwagu Intake System):- This System comprises of the following sources:
  - Mwagu Intake Weir on the Chania River, located 40km North of Nairobi
  - Thika Dam (Ndakaini), located 50km North of Nairobi. The Dam impounds water from Thika River, supplemented by flows diverted from the Kiama and Kimakia Rivers. The Dam was constructed between 1989 and 1994. The design capacity of the Thika Dam-Mwagu System is 460,000m3/d (5.3m3/s). Due to various operational constraints, average production from the System is 415,000m3/d (4.8m3/s).

Figure 8.36 outlines the schematic for the water supply sources named above while their capacities are summarized in Table 8.32:

Table 8.32 Summary of Current Existing Water Sources for Nairobi

Water sources	Capacity (m³/day)
Kikuyu Springs	4,800
Ruiru Dam	21,700
Sasumua Dam	56,200
Thika / Chania / Ngethu System	414,700
Groundwater Sources, including 2,700 individual domestic boreholes	45,000

Source: Feasibility Study and Master Plan for Developing New Water sources for Nairobi and satellite towns. Volume 1: Master Plan Report



Source: NIUPLAN

Figure 8.36 Water Sources for NCWSC

a) Current Demand vs. Supply

According to the 2009 population census, the total population in Nairobi was 3,138,369. Estimates indicate that Nairobi Metropolitan region water demands stands at 1,621,312 m3/day and is estimated to grow to 2,117,194 m^3/day by 2035. Water demand for the rapidly growing Nairobi county has far by passed its average water supply of 460m^3/day (147 litres per capita) to a demand of 837m^3/day (267 litres per capita). This indicates that there is a deficit of 377m^3/day (117 litres per capita). The situation is worsened by high Non Revenue Water (NRW) levels averaging 40% or 189 m^3/day of water losses leaving only 271 m^3/day out of the 460 m^3/day for consumption (Mwaura and Tsuma, 2012).

b) Current challenges facing water resources in Nairobi

Leakage due to over-aged infrastructure: Overaged infrastructure causes leaks and losses. According to AWSB, Unaccounted for Water (UfW) has been reduced from 65% to 42% since its inception. Most of the unaccounted for water is lost through illegal connections and technical losses due to underground leakage from dilapidated piping system (Mafuta et al., 2011).

Continued degradation of water catchment areas: Increased human activities in these areas have led to degradation of the catchment areas and this has led to a decrease in water flows into the rivers.

Lack of access to water supply in informal settlements: Currently only 50% of Nairobi's residents have access to piped water and 40% receive water on a 24 hour basis (NCWSC and AWSB, 2009). Residents in informal settlements are the mostly affected. 60% of Nairobi residents live in these informal settlements. Insufficient supply of piped water often leads to high water prices in water kiosks. This has contributed to the rampant illegal connections especially in slum areas as the residents try to meet their daily water demands.

High poverty levels: This involves payment of user charges which may not be successful among the poor especially in slum areas. This has been a challenge in trying to ensure that the population is adequately supplied with water.

Lack of a comprehensive land policy: The owning of land in water catchment areas has posed a challenge as with various developmental activities on the piece of land, it leads to decreased water flows to the rivers.

Poor governance and corruption; Prevent effective use of resources and may lead to such resources being diverted away from the plans activities if not addressed.

Increased Energy Cost impact on the cost of delivering water services to the people at an affordable price. This problem is also compounded by the fact that people are reluctant to pay for water services.

Discharges to river systems: Various toxic discharges into Nairobi Rivers have led to increased costs in treating the water to make it suitable for use. The Nairobi Rivers Basin Program as spearheaded by the United Nations Environment Program (UNEP) conducted a pollution assessment survey on the 3 main rivers within the basin namely the Nairobi, Motoine Ngong and Mathare Rivers. The survey results demonstrated high levels of pollution throughout the River Basin. Raw sewage from the informal settlements and discharges from industries were found to be the main polluters of the Nairobi Rivers. Other key sources of pollution were identified as incidences of burst/blocked sewers, direct release of industrial effluent and solid waste discarded into the river (UNEP, 2005). A number of factories in Nairobi's industrial area

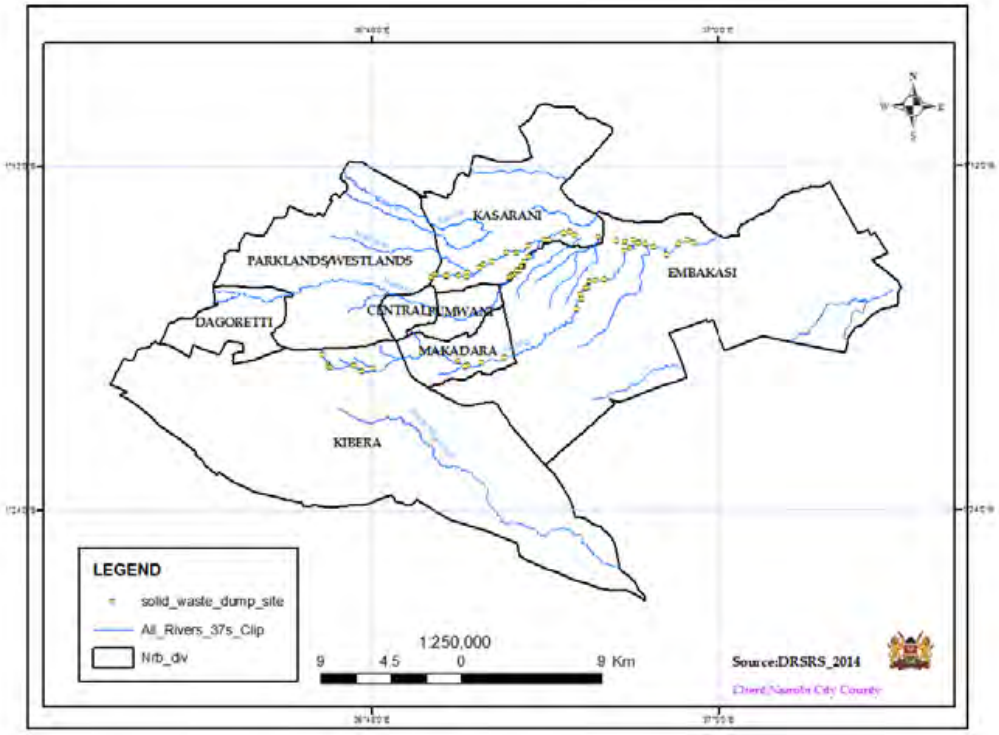
discharge waste directly into the Ngong River, making it the most polluted river in Kenya. Industrial waste effluents include petrochemicals and metals from micro-enterprises and "Jua-kali". As well, oil and grease from the busy roads run off into adjacent waters.

The Nairobi River network also receives improperly treated effluents from the Dandora Sewage Treatment Plant and several drainage channels that gather storm water from Nairobi City. Domestic garbage from informal settlements that have no public waste collection services also finds itself into the rivers as sewage from pit latrines and other on-site sewerage-disposal methods. In addition to locally generated water pollution, the city receives effluents that enter the rivers from human activities of further field.

Figure 8.37 and Figure 8.38 show illegal dumping along the Nairobi Rivers.

Source: NIUPLAN

Figure 8.37 Polluted Section of Nairobi River



Source: NIUPLAN

Figure 8.38 Illegal Dumping Sites along Nairobi Rivers

Water quality test conducted on samples collected by AWSB from Nairobi River at various section in December 2013 are presented in Table 8.33. Results indicate that water quality at most points along the river are beyond established local standards.

Table 8.33 Monitoring Nairobi River Water Quality against Effluent Standards

		STANDARD		RESULTS										
PARAMETER	UNIT	DISCHARGE TO THE ENVIRONMENT	DISCHARGE TO THE PUBLIC SEWER	Nairobi River at Kabuthi bridge	Nairobi river at Car wash	Nairobi River at the bridge of Globe overpass	Nairobi River Bridge Hailie Selassie near police houses	Nairobi River at Kamkunji	Nairobi river at 1st avenue bridge	1 km upstream, Dandora stp at the bypass bridge, Ruai	100m downstream, dandora stp at ruai	Mathare river at muthaiga overpass	Gitathuru river at overpass, gitathuru river	Mathare river at national cement, bab dogo	Mathare river at mathare north bridge
Temperature	°C	±3 ambient temp	20-30	22.1	22.3	22.6	22.8	22.8	23	23.6	23.9	23	22.6	23.2	23.6
pH	pH Scale	6.5-8.5	6–9	7.73	7.75	7.42	7.53	8.09	8.14	7.69	7.96	7.71	8.2	7.75	7.79
Conductivity	µ S/Cm	–	—	542	410	542	553	668	665	670	748	410	272	684	684
BOD5 days at 20°c	mgO_2/l	30	500	2	7	13	13	160	175	150	180	43	NIL	235	210
COD	mgO_2/l	50	1000	26	13	26	33	354	417	506	822	109	8	1138	506
Total Alkalinity	$mgCaCO_3/l$	–	–	70	70	150	160	230	220	240	270	130	60	220	250
Total Suspended Solids	mg/l	30	250	80	70	50	40	950	1100	167	200	50	20	350	300
Total Dissolved Solids	mg/l	1200	2000	336	254	336	343	414	412	415	464	254	169	424	424
Sulfides as S^{2-}	mg/l	0.1	2	<1	<1	<1	<1	6	6	8	10	<1	<1	18	20

Source: NIUPLAN

7) Waste Water Management

a) Current situation

Averagely, wastewater released on a daily basis in Nairobi approximately adds up to 800,000 m3/day. However only 50% of this amount reaches Dandora wastewater treatment plants as the rest is directly used in irrigation without treatment. This poses health risks to the consumers of such crops who are the residents of Nairobi as well as environmental degradation from release of toxic chemicals directly into the environment (Githuku 2009). Sources of waste water in Nairobi include industries such as breweries, domestic sources (black, and offices among others.

