
LAPSSET CORRIDOR AND NEW LAMU PORT FEASIBILITY STUDY AND MASTER PLANS REPORT

VOLUME THREE: LAPSSET CORRIDOR MASTER PLAN AND DEVELOPMENT PLAN

EXECUTIVE SUMMARY

Objectives of the Study

The contract for “*the Consulting Services for the Feasibility Study on Infrastructure Development for the Lamu-Southern Sudan-Ethiopia Transport (LAPSSET) Corridor and the Master Plan for the Proposed Lamu Port at Manda Bay & Detailed Design for the First Three Berths & Associated Infrastructure*” was signed on 13 May 2010 between the Government of Kenya through the Ministry of Transport (MOT) and Japan Port Consultants Ltd. (JPC) in collaboration with BAC/GKA JV Company.

The Services consist of two major activities, i.e. (1) Preparation of a Feasibility Study (FS) for the LAPSSET Transport Corridor Project as a whole and (2) Preparation of a Master Plan (MP) and Design and Development (DD) for the new Lamu Port Project, including preparation of tender documents. This Project is one of the priority “flagship” projects identified in the government’s long-term development policy, *Kenya Vision 2030*. Because of the importance and urgency of the Project, the study period for the provision of the consultancy Services was limited to a total of 13 months.

The final report consists of five volumes, i.e. Volume One: Feasibility Study and Preliminary Design for the LAPSSET Corridor Components; Volume Two: Master Plan for the New Lamu Port and Lamu Metropolis Development Plan; Volume Three: LAPSSET Corridor Master Plan and Development Plan; Volume Four: Summary of Conclusions and Recommendations, and Volume Five: Attachments.

PART I. CORRIDOR ROUTES AND CROSS SECTION PLAN

23. Corridor Arrangement Plan

- 1) The LAPSSET Corridor consists of three major transport infrastructure components, i.e. the railway, highway and pipeline. Basically, the three components will run parallel to one another in view of the need for road transport in the construction and maintenance of all the other components.

Alternative corridor routes in Kenya have been discussed through:

- a. Route analyses based on available geographical maps with scales of 1/50,000 and 1/100,000;
- b. Site surveys on the route conditions by means of aerial reconnaissance observations and land observation from vehicles on site; and
- c. *Network analyses* of the six major alternative routes.

On the basis of the above considerations, the route connecting the following nodes was selected as the routes for aerial photo mapping survey illustrated in **Figure S3-1** below.

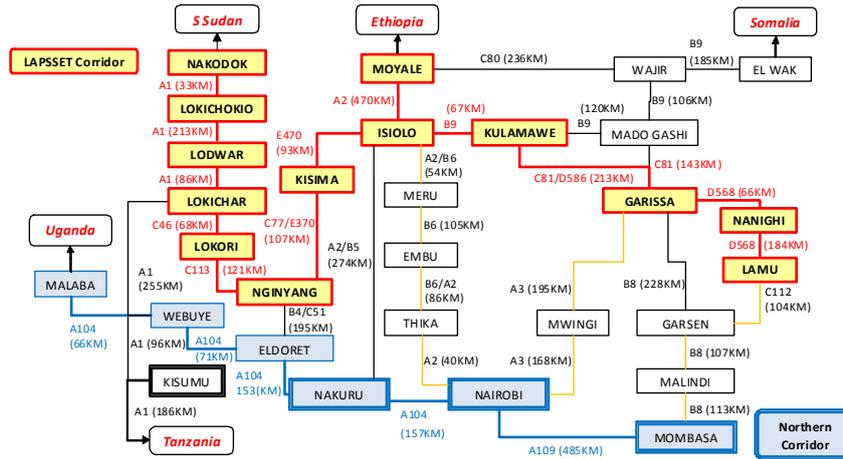


Figure S3-1 Network of LAPSSSET Corridor, Northern Corridor and Existing Main Roads

Source: JPC

(Sudan LAPSSSET Corridor: 1,250km)

Lamu – Garissa – Kula Mawe- Isiolo – Kisima - Ngi Nyang – Lokori – Lokichar – Lodwar – Lokichokio - Nakodok.

