CHAPTER7 URBAN TRANSPORT DEVELOPMENT PLAN

7.1 Urban Transport

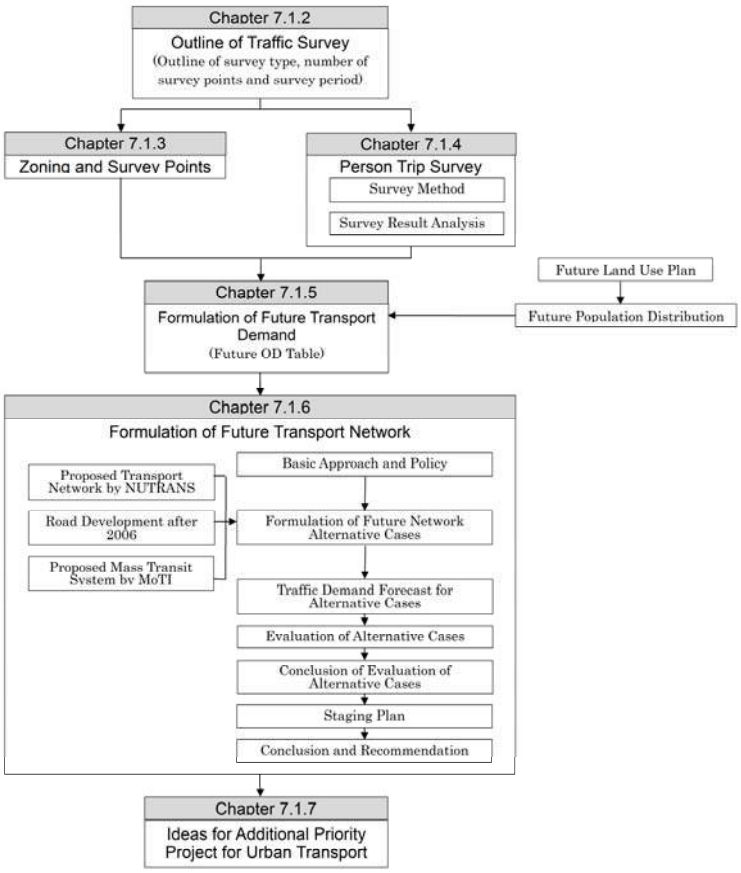
7.1.1 General

(1) Objective of Study on Urban Transport

Future transport network system is investigated taking into consideration the present network, road development projects, land and facility development projects, and land use plan. The basic level of the study is a conceptual plan and it identifies the gap between the existing and necessary capacity estimated by demand forecast, shows the direction about how to fill the gap, and suggests system and institutions for implementation.

(2) Study Procedure

The study procedure for urban transport development plan is shown in Figure 7.1.1.



Source: JICA Study Team (JST)

Figure 7.1.1 Procedure for Urban Transport Development Plan

7.1.2 Outline of Traffic Surveys

A comprehensive traffic survey was conducted by the previous Japan International Corporation Agency (JICA) project on urban transport for Nairobi, namely, The Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area in the Republic of Kenya, March 2006 (hereinafter called NUTRANS). The actual traffic survey was conducted from March to September 2004.

The aim of the traffic surveys in the present Project is to update the result of the previous traffic surveys of 2006 and evaluate the variation of traffic movements thereafter.

(1) Objectives of the Traffic Survey

The major objectives of the traffic surveys in the Nairobi Integrated Urban Development Master Plan (NIUPLAN) are as follows:

(i) To update the result of the previous survey and evaluate the variation of traffic movement.

(ii) To analyse the effect of the transport infrastructure development after 2006.

(iii) To formulate the database for traffic forecast in 2030 because the target year of previous study was 2025.

(2) Outline of Traffic Survey

Seven types of surveys were conducted as shown in Table 7.1.1. Selection of survey types and survey methods was done in consideration of consistency with the 2006 Master Plan surveys. All the surveys were conducted from the beginning to the end of February 2013 to avoid the influence of the general election on 4th March.

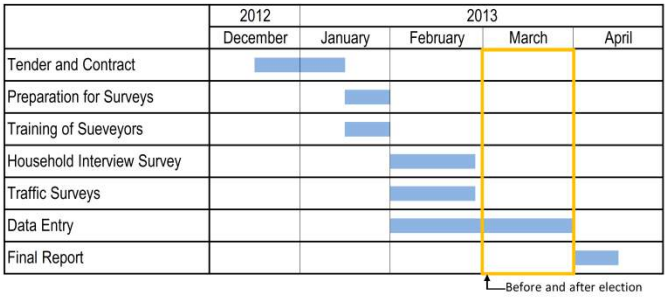
Table 7.1.1 Summary of Traffic Survey

No.	Type of Survey	Purpose	Method	Contents of Survey
1	Person trip survey	To acquire information on the travel activities of residents such as origin, destination, trip purpose, travel time, etc.	Interview to sampled household members at their home and make questions	Interview to 10,000 households in Nairobi City
2	Stated preference survey	To obtain factors for preference of traffic mode selection to enhance use of public transport.	Interview to household members in the person trip survey.	2,000 samples
3	Cordon line survey	To capture traffic movement from/to Nairobi City area and complement the person trip survey	Interview to person at the major road crossing the cordon line of Nairobi City	Roadside interview survey (12 hr, 6:30-18:30): 14 survey points on one workday
				Roadside traffic counts (12 hr, 6:30-18:30): 10 survey points on one workday
				Roadside traffic counts (24 hr, 6:00-6:00): 4 survey points on one workday
4	Screen line survey	To complement the person trip survey by capturing vehicle type, hourly variation, etc.	Traffic counts at the road crossing the screen line	Roadside traffic counts (12 hr, 6:30-18:30): 10 survey points on one workday
				Roadside traffic counts (24 hr, 6:00-6:00): 5 survey points on one workday
5	Traffic counts survey	To grasp general movement of traffic and to complement the traffic model	Roadside: traffic counts at major roads	Roadside traffic counts (12 hr, 6:30-18:30): 30 survey points on one workday
			Traffic counts by direction at major intersections	Intersection traffic counts (12 hr, 6:30-18:30): 20 intersections on one workday
6	Public transport user survey	To acquire information on the movement and requirement of public transport passengers	Interview at the bus terminals to public transport passengers.	Interview to 1,500 passengers at major terminals in Nairobi city centre.
7	Travel speed survey	To analyse vehicle speed affected by traffic congestion	Investigation of travel time by running each route	Survey route: 15 routes, three times a day (morning, afternoon, and evening)

Source: JICA Study Team (JST)

(3) Survey Schedule

Traffic survey was conducted by re-entrustment to national consultants. Traffic survey commenced in the middle of January. January was devoted to preparation of survey including stationing of police officer and training of surveyors. The entire field survey was conducted during February to avoid the unexpected occurrence of the election held on 4th March. The survey schedule is shown in Figure 7.1.2.



Source: JICA Study Team

Figure 7.1.2 Traffic Survey Schedule

7.1.3 Zoning and Survey Points

(1) Zoning System

Zoning inside the study area is based on the locations defined by the 2009 Population and Housing Census. Zoning system has three sizes, namely: large zone, medium zone, and small zone.

Small Zone: Small zone in Nairobi City corresponds to the sub location of census.

Medium Zone: Medium zone in Nairobi City corresponds to the location of census

Large Zone: Large zone in Nairobi City corresponds to the division in 2006.

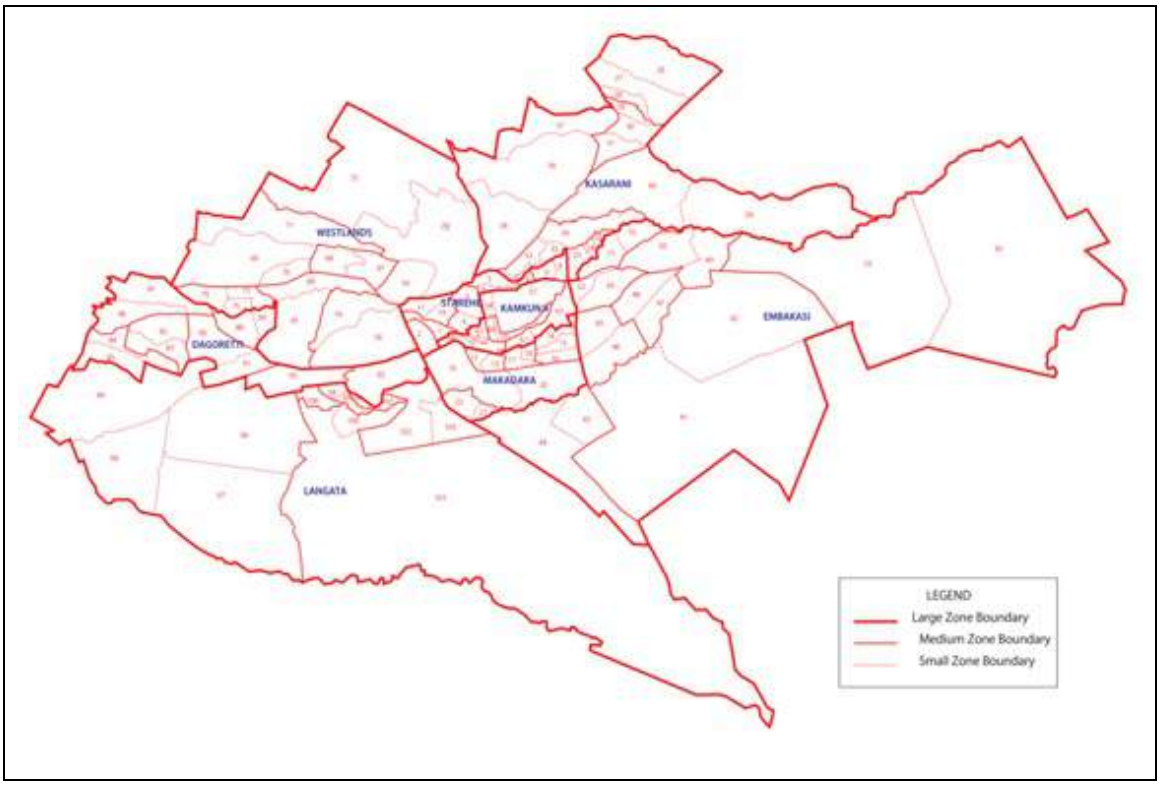
The extent of the surrounding area of the city of Nairobi corresponds to the area in the 2006 NUTRANS Study, but slight modification was made due to the variation of area of wards. In this way, the total number of zones is shown in Table7.1.2. Detailed zone code table is attached in Appendix 3.

Table 7.1.2 Total Number of Traffic Zones

	Small Zone	Medium Zone	Large Zone
Nairobi City area	106	49	8
Surrounding area of Nairobi City	21	9	3
Outside area	23	16	4
Total	150	74	15

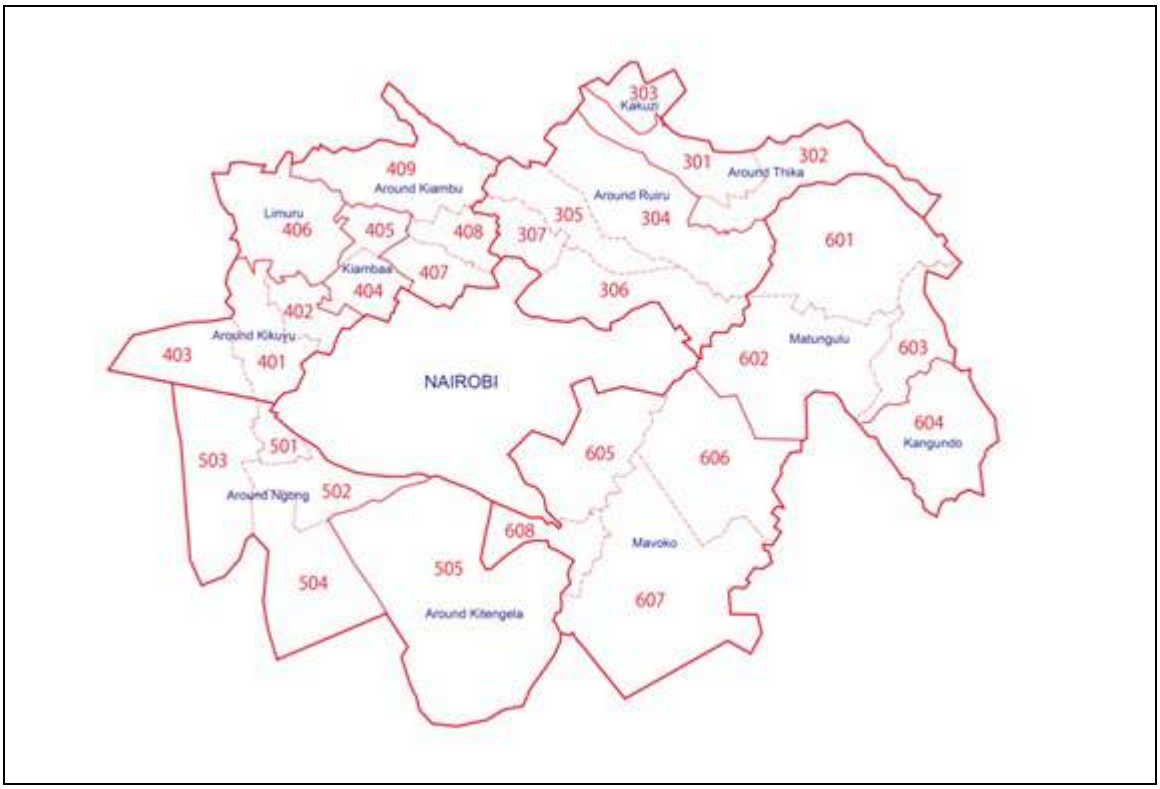
Source: JICA Study Team

Zone maps of Nairobi City area, surrounding area of Nairobi City, and the outside area are shown in Figures 7.1.3, 7.1.4, and 7.1.5, respectively.



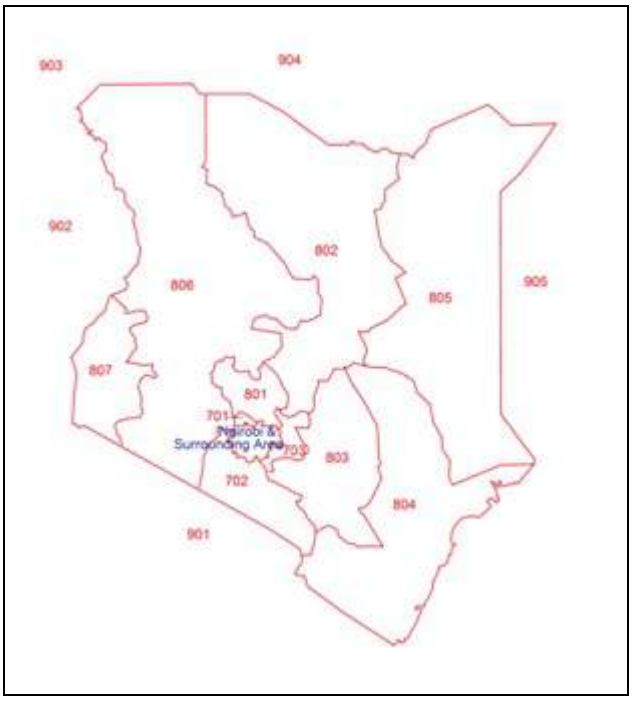
Source: JICA Study Team (JST)

Figure 7.1.3 Zone Map Inside the City of Nairobi



Source: JICA Study Team (JST)

Figure 7.1.4 Zone Map Around the City of Nairobi



Source: JICA Study Team (JST)

Figure 7.1.5 Zone Map Outside the City of Nairobi

(2) Survey Points

Amongst seven types of traffic surveys, five surveys were conducted at fixed survey points and routes.

1) Cordon Line Survey

Survey points for cordon line survey are located at the boundary of Nairobi City area along the major arterial roads.

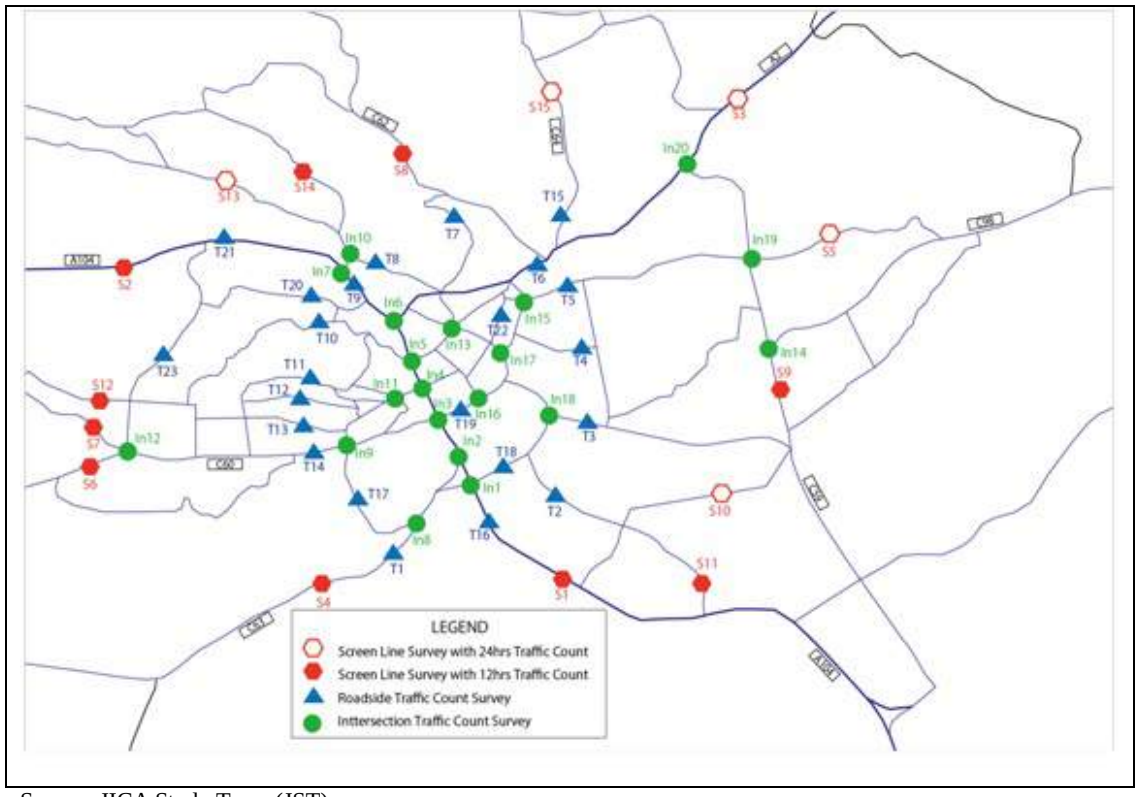
2) Screen Line Survey

Survey locations of screen line survey were set in consistency with the 2006 NUTRANS. Generally, screen line is conducted at the traffic barrier such as the river, but the objective of 2006 NUTRANS was to grasp the inflow and outflow from the densely urbanised area of Nairobi City.

3) Traffic Count Survey

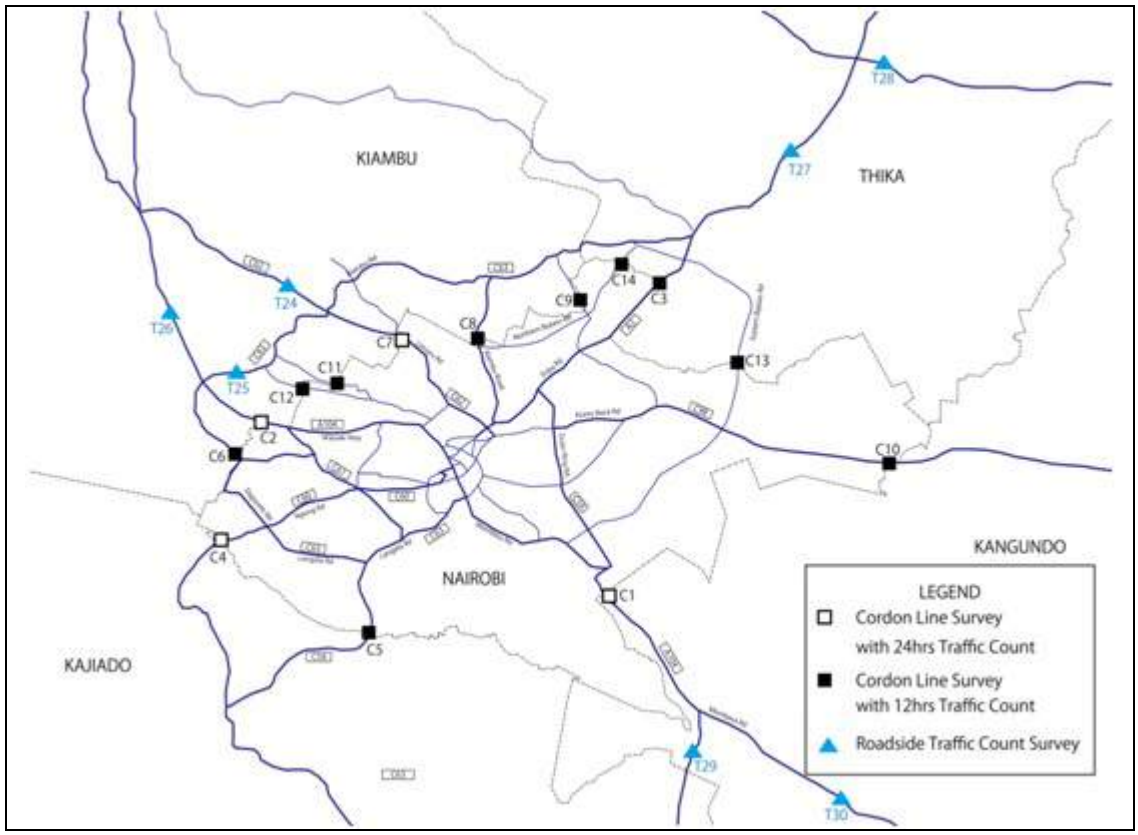
The traffic count survey was conducted based on two objectives. One is to capture the traffic movement/congestion inside Nairobi City centre area, and the other is to grasp the traffic volume along the arterial roads including outside the Nairobi City area.

The locations of the three types of traffic survey are shown in Figure 7.1.6 and Figure 7.1.7.



Source: JICA Study Team (JST)

Figure 7.1.6 Traffic Survey Point in Nairobi Urban Area



Source: JICA Study Team (JST)

Figure 7.1.7 Traffic Survey Point in Nairobi Urbanised Area

4) Public Transport User Survey

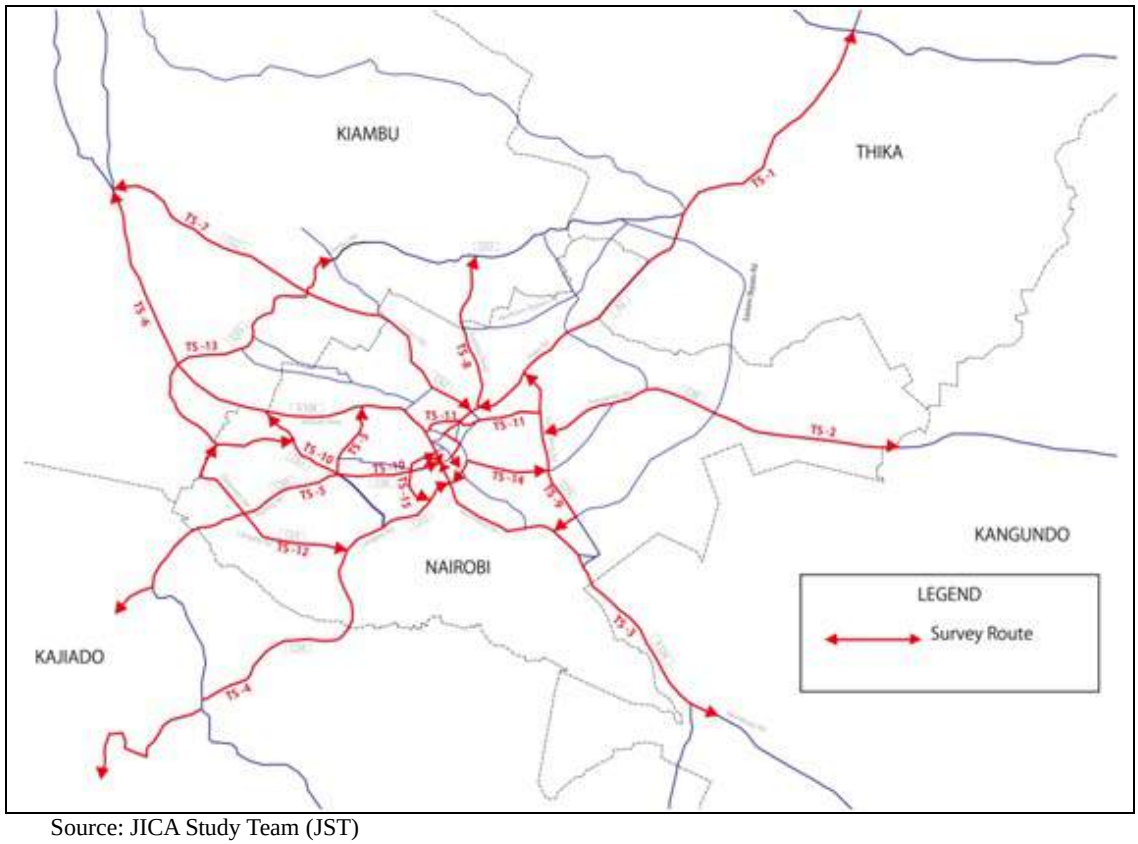
The objectives of public transport user survey was to collect public transport users' information regarding trip movement, fare, reason to use public transport, and required improvement in services. Survey location was in the centre of Nairobi City where various bus services are operated.

Source: JICA Study Team (JST)

Figure 7.1.8 Location of Public Transport User Survey

5) Travel Speed Survey

In total, 15 routes were selected for the travel speed survey as shown in Figure 7.1.9.



Source: JICA Study Team (JST)

Figure 7.1.9 Routes of Travel Speed Survey

7.1.4 Person Trip Survey

(1) Survey Method

1) General

Person trip survey is a method for analysing transport by capturing people's individual movement based on the concept that person's movement is the source of traffic. In order to capture the movement of persons, surveyors will visit households in the survey area and conduct interview about the movements (trips) of household members on a certain day. This was a sample survey, and the targeted households were selected randomly from the households of the survey area.

2) Survey Method

The survey area of the person trip survey is within the city of Nairobi. Total number of households to be interviewed shall be 10,000 households. According to the 2009 Census, the total households in Nairobi City was 985,016; therefore, the sampling rate of household is 1.02%.

The interview was made when the household head was present at home. The questionnaire is categorised into three, namely: household information, household member information, and trip information. Interview was made to cover persons 5 years old and above. Trip information was for trips made on workdays.

Interview items in the person trip survey are shown in Table 7.1.3.

Table 7.1.3 Interview Items in Person Trip Survey

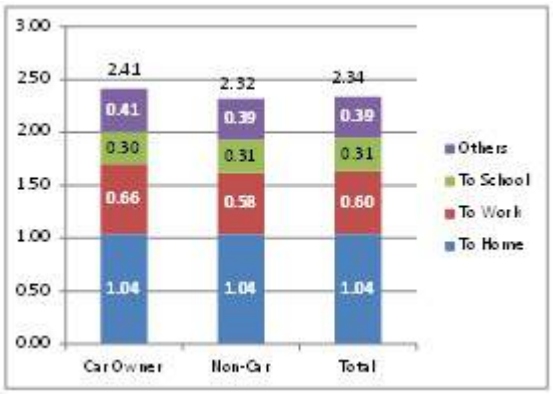
Household Information	Household Member Information	Trip Information
● Home address ● Number of household members ● Household income ● Vehicle ownership ● Land and house ownership	● Address of workplace and/or school ● Sex and age ● Occupation ● Personal income ● Vehicle of its own use ● Driving license	● Origin and destination ● Trip purpose ● Travel mode ● Departing time and arrival time

Source: JICA Study Team (JST)

(2) Survey Results Analysis

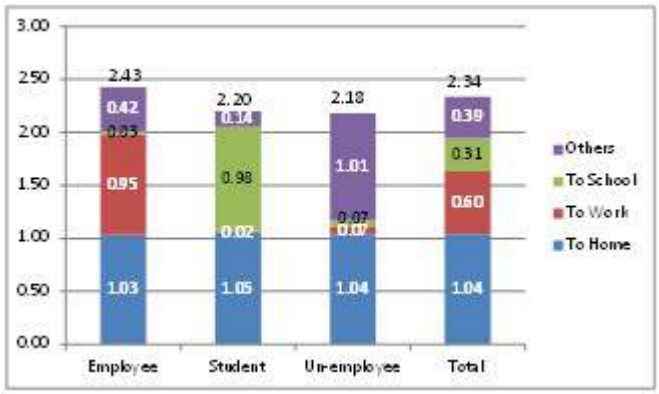
1) Trip Rate per Person

Trip rate per person is a fundamental and constant index by which the total number of trips in the future traffic demand will be controlled. Amongst the attributes obtained from the household information and the household member information by the person trip survey, car ownership and occupation can reflect a variation of characteristics of attributes in the future. As a result of the survey, car owner shows higher trip rate than non-car owner. As for the occupation, employee shows the highest trip rate amongst the three occupation categories.



Source: JICA Study Team (JST)

Figure 7.1.10 Trip Rate per Person by Car Ownership



Source: JICA Study Team (JST)

Figure 7.1.11 Trip Rate per Person by Occupation

Figure 7.1.12 shows the comparison of trip rate per person between 2004 and 2013. Trip rate increased from 2.25 in 2004 to 2.34 in 2013. Figure 7.1.10 shows the difference in trip rate per person by car ownership. Trip rate of car owners is higher than non-car owners. Figure 7.1.11 shows the difference in trip rate by occupation. Trip rate of employees is highest. Increase in trip rate from 2004 is attributed to increase in car ownership and increase of employees.

Source: JICA Study Team (JST)

Figure 7.1.12 Comparison of Trip Rate between 2004 and 2013

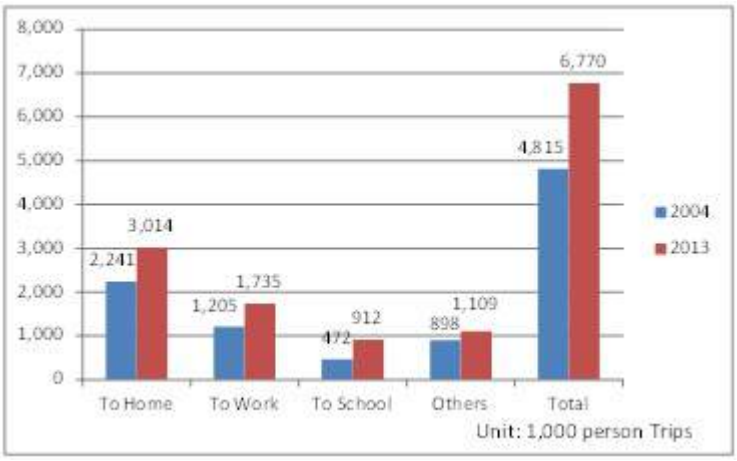
2) Trip Generation

Total person trip generation by persons living inside Nairobi City was 6.8 million person trips. Table 7.1.4 shows the growth rate of population, household, and trip generation. Due to the increase in trip rate, increase in trip generation is larger than increase in population and number of households.

Table 7.1.4 Increase in Population, Household, and Trip Generation from 2004 to 2013

	2004	2013	Rate 2013/2004
Population (persons)	2,656,997	3,601,351	1.36
Household (households)	889,317	1,154,279	1.30
Total trip generation (person trips)	4,815,457	6,769,861	1.43

Source: JICA Study Team (JST)

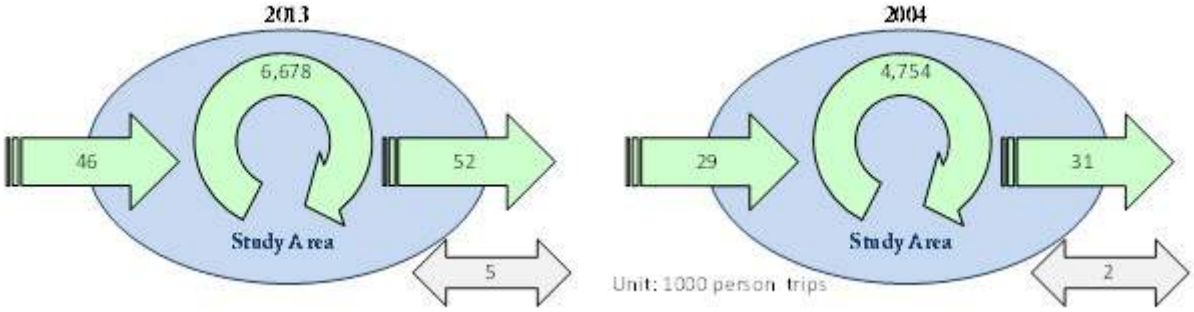


Source: JICA Study Team (JST)

Figure 7.1.13 Trip Generation by Trip Purpose in 2004 and 2013

3) Trip Distribution

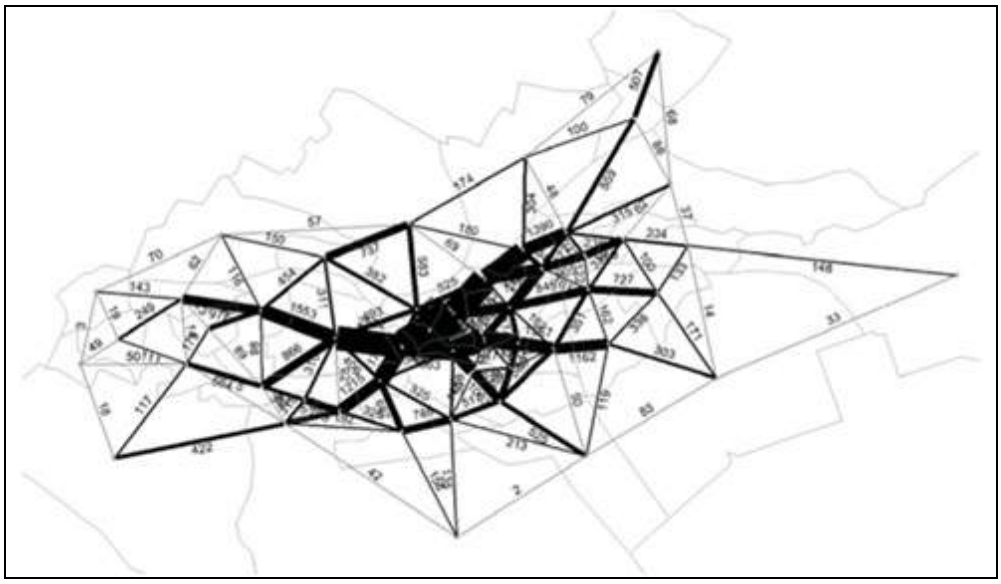
Figure 7.1.14 shows the person trip movement inside a wider area in 2004 and 2013. In 2013, the total number of trips coming to/from the outside of Nairobi City was 98,000 which occupied 1.4% of total trips. Compared with 1.2% in 2004, person trip movement in the wider area became more active.



Source: JICA Study Team (JST)

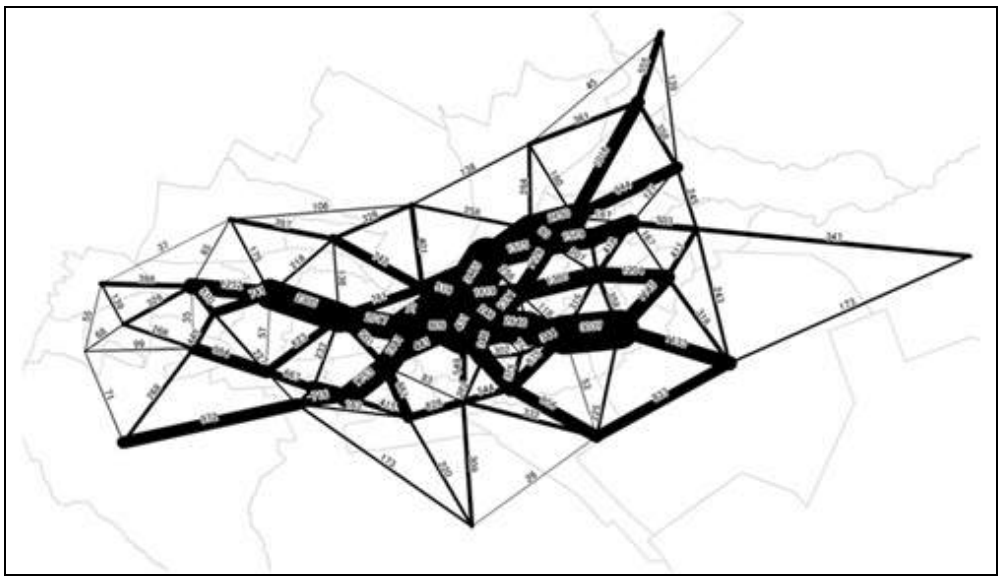
Figure 7.1.14 Person Trip Movement in a Wider Area in 2004 and 2013

Figures 7.1.15 and 7.1.16 show the person trip "desire line" inside Nairobi City in 2004 and 2013, respectively. Due to the distribution of recent population increase in the city area, trip movement in the east-west direction increased more than in the south-north direction. (Refer to Figure 2.1.2)



Source: JICA Study Team (JST)

Figure 7.1.15 Person Trip Desire Line inside Nairobi City in 2004

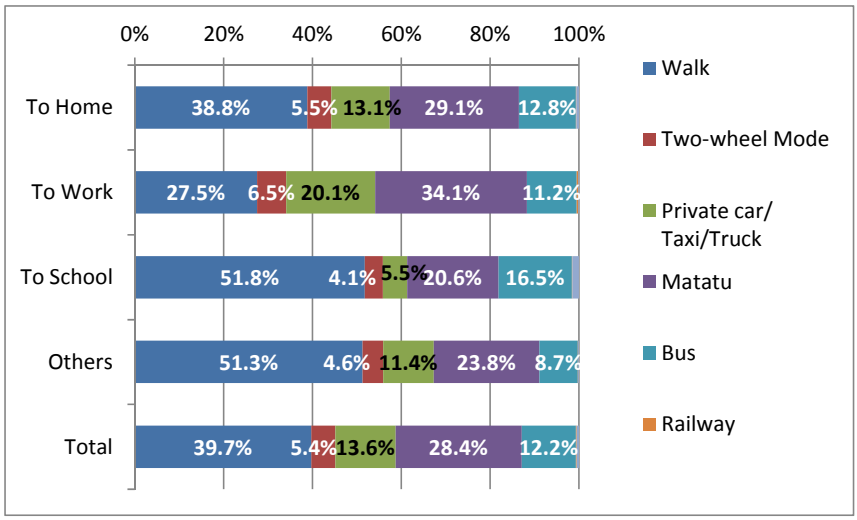


Source: JICA Study Team (JST)

Figure 7.1.16 Person Trip Desire Line inside Nairobi City in 2013

4) Travel Mode

Selection of travel mode has close relationship with trip purpose. Figure 7.1.17 shows the travel mode composition by trip purpose. In every trip purpose, except for "To Work", walking occupies the largest share. *Matatu* occupies the largest share of "To Work" trip purpose, and has the second largest share for other trip purposes.



Source: JICA Study Team (JST)

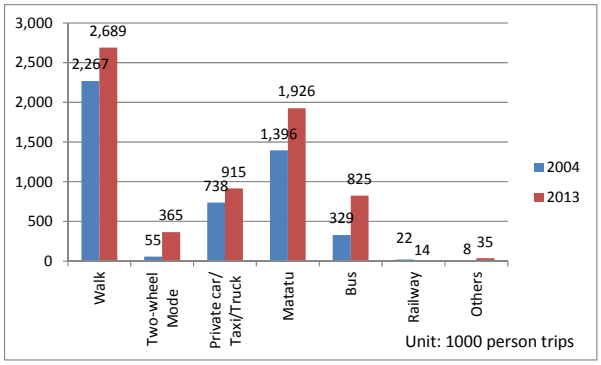
Figure 7.1.17 Travel Mode Composition by Trip Purpose

Table 7.1.5 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

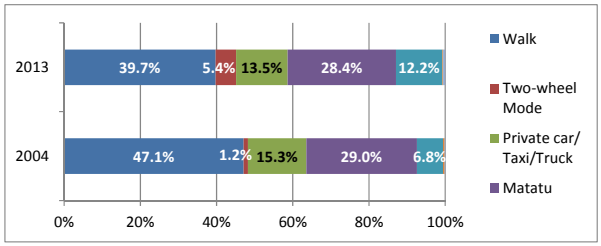
Source: JICA Study Team (JST)

Figures 7.1.18 and 7.1.19 show the comparison of travel modes between 2013 and 2004. Compared with 2002, walking decreased and bus and *matatu* increased. Between *matatu* and bus, the share of bus increased due to the promotion policy of the government.



Source: JICA Study Team (JST)

Figure 7.1.18 Comparison of Number of Trips by Travel Mode between 2013 and 2004



Source: JICA Study Team (JST)

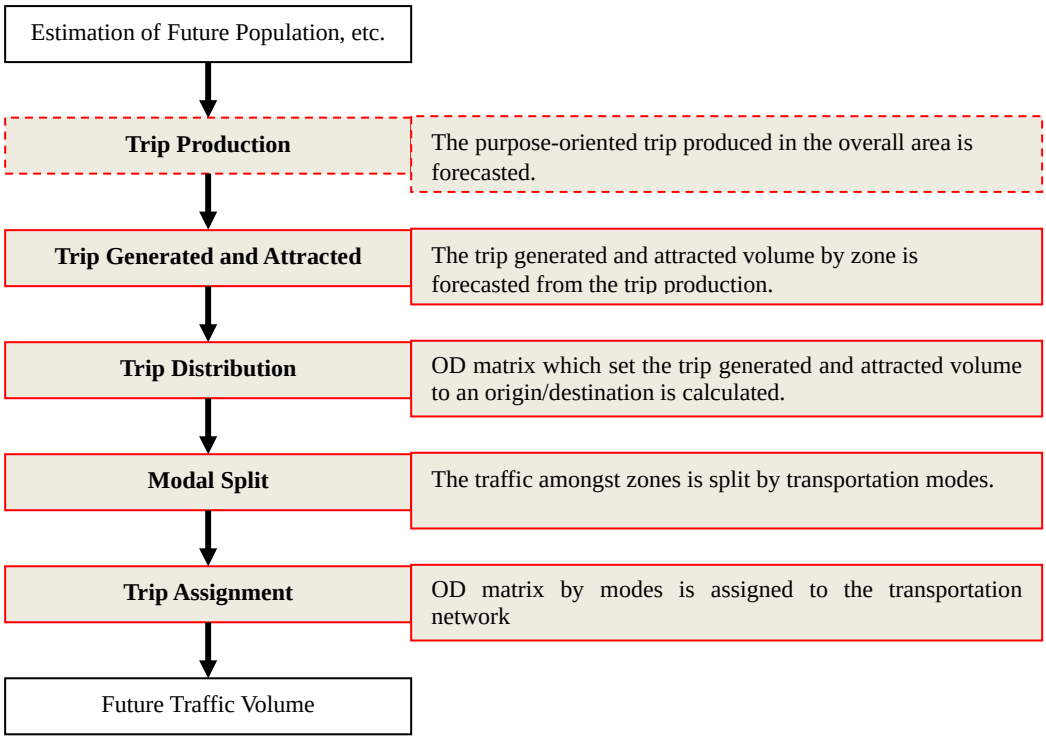
Figure 7.1.19 Comparison of Composition of Travel Mode between 2013 and 2004

7.1.5 Formulation of Future Transport Demand

(1) Methodology

Transportation network is important in delineating the urban structure function as the base of urban development and growth. In parallel with transportation planning, clarifying the necessity for an improvement of the transportation facility is required. Therefore, it is important to forecast the future transport demand and to provide transportation facilities responding to it. Investment for appropriate transportation facilities will be discussed in this study.

A widely practiced method in transport demand forecasting is the four-step method. This study will also forecast transport demand in the future based on the four-step method. The method has four processes, namely: i) trip generated and attracted, ii) trip distribution, iii) modal split, and iv) trip assignment. The flow and outline of the four-step method are shown in Figure 7.1.20. Reproducibility of present condition by the models and detailed calculations of each step are shown in Appendix-4.



Source: JICA Study Team (JST)

Figure 7.1.20 Flow of Four-Step Method

(2) Target Area and Zoning

In the future demand forecast, target area is mainly Nairobi City area, but some of its peripheral area is also considered in the calculation to reflect the movement of traffic from the outside area. The latter case will be referred to as Greater Nairobi hereinafter, as opposed to the former case of Nairobi City.

Zoning system for the forecast is basically a medium zone system which is described in Section 7.1.2 (1). Since the sample rate of person trip survey is relatively low, the number of zones of small zone system is too large for keeping the accuracy in the prediction. To this end, the medium zone system is selected for demand forecast although traffic survey was conducted based on the small zone system.

(3) Forecasting System

Software called JICA System for Traffic Demand Analysis (STRADA) and spreadsheets are used for the calculation of the model building and transport demand forecasting. The JICA STRADA is capable

of assigning future traffic volumes and showing the results visually. Then, Excel spreadsheets are used in the process in which traffic is assigned based on the person trip survey data. The traffic assignment method is the user equilibrium assignment method, which is also widely practiced.

(4) Traffic Assessments to Present Transport Network

Traffic demand forecast to present transport network is conducted for model building and analysis of present traffic condition.

1) Present traffic demand (2013) to present transport network (Existing Case)

This case is calculated to confirm the accuracy of traffic models and to analyse the traffic movement.

2) Future traffic demand (2030) to present transport network (Do-Nothing Case)

This case is calculated to analyse where traffic issues appear if the network is not improved. Based on the analysis, policy for future transport network shall be established.

The calculation of the demand forecast is shown in Appendix-4.

The primary indices of demand forecast for the Existing Case and the Do-Nothing Case are summarised in Table 7.1.6. Traffic assignment results for the Existing Case and Do-Nothing Case are shown in Figure 7.1.21 and Figure 7.1.22, respectively.