Sources of waste water in Nairobi include:

- Storm water rainfall drains from roofs, car parks that may contain traces of oil and fuel;
- Domestic waste water from kitchen, bathroom, toilets and other household sources;
- Industrial waste water from various industries within Nairobi such as breweries.

b) Treatment facilities and efficiency

There are 24 existing sewerage treatment plants (STPs) in Nairobi City, but most of them are localized STPs with a small capacity less than 2,000 m3/day. The major STPs are the Dandora STP (capacity 120,000 m3/day) and the Kariobangi STP (32,000 m3/day).

A report by the Nairobi City Water and Sewerage Company (NCWSC) indicates that these STPs are not well-functioning in terms of actual sewerage treatment volume and water quality of treated outflow as shown in Table 8.34. In particular, the Kariobangi STP suffers from the deterioration and mechanical troubles and is not operational substantially.

Table 8.34 Operating Conditions of Existing Major STPs in Nairobi City

STP	Type	Capacity (m^3/day)	Sewerage Inflow (m^3/day)	Treated Outflow (m^3/day)
Dandora	Lagoon	120,000	90,870	69,941
Kariobangi	Conventional biological aerated filter	32,000	11,933	(N/A)

Treatment

STP	Item	Water Quality (mg/L)		
		Sewerage Inflow	Treated Outflow	Effluent Standard
Dandora	BOD	375	66	30
	COD	924	245	50
	TSS	500	113	30
Kariobangi	BOD	340	194.8	30
	COD	774.7	373.1	50
	TSS	306.5	77.3	30

Source: NIUPLAN

c) Existing challenges

Dumping of overloaded effluent into the sewer system which does not meet the required discharge standards.

These include among others;

- Non-biodegradable detergents;
- Plastics and polythene carrier bags;
- Large physical materials (hides and skin);
- Oils, fats and grease;
- Non-biodegradable solids such as heavy metals, sand and grit;
- High levels of nitrates and phosphates.

Impacts of the above challenges;

- Regular breakdown of machines and equipment at the mechanical treatment facility due to overloading;
- Nuisance presence of plastics and other floating materials in the biological ponds;
- Reduced effectiveness of the pond performance due to these floating materials;
- Proliferation of different species of algae growth and other water weeds, Reduced performance of the biological micro-organisms due to presence of heavy metals, oils and grease;
- Reduced lifespan of the biological ponds due to faster build-up of inorganic solids, Poor final quality of effluent due to high algae growth.

d) Existing plans

AfDB have funded the Nairobi Rivers Sewerage Improvement project through expansion and extension of sewer lines as well rehabilitation and construction of anaerobic ponds at the Dandora wastewater treatment plant (AWSB 2012).

An interview with the Director of Urban Rivers rehabilitation programme Mr. Akotsi on 1 October 2013 indicated that it is prudent to come up with a policy to protect urban Rivers. This will greatly control development around these rivers which contribute to their pollution. If this is applied the rivers in Nairobi will be rehabilitated and hence restore their ecosystems as well

as provide clean water for use by the Nairobi residents.

8) Solid waste management

Nairobi City population continues to rapidly increase every year. This growth has led to increased generation of solid waste. Nairobi solid waste generation is sourced at household, commercial and industrial levels. EMCA 1999 lay down basic guidelines for management of solid waste. Management of solid waste in the city is facilitated by Nairobi City County as stipulated in the Local Government Act. Nairobi City is facing challenges in regard to solid waste management since insufficient personnel and resources are limited. Moreover, the only official dumpsite in Nairobi, located in Dandora is full leading to mushrooming of illegal dumping sites on open grounds around the County.

a) Waste streams

About 50% of waste generation in Nairobi comes from informal settlements which host about 56% of Nairobi population. JICA 1998 study estimated that about 82.6% of wastes generated in Nairobi are from households. This statistics reflect waste generation per capita to be at 0.59 kg/person/day which increased in 2004 to 0.61 kg/persons/day (Kasonzi & Blottnitz, 2010).

Table 8.35 below shows the trends of solid waste composition.

Table 8.35 Trend of Solid Waste Composition

Waste type	Percentage composition			
	MoLG & FARID 1985 (Cited in Kibwage, 1996)	JICA, 1998	ITDG, 2004 (Cited in Bahri, 2005)	UNEP/CCN/NTT , 2009
Organic	78	58	61.4	50.9
Paper	10.2	17	11.8	17.5
Plastic	4.1	12	20.6	16.1
Glass	3.8	2	0.7	2.0
Metals	1.9	3	0.6	2.0
Others	2	8	4.9	11.4

Source: NIUPLAN

The data in the table indicate that organic waste has been decreasing while paper waste increased which can be attributed to change of lifestyle in Nairobi due to increase in packaged food in the market. The increase in plastic, glass and metal waste in the city is because of rapid urbanization that is occurring to meet the city population demand.

Solid waste generation in Nairobi in 2010 was estimated to be at 1,848 tons/day as shown in Table 8.36.

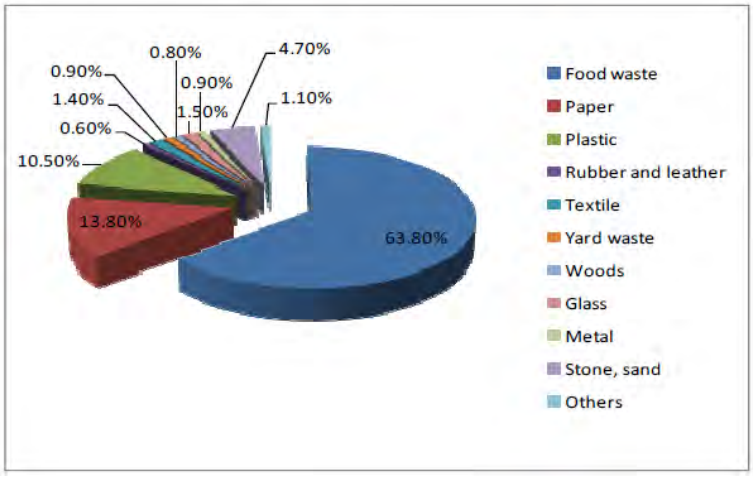
Table 8.36 Amount of Waste Generation in Nairobi in 2010

Generation source		Number [person or establishment]	Unit generation rate [kg/day/number]	Total [kg/day]
Residential	High income	397,362	0.621	246,635
	Middle income	1,066,393	0.474	505,076
	Low income	1,576,245	0.360	566,670
Commercial	Shop	47,941	0.5	23,970.5
	Restaurant	1,582	38	60,116
	Standard hotels	140	350	49,000
	Lodging house	586	100	58,600
	Public facilities	500	137	68,500
	School	2,847	32	91,104
	Industrial plant	501	150	75,150
	Other establishment	27,077	0.5	13,538
Market		44	2045	90,000
Street		563.3	106	(60,000)
Total				1,848 t/day

Source: NIUPLAN

b) Characteristic of solid wastes in Nairobi

Food waste contributes more than 60% of total waste generation in Nairobi indicating that most of the waste generated and collected in Nairobi are organic wastes. Inactivation of control of plastic bag usage in 2017 would reflect to the composition of solid waste in Nairobi in near future.



Source: NIUPLAN

Figure 8.39 Composition of Solid Waste in Nairobi

c) Solid Waste Management

In Nairobi, waste management stakeholders include NCCG, Ministry of Environment, Water and Natural Resources, Ministry of Lands, Housing and Urban development, Non-governmental organizations (NGOs), Community Based Organizations (CBOs) and the private sector (Njoroge, K & Ndunge, 2014). Local Government Act CAP 265 mandates Nairobi City County to regulate and manage waste generation, disposal and collection within the city.

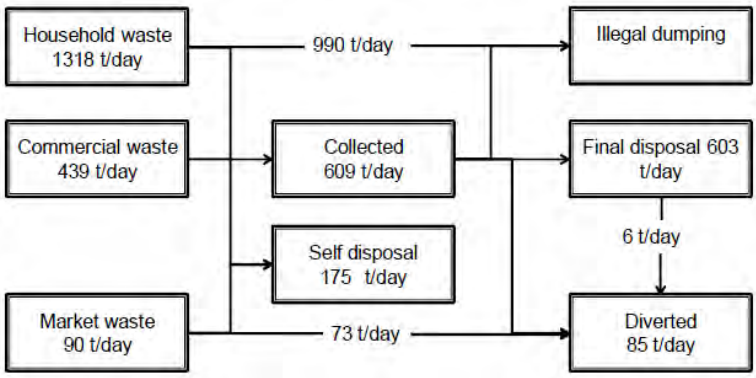
JICA 2013 survey estimated the capacity of total waste generation in Nairobi in 2010 to be 1848 tons/day. Of all the waste generated in Nairobi, only 40% is collected and disposed of in designated dumping site in the county (NEMA 2014). This implies that 60% of waste generated in Nairobi is illegally disposed either in open grounds, drains or burnt.

The collection and transportation of solid waste is implemented by Department of Environment (DOE) in the NCCG, the private companies contracted with DOE, Private Service Providers (PSPs) and Community Based Organizations (CBOs).

To enhance the collection of waste in the city, NCCG hired private service providers who collect 25% of total waste collected around Nairobi County. NCCG use station type method for waste collection while private service providers and Community Based Organizations (CBO) mainly use door to door method of waste collection. Despite the involvement of private service providers and CBOs in waste management, studies estimated that 26 percent of households in high-income areas, 16 per cent of those in middle-income areas, and 75 per cent of those in low-income areas do not receive any service (JICA 1998).