(Ethiopia LAPSSSET Corridor: 460km)

Isiolo – Laisamis - Marsabit – Moyale

(Isiolo-Nairobi Link: 270 km)

These sections do not form a part of the LAPSSSET Corridor, but these are to be furnished to link the Corridor with the existing Northern Corridor.

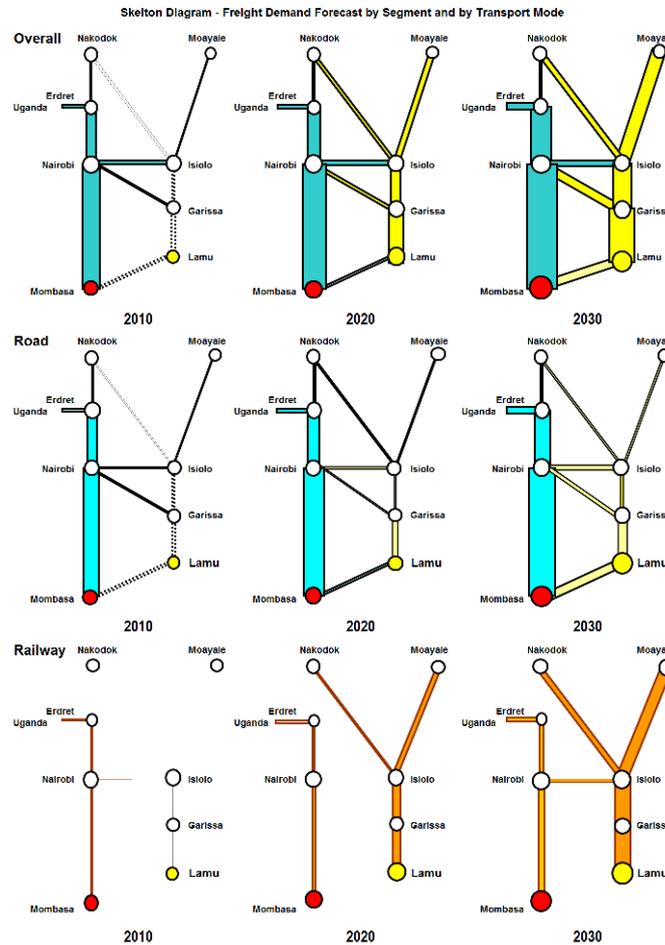
Figure S3-2 illustrates the route of LAPSSSET Corridor by transport mode i.e. crude oil pipeline, railway, highway and location of New Lamu Port, airport and resort cities.



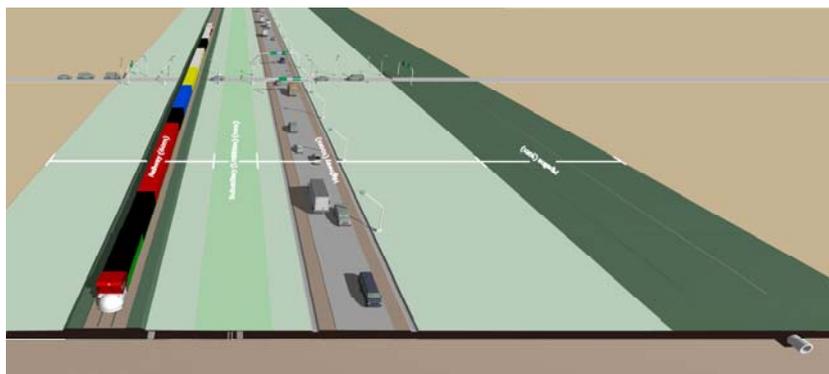
Figure S2 LAPSSSET Corridor Routes

- 1) **Traffic Demand forecast** of freight and passenger has been prepared at the two stages of 2020 and 2030 based on the information and data collected above for planning of Lamu Port and the corridor facilities. It is estimated that the total dry cargo throughput at Lamu port amounts to 13.5 million tons in 2020 and 23.9 million tons in 2030 which is larger than that of present Mombasa Port.
- 2) In consideration of **modal split** by kind and type of commodities, distance of transportation,

etc. the freight volume are assessed to be shared by railway, highway and pipeline. The freight share of **railway** excluding crude oil in 2020 is estimated to be 96.1% at Southern Sudan-Isiolo section, 93.2% at Ethiopia-Isiolo section, 94.3% at Isiolo-Garissa section, and 60.2% at Garissa-Lamu Section as indicated in skeleton diagram below.