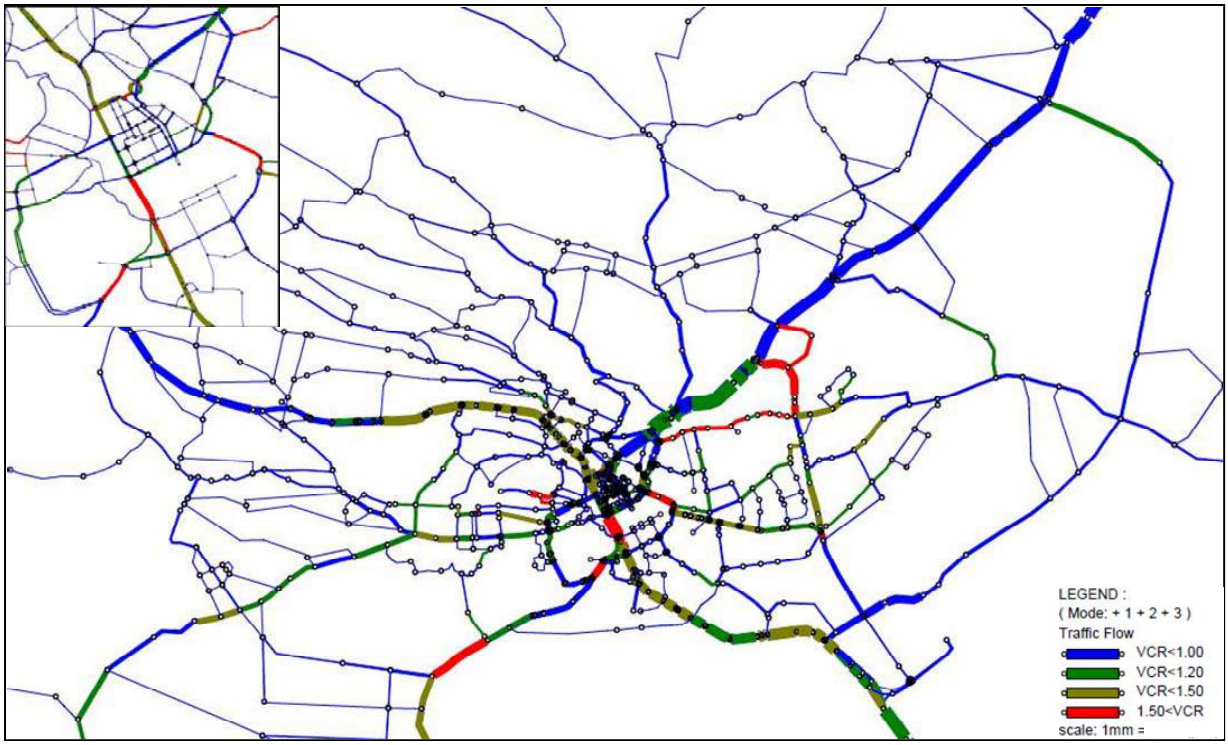
Table 7.1.6 Primary Indices by Vehicle Assignment Results in Existing Case and Do-Nothing Case

Area	Case	Year of Traffic Demand	Year of Network	Vehicle-km Total (PCU-km)('000) (Increase rate)	Vehicle-hours Total (PCU-Hour) (Increase rate)	Average Speed (km/h)	Average VCR (Volume Capacity Ratio)
Greater Nairobi	Existing Case	2013	2013	17,780 (1.00)	431,690 (1.00)	41.2	0.54
	Do-Nothing Case	2030	2013	39,110 (2.20)	1,692,480 (3.92)	23.1	1.19
Nairobi City	Existing Case	2013	2013	10,960 (1.00)	273,910 (1.00)	40.0	0.69
	Do-Nothing Case	2030	2013	25,320 (2.31)	1,254,120 (4.58)	20.2	1.60

Source: JICA Study Team (JST)

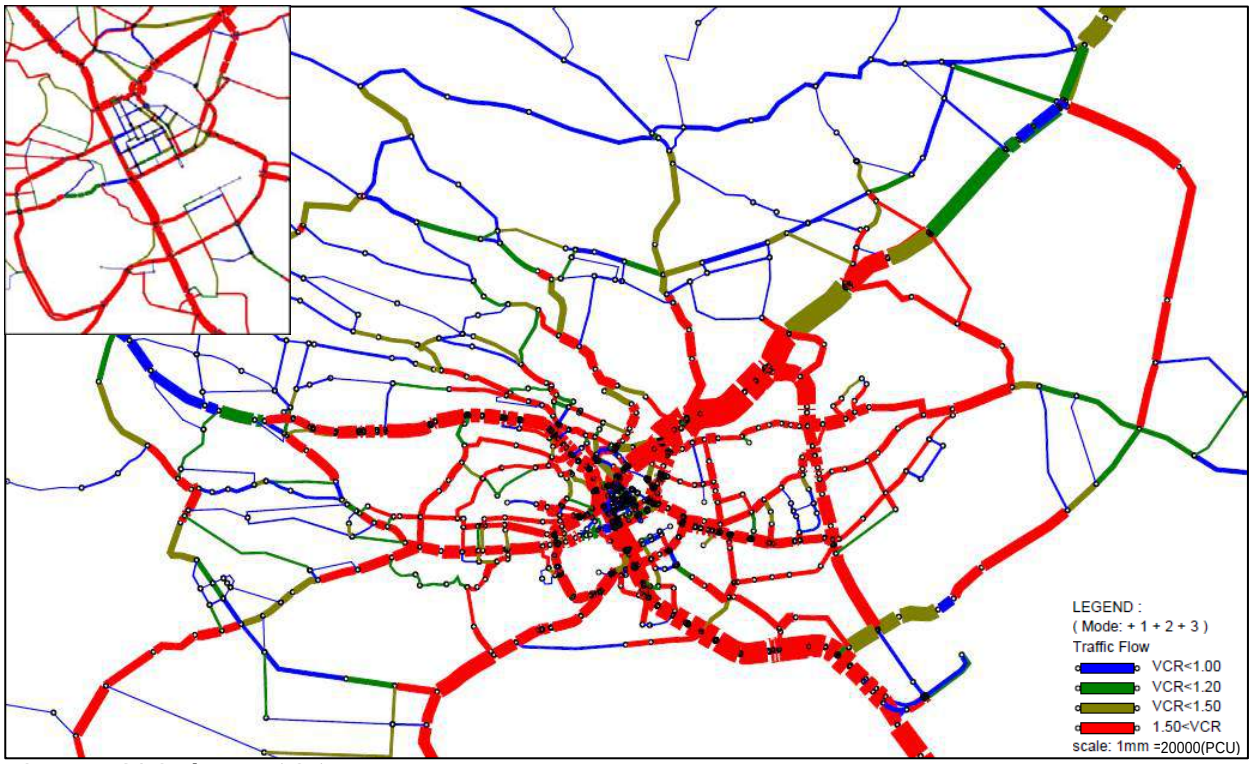
In the Do-Nothing Case, almost all the radial roads going to city centre, the circumferential roads, and the bypass roads such as Outer Ring Road and Eastern Bypass are heavily congested. Also, radial roads connecting the southern area of Nairobi City are heavily congested. Comparing the Do-Nothing Case and Existing Case, total vehicle-hours inside Nairobi City will increase by 5.3 times due to congestion while total vehicle-km will increase by 2.4 times. Congestion in Nairobi City will be more serious than in Greater Nairobi.

It is definite that the congestion of roads will become much more intense. Traffic volume will increase rapidly and road service level will become poorer than the existing condition. Therefore, several countermeasures which will decrease automobile traffic in the future and increase public transportation will be extremely necessary.



Source: JICA Study Team (JST)

Figure 7.1.21 Vehicle Assignment Result in "Existing Case" (2013)



Source: JICA Study Team (JST)

Figure 7.1.22 Vehicle Assignment Result in "Do-Nothing Case" (2030)

7.1.6 Formulation of Future Transport Network

(1) Basic Approach

1) Coordination with Proposed Land Use Plan

Since the future land use plan has been proposed by the JICA Study Team in Chapter 6, the land use plan shall be dealt with a major premise for the establishment of transport development policy.

2) Consistency with NUTRANS, 2006

JICA conducted NUTRANS from 2004 and issued the final report in March 2006. Since then, economic and social conditions have changed a great deal, but the roots of the transport issue did not change much and some of the proposals in the NUTRANS are still effective and valid. Therefore, this study shall be consistent with NUTRANS.

3) Conformity with Government Policies

Transport development policy should be in conformity with the government visions and policies. Kenya Vision 2030, Nairobi Metro Vision 2030, and Integrated National Transport Policy are essential policies in this aspect.

4) Preparation of Alternative Case for Evaluation

After the publication of NUTRANS in 2006, the Consultancy Service for Feasibility Study and Technical Assistance for Mass Rapid Transit System for the Nairobi Metropolitan Region (MRTS) was publicised by MOT. The concept of network of MRTS is reflected in the Nairobi Metro Vision 2030. Nairobi Metropolitan Services Improvement Project (NaMSIP), which emphasised the use of rail line, was issued by WB in 2012. In order to evaluate the measures in terms of reality and effectiveness, the JICA Study Team will prepare alternative cases in reference to MRTS and NaMSIP proposals.

5) Selection of Optimum Alternative Case

By conducting traffic demand forecast, alternative cases will be evaluated by indices regarding road congestion, possibility of coexistence of public and private modes, and mobility of person trips.

6) Staging Plan for Implementation

After selection of the alternative case, short-term plan (2018) and medium-term plan (2023) will be prepared and evaluated by the traffic demand forecast. As a result of evaluation, short-term plan and medium-term plan will be established.

(2) Basic Policy

Based on the present constraints and planning issues, and the policies articulated in the government plans and visions, the urban transport development policy in NIUPLAN is formulated as follows:

1) Key Concept: Ensuring World-class Mobility

Since the Nairobi Metro 2030 envisages a world-class metropolis, transport system should ensure the mobility enabling lively activity of citizens and industries.

2) Road Network Development Policy

i) Establishment of Circumferential/Radial (C/R) Network System

NUTRANS and the Spatial Planning Concept of Nairobi Metropolitan Region recommended the network system comprising radial and circumferential/orbital roads. Especially around the CBD area and in the peripheral area of the city centre, circumferential road is essential to divert the traffic which does not have origin or destination inside the city centre.

iii) Establishment of Hierarchical Classification of Roads

The Former Ministry of Road issued Road Classification Manual in 2009 and the manual classifies urban roads into class H to P. But existing road functions are not corresponding to the classification and the road density is not consistent with population distribution or industry distribution. Classification shall be reviewed considering the function of each road and improvement of road should be conducted by the classification.

iii) Exclusion of Through Traffic from Urban Traffic

According to the cordon survey result, about 46,000 vehicles passed through the Nairobi City area in 2013. As the development in the surrounding area of Nairobi City progresses, through traffic will increase more. Therefore, exclusion of through traffic from urban traffic by sufficient bypass will be required.

3) Public Transport Development Policy

i) Enhancement of Modal Shift to Public Transport

In reference to the demand forecast shown in Section 7.1.4, traffic demand in 2030 is estimated to increase to about two times of the traffic demand in 2013. To cope with the increasing traffic demand, increase in road capacity by road development is limited by the amount of investment and restriction in land acquisition. Modal shift to public transport with large capacity and high convenience is required. To this end, introduction of new public transport system as well as improvement of existing bus/*matatu* service will be examined.

ii) Strengthening of the Existing Railway

Railway is an existing infrastructure which should be utilised more. Although rolling stock is in aging and unreliable condition, infrastructure of railway is in good condition. Concept of commuter railway network is proposed by KR and Ministry of Nairobi Metropolitan Development (MONMD) and FS for commuter rail will be commenced soon. In this study, revamping of existing railway will be investigated as a measure to promote public transport.

iii) Promotion of Transit Oriented Development (TOD)

Viability of public transport depends on the concentration of passenger demand which has relationship with land use. The land use system which enhances public transport and thus reduces the use of private vehicles is called transit oriented development (TOD) and has been introduced to many countries. Land use plan will be established taking into account of this aspect.

4) Non-motorised Transport (NMT)

i) NMT as Prerequisite

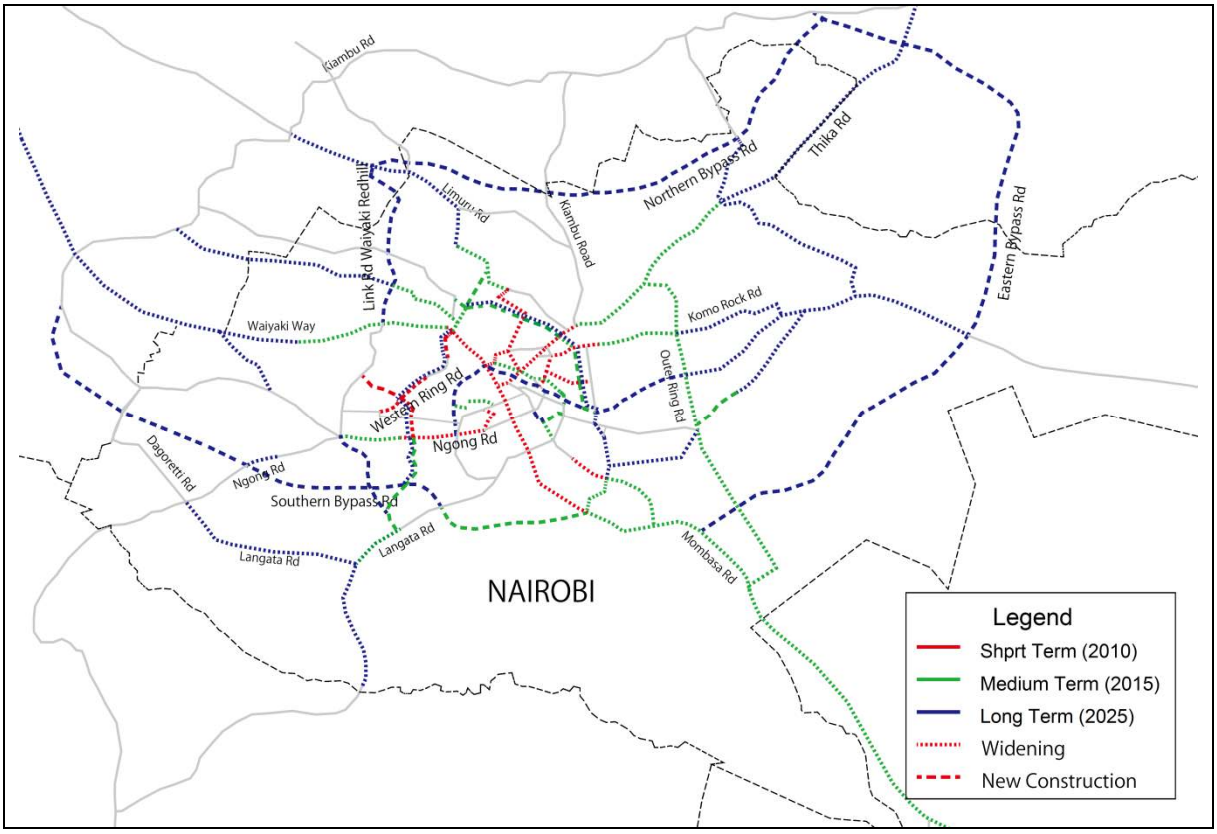
According to the person trip survey result, 40% of travel mode is walking. Additionally, walking is invariably necessary for bus, *matatu* and railway trips as the access/egress trip. Given this condition, facility for NMT is a prerequisite; therefore, development/improvement of facility is required in the entire Nairobi City area.

In developing the NMT facility, priority is given to the roads where demand is concentrated. Detailed description for the priority facilities will be shown in (4) NMT network plan.

(3) Road Network Plan

1) Progress of Road Development after 2006 M/P (NUTRANS)

Target years of the 2006 M/P (NUTRANS) are 2010 (short term), 2015 (medium term), and 2025 (long term). Figure 7.1.23 shows the road development/improvement in each target year by the NUTRANS.



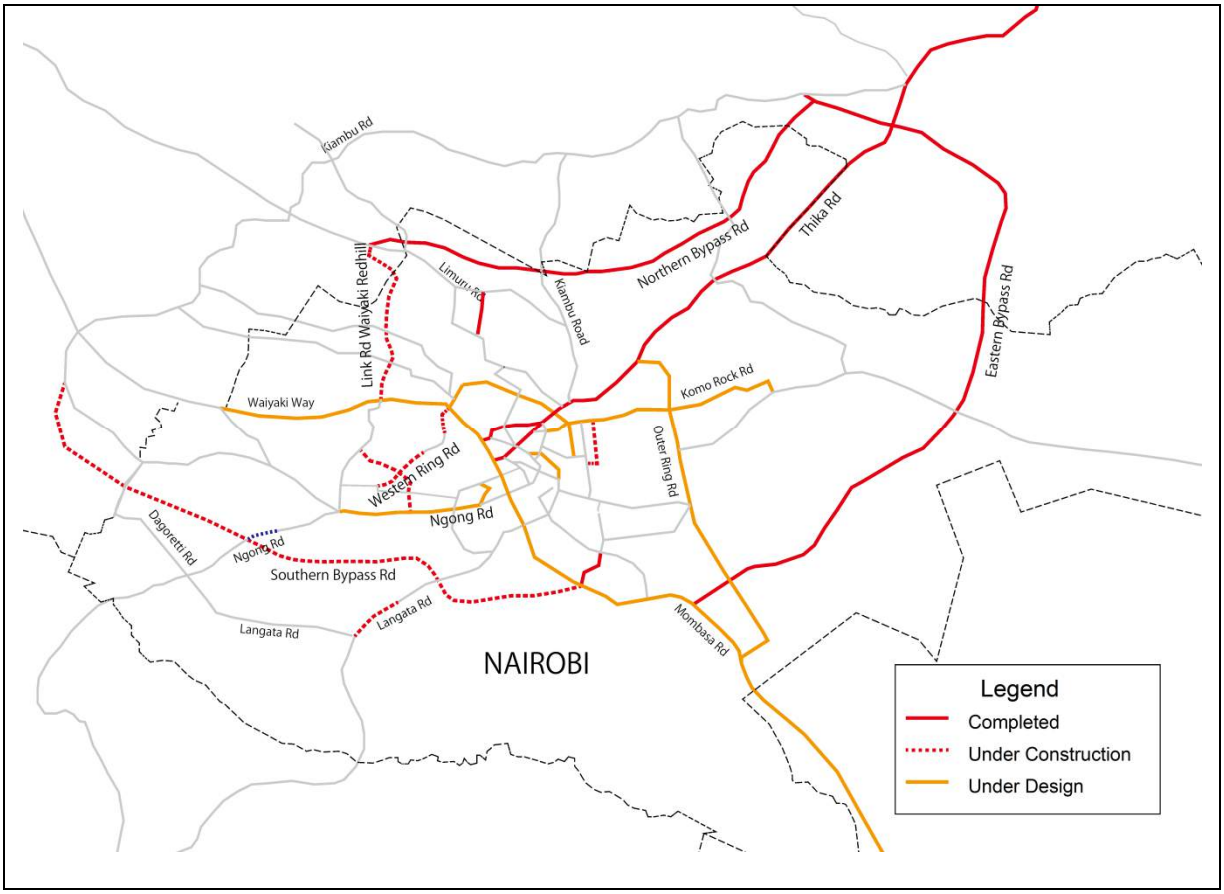
Source: The Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area in the Republic of Kenya, Final Report, 2006

Figure 7.1.23 Recommended Road Development by the 2006 M/P (NUTRANS)

After issuance of 2006 NUTRANS, various developments/improvements of trunk roads made progress. Figure 7.1.24 shows the road developments/improvements after 2006. These developments/improvements are mainly financed by the Kenyan government, African Development Bank (AfDB), World Bank (WB), EU, Japan, and China. In the 2006 M/P, first priority was given to roads around the city centre area, and second priority was given to roads in the suburban area. On the contrary, road development made progress both around the city

centre area and outside the urbanised area. Considering the distribution of future traffic demand, development of roads around the city centre is still urgent; therefore, following the future network and the priority recommended by the 2006 M/P is one of the basic policy in this study.

Detailed information on NUTRANS and progress of development is attached in Appendix-5.



Source: Website of KURA, JICA Study Team (JST)

Figure 7.1.24 Progress of Road Development after 2006 M/P

2) Review of the Traffic Assignment of Future Traffic Demand

Since the target year in this study is 2030, which exceeds the target year of NUTRANS by five years, increase in traffic demand from 2025 to 2030 should be considered. By reviewing the traffic assignment for Do-Nothing Case shown in Figure 7.1.22, analysis on distribution of future traffic demand can be conducted.

Widening of the following roads which are not expected in 2025 is required for future network in 2030:

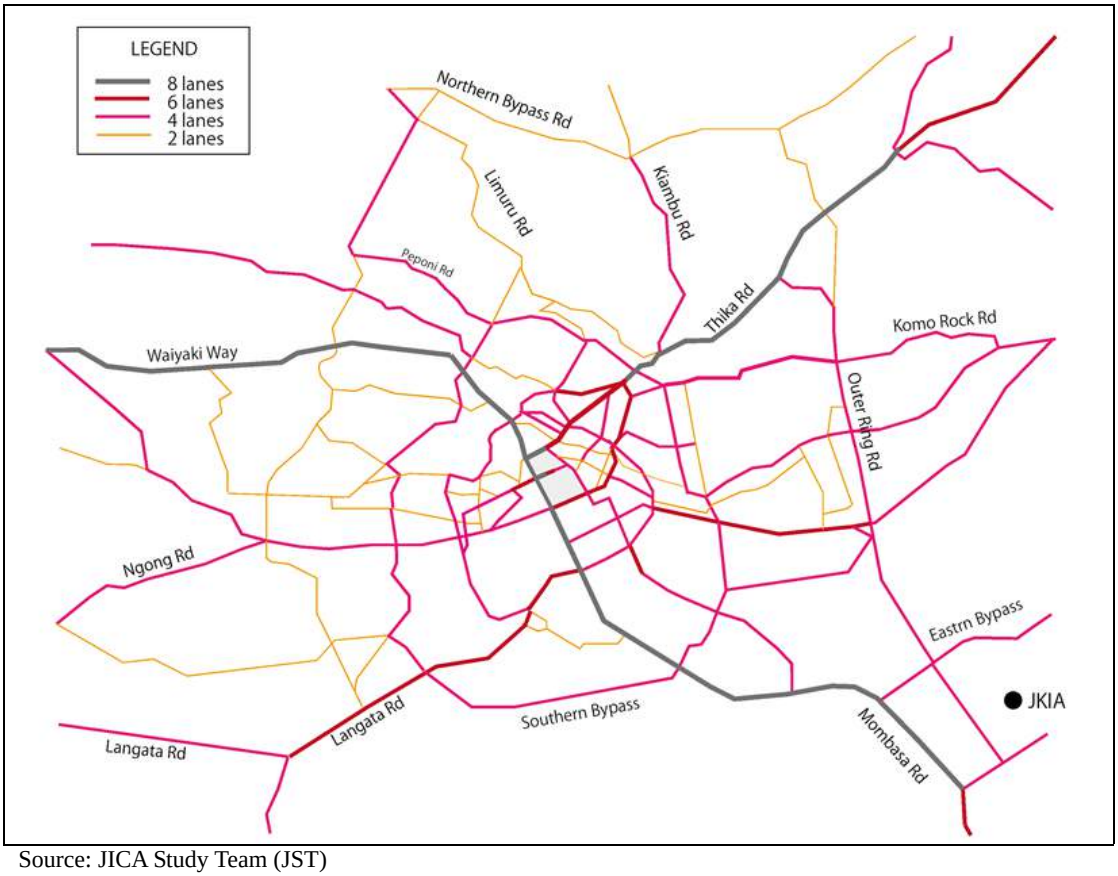
- Eastern Bypass (Mombasa Road-Thika Road)
- Ngong Road (Dagoretti-)
- Langata Road (Uhuru Highway-Magadi Road crossing)
- Jogoo Road (Lusaka Road-Outer Ring Road)
- Naivasha Road (Dagoretti-Kikkuyu Road crossing)
- Kiambu Road (Thika Rd.-Northern Bypass)

- James Gichuru Road (Waiyaki Way-Ngong Road)

3) Future Road Network

Based on the aforesaid analysis, future road network is established as shown in Figure 7.1.25. Modifications were made at the following two routes from NUTRANS:

- Route of circumferential road C-2 was altered due to the present land use.
- Widening of Limuru Road was avoided due to the present land use and instead Peponi Road will be widened.



Source: JICA Study Team (JST)

Figure 7.1.25 Future Road Network (2030)

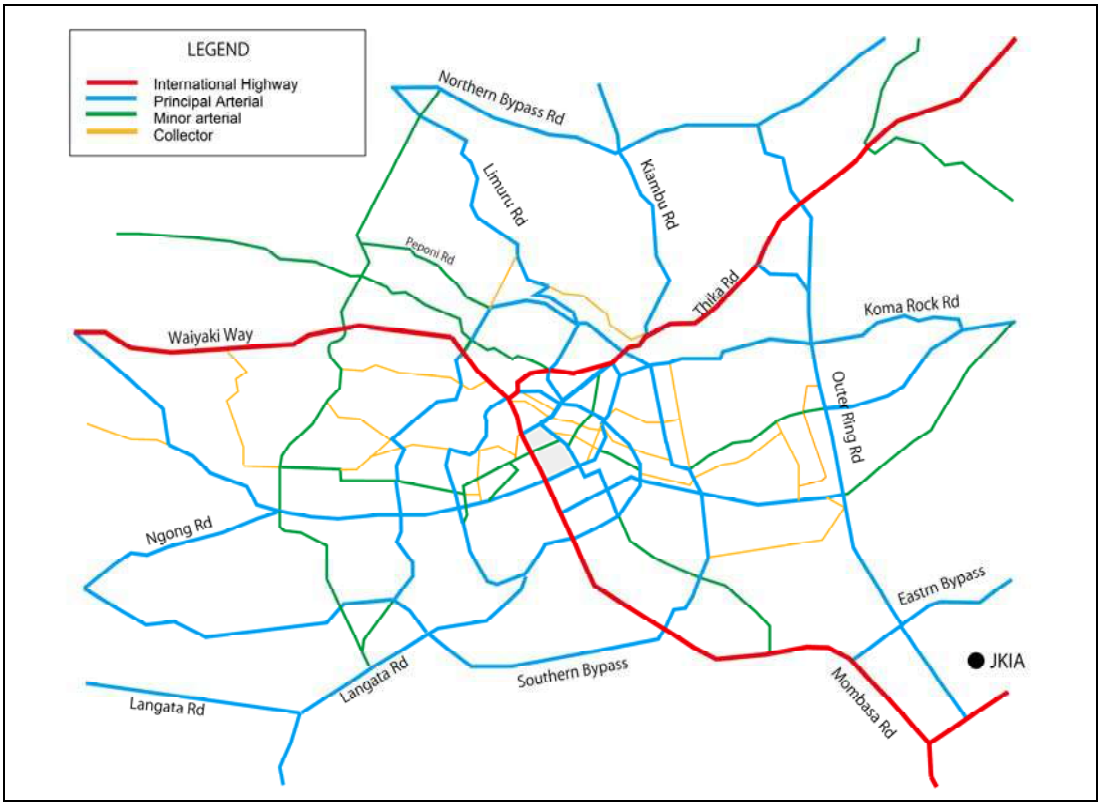
4) Road Classification of Future Network

Road classification was proposed in NUTRANS in 2006. In 2009, Kenya Roads Classification Manual was issued by the MOR. The classified existing road network is shown in Table 4.2.2 and Figure 4.2.1. Future road network in 2030 will be defined taking account of the manual as shown in Table 7.1.7 and Figure 7.1.26. Typical road cross section based on NUTRANS for each classification is shown in Appendix-7.

Table 7.1.7 Road Classification and Definition

International Highway	Roads forming strategic routes and corridors, connecting international boundaries and international terminals such as international ports. (Class A, Class B of the manual)
Major Arterial Road	Roads linking district headquarters and other major designated towns to the higher level network or to each other. Roads for through traffic and relatively long distance movements between widely separated parts of the town or city. (Class C and Class H)
Minor Arterial Road	Minor arterials provide the main means of moving between different zones of the urban area. (Class J)
Collector Road	Collectors provide the link between arterials and local roads, distributing traffic to residential and other defined zones. (Class K and Class L)
Local Road	Roads providing direct access to groups of residential properties, suitable for motorised transport. Roads providing direct access to social or economic activity, including industrial and commercial areas, and government institutions. (Class M, Class N and Class P)

Source: NUTRANS, JICA, Kenya Roads Classification Manual, MOR



Source: JICA Study Team (JST)

Figure 7.1.26 Classification of Future Road Network (2030)

(4) Public Transport Network Plan

1) Existing Public Transport Network Plan

In NUTRANS, the measure for improvement of public transport network plan was bus prioritisation and upgrading of existing railway. Introduction of LRT was envisaged after 2025. After NUTRANS, two public network plans were proposed, one was the MRTS by MOT and the other was NaMSIP by MONMD. Table 7.1.8 shows the summary of public transport network plan by NUTRANS, MRTS, and NaMSIP.

Table 7.1.8 Summary of Existing Public Transport Network Plans

	NUTRANS[*1]	**MRTS[*2]**	**NaMSIP[*3]**
Issued	2006	2011	2011
Ministry	Ministry of Road and Infrastructure	Ministry of Transport	Ministry of Nairobi Metropolitan Development
Assisted by	JICA	AfDB	WB
Project outline	Bus priority/exclusive lane and busway on the following corridors: 1) Northern corridor (Thika Road) 2) Eastern corridor (Juja Road and Jogoo Road) 3) Southwestern corridor (Mombasa Road) 4) Southwestern corridor (Langata Road) 5) Western corridor (Ngong Road, etc.) 6) Northwestern corridor (Waiyaki Way)	Introduction of LRT to the following corridors: 1) Waiyaki Way corridor 2) Jogoo Road corridor 3) Outer Ring Road corridor Introduction of METRO to the following corridors: 1) Thika Road corridor (NRS-Githurai) 2) Thika Road corridor (Githurai-Ruai) 3) Juja Road corridor 4) Ngong Road corridor Introduction of BRT to the following corridors: 1) Limuru Road corridor 2) Langata Road corridor 3) Mombasa Road corridor Introduction of BRT to METRO corridor extension	Improvement of existing railway to commuter train 1) NRS-Ruiru section 11 stations (including NRS) 2) NRS-Kikuyu section 9 stations (excluding NRS) 3) NRS-Syokimau 4) Introduction of Diesel Multiple Unit (DMU) Land development is associated with the opening of new station.
Total cost	KSh34,795 million (including all roads)	BRT: KSh74,441 million LRT: KSh134,740 million Metro: KSh218,969 million	KSh8,000/12,000 million [*4]
Target year	2025	2030	2012

Source: *1: The Study on Master Plan for Urban Transport in the Nairobi Metropolitan Area in the Republic of Kenya, March 2006
*2: Consultancy Services for Feasibility Study and Technical Assistance for Mass Rapid Transit system for the Nairobi Metropolitan Region, June 2011
*3: NaMSIP, Nairobi Metropolitan Leadership (Presentation document for 2 July meeting)
Remark: Since NamSIP is in the conceptual stage, cost estimation was roughly conducted.

2) Future Public Transport Network

MRTS has its implementation schedule divided into two phases: the first phase is from 2011 to 2022, and the second phase is from 2019 to 2030. After the issuance of MRTS report, development of roads for the MRTS corridor has made progress such as Ngong Road and Juja Road, but the necessary process for the realisation of MRTS has not made much progress. This is because investment for MRTS, which was expected to be by PPP, is too large to handle easily. Considering this condition, future public transport network shall be based on NUTRANS incorporating the concept of MaMSIP. As for the proposal by the MRTS, BRT will be introduced to possible corridors and selected LRT corridors will be introduced until the target year.

Evaluation of the public transport system will be conducted by traffic demand forecast of alternative cases.

3) Public Transport Terminal Plan

Currently, most of the terminals for bus and *matatu* are concentrated in the city centre area. As a result, access roads to bus/*matatu* terminals are heavily congested. To alleviate the congestion by bus/*matatu*, the following measures are required:

i) Development of New Terminal at the City Centre

The location and the size of new terminal will be scrutinised through the detailed plan of city centre development.

ii) Removal of Long Distance Bus Terminals to Outside the City Centre

Disposition of the new terminals will be examined considering the location of sub-centres by the land use plan because new bus terminal will become the core of the sub-centre.

iii) Development of Sub-terminal at the City Sub-centre

During the stage when MRTS is the major public transport in the city, existing m*atatu* will operate as feeder service mode and cover the area which MRTS will not cover. Therefore, sub-terminal is expected to function as transfer terminal from *matatu* to MRTS or large bus.

(5) Future Network Alternatives

(i) Objective of Evaluation of Alternative Case

In this study, road network is fundamentally based on the network recommended by NUTRANS. The basic policy for the network plan declares that enhancement of modal shift to public transport is requisite to address the increasing traffic demand. On the other hand, several public transport plans are proposed by the studies financed by development partners. Introduction of new public transport system will be studied under the MOTI initiative. Hence, the objectives of the evaluation of alternatives are as follows:

1) Evaluation of traffic condition by development of road network.
2) Evaluation of effect by introduction of public transport systems in decreasing vehicle traffic.
3) Proposal of a concept for introduction of new public transport, and the presentation of the demand forecast result.

(ii) Establishment of Alternative Cases

Since the future road network is based on NUTRANS with updates, the objective of network alternative case in 2030 is for the evaluation of the effectiveness and viability of public transport systems. Based on this concept, four alternative cases shown in Table 7.1.9 are established.

Table 7.1.9 Summary of Alternative Cases

	Name	Road Network	Public Transport Network	Remark
Alternative 0	On-going Project Case	Existing network and on-going road project	Existing network	
Alternative 1	Road Development Oriented Case	Future road network shown in Figure 7.1.15	Existing network	
Alternative 2	Utilisation of Commuter Rail Case	Same as Alternative 1	Existing network and introduction of commuter rail	Three commuter rail lines
Alternative 3	Introduction of Selective MRTS Case	Same as Alternative 1	Commuter rail and introduction of BRT, LRT	Four BRT routes and one LRT route

1) Alternative 0 (Ongoing Project)

Road network of alternative 0 is the existing network with the ongoing projects shown in Figure 7.1.24. This case is the base case for the comparison of effectiveness of measures selected in each alternative.

The following projects are included in the ongoing projects:

- Expanding and Upgrading of the Northern Corridor Road including the Elevated Highway over the Uhuru Highway
- Construction of Southern Bypass Road
- Construction of Missing Link Nos. 1, 5, 10, 15a, 15b, and 16
- Dualling of Outer Ring Road
- Construction of Western Ring Roads
- Widening of Ngong Road from Kenyatta Avenue Intersection to Dagoretti
- Widening of Juja Road
- Upgrading of Langata Road of KWS Gate-Bomas Junction Section
- Widening of Outer Ring Road

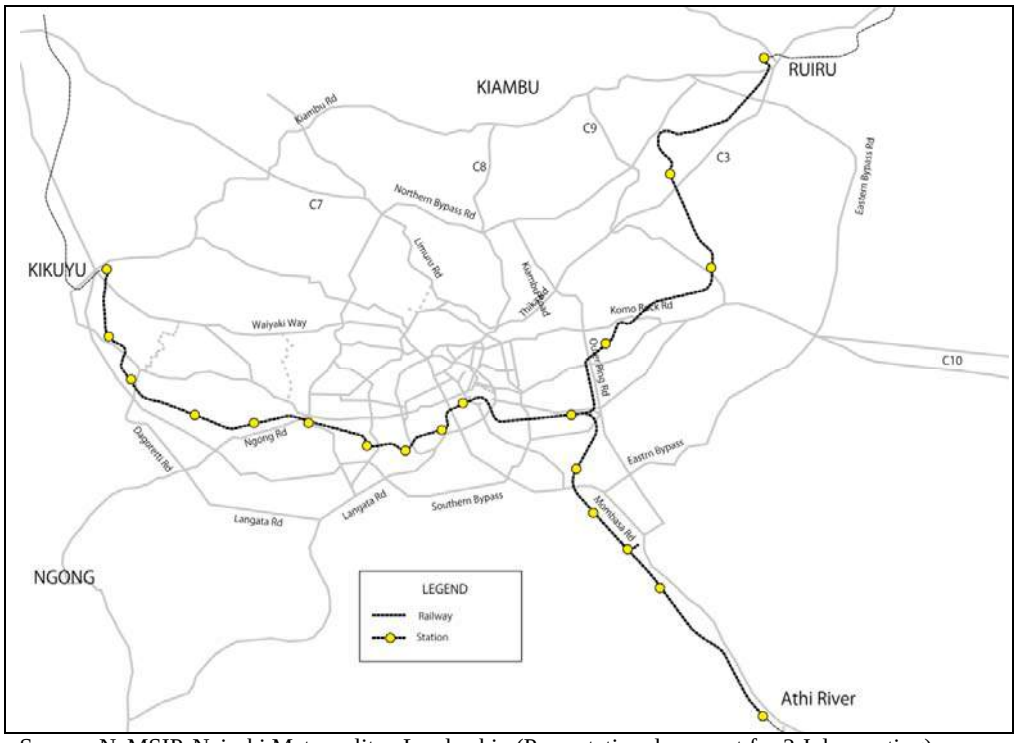
2) Alternative 1 (Road Development Oriented Case)

The objective of alternative 1 is to solve the transport issues solely by road development. Road network for alternative 1 is shown in Figure 7.1.25.

3) Alternative 2 (Utilisation of Commuter Rail Case)

To solve the transport issues, strengthening of public transport is inevitable. In alternative 2, commuter railway plan proposed by NaMSIP is introduced as the essential measure for public transport reinforcement. Proposed railway network is shown in Figure 7.1.27.

Introduction of diesel multiple unit (DMU), which is flexible for the variation of passenger demand, is recommended. On this premise, the assumption in this study is that the railway track is existing single with double track at the stations, the number of services per hour is two, and the schedule speed is 30 km per hour.



Source: NaMSIP, Nairobi Metropolitan Leadership (Presentation document for 2 July meeting)

Figure 7.1.27 Railway Network in Alternative 2

4) Alternative 3 (Introduction of Selective MRTS Case)

i) Evaluation of Priority Corridor

The objective of introduction of new public transport systems proposed by MRTS is to enhance modal shift to public transport and consequently to alleviate traffic congestion. Nine corridors are proposed for MRTS corridors. In this study, priority corridors are evaluated based on the following aspects:

(i) Vehicle traffic volume: Concentration of large amount of vehicle traffic requires shifting to public transport because countermeasure by road development is limited against the increasing traffic.

(ii) Vehicle capacity ratio (VCR): VCR also indicates the concentration of vehicle traffic demand in comparison with the road capacity.

(iii) Demand overlapping with commuter rail: Commuter railway by NaMSIP was publicised after the MRTS, and thus nine corridors proposed by MRTS did not take into account the commuter rail. Therefore, routes for MRTS should be examined in terms of overlap with commuter rail. BRT will be introduced to the route with extremely large vehicle demand even if the route overlaps with the commuter rail.

(iv) Possibility of widening to more than six lanes: On the MRTS corridors, roads with more than four lanes should be secured for the general vehicles. Decreasing road capacity for general vehicles into two lanes will give too large an impact and make it impossible to obtain consensus amongst the citizens.

Detailed evaluation of priority corridor is shown in Table 7.1.10.

Table 7.1.10 Evaluation of Priority of MRTS Corridors

No.	Road Name	Starting Station	Ending Station	Traffic Demand in Alt. 1 (Max) ('000)	VCR in Alt. 1 (Max)	Overlap with Commuter Rail	Possibility of Widening	Evaluation	Priority
1	Thika Road	NRS	Kasarani	253	>1.50	No overlap	Existing	Vehicle traffic demand is **extremely large** and VCR is **highest**. No route overlaps with commuter rail.	Highest
		Kasarani	Eastern Bypass	141	1.50> >1.20	Overlap	Existing	Vehicle traffic demand is very large and VCR is high. Route overlaps with commuter rail.	High
2	Juja Road	NRS	Outer Ring	77	>1.50	No overlap	Ongoing	Vehicle traffic demand is large and VCR is **highest**. No route overlaps with commuter rail.	Highest
		Outer Ring	Kayole	56	>1.50	Overlap	Possible	Vehicle traffic demand is large and VCR is **highest**. Route overlaps with commuter rail.	High
3	Jogoo Road	NRS	Outer Ring	96	>1.50	Overlap	Possible	Vehicle traffic demand is **very large** and VCR is **highest**. Route overlaps with commuter rail.	High
		Outer Ring	Kayole	49	1.50> >1.20	No overlap	Possible	Vehicle traffic demand is not large and VCR is high. No route overlaps with commuter rail.	Low
4	Mombasa Road-Athi River	NRS	JKIA North	243	>1.50	Overlap	Existing	Vehicle traffic demand is **extremely large** and VCR is **highest**. Route overlaps with commuter rail.	Highest
		JKIA North	Athi River	123	>1.50	Overlap	Ongoing	Vehicle traffic demand is **very large** and VCR is **highest.** Route overlaps with commuter rail.	High
5	Langata Road	NRS	Bomas of Kenya	105	>1.50	No overlap	Possible	Vehicle traffic demand is **very large** and VCR is **highest**. No route overlaps with commuter rail.	Highest
6	Ngong Road	NRS	Dagoretti Corner	53	1.50> >1.20	Overlap	Ongoing	Vehicle traffic demand is large and VCR is high. Route overlaps with commuter rail.	Low
		Dagoretti Corner	Karen Bus Stop	32	1.50> >1.20	No overlap	Possible	Vehicle traffic demand is not large and VCR is High. No route overlaps with commuter rail.	Low
7	Waiyaki Way	NRS	Kabete	198	>1.50	No overlap	Existing	Vehicle traffic demand is **extremely large** and VCR is **highest.** No route overlaps with commuter rail.	Highest
		Kabete	Kikuyu	61	1.20> >1.00	No overlap	Ongoing	Vehicle traffic demand is large and VCR is low. No route overlaps with commuter rail.	Low
8	Limuru Road	NRS	Ruaka Bus Station	66	1.50> >1.20	No overlap	Difficult (Forest)	Vehicle traffic demand is large and VCR is high. No route overlaps with commuter rail.	High
9	Outer Ring Road	GSU	Mombasa Road	98	>1.50	No overlap	Ongoing	Vehicle traffic demand is **very large** and VCR is **highest**. No route overlaps with commuter rail.	Highest

Source: JICA Study Team (JST)

Remark: Traffic demand - Extremely large: more than 150,000
Very large: more than 90,000
Large: more than 50,000

As a result of the evaluation, the following six corridors are selected as the priority corridors:

(i) Thika Corridor (from Nairobi Station to Kasarani);

(ii) Juja Corridor (from Nairobi Station to Outer Ring Road);

(iii) Mombasa Corridor (from Nairobi Station to JKIA North);

(iv) Waiyaki Corridor (from Nairobi Station to Kabete);

(v) Langata Corridor (from Magadi Road Crossing to Nyayo Stadium); and

(vi) Outer Ring Corridor (from Thika Road to Mombasa Road).

Additionally, circular mass transit route surrounding Central Business District (CBD) area is proposed by the CBD development policy in order to create high accessibility in CBD and reduce the vehicle traffic in CBD. This route is taken into consideration as one of the transit corridors.

ii) Selection of Transport Mode

The mode to be introduced to each corridor is re-examined through the following aspects:

(i) Physical condition: In case of elevated LRT, a strip with sufficient width for the construction of piers is required.

(ii) Progress of related project: Several roads which are supposed to be MRTS route are in the design stage. Design condition for the road development should be taken into consideration.

Table 7.1.11 shows the result of examination of transportation mode.

Table 7.1.11 Selection of Mode for MRTS Corridors

No.	Road Name	Starting Station	Ending Station	Proposed Mode by MRTS	Physical Condition for MRT/LRT	Progress of Related Project	Implementation Phase		
							Medium Term (2023)	Long Term (2030)	Long-long Term (after 2030)
1	Thika Road	NRS	Kasarani	Metro	The width of the existing median strip is not enough for the construction of viaduct piers.	Completed by AfDB finance		BRT	Metro
		Kasarani	Eastern Bypass	Metro		Completed by AfDB finance			Metro
2	Juja Road	NRS	Outer Ring	Metro	There seems to be no difficulty in the construction.	Design stage by WB finance including **BRT** lane		BRT	LRT
		Outer Ring	Kayole	Metro		Design stage by WB finance including **BRT** lane			BRT
3	Jogoo Road	NRS	Outer Ring	LRT	Jogoo Road has a wide median strip enough for the construction of LRT piers up to the crossing with the Outer Ring Road.	Not implemented			LRT
		Outer Ring	Kayole	LRT		Not implemented			LRT
4	Mombasa Road-Athi River	NRS	JKIA North	BRT	(BRT by MRTS)	Design stage by WB finance including **BRT** lane	BRT	BRT	BRT
		JKIA North	Athi River	BRT		Design Stage by WB finance including **BRT** lane			BRT
5	Langata Road	NRS	Bomas of Kenya	BRT	(BRT by MRTS)	Not implemented		BRT	BRT
6	Ngong Road	NRS	Dagoretti Corner	Metro	There is a steep slope of 5.5% between Railway Golf Course and Upper Hill. It is necessary to introduce system using rubber tire.	Design stage by Japanese finance including **LRT** lane			LRT
		Dagoretti Corner	Karen Bus Stop	Metro		Design stage by Japanese finance including **LRT** lane			LRT
7	Waiyaki Way	NRS	Kabete	LRT	There will be no difficulty in the construction of LRT along this road except for overpassing interchanges with crossing road.	Design stage by WB finance including **BRT** lane	BRT	BRT	BRT
		Kabete	Kikuyu	BRT		Design stage by WB finance including **BRT** lane			BRT
8	Limuru Road	NRS	Ruaka Bus Station	BRT	(BRT by MRTS)	Not implemented			BRT
9	Outer Ring Road	GSU	Mombasa Road	LRT	Prior to the construction of LRT, the road shall be widened with a median strip for future pier construction.	Design stage by AfDB finance including **BRT** lane		BRT	BRT
	CBD Circular Route	NRS	NRS	-	There is a steep slope of 5.5% between Railway Golf Course and Upper Hill.	None		LRT	LRT

Source: JICA Study Team (JST)

As a result of evaluation of priority corridors and examination of transportation mode, the following six routes are selected as the public transport development plan in the target year:

(i) BRT Route 1 (Thika Road, from Nairobi Station to Kasarani)

Development of Thika Highway was already completed, but the future traffic demand will exceed the capacity. In order to address this issue, introduction of BRT from Nairobi Station via Ring Road Ngara along Thika Road is a necessary measure. The route will attract passenger demand from the northeast direction.

(ii) BRT Route 2 (Juja Road, from Nairobi Station to Outer Ring Road)

Westward vehicle traffic demand is concentrated to Juja Road. Road widening including MRTS corridor is ongoing under WB finance. The BRT will attract passenger demand and improve the traffic condition in the western part of CBD.

(iii) BRT Route 3 (Mombasa Road, from Nairobi Station to JKIA North)

This is the route where traffic demand is concentrated. Road widening is under design by KeNHA including BRT route in the median. The BRT route will attract passenger demand from the south and east to CBD.

(iv) BRT Route 4 (Waiyaki Way, from Nairobi Station to Kabete)

This is the route where traffic demand is concentrated. Road widening is under design by KeNHA including BRT route in the median. The BRT route will attract passenger demand from the western area of CBD.

(v) BRT Route 5 (Langata Road, from Magadi Road Crossing to Nyayo Stadium)

Based on the future traffic assignment, traffic demand exceeds the current capacity and expansion of road to six lanes is required. In this case, by shifting two lanes to the BRT route, road capacity will increase. The route will attract passenger demand from the southwest direction.

(vi) BRT Route 6 (Outer Ring Road, from Thika Road to Mombasa Road)

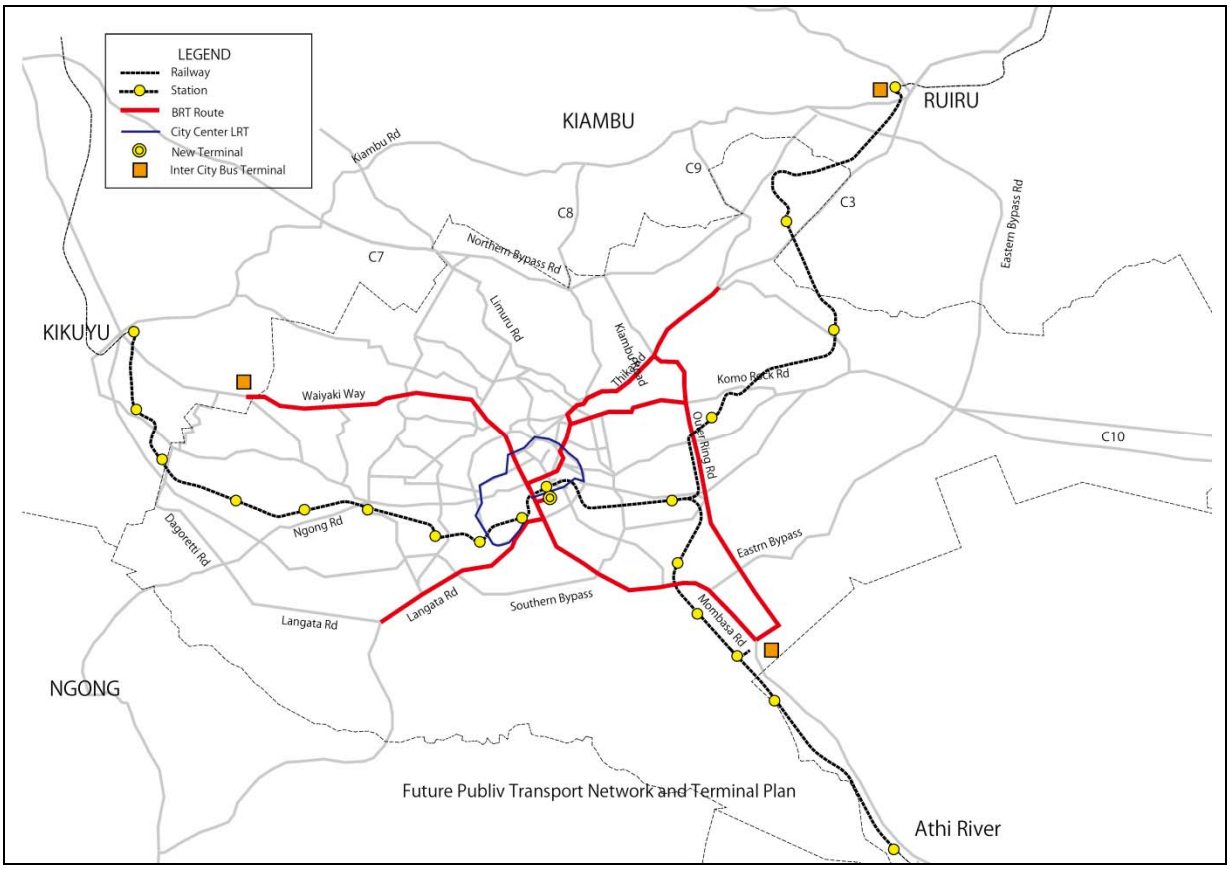
Vehicle traffic demand is large throughout the route. Introduction of BRT will disperse the traffic demand and ease the traffic demand on radial roads.