Waste picking is done either at point source, area or at Dandora dumping site at a very small scale especially by low income earners. The wastes picked are majorly recyclable and reuse materials which are sold to junk buyers.

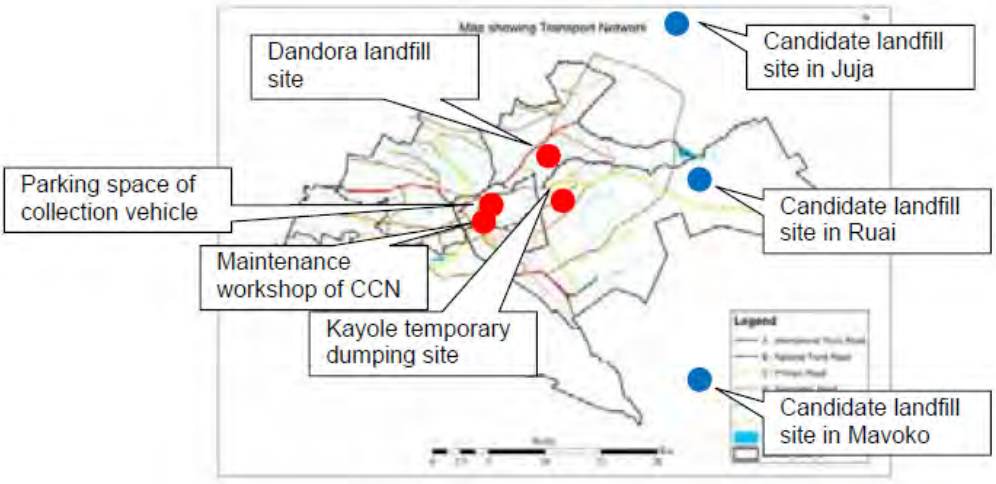
The collected waste is transported into Dandora landfill site or other dumping sites. Some of the collected waste is illegally dumped. There are some areas where wastes cannot be collected by CCN or private company due to not enough wide access road. In such cases, CBO collected the waste. The waste flow from generation source to final disposal site is shown in Figure 8.40.



Source: NIUPLAN

Figure 8.40 Solid Waste Flow in Nairobi County (2009)

The facilities related to solid waste management and management situation are shown in Figure 8.41.



Source: NIUPLAN

Figure 8.41 Solid Waste Management Facilities

Environmental challenges of solid waste management in Nairobi City County include:

- Insufficient resources for waste collection leading to illegal dumping and littering in the city;
- Rapid increase in population in the city and mushrooming of informal settlements;
- Uncontrolled and indiscriminate dumping of waste; x Pollution of air, water and soil since the dumping sites are open;
- Health risks associated with waste since some of people lack appropriate tools to sort out waste in dumping site such as zoonotic diseases from stray animals found in at dumping site;
- Waste droppings along the roads from vehicles that transport waste to the dumping site; and
- Safe disposal and management of increasing inorganic waste characteristics in the city.

Although Nairobi City County regulates and control waste management activities in Nairobi City County, there is limited performance shown in proper waste management in the city such as

- The trucks used to collect waste are old and not up to standards to ensure safe transportation of waste to the dumping site.
- Lack of sufficient resources supply to the county waste collectors hence most people end up picking waste with their bare hands
- There is a gap between the administrators and the people on the ground who have been permitted to collect waste hence encouraging illegal dumping
- Minimal support is provided to the low income people who practice recyclable activities from the waste collected
- No buffer zone created around the Dandora dumping site since there is encroachment of people into the dumping area and a lot of informal settlements have come up.

However, privatization of solid waste in Nairobi City County will enhance better management of solid waste in the city. Studies have shown that private waste collection and CBOs dealing with waste collection have significant importance in the city since most people are opting for them as an alternative way of waste collection (Kasonzi & Blottnitz, 2010).

d) Reduction, Reuse and Recycling (3R)

There is no separate collection system or sorting facilities in Nairobi. 3R activity is mainly operated in unofficial basis by low income people who sell the reused and recycled materials to junk buyers or recycling factories. More than half of the waste generated in Nairobi is recyclable waste. However, due to indiscriminate collection and dumping of waste in Dandora dumping site, most of the recyclable materials become difficult to be picked in the huge load of waste deposited.

e) Solid waste and health

An environmental evaluation conducted in Dandora dumpsite and its surroundings in 2007 established that the dumpsite exposes residents around it to unacceptable levels of environmental pollutants with adverse health impacts. Soil samples analysed from locations adjacent and within the dumpsite showed higher levels of heavy metals than acceptable

thresholds, emanating from the site in particular lead, mercury, cadmium, copper and chromium. Medical evaluation of the children and adolescents living and schooling near the dumpsite indicated a high incidence of diseases associated with high exposure levels to these metal pollutants. For example, about 50% of 328 children examined who live and school near the dumpsite had respiratory ailments and blood lead levels equal to or exceeding internationally accepted toxic levels (10 µg/dl of blood), while 30% had size and staining abnormalities of their red blood cells, confirming high exposure to heavy metal poisoning.

The prevalent illnesses were related to the respiratory, gastrointestinal and dermatological systems such as upper respiratory tract infections, chronic bronchitis, asthma, fungal infections, allergic and unspecified dermatitis/pruritis– inflammation and itchiness of the skin.

Table 8.37 summarizes the health results of the 328 children aged 2-18 years examined in the study.

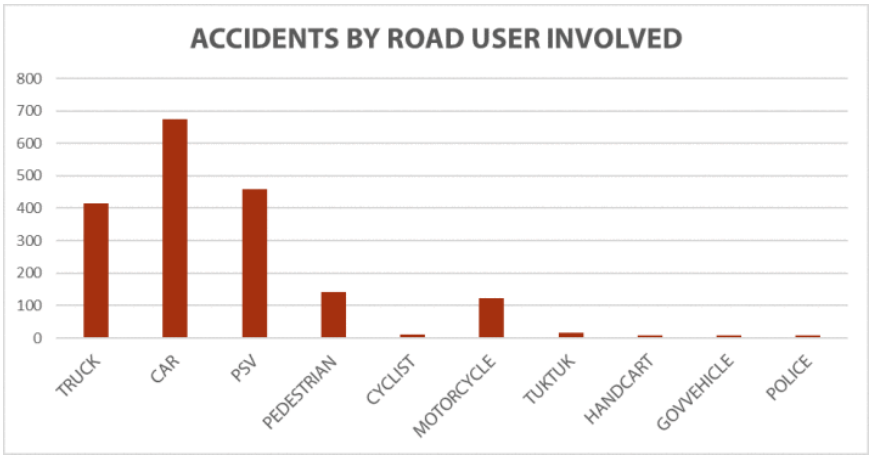
Table 8.37 Impacts of Dandora Dumping Site and Systems Affected

System Affected	No. of children Affected	% with disorders
Dermatological (Skin disorders)	48	14.5
Respiratory	154	46.9
Gastroenterities(GE) (abnominal and intestinal problems)	59	17.9
Dental Disorders	31	9.5
Oto (affecting the hearing system)	15	4.6
Skeletal/Muscular systems	8	2.4
Central Nervous System	7	2.13
Eye Infections	32	9.8
Blood Anemia	1	0.3
others	21	6.4
Normal	26	7.9

Source: NIUPLAN

8.5.1.13 Traffic Accidents

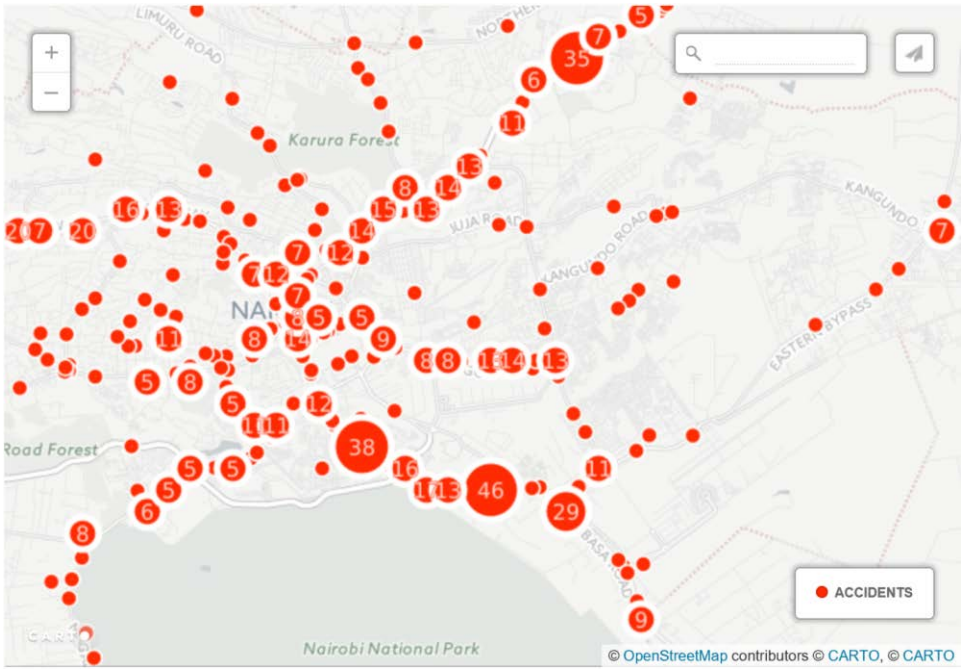
Figure 8.42 shows the number of accidents involving various types of road users. Some accidents involved more than one type of road users, thus the figure does not necessarily reflect the true number of accidents. Private cars have higher share of accidents than any other types of road users. However, when the number of people affected by the accidents is considered, Public Service Vehicles (PSVs) have the greatest impact on people simply because they carry the most number of people.