- 3) **Air passenger** demand is forecasted for Lamu, Isiolo and Lokichokio. In 2030, Lamu is expected to have 600,000 persons per annum. A certain number of railway **passengers on the Corridor trains** are also expected, especially once the tourism corridor will be fully developed. **Passengers between Nairobi and Isiolo** who may take cars and buses are projected to be more than 7 million persons per year in 2030. It is estimated that by the year 2030, there will be 700,000 passenger traffics per year between Nairobi and Lamu through Garissa.
- 4) The cross section of the Corridor is planned to have a total width of 200m at **standard sections** where the width or Right of Way (ROW) is shared by Railway, Highway, Pipeline, and allowance for Services consisting of 60m, 100m 30m, and 10 meters wide, respectively.

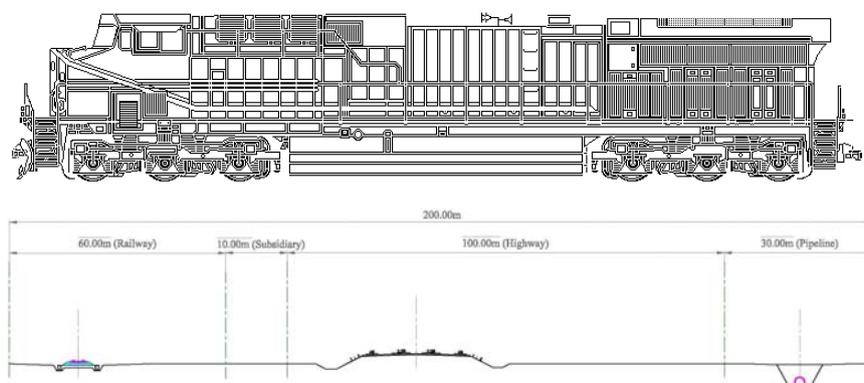


PART II. LAPSSET CORRIDOR COMPONENTS PLANS

24. Master Plan of LAPSSET Railway

(1) Overview of LAPSSET Railway Plan

- 1) Based on the demand forecast, design standards, and temporary route setting, the **railway construction plan** with the **standard gauge** has been formulated for the *Lamu Section*, i.e. Lamu-Garissa-Isiolo, the *Southern Sudan Section*, i.e. Isiolo-Nginyang-Nakodok., and the *Ethiopia Section*, i.e. Isiolo-Moyale.
- 2) It is estimated that number of freight trains on the busiest Lamu Section will reach 78 trains (74 freight trains and 4 passenger trains) per day at the busiest section between Lamu-Isiolo in 2030. Thus, it is planned that, until the target year of 2030, the railway keeps **the single track line**. Furthermore, in view of long distance and high construction cost for electricity supply (Cost of KShs 80 billion for about 1,800km long power transmission line) the railway shall be operated by the **diesel driven system** to minimize the capital and maintenance costs.