In addition to the six BRT routes shown above, the following option is added by the JICA Study Team for the smooth transportation in the city centre area.

(vii) LRT Circular Route in City Centre

Introduction of LRT in the city centre is based on the policy to realise world-class city centre. To create safe and high mobility city centre, LRT will provide the service around the city centre. Area inside the LRT route will be the NMT zone, where pedestrians and bicycles can move without obstacles by vehicles.

Based on the above concept, public transport network for alternative 3 is shown in Figure 7.1.28.



Source: JICA Study Team (JST)

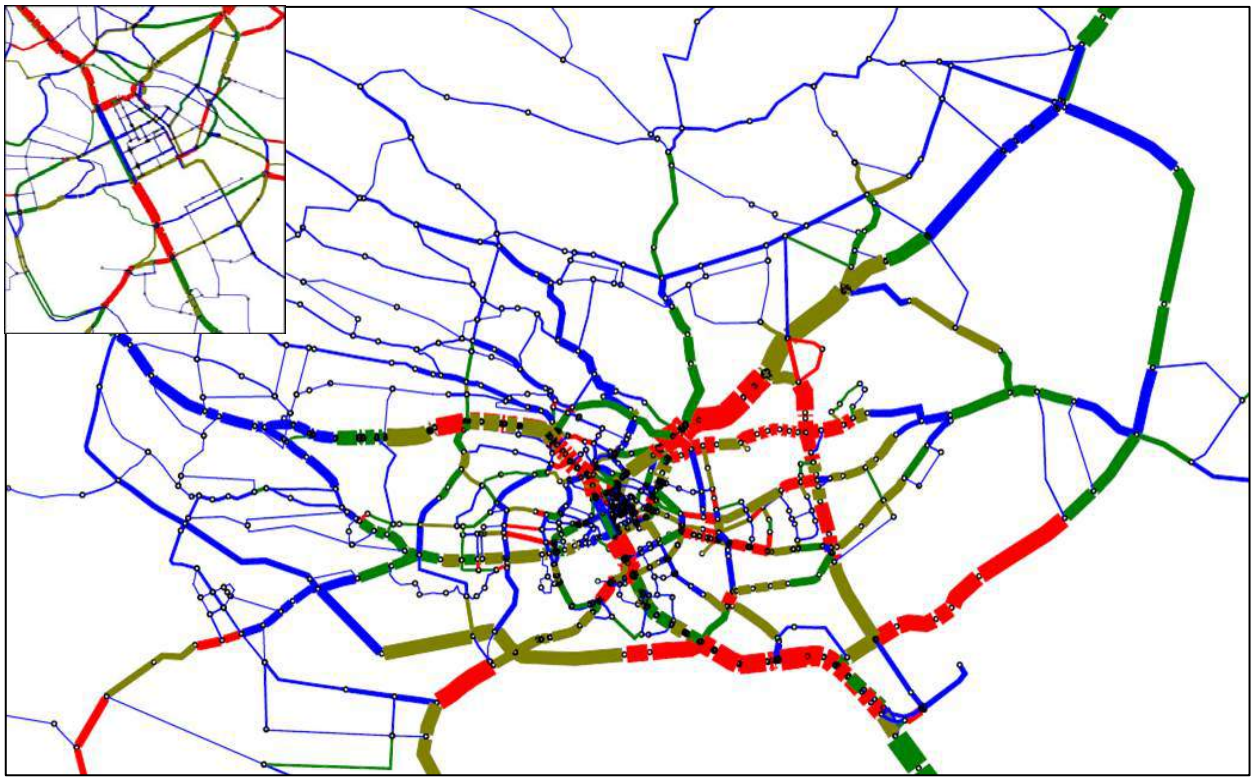
Figure 7.1.28 Public Transport Network in Alternative 3

iii) Traffic Demand Forecast for the Alternative Cases

Future traffic demand in 2030 is forecasted by the traffic models established in Section 7.1.4. Results of vehicle assignment for alternative case 0, case 2, and case 3 are shown in Figures 7.1.29, 7.1.30, and 7.1.31, respectively. Results of passenger assignment of public transport (railway, BRT, and LRT) for case 3 are shown in Figure 7.1.32.

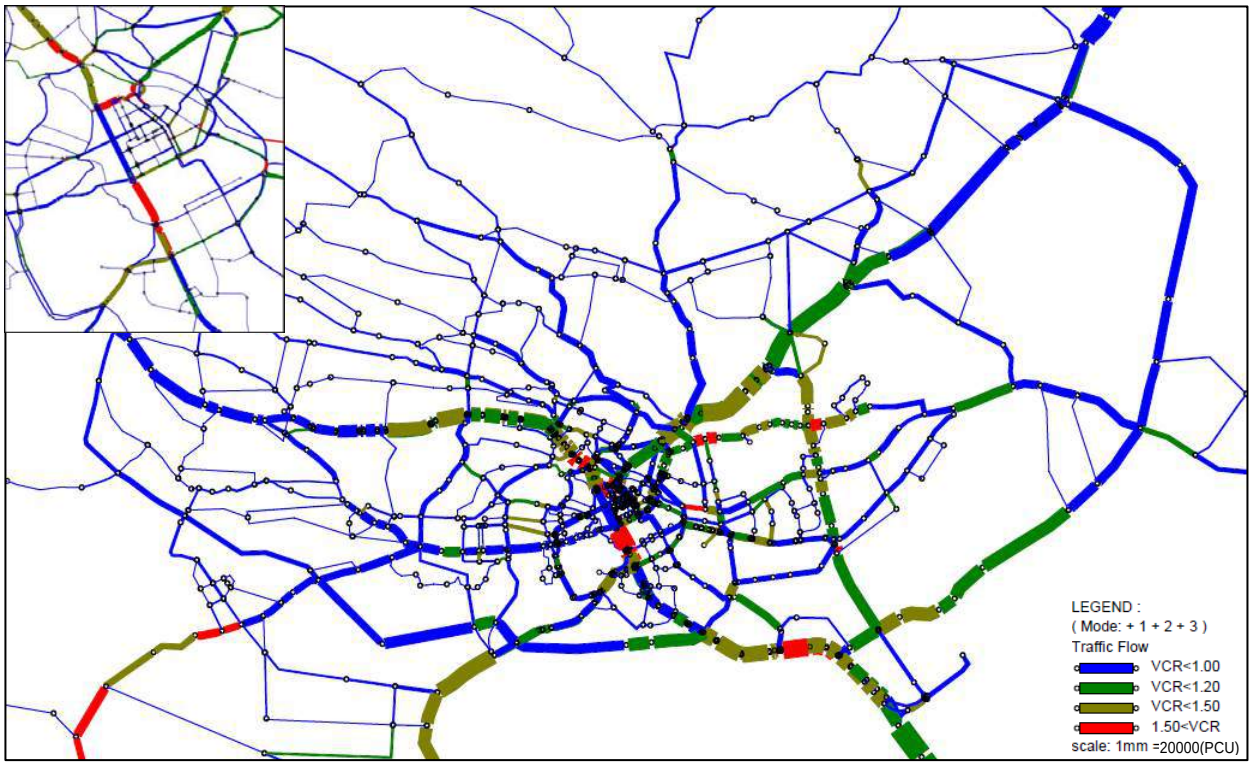
Source: JICA Study Team (JST)

Figure 7.1.29 Vehicle Assignment Result of Alternative 0 in 2030



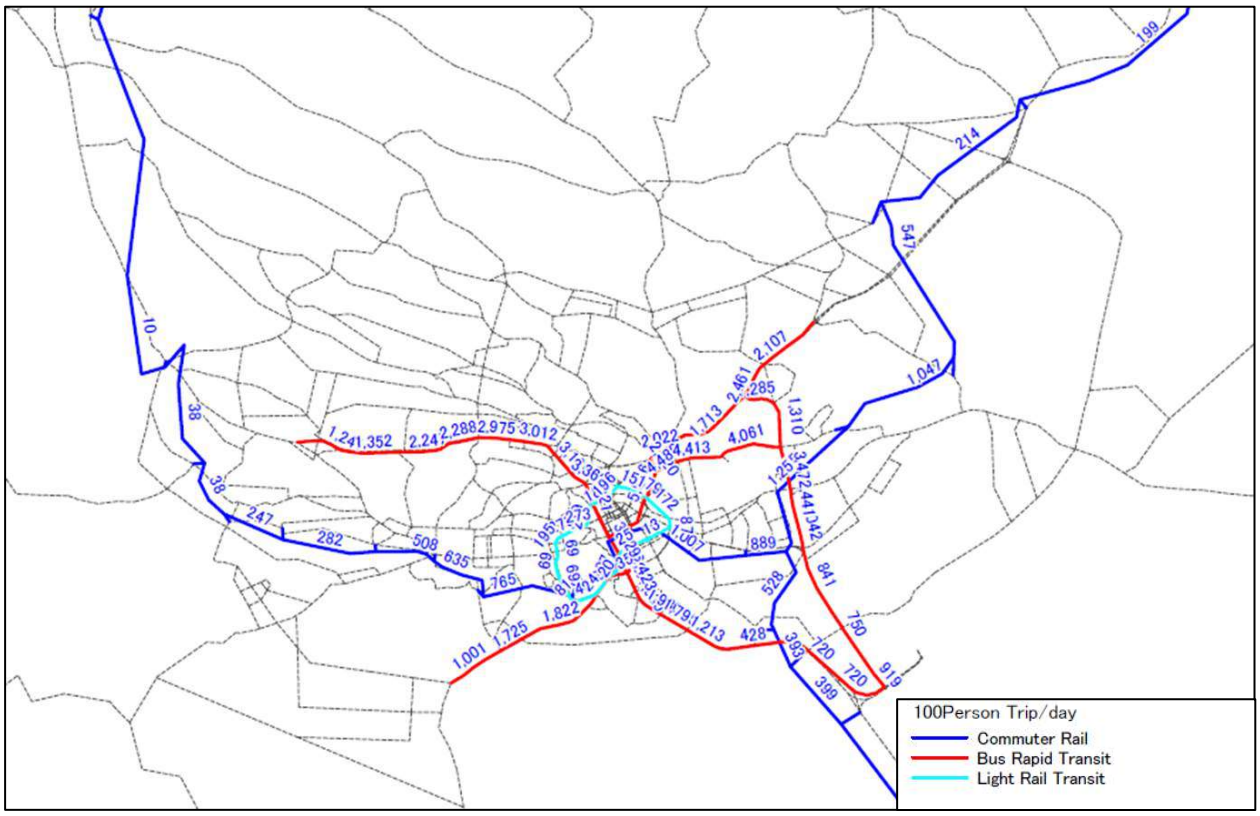
Source: JICA Study Team (JST)

Figure 7.1.30 Railway Passenger Assignment Result of Alternative 2 in 2030



Source: JICA Study Team (JST)

Figure 7.1.31 Vehicle Assignment Result of Alternative 3 in 2030



Source: JICA Study Team (JST)

Figure 7.1.32 Public Transport (Railway, BRT, and LRT) Passenger Assignment Result of Alternative 3 in 2030

(6) Evaluation of Alternative Cases

1) Modal Share by Alternative Case

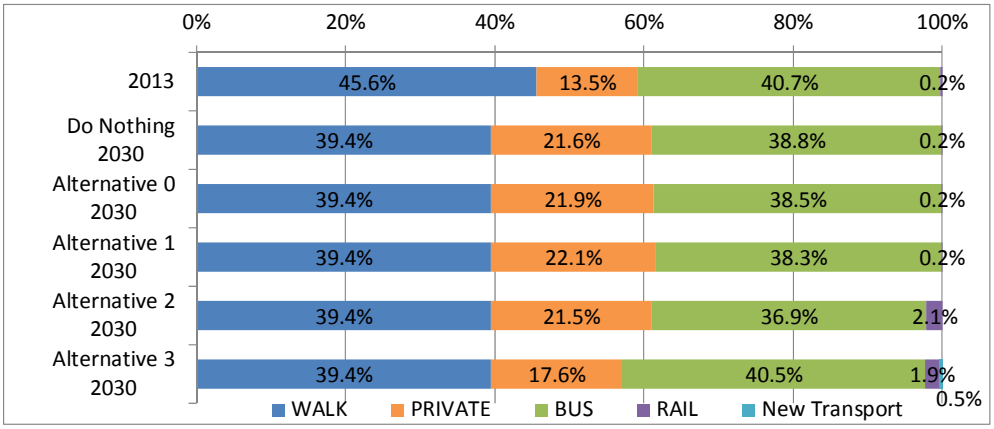
The number of trips by transport mode forecasted for each alternative case is shown in Table 7.1.12 and modal share for each alternative case is shown in Figure 7.1.33. In alternative 2, the number of railway trips is 215,000, and the number of private mode trips decreases by 58,000 from alternative 1. In alternative 3, the number of bus trips increases by 366,000 from alternative 2, and the number of new transport trips is 46,000. On the other hand, the number of private mode trips decreases by 388,000 and the modal share decreases by 3.9% from alternative 2.

Table 7.1.12 Number of Trips by Mode by Alternative Case in 2030

(Unit: km)

Alternative		Year	WALK	PRIVATE	BUS	New Transport	RAIL	TOTAL
	Existing Case	2013	3,090,103	916,624	2,754,489	-	14,006	6,775,222
	Do Nothing	2030	3,951,711	2,161,718	3,885,662	-	18,587	10,017,678
0	Ongoing Project	2030	3,951,711	2,195,331	3,852,215	-	18,421	10,017,678
1	Road Development Oriented	2030	3,951,711	2,213,695	3,833,869	-	18,403	10,017,678
2	Utilisation of Commuter Rail	2030	3,951,711	2,155,726	3,695,692	-	214,549	10,017,678
3	Introduction of Selective MRTS	2030	3,951,711	1,767,773	4,062,046	45,692	190,456	10,017,678

Source: JICA Study Team (JST)



Source: JICA Study Team (JST)

Figure 7.1.33 Modal Share by Alternative Cases in 2030

2) Average Speed and Average VCR by Alternative Case

As a result of vehicle traffic assignment, future traffic condition is indicated by total vehicle-km, total vehicle-hours, average speed, and average VCR as shown in Table 7.1.13. Compared with the existing case in 2013, the average speed and VCR worsen in the Do-Nothing case in 2030. But due to the measures introduced by the alternatives, the indices improve in alternatives 0–3.

In alternative 3, in which maximum measures are introduced, the average speed improves compared with the existing case. As for VCR, alternative 3 shows the least value, which is still larger than the existing case.

Table 7.1.13 Major Indices by Vehicle Traffic Assignment

Alternative			Year	Total Vehicle-km PCU-km('000)	Total Vehicle-hours PCU-Hour	Average Speed (km/h)	Average VCR (Volume Capacity Ratio)
Study Area		Existing Case	2013	17,780	431,690	41.2	0.54
		Do Nothing Case	2030	39,110	1,692,480	23.1	1.19
	0	Ongoing Project Case	2030	37,670	1,173,180	32.1	1.02
	1	Road Development Oriented Case	2030	36,510	928,970	39.3	0.85
	2	Utilisation of Commuter Rail Case	2030	35,100	879,350	39.9	0.81
	3	Introduction of Selective MRTS Case	2030	30,500	723,920	42.1	0.71
Nairobi City		Existing Case	2013	10,960	273,910	40.0	0.69
		Do Nothing Case	2030	25,320	1,254,120	20.2	1.60
	0	Ongoing Project Case	2030	25,520	805,560	31.7	1.32
	1	Road Development Oriented Case	2030	24,850	620,560	40.1	1.04
	2	Utilisation of Commuter Rail Case	2030	23,780	581,190	40.9	1.00
	3	Introduction of Selective MRTS Case	2030	19,430	432,490	44.9	0.82

Source: JICA Study Team (JST)

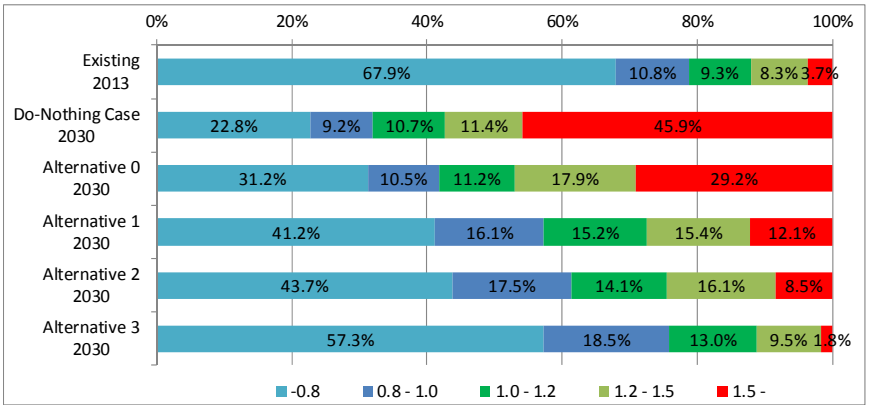
3) Distribution of VCR

Table 7.1.14 shows the road length distribution by VCR value in Nairobi City. It is observed that the roads with low VCR value increase as more measures to improve traffic condition are introduced from alternatives 1 to 3. Although average VCR of alternative 3 increases from the present, roads with high VCR value decrease.

Table 7.1.14 Road Length Distribution by VCR in Nairobi City Unit: km

VCR	Existing in 2013	Do Nothing in 2030	Alternative 0 in 2030	Alternative 1 in 2030	Alternative 2 in 2030	Alternative 3 in 2030
-0.8	510.2	171.1	243.3	337.8	358.5	469.7
0.8 - 1.0	81.0	69.2	81.8	132.1	143.8	151.4
1.0 - 1.2	69.5	80.6	87.2	124.2	115.8	106.7
1.2 - 1.5	62.3	85.8	139.1	126.2	132.3	77.6
1.5 -	28.1	344.5	227.4	99.6	69.4	14.4
TOTAL	751.2	751.2	778.9	819.8	819.8	819.8

Source: JICA Study Team (JST)



Source: JICA Study Team (JST)

Figure 7.1.34 Road Length Distribution by VCR in Nairobi City

4) Conclusion of Evaluation of Alternative Cases

(i) Comparing the indices of alternatives 0 to 3, vehicle-km, vehicle-hours, and average VCR decrease due to the development of mass transit.

(ii) Development of roads alone cannot solve the traffic congestion as shown in Figure 7.1.30. Reinforcement of mass transit and introduction of new transit system are requisite.

(iii) By reinforcement of commuter rail and introduction of BRT to six corridors, traffic congestion is eased especially in the eastern area of the city centre.

(iv) As a result, alternative 3 is recommended as the solution against the future increasing traffic demand.

(7) Staging Plan

1) Basic Strategy for Staging Plan

In the NUTRANS, staging plan for the short term (2010), medium term (2015), and long term (2025) was proposed. But in the years from 2006, conditions for network formation changed greatly, such as development of bypasses and Thika Highway. Therefore, staging plan by NUTRANS will be reviewed and reorganised in this study.

The target of road and urban transport development is:

(i) Network in coordination with land use: The land use structure plan proposes to strengthen the function in CBD and to dispose the sub-centres. Road and urban transport network should support the formation of planned land use structure by harmonious flow of people and fleet.

(ii) Network for world-class mobility: Nairobi Metro 2030 envisages a world-class metropolis. To encourage the realisation of world-class metropolis, road and urban transport network should have high mobility. To this end, principal measures to promote high mobility are expansion of efficient public transport network and establishment of circumferential/radial (C/R) road network.

In order to achieve the target, the required strategy in each phase is described in Table 7.1.15.

Table 7.1.15 Strategy for Staging Plan of Urban Transport Development

	1st Phase Present to 2018	**2nd Phase 2019 to 2023**	**3rd Phase 2024 to 2030**
Network in coordination with land use	・ Study/technical assistance for development of infrastructure in CBD, sub-centres / Railway City.	・ Development of infrastructure in CBD, sub-centres / Railway City.	・ Network development to connect sub-centres.
Network for world-class mobility	・ Improvement of network to solve existing issues. ・ Institutional arrangement for strengthening public transport.	・ Introduction of MRTS to pilot corridors. ・ Development of road corridors to introduce MRTS. ・ Strengthening of circumferential roads to form the C/R network.	・ Expand introduction of MRTS to plural corridors. ・ Establishment of C/R network system.

Source: JICA Study Team (JST)

2) Transport Network in the Short Term (2018)

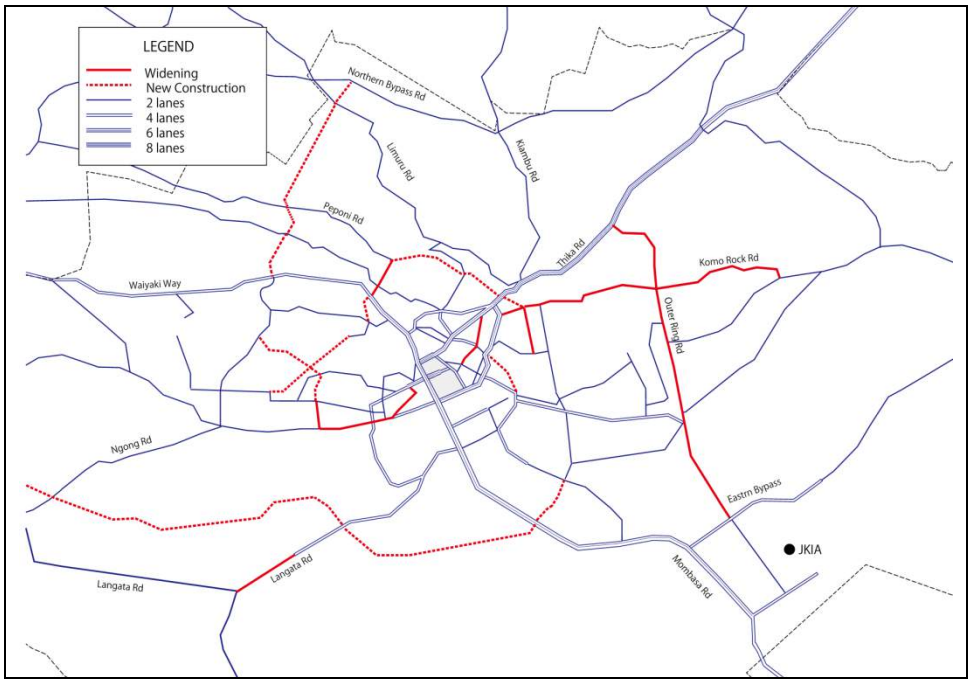
i) Road Network

The road network in the short term is basically composed of the present network and ongoing projects. Name and length of roads to be developed in the short term are shown in Table 7.1.16, and the road network is shown in Figure 7.1.35.

Table 7.1.16 Road Development Length in the Short Term (2018)

Type	Road Name	Section	Inside Nairobi (km)	Outside Nairobi (km)	Total (km)
New Construction	Southern Bypass Road		20.7	7.8	28.5
	Western Bypass Link Road	Northern Bypass - Waiyaki Way	6.5		6.5
	Missing Link	M-3	0.8		0.8
		M-6	2.9		2.9
		M-7	3.0		3.0
		M-10	1.5		1.5
		M-15a	1.8		1.8
		M-15b	1.5		1.5
		M-5	3.2		3.2
		M-16	1.1		1.1
		M-15b to M-5	0.8		0.8
	Total		43.8	7.8	51.6
Widening	Langata Road	KWS Gate - Karen Shopping Centre	2.0		2.0
	Outer Ring Road	Thika Road – Eastern Bypass	13.0		13.0
	Ring Road Kilimani	Argwings Kodheck –Ngong Road	1.7		1.7
	Missing Link	M-16 (Ring Road Parklands)	1.8		1.8
	Ngong Road	Kenyatta Ave – Adams Arcade	4.5		4.5
	Juja Road	Ring Road Ngara – Outer Ring Road	5.0		5.0
	Park Road	Muranga Road – Ngra Road	0.8		0.8
	Koma Rock Road	Outer Ring Road – Kangundo Road	4.5		4.5
	Total		33.3	0.0	33.3

Source: JICA Study Team (JST)



Source: JICA Study Team (JST)

Figure 7.1.35 Road Network in the Short Term (2018)

ii) Public Transport Network

Improvement of existing railway to commuter rail and development of BRT system including establishment of operator is thought to take more than five years. Therefore, public transport system in the short term is the same as the existing public transport network.

3) Transport Network in Medium Term (2023)

i) Road Network

The road network in the medium term consists of roads of the following four categories:

a) Ongoing road projects to be completed until 2018;

b) Roads which assist in the creation of the Railway City;

c) Roads which form the C/R network system; and

d) Roads which connect the proposed sub-centres.

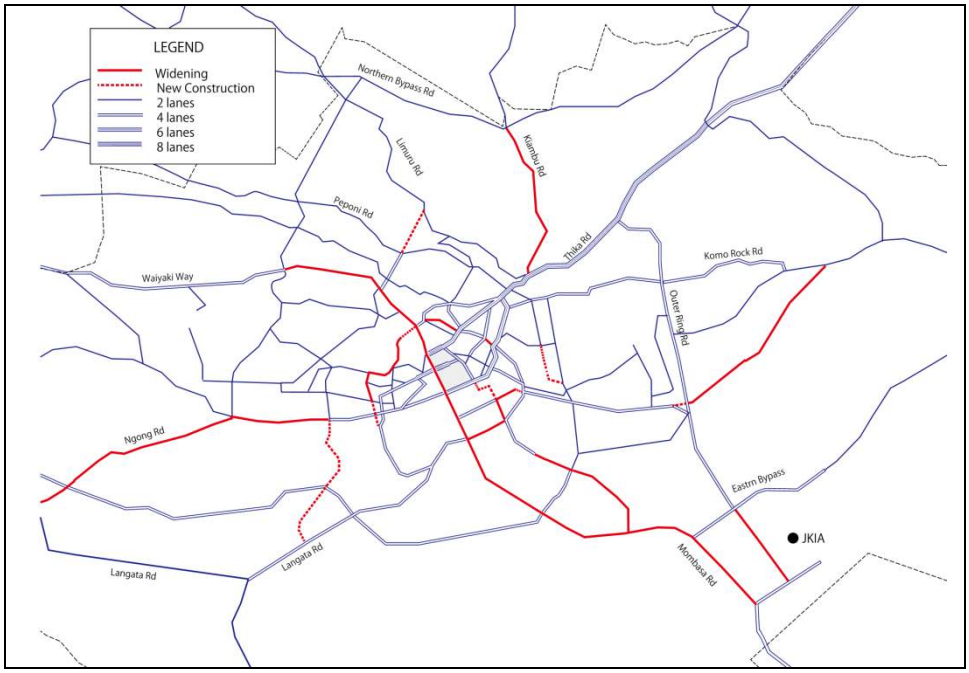
Name and length of roads to be developed in the medium term are shown in Table 7.1.17, and the road network is shown in Figure 7.1.36.

Table 7.1.17 Road Development Length in the Medium Term (2023)

Type	Road Name	Section	Inside Nairobi (km)	Outside Nairobi (km)	Total (km)
New Construction	Missing Link	M-12 (Ngong Road – Langata Road)	4.5		4.5
		M-15c	1.7		1.7
	Circumferential Road	C-2 (Uhuru Highway – State House Road)	2.4		2.4
		C-2 (Arwings Kodek – Magathi Way)	0.7		0.7
	Railway Viaduct	Over NRS	1.9		1.9
		Factory Street	0.3		0.3

Type	Road Name	Section	Inside Nairobi (km)	Outside Nairobi (km)	Total (km)
	Extension of M-5	M-5 – Eastleigh 1st Road	1.5		1.5
	Total		13.0	0.0	13.0
Widening	Mombasa Road	JKIA – James Gichuru Road	7.0		7.0
	Enterprise Road	Factory Street – Lusaka Road	2.5		2.5
		Homa Bay Rd – Mombasa Road	4.3		4.3
	Kiambu Road	Thika Road – Northern Bypass	5.5		5.5
	Ngong Road	Adams Arcade – Dagoretti Corner	2.1		2.1
		Dagoretti Corner – Langata Road	6.7		6.7
	Circumferential Road	C-2 (State House Road – Woodlands Road)	1.7		1.7
	Lusaka Road	Enterprise Road – Uhuru Highway	1.3		1.3
	Factory Street	Enterprise Road – Railway	0.7		0.7
	Kayole Road	Outer Ring Road – Kangundo Road	6.1		6.1
	Airport South Road	Eastern Bypass – Airport Terminal Road	2.7		2.7
	Ngara Road	Museum Hill – Muranga Road	1.1		1.1
		Park Road – Park Road Ngara	0.8		
	Total		42.5	0.0	42.5

Source: JICA Study Team (JST)

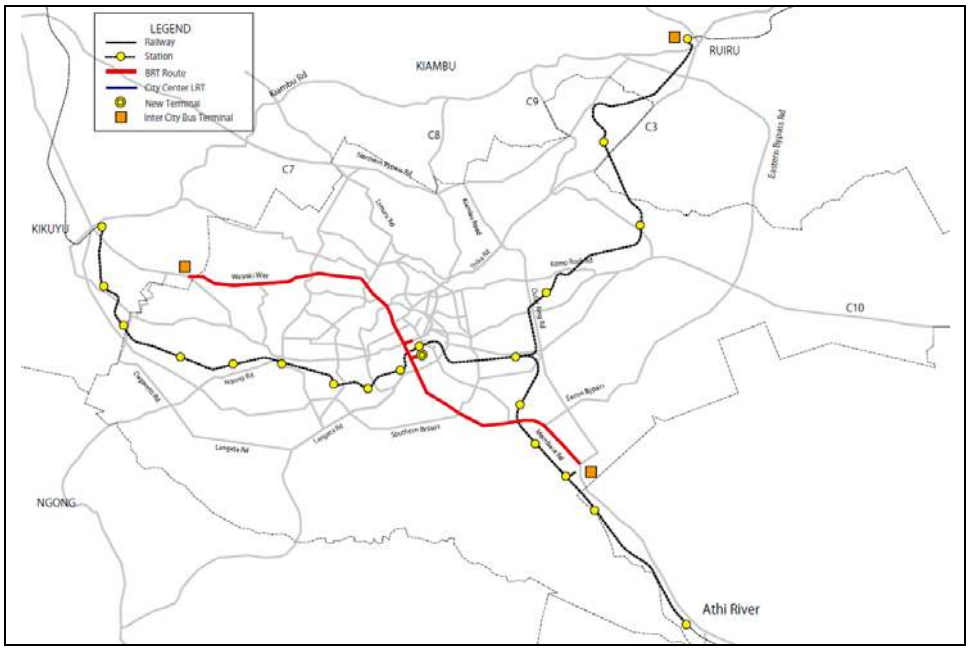


Source: JICA Study Team (JST)

Figure 7.1.36 Road Network in the Medium Term (2023)

ii) Public Transport Network

Public transport network in the medium term is composed of commuter rail and BRT pilot route. Location of sub-centres envisaged in the land use plan is connected to stations of commuter rail line. Therefore, in order to induce the creation of sub-centres, development of commuter rail line is prioritised. Because passenger demand is large and road development will progress on Waiyaki Corridor and Mombasa Corridor, these corridors are selected as the pilot corridor for BRT. The selected medium-term public transport network is shown in Figure 7.1.37.



Source: JICA Study Team (JST)

Figure 7.1.37 Public Transport Network in the Medium Term (2023)

4) Transport Network in the Long Term (2030)

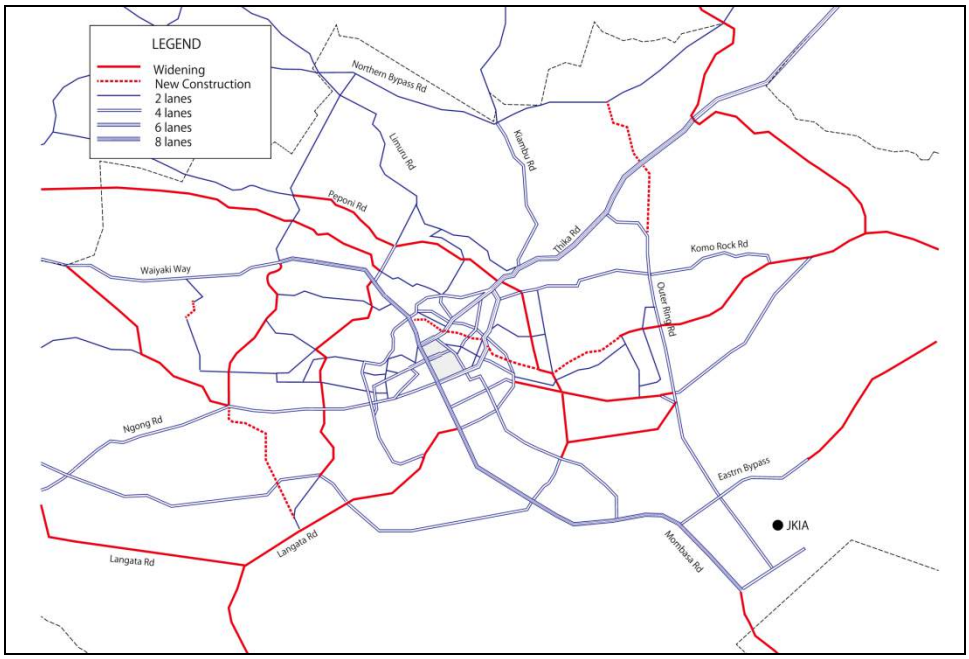
i) Road Network

Road network in the long term is the future road network in 2030. Roads to be developed in the 3rd phase (2024-2030) are shown in Table 7.1.18 and Figure 7.1.38.

Table 7.1.18 Road Development Length in the Long Term

Type	Road Name	Section	Inside Nairobi (km)	Outside Nairobi (km)	Total (km)
New Construction	Outer Ring Extension	Outer Ring Road – Northern Bypass	4.8		4.8
	Western Bypass Link Road	Ngong Road – Missing Link M-12	5.0		5.0
	Dandora Road Extension	Eastleigh 1st Ave – Outer Ring Road	3.6		3.6
	Riverside Road	M-5 Extension – Waiyaki Way	4.7		4.7
	Total		18.1	0.0	18.1
Widening	Langata Road	Mombasa Road – Magadi Road	8.3		8.3
		Magadi Road – Ngong Road	7.4		7.4
	Magadi Road	Langata Road – Ongata Rongai	13.8	3.6	17.4
	Eastern Bypass	Airport North Road – Thika Road	13.0	9.2	22.2
	Kangundo Road	Outer Ring Road – Eastern Bypass	12.0		12.0
	Mombasa Road	JKIA - Athi River	12.7	10.8	23.5
	Naivasha Road	Dragotti Corner – Waiyaki Way	7.0		7.0
	Jogoo Road	Lusaka Road – Outer Ring Road	5.2		5.2
	Likoni Road	Jogoo Road – Enterprise Road	2.1		2.1
	Lunga Lunga Road	Likoni Road – Outer Ring Road	4.0		4.0
	Peponi Road	Ring Road Parkland - Western Bypass Link Road	4.3		4.3
	Lower Kabete Road	Ring Road Parkland - Gitaru/ndernderu Road	7.8	4.2	12.0
	Kamiti Road	Yhika Road – Northern Bypass	3.1		3.1
	Kasarani Road	Thika Road – Koma Rock Road	8.0		8.0
	James Gichuru Road	Waiyaki Way – Ngong Road	5.2		5.2
	Total		105.6	27.8	141.7

Source: JICA Study Team (JST)

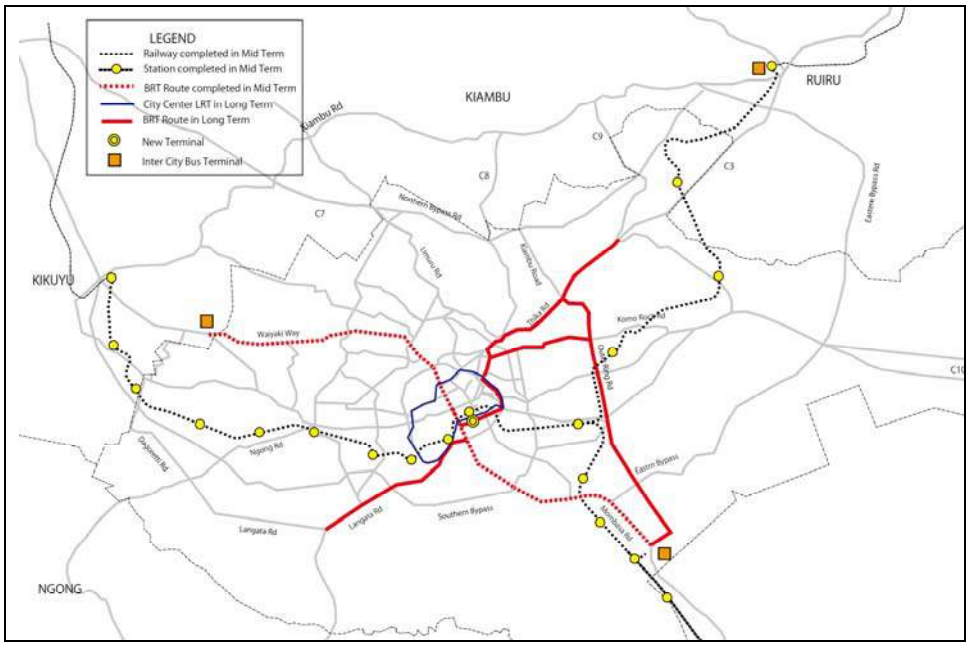


Source: JICA Study Team (JST)

Figure 7.1.38 Road Network in the Long Term (2030)

ii) Public Transport Network

Public transport network in the long term is shown in Figure 7.1.39. Development of four BRT corridors and development of LRT Circular Route are the major developments in the 3rd phase.



Source: JICA Study Team (JST)

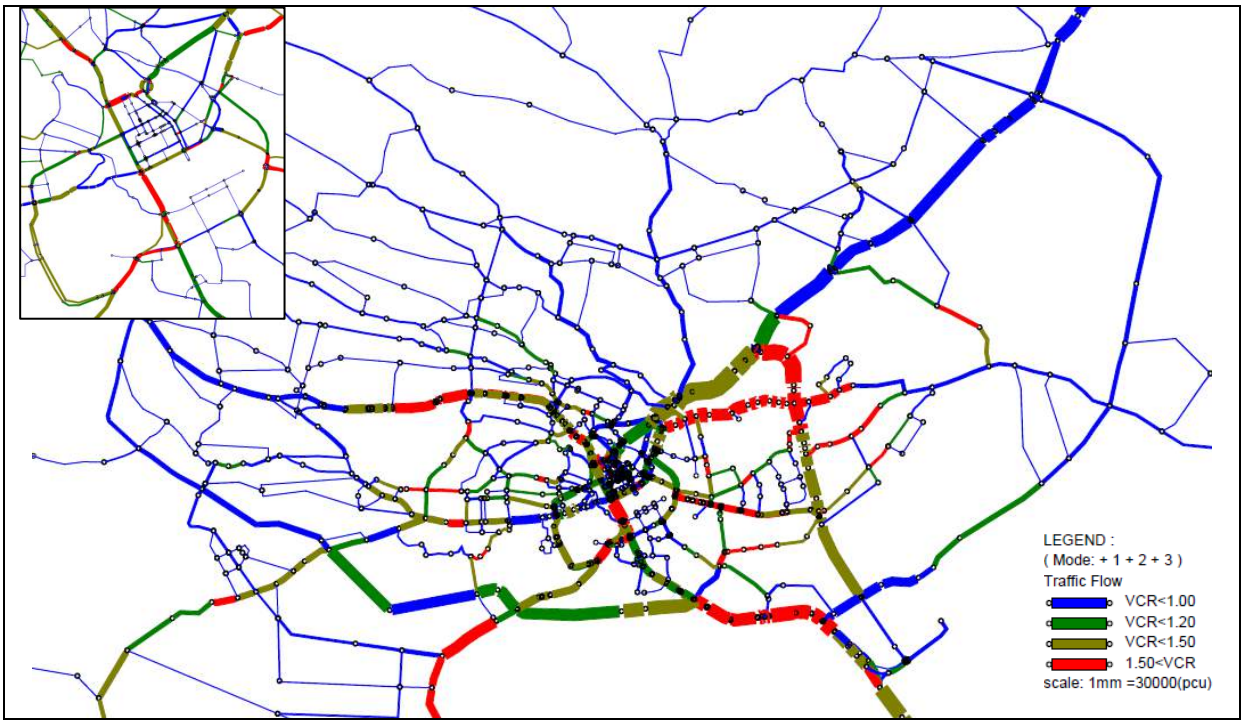
Figure 7.1.39 Public Transport Network in the Long Term (2030)

5) Traffic Demand Forecast in the Short Term, Medium Term and Long Term

Based on the established network staging plan, traffic demand forecast is conducted.

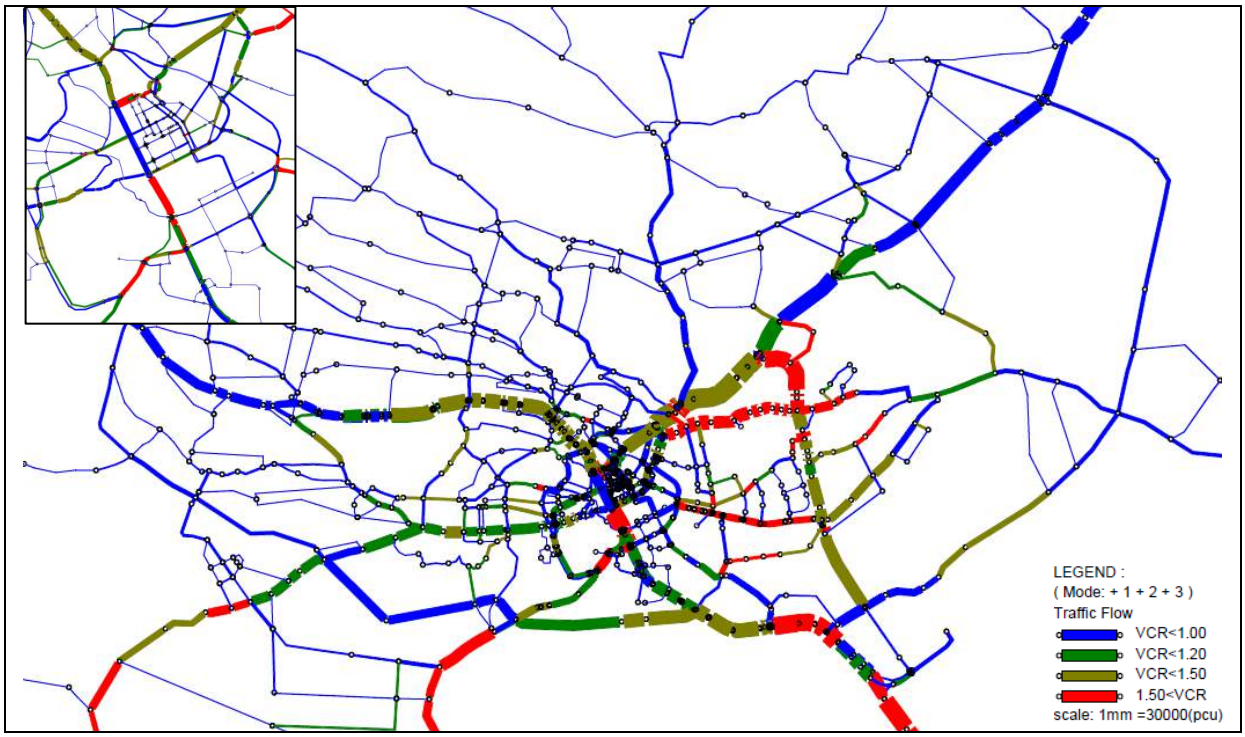
i) Traffic Assignment

Results of vehicle traffic assignment in the short term, medium term, and long term are shown in Figures 7.1.40, 7.1.41, and 7.1.43, respectively. Public transport passenger assignment results in the medium term and long term are shown in Figures 7.1.42 and 7.1.44, respectively.