Source: Nairobi Accident Map (https://nairobiaccidentmap.com/)

Figure 8.42 Accidents by Road User Involved

Figure 8.43 shows all accidents in Nairobi County. Accidents are clustered by proximity. Notice that largest clusters of accidents occur along Thika road and Mombasa road.



Source: Nairobi Accident Map (https://nairobiaccidentmap.com/)

Figure 8.43 Traffic Accident Map of All Road User Involved

8.5.1.14 Urban Landscape

The landscape character of the project area is urban as it is comprised of buildings, pavements, infrastructure networks and vegetation. However the composition of these three elements varies from one zone to another due to the difference in the Zoning regulations of the NCCG. The elements with the highest influence on the landscape character of the project area are discussed below.

Road infrastructure is a huge component of the landscape character as there construction results in the introduction of alien elements into the existing landscape. One of the ways to harmonise road infrastructure into the exiting landscape is to apply an appropriate highway landscape design. A well designed highway landscape results in a good visual environment which in turn enhances the road user's experience. Proper highway landscaping lacks on the City's roads as they usually not part of the road planning and design process.

Among all the roads within the project area Uhuru highway has the best visual environment, This is mainly due to the green belt that runs along one side from Bunyala Roundabout all the way to Museum Hill interchange and the pedestrian paths constructed by NCCG. The green belt comprises of Railway Golf club, Uhuru Park, Central Park & University of Nairobi Field. The pedestrian walk between the Haile Selassie round about and the University way is well designed with an adequate width and this adds more quality to the landscape character.

Thika highway is another road that has greatly altered the Nairobi landscape. The overpass structures built were not properly harmonized with the existing landscape and this resulted in a reduction of landscape quality along the road. However, there is a substantial amount of highway landscaping on the highway's median.

A Park is a public or private land set aside and available for recreational, educational, leisure,

cultural, scenic, or aesthetic use, or for preservation of open space with vegetation or features for active recreation or other activities. Nairobi city has several public parks namely;

- Uhuru Park
- Central Park
- City Park
- Uhuru Gardens
- Jeevanjee Gardens
- Kamukunji grounds
- Jamuhuri Park

All these public spaces greatly influence the landscape character of the city county. They provide residents of the city with the much required recreation spaces both during the week and over the weekends.

Among these parks, of the most influence are Uhuru and Central Parks. This influence can be attributed to both their size and location. The two parks are located adjacent to each other along Uhuru highway and are separated by Kenyatta Avenue. They are easily accessible to the bulk of the population who work in the CBD and also provide a convenient venue for political functions and corporate events. The parks have interlinking pedestrian circulation, massed vegetation, monuments among other landscape features.

1) Utility Facility

There are three common types of utility facility associated with the urban landscape in Nairobi City County. They are;

- Telecommunications antenna;
- Power transmission lines; and
- Underground communication cables.

Telecommunication antenna and power transmission lines are above the ground and therefore usually alter the character of the landscape. Underground cables are less intrusive; however field observations show that the landscapes adjacent to the trench are rarely restored to their prior conditions.

2) Solid waste

Currently solid waste is disposed in the open dumping site in Dandora, which causes the pollution problem to surrounding environment. In addition, some of the waste including both the collected waste and the un-collected waste is usually dumped illegally in undesignated dumpsites. This adhoc waste dumping creates an eyesore on the landscape and greatly reduces the quality of the landscape character.

3) Rivers

There are several rivers within the project area. They are Nairobi River, Ngong River, Riara River, Kiu River among others. The riparian environment along these rivers has been greatly degraded due to pollution from both sewer and industrial waste.

4) Overall Restoration of Degraded Environments

The City County should develop a framework to facilitate the rehabilitation of degraded environments including quarry sites and afforestation of green areas and parks managed by the City County.

Collaborative agreements can be drawn with NEMA, WRMA, Mines and Geology Department and the KFS.

Meaningful stakeholder involvement can help assure the City County Government that the envisioned aesthetic value of the rehabilitated area is as perceived by the various intended beneficiaries of these programs.

8.5.2 Results of Strategic Environmental Assessment

8.5.2.1 Predicted Environmental and Social Impacts for Each Policy

1) Policy I: Establishment of Comprehensive Mobility Management

Reorganisation of the Matatu and buss passenger transport in Nairobi is long overdue. Immediate impacts would be removal of traffic congestion which would allow ease of travel for other road users. Other benefits would accrue from elimination of the culture of impunity and corruption bred by the matau sector, reduction of noise and atmospheric emissions, petty accidents which would make Nairobi a safer place to live and work in. Restriction of private transport to designate peripheral areas will further decongest the city and will trigger re-planning to create commercial centres at the intermodal areas. This is likely to create new growth areas especially where the intermodal facilities are further removed from the CBD.

A major concern with reorganisation of Matatu transport in Nairobi is the associated job and income losses to both owners and operators. However, given that Matatu operators and their SACCOs enjoy substantial political and economic power, they can easily transform and invest in the new transport systems.

2) Policy II: Proposal for Future Re-alignment of BRT

The main adverse impact with all BRTs is that, they will require space and thus could displace property and livelihoods. Reorganisation of BRT 3 to pass through Racecourse road would have the largest displacement impact. By utilising alignment of existing commuter line, BRT4 has minimal impact. The greatest positive impact will however accrue from reorganisation of BRT 1 to remove it from the CBD and BRT2 to go underground. Both have the benefit of minimising both physical and economic displacement.

3) Policy III: Application of Rail-based Transport System

An underground rail [-based transport (subway system) is the most beneficial intervention in Nairobi in terms of minimising both physical and economic displacement, eliminating traffic conflict, accidents and atmospheric pollution while solving a chronic transport problem. Mai adverse impacts are associated with possible interference with underground drainage systems and proximity to crime. Additionally, the need to put up several subway stations to cater for midway passengers (Southern bypass, Githurai, Roysambu/Kasarani, Kenyatta University, Juja Road, etc) would pose challenges regarding land use.

A major pre-requisite for development of a subway system is te need to undertake comprehensive investigation the structure integrity of buildings within the sphere of impact given possible impacts from vibrations.

8.5.2.2 Evaluation of the Impacts for Each Policy

Based on the scoping analysis of the comprehensive idea of integrated transport system, the overall evaluation of each impact for the proposed policies will be studied to ensure that the environmental impact assessment is comprehensively evaluated for further progress of the projects relevant with transport system in Nairobi Urban Core. The evaluation study is done by considering all of the evaluations of scoping items and taking into consideration the quantity and quality of negative and positive values in order to reach a final evaluation for each sector of impacts. The results of SEA analysis for the selected proposed policies are summarised in Table 8.39, Table 8.40 and Table 8.41.

Table 8.38 Impact Evaluation for the Policy I (Establishment of Comprehensive Mobility Management)

Category	#	Environmental Items	Stages				Remarks
			P	C	O	Z	
Anti-pollution measures	1	Air quality	B-	A-	B+	A-	Successful decongestion of NUC will cut down on emission of atmospheric pollutants. Applying electric bus and time saving bus on/off board system will improve air quality in the NUC.
	2	Water quality	B-	B-	B+	A-	Chronical traffic congestion of zero option would affect to quality of drainage water and river water.
	3	Soil contamination	D	D	D	D	They're very little bare soil in NUC hence impacts not clearly significant.
	4	Waste	B-	B-	B+	A-	Decongestion of NUC coupled with waste management policies will cut down in waste accumulation at bus stands.
	5	Noise and vibration	B-	B-	B+	A-	Decongestion of NUC will greatly cut down on noise and vibrations.
	6	Ground subsidence	D	D	D	D	Likely negative impacts are insignificant.
	7	Odour	C-	D	D	C-	Likely negative impacts are insignificant.
	8	Bottom Sedimentation	D	D	D	D	Likely negative impacts are insignificant.
Natural Environment	9	Protected areas	D	D	D	D	There is no protected area affected for the policy.
	10	Ecosystem	D	D	D	D	Likely negative impacts are insignificant.
	11	Hydrology	D	B-	B-	D	Possible negative impacts of surface drainage are concerned during both construction and operational phase.
	12	Topography and geology	D	D	D	D	Likely negative impacts are insignificant.
	13	Climate change	D	D	D	D	Likely negative impacts are insignificant.
Social Environment	14	Involuntary resettlement	D	D/ B-	D	D	Soft program will not require any involuntary resettlement. Road rehabilitation requires more or less involuntary resettlement.
	15	Living and livelihood	D	D	B+	D	As above During operational phase, progress of commuting environment would raise citizen's quality of life.
	16	Cultural heritage	D	D	D	D	Soft program will not require any disturbance of cultural heritage.
	17	Landscape	D	D	D	D	Likely negative impacts are insignificant.
	18	Ethnic minorities and indigenous peoples	D	D	D	D	No such groups are resident in the NUC.
	19	Working conditions	D	D	A+	A-	Efficient transport will greatly improve working conditions.
	20	Water use/rights	D	D	D	D	Likely negative impacts are insignificant.
	21	Poverty group	A-	C+	C+	A-	Improvement of transport alone has limited impact on poverty.
	22	Existing social infrastructures and services	D	D/ B-	B+	D	Rehabilitation of road for missing rink will deteriorate road function during construction phase.
	23	Misdistribution of benefits and damage	D	D	D	D	Likely negative impacts are insignificant.
	24	Local confliction of interests	B-	B-	D	B-	Poor coordination among SHs is potential cause of conflict
	25	Land use and unification of local resources	D	C-	C-	D	Likely impacts of rerouting of public transport on land use requires further investigation.
	26	Social institutions and local decision making institutions	D	D	D	D	Likely impacts are unknown
	27	Sanitation	C-	B-	D	D	Influx of workers from other region during construction phase will raise sanitation concerns.