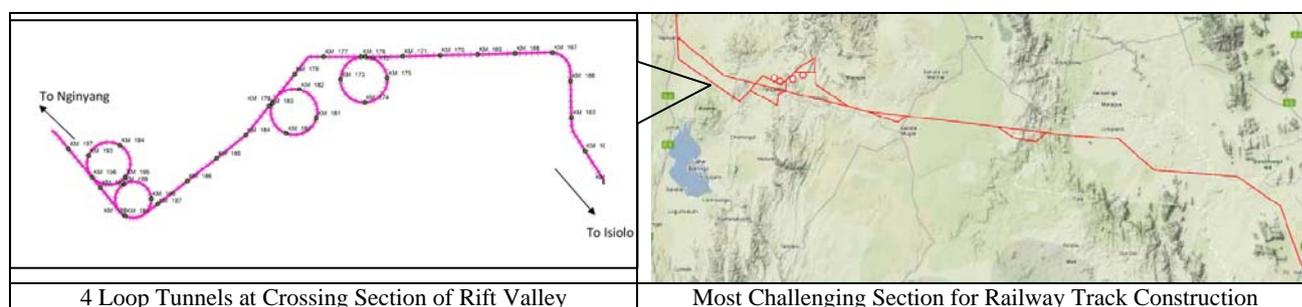
- 3) The railway line crosses many rivers and needs many **bridges**, most of which are less than 100 meters long. At the section between Isiolo and Nginyang, it is estimated that five **tunnels** of 5 km long each and six short tunnels will become necessary to abide by the maximum gradient of 1.5% to pass the Rift Valley part. At the Isiolo-Moyale section two tunnels with lengths of 2 to 4 km are necessary.
- 4) **Construction of LAPSSET Railway Network** is expected to take three years and will complete by the end of 2016, subject to all necessary arrangements for implementation of the Project being satisfactorily made. In order to improve economic investment efficiency, it may be considered that construction of the Southern Sudan – Isiolo section should be deferred until the time when agriculture and other new industries in Southern Sudan will be developed substantially, say five years after the other sections.
- 5) The overall **construction schedule** plan of all the LAPSSET Transport Corridor components are shown in **Table S3-1** on the next page. The completion date of the Corridor is set at the end of 2016 except the Southern Sudan section of the Railway and Other Components.

(2) Railway Transportation Volume

- 1) **The share of railway transportation volume** constitutes more than 90% of long-hauling cargo movement between Lamu and Southern Sudan/Ethiopia.
- 2) **The total volume in 2020** is 3 million tonnes for import and 4.7 million tonnes for export, including containers of 2.1 million and 1.8 million tonnes for import and export, respectively. **In 2030**, they increase to 5.1 million tonnes and 9.3 million tonnes, including containers of 3.5 million and 3.8 million tonnes, respectively.

(3) Track Alignment

- 2) **The landform pattern** is classified as: (Lamu Section) Lamu-Garissa: Flat, Garissa-Isiolo: Moderate, (Sudan Section) Isiolo-Nginyang: Mountainous, Nginyang-Lodwar: Moderate, Lodwar-Lokichokio: Hilly, and Lokichokio-Nakodok: Moderate. (Ethiopia Section) Isiolo-Marsabit: Hilly, and Marsabit-Moyale: Hilly.
- 3) The number of **passing loops** and **switchbacks** employed are 56 and 3, respectively. The total length of **partial double tracks** is 100 km. The switchbacks are constructed only in Isiolo-Nginyang section to cross the Rift Valley.
- 4) The number and distance of **tunnels** are 25 and 62.5 km, respectively, in which a distance of 16.65 km has double track structure. Four of the tunnels are **loop tunnels** with a length of 5 km. (See figure below) At the section between Isiolo and Nginyang, it is estimated that five **tunnels** of 5 km long each and ten short tunnels will become necessary to abide by the maximum gradient of 1.5% to pass the Rift Valley part. At the Isiolo-Moyale section two tunnels with lengths of 2 to 4 km are necessary.