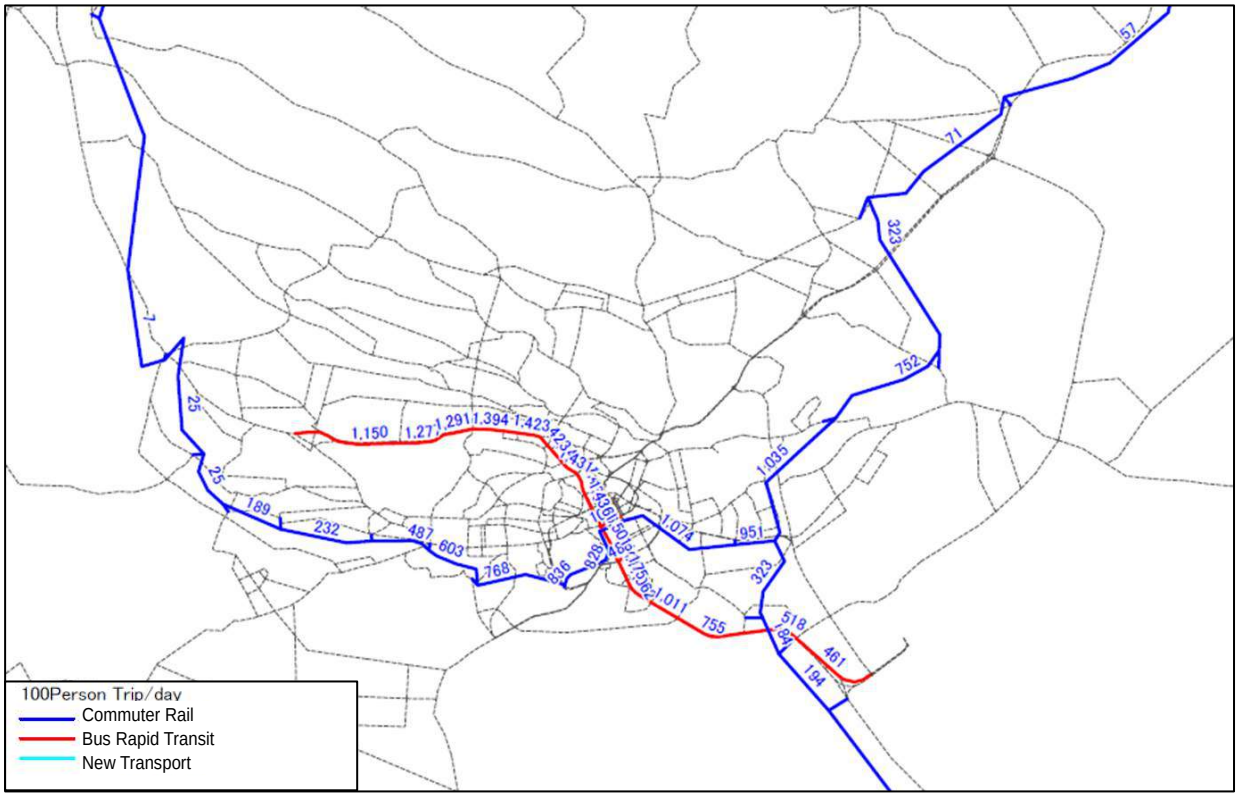
Source: JICA Study Team (JST)

Figure 7.1.40 Vehicle Assignment Result of Short-term Plan in 2018



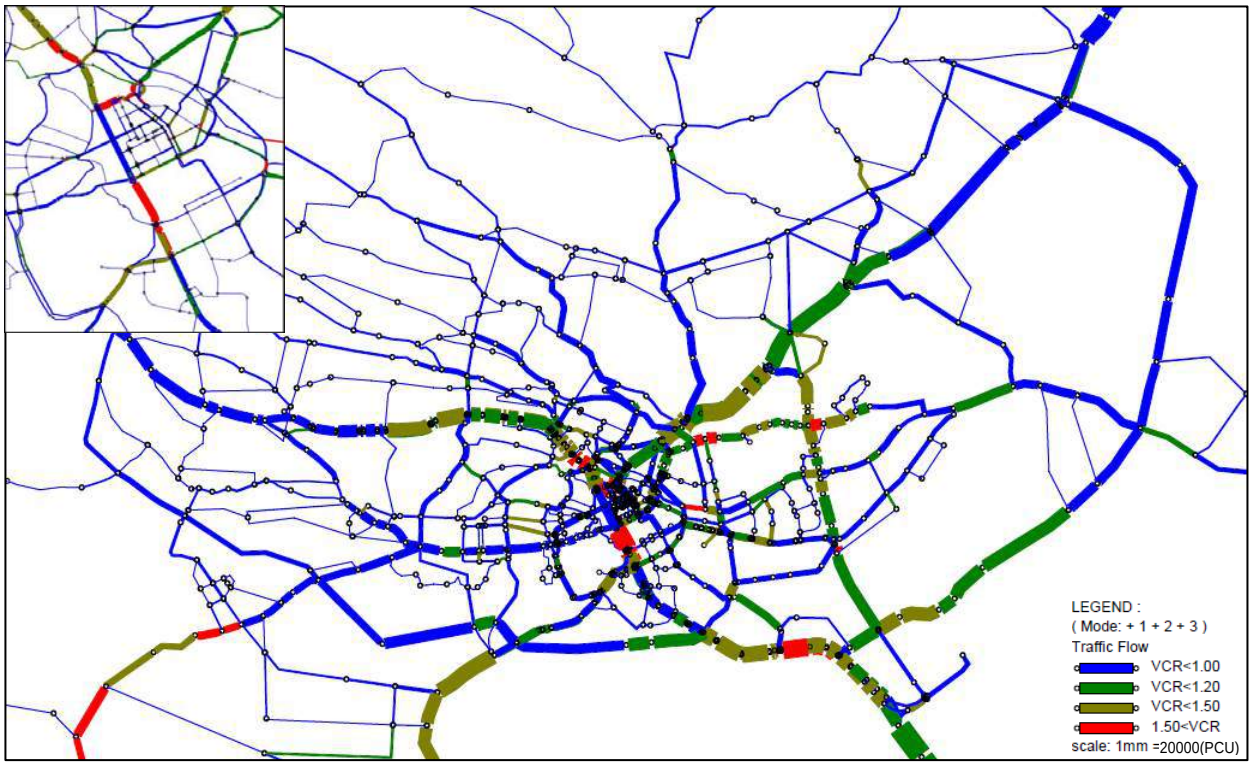
Source: JICA Study Team (JST)

Figure 7.1.41 Vehicle Assignment Result of Medium-term Plan in 2023



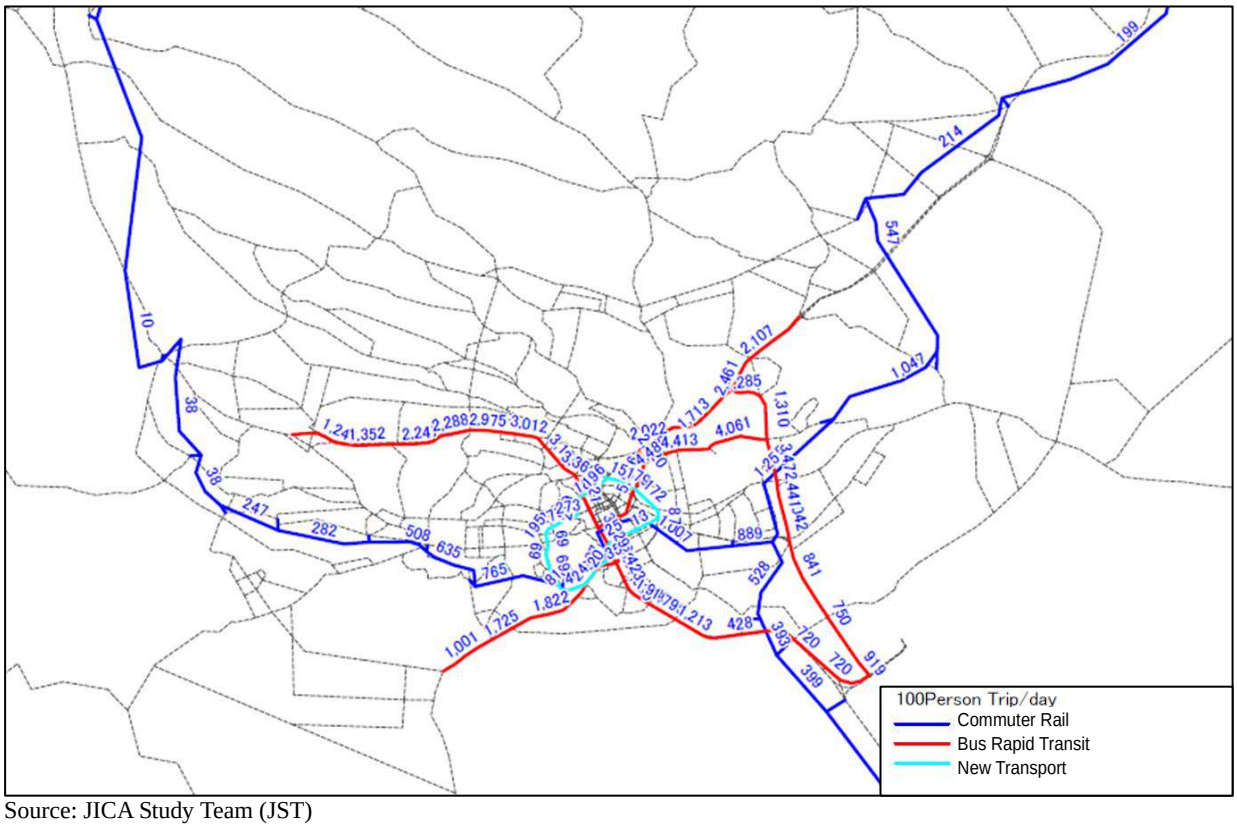
Source: JICA Study Team (JST)

Figure 7.1.42 Public Transport (Railway and BRT) Passenger Assignment Result of Medium-term Plan in 2023



Source: JICA Study Team (JST)

Figure 7.1.43 Vehicle Assignment Result of Long-term Plan in 2030



Source: JICA Study Team (JST)

Figure 7.1.44 Public Transport (Railway, BRT and LRT) Passenger Assignment Result of Long-term Plan in 2030

ii) Transition of Modal Share

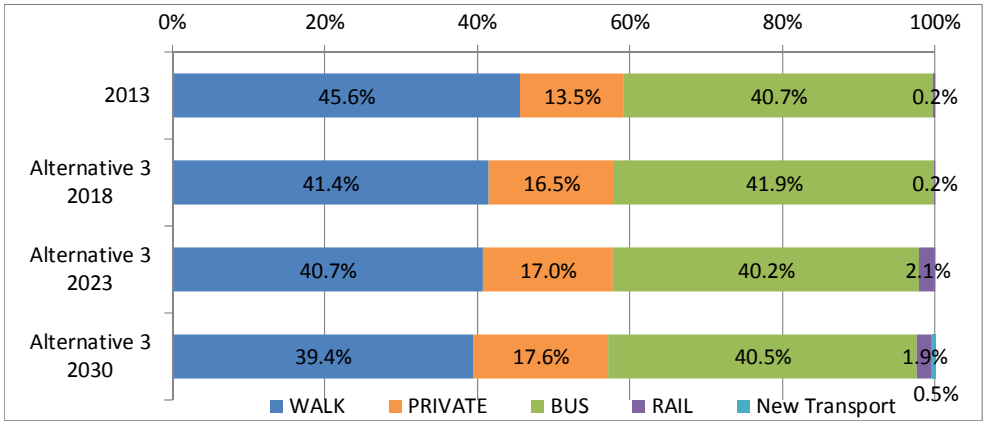
Table 7.1.19 and Figure 7.1.45 show the transition of modal share in the short, medium and long terms. Due to the increase in the number of vehicles, modal share of private mode gradually increases. But by the introduction of new public transport system, total share of bus and railway increases in the medium term and long term.

Table 7.1.19 Number of Trips by Mode in the Short, Medium, and Long Terms

Unit: Trips

Alternatives and Target Year	Walk	Private	Public	Rail	New Transport	Total
2013	3,090,103	916,624	2,754,489	14,006	--	6,775,222
Alternative 3 2018	3,246,051	1,289,796	3,281,824	14,416	--	7,832,087
Alternative 3 2023	3,606,326	1,506,186	3,564,101	181,736	--	8,858,349
Alternative 3 2030	3,951,711	1,767,773	4,062,046	190,456	45,692	10,017,678

Source: JICA Study Team (JST)



Source: JICA Study Team (JST)

Figure 7.1.45 Modal Share in the Short, Medium and Long Terms

iii) Transition of Average Speed and Average VCR

Table 7.1.20 shows the future traffic condition by total vehicle-km, total vehicle-hours, average speed, and average VCR. In the short term, average speed and average VCR worsen because improvement of network cannot catch up with the increasing traffic demand. In the medium term and long term, average speed and average VCR gradually improve compared with the short term condition.

Table 7.1.20 Major Indices by Vehicle Traffic Assignment in Nairobi City

Alternative		Year	Vehicle-km Total PCU-km ('000)	Vehicle-hours Total PCU-Hour	Average Speed (km/h)	Average VCR (Volume Capacity Ratio)
	Existing Case	2013	10,960	273,910	40.0	0.69
3	Introduction of Selective MRTS Case	2018	16,210	424,160	38.2	0.92
3	Introduction of Selective MRrTS Case	2023	18,040	444,960	40.6	0.90
3	Introduction of Selective MRTS Case	2030	19,430	432,490	44.9	0.82

Source: JICA Study Team (JST)

iv) Distribution of VCR

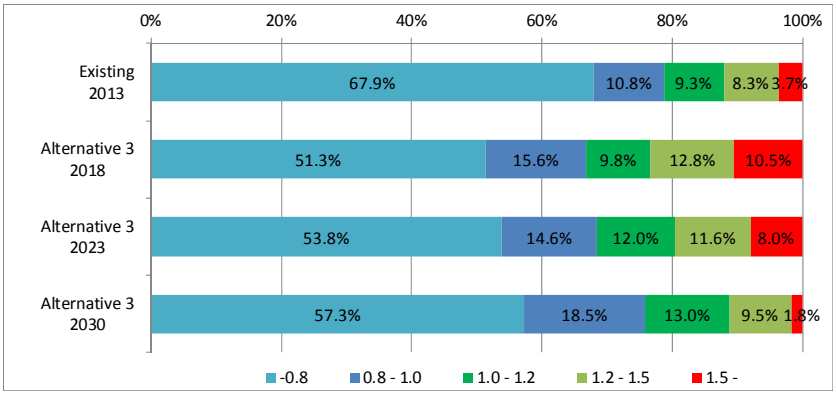
Table 7.1.21 and Figure 7.1.46 show the road length distribution by VCR value in the short, medium, and long terms in Nairobi City. In the short term, the road length with VCR value of more than 1.0 increases. But in the medium term and long term, condition of congestion will be gradually improved.

Table 7.1.21 Road Length Distributions by VCR in the Short, Medium and Long Terms in Nairobi City

Unit: km

VCR	Existing in 2013	Alternative 3 in 2018	Alternative 3 in 2023	Alternative 3 in 2030
-0.8	510.2	404.6	431.4	469.7
0.8 - 1.0	81.0	122.6	116.9	151.4
1.0 - 1.2	69.5	77.7	95.9	106.7
1.2 - 1.5	62.3	100.9	93.1	77.6
1.5 -	28.1	83.0	64.3	14.4
TOTAL	751.2	788.7	801.7	819.8

Source: JICA Study Team (JST)



Source: JICA Study Team (JST)

Figure 7.1.46 Road Length Distribution by VCR in the Short, Medium, and Long Terms Nairobi City

(8) Conclusion and Recommendation

1) Conclusion

General

(i) In the short term and medium term, traffic condition will worsen because improvement of transport network cannot catch up with the increasing traffic demand. In this regard, various measures should be implemented to avoid heavy traffic jam. Proposed measures are described in the recommendation.

(ii) Under the condition that the proposed plan is implemented, transport condition will be improved in the target year of 2030. But road development alone cannot improve the traffic condition. The strengthening of public transport network is essential to improve the future transport condition.

Road Network

(i) Road development/improvement shall be implemented based on the consistent programme. In this regard, implementation schedule by NUTRANS was not followed. In this study, the JICA Study Team presented the implementation schedule for the efficient and effective solution of the traffic issues and it is the most essential output of the study. Therefore, establishment of consensus amongst the stakeholders is expected in the next stage.

Public Transport Network

(i) Public transport plan in this study is a recommendation based on the traffic survey results and their analysis. From now on, many studies and discussions will be conducted for the development of public transport. The JICA Study Team hopes that the recommendation will contribute to clarify the necessity and the effect of development of public transport.

(ii) At present, for the introduction of the new public transport, relevant organisations are conducting studies individually but consistent policy for the development is not established, such as priority mode, priority corridor, physical standard for each mode, and financial method to attract investment. Comprehensive study for introduction of new public transport is required.

(iii) In order to materialise the MRTS plan, not only the physical infrastructure but also institutional framework, especially establishment of operator, is the most crucial challenge requested to the relevant authorities.

(iv) Obtaining general consensus for the improvement of transport network, especially introduction of BRT, amongst the passengers and operators of bus/*matatu* is highly requested.

2) Recommendation

Road Development

(i) Currently, through traffic of heavy vehicles are passing through international highways, and obstructing traffic inside the city. After the completion of the Southern Bypass, heavy vehicles should be restricted in entering into the area surrounded by Eastern Bypass, Northern Bypass, and Southern Bypass.

(ii) Land use policy emphasises the development of the central business district. Road development which will improve the accessibility in the central business district is required to be enhanced. Likewise, creation of circumferential/radial (C/R) road network system which enables diversion of traffic unnecessary to pass through CBD should be promoted.

Public Transport Development

(i) Since the beneficiaries and the most affected participants of the public transport projects are the citizens of Nairobi City, deeper involvement of Nairobi City County (NCC) in the projects is essential. Moreover, NCC established the land use plan which should harmonise with the transport system. Therefore, NCC should be the prime member of transport development project team and the opinions from NCC should be reflected in the project.

(ii) In order to demonstrate the effectiveness of the introduction of new system for public transport and to obtain the consensus amongst the citizens, pilot experiment is an effective way which was introduced to many countries. For the introduction of BRT

system, pilot experiment shall be implemented for a certain period, and effects will be evaluated after the implementation.

Short-term Measures

Result of traffic demand forecast shows that the traffic congestion will worsen in the short term and medium term. To cope with the issue, various measures should be undertaken.

i) System Signal Control

the Integrated Urban Surveillance System (IUSS) is now introduced to the CBD area. But because traffic congestion occurs in wider area, especially along the radial trunk road in the city, system signal control in the whole city area is expected.

ii) Introduction of Bus-exclusive Lane

Even before introduction of BRT, bus-exclusive lane is effective to enhance the use of public transport.

iii) Staggered Working Hours

During morning peak, more than 20% of private car arrival is from 7:00 to 8:00. But before and after the peak hour, traffic volume decreases to only 5%. The transport facilities can be used more efficiently in case of staggered working hours.

iv) Streamline the Freight Carrier

In the information age, volume of commodity has become smaller but frequency has become high. Introduction of cooperating distribution system is highly required to decrease the number of vehicle trips in the business area.

v) Development of Freight Terminal

Together with the policy to exclude heavy trucks within the city area, development of freight terminal outside urban area is required. Basic function of freight terminal is to consolidate freight at a port or a rail yard before onward shipment. Terminals may also be points of interchange involving the same mode of transport. In this regard, the Nairobi Freight Terminal will have two functions. One is modal exchange from freight train for the transport by trucks. The other is exchange of freight within trucks, from heavy trucks to light trucks for delivery in the urban area.

vi) Relocation of Bus Terminals

Along with the land use plan for development of sub-centres in the outskirts area, disposition of bus terminals is expected. These terminals will function as the transfer terminal from *matatu* to large bus.

7.1.7 Ideas for Additional Priority Project for Urban Transport

Considering the objective of the study, urban transport projects which promote the realisation of the land use plan are prioritised. Based on the future land use plan and future traffic demand, the following projects are recommended as the priority project for urban transport:

(1) Flyover in CBD for Railway City

1) Objective and Necessity of the Project

This project aims at the development of Railway City by harmonious planning of land use and urban transport.

(i) To encourage development potential in the southern part of the Nairobi Station by improvement of accessibility to the area; consequently remove the functions unnecessary in the CBD; and promote the creation of the Railway City.

(ii) To alleviate traffic congestion in the northern part of the station by means of relocation of the bus and *matatu* terminals to the new terminal in the Railway City.

(iii) To guide traffic flow from the southern part of Nairobi City promptly and decongest the traffic in the peripheral area.

2) Relevant Organisation

KURA, NCC Engineering Department

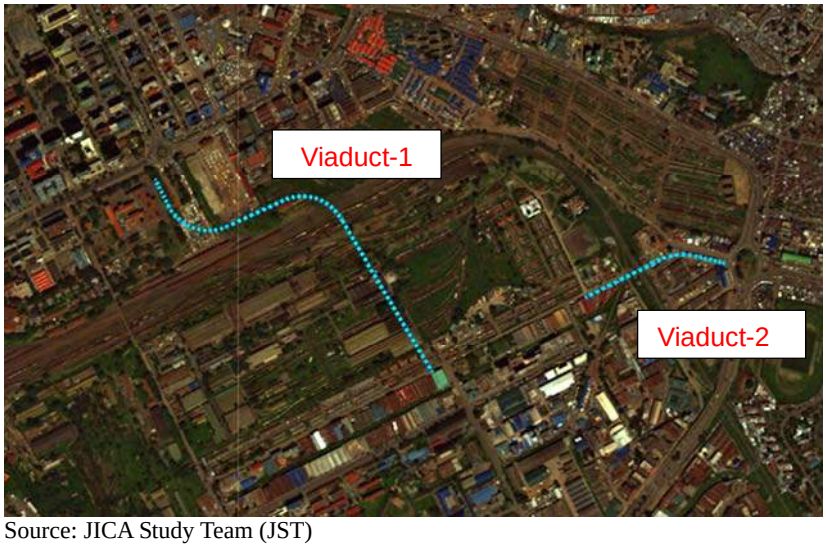
3) Summary of the Project

i) Viaduct-1 (Length: 1,000 m, 4-lane, Project cost: US$30-40 million)

The viaduct connects Moi Avenue, which is the trunk road of CBD, and Enterprise Road, which is the trunk road of the southern area of the station. Moreover, the viaduct together with the widening of Enterprise Road to four lanes will disperse the traffic on Mombasa Road.

ii) Viaduct-2 (Length: 400 m, 2-lanes, Project cost: US$10 million)

The viaduct guides bus and *matatu* traffic to the new terminal in the Railway City, removes the traffic on Landhies Road and thus alleviates the congestion around the terminus in the northern part of the station.



Source: JICA Study Team (JST)

Figure 7.1.47 Routes of Viaduct-1 and Viaduct-2

(2) Widening of Enterprise Road

1) Objective and Necessity of the Project

This project aims to promote the development of Railway City by improvement of accessibility.

(i) To encourage the development potential of Railway City by improvement of accessibility from southern area.

(ii) To disperse the traffic demand on Mombasa Road and Uhuru Highway especially during the construction stage of the northern corridor.

2) Relevant Organisation

KURA, NCC Engineering Department

3) Project Summary

(i) Widening of existing 2-lanes section to 4-lanes (Length: 4.3 km, Project cost: US$15 million): Existing 4-lane section of Enterprise Road is from Lusaka Road to Homa Bay Road. As a result of the project, the section from Homa Bay Road to Mombasa Road will be widened to a 4-lane road.

(ii) Improvement of NMT along existing 4-lane section: After the development of Railway City, the number of pedestrians in Railway City will increase significantly. Therefore, comfortable facilities for NMT should be developed to make the Railway City more attractive.

Source: JICA Study Team (JST)

Figure 7.1.48 Route of Widening of Enterprise Road

(3) Construction of Northern Part of Circumferential Road C-2

1) Objective and Necessity of the Project

Road network system in Nairobi City at present is composed of radial roads. Development of western ring roads partially contributed to form the C/R road network system. If the circumferential road C-2 is developed, the network system in CBD will change fundamentally.

Additionally, the circumferential road C-2 will encircle the CBD area, and will ease the traffic movement around the CBD.

2) Relevant Organisation

KURA, NCC Engineering Department

3) Summary of the Project

Development of Circumferential Road C-2

Beginning Point: Thika Road/Uhuru Highway Intersection

Ending Point: Crossing with Mbagathi Way

Distance: (Widening) 2.2 km

(New construction) 1.5 km

Number of Lanes: 4 lanes

Source: JICA Study Team (JST)

Figure 7.1.49 Supposed Route of Northern Part of Circumferential Road C-2

(4) Creation of ITS City

1) Objective and Necessity of the Project

(i) Traffic demand in Nairobi City is increasing in the entire area, and congestion of road is also spreading in the whole area. Through traffic in CBD is deteriorating the traffic congestion in CBD area. By introduction of ITS technology to Nairobi City area, traffic flow will be improved and traffic concentration to CBD will be rectified.

(ii) In the current circumstances, ITS is introduced individually such as installation of CCTV. Comprehensive policy for development of ITS in Nairobi City does not exist. Hence, the project aims at the establishment of a comprehensive plan for the development of ITS in Nairobi City including the installation and management of ITS facilities.

2) Relevant Organisation

NCC Engineering Department, Police

3) Summary of the Project

i) Establishment of ITS Master Plan, Dispatch of Expert

ii) Expected Component Technology

Traffic Control and Surveillance System (TCSS) Centre, Traffic Signal Optimisation System, Illegal Parking Control System, Traffic Accident Detection System, Bus Location System, Public Transport Transfer Information System, Flooding Detector System, Parking Guidance System, Variable Message Sign (VMS) Information System, and Transport Database (road and facility, statistics for traffic accident, etc.).

iii) Other Supplemental Function

Traffic Demand Management (TDM), Traffic Safety

iv) The ITS project in CBD will play a role as a showcase of this project.

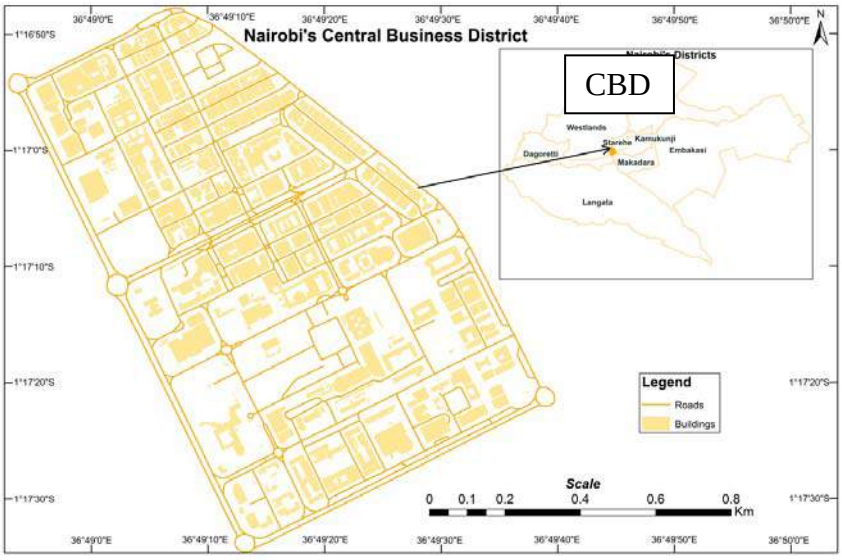


Figure 7.1.50 Project Area for Creation of ITS City

7.2 Railway

7.2.1 Demand and Gap Analysis

There is no doubt that the potential demands for the commuter train operation in Nairobi City and surrounding areas are always higher than actual capacities. Due to the insufficient locomotives and wagons, RVR is operating only one or two commuter trains on each line in the morning. Due to the poor condition of railway track, trains are running at a very low speed and the quality of service is not good enough so that a number of commuters are using bus transportation rather than the railway. Unless substantial improvement is made on the railway system, the present situation would not change much.

Source: Nairaland Forum
(http://www.nairaland.com/51356/nairobi-photos-kenya-beautiful-east/103)

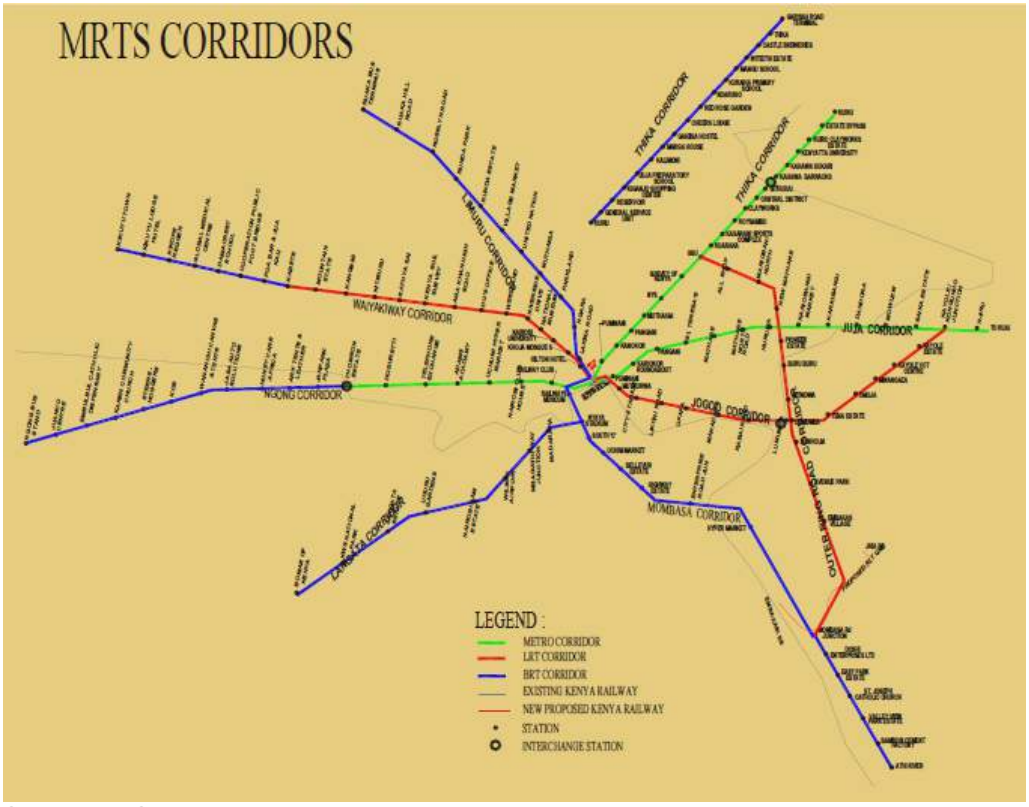
Figure 7.2.1 Commuter Train Operation by RVR

7.2.2 Development Policy

There seems to be insufficient coordination between the Ministry of Transportation and Kenya Railways Corporation (KRC) on the planning of urban transportation by rail. MRT/LRT lines planned in MRTS (2011) were not considered in the new line construction plan recently prepared by KRC. In order to avoid overlapping of projects, close coordination and communication shall be kept amongst those authorities concerned.

Since railway projects have time and cost consuming natures, projects shall be classified into short-, medium-, and long-term plans.

The projects utilising the existing railway facilities and equipment, such as introduction of DMU on the existing lines, can be categorised under short-term projects. Those new line constructions, such as MRT/LRT construction, shall be categorised as medium- or long-term projects.



Source: MRTS Report

Figure 7.2.2 Planned MRTS Corridors

7.2.3 Priority Projects

Considering current transportation demands, development policy and site conditions, higher priority to the following projects shall be given:

(1) Introduction of DMU for the Existing KRC Lines

As described in Section 7.2.1, the existing commuter train operation by RVR using diesel locomotives and wagons is insufficient in the aspects of capacity, speed, and riding comfort. Because of the high demands and low capacity, trains are always fully loaded and passengers are forced to tolerate the uncomfortable condition.

In order to ease such situation, introduction of DMU is suggested. It was calculated by a preliminary analysis that three train sets (consisting of six cars each) can carry 7,000 to 10,000 passengers within two hours in the morning between Ruiru-Nairobi, Kikuyu-Nairobi, and the Athi River–Nairobi, respectively.

Introduction of DMU does not mean procurement of DMU only, but also provision of the maintenance facilities and equipment, spare parts, and staff training.

(2) Track Rehabilitation of Existing KRC Lines

Rehabilitation of the existing track is another way to increase the transportation capacity of a railway. If the schedule speed (average speed including stopping time at stations) can be doubled, transportation capacity of the train will be doubled. Due to the existing poor condition of track, the schedule speed at this moment is less than 20 km/h. If the rail is welded and placed on properly shaped ballast, the schedule speed can be doubled easily. This track rehabilitation project shall include staff training and provision of track maintenance equipment, if required.

(3) Introduction of Signaling System for DMrU Operation

When introduction of DMU and track rehabilitation are planned, introduction of a modern signaling system shall also be planned in order to keep the safety of train operation. At this moment, there is no signal system existing on the KRC Lines. Train operation is controlled by telephone communication between stations and using a paper sheet instead of tablet for the confirmation of track occupancy. Radio communication system can be adopted for communication between stations and between station and train driver. GPS can be utilised for positioning of trains.

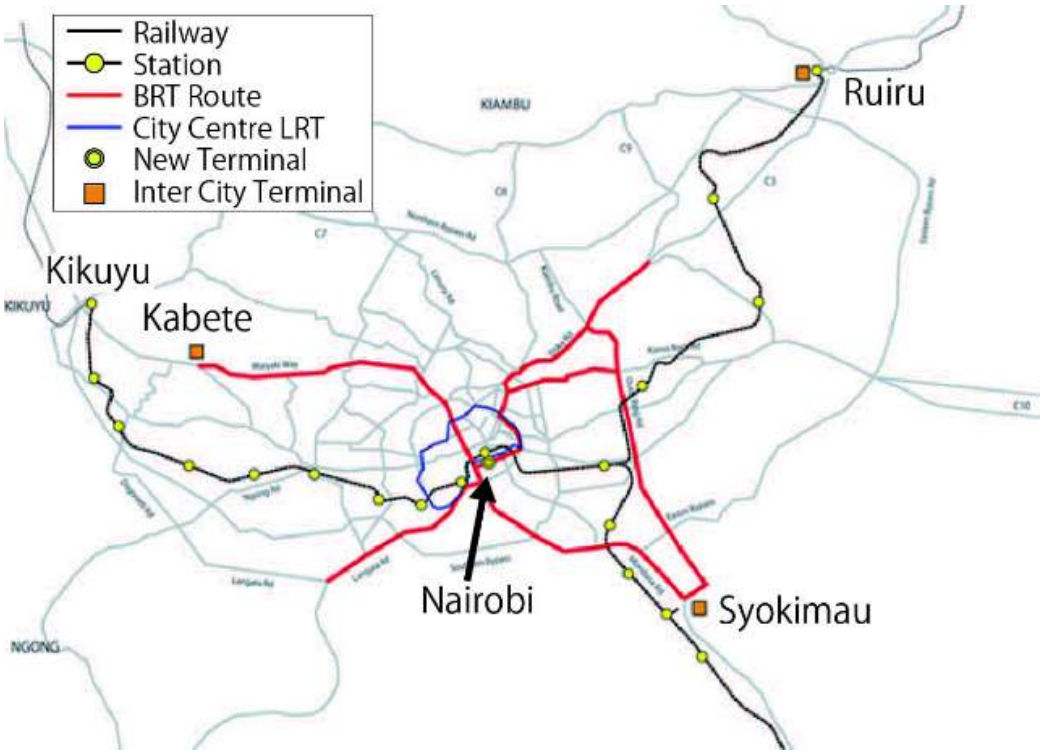
(4) Feasibility Study for the East-West Corridor MRT Line

The MRTS report has been prepared in June 2011. Three MRT lines and three LRT lines along the existing major roads are planned in the report, and the first priority was given to a MRT line along Thika Road.

Table 7.2.1 Existing Condition of Planned MRT/LRT Routes

Priority in NMRTS	Route	Construction	Existing Condition of the Route
1	Thika Road	2013-2016	Expressway is completed. KRC line is available.
2	Juja Road	2015-2018	Road widening is required at east side of the route.
3	Jogoo Road	2017-2020	Road widening is required at east side of the route.
4	Ngong Road	2019-2022	90% of the route is ready for construction.
5	Waiyaki Way	2021-2024	80% of the route is ready for construction.
5	Outer Ring Road	2021-2024	Road widening is required at whole route.

Source: JICA Study Team (JST)



Source: JICA Study Team (JST)

Figure 7.2.3 Existing KRL Lines and Planned MRT/LRT Lines

According to the results of the site visits, it was found that the 6-lane expressway between Nairobi and Ruiru and the 4-lane expressway between Ruiru and Thika were completed. In addition, KRC is planning to improve the commuter train operation up to Thika. Therefore, the first priority of MRT construction between Nairobi and Ruiru can be reduced.

There seems to be right of way problems at the second priority MRT route (Juja Road) and the third priority LRT route (Jogoo Road).

The site is ready for construction at the fourth priority MRT route (Ngong Road) and the fifth priority LRT route (Waiyaki Way).

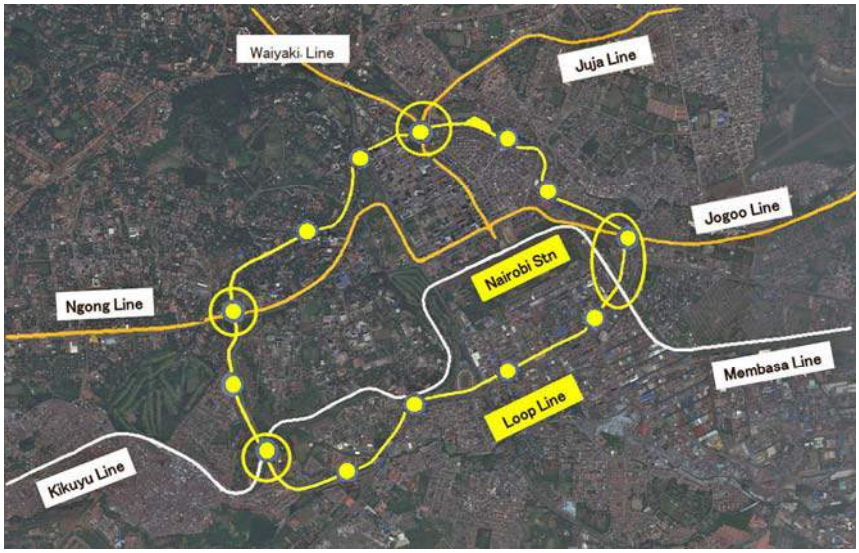
The whole section of LRT route (Outer Ring Road) requires road widening. It will take time for it to be ready for construction.

Considering demand forecast and site condition, the first priority MRT/LRT route shall be selected for a feasibility study for construction purpose.

(5) Feasibility Study for the Ring Line

All the urban railway lines radiating from Nairobi station proposed in NMRTS study. It may cause severe traffic congestion at CBD area. In order to avoid the concentration at CBD near Nairobi station, provision of a Loop Line can be considered. AGT or Monorail system will be suitable for the Loop Line circulating sub-centers which may be formed at the interchange stations.

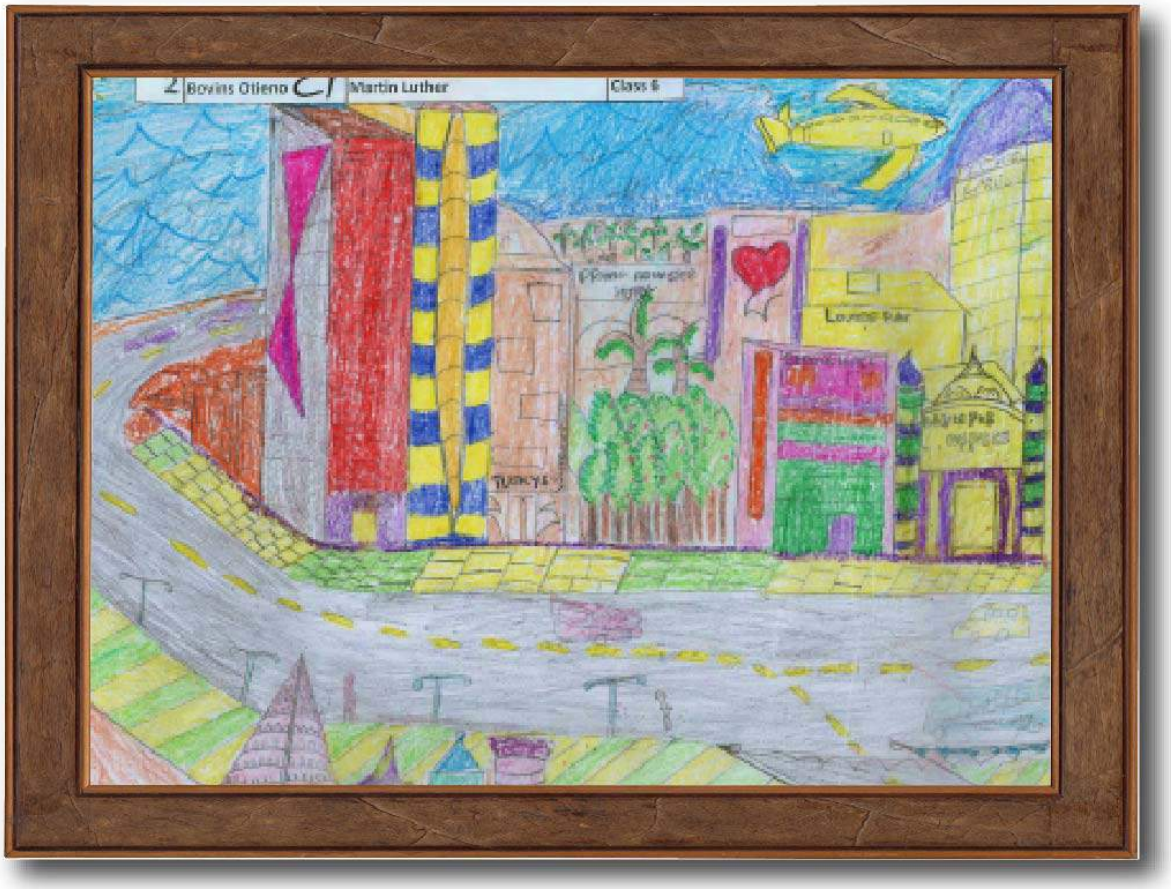
The blue line shown on the following map is an example of the Loop Line.



Source: JICA Study team

Figure 7.2.4 Loop Line circulating CBD and Sub-centres

At the same time of the feasibility study for the first MRT Line, this Loop Line shall also be studied.



Bovins Otieno, Martin Luther Primary School (Rank 1 of Class 6)

CHAPTER8 URBAN INFRASTRUCTURE DEVELOPMENT STRATEGY

8.1 Water Supply

8.1.1 Demand and Gap Analysis

(1) Water Demand Projection

1) Population

The projected population in this study has adopted the water demand projection. The projected population is presented in Table 8.1.1.

Table 8.1.1 Population Projection of Nairobi City

City	2009	2013	2018	2023	2030
Nairobi City	3,138,372	3,601,351	4,174,952	4,677,677	5,212,500

Source: JICA Study Team (JST) and Census 2009 data

2) Unit demand

i) Residential, institutional, and commercial demand

The residential demand was based on the figures stipulated in the Guidelines for Water Allocation issued by the Water Resources Management Authority (WRMA) 2009 (hereafter referred to as the WRMA guidelines).

The allowance of water loss stipulated in the WRMA guidelines was deducted from the residential unit demand. Enough information on water loss of water treatment plants, raw water pipelines, treated water pipelines, pump stations, and distribution network for Nairobi City is not available. The rate of unaccounted for water (UfW) in 2008 reported in Impact No. 3 (Water Services Regulatory Board (WSRB), 2010) is twice the allowable rate, although UfW includes the amount caused by the maloperation of water tariff. Thus, water loss in the projection does not simply utilise the allowable rate. It will be discussed in the latter sections.

The minimum requirement of unit demand at 25 litres/capita/day mentioned in the draft of Water Act 2012 was adopted as an adjustment to the figure. The basis of the residential water demand from the WRMA guidelines is presented in Table 8.1.2.

Table 8.1.2 Basis of the Residential Water Demand from the WRMA Guidelines

Category of Area	For High-class Housing (litres/capita/day)		For Medium-class Housing (litres/capita/day)		For Low-class Housing (litres/capita/day)	
	Including 20% of Water Loss*1)	Without Water Loss	Including 20% of Water Loss	Without Water Loss	Including 20% of Water Loss	Without Water Loss
With Individual Connection	250	200	150	120	75	60
Without Individual Connection	-	-	-	-	30	30

Note *1): Allowance for water loss stipulated in the guidelines is 20%.
Source: JICA Study Team (JST) and the Guidelines for Water Allocation (WRMA 2009)

As there is not enough information for demand projection on the population of the high-, medium- and low-class housing, the population ratio of the income level proposed in the Feasibility Study and Master Plan for Developing New Water Sources for Nairobi City and Satellite Towns (FSMPNWS) was utilised for the projection.

In the study, the high-, medium-, and low-income groups are regarded as the high-, medium- and low-class housing, respectively.

Categorising the low-class housing with/without individual connection was based on the coverage ratio of water supply by the Nairobi City Water and Sewerage Company Limited (NCWSC). The ratio of the high-, medium-, and low-class housing is presented in Table 8.1.3 and the calculated residential demand based on the ratio is presented in Table 8.1.4.

Table 8.1.3 Ratio of the High-, Medium-, and Low-Class Housing

Class		2009	2013	2018	2023	2030
High-class Housing		6 %	6 %	6 %	6 %	6 %
Medium-class Housing		50 %	50 %	50 %	50 %	50 %
Low-class Housing	With Individual Connection	9 %	12 %	16 %	18 %	22 %
	Without Individual Connection	35 %	32 %	28 %	26 %	22 %

Source: JICA Study Team (JST) and FSMPNWS

Table 8.1.4 Ratio of the High-, Medium-, and Low-class Housing

Class		Unit Demand	2009		2013		2018		2023		2030	
			Ratio	Demand	Ratio	Demand	Ratio	Demand	Ratio	Demand	Ratio	Demand
High-class Housing		200	6	12	6	12	6	12	6	12	6	12
Medium-class Housing		120	50	60	50	60	50	60	50	60	50	60
Low-class Housing	With Individual Connection	60	9	5	12	7	16	10	18	11	22	13
	Without Individual Connection	30	35	11	32	10	28	8	26	8	22	7
Total (litres/capita/day)			88		89		90		91		92	

Source: JICA Study Team (JST) and FSMPNWS

Institutional and commercial demand was assumed at 10% and 15% of the residential demand by the study team, respectively. The assumption was adopted from the projection to cover the lack of raw date in line with international practice.

From the conditions showed in this section, the residential unit demands were set without water loss as presented in Table 8.1.5.

Table 8.1.5 Residential Unit Demand without Water Loss

Year	2009	2013	2018	2023	2030
Residential Unit Demand (litres/capita/day)	88	89	90	91	92
Institutional Unit Demand (litres/capita/day) (10% of Residential Demand)	9	9	9	9	9
Commercial Unit Demand (litres/capita/day) (15% of Residential Demand)	13	13	14	14	14
Total (litres/capita/day)	110	111	113	114	115

Source: JICA Study Team (JST)

ii) Industrial Demand

In the projection of industrial demand, the rate of residential demand for the current demand and growth of gross domestic product (GDP) in Nairobi City for future demand were adopted, considering the following situations:

Industrial demand depends on the type and size of the firm's activity. The data such as number of workers, type of products, process taken by the factory, and water demand of the existing industries for each type of industry are necessary to evaluate and analyse industrial demand. On that note, there is not enough data available for evaluation.

An approach was taken from the Aftercare Study 1998 on the National Water Master Plan in 1992 to set the ratio of residential demand for Nairobi City at 25%. In this study, the approach is adopted to consider the current industrial demand.

From the above conditions, the industrial demand is presented in Table 8.1.6.

Table 8.1.6 Industrial Demand

Year	2009	2013	2018	2023	2030
Industrial Demand (litres/capita/day)	22	22	23	23	23

Source: JICA Study Team (JST)

3) Water loss

According to the WRMA guidelines, water loss is defined as the total leakage and wastage with an allowance of 20%. The targeted non-revenue water (NRW) was declared in the Water Service Strategic Plan 2009 prepared by the Ministry of Water and Irrigation (MWI) based on Kenya Vision 2030. From the two facts mentioned above, the targeted water loss in 2030 is 20%.

In line with the current water loss, there is not enough information available to evaluate its ratio.

The UfW was 40% in 2008 as reported by Impact No. 3 (WSRB, 2010). Since UfW includes part of the amount of supplied water such as illegal connection and human error in the operation of water tariff, the total amount of UfW is larger than water loss. In the demand projection, the study team, however, considered that the adoption of UfW in the current situation is applicable to evaluate higher risk than the actual.

From the situation described above, the water loss in 2009 is 40% or the same as the UfW reported in 2010 and is linearly reduced to 20% in 2030 in the demand projection.

4) Summary of water demand

Based on the conditions mentioned above, the water demand of Nairobi City is presented in Table 8.1.7.

Table 8.1.7 Water Demand of Nairobi City

Class		2009	2013	2018	2023	2030
Population (capita)		3,138,372	3,601,351	4,174,952	4,677,677	5,212,500
Residential, Institutional, and Commercial Demand	Unit Demand (litres/capita/day)	110	111	113	114	115
	Demand (m^3/day)	345,221	399,750	471,770	533,255	599,437
Industrial Demand	Unit Demand (litres/capita/day)	22	22	23	23	23
	Demand (m^3/day)	69,044	79,229	96,024	96,024	119,888
NRW	Ratio (%)	39	35	31	26	20
Total		576,000	647,000	744,000	808,000	864,000

Source: JICA Study Team (JST)

(2) Existing Demand Projection and Development Plan

As mentioned in Subsection 4.1.5, FSMPNWS was carried out under the Athi Water Services Board (AWSB) with the assistance of the World Bank (WB) and the French Development Agency (Agence Francaise de Developpement: AFD). The demand projection and development plan recommended in FSMPNWS are presented as follows:

1) Demand Projection

The characteristic conditions of demand projection in FSMPNWS are as follows:

(i) Demand projection in FSMPNWS utilised the method pursuant to the WRMA guidelines,

(ii) Projected population is the same as that of this study, and

(iii) Water loss is set by the study team of FSMPNWS.

The projected water demand in FSMPNWS is presented in Table 8.1.8.

Table 8.1.8 Water Demand of FSMPNWS

Class	2010	2017	2020	2030
Population (capita)	3,250,338	4,0040,325	4,403,791	5,693,457
Water Demand (m^3/day)	378,495	480,068	533,560	746,174
NRW (%)	53	40	37	37
Total (m^3/day)	579,000	672,000	731,000	1,022,000

Source: FSMPNWS

2) Development Plan of the Water Resources and Water Supply System in FSMPNWS

In order to meet the requirement presented in Table 8.1.8, one plan was recommended by FSMPNWS after reviewing and evaluating several alternative scenarios.

The recommended plan comprises five phases and its components are presented in Table 8.1.9 and the general layout is presented in Figure 8.1.1.

Table 8.1.9 Recommended Water Resources Development Plan of Nairobi City

Phase	Component	Financer	Completion Year	Planned Capacity (m^3/day)	Status of the Plan as of September 2013
1	Well Field in Kunyu	WB	2014	34,560	
	Well Field in Uriru	WB	2015	30,240	Detailed Design
2	Northern Collector Tunnel Phase I to Thika Dam	WB	2016		
	Ngorongo WTP	AFD	2016	120,960	Detailed Design
3	S. Mathioya Transfer				
	Maragua Dam	-	2020	132,192	Master Plan

	Ndunyu Chege WTP				
4	Northern Collector Tunnel Phase II to Tika Dam	-	2026	120,096	Master Plan
5	Ndarugu Dam				
	Raw Water PS				
	Ndarugu WTP				
	Treated Water PS				
	Kasarani BPS	-	2029	216,000	Master Plan
Total				654,000	

Source: FSMPNWS

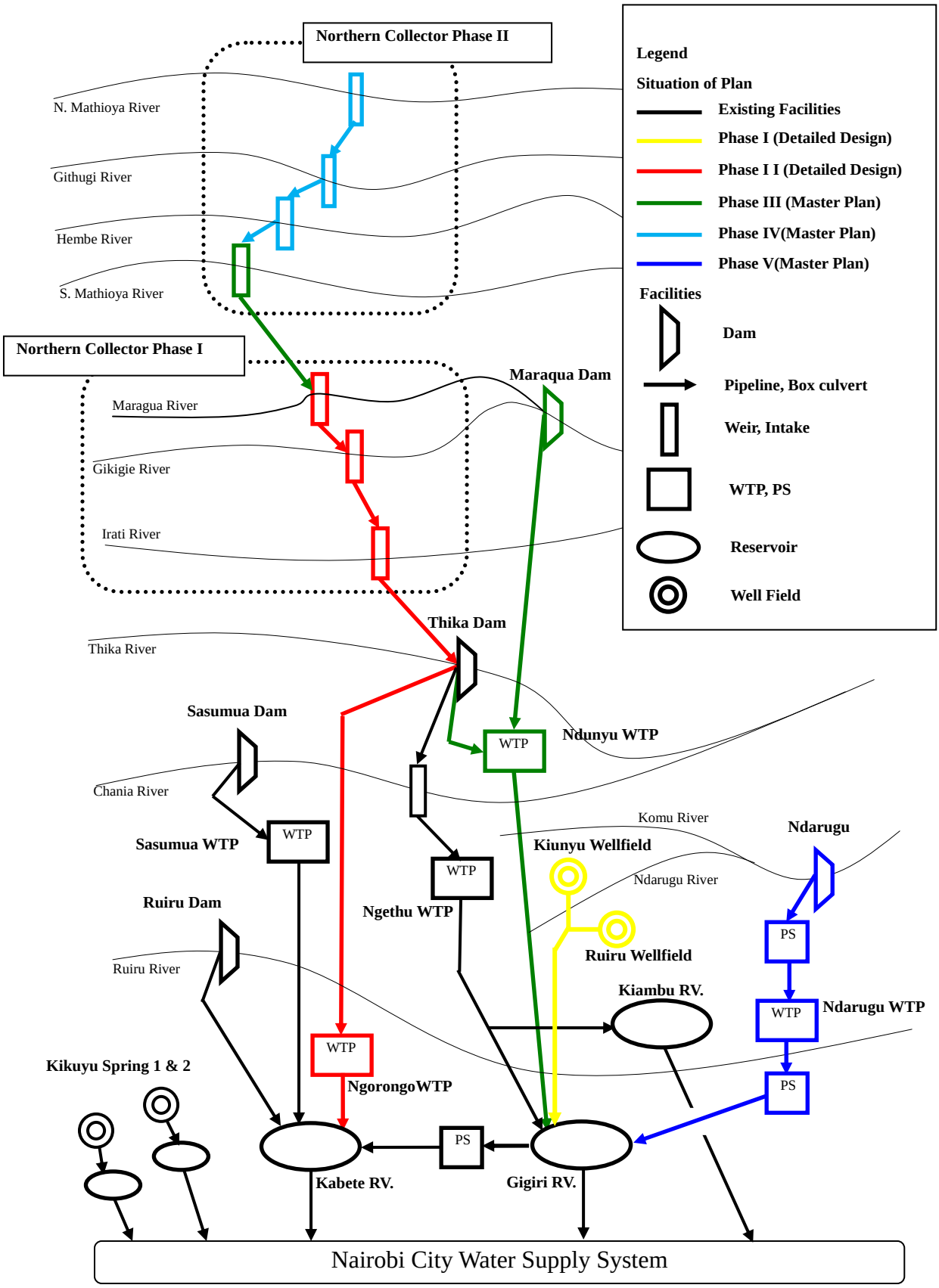


Figure 8.1.1 General Layout of the Existing and Planned Facilities

(3) Gap of Demand Projection between FSMPNWS and this Project and its Analysis

1) Summary of Demand Projection and Water Supply Capacity

The comparison amongst the demand projected in FSMPNWS (hereafter referred to as the demand by WB) and that of the study team (hereafter referred to as the demand by the study team) is presented in this section.