	28	Infectious diseases, HIV/AIDS	D	B-	D	D	Influx of workers from other region during construction phase will raise sanitation concerns.
Other	29	Accidents prevention measure	C-	B-	B-	A-	Failure to take action could escalate accidents in the NUC.

Notes: P: Planning stage, C: Construction stage, O: Operation stage, Z: Zero option
A+/-: Significant positive/negative impact is expected. B+/-: Some positive/negative impact is expected.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the study progresses.), D: No impact is expected.
Source: JICA Study Team

Table 8.39 Impact Evaluation for the Policy II (Proposal for Future Re-alignment of BRT)

Category		Environmental Items	Stages				Remarks
			P	C	O	Z	
Anti-pollution measures	1	Air quality	B-	A-	B+	A-	Although deterioration of air quality due to inappropriate heavy machine maintenance will be expected during the construction phase, successful decongestion of NUC will cut down on emission of atmospheric pollutants on operational phase.
	2	Water quality	B-	B-	B+	A-	Chronical traffic congestion of zero option would affect to quality of drainage water and river water.
	3	Soil contamination	D	D	D	D	They're very little bare soil in NUC hence impacts not clearly significant.
	4	Waste	B-	B-	B+	A-	Decongestion of NUC coupled with waste management policies will cut down in waste accumulation at bus stands. However road rehabilitation for BRT would increase either construction wastes or domestic wastes from construction camp.
	5	Noise and vibration	B-	B-	B+	A-	Decongestion of NUC will greatly cut down on noise and vibrations.
	6	Ground subsidence	D	D	D	D	Likely negative impacts are insignificant.
	7	Odour	C-	D	D	C-	Likely negative impacts are insignificant.
	8	Bottom Sedimentation	D	D	D	D	Likely negative impacts are insignificant.
Natural Environment	9	Protected areas	D	D	D	D	There is no protected area on planned alignment of BRT.
	10	Ecosystem	D	D	D	D	Likely negative impacts are insignificant.
	11	Hydrology	D	B-	B-	D	Possible negative impacts of surface drainage are concerned during both construction and operational phase.
	12	Topography and geology	D	D	D	D	Likely negative impacts are insignificant.
	13	Climate change	D	D	D	A-	Accumulative gas emission from traffic congestion would be controversial in regional level.
Social Environment	14	Involuntary resettlement	A-	A-	D	D	Construction will require a large volume of involuntary resettlement along the road to be rehabilitated.
	15	Living and livelihood	B-	B-	B+	B-	As above During operational phase, progress of commuting environment would raise citizen's quality of life.
	16	Cultural heritage	D	B-	B-	D	Possible negative impacts on cultural heritage during construction phase are concerned.
	17	Landscape	D	B-	B+	A-	Construction camp deteriorate urban landscape in the NUC, however it would be improved by new buses driving on uncongested roads.
	18	Ethnic minorities and indigenous peoples	D	D	D	D	No such groups are resident in the NUC.
	19	Working conditions	B-	B-	A+	A-	Efficient transport will greatly improve working

							conditions.
	20	Water use/rights	D	D	D	D	Likely negative impacts are insignificant.
	21	Poverty group	B-	B+	B+	A-	Improvement of transport alone has limited impact on poverty.
	22	Existing social infrastructures and services	B+	B-	B-	B-	Rehabilitation of road for BRT will deteriorate road function during construction phase. Dedicated BRT lane would affect pedestrian convenience. Chronical traffic congestion deteriorate accessibility of social infrastructure.
	23	Misdistribution of benefits and damage	D	D	D	D	Likely negative impacts are insignificant.
	24	Local confliction of interests	B-	B-	D	B-	Poor coordination among SHs is potential cause of conflict
	25	Land use and unification of local resources	D	D	D	D	Likely negative impacts are insignificant.
	26	Social institutions and local decision making institutions	D	D	D	D	Likely negative impacts are insignificant.
	27	Sanitation	C-	B-	D	D	Influx of workers from other region during construction phase will raise sanitation concerns.
	28	Infectious diseases, HIV/AIDS	D	B-	D	D	Influx of workers from other region during construction phase will raise sanitation concerns.
Other	29	Accidents prevention measure	C-	B-	B-	A-	Failure to take action could escalate accidents in the NUC.

Notes: P: Planning stage, C: Construction stage, O: Operation stage, Z: Zero option: A+/-: Significant positive/negative impact is expected. B+/-: Some positive/negative impact is expected. C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the study progresses.), D: No impact is expected.

Source: JICA Study Team

Table 8.40 Impact Evaluation for the Policy III (Application of Rail-based Transport System)

Category	#	Environmental Items	Stages				Remarks
			P	C	O	Z	
Anti-pollution measures	1	Air quality	B-	B-	A+	A-	Successful decongestion of NUC by electric power based transportation will cut down on emission of atmospheric pollutants. However, deterioration of air quality due to inappropriate heavy machine maintenance will be expected during the construction phase.
	2	Water quality	B-	B-	B+	A-	Chronical traffic congestion of zero option would affect to quality of drainage water and river water.
	3	Soil contamination	D	D	D	D	They're very little bare soil in NUC hence impacts not clearly significant.
	4	Waste	B-	B-	B-	A-	Introduction of underground transport likely to induce non-industrial wastes accumulation.
	5	Noise and vibration	B-	B-	B-	B-	Noise and vibration will increase vibrations with likely negative impact on adjacent buildings in both construction and operation phase.
	6	Ground subsidence	D	D	D	D	Likely negative impacts are insignificant.
	7	Odour	C-	D	D	C-	Likely negative impacts are insignificant.
	8	Bottom Sedimentation	D	D	D	D	Likely negative impacts are insignificant.
Natural Environment	9	Protected areas	D	D	D	D	There is no protected area on planned alignment of METRO.
	10	Ecosystem	D	D	D	D	Likely negative impacts are insignificant.
	11	Hydrology	D	B-	B-	D	Possible negative impacts of tunnelling on shallow groundwater will be concerned.
	12	Topography and geology	D	D	D	D	Likely negative impacts are insignificant.
	13	Climate change	D	D	D	D	Likely negative impacts are insignificant.

Social Environment	14	Involuntary resettlement	D	C-	D	B+	Applying elevated railway reduce possibility of involuntary resettlement.
	15	Living and livelihood	D	B-	B+	B+	As above. During operational phase, progress of commuting environment would raise citizen's quality of life.
	16	Cultural heritage	D	C-	C-	D	There is no cultural heritage on the planned alignment of METRO.
	17	Landscape	D	B-	B+	A-	Construction camp deteriorate urban landscape in the NUC, however METRO system and station would be part of symbolic urban landscape in the NUC.
	18	Ethnic minorities and indigenous peoples	D	D	D	D	No such groups are resident in the NUC.
	19	Working conditions	A-	A-	A+	A-	Efficient transport will greatly improve working conditions.
	20	Water use/rights	D	D	D	D	Likely impacts are unknown
	21	Poverty group	A-	C+	C+	A-	Improvement of transport alone has limited impact on poverty
	22	Existing social infrastructures and services	B+	A-	B-	B+	Construction phase is highly destructive of infrastructure
	23	Misdistribution of benefits and damage	D	D	D	D	Likely negative impacts are insignificant.
	24	Local confliction of interests	C-	C-	D	C-	Poor coordination among SHs is potential cause of conflict
	25	Land use and unification of local resources	D	D	B+	D	Regional development would be escalated during operational phase as synergy effect of METRO development.
	26	Social institutions and local decision making institutions	D	D	D	D	Likely negative impacts are insignificant.
	27	Sanitation	C-	B-	D	D	Influx of workers from other region during construction phase will raise sanitation concerns.
	28	Infectious diseases, HIV/AIDS	D	B-	D	D	Influx of workers from other region during construction phase will raise sanitation concerns.
Other	29	Accidents prevention measure	C-	B-	B+	A-	Applying elevated railway system could reduce conflict with road transportation.

Notes: P: Planning stage, C: Construction stage, O: Operation stage, Z: Zero option
A+/-: Significant positive/negative impact is expected. B+/-: Some positive/negative impact is expected.
C+/-: Extent of positive/negative impact is unknown. (Further examination is needed, and the impact could be clarified as the study progresses.), D: No impact is expected.
Source: JICA Study Team

8.5.2.1 Summary of SEA

Study of SEA is summarized as shown on the table below.

Table 8.41 Summary of SEA

#	Policy	Description	Economic Impact		Social Impact		Environmental Impact	
Zero Option			B-	Time lost in traffic congestion. No economic activity at late night in the CBD because of low availability of public transportation	B-	Increase in anti-social behaviour including crime	A-	Increased atmospheric pollution, such as air and noise in CBD caused by chronic traffic congestion
Policy I: Establishment of Comprehensive Mobility Management								
P-I-1	Improvement of Bus Service	(i) Re-organization of Matatu and other ordinary bus service route Replace Matatu and ordinary bus service to feeder transport service to avoid concentration of traffic volume in the CBD.	A+	Will decongest CBD and expand the space for doing business. Removal of Matatus and buses would reflect to job and income decrease for Matatu owners and	A+	City residents will enjoy more space and comfort in doing business including cross city movement. Control of Matatu will improve road safety for pedestrians.	A+	Applying new bus fleet will cut down on noise, atmospheric pollutants and general nuisance in the CBD.