(4) Preliminary Design of Facilities and Equipment

- 1) The main **design standards** employed are, based on *American Railway Engineering and Maintenance-of-Way Association (AREMA)* Standards, Design speed: (Passenger train) 160 km per hour (Kph), (Freight train) 120 Kph, Gauge: 1,435 mm (*Standard Gauge*), Maximum grade: 1.0% in flat area and 1.5% in mountainous area, and Minimum horizontal curvature: 2,000m (desirably 2,500m).
- 2) Based on the demand forecast, design standards, and route setting; the **railway construction plan** with the **standard gauge** has been formulated for the *Lamu Section*, i.e. Lamu-Garissa-Isiolo, the *Southern Sudan Section*, i.e. Isiolo-Nginyang-Nakodok., and the *Ethiopia Section*, i.e. Isiolo-Moyale.
- 3) It is estimated that **number of freight trains** on the busiest Lamu Section will reach 39 trains for one way per day at the busiest section between Lamu-Isiolo in 2030. Thus, it is planned that, until the target year of 2030, the railway keeps **the single track line**. Furthermore, in view of long distance and high construction cost for electricity supply (Cost of KShs 80 billion for about 1,800km long power transmission line) the railway shall be operated by the **diesel driven system** to minimize the capital and maintenance costs.
- 4) The railway line crosses many rivers and needs **bridges** and **culverts**, i.e. 181 and 316, respectively. Most of them are less than 100 meters long. Bridges are designed by categorizing into nine kinds from 20m to 300m.
- 5) The volumes of **fill and cut** works are 84.0 million m³ and 95.8 m³, respectively
- 6) **Stations** are planned and designed at eight nodal points, i.e. Lamu, Garissa, Isiolo, Nginyang, Lodwar, Nakodok, Marsabit and Moyale. Freight handling is made at Lamu. Train composition is done at Lamu and Isiolo, and locomotive change is at Lamu, Isiolo, Moyale, Lodwar and Lokichokio. **Lamu Station** has a Port Yard and a *Railway Freight Terminal (RFT)*. The Port Yard has arrival/departure tracks and sorting/storage train make-up tracks, a depot and a workshop, passenger station, and other facilities. At RFT, Reach Stacker System

is employed to handle containers.

- 7) **Signal systems** are planned, including Automatic Blocking System (ABS), Centralized Train Control System (CTC), and Automatic Train Stop System (ATS-P). **Telecommunication Systems** include Train Radio System equipped with GSM
- 8) The railway development between **Isiolo and Nairobi** through the eastern skirts of Mt. Kenya is considered necessary as an additional link of the Corridor. The route is aligned on the eastern periphery of Mt. Kenya based on geographical analysis by means of the aerial photo maps, of which design is laid at the later stage of Detailed Design.

(5) Construction Plan

- 1) **Construction of LAPSET Railway Network** is expected to take three years to complete and it is planned to be completed by the end of 2016, subject to all necessary arrangements for implementation of the Project being satisfactorily made. In order to improve economic investment efficiency, it may be considered that construction of the Southern Sudan – Isiolo section should be deferred until the time when agriculture and other new industries in Southern Sudan will be developed substantially, say five years after the other sections.
- 2) The overall **construction schedule** plan of all the LAPSET Transport Corridor components are shown in **Table S3-1** on the next page. The completion date of the Corridor is set at the end of 2016 except the Southern Sudan section of the Railway and Other Components.

(6) Cost Estimate

- 1) **Costs for construction of LAPSET Corridor Railway and procurement of rolling stocks** are estimated, as summarized in **Table S3-2**, at approximately US\$ 7,100 million in total, including civil works US\$ 3,480, tracks US\$ 1,200, rolling stock US\$ 1,220, signal and telecom US\$ 520, buildings USD\$ 300, and others in million.
- 2) The costs by sections are divided into Lamu-Isiolo (530 km) US\$ 1,540 million, Isiolo-Moyale (460 km) US\$ 1,640 million, and Isiolo-Nakodok (720 km) US\$ 3,920 million. The share is 21.7%, 23.1% and 55.2%, respectively. In other words, more than a half of the investment is for Isiolo-Sothern Sudan border section.
- 3) The unit costs for these sections are US\$ 2.91 million/km, US\$ 3.56million/km and US\$ 5.44 million/km, respectively. Thus, the cost at mountainous areas to pass Rift Valley (Isiolo-Nakodok section) is almost twice expensive than that of flat areas (Lamu-Isiolo section).

(7) Economic Evaluation

- 1) **Railway** has overall Economic Internal Rate of Return (EIRR) of 15.6% for all sections combined. The project is considered feasible from the viewpoint of national economy.
- 2) It can be 17.8%, which is derived based on an assumption that construction of the Sothern Sudan section will be done after five years from the start of the Corridor Projects waiting for development of export industries in Southern Sudan such as agriculture.
- 3) In the case of **LAPSET Railway** under PPP Scheme, required **tariff** can be US\$ 0.131, US\$ 0.98, US\$ 0.65/ton-km for break bulk, container and bulk cargos, respectively. The **lease charge** of track is US\$ 343 million/year from the private operator under PPP.