The trend of the demand by WB is in almost gradual increment until 2035 and the capacity of water supply is developed to cover the demand.

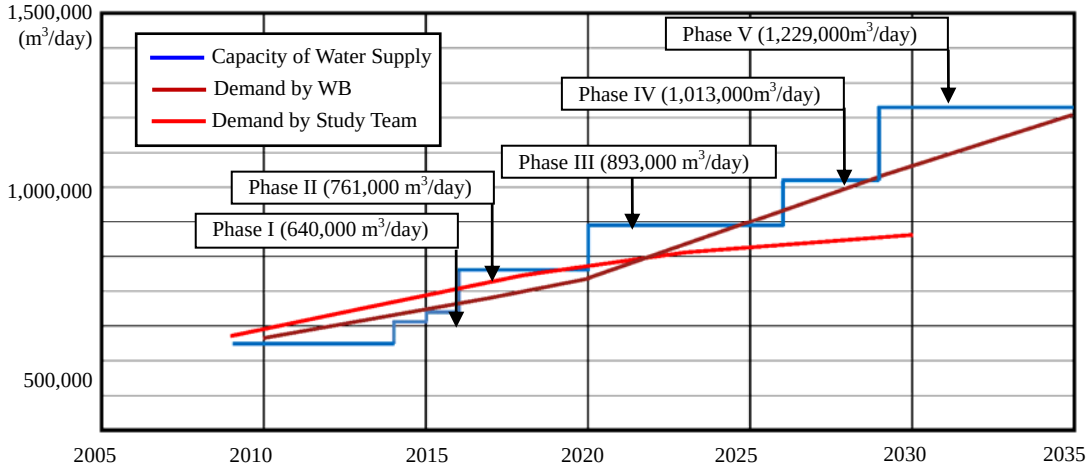
On the other hand, the demand by the study team gradually increases until 2017 and the degree of increment falls down until 2030.

Until 2023, the trends of the two projections will be kept almost on the same line. After 2023, the gap between the projections will occur and expand year by year. The demand by WB is higher with 158,000 m^3/day than that of the study team. The summary of demand projections and the capacity of water supply is presented in Table 8.1.10 whereas the comparison between water demands and capacity of water supply is presented in Figure 8.1.2.

Table 8.1.10 Summary of Demand Projections and Capacity of Water Supply

Class		2009	2010	2013	2017	2020	2023	2030
Population (capita)	WB		3,250,338		4,0040,325	4,403,791		5,693,457
	ST[1)]	3,138,372		3,601,351			4,677,677	5,212,500
Water Demand (m^3/day)	WB		579,000		672,000	731,000		1,022,000
	ST	576,000		647,000			808,000	864,000
Water loss (%)	WB		53		40	37		37
	ST	39		35			26	20

Source: JICA Study Team (JST) and FSMPNWS



Note: ST (the Study Team)
Source: JICA Study Team

Figure 8.1.2 Comparison between Water Demand and Capacity of Water Supply

2) Gap Analysis

The main reason of the gap between the water demand by WB and that of the study team is the difference on water loss assumptions included in the demands. As presented in Table 8.1.10, the adopted water loss in the demand by WB is much higher than that of the study team. The difference approximately accounts for the gaps.

The water loss adopted in the demand by WB was estimated based on the current situation in Nairobi City as of July 2012. The water loss composed of distribution losses, transmission losses, and treatment losses. In the study, the transmission loss and treatment loss were fixed. The improvement of distribution loss changed from 40% in 2010 to 25% in 2020. The distribution loss is fixed at 25% in the period from 2020 to 2035. The total water loss adopted in FSMPNWS is presented in Table 8.1.10.

According to Impact No. 3 (WSRB, 2010), the UfW in Nairobi City was 40% in 2008. The amount is the same as the distribution loss in 2010 adopted in the demand by WB. The UfW composes physical loss, illegal connection losses, and administrative mistakes in the operation of water tariff. As the amount of illegal connection losses and administrative mistakes is the water supplied to people without collecting fees, it is not included in the water demand. The reason of the adoption is assumed that the lack of data on water loss in the water supply system of Nairobi City and the portion was regarded as the allowance of the projection.

On the other hand, the study team set the transition of water loss as declining from 40% in 2008 to 20% in 2030 as mentioned in Item (1) 3) of Subsection 8.1.1.

From the situation described above, the difference on water loss accounts to the gaps as presented in Table 8.1.10 and Figure 8.1.2.

8.1.2 Development Policy

The master plan of water supply in the area including Nairobi City with the target for completion in 2035 (FSMPNWS) has been prepared by AWSB supported by WB and AFD. The development of water supply is carried out in accordance with the master plan.

As mentioned in Item (2) of Subsection 8.1.1, the development plan of water resources and facilities for intake, raw water transmission, water treatment plant, and treated water transmission has already been established and is expected to be conducted in five phases.

Phase I is the well field development in Kiunyu and Ruiru and Phase II of the northern collector and water supply system including Ngorongo Water Treatment Plant (WTP) have commenced with WB and AFD funds. Although the development includes raw water transmission, water treatment plant, and treated water transmission, the distribution network to cover the expanded capacity of water supply has not been included in the proposed plan under FSMPNWS. Thus, the development plan of the distribution network needs to be studied separately.

Phase III of the S. Mathioya River transfer, Maragua Dam, and Ndunyu Chege WTP is under planning stage. Expanding the capacity through development is necessary to cover water demand after 2020. The water resources and facilities are located outside Nairobi City. Thus, an agreement between counties on the development of the water supply facilities for Nairobi City is indispensable. Phases IV and V of the northern collector's second phase and Ndarugu Dam, Ndarugu WTP, three pump stations, and pipelines are planned on the basis of the demand projection by WB for 2030 and 2035, respectively. Phases IV and V could be postponed after 2035 subject to the improvement of water loss. The projected demand with 20% of the water loss will be below the total capacity of Phases I, II, and III as presented in Figure 8.1.2. Depending on the improvement level of water loss, revision of the master plan of the development needs to be studied.

8.1.3 Priority Project

(1) Background

The comprehensive plan of the distribution network in Nairobi City needs to be considered as a priority project for the following reasons;

According to the information presented by NCWSC participated in by the working group of the water sector, the pipelines and reservoirs of the distribution network need to be rehabilitated due to overage and unsuitable material for potable water as well as construction of buildings for pipeline alignments.

The necessity of expanding the distribution network has become significant year by year in response to the drastic urbanisation of Nairobi City, especially in the area along Thika Road.

The development of the water supply system up to the main reservoirs of Nairobi City has commenced with the support of WB and AFD. To cover the strengthened capacity based on the development, the comprehensive plan of the distribution network is urgently required.

According to the Water Service Strategic Plan 2009 prepared by MWI, the UfW rate should be improved to 20% from the current UfW of 40% in 2008 for efficient water use. As physical water losses of UfW mainly occur in the distribution network, the comprehensive plan of the distribution network is one of efficient activities to improve UfW.

(2) Outline of the Project

In order to establish the policy and direction of the distribution network in Nairobi City, the master plan of the distribution network is meaningful and necessary considering the situation described above.

Since the construction works of pipelines in the distribution network need to be carried out stepwise due to budgetary requirements and the necessity to coordinate with other activities in the city such as transportation, the master plan followed by detailed design of the immediate phase of implementation is indispensable.

In the master plan, technical issues such as arrangement of pipelines and its pressure are mainly discussed. Expected activities to complete the project are presented below.

1) Survey of the Current Situation

To prepare a concrete plan of expansion, rehabilitation, and replacement of the distribution network, concrete technical information is indispensable. For this purpose a detailed site survey to complement the existing information needs to be carried out.

(i) Location of pipeline, diameter, and material,

(ii) Water pressure in distribution network,

(iii) Topographic information including road, administrative, and distribution network boundaries, and

(iv) Existing facilities and equipment such as reservoirs and pumps.

2) Study of Pipeline Arrangement in the Distribution Network

Some alternatives of the pipeline arrangement are prepared and evaluated on the reduction of NRW and the possibility of its realisation.

The arrangement of pipeline is studied considering the following:

(i) Clustering of looped pipelines to main distribution pipeline for identification of problems such as physical leakage, illegal connection, and malfunctioning water meter,

(ii) Arrangement of reservoirs to keep regular release pressure between the main pipeline and pipelines connected to each customer,

(iii) Utilisation of the existing pipelines, and

(iv) Stepwise development based on the development of water resources.

3) Preparation of Direction on the Rehabilitation and Replacement of Pipelines

The direction for the evaluation of existing pipelines for its required rehabilitation and replacement needs to be studied and recommended in the master plan.

In the existing distribution network, overaged pipes, harmful materials such as asbestos pipe, and unsuitable location of pipelines installed under buildings are reported through the interview with NCWSC. These problems on the existing pipes are evaluated in order to clarify the direction of improvement.

4) Preliminary cost estimates to complete the development of the distribution network

Based on the above, preliminary cost for the proposed development of the distribution network shall be estimated.

(3) Rainwater Collection Equipment for Buildings

The Urban Development Department of the Nairobi City County (NCC) is interested in introducing the equipment or instrument for the collection of rain water in urban development in order to use the water for non-drinking purposes such as gardening and washing cars.

While the quantification of its effect has not been carried out due to lack of sufficient information such as the number of buildings that have the instrument, its capacity, legal framework for enforcement to equip the instrument in urban development, and responsible organisation, the effects of the instrument have not been reflected in the projection of water demand.

The issue on law enforcement and organisation on NCC's recommendation need to be discussed in the department which is in charge of building development.

In relation to the issue, comprehensive development of recycled water in the sewerage system and rain water in the drainage system as alternative source of water will be discussed in the section on sewerage and drainage in Nairobi City.

(4) Priority Project Operated by AWSB

With regard to water supply for Nairobi City, many projects by AWSB are in progress to meet the demand for water. NCC needs to monitor its progress in order to update the comprehensive information on urban development for its provision to other sectors such as transportation, electricity, and telecommunications.

1) Development of the Spring Fields and the Northern Collector Phase I

In Nairobi City, the lack of water supply has been one of the most serious problems due to the drastic expansion of its population. The capacity of the water supply system is below the demand, which causes the development of private boreholes in Nairobi City.

The development of new water resources and water supply system is one of the main measurements to meet the demand. From the above situation, the project is considered a high priority.

2) Improvement of Operation on Leakage Detection, Repair and Water Tariff

One of the causes of water shortage in Nairobi City is UfW based on physical leakage, illegal connection, and malfunctioning/non-installation of water meter. Reinforcement of skillful organisation in terms of technical and administrative activity is one of the priority projects.

On the above issue, AWSB, in cooperation with NCWSC and financial aid of AFD, set some pilot areas in Nairobi City and has carried out a survey on the condition of pipelines, valves, and water meters as well as the performance on collecting water tariff.

The MWI and Kenya Water Institute supported by JICA have carried out the Technical Cooperation Project for the Project for Management of Non-revenue Water in Kenya. Some pilot areas in the satellite city of Nairobi City were set in the project and transferring of engineering skills on leak detection methods in the distribution network.

8.2 Stormwater Drainage and Sewerage

8.2.1 Demand and Gap Analysis

(1) Stormwater Drainage

1) Management of Rivers

In Nairobi City, stormwater is collected through both natural and man-made drainage systems and drained to the Nairobi River system comprising the Gitathuru, Rui Ruaka, Nairobi, and Ngong rivers and then discharged through the main stream of the Nairobi River.

The development and maintenance of these rivers should be regarded as a primary task for the management of stormwater drainage in Nairobi City. Each of these rivers should be maintained with a hydraulic capacity sufficient for discharging stormwater runoff concentrated from its catchment area. Within the catchment area of the river, the stormwater drainage systems draining the individual subcatchment areas should be designed in conformity with the hydraulic capacity of the river. In the meantime, the riparian reserves need to be delineated and secured to maintain better river environment.

The principal activities for the development and maintenance of these rivers are as follows:

(i) Longitudinal and cross section survey of the river,

(ii) Investigation of associated works (e.g., dikes, revetments, drainage outfalls, bridges, culverts, etc.),

(iii) Evaluation of stormwater runoff from catchment area and hydraulic capacity of the river,

(iv) Identification of river stretches to be developed and/or maintenance requirements,

(v) Plan, design, and implementation of river training works,

(vi) Maintenance of river and associated works, and

(vii) Monitoring and feedbacks.

Within the catchment area of each river, stormwater drainage systems draining the subcatchment areas should be designed in conformity with the hydraulic capacity of the river.

The regional office of WRMA is responsible for the abovementioned activities, but the status of the activities is not clearly identified as there is no sharing of information or coordination with the City Engineering Department of NCC regarding such activities in Nairobi City.

2) Management of Drains and Sewers

The stormwater drainage system comprises a network of canalised trunk drains, ditches, and storm sewers for draining a subdivided catchment area. The City Engineering Department is responsible for checking the design of the stormwater drainage system and/or elements in the appraisal of construction works. Moreover, it is also responsible for carrying out the maintenance of the stormwater drainage systems constructed by the public sector.

These activities of the City Engineering Department, however, are not functioning satisfactory due to the following situations that are attributable to the essential problems on stormwater drainage in Nairobi City as previously described in Subsection 4.2.5:

(i) Most of the technical data (master plan, project documents, as-built drawings, etc.) for the existing stormwater drainage systems were lost in a fire which engulfed the city hall in 2004. The loss of technical data makes it hard for the City Engineering Department to carry out proper maintenance of the existing stormwater drainage systems;

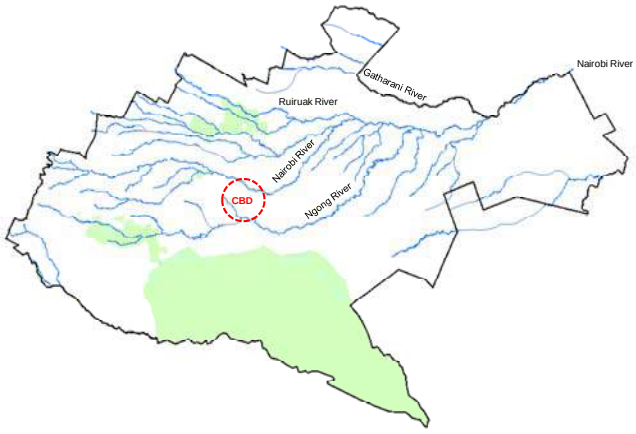
(ii) The appraisal of construction works including stormwater drainage by the City Engineering Department is difficult, as the report on the master plan for stormwater drainage in 1998 was misplaced and often neglected; and

(iii) The development of stormwater drainage in Nairobi City is envisaged by the government under the ongoing projects; the Kenya Municipal Programme (KMP) and Nairobi Metropolitan Services Improvement Project (NaMSIP) financed by WB. But the involvement of the City Engineering Department in the projects is limited and details of the projects (project descriptions, schedule, current progress, etc.) are not available in their department.

3) Major Issues

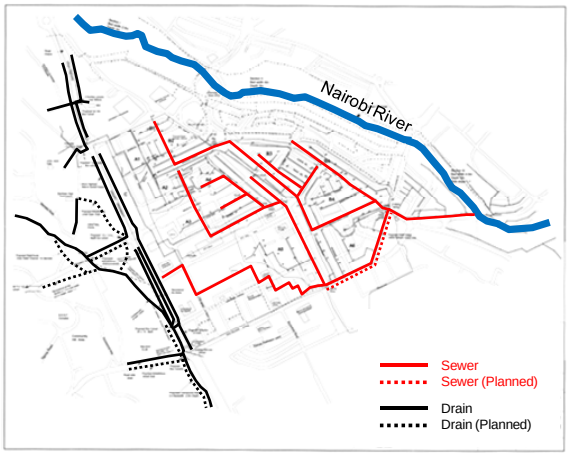
At present, the development of stormwater drainage in Nairobi City is likely to focus on the localised drainage network consisting of canalised trunk drains, ditches, and storm sewers in the urban areas individually. Due to the manner of development, in the future, it is anticipated that an integrated stormwater runoff drained from the localised drainage networks developed and extended toward the future would be excessive and inconsistent with the hydraulic capacity of the river. Therefore, the stormwater drainage should be developed by integrating the river and localised drainage networks as a system.

Nairobi River and Tributaries



Source: JICA Study Team (JST)

Localised Drainage Network in CBD



Source: NCWSC

Figure 8.2.1 River and Localised Drainage Network

The City Engineering Department should restore its functions to manage the stormwater drainage systems in Nairobi City. The principal needs are the following: (i) collection, review, and update of technical data for the maintenance of the existing stormwater drainage systems, (ii) involvement in the development of the stormwater drainage under KMP and NaMSIP, and (iii) development of capability for the appraisal of construction works including stormwater drainage and maintenance of the existing stormwater drainage systems.

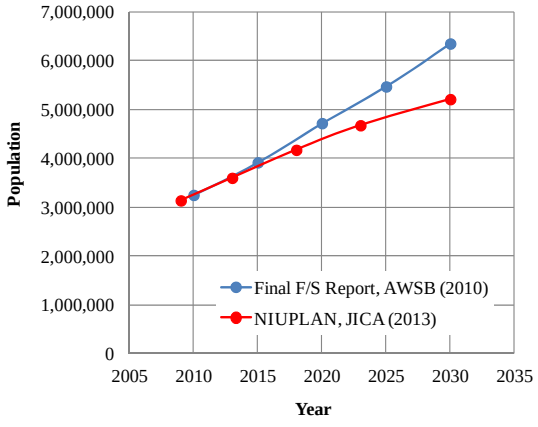
(2) Sewerage

1) Estimates of the Required Sewerage Treatment Capacity

i) Population

The Final Feasibility Study Report of the Nairobi Rivers Rehabilitation and Restoration Program: Sewerage Improvement Project (NaRSIP) indicates that the population in Nairobi City is projected to be 6.35 million by year 2030. This estimate is lower than the 5.21 million projected by Nairobi Integrated Urban Development Master Plan (NIUPLAN).

The Final Feasibility Study Report of NaRSIP used 3.8% for 2011-2020 and 3.0% for 2021-2030, while NIUPLAN applies a population growth rate of 2.4%/year for the period of 2009-2030.



Source: JICA Study Team (JST)

Figure 8.2.2 Comparison of Population Projections

Table 8.2.1 Comparison of Population Projections

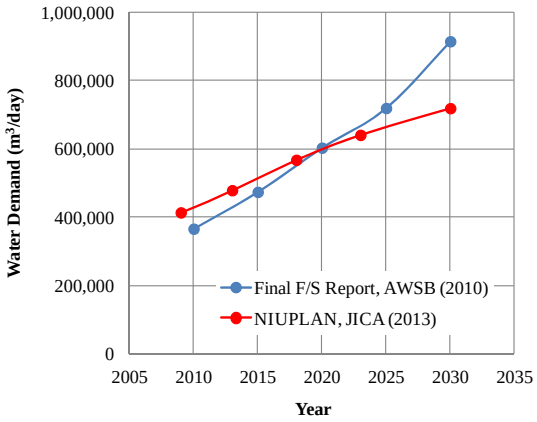
Final F/S Report	Year	2010	2015	2020	2025	2030
AWSB (2010)	Population	3,251,219	3,917,716	4,720,845	5,472,753	6,352,396
NIUPLAN	Year	2009	2013	2018	2023	2030
JICA (2013)	Population	3,138,372	3,601,351	4,174,952	4,677,677	5,212,500

Source: JICA Study Team (JST)

ii) Water Demand

The Final Feasibility Study Report of NaRSIP estimated that the water demand in Nairobi City excluding UfW would increase up to 914,812 m^3/day by year 2030.

The water demand projection by NIUPLAN is discussed in Subsection 4.4 previous to this chapter. The water demand in year 2030 is projected to be 719,000 m^3/day excluding UfW.



Source: JICA Study Team (JST)

Figure 8.2.3 Comparison of Water Demand Projections

Table 8.2.2 Comparison of Water Demand Projections

Unit: m^3/day

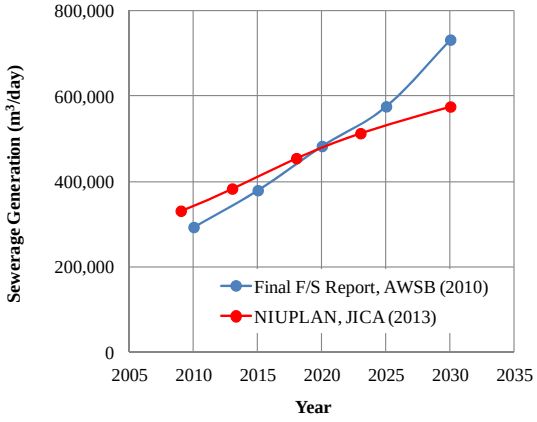
Final F/S Report	Year	2010	2015	2020	2025	2030
AWSB (2010)	Demand	366,418	474,199	603,493	719,529	914,812
NIUPLAN JICA (2013)	Year	2009	2013	2018	2023	2030
	Demand	414,000	479,000	568,000	641,000	719,000

Source: JICA Study Team (JST)

iii) Sewerage Generation

For the purpose of sewerage development planning, AWSB assumes that sewerage generation would be 80% of water demand. Accordingly, the Final Feasibility Study Report of NaRSIP estimated that the sewerage generation in Nairobi City would be 731,850 m^3/day in year 2030.

NIUPLAN estimates the sewerage generation in the same manner as above. The estimated sewerage generation is 575,200 m^3/day in year 2030.



Source: JICA Study Team (JST)

Figure 8.2.4 Comparison of Sewerage Generation Estimates

Table 8.2.3 Comparison of Sewerage Generation Estimates

Unit: m^3/day

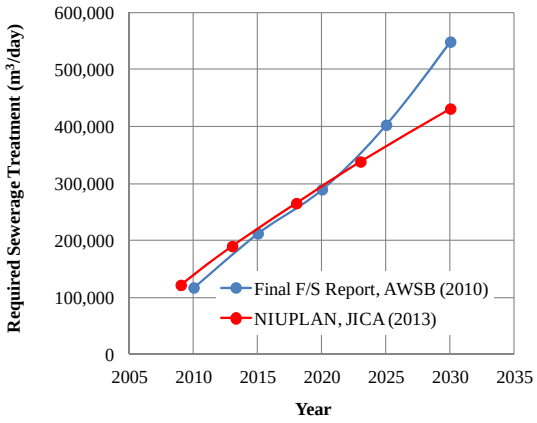
Final F/S Report	Year	2010	2015	2020	2025	2030
AWSB (2010)	Sewerage	293,134	379,359	482,794	575,623	731,850
NIUPLAN JICA (2013)	Year	2009	2013	2018	2023	2030
	Sewerage	331,200	383,200	454,400	512,800	575,200

Source: JICA Study Team (JST)

iv) Required Sewerage Treatment Capacity

In the Final Feasibility Study Report of NaRSIP, a service coverage rate of the existing sewerage system was estimated at 40% in year 2010 and assumed to increase up to 75% by year 2030. The required sewerage treatment capacity in year 2030 was estimated at 548,887 m^3/day accordingly.

NIUPLAN estimates the required sewerage treatment capacity in the same manner as above. The estimated sewerage generation is 431,400 m^3/day in year 2030.



Source: JICA Study Team (JST)

Figure 8.2.5 Comparison of Required Sewerage Treatment Capacity Estimates

Table 8.2.4 Comparison of Required Sewerage Treatment Estimates

Final F/S Report	Year	2010	2015	2020	2025	2030
AWSB (2010)	Coverage	40%	56%	60%	70%	75%
	Treatment	117,254	212,441	289,677	402,936	548,887
NIUPLAN JICA (2013)	Year	2009	2013	2018	2023	2030
	Coverage	37%	50%	58%	66%	75%
	Treatment	121,882	190,067	265,370	338,448	431,400

Source: JICA Study Team (JST)

v) Summary

The estimates of required sewerage treatment capacity in year 2030 are summarised below. Based on the socioeconomic framework prepared by NIUPLAN, results showed that the required sewerage treatment capacity is lower in comparison with the Final Feasibility Study Report of NaRSIP.

Table 8.2.5 Summary of Estimated Required Sewerage Treatment Capacity (2030)

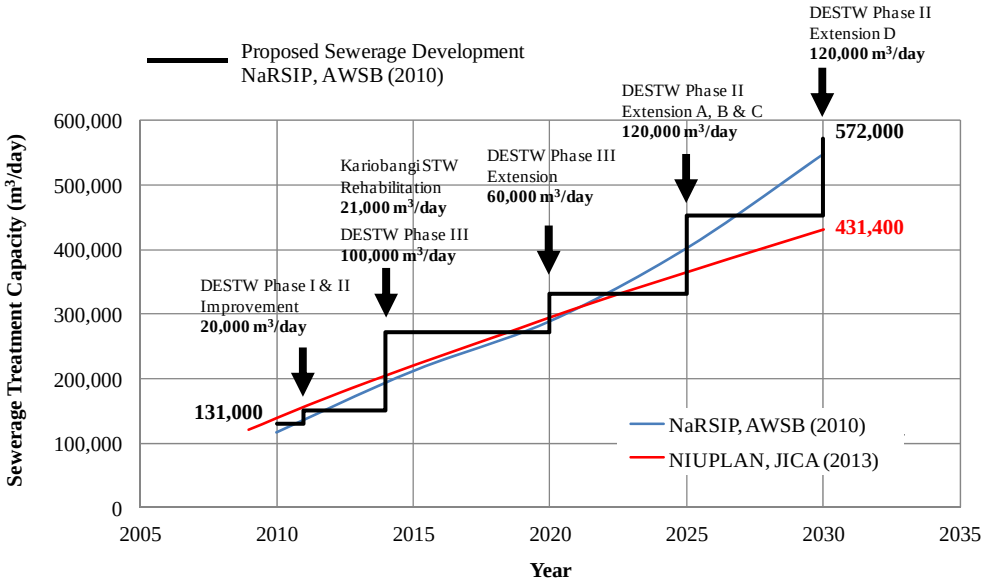
Planning Indicators	NaRSIP AWSB (2010)	NIUPLAN JICA (2013)	Remarks
(i) Population	6,352,396	5,212,500	
(ii) Water Demand, m^3/day	914,812	719,000	Excluding UFW
(iii) Sewerage Generation, m^3/day	731,850	575,200	80% of (ii)
(iv) Required Sewerage Treatment Capacity, m^3/day	548,887	431,400	75% of (iii)

Source: JICA Study Team (JST)

2) Development of Sewerage Treatment Works

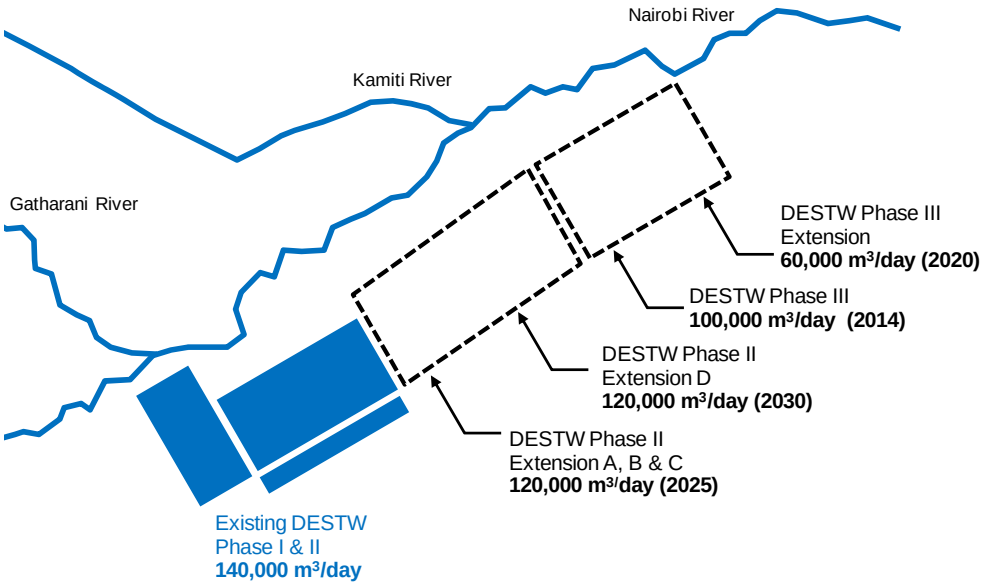
The Final Feasibility Study Report of NaRSIP describes the development of sewerage treatment works (STWs) toward year 2030. The total capacity of STWs is planned to be incremented from 131,000 m^3/day in 2010 to 572,000 m^3/day utilising the extension of the Dandora Estate STW (DESTW) and rehabilitation of the Kariobangi STW. The planned development of sewerage treatment capacity by 2030 is enough to meet the required sewerage treatment capacity of 431,400 m^3/day estimated by NIUPLAN.

Of the planned development of STWs, the improvement of DESTW Phase I and II was completed by the Water and Sanitation Service Improvement Project (WaSSIP). The NaRSIP includes the rehabilitation of Kariobangi STW and part of the development of DESTW Phase III.



Source: JICA Study Team (JST)

Figure 8.2.6 Development of Sewerage Treatment Works



Source: Nairobi City Water and Sewerage Company Limited (NCWSC)

Figure 8.2.7 Planned Development of the Dandora Estate STW

3) Development of Sewerage Collection and Conveyance System

The existing trunk sewers is 162.7 km long, and collect wastewater from the sewerage service areas of about 208 km^2, which accounts for approximately 40% of the total area covered by the water supply service.

The WaSSIP developed the trunk sewers with a total length of 81 km including Gatharaini Trunk Sewers (construction: 49 km), Lavington-Riruta Trunk Sewers (extension: 8 km), and Ngong Trunk Sewers (rehabilitation/reconstruction: 24 km).

The Final Feasibility Study Report of the NaRSIP describes the development of trunk sewers to cope with the sewerage collection and conveyance that will be required toward year 2030. The proposed development consists of the following 12 trunk sewers that were prioritised by the sewerage master plan in 1998 and also covers 40 km of reticulation lines (secondary sewers).

Table 8.2.6 Existing Trunk Sewers (Separated Sewers) in Nairobi City

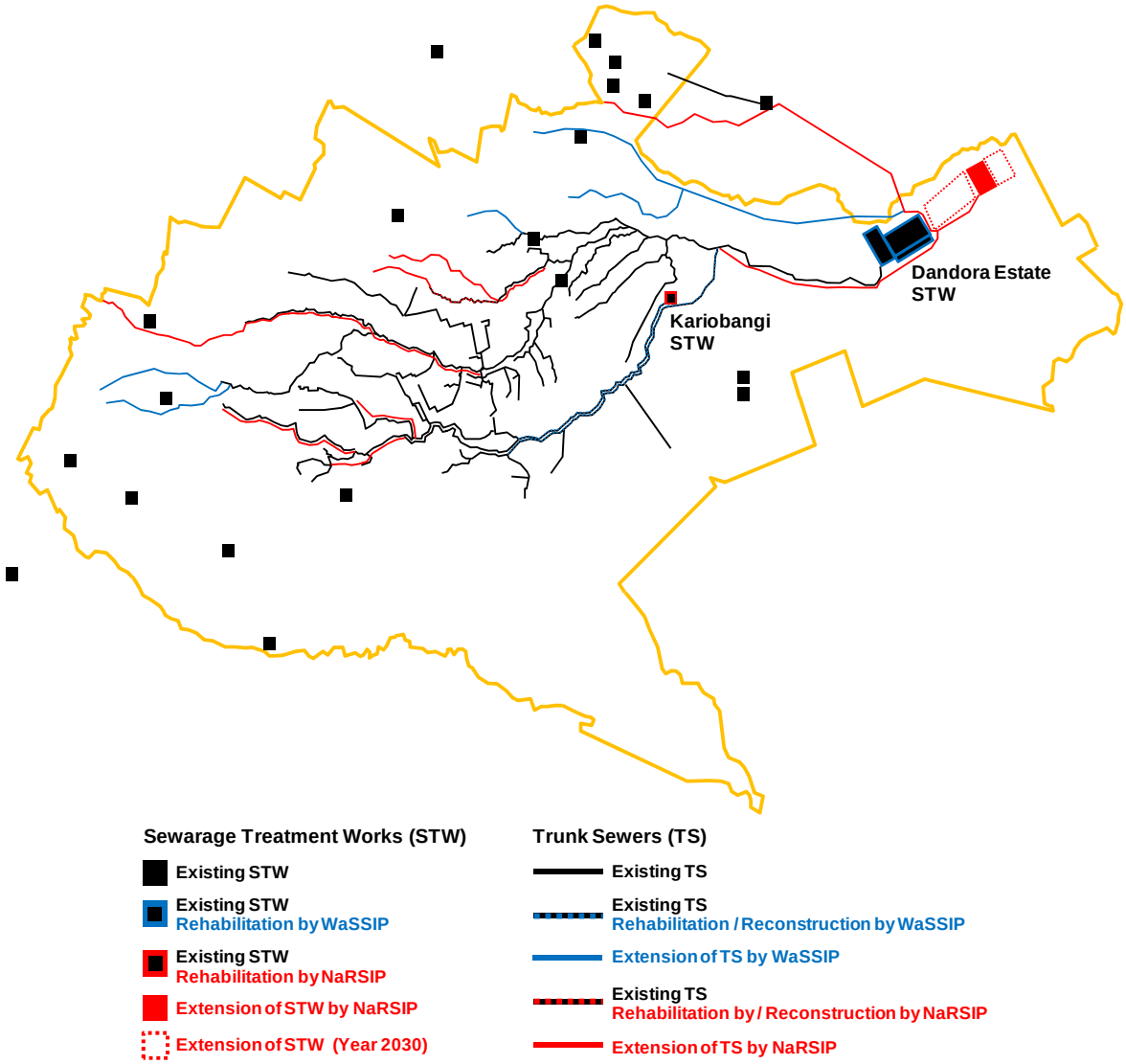
	Trunk Sewer	Length (km)
1	Dandora Estate	12.3
2	Kariobangi - Ruiruaka	4.6
3	Ngong River (several phases)	15.1
4	Mombasa - Enterprise road	3.5
5	Southern Outfall	5.0
6	Kayole Estate	2.3
7	Dandora Community Phase I	5.3
8	Dandora Community Phase II	4.3
9	Dandora Industrial Area	5.8
10	Ruiruaka	1.2
11	Gitathuru	1.2
12	Chiromo (several phases)	8.4
13	Kibera	5.2
14	Upper Hill	6.1
15	Karura	1.7
16	Kahawa West	3.0
17	Lavington & Bernard Estate	3.0
18	Uhuru Highway By-pass	2.6
19	Mathare River	3.2
20	Nairobi River (several phases)	15.7
21	Parklands - Eastleigh	3.1
22	Upper Parklands	0.8
23	Milimani	3.1
24	Others	46.2
	Total	162.7

Source: Final Feasibility Study Report of NaRSIP, AWSB (2010)

Table 8.2.7 Planned Development of Trunk Sewers under NaRSIP

	Trunk Sewer	**Length (km)**
1	Getathuru Trunk Sewer duplication	5.4
2	Mathare Trunk Sewer extension	3.5
3	Getathuru Trunk Sewer extension	4.0
4	Upper hill trunk sewer duplication	2.8
5	Dandora Estate Trunk Sewer duplication, Ngong River confluence to DESTW	7.5
6	South Nairobi Dam Trunk Sewer	2.6
7	Nairobi River Trunk Sewer duplication	4.3
8	Riruta North Trunk Sewer	1.7
9	Nairobi River Trunk Sewer Phase VIII extension up to Dagoretti Market	8.5
10	Kiu River Trunk Sewer	5.5
11	Riara River (Githurai) Trunk Sewer	2.4
12	Kiu River Outfall Trunk Sewer	5.8
	Total	54.0

Source: Final Feasibility Study Report of NaRSIP, AWSB (2010)



Source: Nairobi City Water and Sewerage Company Limited (NCWSC)

Figure 8.2.8 Existing and Planned Development of Trunk Sewers

4) Major Issues

i) Effluent Quality from Dandora Estate STW

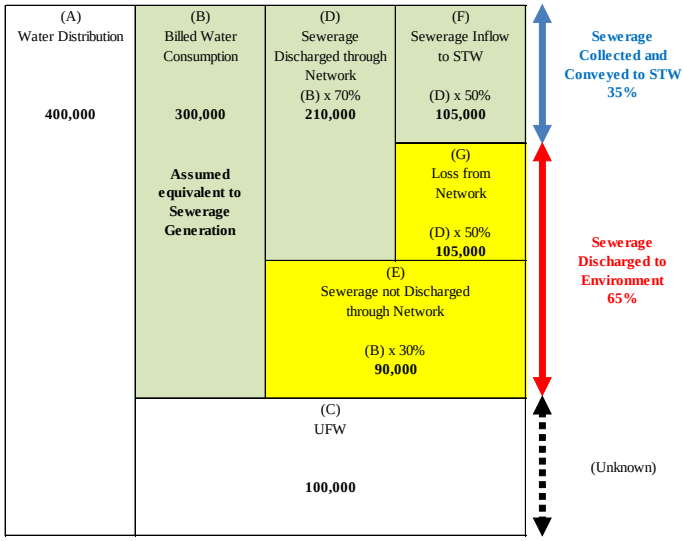
The development of STWs is planned to cope with the estimated sewerage generation in year 2030. Early stages of the development have already been implemented and/or on-going under WaSSIP and NaRSIP.

Most of the sewerage generated within Nairobi City is planned to be conveyed to and treated in the Dandora Estate STW. In the early stage of the development of STWs, the rehabilitation of the Dandora Estate STW was implemented under WaSSIP. However, the water quality data of the effluent from STW (for the period of July-September 2011) indicates that the values of biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS) do not meet the effluent standards of Kenya even after the completion of the rehabilitation works. During NIUPLAN, NCWSC reported that the effluent quality still remains unimproved for the period of April-June 2013.

It is presumed that some trouble still remains in the Dandora Estate STW even after the rehabilitation by WaSSIP. The cause of low treatment efficiency at the Dandora Estate STW should be investigated in pursuit of countermeasures to improve the effluent quality in order to meet the effluent standards of Kenya. Consequently, feedbacks from the investigation should be taken into account for operation and maintenance (O&M) and further sewerage development.

ii) Sewerage Collection and Conveyance

The available data suggests that the total water distribution in Nairobi City is around 400,000 m^3/day during the recent years. The billed water consumption was 295,597 m^3/day as of 2010/2011. The sum of the recorded sewerage inflows to the Dandora Estate STW and Kariobangi STW in 2010 was 102,803 m^3/day accounting for 35% of the billed water consumption. Assuming that the sewerage generation would be equivalent to the billed water consumption, the sewerage collection rate is approximately 35% (= 102,803 / 295,597).



Source: Prepared by the JICA Study Team (JST)

Figure 8.2.9 Estimate of Present Sewerage Generation, Collection and Conveyance

The NCWSC has around 240,000 of the water supply service connections and 170,000 of the sewerage service connections as of 2013. In terms of service connections, the service coverage rate of the sewerage system is approximately 70% (= 170,000 / 240,000).

From the above figures, the following points are identified regarding the sewerage collection and conveyance:

(i) Volume of sewerage collected and conveyed to STWs accounts for 35% of the sewerage generation and the remaining 65% are discharged to the environment without treatment.

(ii) 70% of the sewerage generated is collected once by the sewerage network but half of the volume is lost from the sewerage network.

(iii) 30% of the sewerage generated is not collected by the sewerage network and is discharged directly to the environment.

Assuming that the sewerage collection rate should be equivalent to the percentage of service coverage area as planned, the sewerage development will need to attain a sewerage collection rate of 75% by 2030. The sewerage collection rate should be improved with the rehabilitation and development of the sewerage network comprising trunk sewers, reticulation lines, and service connections accordingly. Effects of sewerage development (trunk sewers and reticulation lines) by WaSSIP and NaRSIP should be monitored continuously. And then feedbacks from the monitoring should be taken into account for O&M and further sewerage development.

8.2.2 Development Policy

The stormwater drainage in Nairobi City should be developed by integrating the river and localised drainage networks. Within the catchment area of the river, the development and maintenance of the river should be initially planned and implemented to ensure the required hydraulic capacity for the stormwater drainage as well as the riparian reserves in order to maintain better water environment. The localised drainage networks should be developed under these conditions given by the plan for the development and maintenance of the river.

The sewerage development is currently implemented to extend the capacity of treatment. Moreover, the sewerage system in Nairobi City needs to improve its performance in terms of effluent quality from STWs and sewerage collection/conveyance.

The comprehensive framework for water environment management in Nairobi City was elaborated by the former Nairobi River Basin Programme (NRBP) supported by the United Nations Environment Programme (UNEP) during the last decade. Under the said framework, the development of stormwater drainage and sewerage should be recognised as part of the subsequent activities being taken by the Nairobi Rivers Basin Rehabilitation and Restoration Programme. At present, the activities relevant to the water environment management in Nairobi City are taken by the initiatives of the government organisations in charge. For further enhancement of the activities, NCC should increase its involvements with such activities through its capacity development.

8.2.3 Priority Projects

(1) River Improvement Project

1) Objectives

The project aims at the following: (i) establishment of a river management master plan for integrating the river and localised drainage networks as a stormwater drainage system and; (ii) development of the river channels and riparian reserves to restore and maintain better water environment. The target areas are the river stretches and corresponding riparian areas of the Nairobi River and its major tributaries.

2) Descriptions

i) Phase-1: Preparation of the master plan and feasibility study,

(i) Longitudinal profile and cross section survey of river stretches,

(ii) Investigation of associated works (e.g., dikes, revetments, drainage outfalls, bridges, culverts, etc.) along the surveyed river stretches,

(iii) Estimates of stormwater runoff drained from catchment area to the river,

(iv) Analysis of hydraulic capacity required for each of the river stretches,

(v) Preparation of design discharge and water level for each of the river stretches,

(vi) Identification of the river stretches to be improved,

(vii) Delineation of riparian reserve to be secured,

(viii) Preliminary design of river training works, riparian reserves, and associated works including localised drainage networks,

(ix) Evaluation for justification of the works through cost-benefit analysis and social/environmental impact assessment, and

(x) Preparation of implementation plan for river training works, riparian reserves, and associated works including localised drainage networks.

ii) Phase-2: Detailed Design and Implementation

(i) Detailed surveys and investigations for the detailed design of the selected river stretches (e.g., topographic mapping, longitudinal profiles and cross sections, soils, utilities, associated works, resettlement requirements, etc.);

(ii) Detailed design of river training works, riparian reserves, and associated works including localised drainage networks;

(iii) Preparation of construction plan and cost estimates;

(iv) Preparation of O&M plan, environment management plan (EMP), and resettlement action plan (RAP);

(v) Preparation of tender documents;

(vi) Procurement; and

(vii) Implementation.

3) Implementation Arrangements

The regional office of WRMA will be the responsible organisation for implementing the project. Meanwhile, it is recommended that WRMA should focus on sharing the responsibility for the management of the rivers within Nairobi City to NCC in the future. Therefore, a project management unit (PMU) needs to be jointly organised by the representatives of WRMA and NCC.

The project will formulate the river management master plan for each of the Nairobi River and its major tributaries. The subsequent stormwater drainage developments in the individual subcatchment areas will need to be kept consistent with the river improvement master plan. Furthermore, the project will need to coordinate closely with the stormwater drainage master

plan that will be prepared under KMP for common understanding of the basic planning conditions amongst each other.

4) Outcomes/Benefits

The project will prepare a river management master plan to define clear guidelines for the systematic development of the stormwater drainage systems in different urban centres in Nairobi City. The development and maintenance of the river channels and riparian reserves will provide a basic framework to practice a series of activities for the betterment of the water environment.

(2) Sewerage Improvement Project

1) Objectives

The project aims at the following: (i) carrying out countermeasures to improve the effluent quality from the Dandora Estate STW to comply with the effluent standards of Kenya and; (ii) improving sewerage collection and conveyance through the sewerage network comprising trunk sewers, reticulation lines, and sewerage connections.

2) Descriptions

i) Phase-1: Preparation of Improvement Plan

(i) Monitoring and analysis of the sewerage treatment performance of the Dandora Estate STW to identify the needs for improvement;

(ii) Investigation and analysis of trunk sewers, reticulation lines, and sewerage connections to identify the needs for improvement;

(iii) Plan and design the improvements for the Dandora Estate STW;

(iv) Plan and design the improvements for trunk sewers, reticulation lines, and sewerage connections; and

(v) Preparation of the implementation plan including cost estimates and budgetary arrangement.

ii) Phase-2: Implementation

(vi) Implementation of the improvement for the Dandora Estate STW;

(vii) Implementation of the improvement for trunk sewers, reticulation lines, and sewerage connections;

(viii) Monitoring, review, and analysis of the sewerage treatment performance of the Dandora Estate STW;

(ix) Monitoring, review, and analysis of the sewerage collection and conveyance by the sewerage network comprising trunk sewers, reticulation lines, and sewerage connections; and

(x) Preparation of feedbacks for O&M and further sewerage development.

3) Implementation Arrangements

The AWSB will be the responsible organisation for implementing the project. Meanwhile, it is recommended that AWSB should focus on sharing the responsibility for managing the

sewerage system within Nairobi City to NCC in the future. Therefore, a PMU needs to be jointly organised with the representatives of AWSB and NCC. NCWSC as the operator of the sewerage system will also be essentially involved with the project management.

4) Outcomes/Benefits

The project will contribute to: (i) alleviating the water pollution in the Nairobi River and its tributaries through an increase in the sewerage collection and conveyance as well as improvement of the sewerage treatment performance to cope with the effluent standards of Kenya; and (ii) evolving further improvements of the sewerage system through feedbacks.

(3) Capacity Development Project for Water Environment Management

1) Objectives

The project consists of the following three components:

Component 1 – Water Environment Management, aims at supporting capacity development for NCC; (i) to establish an administrative framework for implementing the water environment management in Nairobi City; and (ii) to strengthen the administrative capability of the county departments to implement water environment management.

Component 2 – Storm Water Drainage Management, aims at supporting capacity development for the City Engineering Department; (i) to restore its administrative functions to maintain the stormwater drainage systems; (ii) to establish its administrative capability to manage the plan, design, and construction of stormwater drainage works within the catchment areas of the Nairobi River and its major tributaries in conformity with a river management master plan of the proposed river improvement project.

Component 3 – Sewerage Management, aims at supporting capacity development for the City Engineering Department; (i) to establish its administrative capability to manage the plan, design, construction, and O&M of the sewerage system; and (ii) to supervise NCWSC to carry out O&M of the sewerage system in order to ensure the improvements through the proposed Sewerage Improvement Project.