#	Policy	Description	Economic Impact		Social Impact		Environmental Impact	
		(ii) Application of new bus fleet standard Applying bigger fleet, wider entrance door and electric power unit. (iii) Renovation of bus service system Applying approaching notification system integrated with other transport system. (iv) Revision of regulation for bus service Revision of standing seat regulation can resolve having limitation of carrying volume of passengers.		operators but will create new opportunities for investment.				
P-I-2	Improvement of Road Networks	(i) Missing link improvement Establishment of grid road network structure in Nairobi Urban Core as well as Westlands and Eastleigh. (ii) Promotion of road space management Open space development by utilising part of road space.	A+	This will reroute traffic away from the city thus free more space for business.	A+	Travellers will enjoy extra time which can be invited productively.	A+	Decongestion of CBD will eliminate pollution and the stress caused by waiting long hours in traffic.
P-I-3	Improvement of Pedestrian Service	Improvement of pedestrian accessibility in CBD by facilitating signs and clearing access route to nodal point of other transport system.	A+	This will reduce the time wasted getting to work. Will increase productivity.	A+	Pedestrians will be more comfortable, less open to mugging and other nuisances such as soiling of clothes.	A+	Clearing of alleyways will eliminate dumping and associated health hazards.
P-I-4	Application of Intermodal Facility	Development of intermodal facility such as station for BRT and METRO	B+	Will enhance passenger transfer and cut on time wasted walking and waiting.	B+	Will eliminate the disturbance associated with having to walk in the sun or rainy weather to change modes of transport. Could trigger traffic congestion in the intermodal facility.	B-	Deterioration of waste management in the intermodal facility is concerned.
P-I-5	Application of Transport Demand Management Measure and Policy	(i) Promotion of off-peak measure Off-peak measure can control part of traffic volume by avoiding vehicle in peak time. (ii) Reinforcement of parking policy Minimisation of on-street parking in CBD. Development of off-street parking lot in the fringe or out skirt of Nairobi Urban Core. (iii) Establishment of pricing policy Charging road price for private vehicle in designated district in Nairobi Urban Core.	A+	Will decongest city and cut down on economic time wasted. New opportunities will evolve at the passenger transfer points.	B+	A new culture of using public transport will free time for passengers to engage in other activities.	B+	Reduction in traffic volume on roads will cut down on fuel usage and by extension, release of pollutants into the atmosphere.
	Policy II: Proposal for Future Re-alignment of BRT							
P-II-1	Re-organisation of Current Alignment of BRT Line 3 and 4	Re-alignment of BRT Line 3 and 4 utilising existing viaduct of commuter rail as well as part of ROW of commuter rail. Coordinating BRT with viaduct project to utilise future viaduct route. Re-alignment of BRT 4 running adjacent to railway city for future demand.	B-	Displacement of livelihoods and business along Racecourse road and others.	B+	Reduced traffic congestion in CBD will provide positive impacts to business persons. Provision of more convenient public transport gather more people and re-vitalize economy in the CBD.	B+	Decongestion of traffic results in improvement of air and noise quality.
P-II-2	Re-organisation of Current Alignment of BRT Line 1	Simplification of BRT alignment for BRT Line 1, Mombasa, Uhuru and Waiaki Highway, to traverse the line as the dedicated linear alignment.	A+	Will greatly cut down on displacement of property and livelihoods.	B+	Will eliminate the disturbance associated with extended construction in the CBD.	A+	Will forestall the noise, vibrations, emissions and concentration of people associated with extensive construction within CBD.
P-II-3	Re-organization of Current Alignment of BRT Line 2	Modifying the BRT line to METRO to meet future transport demand from West and East part of Nairobi City County.	A+	This will eliminate the potential displacement of property and buildings to create surface space to BRT.	C-	Possible proliferation of crime in underground tunnels requires counter measures for public safety.	B-	Possible impact of tunnelling on safety of buildings, groundwater, etc. requires further detailed study.
	Policy III: Application of Rail-based Transport System							
P-III-1	Development of METRO Connecting Thika and Ngong Roads	Development of METRO on Thika and Ngong road connecting in the CBD underground. Construction of subway station in CBD would be associated with possible underground property development	A+	Will eliminate pressure on space for development and create new opportunities for economic activity underground. Accidents within CBD will reduce.	C-	As for P-I-3 above Applying elevated railway and METRO in the NUC will be symbolic urban landscape for Kenya.	B-	As above. The potential of flooding during the rains will be concerned.

Source: JICA Study Team

8.5.3 Mitigation Measures

1) Policy I: Establishment of Comprehensive Mobility Management

Economic displacement associated with transport reorganisation will be mitigated through discussion and negotiated agreement with stakeholders. As a starting point, all affected stakeholders should be given priority in investing in new transport systems. Additionally, it would be indispensable for the public to know newly applied transport system before the system starts, therefore announcement of the policy in timely manner is very important.

2) Policy II: Proposal for Future Re-alignment of BRT

The main adverse impact with all BRTs is that, they will require space and thus could displace property and livelihoods and cause traffic conflict at crossing points. Mitigation will target optimization of space available including option of elevated BRTs to eliminate traffic conflicts. Comprehensive EIA and Resettlement Action Plans based on fair compensation policy will be prepared to allow for resolution of all environmental, social and displacement issues. To determine detailed negative impact of air quality, continuous air quality monitoring in the NUC should be carried out. Moreover, mitigation measures such as installation of safety sign or traffic lights designed for BRT at crossing point of dedicated BRT lanes and pedestrian walks should be implemented for road safety.

3) Policy III: Application of Rail-based Transport System

A comprehensive investigation of the geology and hydrogeology of the Nairobi CBD should precede proposed development of underground transport to better understand rock formation and shallow aquifer systems. Subsequent EIA studies should develop Environmental Management Plans to resolve potential impact on aquifers. From seismic studies, the possible impact of underground tunnelling on structure stability and integrity of structures within the sphere of interest will be developed. The same will be coupled up with a structures management plan to insure against collapse of buildings. For security of subway area, enforcement of surveillance system in public space will be required. Additionally, further feasibility study will be required to examine financial practicability to apply the METRO system in the NUC.

8.5.4 Monitoring Program

At SEA level, the proposed monitoring programme is to ensure that each investment option will be subjected to statutory EIAs and RAP Studies which will be opened up to stakeholder participation.

8.6 Stakeholder Engagement

8.6.1 Stakeholder Meeting (General)

8.6.1.1 Background

Through bilateral agreement with Nairobi City County Government (NCCG), Japan International Cooperation Agency (JICA) decided to formulate the project for the Detailed Planning of Integrated Urban Transport System and Loop Line in the Nairobi Urban Core (Project), which is approached by the Nairobi Integrated Urban Development Master Plan (NIUPLAN) certified by NCCG with the technical support from JICA in 2014.

During the NIUPLAN study, Strategic Environmental Assessment (SEA) study was carried out covering various sectors including land use, transportation, energy, water supply, drainage and sewage.

Since the environmental study for the Project is categorized as supplemental SEA which can be called as Environmental Assessment (EA) study, holding stakeholder meeting (SHM) will be required at the particular stages of the Project in order to follow basic procedure stated in the National Guideline of SEA in Kenya.

8.6.1.2 Objectives of the SHM

Basic objectives of the stakeholder meetings are clarified below.

(Scoping stage)

- To share information about the study for the Project and enlighten possible environmental and social impacts triggered by the Project.
- To collect opinions of the study associated with environmental and social issues from the aspects of stakeholder's side.

(Draft Final stage)

- To share information about results of the study and enlighten determined possible environmental and social impacts triggered by the Project.
- To collect opinions of the study results associated with environmental and social issues from the aspects of stakeholder's side.

8.6.2 Stakeholder Meeting (SHM)

8.6.2.1 Profile of the SHM

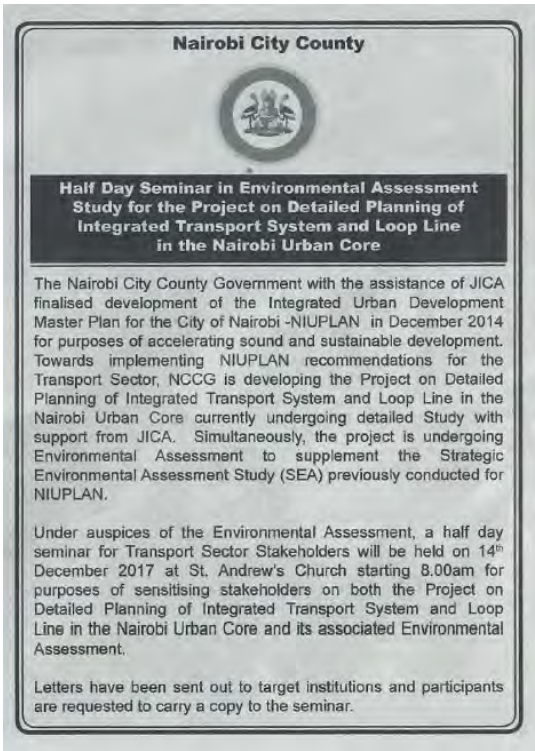
Profile of the SHM, as shown on Table 8.43, was prepared through the discussion between JST and NCCG, and invited participants were determined based on stakeholder analysis including referring the previous stakeholder meeting held on 2014. When the date of the meeting was set on 14th December 2017, NCCG issued invitation letters to all the invited participants. Addition to the invitation letter, for other citizens who would be interested in the project, NCCG put an announcement of this stakeholder meeting on the local newspaper. (Figure 8.54)

Table 8.42 Profile of SHM

#	Item	Description	
1	Organizer (Host)	NCCG	
2	Co-Organizer	JICA Study Team (Local Consultant)	
3	Date (Provisional)	TBA	
4	Venue	St. Andrew Church in Nairobi	
5	Organizer	(Organizer (Host)t) Urban Planning Department, NCCG, Other relevant department, NCCG	
		(Co-Organizer) JICA, Nairobi office, JICA Study Team	
6	Main issues	•Overview of the project •Environment and social consideration study •Free discussion about the project	
7	Announcement to Participants	All participants are announced by official letter from NCCG	
8	Invited Participants		
	1. AREA ASSOCIATIONS ➢ Kenya Association of Resident Association ➢ Westlands Association Ltd.	**5. PROFESSIONAL BODIES** ➢ Architectural Association of Kenya (A.A.K.) ➢ Kenya Institute of Planners (K.I.P)	

#	Item	Description
	➢ Nairobi Central Business District Association (N.C.B.D.A.) ➢ Upper hill Business Association, ➢ Eastleigh Business District Association **2. MINISTRIES** ➢ Ministry of Lands Housing &Urban Development (Dept of Nairobi, Metropolitan Development, Urban Development, Department of Physical, Planning, Department of Surveys) ➢ Ministry of Transport & Infrastructure ➢ Ministry of Environment, Water & Renewable Resources, ➢ Ministry of Industrialisation ➢ Ministry of interior and National Coordination (CC Nairobi, SCC Westlands, SCC Dagoretti, SCC Starehe) Kenya police Service (Traffic Headquarters), NSIS **3. ELECTED REPRESENTATIVE** ➢ Members of Parliament (Westlands, Dagoretti, Starehe) ➢ Members of County Assembly (Westlands, Upperhill, Starehe) **4. AGENCIES** ➢ Kenya Urban Roads Authority, ➢ Nairobi Metropolitan Transport Authority, ➢ Kenya National Highways Authority, ➢ National Environmental management Authority ➢ Nairobi Water and Sewerage Company ➢ Kenya Power & Lighting Company ➢ National Chamber of Commerce & Industry ➢ Federation of Kenya Employers (F.K.E.) ➢ Kenya Railways Cooperation ➢ Kenya National Bureau of Statistics ➢ Communication Authority of Kenya ➢ Kenya National Chamber of Commerce & Industry ➢ Kenya Institute of Public, Policy, Research & Analysis ➢ Parliamentary service Commission, ➢ National Museaums of Kenya, ➢ Central Bank of Kenya, ➢ Kenya Meteorological Department, ➢ Kenya Forest Service, ➢ Water Resources Management Authority ➢ Kenya Ports Authority, ➢ Kenya Civil Aviation Authority, ➢ Kenya Wildlife Service, ➢ Vision 2030 Directorate, ➢ PPP Secretariat	➢ Institute of Surveyors of Kenya ➢ Law Societies of Kenya (L.S.K) ➢ Institute of Engineers of Kenya, ➢ Kenya Medical practitioners and Dentists Union **6. FINANCIAL INSTITUTIONS** ➢ Kenya Bankers Associations **7. PROPERTY MANAGERS** ➢ Shopping Centers Association of Kenya, ➢ Representatives of Wakulima & City market traders ➢ Villa Care ➢ Tysons Limited ➢ Llyod Masika ➢ Knight Frank **8. ACADEMIA** ➢ Commission of University Education, ➢ Nairobi University, ➢ Kenyatta University, ➢ Moi University, ➢ Maseno University, ➢ Masinde Muliro university ➢ Technical University of Kenya, ➢ Kenya Methodist University ➢ Mount Kenya University, ➢ Catholic University ➢ African Nazarene University **9. TRANSPORT SECTOR OPERATORS** ➢ Trasport licencing Board, ➢ Matatu Owners Associations, ➢ Kenya Transporters Association, ➢ Association of Bus operators ➢ Boda-boda Association ➢ Taxi owners ➢ National Transport & Safety Authority **10. DONOR INSTITUTIONS** ➢ UN Habitat, ➢ World bank, ➢ International Finance Cooperation ➢ African Development Bank ➢ European Union ➢ United Nation Development Programme ➢ International Union for Conservation of Nature ➢ United Nations Office on Drugs and Crime ➢ African Economic Research consortium **11. NEIGHBOURING COUNTIES** ➢ Machakos County, ➢ Kiambu County, ➢ Kajiado County,

Source: JICA Study Team



Nairobi City County

Half Day Seminar in Environmental Assessment Study for the Project on Detailed Planning of Integrated Transport System and Loop Line in the Nairobi Urban Core

The Nairobi City County Government with the assistance of JICA finalised development of the Integrated Urban Development Master Plan for the City of Nairobi -NIUPLAN in December 2014 for purposes of accelerating sound and sustainable development. Towards implementing NIUPLAN recommendations for the Transport Sector, NCCG is developing the Project on Detailed Planning of Integrated Transport System and Loop Line in the Nairobi Urban Core currently undergoing detailed Study with support from JICA. Simultaneously, the project is undergoing Environmental Assessment to supplement the Strategic Environmental Assessment Study (SEA) previously conducted for NIUPLAN.

Under auspices of the Environmental Assessment, a half day seminar for Transport Sector Stakeholders will be held on 14th December 2017 at St. Andrew's Church starting 8.00am for purposes of sensitising stakeholders on both the Project on Detailed Planning of Integrated Transport System and Loop Line in the Nairobi Urban Core and its associated Environmental Assessment.

Letters have been sent out to target institutions and participants are requested to carry a copy to the seminar.

Figure 8.44 Public Notice of the Stakeholder Meeting

8.6.2.2 Collected Opinions

Collected opinions and answers from the stakeholder meeting are summarized in the table below.

Table 8.43 Opinions and Answers from the SHMM at Scoping Stage

#	Name of respond Institution	Question asked	Response
1	KPC	Some key scoping issues such as Public Safety, Impact on Utilities, Public health etc. not covered in the otherwise good environmental presentation.	JST responded that, the main presentation covers all screening criteria. Downstream projects will also undergo EIA where all issues will be investigated
		What are the measures for harmony with other sectoral plans?	NCCG responded that NIUPLAN was cross sectoral and had in-build measure to secure cross sectoral harmony
2	KURA	Who is the financier and will Project expose Kenyans to indebtedness?	JICA appreciated this comment and said that modalities for financing would be addressed as part of the Detailed Design for selected options
		What target reserves will be exploited to avoid displacement and resettlement?	Detailed possibility of land acquisition and resettlement will be determined in next phase of study
3	Representative of People living with disability	Expressed dissatisfaction because past meetings discussed similar issues yet project implementation is faulty; cases of Thika Rd, Outering Rd. Why not discuss current concerns rather that new projects whose implementation is likely to be faulty.	NCCG replied that there is a Team that hands implementation of Outer Ring Rd Project which can handle all complains. A full EIA will be conducted for each intervention to resolve all potential concerns.

#	Name of respond Institution	Question asked	Response
4	KIPPRA	What is the way forward in terms of consensus given that there is NIUPLAN?	JICA replied that the Detailed Design would chart the way forward.
		What is the threshold of investment?	This would be resolved at the Scoping Stage
		Is economic impact part of Environmental and Social Assessment?	Yes. The same will be integrated.
		What are the measures to ensure harmony in terms of resource utilization?	This will be fine-tuned at Detailed Design
5	TISA	Pointed out dangers of entrusting Project implementation to NAMATA given that the NAMATA Act is faulty.	NAMATA explained that NAMATA was legally created but like all laws, its legal framework will be reviewed as need arises.
6	NMK	Wondered what measures will be taken to address Cultural Heritage issues given that many projects ignore the same at planning stage.	A Cultural Impact Assessment would be undertaken as part of ESIA/.
		Current planning of roads is encroaching on social space eg NMT lanes, parking space etc. Will the same be safeguarded in the project?	All Designs will be subjected to Stakeholder Review (NCCG).
7	KPA	SGR is likely to reduce trucks on Mombasa Rd diverting them to Nairobi and other Dry Container Terminals, what are the proposals for mitigation?	Matter will be taken up for review internally (NCCG)
		Are there opportunities for PPP?	This will depend on outcome of Detailed Design (NCCG)
		Are there opportunities for capacity building and transfer?	The same is recommended (NCCG).
8	NCCG	What are the future trends in pollution and how will project mitigate the same.	This information is available in the whole presentation (MMW)
		How will project safeguard open spaces that serve air cleaner functions?	An EIA will be undertaken for each intervention (MMW).
9	NaMATA and KURA	How the proposed nodal integration be approached?	This will be addressed during detailed Design but current arrangement of BRT has level crossing has challenges (NCCG).
		How will project safeguard interests of small scale traders who depend bus termini to make a living?	A Resettlement Action Pan will be prepared to address all displacement impacts (JST)
10	NCCA	Observed that Project implementation will require new laws and bylaws hence the need to embrace all stakeholders including the Nairobi City County Assembly.	Good observation (NCCG)
11	KWS	Observed that in rolling out the Project, the Nairobi National Park is a no go zone.	Project has no intention of encroaching into NNP (MMW)
12	KFS	Good environmental practices require that 5% of urban space be committed to green spaces for air quality maintenance, is there hope that this space can be expanded under the Project?	Detailed Design will explore options of expanding green areas. (JICA)
		Unnecessary clearing of trees should be avoided. Cited case of Nairobi Southern bypass impact on Ngong Forest.	Noted