2) Descriptions

i) Component 1 – Water Environment Management

(i) Review of the actions to be taken by the county under the Nairobi Rivers Basin Rehabilitation and Restoration Programme and update the issues and approaches for implementing the water environment management in Nairobi City;

(ii) Study on the administrative system comprising the county's departments to perform their roles for water environment management;

(iii) Practices for operating the administrative system, e.g., water quality monitoring, regulation of industrial effluent, riparian reserve conservation and utilisation, and information, education, and communication (IEC) for creating social understandings; and

(iv) Review of outcomes from the practices and feedbacks.

ii) Component 2 – Stormwater Drainage Management

(i) Collection, review, and update of technical data (master plan, project documents, as-built drawings, etc.) for the maintenance of the existing stormwater drainage systems;

(ii) City Engineering Department to practice the maintenance of the existing stormwater drainage systems in the systematic approaches based on the technical data;

(iii) Organisational reform for the City Engineering Department to take the responsibility for managing the Nairobi River and its major tributaries and associated stormwater drainage systems in the individual subcatchment areas;

(iv) City Engineering Department to be involved in the proposed river improvement project to prepare the river management master plan for integrating the river and localised drainage networks and securing the riparian reserves; and

(v) Review, update, and application of design standards and specifications for the stormwater drainage works through O&M practices and feedbacks.

iii) Component 3 – Sewerage Management

(i) Organisational reform for the City Engineering Department to take the responsibility for the administrative management of plan, design, construction, and O&M of the sewerage system in Nairobi City;

(ii) City Engineering Department to be involved in the proposed sewerage improvement project to improve the performance of the sewerage system;

(iii) City Engineering Department to supervise NCWSC to practice O&M methods applied resulting from the sewerage improvement project and feedbacks; and

(iv) Review, update, and application of design standards and specifications for the sewerage works through O&M practices and feedbacks.

3) Implementation Arrangements

The NCC will be the responsible organisation for implementing the project with the support from relevant organisations including Ministry of Environment and Mineral Resources (MEMR), National Environmental Management Authority (NEMA), WRMA, Road Authorities, AWSB, and NCWSC. Because the project will include technical, organisational, and institutional subjects to be coordinated with different organisations, the council will need to organise a project coordination committee with the representatives of the council and relevant organisations.

In preparing the project, further details on stakeholder coordination should be discussed in conformity with the comprehensive framework for water environment management under the Nairobi Rivers Rehabilitation and Restoration Programme.

4) Outcomes/Benefits

The administrative system for water environment management will be clearly defined and activated under the responsibility of NCC. The council's departments will be able to activate their respective roles for the betterment of the water environment as envisaged by the Nairobi Rivers Rehabilitation and Restoration Programme. The City Engineering Department will be able to take the initiatives in managing the stormwater drainage and sewerage in Nairobi City through its involvement in the proposed projects.

8.3 Power Supply

8.3.1 Demand and Gap Analysis

(1) Power Demand Forecast

The existing power demand forecast described in Section 4.1.7 is based on the Updated Least Cost Power Development Plan Study Period: 2011-2031 (LCPDP). JST reviewed the GDP growth rate and the future population, and reviewed the demand forecast using the GDP growth rate and future population projected by NIUPLAN in order to study appropriate demand forecast. The demand forecast by NIUPLAN will be called the project demand forecast (PDF).

The PDF will follow the method of projection by LCPDP. According to the structure of LCPDP, first of all, the power demand forecast of Kenya will be calculated. Secondly, the power demand forecast of NCC will be examined. The sequence in calculating PDF is as follows:

(i) Calculate the rate of power demand at 7% GDP growth rate each year from the power demand at 8% GDP growth rate (low scenario), 9% (reference scenario), and 10% (high scenario) in LCPDP,
(ii) Calculate the power demand of Kenya by 2030 from the demand of Kenya at the first year and the rate of power demand calculated above,
(iii) Estimate the rate of population number of the PDF in Kenya to LCPDP,
(iv) Calculate the PDF of Kenya from the ratio of (iii) and power demand of (ii),
(v) Calculate the proportion of power demand of NCC to Kenya in order to seek the PDF of NCC, and
(vi) Grasp the PDF of NCC from the proportion calculated in (v) and the PDF of Kenya calculated in (iv).

The following description evaluates the concrete value of the PDF of Kenya and of NCC:

1) Power Demand Forecast for Kenya

The PDF of LCPDP has three scenarios, namely, high scenario, reference scenario, and low scenario. The difference of the three scenarios is due to the difference of the GDP growth rate. For example, high scenario is 10% as the GDP growth rate in 2030. This is because Kenya Vision 2030 assumes the GDP growth rate at 10% by 2030 and high scenario adopts the GDP growth rate of Kenya Vision 2030. Reference scenario's and low scenario's GDP growth rate are 9% and 8%, respectively, based on high scenario. On the other hand, NIUPLAN sets GDP growth rate at 7% as discussed in Section 6.3.3, therefore, PDF adopts 7% as GDP growth rate.

Regarding population, the existing demand forecast assumes that the population will increase to 60.5 million by 2030 in reference to the Kenya Vision 2030 and all scenarios assume this population. While the project sets the future population as 65.6 million as discussed in Section 6.1.1, PDF assumes the population to be 65.6 million by 2030.

Table 8.3.1 and Figure 8.3.1 show the PDF by 2030 with using the GDP growth rate and the future population forecast assumed by JST. From the figure, it is confirmed that PDF is always the lowest in the scenarios. The table also shows 9,343 MW as the value of PDF in 2030 is less than 70% of 15,026 MW as the reference scenario's value.

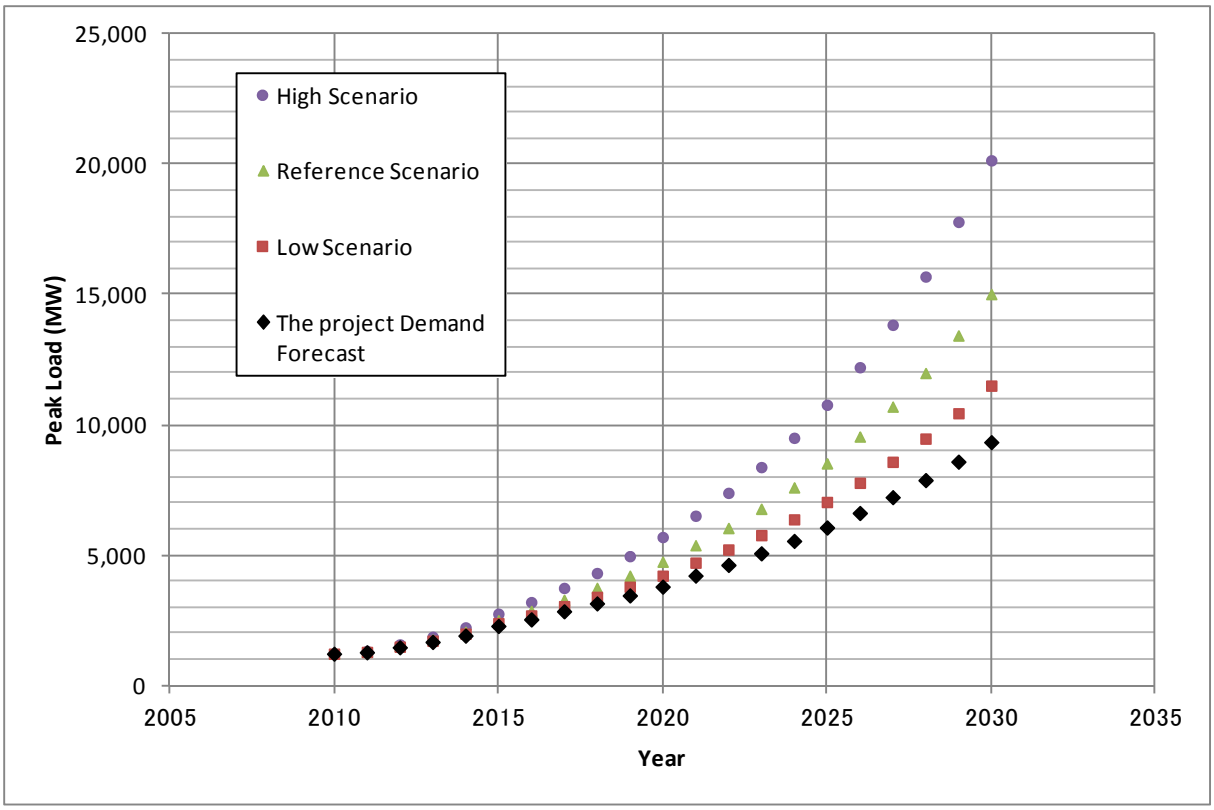
The result is due to following reasons: Regarding the assumption of future population, the values of NIUPLAN forecast are larger than the LCPDP forecast. The proportion of the population in the Project forecast to LCPDP forecast is 8.4% larger. This result brings PDF to a higher figure. However, regarding the assumption of GDP growth rate, the Project forecast is the lowest in all scenarios. The proportion of GDP growth rate in the Project forecast (7%) to

low scenario (8%) is 12.5% lower. This result effectively brings PDF to a lower figure. Therefore, even the assumption of future population of the Project forecast is higher than the LCPDP forecast, PDF becomes lower because of the low rate of GDP growth.

Table 8.3.1 Demand Forecast of Kenya by 2030

YEAR	Project Demand Forecast	Low Scenario	Reference Scenario	High Scenario
	MW			
2010	**1,227**	1,227	1,227	1,227
2015	**2,292**	2,398	2,511	2,760
2020	**3,800**	4,220	4,755	5,703
2025	**6,069**	7,050	8,528	10,778
2030	**9,343**	11,510	15,026	20,156

Source: JICA Study Team (JST)



Source: JICA Study Team (JST)

Figure 8.3.1 Demand Forecast of Kenya by 2030

2) Demand Forecast of NCC

The LCPDP also forecasts the power demand of NCC as indicated in Table 8.3.2. The table shows the demand forecast of NCC and Kenya. However, the numbers of Kenya in the table below is different from the previous numbers of Kenya shown in Table 8.3.1. This is because the approach to the demands is different. The previous data is calculated based on a model simulation but the latter data is based on the section of the transmission line network project in LCPDP. Yet the power demand of NCC is described only in the latter data, therefore, the latter data will be used as the existing power demand of NCC.

Table 8.3.2 Existing Demand Forecast of LCPDP

Region	Year	2015	2020	2025	2030
Nairobi	(MW)	1,241	2,214	3,726	5,996
Kenya		2,386	4,519	8,102	14,273
Demand Ratio of Nairobi to Kenya		52%	49%	46%	42%

Source: LCPDP

In order to calculate the PDF of Nairobi City, first of all, the ratio of NCC demand to Kenya demand as existing data will be calculated. Table 8.3.3 below describes the demand forecast ratio of NCC to Kenya, so the PDF adopts the ratio in the table. From the table, it is confirmed that the ratio is decreasing as time advances. This is because LCPDP assumes lower demand growth of NCC compared with other regions in the longer term.

As already discussed, the PDF of Kenya has been assumed. Therefore, it is possible to calculate the PDF of NCC by utilising the PDF of Kenya and the ratio of NCC demand to Kenya demand. As a result of calculation, the PDF of NCC is shown in Table 8.3.3 and Figure 8.3.2.

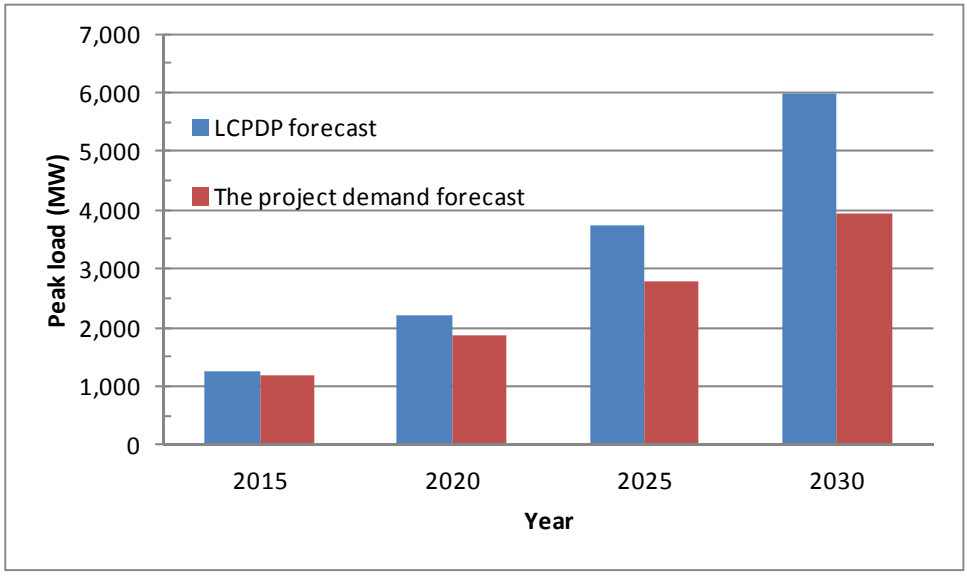
Table 8.3.3 shows the PDF of Nairobi City and Kenya. As a result, the PDF assumes approximately 4,000 MW of demand in Nairobi City by 2030. The maximum demand of Nairobi City in 2011/12 was 662 MW, so the demand in 2030 is expected to increase six times as compared with the demand in 2011/12.

Table 8.3.3 Project Demand Forecast of NCC and Kenya

Region	Year	2015	2020	2025	2030
Nairobi City	(MW)	**1,192**	**1,862**	**2,791**	**3,925**
Kenya		2,292	3,800	6,069	9,343

Source: JICA Study Team (JST)

Moreover, the following chart describes the demand forecast of NCC. One is the existing data from LCPDP and the other is from the Project forecast. From the chart, PDF is lower than the LCPDP forecast at any time. The Project forecast of NCC is assumed to be two-thirds of the LCPDP forecast by 2030.



Source: JICA Study Team (JST)

Figure 8.3.2 Demand Forecast of NCC Compared with the Project and LCPDP

According to the above consideration, the PDF of NCC and Kenya is assumed to be less than the current power sector forecast. The demand of NCC in 2030 is estimated to be 4,000 MW

and the number equals to two-thirds of the LCPDP forecast. The main reason for this is that the GDP growth rate of the Project is lower than the LCPDP assumption.

By the way, NCC and the infrastructure sectors hope for the realisation of electric trains. Although some trains are running as commuter train, the trains in NCC are operated using diesel locomotives. In addition, the priority project of railway does not consider adopting the electric railroad system in the immediate future. Diesel locomotives do not consume electricity, so there is no need to consider the electric requirement for railway at the current situation.

Moreover, at present, the new building is supposed to have solar water heating system under certain conditions due to the Energy Act published in 2012. This is one of the provisions to suppress electricity demand. Like this example, if regulations to restrain electricity demand become effective, it will contribute to the taming of the sharp increase in electricity demand.

The recommendation to the power sector, therefore, is to review the demand projection with the setting of the GDP growth rate and future population forecast. It may be important to ensure adequate power equipment, but excess forecast may lead to excess construction of power equipment, which would result to the increase in electricity cost.

(2) Development of Land around the Dandora Railway Station

The JST proposes the Dandora Railway Station area to be one of sub-centres to supplement the present central business district (CBD). Figure 8.3.3 below shows the land around the Dandora Station with some pictures of the site. The orange lines show the roads and the yellow belts show the power line areas. From this figure, the power lines occupy quite sizable areas. Picture No. 1 and No. 2 show 132 kV transmission lines and picture no. 3 shows five 66 kV transmission lines and one 11 kV distribution line. This area is the sub-centre for NIUPLAN, so the land of power line needs to be effectively utilised. Regarding the problem on land use, the following two measures are considered: 1) reviewing regulations, and 2) laying underground.

Source: JICA Study Team (JST)

Figure 8.3.3 Land around the Dandora Railway Station

1) Reviewing Regulation

Reviewing the regulation concerning transmission lines could be one of the solutions for using land effectively. Figure 8.3.3 shows the pictures of the 132 kV transmission line shown as No. 1 and No. 2. From these pictures, the ample vacant land is spread around the transmission line. Therefore, if the regulation changes, it may be possible to use the land for buildings or houses. Concerning regulation, the contention is divided into two points, i.e., wayleaves and minimum clearance.

First, consideration of the regulation focuses on the wayleaves. Wayleaves are defined by Kenya Power as follows:

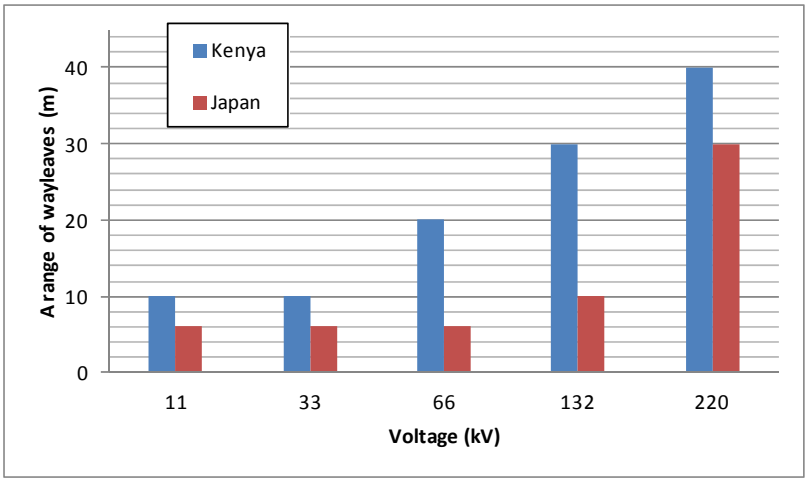
8.1 WHAT IS WAYLEAVES?

Definition
It is an easement or rights of way (ROW) which gives the right of use or restricts the use of land of another in a way that benefits other people other than the owner of the land. Other than KPLC, rights of way are also established for railways, roads, airways, pipelines.

Source: Design Standards and Guidelines (Kenya Power and Lighting Company)

Figure 8.3.4 Definition of Wayleaves

It seems that the range of wayleaves in Kenya are too large. Figure 8.3.5 shows the comparative chart of Kenya and Japan, showing the range of wayleaves from 11 kV to 220 kV. Apparently, in all the ranges, the wayleaves of Kenya are higher than that of Japan. In more detail, 11 kV and 33 kV of a range of wayleaves is of the same distance as 10 m. However, a range of wayleaves that is more than 33 kV increases as the voltage increases and finally, a range is 40 m at 220 kV. On the other hand, Japan's regulation reaches 30 m at 220 kV. Particularly, the difference of Kenya and Japan at 132 kV is as large as 20 m, so it can be said that a range of wayleaves in Kenya is wide, and may need to be reviewed.

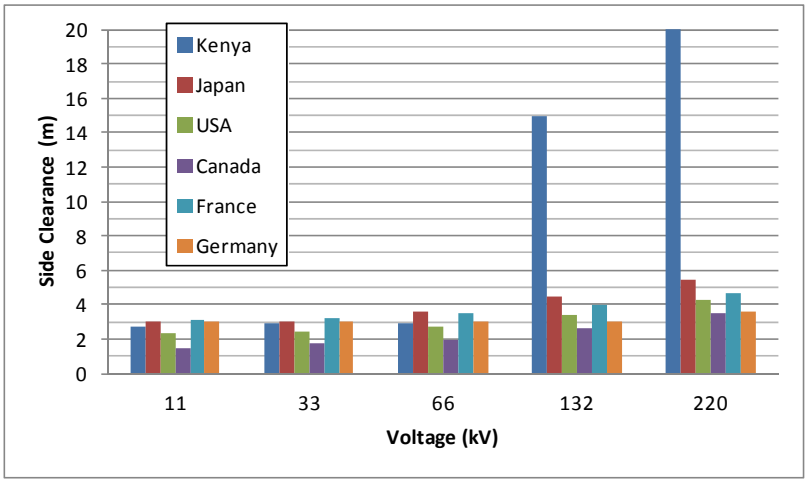


Source: JICA Study Team (JST) based on the following documents:
Wayleaves trace for power lines (Kenya Power),
Kenya Electricity Expansion Project (EASP)-KPLC Distribution Component (Kenya Power),
The Survey on the Transition from Overhead Line to Underground Cable 2010 (Geo-space Engineering Center).

Figure 8.3.5 Comparison of Wayleaves between Kenya and Japan

The second point is the minimum clearance. Minimum clearance is the distance from the overhead lines to buildings, trees, and vegetation. Especially, the side clearance from the overhead lines to buildings is discussed here. The comparison of minimum side clearance is

shown in Figure 8.3.6 below. The side clearance of 66 kV or less in Kenya is almost the same as that of other countries, yet the requirement in Kenya over 66 kV is much higher than that of other countries. As a result, minimum clearance over 132 kV of Kenya might also be large.



Source: JICA Study Team (JST) based on the following documents:
Design Standards and Guidelines (Kenya Power)
Wayleaves Trace for Power Lines (Kenya Power),
Clearance of Transmission Line over 170 kV
(Japan Electrotechnical Standards and Codes Committee)

* Side clearance of Kenya 132 kV and over is the distance from center of wayleaves, while the others assume the distance from the edge of wires.
* Side clearance of Kenya 132 kV and over is based on "Wayleaves Trace for Power Lines" as a result of hearing from an official of Kenya Power.

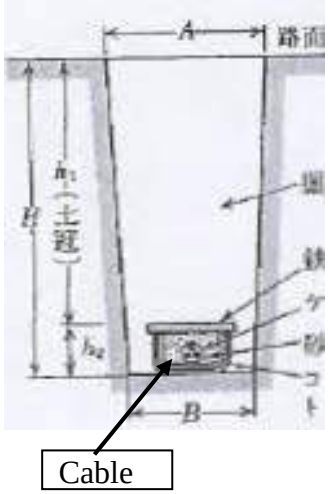
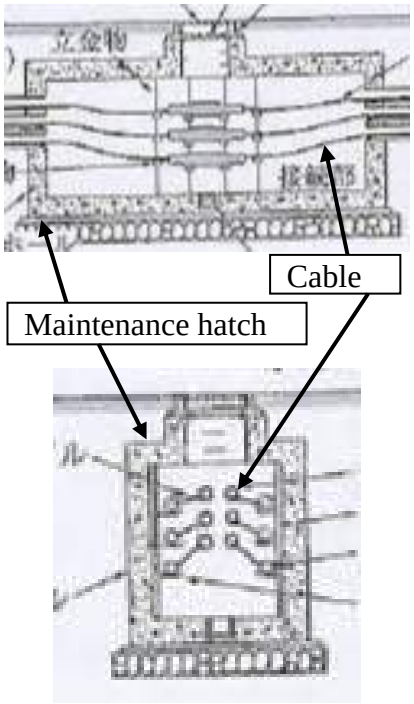
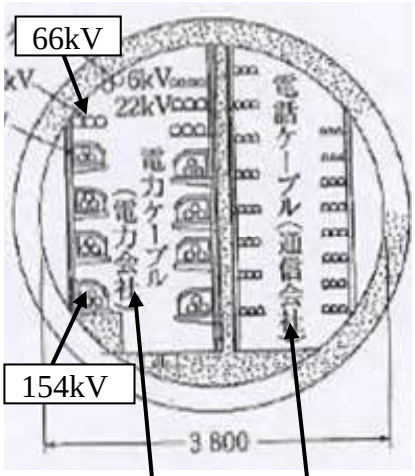
Figure 8.3.6 Comparison of Side Clearance

According to these examinations, there might be opportunities to review the regulations concerning transmission lines, which could lead to increase of usable lands along the transmission lines. This could be advantageous for NCC as well as for Kenya Power. Therefore, it is recommended to review regulations.

2) Developing Underground Cable

Another method for effective use of land along the transmission lines is to adopt underground cables. By laying cables underground, overhead lines can be removed and the land after removal can be used for other purposes such as commercial facilities or for industry area.

Table 8.3.4 Features of Underground Cable

Direct Buried System	Duct System	Common Duct
		
Low cost	High cost	Very high cost
Disadvantageous for addition and removal of cables	Possible for addition and removal of cables	Advantageous for many cables
Disadvantageous for maintenance	Advantageous for maintenance	Advantageous especially for maintenance

Source: Transmission and Distribution Engineering (Denki-gakkai)

The underground cable is divided into three types, namely, direct buried system, duct system, and common duct system. The features of the underground cables are shown in Table 8.3.4 above. Direct buried system is common in Kenya, as it can be constructed at a low cost. However, additional cables and maintenance for cables are troublesome, posing a disadvantage. Furthermore, it may incur high cost for the duct system but additional cables and maintenance are easier than direct buried system. The common duct is the most expensive method, but the system can offer easy maintenance and easy addition of cables. Moreover, the common duct system is shared by some other sectors such as the telecommunications sector and road sector. Consequently, even the cables for street lighting or communication cables can be kept in the same duct.

According to an official of Kenya Power, the area which is shown in picture No. 3 along Kangundo Road in Figure 8.3.3 seems to have a plan to install more overhead lines in the future. Under such circumstances, the duct system or common duct is suitable for the area because these two ways have the opportunities to install additional cables after construction.

(3) Information Sharing of Map

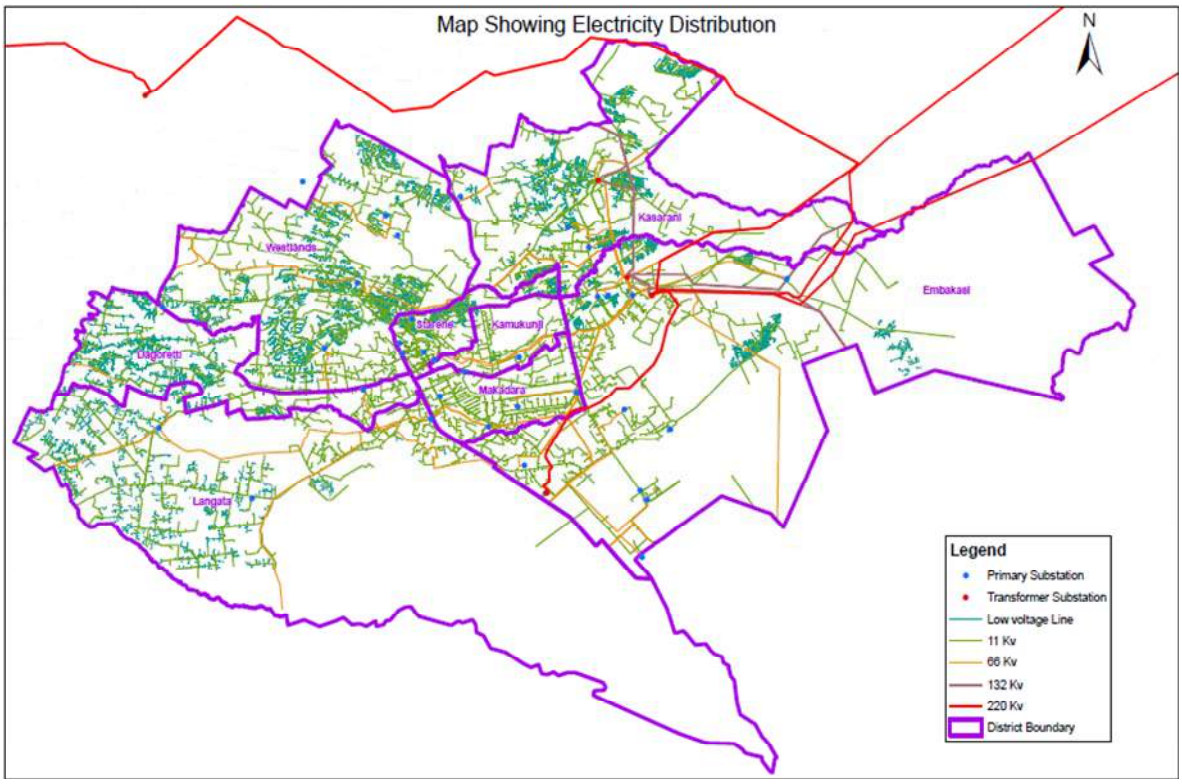
In the Technical Working Group (TWG), NCC requested for the geographic information system (GIS) data from the power sector because NCC needed the information on the location of the power equipment in order to make the land use plan. On the other hand, Kenya Power also wants to obtain other sector's mapping data because underground cables are related to the facilities of other sectors such as telecommunications, water, drainage, and gas. From the TWG discussions, it was noted that

the mapping information of all sectors seems to be useful for NCC and other sectors, so it may be necessary to share mapping data.

Figure 8.3.7 is the GIS data based on the data owned by Kenya Power. The figure shows transmission lines, low voltage lines, and substations. From this figure, it seems that Kenya Power manages the GIS data without any problem.

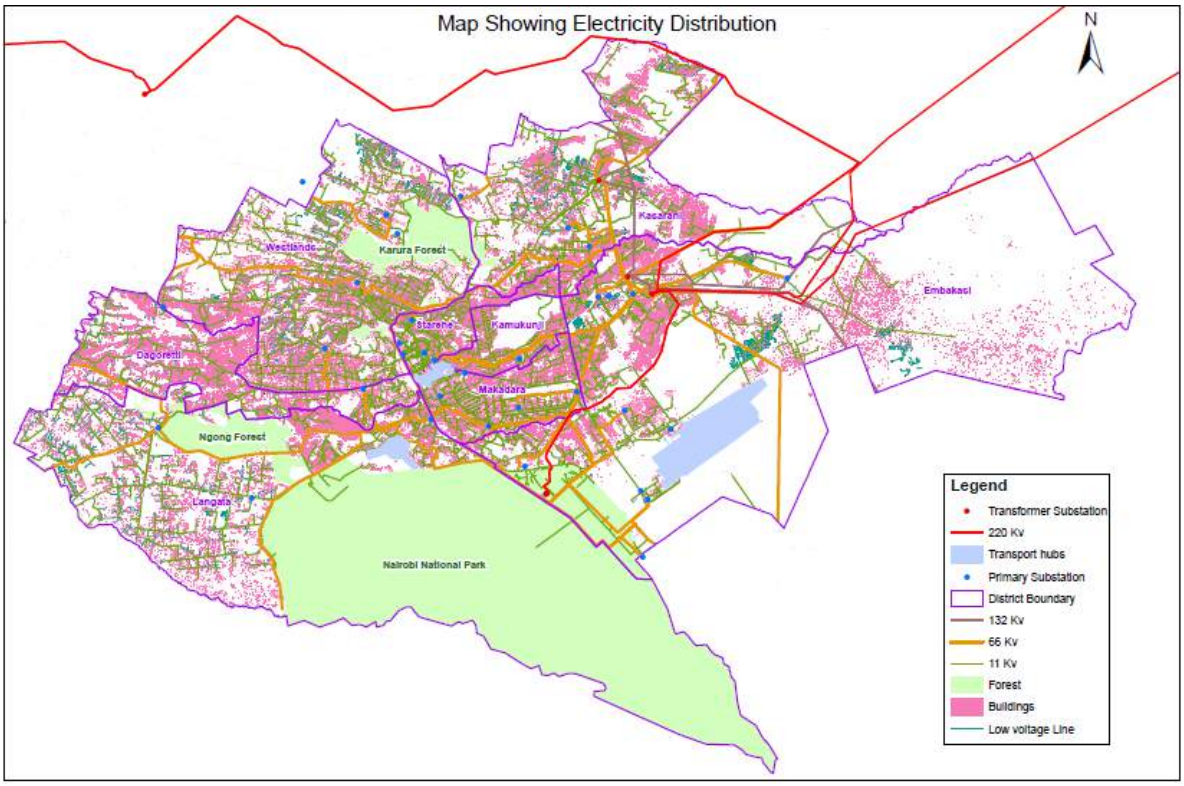
Moreover, Figure 8.3.8 is the data which adds buildings and transport hubs to Figure 8.3.7. However, these added data are used as data of JST, because the data of JST is more precise than that of Kenya Power. From this viewpoint, it is profitable for Kenya Power to share the land data.

As an example, paying attention to Embakasi, which is shown in the right side of Figure 8.3.8, it can be seen that there are buildings, but it seems that there are no 11 kV lines and low voltage lines in the area. To confirm this point, Figure 8.3.9 describes the power facilities on the satellite image. In the said figure, the 11 kV line shown in orange colour is running from the left side but stops at the centre of the figure. As another example, the red lines which represent low voltage lines can be seen in the left part of the the figure, but there are no red lines in other areas. On the other hand, it is no wonder that these buildings can utilise electricity. Therefore, the GIS data is thought to be uncompleted yet.



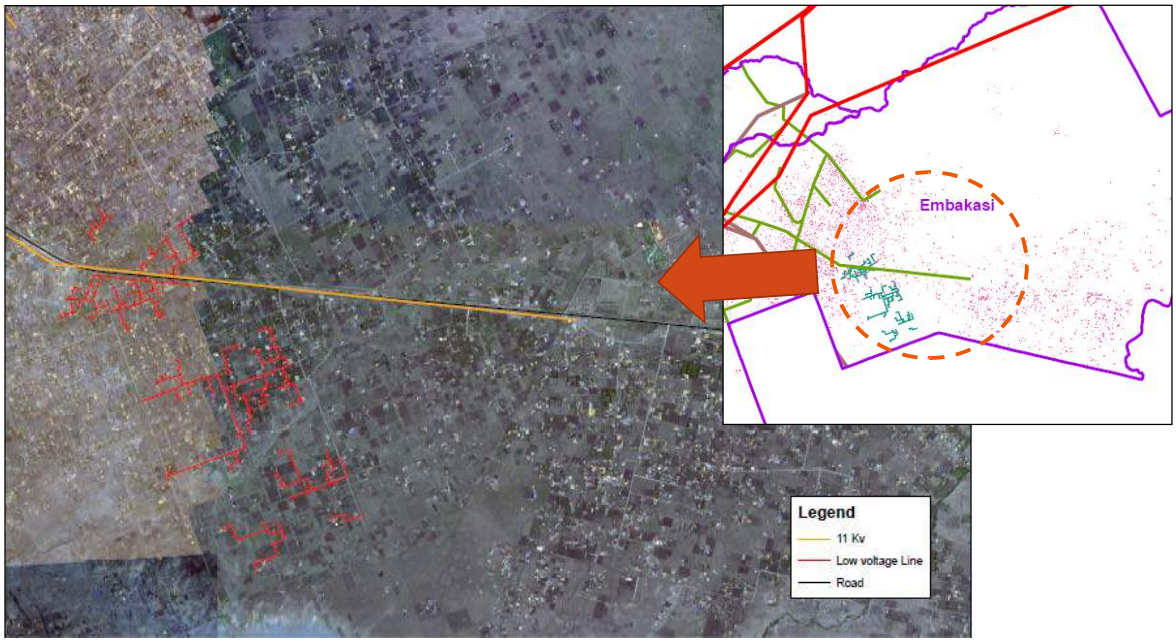
Source: JICA Study Team (JST) based on Kenya Power

Figure 8.3.7 GIS Data of Kenya Power



Source: JICA Study Team (JST)

Figure 8.3.8 Combination of GIS Data of Kenya Power and JST



Source: JICA Study Team (JST)

Figure 8.3.9 Data of Power Facilities in Embakasi

From this, it is required to forward the GIS data to Kenya Power. According to an official of Kenya Power, progress has been seen in the current GIS data, and continuous updating work is expected. Besides, the current GIS data has no underground information, so the information is recommended to be added to GIS.

(4) Gas Distribution for Buildings

Liquefied petroleum gas (LPG) which is a product of fractional distillation of crude oil has wide and increasing domestic and commercial use in Nairobi City. Various oil companies have facilities where they fill the LPG into gas cylinders of 6 kg, 13 kg, 25 kg, and 50 kg which are sold to consumers.

In Kenya, there are no gas pipelines for distributing gas to household and commercial premises. When gas is exhausted in the cylinders, the consumers exchange the empty cylinders with filled ones at a cost. Even though consumers do not bring cylinders to a facility for filling gas, a person from the oil company comes to the consumer's house or shop and exchange empty cylinders with full cylinders. The average cost for refilling 6 kg and 13 kg cylinders is KSh1,200 and KSh2,500, respectively. The various oil companies have different retail names for their LPG products like TotalGaz, K Gas, Hashi Gas.

Taking into account this condition, NCC and the infrastructure sectors discussed the problem and hoped to realise the construction of distribution pipelines to eliminate use of gas cylinders. In Kenya there are more than ten oil companies that sell LPG to customers, and it does not seem easy to implement the distributed pipeline in NCC. If the pipelines will be constructed by development partners such as WB or JICA for a particular gas company to utilise, it would be unfair for other companies. Because of the competition amongst gas companies, constructing the pipelines does not seem to be an easy task for NCC.

8.3.2 Development Policy

From the demand and gap analysis, two points are set for development policy of the power sector, i.e., appropriate planning for the energy sector and development based on the concept of sub-centres.

(1) Appropriate Planning for the Energy Sector

This is the policy for effective and appropriate planning, not to plan with excess design. From the previous section, there seems to be excessive capacity in planning and design. For example, according to the analysis of demand forecast, the existing demand forecast is substantially higher than the PDF. As another example, the wayleaves and minimum clearance of overhead lines are higher than the regulation of other countries. Therefore, appropriate planning is needed for the current energy sector.

(2) Development based on the Concept of Sub-centres

The main overall objective of NIUPLAN is to implement sustainable urban development and the improvement of living conditions in Nairobi City. Hence, the energy sector needs to assist partly in this objective. For example, as already mentioned, the Dandora area can be the place to be assisted by the power sector. Although there is much area of power-line wayleaves in Dandora under the current condition, this area is assumed to become sub-centres. Therefore, effective use of the lands currently used for power lines may be considered.

8.3.3 Priority Projects

As the priority project, the following table can be listed.

Table 8.3.5 Priority Projects

Priority	Project	Estimated Cost	Implementing Organisation	Possible Funding Source
1st	Amendment for Technical Criteria of the Overhead Line	US$0.5 million	Kenya Power	ODA (Technical Cooperation)
2nd	Reviewing the LCPDP	US$0.5 million	Energy Regulatory Commission	ODA (Technical Cooperation)
3rd	Development of the System for Map Information Sharing	Refer to Section 9.4.2 Management Proposal of GIS Data		
4th	Development of Underground Cable in Dandora Area	US$10 million	NCC	ODA Loan
5th	Power Supply for Dandora Industrial Area	US$5 million	NCC	ODA Loan

Source: JICA Study Team (JST)

The first, second, and third projects are for appropriate planning for the energy sector in line with the development policy. The rest of the projects are for development based on the concept of sub-centres. These projects are set as priority projects of the power sector and the following explains the detail:

(1) Amendment for Technical Criteria of the Overhead Line

As first priority project, the Amendment for Technical Criteria of the Overhead Line" needs to be executed. This project will review the current wayleaves regulation and current minimum clearance for overhead line. The background for the project is mainly for the following four accounts:

(i) First account is that a range of wayleaves in Kenya seems excessive. Comparing the range of wayleaves in Kenya with that of Japan, the wayleaves in Kenya are larger than the Japanese range of wayleaves. Moreover, the range of wayleaves, where it is assumed that steel towers and power poles have collapsed, have not been previously reviewed;

(ii) Next point is the minimum clearance. Minimum clearance over 132 kV from electrical wires to buildings is much larger than other countries. Thus, there is still a necessity to review the regulation;

(iii) NCC is expected to develop or utilise their land more effectively in the future. As the economy of NCC grows steadily, the land within NCC is much needed for housing units, offices, and commercial facilities; and

(iv) If the land for overhead line is reduced, the cost to an electric power company might be reduced and might possibly decrease electricity tariff for consumers.

The project has two objectives. One is to reduce the cost of wayleaves for an electrical power company and the other is to reduce the land of overhead line, so that the land could be used more effectively for NCC. The project is assumed to be carried out in consideration of the following viewpoints:

(i) The technical criteria may be revised in consideration of construction techniques, quality of electrical power equipment, and safety; and

(ii) The project will review the criteria of Kenya in comparison with other country's technical criteria. From the comparison and investigation, the criteria of Kenya may be revised.

Source: JICA Study Team (JST)

Figure 8.3.10 Current Wayleaves of Transmission Lines

(2) Reviewing the LCPDP

Review of LCPDP is proposed for the future project.

In Section 4.6.1, the LCPDP was referred to in relation to electrical demand. The chapter concluded that review of the GDP growth rate and future population forecast are recommended. Hence, if the power sector of Kenya has the ability to review LCPDP without an external consultant to help, this project is not needed. If they need external consulting services, the proposed project should be required. Actually, LCPDP was made by the power sector of Kenya together with the AFD assistance. Therefore, it is possible to require the consulting services for revising LCPDP.

Source: Energy Regulatory Commission

Figure 8.3.11 The Latest LCPDP

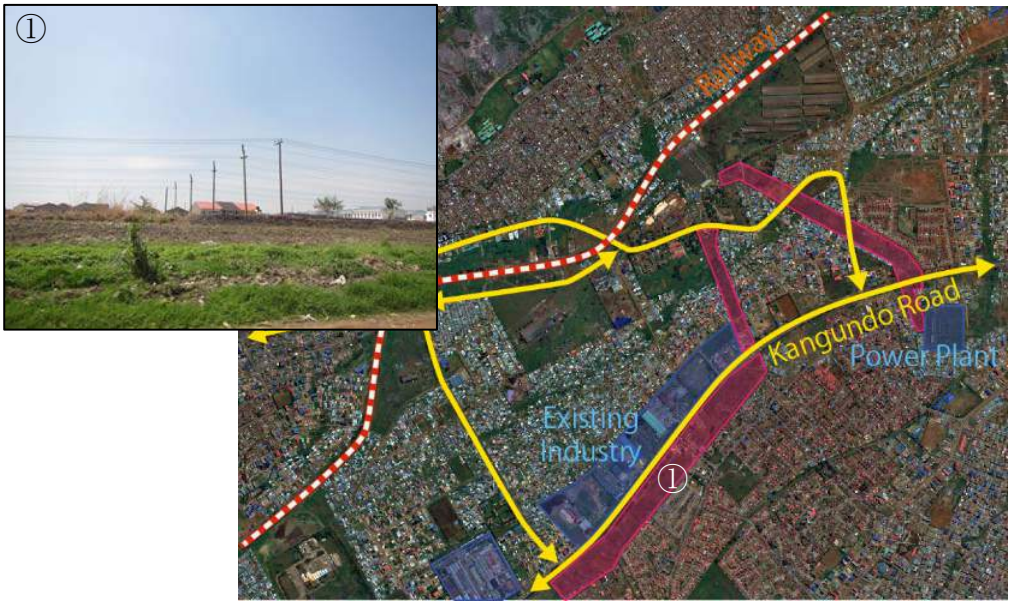
(3) Development of the System for Map Information Sharing

As the third priority project, it may be needed to develop the system for map information sharing with NCC, Kenya Power, and other infrastructure sectors. Information sharing of map was discussed by using GIS in Section 4.6.1. As a result of the discussion, it was clear that much data of actual situation has been reflected in the GIS by Kenya Power.

However, there are some problems in sharing map data. The main point of the problem is what kind of data is needed for other sectors such as NCC and the infrastructure sectors. Although the information of underground cable is needed for those sectors at least, they do not grasp each other's' requirements for mapping. Therefore, first of all, it may be important to understand the requirement of other concerned parties. Second, construct a system of information sharing. There is no circumstance to share GIS at the current condition, and if this project starts, building the system of map sharing may be needed from scratch.

(4) Development of Underground Cable in Dandora Area

The next priority project is the development of underground cables in Dandora area, which is one of the proposed sub-centres. As mentioned earlier, the Dandora area has more than 30 ha of land used for power line wayleaves and the development concept of sub-centres demands the utilisation of the wayleaves. From this view point, installation of underground cables can be considered as a practical option. Specifically, the area along Kangundo Road with a length of 2 km, which is shown in Figure 8.3.12, can be proposed for underground cables.



Source : JICA Study Team (JST)

Figure 8.3.12 Proposed Industry Area along Kangundo Road in Dandora

In order to implement the project, the following three points need to be considered:

(i) Firstly, there will be a need to decide who should bear the costs for the construction of the underground cables. The existing overhead lines are Kenya Power's property, but Kenya Power does not need to replace the overhead lines with underground cables. On the other hand, NCC hopes that Kenya Power will replace them. Therefore, there is a need to establish which part should be shouldered by NCC or Kenya Power. Furthermore, a scheme with a third party is also conceivable;

(ii) The second point is to define the concrete construction area in Dandora. The purpose of the construction of underground cables is to utilise the vacant land after the overhead line. Thus, before discussing underground cables, first, there is a need to define which area is industrialised; and

(iii) The third point is to study the type of underground cable. Although Subsection 4.6.1 introduced three types of underground cables, each type should be studied considering technical aspects, costs, and operation, etc.

(5) Power Supply for Dandora Industrial Area

As the previous fourth project is described, the Dandora area is the proposed sub-centre. Moreover, the area along Kangundo Road was considered to become an industrial area, and the total site for the industrial park is 45 ha. Because of this concept, power supply for the area is required when industrialisation is realised.

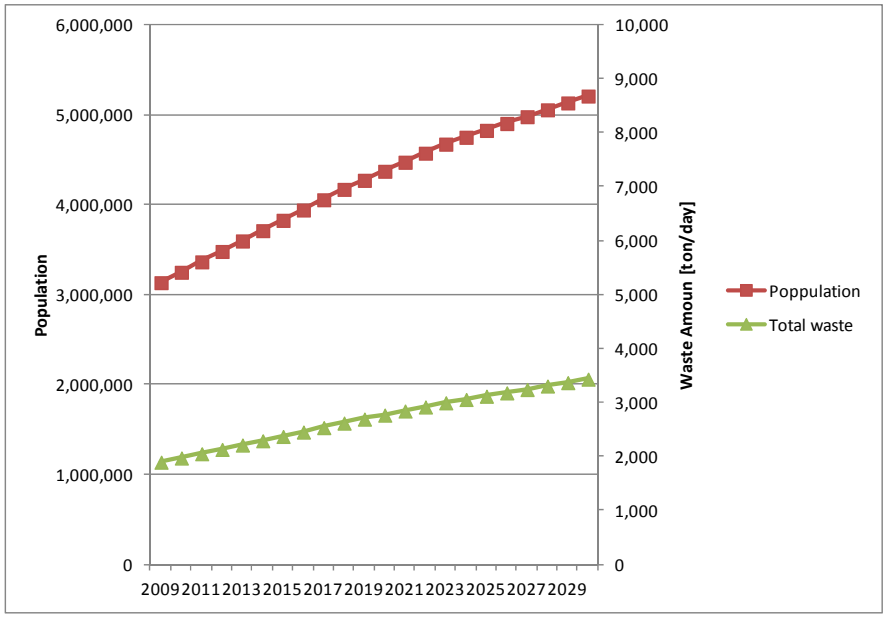
In this project, there is a need to construct transmission lines from a substation to the Dandora industrial area. There are two substations near the proposed industrial area and both substations, Juja Substation and Dandora Substation, are about 1 km from the industrial area. Moreover a substation inside the industrial area and distribution lines are needed.

8.4 Solid Waste Management

8.4.1 Demand and Gap Analysis

(1) Basic Condition of Demand Analysis

Future amount of solid waste generation is projected based on the socioeconomic framework of this study as shown in Figure 8.4.1.



Source: JICA Survey Team (JST)

Figure 8.4.1 Waste Generation Project based on Population

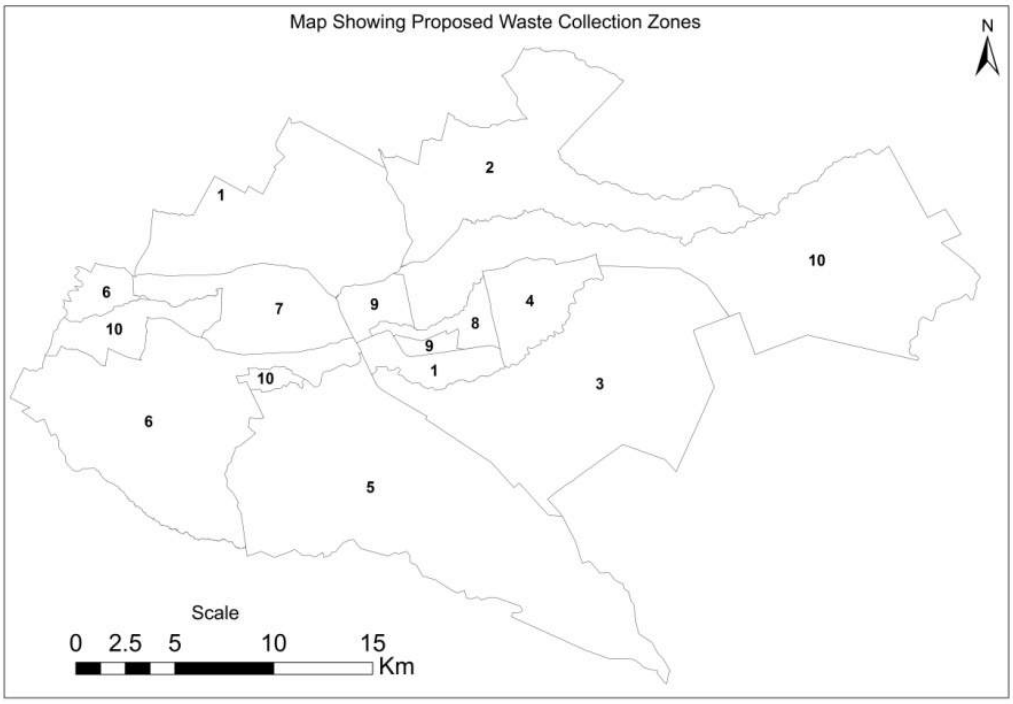
According to the JICA Solid Waste Management (SWM) Survey (2010), the collection is separated for every collection zones in consideration of income levels.