Source: JICA Study Team

	
Photo 1: Opening remark by Deputy Minister	Photo 2: Opening Remark by JICA
	
Photo 3: Presentation 1	Photo 4: Presentation 2

Source: JICA Study Team

Figure 8.45 Photos of the Stakeholder Meeting on 14th December

Part-III

Action Plan for Comprehensive Mobility Improvement

Chapter 9 Way Forward

9.1 Practical projects

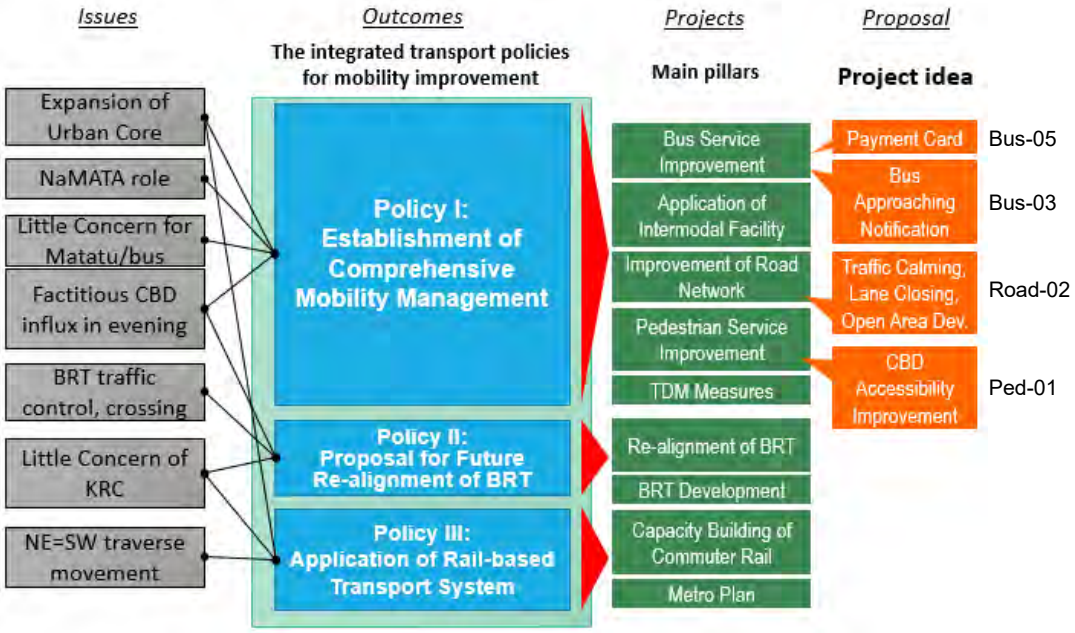
As the strategic approach for the integration of transport system in the Nairobi urban core, 3 policies have been proposed in Chapter 5. Table 9.1 shows the practical projects of each policy per the expected implementation periods of immediate, short-term and Mid-long term.

Table 9.1 Practical Projects and Expected Implementation Schedule

PLANS AND PROJECTS	Immediately	Short-mid (before BRT open in 2022)	Mid-long (before Metro target in 2030)	Remarks
Policy I: Establishment of Comprehensive Mobility Management				
Improvement of Bus Service				
Bus-01 Reorganization of Matatu/Bus routes		✓	✓	Synchronized with BRT installation
Bus-02 New Bus Fleet Standard Development		✓	✓	Can be started, but will take time
Bus-03 Bus approaching notification for passengers	✓			Improve Bus Service, No Land acquisition & PAPs, Low Cost
Bus-04 Bus standing seat regulation revision		✓		Synchronized with BRT installation
Bus-05 Commuter Payment Card and Clearing House System (CHS) Installation	✓			Improve Bus Service, No Land acquisition & PAPs, Low Cost
Improvement of Road Network				
Road-01 Missing Link Improvement			✓	Need long-term investment
Road-02 Traffic Calming, Lane Closing, Open Area Development	✓			Increase Ridership of Public Transportation, No Land acquisition & PAPs, NCC
Improvement of Pedestrian Service				
Ped-01 CBD Accessibility Improvement	✓			Improve Accessibility, No Land acquisition & PAPs, Low Cost, NCC
Application of Intermodal Facility				
IM-01 Transit Place Development		✓		Synchronized with BRT installation
IM-02 Park & Ride Minimization, Improve the Station Accessibility		✓	✓	Need for coordination with Metro/BRT/KRC
Application of TDM Measure and Policy				
TDM-01 Commuting Time Staggering and Operation Hour Extension		✓		TDM enforcement to private car users requires proper development of Metro/BRT network and transit system.
TDM-02 On-Street Parking Restriction, Fringe Parking Development			✓	
TDM-03 Pricing Policy			✓	
TDM-04 Statistics Improvement for Motorization Monitoring		✓		
Policy II: Proposal for Future Re-alignment of BRT				
Re-alignment of BRT Line				
BRT-01 BRT Development			✓	
Policy III: Application of Rail-based Transport System				
Rail-01 Development of Metro on Thika Road			✓	
Rail-02 Capacity Enhancement of Commuter Rail				F/S is under preparation by another donor

Source: JICA Study Team

It is proposed to carry out the project which can be carried out immediately and can obtain high effectiveness. Bus-03, Bus-05, Road-02 and Ped-01 can be selected as the suitable projects for next stage.



Source: JICA Study Team

Figure 9.1 Selection of the Project in Next Stage

9.2 Project Idea

9.2.1 Bus approaching notification for passengers

No.:	Bus-03
Cost:	17 million KSh (100 buses)
Source of fund:	(Proposed by JST) JICA
Executing Agency:	NTSA or NCCG
Benefit:	Increased service level of buses, Easy to setup and existing buses can be introduced
Summary:	On board GIS devices installed and it notifies passengers the location of buses approaching

Description:

- When the BRT/Metro network is completed, the real time approaching information of feeder services is required to secure the BRT passenger services. JST proposes to install this service as soon as possible to bus fleets immediately, not waiting for BRT service commencement.

- Thanks to GPS, mobile internet services and smartphones, the approaching notification of bus fleets can be realized easily with lower cost.

- Platform shows the real-time locations of ordinary buses and BRTs.
  It comes easy than before due to GPS, smartphones, and internet.

On board smartphone on each bus can report its location in real time to the server.

Passenger can see the real-time bus approach with their own smartphones

Image of Platform

Source: JICA Study Team

Figure 9.2 Image of Bus Approaching Notification System

9.2.2 Commuter Payment Card and Clearing House System (CHS) Installation

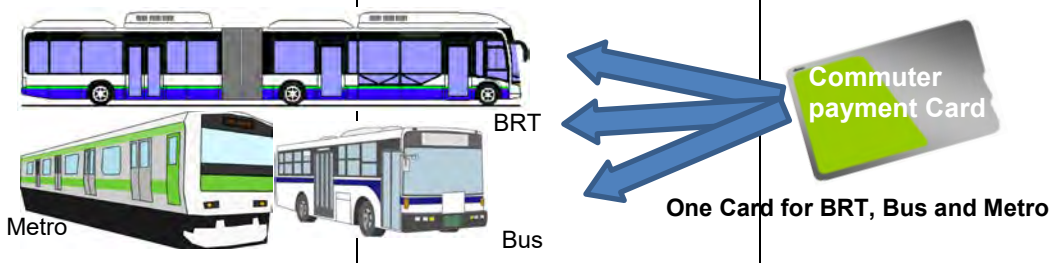
No.:	Bus-05
Cost:	400 million KSh
Source of fund:	(Proposed by JST) JICA
Executing Agency:	NTSA or NCCG
Benefit:	Minimization of passenger loading time Discount joint fare system between means of transportation can be adopted
Summary:	This project will develop business model of installation of the CHS.

Description:

- By installing the CHS system which is capable to handle the commuter payment cards of all BRT and bus operators, discount joint fare system can be adopted. Functions of CHS are as follows.

Table 9.2 Functions of CHS

Apportionment	Approval Management	Clearing
- Appointment Rule definition - Revenue/Cost/Fee Calculation by operators - Revenue/Cost/Fee apportionment - Apportionment Adjustment	- Approval workflow - Review and Approve of proposed cost/revenue apportionment	- Reconciliation of all transactions - Clearing Account Management - Clearing and Settlement Execution



Source: JICA Study Team

9.2.3 Traffic Calming, Footpath improvement, Open Area Development

No.:	Road-02
Cost:	2.2 million KSh per km (Pedestrian Footpath)
Source of fund:	JICA (Proposed by JST, for Pedestrian Facility Development)
Executing Agency:	NCCG
Benefit:	Enhancing the walkability, Improving pedestrian accessibility, Making attractive land scape
Summary:	Improvement and upgrade of the footpath, Conquest of the pedestrian space

Description:

- The road ratio in the CBD district is more than 23%, which attract the car traffic into the pedestrian oriented districts. To enhance the walkability and accessibility, it is necessary to execute lane closing and excluding on-street parking, and improving footpath. This could be implemented in CBD and even in Downtown, which could improve the security of the district.

- In addition, it is expected that open area development will be done by using private sector resources. Photos presents implications of lane closing in European cities, which exclude on-street parking and expanding footpath, then install café space, which will enhance the city branding concept of Nairobi.

Source: Urb-i

Figure 9.3 Implications of Lane Closing – Before and After

9.2.4 CBD Accessibility Improvement

No.:	Ped-02
Cost:	10 million KSh per Pedestrian bridge
Source of fund:	(Proposed by JST) JICA
Executing Agency:	NTSA or NCCG
Benefit:	Enhancing the walkability, Improving pedestrian accessibility, Decreasing the traffic congestion
Summary:	Installing the pedestrian bridge/pedestrian deck for convenience of pedestrians.

Description:

- There are two major pedestrian corridors in the urban core, i) Community, Uhuru park and city hall avenue, and ii) the pedestrian footbridge crossing the railway yards connecting the workshop road.

- The former movement cross the Uhuru highway which generates the conflict between pedestrians and vehicles. The NCCG considers possibility of exclusive foot bridge or other grade separated method, however, the bridge should be coordinated with the BRT Line 1 installation and expected road improvement proposed by the NUTRANS.

- The latter movement needs improvement of the pedestrian bridge itself.