Based on the total population projection in this study, the population projection for collection zones (refer to Figure 8.4.2) is summarised as Table 8.4.1.

Table 8.4.1 Projected Population in Each Collection Zone

Name of Collection Zone	2013	2018	2023	2030
Collection Zone 1	197,724	235,405	268,699	304,618
Collection Zone 2	343,333	406,378	461,147	518,525
Collection Zone 3	401,897	475,141	538,545	604,549
Collection Zone 4	482,778	574,086	654,493	740,737
Collection Zone 5	214,232	257,613	296,949	341,215
Collection Zone 6	234,453	275,657	310,699	346,013
Collection Zone 7	182,367	223,132	261,512	307,223
Collection Zone 8	119,909	127,887	133,917	138,561
Collection Zone 9	156,270	163,750	169,403	173,757
Collection Zone NCC/SWMPC	1,268,388	1,435,904	1,582,306	1,737,302
Total (Residential)	3,601,351	4,174,952	4,677,671	5,212,500

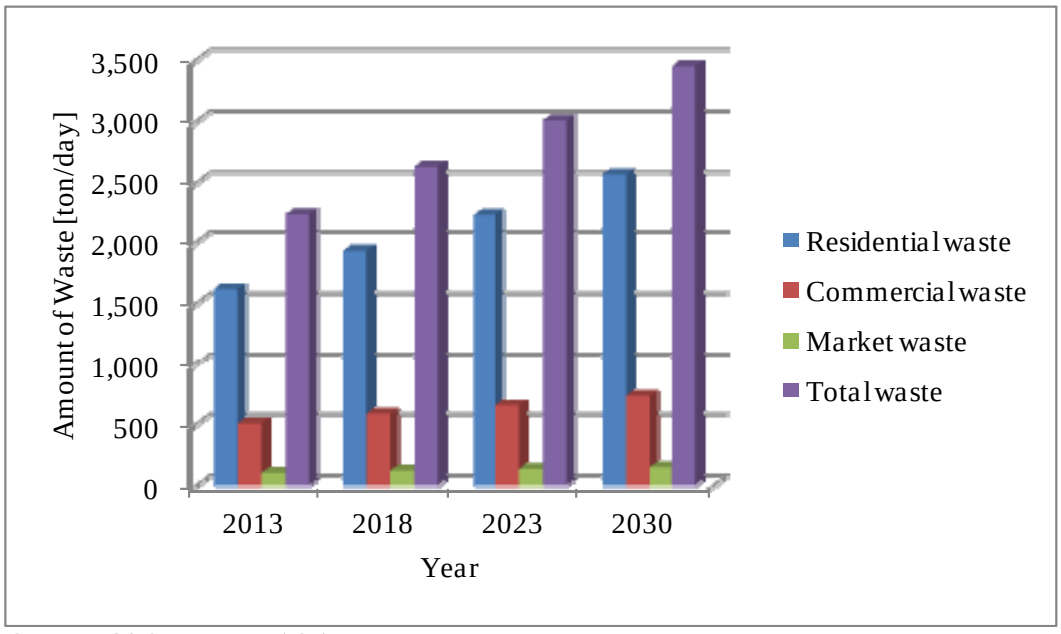
Source: JICA Survey Team (JST)



Source: JICA Survey Team (JST)

Figure 8.4.2 Map of Each Collection Zone

According to the JICA SWM Survey (2010), future solid waste amount by year 2030 is projected based on the field survey conducted in 2010. As there are no other field survey data from 2010 to 2013, it is assumed that there is no significant change in solid waste generation during the period. Therefore, the unit generation ratio of solid waste used in 2010 and the projected socioeconomic data in this study will be used in this demand analysis. Based on the assumption, the estimated solid waste is shown in Figure 8.4.3.



Source: JICA Survey Team (JST)

Figure 8.4.3 Estimated Solid Waste Projection

According to the above Figure 8.4.3, the amount of generated waste in 2030 will be approximately 1.5 times as that of 2013. In addition, there are many issues related to solid waste management. While the solid waste collection, transportation, treatment, and disposal system are not sufficient, which cause environmental issues like illegal dumping or pollution of the surrounding environment as discussed in Subsection 4.2.7. Main gaps from the current desirable situation are shown in Table 8.4.2.

Based on the demand of solid waste generation and disposal, it is necessary to prepare the development of the collection and transportation system and waste disposal and treatment system.

Table 8.4.2 Current Situation of Solid Waste Management and its Gaps between Desirable Situations

Item	Current Situation	Demand/Desirable Situation	Gap
Waste Generation	Generated waste is not properly treated and there is no suitable action for waste reduction.	All the generated waste is treated properly.	Suitable system of solid waste based on the projection should be developed.
Collection and Transportation	The ratio of collection and transportation is less than 50%.	The collection ratio should be almost 100% to prevent illegal dumping.	Necessity of collection and transportation system.
Reuse and Recovery System	Reuse and recovery is carried out by waste pickers for only a part of recyclable waste in illegal dumping site, waste collection points, and the Dandora Dumping Site.	Recycling system of suitable scale is necessary.	Recycling system at community level should be developed.
Waste Disposal	Waste is disposed in the open dumping site in Dandora, which causes pollution problem to the surrounding environment.	Waste should be disposed of in a sanitary manner through a suitable waste disposal method.	A sanitary landfill site is necessary.
Institutional Framework	There is no comprehensive institutional framework for solid waste management.	Comprehensive institutional framework for solid waste management and future establishment of recycling-based society.	Establishment of the revision of the law and new regulation is necessary.
Financial Situation	There is little capacity to cover the solid waste management by the current waste collection tariff.	It is necessary to increase the revenue from waste collection tariff, benefit from 3R activities, and subsidy as well as reduction of expenditure.	Improvement of the current financial system of solid waste management is necessary.

Source: JICA Survey Team (JST)

(2) Future Waste Stream and Future Demand of Each System

Currently, some of the wastes are illegally dumped which causes environmental pollution in NCC. In addition, it is necessary to implement the 3R (Reduce, Reuse, Recycle) activities to divert wastes into the landfill site to prolong its life as well as reduction of collection and transportation costs as considered in the JICA SWM Survey (2010). The target collection, diversion, and disposal rates set as target indicators are follows:

$$WCR_i = WCA_i / WGA_i$$

$$WDIVR_i = WDIVA_i / WGA_i$$

$$WDISR_i = WDISA_i / WGA_i$$

Where, WGA_i is the amount of waste generated in a year i

WCA_i is the amount of waste collection in a year i

$WDIVA_i$ is the amount of waste disposal in a year i

WCR_i is collection ratio in a year i

$WDIVR_i$ is diversion ratio in a year i

$WDISR_i$ is disposal ratio in a year i

The target indicators in each year are shown in Table 8.4.3.

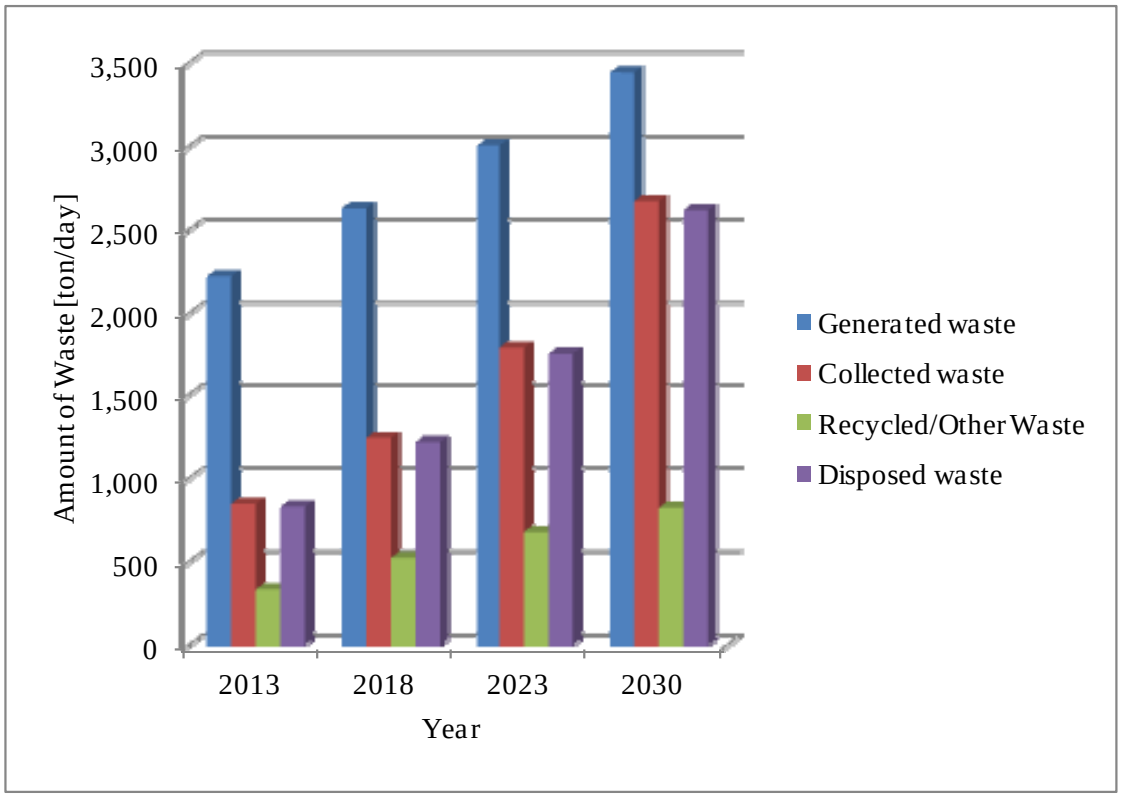
Table 8.4.3 Target Indicators for Future Waste Stream

Item	2013	2018	2023	2030
Collection Ratio	38%	47%	60%	78%
Diversion Ratio	15%	20%	23%	24%
Disposal Ratio	37%	46%	59%	76%

Source: JICA Survey Team (JST)

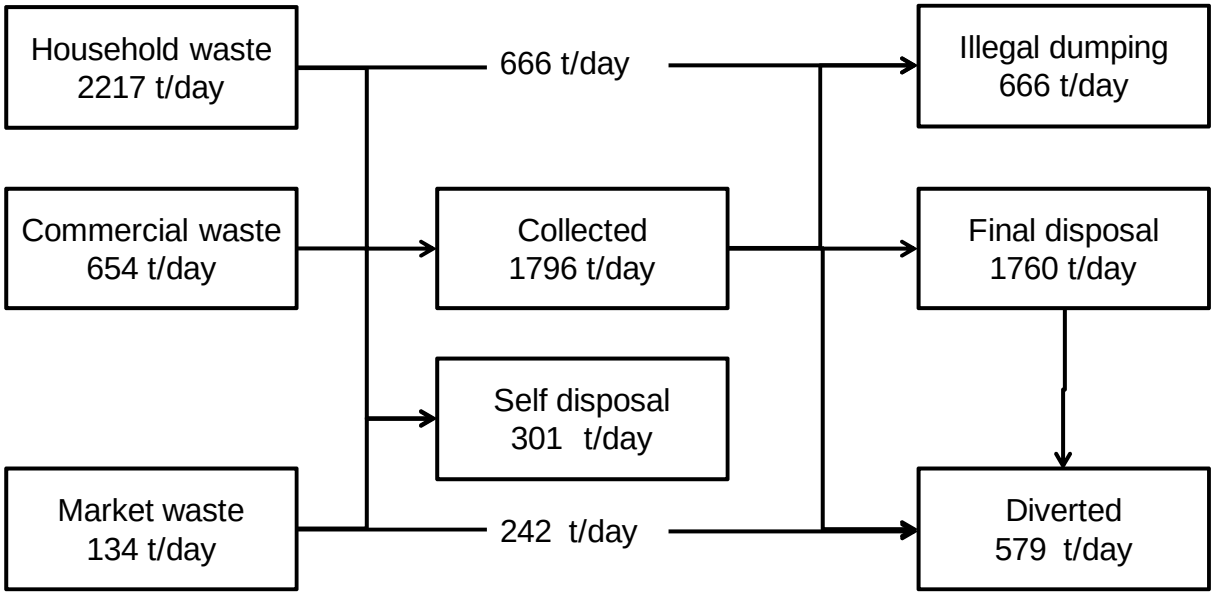
Future projection on the amount of generated, collected, recycled, and other wastes and disposed waste are calculated based on the target indicators shown in Table 8.4.3 above.

In addition, the waste stream in 2023 and 2030 is shown in Figure 8.4.5 and Figure 8.4.6.



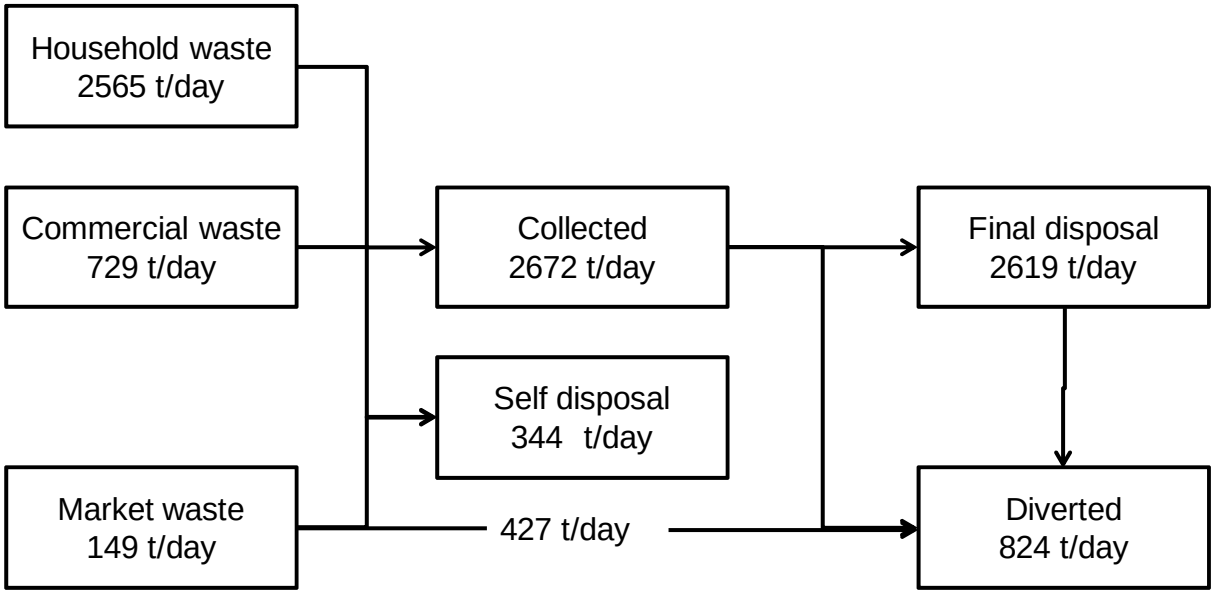
Source: JICA Survey Team (JST)

Figure 8.4.4 Estimated Solid Waste Projection



Source: JICA Survey Team (JST)

Figure 8.4.5 Estimated Solid Waste Projection in 2023



Source: JICA Survey Team (JST)

Figure 8.4.6 Estimated Solid Waste Projection in 2030

8.4.2 Development Policy

(1) General Development Policy of Solid Waste Management

Based on the proposal of JST and the discussion in the TWG, "clean" and "safe" are two of the keywords for the development of NCC. The purpose of solid waste management is mainly to ensure safe and clean environment for the people by reducing and removing the hazardous, toxic, and infectious materials with suitable treatment and disposal. This process has to be carried out in consideration of the technical, financial, and organisational aspects toward environmental friendly society as well as in line with the change of life style towards less environmental impacts. In this context, the development policy of the solid waste management sector is set as follows:

1) Application of feasible methods of waste management in terms of environmental, social, economic, and technical aspects to keep a clean and safe environment for the people;

2) Development of a system to manage various stakeholders including private contractors, licensed private companies, waste dischargers, and waste pickers; and

3) Implementation of capacity development for target organisations and staff in a suitable manner.

(2) Responsibility of Relevant Organisations and Stakeholders

There are various relevant organisations and stakeholders related to solid waste management in NCC. Amongst the organisations, NCC has the main responsibility for the implementation of solid waste management. The responsibilities of relevant organisations are clarified as shown in Table 8.4.4.

Table 8.4.4 Responsibility of Relevant Organisations and Stakeholders

Organisation/Stakeholder	Responsibilities
Central Government (National Environmental Management Agency)	- To formulate national law and regulations related to solid waste management. - To prepare solid waste management plan in the national level. - To prepare the guidelines and technical standards. - To provide guidance to local governments.
Nairobi City County	- To formulate the local policy of Nairobi City County - To implement and finance solid waste management in Nairobi City County
Private Contractors	- To provide waste collection, transportation, and street sweeping services based on the contract.
Business Waste Generators (Industrial and Commercial)	- To manage their waste except the municipal waste handled by the local government.
Residents	- To comply with the law and regulations related to solid waste management. - To reduce waste generation and recycle the recyclable waste. - To discharge the waste to determined places and time. - To burden the waste collection service fee based on polluters pay principle.

Source: JICA Survey Team (JST) based on the hearing with NCC

(3) Planning Strategy of Solid Waste Management

Based on the general development policy, the planning strategy is formulated as follows:

1) Collection and Transportation Plan

It is necessary to consider an effective collection and transportation system for maximum service provision with utilisation of current resources such as equipment and human capacity. In this moment, there are so many private companies which implement solid waste collection services but it is focused only on high income areas, which have the capacity to pay the tariff waste collection service. NCC cannot supervise such activity with so many private companies. Therefore, participation of a few private companies which has the capability of collecting and transporting solid wastes is necessary. It may also be necessary to introduce a franchise system for collection and transportation services for the comparatively higher and middle-income areas in consideration of the balance of income level, and introduction of collection by the public for low-income or slum areas.

2) 3R and Intermediate Treatment Plan

It is necessary to introduce the 3R system and intermediate treatment system to divert wastes to be disposed in the landfill site. In this context, the waste characterisation in NCC should be considered as well as with the financial and technical capability of the existing organisations. The calorific value of the waste generated in NCC is too low to consider incineration or gasification, and organic waste occupies the higher portion of waste composition. However, it

will be difficult to introduce large-scale compost or methanisation technology because the technology needs slightly higher technical capability. Therefore, small- or middle-scale compositing will be considered as 3R and intermediate for NCC.

3) Final Disposal

The final disposal is necessary for waste disposal and treatment as one of the cheapest and technical feasible options. However, the current final disposal method of NCC is open dumping which causes environmental deterioration in the surrounding environment. To improve this situation, the development of a sanitary landfill site and its operation procedure should be considered taking into account its financial and technical capability. The safe closure of the existing dumping site should be considered in parallel with the development.

4) Organisational Restructuring Plan

The development of the organisational capacity is critical to manage the private contractors and franchised company as well as improvement of the operational capacity of direct collection and transportation.

5) Legal and Institutional Improvement Plan

The related acts, regulations, and by-laws should be improved for better enforcement of solid waste management in consideration of a PPP structure, tariff setting, proper zoning, and cross-subsiding system as well as future 3R society.

6) Financial Management Plan

It is necessary to establish a special account for solid waste management in consideration of possible increase of revenue and budgetary allocation as well as waste collection charge.

7) Private Sector Participation Plan

Private sector participation is crucial for effective solid waste management. It is important to establish a management system for the private sector in consideration of suitable schemes such as introduction of a franchise system.

8) Community Participation Promotion Plan

Public education is important for effective solid waste management, especially in the low income or slum areas in case of NCC as there may not be sufficient roads for solid waste collection and transportation services. Source segregation system in community base or waste bank system should be considered in community participation plan as well as environmental education in schools.

(4) Consideration of Technical Options

In the JICA SWM Survey (2010), technical options have been considered for collection, transportation, treatment, and final disposal. These options are considered to be valid in the present study, as summarised below.

1) Treatment and Disposal

Considering the current financial situation and technical and organisational capacity of NCC, the easiest feasible technical option considering financial and technical aspects, especially for short term should be selected. According to the waste characterisation survey in the JICA SWM Survey (2010), the low calorific value of waste is approximately 3,300 kJ/kg, which is

considerably lower than the required average value for incinerators without power generation, which is approximately 7,500 kJ/kg in Japan. The low calorific value is considered to be too low to adopt the incineration technology. If NCC will not succeed in segregating biodegradable wastes that have high moisture contents, incineration is not a suitable technology.

For organic wastes, the methanisation also needs high technical skill for operation and requires appropriate segregation before the treatment. In this context, the combination of the segregation of plastic, paper, and metal for 3R and small-scale composting will be an adoptable technology. The residual waste should be disposed of in a sanitary landfill site.

Table 8.4.5 Merit and Demerit of Each Technical Option for Treatment and Disposal

Options	Merit	Demerit
Landfill	- Comparatively cheaper option - Technically feasible	- No waste reduction
3R+Landfill	- Comparatively cheaper option - Technically feasible	- If no cooperation with waste generator, there is not enough waste reduction
3R+Incineration+Landfill	- Effective volume reduction of wastes	- Expensive for initial cost and O&M cost
3R+Composting+Landfill	- Effective volume reduction of organic wastes - Not an expensive option	- Waste separation is necessary and there is a need to market the compost

Source: JICA Survey Team (JST)

Considering the merits and demerits of the options for treatment and disposal, it will be better to select the option of "3R+Composting (including home composting and community composting)+Landfill" will be the most suitable option for waste treatment in NCC.

2) Collection and Transportation

According to the JICA SWM Survey (2010), various technical options of the transport system including secondary transportation system for various site selection options have been studied in the economic aspects. Finally, the site for final disposal is selected in Ruai and direct hauling is recommended due to economic aspects. However, the directly hauled wastes will include recyclable materials for market or commercial wastes, which can be removed in the material recovery facility (MRF). In addition, the waste pickers may lose their jobs after the closure of the Dandora Open Dumping Site, if there is no other facility in Dandora. In this context, JST recommends the preparation of MRF for the segregation of wastes for recyclable and biodegradable in the Dandora Open Dumping Site.

8.4.3 Priority Projects

Based on the development policy, it is necessary to develop a new sanitary landfill site, carry out the safe closure of the existing dumping site and develop an MRF in Dandora. In addition, it is necessary to improve the collection and transportation system in consideration of financial and organisational requirements. Furthermore, promotion of 3R and the establishment and improvement of laws, regulations, and guidelines for effective solid waste management is necessary.

In this regard, the following projects are proposed as priority projects:

(1) Development of a New Landfill Site

As proposed in the JICA Preparatory Survey (2012), a new sanitary landfill is necessary for final disposal of residual wastes. In the JICA Preparatory Survey (2012), the project site is surveyed based on findings of the previous JICA SWM Survey (2010). The site was proposed in Ruai which is approximately 28 km from the central business district of Nairobi City. The whole area of 80 ha is owned by NCC, although the procedure of obtaining title deeds is still ongoing.

It is proposed that the new landfill will be for a total usage period of about 15 years and approximately 9.8 million tons of wastes will be disposed of in the landfill. In consideration of the soil for soil cover, in total, 13.1 million tons of waste and soil will be accumulated at the site for the entire design life of the project.

The following table shows the outline of the new sanitary landfill structure:

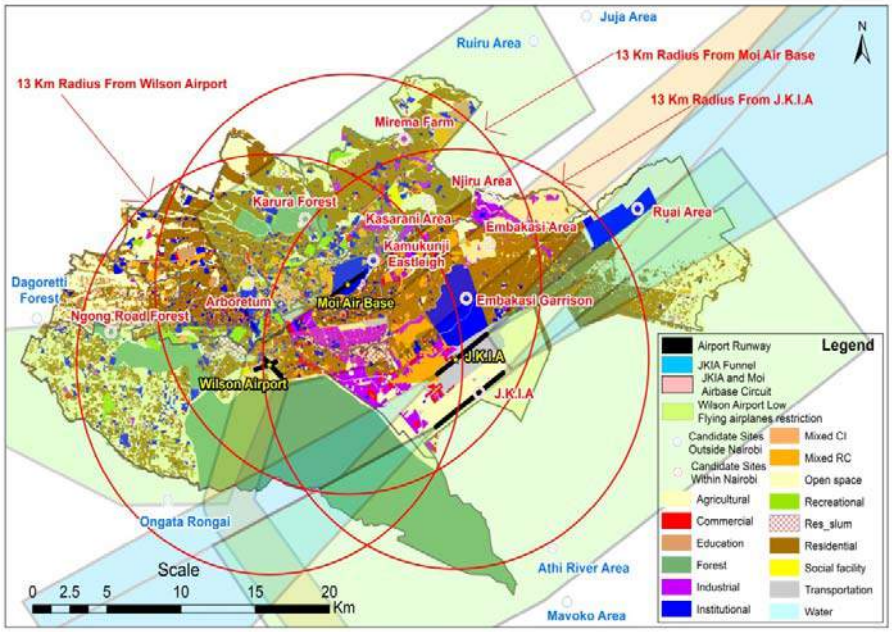
Table 8.4.6 Outline of the New Sanitary Landfill Structure

Category	Facility		Description
Principal Facilities	Landfill	Waste disposal facility	Soil embankment for retaining solid waste
		Lining system	Waterproof liner using black cotton soil available at the site
		Leachate collection facility	Leachate collection piping network at the bottom of the disposal area
	Landfill gas exhaust facility		Distribution of landfill gas exhaust pipes
	Leachate treatment facility		Anaerobic pond, facultative pond, coagulating sedimentation pond, etc.
	Stormwater drainage		Prevention of rainwater flowing into the disposal area
	Monitoring facility		Monitoring well
Administration	Administration building		Office building and transport control station
	Others		Weigh bridge, parking lots
Others	Road network		Hauling road, access road, on-site road
	Enclosure facilities		Fence, gate, etc.

Source: JICA Survey Team (JST)

The sanitary landfill system will include the waste disposal area, a leachate treatment area, and a small area for administration. The semi-aerobic method will be applied for this sanitary landfill for quicker decomposition of organic matter in the accumulated waste and for reduction of the methane gas which is greenhouse gas. The system will prevent environmental pollution of the surrounding area.

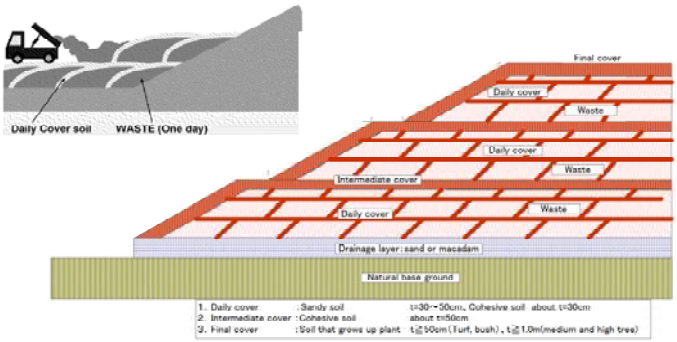
However, the Kenya Airport Authority (KAA) and the Kenya Civil Aviation Authority (KCAA) opposed to the proposed Ruai site, as it is on the flight path of the Jomo Kenyatta International Airport (JKIA). Although there are no international and local regulations that specifically prohibit the development of a landfill site in this location. In addition, they also opposed to the utilisation of the circuit area for take-off and landing in JKIA,Wilson Airport, and the army base. The restricted areas based on the suggestions of KAA and KCAA are shown in Figure 8.4.7. The restricted areas cover most area of NCC and all the possible candidate sites proposed in the JICA SWM Survey (2010) are in the restricted areas.



Source: JICA Study Team (JST)

Figure 8.4.7 Candidate Sites of New Landfill Site and Restriction Areas

Therefore, JST suggested the importance of the methods of soil cover during landfill operation for sanitary landfill site to protect disposed waste from birds, as well as the introduction of semi-aerobic landfill method such as leachate collection and treatment system, lining system at the bottom of the site by using black cotton soil, and gas collection system. The landfill area is divided into six sections of landfill areas which are designed by the JICA SWM Survey (2010).



Source: JICA Study Team

Figure 8.4.8 Image of a Cell Method Operation

Regarding the operation of this sanitary landfill, a cell method, in which the waste cell is covered with soil every day, will be recommended following the JICA Preparatory Survey (2012), In order to secure the reliability of this sanitary landfill activity, it is also strongly recommended to train the landfill operators with required skills. There are various methods to prevent birds in the landfill sites. JST suggested that a pilot project for sanitary landfill operation should be implemented by NCC with relevant stakeholders including NEMA, KAA, and KCAA as shown in Figure 8.4.9, as well as the preparation of site visits of the best practices in other areas and holding workshops with relevant stakeholders related to sanitary landfill and airport operations.

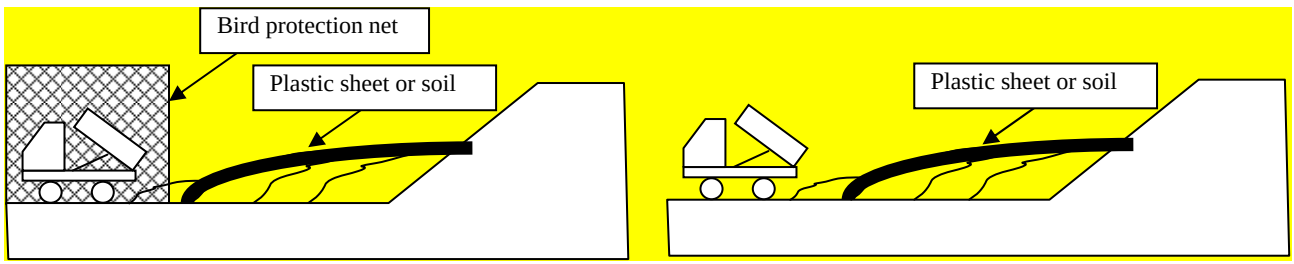


Figure 8.4.9 Image of Landfill Operation Options

(2) Safe Closure of the Existing Landfill Site

The site at Dandora has been utilised as the area for dumping wastes since 1981, and has gradually expanded to 46 ha. According to the current site boundary map provided by the City Planning Department of NCC to JST on 27 September 2011, about 1.5 ha of the area within the dumping site is currently privately owned. In addition, some structures such as houses and schools built by some private individuals and religious and community organisations have been observed and immediately around the dumping site.

Existing landfill of Dandora Dumping Site is poorly managed and the area is not designed for a sanitary landfill. In addition waste disposal in Dandora has exceeded the design capacity for landfill operation.

Considering the current conditions at the site, it is better to decommission the Dandora Dumping Site. The following design concepts should be applied for the decommissioning of the Dandora Dumping site as described in the JICA Preparatory Survey (2012):

(i) Existing dumped waste shall not be transported outside of Dandora Dumping Site;

(ii) Part of the NCC area where no waste has been dumped will remain in that state;

(iii) A buffer zone should be secured for the surrounding environment;

(iv) Waste located on the private land and the area adjacent to the project site shall be cleansed and removed from the project site; and

(v) Environmental impact of leachate and bird strikes shall be paid to mitigate for environmental protection.

The following table shows the necessary facility and the role of the decommissioning of the Dandora Dumping Site:

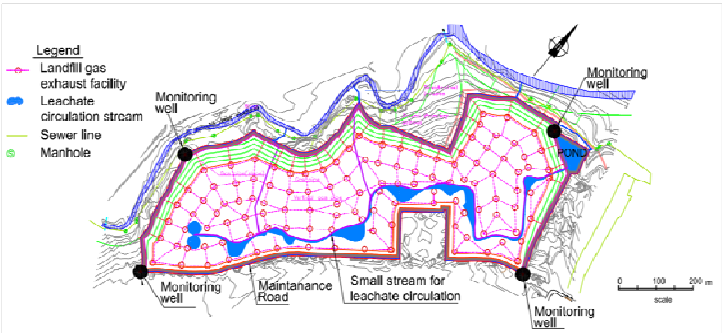
Table 8.4.7 Outline of the Decommissioning of the Dandora Dumping Site

Category	Facility	Description
Principal Facilities	Landfilling area	Disposal area shall be limited and controlled in accordance with the decommissioning plan and waste quantity to be continuously disposed of at the site until the Ruai site will become operational.
	Leachate collection facility	Concrete ditch with collection pipes along the boundary facing the Nairobi River
	Stormwater drainage	Prevention of rainwater from flowing into the closed dumping site
	Landfill gas exhaust facility	Distribution of landfill gas ventilation network
	Leachate treatment facility	Leachate storage pond and artificial stream
Administration	Monitoring facility	Distribution of monitoring wells
Others	Perimeter facility	Surrounding wall, gate etc.

Source: JICA Study Team based on the JICA Preparatory Survey in 2012

Some of the accumulated waste shall be moved to another part of the site with a stable slope and flat the surface of waste layer. Then, the surface cover soil will be put on the whole surface of the waste. The thickness of this final cover soil will be 1 m or more to protect the surrounding environment from waste layer.

Landfill gas will be captured by a gas collection pipe installed in the surface layer of the site and released to the atmosphere through gas ventilation pipes.



Source: JICA Preparatory Survey in 2012

Figure 8.4.10 Layout Plan of Decommissioning of the Dandora Dump Site

Leachate will be collected using a concrete ditch with collection pipe installed along the site boundary and will be diverted to the storage pond and tanks. The collected leachate will be circulated within the area by pumping it up to the small pond prepared and then allowing it to flow down to the pond through the artificial stream for evaporation and natural purification.

As mentioned above, development of the new landfill site in Ruai cannot be secured due to the opposition by KCAA, and NCC is considering using the Dandora Dumping site as an alternative measure. The use of the Dandora Dumping Site can be considered only if new technology can be applied to reduce the burden of environmental condition.

(3) Development of MRFs

According to the JICA SWM Survey (2010), there is a sizable quantity of biodegradable waste for composting and recyclable waste for recycling, based on the waste characterisation survey. For the diversion of such compostable and recyclable wastes, the development of material recovery facility (MRF) near the source of waste generation is crucial for effective solid waste management in regard to the reduction of transportation cost and the cost for segregation. Then, it is necessary to divert the waste from the landfill site to extend the life of the landfill site.

Basically, waste characteristics are different from various generation sources. Therefore, the waste at specific generation sources such as market or office will be the target waste in MRF for compost or recycling process, respectively.

The preliminary proposed flow of waste to MRF is as follows:

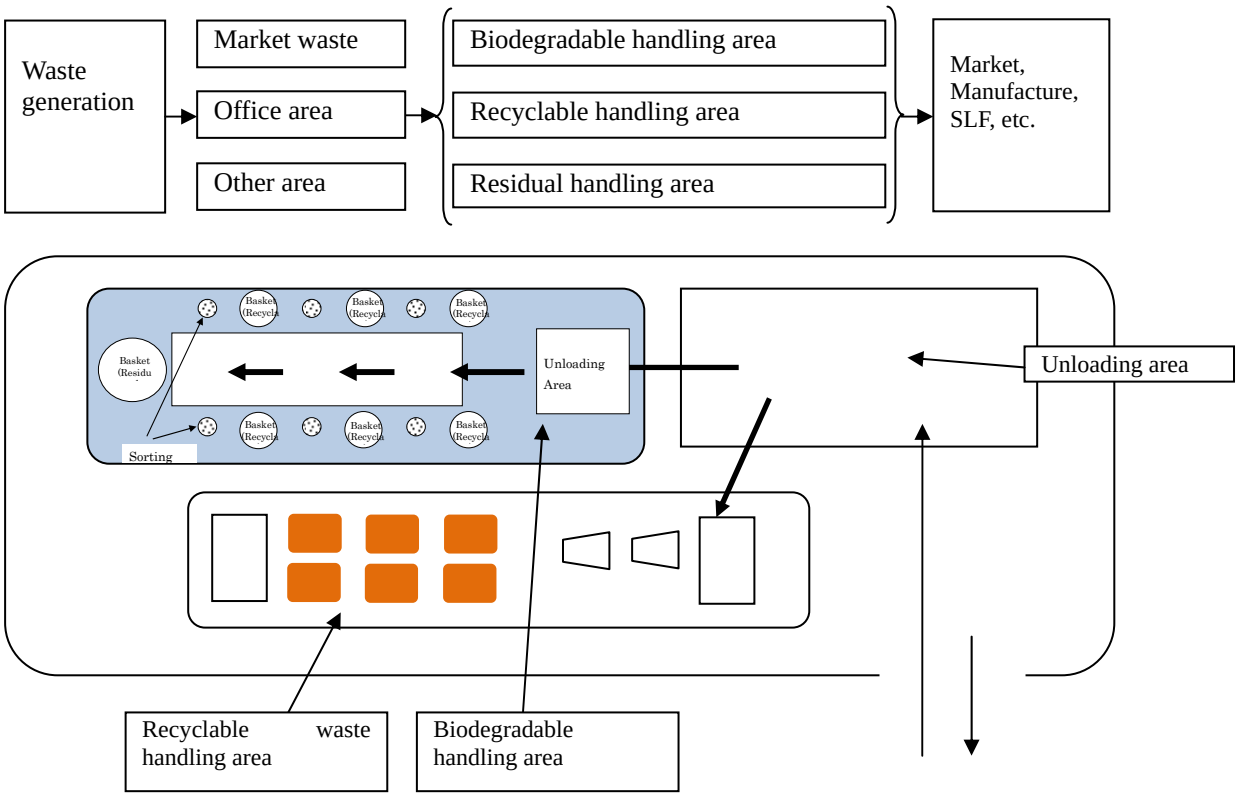
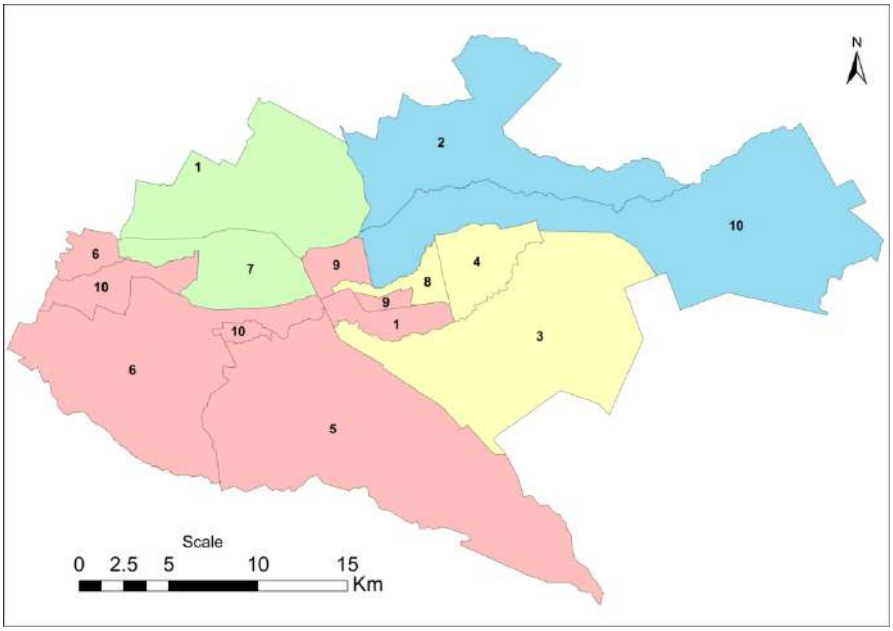


Figure 8.4.11 Image of the Operation of MRF

(4) Improvement of Collection and Transportation System

At present, solid waste collection and transportation services are provided by NCC, although there are a number of private contractors and registered private companies in NCC. In this situation, there are

various issues regarding the supervision of activities including the following: 1) Insufficient supervision of the private contractors and registered private companies, and 2) Unequal waste collection service charges for waste generators in each income level. To improve the condition, it is necessary to set up the collection zone by considering the socioeconomic level (especially, income level) in order to consider the waste collection service charges in each zone. Also the location of the collection zone and franchised system need to be examined to utilise the technology and know-how of each private company related to the collection and transportation services. In addition, waste diversion of market waste and other domestic waste after collection is recommended as described in Subsection 4.2.7, for which an MRF needs to be considered for waste separation. In this context, the collection and transportation area for each MRF are specifically proposed, as shown in Figure 8.4.12 with the number of zones and colour. Currently, the pilot project for zone 7 is being implemented in the JICA technical cooperation project.



Source: JICA Study Team

Figure 8.4.12 Collection Zone and Proposed Four Areas for the Transportation System

If the private sector participates in the collection and transportation service, NCC should supervise the activities of the private sector suitably. After the introduction of a franchise system, the franchise company will provide the collection and transportation service in one zone and manage the system under their own responsibility with the supervision of NCC. In this context, it is important to introduce a robust system as follows, as described in the JICA SWM Survey (2010):

1) Step-wise establishment of an operational zone based on cross-subsidy within the zone

In Nairobi City, income levels have been identified based on the poverty map prepared by WB. Based on the concept of affordability to pay (ATP), it is better to adjust the collection fee with the income level. Each zone in a franchise system should be in similar income level on average for each franchise company. In this context, the area of the zone and its location should be considered with the income level of waste generators as well as the location of zone. Therefore, the collection area is proposed in Figure 8.4.12 as described in the JICA SWM Survey (2010).

2) Suitable Collection System

Appropriate waste collection and transportation systems need to be considered to cope with the current waste generation source and type. As for collection, there are a number of options such as house to house collection and station collection. Station collection is suitable for

apartment or housing complex and possibly, in densely populated areas. Individual collection is suitable for detached housing areas and suburbs. As for the collection equipment, the merits and demerits of equipment shall be considered, and the selection of collection equipment should be in accordance with the area characteristics. The proposed collection method and collection equipment for each area is described as follows:

Options	Merit	Demerit	
Handcart	-Easy to collect along small road -Cheap cost	- Not effective for collection	Area of narrow road
Compactor vehicle	-Easy to collect and transport effectively	-Slightly expensive	Area of high income
Container vehicle	-Easy to collect -Effective collection	-Necessary for maintenance	Area of station collection
Dump truck	- Not so expensive	- Slightly taking time for collection	Other area

Options	Merit	Demerit	
House to house collection	-Easy to collect -No incentive for waste reduction	-Taking the time for collection	Individual house
Station collection	-Effective collection	Necessary to monitor the collection point	Apartment, secondary collection area

Figure 8.4.13 Proposed Collection Methods and Equipment

(5) Establishment and Improvement of Laws, Regulations, and Guidelines for Effective Solid Waste Management

While the Environmental Management and Coordination Regulation (2006) is the basic law in Kenya and the NCC bylaws of 2007 have been established, there are no specific regulations or guidelines for the planning and operation of solid waste management in the national and county levels. It is necessary to establish the institutional system in the national level. NEMA has the responsibility of solid waste management in the national level to set up the law, regulations, and guidelines. NEMA should take an initiative to establish the institutional system for solid waste management. The proposed system is shown in Figure 8.4.14, which includes the institutional system about basic laws on waste management and sound material-recycle society for future establishment of the regulation for promotion of utilisation of resources, regulation on the promotion of green purchasing, and regulations related to E-waste, etc..

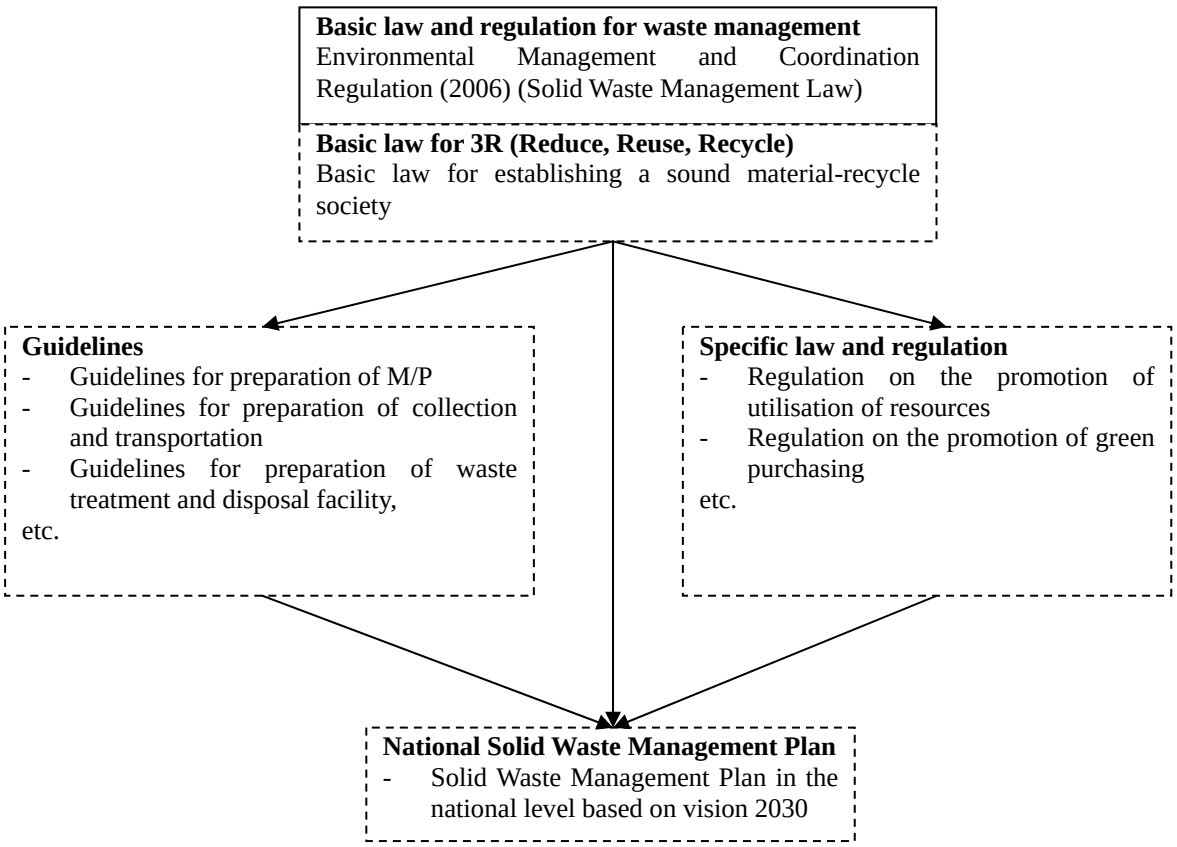


Figure 8.4.14 Image of Future Institutional System for Solid Waste Management

8.5 Telecommunications

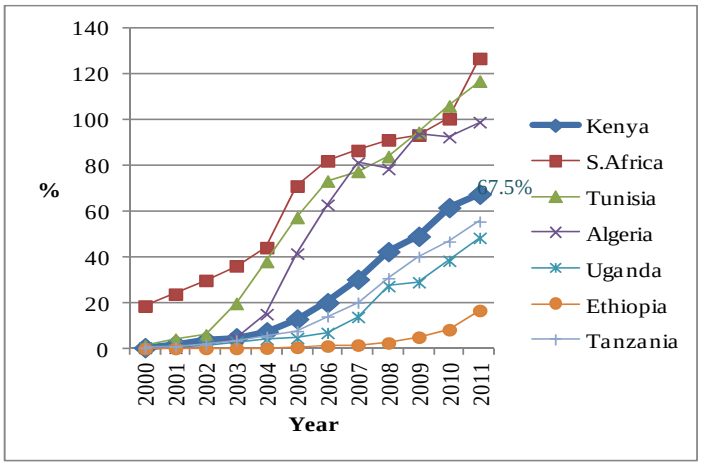
8.5.1 Demand and Gap Analysis

Future demand for telecommunications is calculated in consideration of the future population studied in this report and the world trends of the telecommunications sector.

(1) Mobile Telephone

Figure 8.5.1 shows the mobile penetration ratio of countries in Africa. The mobile penetration ratio of Kenya was 67.5% in 2011 according to the International Telecommunications Union (ITU) statistics and it is expected to reach 69% based on the Communications Commission of Kenya (CCK) sector statistics report (3rd quarter 2012/13). The mobile penetration ratio of South Africa, Algeria, and Tunisia started to rise after around 2005 while that of Kenya's neighbouring counties - Uganda, Ethiopia, and Tanzania - rose one year later. The growth rate of mobile penetration ratio in each country was nearly constant after the mobile penetration started to rise. On the other hand, as shown in Table 8.5.1, mobile penetration of G7 countries moved up at 50% points per decade on average. Applying this growth rate to calculate the future mobile penetration ratio in Kenya, mobile demand is expected to grow as shown in Table 8.5.2.

From Table 8.5.2, it is observed that mobile subscriptions will exceed the current capacity of mobile phones before 2018.



Source: JICA Study Team (JST) based on ITU statistics

Figure 8.5.1 Mobile Phone Penetration Ratio of African Countries

Table 8.5.1 Penetration Ratio of Developed Countries

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Growth Rate (2011)-(2001)
France	49.20	**62.29**	64.55	69.29	73.51	78.84	84.17	89.66	93.36	92.75	92.03	**94.79**	32.50
Japan	53.12	**59.43**	64.35	68.67	72.43	76.34	78.94	84.84	87.24	91.90	97.43	**104.95**	45.52
United Kingdom	73.80	**78.32**	82.96	91.03	99.66	108.75	115.76	121.25	125.24	130.17	130.76	**130.75**	52.44
United States	38.75	**45.00**	49.16	55.15	62.85	68.63	76.64	82.47	85.68	89.14	91.86	**92.72**	47.72
Germany	58.53	**68.13**	71.73	78.56	86.43	96.04	103.78	116.62	127.95	127.42	127.04	**132.30**	64.17
Canada	28.46	**34.39**	37.95	42.05	47.02	52.71	57.46	61.49	66.29	70.71	75.92	**79.73**	45.34
Italy	74.13	**89.59**	94.26	98.11	107.70	121.87	136.11	150.94	150.84	149.44	154.64	**157.93**	68.34
											Average Growth Rate of the Decade		**50.86**

Source: JICA Study Team (JST) based on ITU statistics

Table 8.5.2 Mobile Telephone Demand

Year	2013	2018	2023	2030
Population	43,300,000	49,500,000	56,000,000	65,600,000
Mobile Penetration (%)	69	102	127	162
Estimated Mobile Subscriptions	29,849,336*1	50,490,000	71,120,000	106,272,000
Capacity	49,977,000*2			
Note *1: Sector Statistics Report Q3 2012/13 issued by CCK on July 2013 *2: Figure of capacity is as of 2012 based on CCK Annual Report 2011/12				

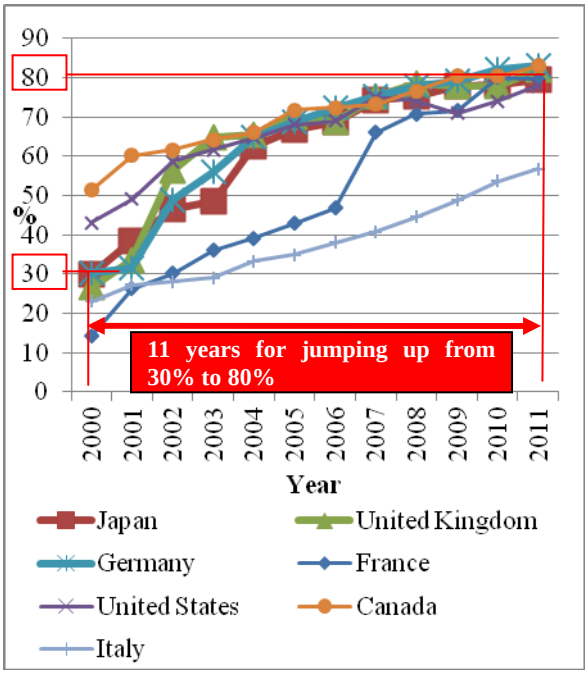
Source: JICA Study Team (JST) based on CCK Report

(2) Internet Use

Internet use penetration ratio in Kenya has been rising sharply and came up to approximately 28% in 2011 based on ITU statistics. This is due partly to the introduction of affordable internet access devices, including smart phones and social networking applications as well as aggressive promotion, special offerings, and reduced tariffs launched by operators. Furthermore, the internet use ratio is estimated to stand at around 37% in 2013, calculated based on the CCK sector statistics report in the 3rd quarter of 2012/13. From 30%, it took 11 years for the internet use penetration ratio of G7 countries to reach up to 80% (Figure 8.5.2). Furthermore, in Nordic Countries, where a much higher penetration ratio is seen, such as Norway, Sweden, and Iceland, it took approximately eight years for the ratio to rise from 80% to 90%. Applying this growth rate to calculate the internet use penetration in Kenya, the demand is assumed as shown in Table 8.5.3. Following the trend of developed countries

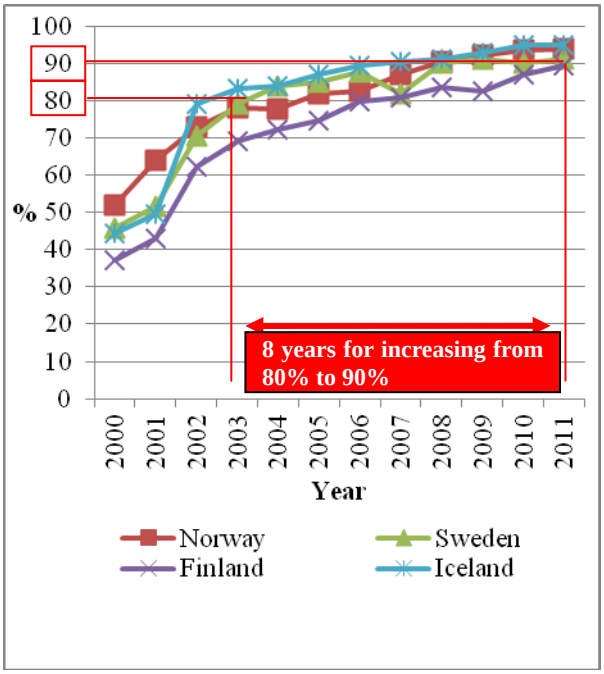
worldwide, the internet penetration ratio of Kenya will reach 60% by 2018, 81% by 2023, and 90% in 2030.

As seen on Table 8.5.3, it is expected that the majority of Kenya's population will use the internet by 2030. With reference to the increasing internet penetration ratio, the expansion of the international communication bandwidth capacity to be connected outward through undersea cable and satellite will become necessary. Demand forecast for international communication bandwidth capacity is studied next.



Source: JICA Study Team (JST) based on ITU statistics

Figure 8.5.2 Penetration of Internet Use of Developed Countries



Source: JICA Study Team (JST) based on ITU statistics

Figure 8.5.3 Penetration of Internet Use of Nordic Countries

Table 8.5.3 Internet Use Demand

Year	2013	2018	2023	2030
Population	43,300,000	49,500,000	56,000,000	65,600,000
Internet Penetration (%)	37	60	81	90
Estimated Internet User	16,444,861*	29,700,000	45,360,000	59,040,000

Note

*: Sector Statistics Report (Q3 2012/13) issued by CCK on July 2013

Source: JICA Study Team (JST) based on ITU statistics

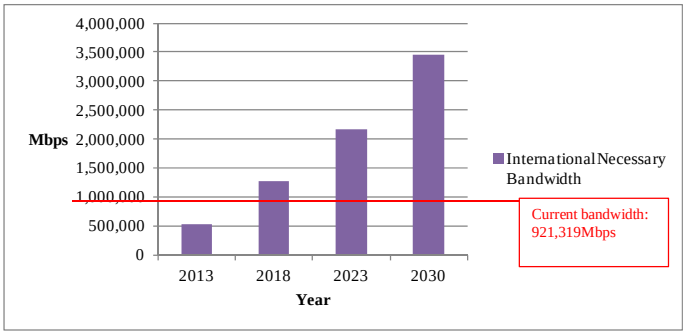
(3) International Communication Bandwidth Capacity

The international communications of Kenya is provided through undersea fibre optic cables and by satellite. The total international communication bandwidth capacity is 921 Gbps as of May 2013 according to the CCK sector statistics report (3rd quarter 2012/13). Amongst the total international communication bandwidth capacity, the capacity of the undersea fibre optic cables accounts for more than 99% while the satellite communication has little share. As for the undersea fibre optic cables, four undersea cable operators named SEACOM, TEAMS (The East African Marine System), EASSY (Eastern Africa Submarine Cable System), and LION2 (Lower Indian Ocean Network) land their undersea cables at Mombasa, on the East Coast of Kenya.

With the increase in the number of internet users, there is a need for the international communication bandwidth capacity to expand in order to provide smooth internet connection for users. Demand for international communication bandwidth capacity is studied based on the following assumptions listed below. Table 8.5.4 shows the result of demand forecast for international communication bandwidth capacity.

Assumption
- Broadband subscription :Linear increase
- Individual data usage per day :3 GByte (broadband user)
  :300 MByte (narrowband user)
- International connection ratio :0.7
  (Not all data go outward through the undersea fibre optic cables and satellite communications)

As shown in Table 8.5.4, although the current available international communication bandwidth capacity is 921 Gbps, the estimated international capacity will be 1,270 Gbps in 2018 as highlighted in green. This forecast shows that the international communication bandwidth capacity will exceed the current capacity before 2018 (Figure 8.5.4).



Source: JICA Study Team (JST)

Figure 8.5.4 International Communication Bandwidth Capacity Demand

Table 8.5.4 International Communication Bandwidth Capacity Demand

No.	Items	Unit	2013	2018	2023	2030	Calculation
1	Population		43,300,000	49,500,000	56,000,000	65,600,000	
2	Internet User		16,444,861	29,700,000	45,360,000	59,040,000	
3	Internet User Ratio	%	38	60	81	90	
4	Broadband User Ratio	%	2.7	8	13	20	
5	Broadband user		1,178,077*	3,960,000	7,280,000	13,120,000	No.1 x No.4 /100
6	Individual Data Use per day	Mbyte	3,000	3,000	3,000	3,000	
7	Individual Data Use per day	Mbit	24,000	24,000	24,000	24,000	
8	Total Data Per day	Mbit	28,273,848,000	95,040,000,000	174,720,000,000	314,880,000,000	No.5 x No.7
9	**Necessary Bandwidth (Broadband User)**	Mbps	**327,244**	**1,100,000**	**2,022,222**	**3,644,444**	No.8/24/60/60
10	Narrowband user		15,266,784	25,740,000	38,080,000	45,920,000	No.2-No.5
11	Individual Data Use per day	Mbyte	300	300	300	300	
12	Individual Data Use per day	Mbit	2,400	2,400	2,400	2,400	
13	Total Traffic Per day	Mbit	36,640,281,600	61,776,000,000	91,392,000,000	110,208,000,000	No.10 x No.12
14	**Necessary Bandwidth (Narrowband User)**	Mbps	**424,077**	**715,000**	**1,057,778**	**1,275,556**	No.13/24/60/60
15	**Necessary Bandwidth (Internal)**	Mbps	**751,321**	**1,815,000**	**3,080,000**	**4,920,000**	No.9+No.14
16	Internal Connection Ratio		0.7	0.7	0.7	0.7	
17	**International Necessary Bandwidth**	Mbps	**525,925**	**1,270,500**	**2,156,000**	**3,444,000**	No.15 x No.16
18	International Available Bandwidth	Mbps	921,319*				

Note:Figures with * comes from CCK Quarterly Sector Statistics Report Q3 2012/13 issued on July 2013
Figures colored in red comes from the assumption.

Source: JICA Study Team (JST) based on ITU statistics

8.5.2 Development Policy

(1) Development Policy

Based on the study of the current conditions previously stated in Chapter 2, JST set up the following policies for the development of telecommunications in NCC to achieve Kenya Vision 2030 and the National Broadband Strategy.

Development Policy
1. High Speed and Reliable Communications Network and its Connectivity,
2. Collaboration amongst Governmental Players and Operators,
3. Policy, Regulation, and Institution Development,
4. Promotion of E-government, and
5. Protecting Citizens from Disasters and Emergencies.

1) High Speed and Reliable Communications Network and its Connectivity

Building reliable information and communications infrastructure is essential to develop the country and to improve the quality of life. Furthermore, it contributes to operating and maintaining other sector infrastructures effectively and reasonably. To realise this, all communication infrastructure layers including the national backbone communication network, the metro trunk communication network, and the access network - which is an interface with users, need to be improved. Similarly, the bottleneck of data stream should be solved by introduction of proper network equipment that can process the increasing data bandwidth that goes together with the expansion of internet users.

2) Collaboration amongst Governmental Players and Operators

Telecommunications network is a public infrastructure. Therefore NCC shall administer the construction, installation, and maintenance works conducted by the telecommunications contractors/operators, because telecommunications infrastructure partially occupying municipal roads or lands and antenna towers built operator-by-operator impair the urban landscape. Thus, the public-private sector partnership should be improved to optimise telecommunications infrastructure development in Nairobi City.

3) Policy, Regulation, and Institution Development

According to the enforcement of a new law after the elections in 2013, NCC is supposed to have the authority to consider and approve all development applications and grant all development permissions. Moreover, it is expected to control the use and development of land and buildings in the city area, and to have jurisdiction over the control of the use and development of land and infrastructure in the interests of proper and orderly development. For this reason, NCC is required to formulate and enforce the policy, regulations, and institutions when developing the telecommunications infrastructure.

4) Promotion of E-government

E-government delivers a next generation of administrative services that enable the share and utilisation of information and data amongst the national and local governments through computer network instead of the current administrative services conducted face-to-face through documents. To promote E-government, raising the level of information and communications technology (ICT) literacy education and developing an exclusive government network that is not affected by data stream of the private sector, are recommended to be introduced.

5) Protecting Citizens from Disasters and Emergencies

Disasters and emergencies occur without previous notice and they usually cause damage to the people as well as damage to the infrastructure. In Kenya, most people receive disaster information through the media such as television and radio broadcasting. Most people in the disaster zone may panic for lack of information brought on by the unavailability or disability of the media due to the disaster. Thus, correct disaster information and its prompt dissemination are essential to minimise the damage of the disaster and to prevent a secondary disaster which may occur sequentially.

(2) Development Goals

According to the development policy, JST's development goals for the telecommunications sector are as follows:

Development Goals
1. Expansion of Broadband Services to the Whole Area under Nairobi City County,
2. Provision of Prompt and Reliable Governmental Administrative Services to Nairobi City Citizens,
3. Establishment of the National Infrastructure Sharing Policy,
4. Improvement of the Digital Literacy of Nairobi City Citizens, and
5. Disaster Prevention Information Dissemination to the Citizens.

8.5.3 Priority Projects

(1) Projects Necessary to Achieve the Developmental Goals

The JST proposes nine projects to be carried out by 2030 to achieve the goals set for the telecommunications sector; they are as follows: These projects are divided into two categories. The six projects from No. 1 to No. 6 are to be carried out for telecommunications infrastructure development. Meanwhile, the three projects from No. 6 to No. 9 are for institutional development. Since Project 1 is on communication network development, the operators shall be fully involved. Projects 2 to 9, on the other hand, shall be implemented with government initiative because these projects promote e-government and improve government services to Nairobi City residents. Outline, objectives, and effects of each project are explained in this section.

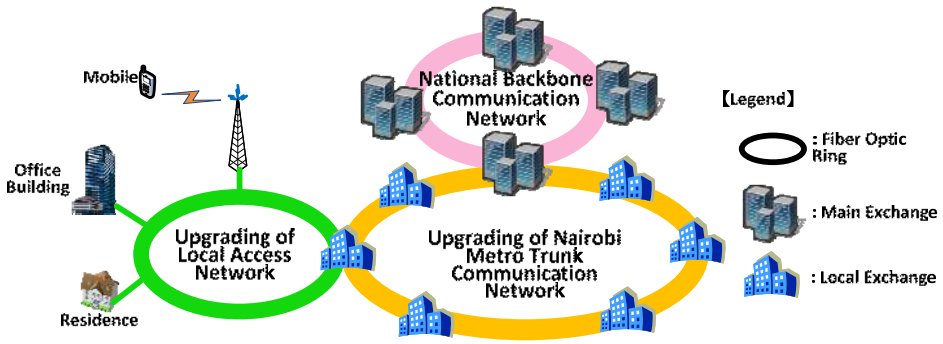
Projects to Achieve the Development Goals
1. Optic Trunk Communication Network in Nairobi City
2. Common Infrastructure for Operators
3. Introduction of a Dedicated Government Network amongst Government Offices
4. Disaster Information Gathering and Dissemination System
5. Local Government Data Centre and Cyber Security
6. Upgrading the National Addressing System
7. ICT Literacy Education for Citizens
8. Establishment of Framework on Construction Supervision and Maintenance Works
9. Infrastructure Sharing Policy

1) Fibre Optic Trunk Communication Network in Nairobi City

Upgrading the optic fibre trunk network for the metro trunk communications and local access network is essential to solve the telecommunications infrastructure issues. Similarly, the undersea cables landing at Mombasa should be enhanced to remove the fundamental bottleneck that decreases internet speed. Enhancement of communications network contributes not only to the improvement of internet user convenience but also to the introduction of the

Intelligent Transport Systems (ITS) which provide innovative services to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.

This development, the conceptual diagram of which is shown in Figure 8.5.5, is in line with the global trends of ICT as well as with the development policy. The initiative to develop the fibre optic trunk communications network should be taken on by the operators.



Source: JICA Study Team (JST)

Figure 8.5.5 Conceptual Diagram of the Telecommunications Network

i) Objectives

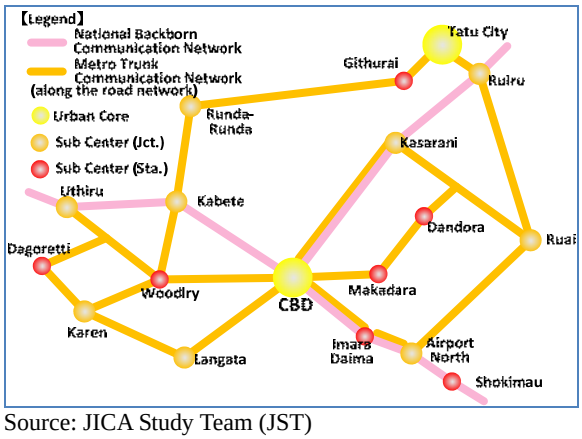
- To establish high speed networks,
- To improve connectivity for users, and
- To upgrade submarine cable capacity.

ii) Effects

- Increase in the number of internet users,
- Enhanced convenience in the use of the internet,
- Promotion of the citizens' participation in e-government (access to on-line government services), and
- Promotion of ITS.

iii) Development Items

- Upgrade the trunk communications network and accessibility
  - ➢ Network construction amongst the urban cores and sub-centres by connecting fibre optic cables laid along the roads and railways as shown in Figure 8.5.6.
  - ➢ Upgrade the networking equipment including optical transmission device, router, switch, and network control unit to expand the network bandwidth capacity.
  - ➢ Introduce the Long-Term Evolution (LTE) for accessibility improvement.
- Upgrade undersea cable bandwidth capacity
  - ➢ The government should assist operators to expand the undersea cable bandwidth capacity.



Source: JICA Study Team (JST)

Figure 8.5.6 Network Construction Plan

iv) Responsible Organisations

- Operators in partnership with the Ministry of Information Communications and Technology (MOICT)

2) Common Infrastructure for Operators

Currently, operators deploy their telecommunications infrastructure based on their own marketing strategy. Thus, cable laying works under the road conducted by every operator affect road traffic and increase the workload of officers in the road sections of NCC. On the other hand, a few antenna towers are shared based on the rent paid by a borrower to the owner of a tower. However, the majority of the antenna towers are installed by individual operators. These antenna towers have an adverse effect on urban landscape.

The JST recommends the development of a common infrastructure for operators to facilitate the expansion of telecommunications services. JST proposes a common underground duct for cables and shared antenna towers for mobile base transceiver stations and fixed wireless access to be shared amongst operators. Comprehensively, common infrastructure will not only expand the telecommunications services but also reduce operators' burden for its expansion.

The common underground duct buried under the ground accommodates indispensable primary infrastructure that includes communication and power cables. NCC should charge common underground duct users a fee to operate and maintain the common underground duct instead of applying for the wayleaves fee for laying the cable under the road. The common underground duct is environmentally friendly and leads to a reduction in road construction and provides for an urban infrastructure that is resistant against disasters.

Shared antenna towers are proposed to be operated and maintained by local governments such as NCC or a third party partially funded by public sources. It would be particularly beneficial because operators would provide their telecommunications services nationwide, not limited to the Nairobi City area. Shared antenna towers will improve urban landscape by reducing the number of antenna towers of individual operators and will promote effective land use. It is essential to expand the services with shared antenna towers to rural areas, because operators have a negative stance on offering their services there.

i) Objectives

- To avoid uncoordinated infrastructure deployment by operators.

ii) Effects

- Enhancement of the expansion of the telecommunications services,
- Coordinated land use,
- Improvement of urban landscape,
- Reduction of road construction and increase in road users’ satisfaction,
- Reduction of operators' burden for construction and maintenance works,
- Enhancement of the expansion of telecommunications infrastructure (operator's investment), and
- Protection against vandalism.

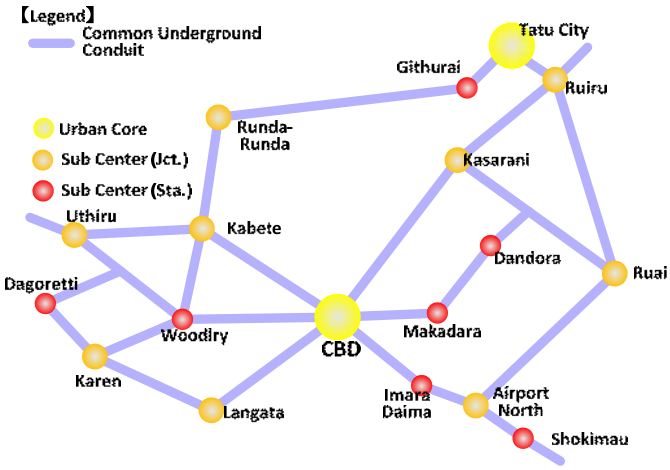
iii) Development Items

- Common underground ducts along trunk roads connecting the urban cores with the sub-centres
  - Infrastructure to be accommodated: communications, power, water, and drainage water; and
  - Accommodation capacity of the telecommunications operators: over 16 operators.

• Shared antenna towers in rural areas to promote operators' expansion of mobile service areas

iv) Responsible Organisation

• NCC



Source: JICA Study Team (JST)

Figure 8.5.7 Network Construction Plan

Table 8.5.5 Current Operators Who have their Own Infrastructure

1	Airtel Networks Kenya Limited
2	Accesskenya Group Limited
3	Alldean Satellite Networks (Kenya) Limited
4	Bell Western Limited
5	Essar Telecommunications Kenya Ltd
6	Frontier Optical Networks Limited
7	Gateway Telecommunications (kenya) Limited
8	Iway Africa Kenya Limited
9	Jamii Telecommunications Limited
10	Kenya Data Networks Limited
11	Mobile Telephone Networks Business Kenya Limited
12	Safaricom Limited
13	Sea Submarine Communications Ltd
14	Simbanet Com Limited
15	Telkom Kenya Limited
16	Wananchi Group (Kenya) Limited

Source: JICA Study Team (JST) based on hearing survey to CCK

3) Introduction of a Dedicated Government Network amongst Government Offices

This fibre optic network is developed exclusively for the use of government offices in order to share information and data, to promote effective administrative management as well as to provide prompt administrative services to citizens. Currently, the network for 38 national government buildings is connected through a telecommunications operator's leased network. However, it has a high risk for communication failure in case of disasters and emergencies due to the concentration of communication traffic on the telecommunications operator's network.

Efficient administrative management needs a reliable and sound exclusive network built on fibre optic cables connecting government offices, its site offices, ministries, and agencies. This also promotes prompt and effective implementation of administrative management and provides the groundwork to introduce e-government. It is considered reasonable and proper that the NCC Headquarters is connected to the Ministry of Devolution and Planning as these two organisations have a close relationship with each other in terms of local administration affairs. The fibre optic cables have the advantage, which is ordinarily consisting of multiple cores. Some cores are used for the government network, while the other cores can be leased to operators or private companies for their network expansion.

Figure 8.5.8 shows a conceptual diagram on the introduction of the dedicated government network.

i) Objectives

- To establish a dedicated government network unaffected by the private sector data streaming; and
- To share information amongst government offices, its site offices, ministries, and agencies.

ii) Effects

- Prompt and effective implementation of administrative management,
- Provision of prompt administrative services to citizens,

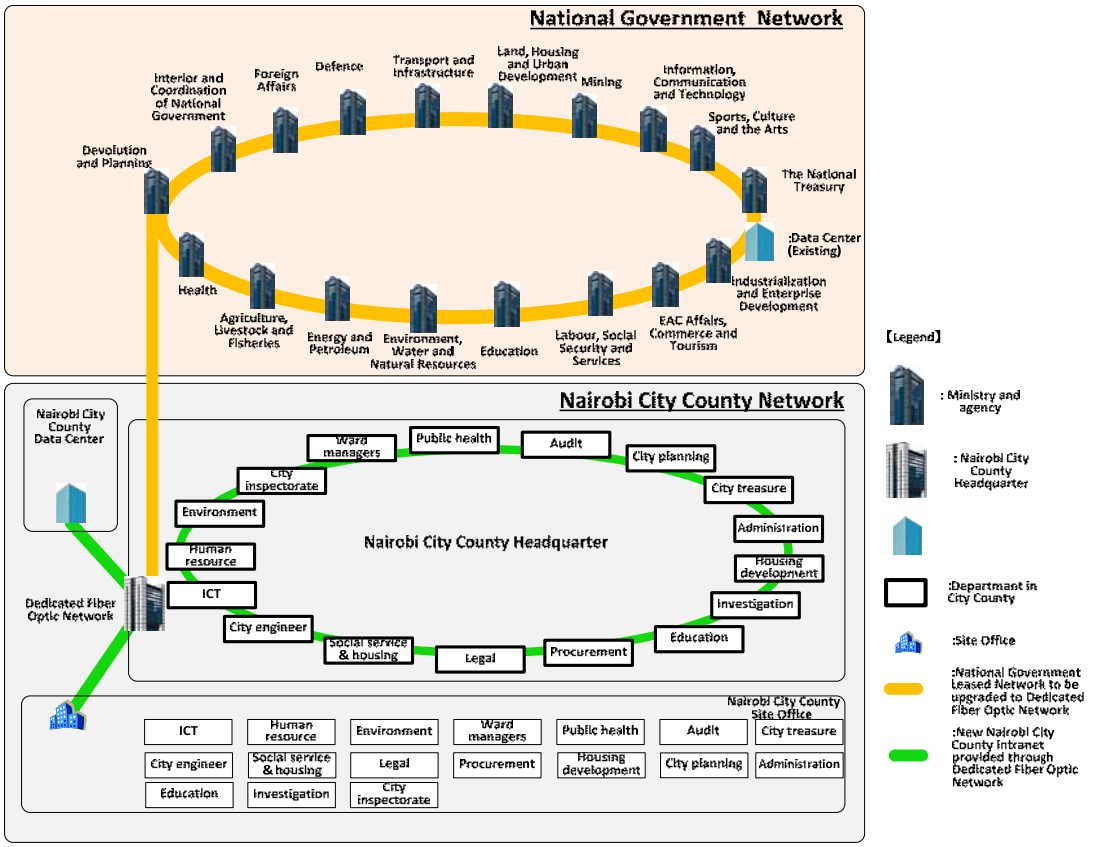
- Implementation of an efficient business continuity planning (BCP) during disasters/emergencies ,
- Basis for the introduction of e-government,
- Promotion of ITS by information sharing, and
- Fibre optic core lease.

iii) Development Items

- Introduction of intranet in NCC,
- Introduction of the NCC internal dedicated fibre optic network including site offices,
- Connection between the NCC headquarters and the national government (Ministry of Devolution and Planning), and
- Upgrading the existing national government network connecting the national government offices to a dedicated fibre optic network.

iv) Responsible Organisations

- NCC for NCC internal dedicated fibre optic network and intranet, and
- MOICT for a dedicated national government fibre optic network.



Source: JICA Study Team (JST)

Figure 8.5.8 Conceptual Diagram of a Dedicated Government Network for Government Offices

4) Disaster Information Gathering and Dissemination System

Widespread and coinstantaneous information dissemination helps citizens evacuate to safety in case of disasters or emergencies; hence, the disaster information gathering and dissemination system is proposed to be introduced in NCC.

Currently, the Kenya Meteorological Department and the Kenya National Disaster Operation Centre are in charge of meteorological information and river water level information concerning disaster prevention. To improve information dissemination, it is recommended that

NCC disseminates information to citizens through various ICT equipment including internet, message boards, and public megaphones. NCC needs to share the collected information with the relevant organisations through the dedicated government network previously mentioned. Furthermore, it is recommended that NCC should have its own observation station to stay informed about the current rainfall and water level conditions in the city area. The rainfall and water level information observed at the site will be sent to NCC Headquarters at regular intervals through dedicated wireless radio communications. When the rainfall and river water levels rise and there is a potential for flooding, the NCC Headquarters will announce the information on rising water levels to give notice in order to evacuate the residents living near the river.

i) Objectives

- Widespread and coinstantaneous information dissemination to citizens

ii) Effects

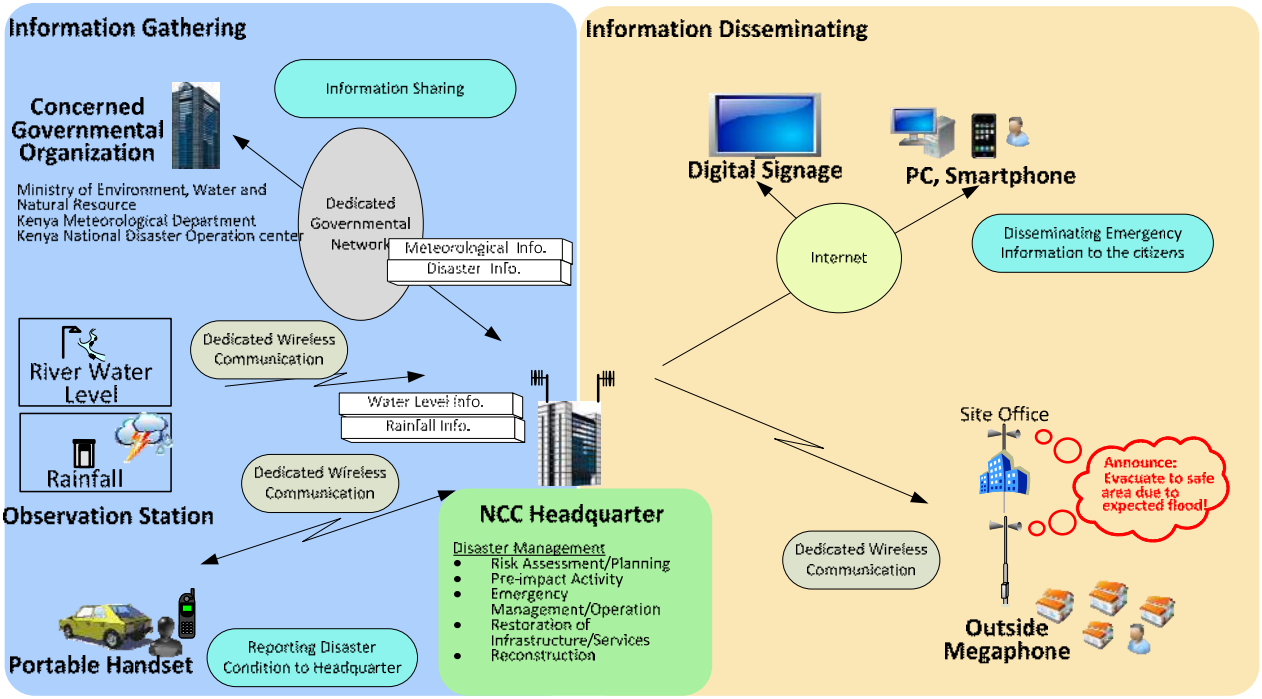
- Protection of lives and property, and
- Provision of regular public announcements.

iii) Development Items

- Rainfall and river water level information observation and telemetric information transmission system with security fence, and
- Wireless information dissemination including outside message boards and public megaphones with security fence.

iv) Responsible Organisation

✓ NCC



Source: JICA Study Team (JST)

Figure 8.5.9 Conceptual Diagram of the Disaster Information Gathering and Dissemination System

5) Local Government Data Centre with Cyber Security

The data centre is a centralised repository, either physical or virtual, for the storage, management, and dissemination of data and information. On the national government level, the Government of Kenya has built a government data centre for processing and storage of government applications and data through the Directorate of e-Government. The national governmental data centre implementation started in 2008 and is now ready to host government systems and services. Pursuant to the national government level, it is recommended that NCC set up their local government data centre. For efficient data exchange between the local government data centre and NCC, the dedicated government network can be utilised effectively to centralise the governmental information in the data centre. The conceptual drawing of the local government data centre is incorporated in Figure 8.5.8.

In addition, cyber attacks of fraudulent access and distributed denial of service (DDoS) have hit and damaged the intranet system of companies and government offices and concurrently might have caused a leak of confidential information or an organisation's defamation. Cyber attack protection does not only serve to block an attack from outside of the intranet, but also includes countermeasures which are premised on intrusion into the intranet (Figure 8.5.10).

i) Objectives

- To centralise data and information, and
- To protect data and information against cyber attacks.

ii) Effects

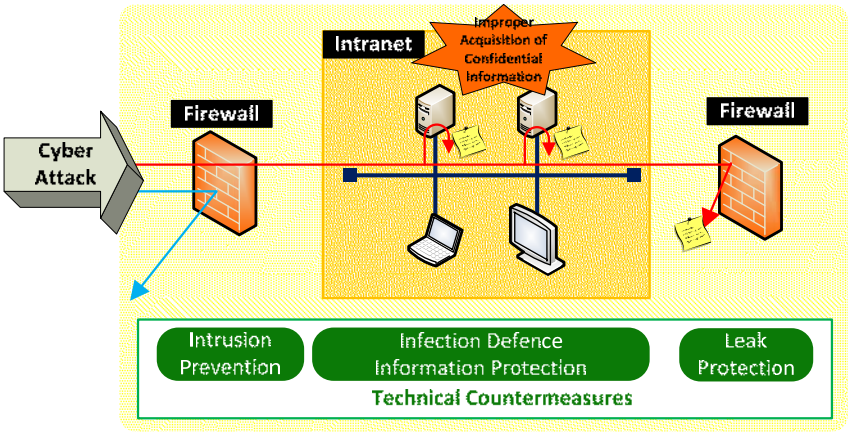
- Ensuring the security of government information and data,
- Efficient implementation of administrative management,
- Optimal use of the human resources, and
- Building a society with a sense of security.

iii) Development Items

- NCC data centre

iv) Responsible Organisation

- NCC



Source: JICA Study Team (JST)

Figure 8.5.10 Cyber Security

Countermeasures against cyber attacks are categorised into three types, namely, technical, human, and physical countermeasures. The methodologies of each countermeasure are proposed as shown in Table 8.5.6.

Table 8.5.6 Countermeasures against Cyber Security

Item		Methodology
Technical Countermeasure	System	● Update the operating system and install security patch on personal computers ● Introduce user authentication system ● Apply strict access control to network resources
	Network	● Monitor the network and detect malfunctions ● Install firewall to avoid intrusion from outside ● Install the Intrusion Detection System (IDS) and Intrusion Prevention System (IPS) for prompt detection and intrusion prevention
	Data Security	● Encipher data and hard disk
	Virus	● Install antivirus software ● Update virus definitions
Human Countermeasure	Information Security Policy	● Establish an information security policy ● Compliance with the information security policy
	Internal Rule	● Stipulate ethical codes and punitive clauses to prevent improper use
	Information Security Education	● Raise awareness about the importance of information security
	Password Control	● Periodic renewal of passwords ● Select a difficult password
Physical Countermeasure	Disaster	● Earthquake resistance for buildings ● Fire prevention system and fire alarm box ● Waterproofing floor, wall, and ceiling
	Crime	● Locking premises, building, and room ● Entering/leaving record system and monitoring camera
	Equipment Trouble	● System redundancy ● Data backup

Source: JICA Study Team (JST)

6) Upgrading the National Addressing System

The National Addressing System is a database and provision system to facilitate identification of citizens, revenue collection, improved city management, and provision of efficient rescue services. The system would also assist the provision of security and utility services, and a host of other services including efficient delivery of postal/courier items. There is a system for identifying streets, buildings, and plots. However, the existing system is unable to keep up with the pace of urbanisation. As a result, most of the streets in urban areas have no names or address.

The outline of the National Addressing System is described below. Basic data for the system consisting of property number, name of landlord and property owner, street name, and its geographical coordinates, etc. are given by each county and stakeholder including power and water utility companies and telecommunications operators. Each county sends the data to a processing server that will be installed in MOICT. MOICT will manage the data for information provision to relevant organisations such as postal/courier operators, emergency/security service organisations, and tax office. Similarly, information on residents shared by the stakeholders will be used to improve the accuracy of the information sent by each county. Each county should collect and provide the data necessary for the system early on to make the system useful.

i) Objectives

- To make a property and road database by linking geographical coordinates, and
- To provide information to relevant organisations.

ii) Effects

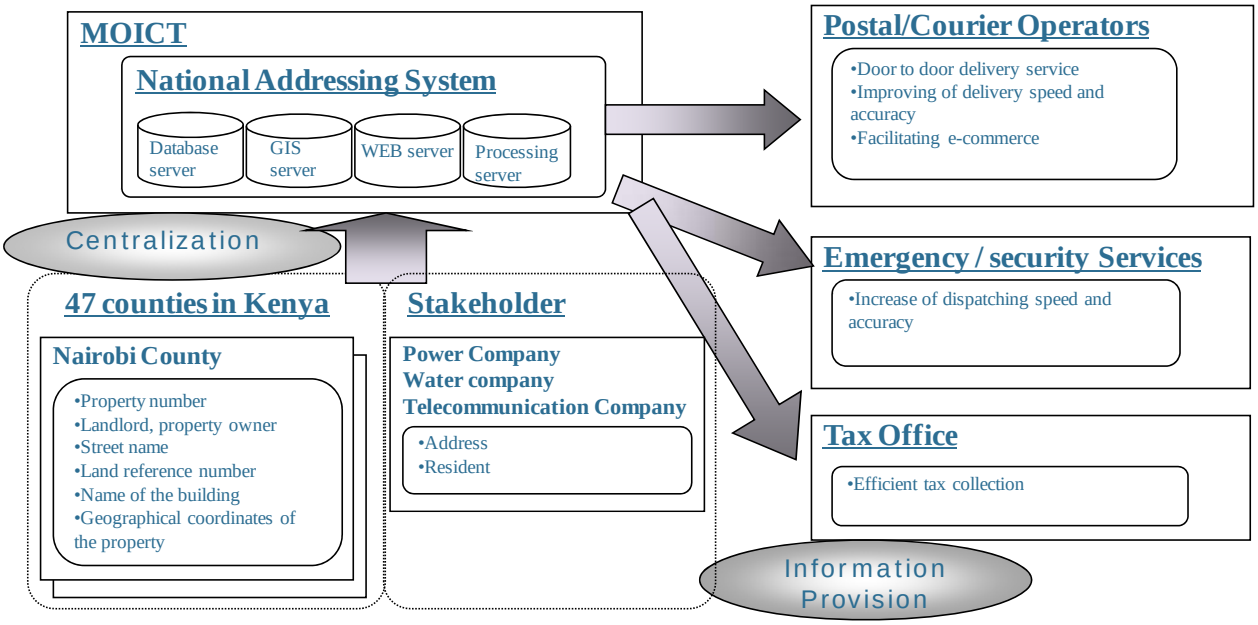
- Efficient city management,
- Speedup of administrative services, and
- Facilitate identification of citizens, revenue collection, and provision of efficient rescue services.

iii) Development Items

- National Addressing System including data gathering and provision

iv) Responsible Organisations

- MOICT



Source: JICA Study Team (JST)

Figure 8.5.11 Upgraded National Addressing System

7) ICT Literacy Education for Citizens

With reference to the introduction of the dedicated government network connecting government offices and the current ICT education programme in which MOICT plans to distribute computers to all pupils attending primary school in 2014, it is essential to improve the officers' ICT literacy. Consequently, it will promote efficient administrative management through the dedicated government network as well as raise citizens' ICT literacy to achieve social and economic benefits based on improved productivity and further promote e-commerce.

People who have low ICT literacy are not familiar with computers. Therefore, it is necessary to provide basic ICT education such as what computers are and how they work (Table 8.5.7). Operating word processing, spreadsheet, and presentation software are the minimum ICT literacy requirement for productivity improvement and effective city management.

i) Objectives

- To improve the citizens' ICT literacy.

ii) Effects

- Prompt and effective implementation of administrative management,
- Job creation,
- Growth of investment opportunities, and
- Access to online government services.

iii) Development Items

- The ICT Department is in charge of ICT literacy education for government officers and citizens.
- ICT literacy education for students in primary and secondary schools is under the authority of the Ministry of Education.

iv) Responsible Organisations

- NCC in collaboration with MOICT and MOE

Table 8.5.7 Basic ICT Literacy Education

Step	Content
1.Computer Fundamentals	● Why do we need computers ● Major computer components ● Computer terminologies ● Performance and functions ● Operating system
2. Internet and World Wide Web	● About the internet ● How to operate browser softwares ● E-commerce ● How to send and receive e-mail messages
3.Raise Productivity through the Use of Computers	● Word processing ● Spreadsheet ● Presentation ● Database
4.Security and Privacy	● Outlines of computer security and privacy ● Privacy protection ● Securing computer with latest security conditions ● Computer ethics

Source: JICA Study Team (JST)

8) Establishment of a Framework on Construction Supervision and Maintenance Works

The quality of construction or maintenance works for telecommunications infrastructure are various and nonconstant. This comes from insufficiency of regulations or codes to define the procedure of the works. Meanwhile due to the expansion of the jurisdiction of NCC based on the enforcement of the new law after the election in 2013, NCC was supposed to have the power to consider and approve all development applications and grant all development permissions, and control the use and development of land and buildings in the city area. In this situation, in order to upgrade the quality of the telecommunications infrastructure works, the regulations and codes for developing supervision and maintenance works on telecommunications infrastructure should be strengthened and strictly complied with. In view of this, NCC has the responsibility for managing and controlling the works without depending on operators and contractors.

i) Objectives

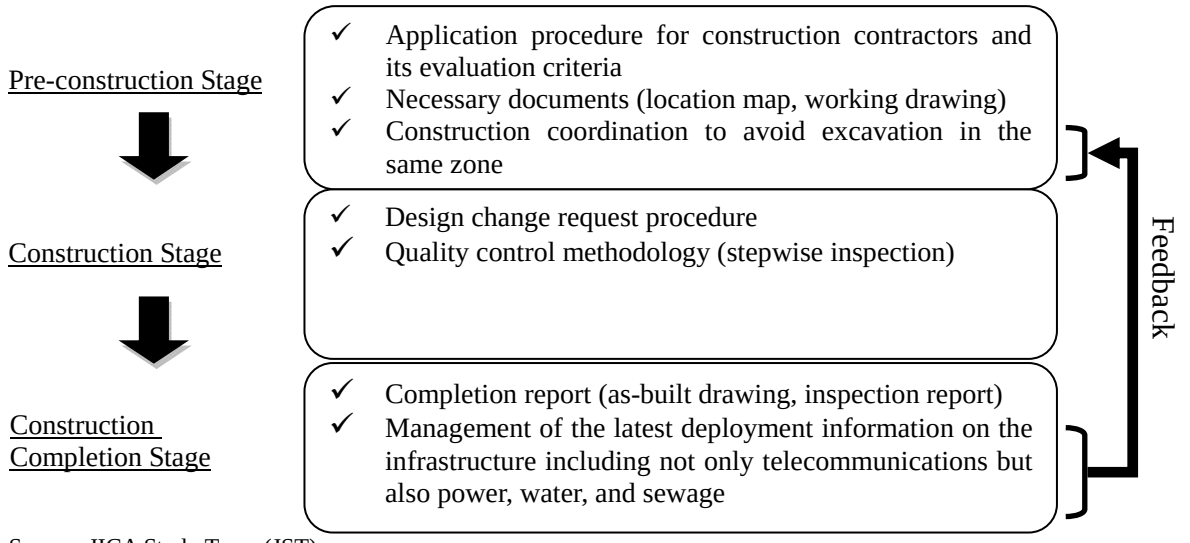
- Improvement of construction and maintenance works' quality.

ii) Effects

- Prolonging the life of infrastructure,
- Improved reliability of telecommunications infrastructure,
- Reduction of maintenance costs, and
- Promotion of cooperation amongst operators, contractors, and NCC.

iii) Development Items

- Framework on Construction Supervision and Maintenance Works.



Source: JICA Study Team (JST)

Figure 8.5.12 Framework on Construction Supervision and Maintenance Works

iv) Responsible Organisation

- NCC

9) Infrastructure Sharing Policy

The introduction of common infrastructure provides benefits to both NCC and the operators in terms of cost, infrastructure management, urban landscape, and future planning of urban development. With reference to the introduction of common infrastructure, JST proposes to set up an operation and maintenance policy for each operator to use the common infrastructure fairly and efficiently as well as for NCC to administer it securely and effectively. Since the properties of various operators will be committed to the common infrastructure, NCC should operate the common infrastructure responsibly according to the O&M policy.

i) Objectives

- To consolidate management of common infrastructure, and
- To set the methodology and procedures for the common infrastructure.

ii) Effect

- Effective infrastructure management

iii) Development Items

- Infrastructure sharing policy
  - Administration and management of common infrastructure,
  - Formulate application and operation procedures for common infrastructure users,
  - Equipment, cables, and related apparatus allowed to be installed on common infrastructure,
  - Loss and damages and dispute treatment, and
  - Cost sharing for construction and maintenance of common infrastructure.

iv) Responsible Organisation

- NCC

(2) Priority Projects

1) Selection of Priority Projects

From amongst the nine projects, five were selected for priority implementation based on their urgency, the rate of involvement of NCC, and the range of beneficiaries that can be reached. Projects that receive high evaluation scores are selected as priority projects.

As a result of the evaluation, JST proposes the prompt implementation of the following five projects. The evaluation results are shown in Table 8.5.8.

Priority Projects
1. Optic Trunk Communication Network in Nairobi City
2. Common Infrastructure for Operators
3. Introduction of Dedicated Government Network amongst Government Offices
4. Disaster Information Gathering and Dissemination System
5. Infrastructure Sharing Policy

Table 8.5.8 Evaluation of the Project

Project	Urgency	Score	NCC's involvement	Score	Range of Beneficiaries of the project (Direct benefit)	Score	Evaluation Score	Note
1. Optic Trunk Communication Network in Nairobi City	High	2	Middle	1	NCC/Operator/Government /User	2	**5**	Selected
2. Common Infrastructure for Operators	High	2	High	2	NCC/Operator	1	**5**	Selected
3. Introduction of Dedicated Government Network among Government Offices	High	2	High	2	NCC/Government	1	**5**	Selected
4. Disaster Information Gathering and Disseminating System	High	2	High	2	NCC/User	1	**5**	Selected
5. Government Data Center with Cyber Security	Middle	1	High	2	NCC	0.5	**3.5**	
6. Upgrading National Addressing System	Middle	1	Middle	1	NCC/Government	1	**3**	
7. ICT Literacy Education for Citizens	Middle	1	High	2	User	0.5	**3.5**	
8. Establishment of Framework on Construction Supervision and Maintenance Works	Middle	1	High	2	NCC/Operator	1	**4**	
9. Infrastructure Sharing Policy	High	2	High	2	NCC/Operator	0.5	**4.5**	Selected
Note: Evaluation scores	High:2 pt. Middle:1 pt.		High:2 pt. Middle:1 pt.		4 players: 2 pt. 3 players: 1.5 pt. 2 players: 1 pt. 1 player: 0.5 pt.			

Source: JICA Study Team (JST)

2) Evaluation

Each project is evaluated based on the following: a) urgency, b) role of NCC to the initiative, and c) beneficiary of the project. Contents of the evaluation conditions are explained below.

i) Urgency

Either "High" or "Middle" is put for each project based on its urgency. "High" is applied to a project that needs to commence as soon as possible in consideration of the current condition of the telecommunications sector. The evaluation chart is presented in Table 8.5.8.

ii) NCC's Involvement in the Implementation of the Project

To evaluate NCC's involvement in the development of the project, similarly either "High" or "Middle" mark is put for each project. "High" is marked to a project where NCC should be involved in its implementation. JST proposes that NCC should be involved in the implementation of the following projects:

Project No.2: Common Infrastructure for Operators

Project No.3: Introduction of Dedicated Government Network amongst Government Offices

Project No.4: Disaster Information Gathering and Dissemination System

Project No.5: Local Government Data Centre and Cyber Security

Project No.7: ICT Literacy Education for Citizens

Project No.8: Establishment of Framework on Construction Supervision and Maintenance Works

Project No.9: Infrastructure Sharing Policy

iii) Range of Beneficiaries of the Project

The projects are also evaluated according to the number of people they benefit. A high rating is given to projects that will benefit a large number of people.

Doris Severino, Kileleshwa Primary School (Rank 2 of Class 6)