(8) Investment Plan

- 1) In consideration of the past experience of failure in concessioning the existing railways in Kenya, **government involvement** for the initial capital investment for the LAPSET Corridor railway will be indispensable, because the cost is huge.
- 2) Another important fund raising method is to procure funds not only from **multi-lateral and bi-lateral sources** such as co-financing, but also from the **beneficiary countries** of the Corridor, i.e. Southern Sudan and Ethiopia.
- 3) The **PPP scheme** could be applied, whereby **the private sector** participates in management

and operation of the railway with adequate expertise and financial capacity based on lease contract of the infrastructure with the government.

(9) Institutional and Legal Framework

- 1) A new Implementing Organizations for LAPSSET Corridor management, i.e. **LAPSSET Corridor Authority (LCA)**, will be established as the planning, coordinating, fund raising and management organization for LAPSSET Corridor, .
- 2) For railway, **LAPSSET Regional Railway Authority (LRRRA)** would be set up, which is financed from a membership fee and a part of access charge paid by the concessionaire for use of the LAPSSET railway infrastructure.

25. Master Plan for LAPPSET Highway

(1) Highway Planning

- 1) **Alignment of LAPSSET Highway** routes are planned, considering the natural conditions such as geology, geography, hydrology and vegetation, the social and economic conditions such as population, industry and urbanization. Several alternative routes are compared and discussed by *the Network Analysis*, e.g. four routes between Isiolo and Lodwar. The selected route runs mostly through the same route as that of railway on the plain areas. The routes, as shown in **Figure S3-1**, basically follow the existing roads except Ijara-Garissa on the Lamu-Garissa section, Junction of C81-D586-Kulamawe on the Garissa-Isiolo section, and several **missing links** between Isiolo and Nginyang.
- 2) In consideration of sections between Isiolo-Moyale and Isiolo-Nairobi which are under construction by *the African Development Bank* and *the World Bank*, the remaining length is about 880km for **the LAPSSET Corridor Highway Project**.

(2) Preliminary Design of Highway Facilities and Equipment

- 1) The main **design conditions of the highway** are *the Ministry of Road Design Manual (RDM)* and the *American Association of State Highway & Transportation Officials (AASHTO)* standards: Design vehicle: WB-15 (semi-trailer), Maximum design speed: 140 Kph, Maximum grade: 3%, and Minimum radius of horizontal curve: 1,400m except mountainous area, respectively,
- 2) Initially, the highway is to be constructed as **two-lane road** with a standard width of 11m (= 2 x carriage way 3.5m + 2 x shoulders 2.0m). There are **no tunnels** on the routes.
- 3) Typical **box culvert** and reinforced concrete (RC) **bridge** structures are designed.
- 4) **Pavement** structure is designed for *Heavy Good Vehicles (HGV)* and buses, based on *the Expected Standard Axles (ESA)/day* and *Traffic Class T3* calculated from *the Annual Average Daily Traffic (AADT)* and *Equivalence Factor (EF)* with the design life of 15 years. As the result, pavement type is divided into two, i.e. one is for Lamu-Garissa section (Sub-base: GCS 275mm, Base: Cement Stabilized Gravel 200mm, and Surface Course: Asphalt Concrete (AC) 100mm) and the other is Garissa-Northwards (Sub-base: Cement/lime improved material 200mm, Base: Same 150mm, and Surface: AC 50mm).

(3) Construction Plan

- 1) **Construction bases** will be located at five towns: Lamu, Garissa, Isiolo, Nginyang and Lokichar. Each base shall cover the following one segment on the Corridor.
- 2) **Construction** will be carried out by separating the total length into five segments or eight sections with a length of less than 140 km each, which are to be constructed simultaneously: a. Lamu to Garissa (250km):2 sections, b. Garissa to Isiolo (280km):2 sections, c. Isiolo to Kisima (100km):1 section, d. Kisima to Nginyang (100km):1 section, and e. Nginyang to Lokichar (190km):2 sections.

- 3) The **period necessary for construction** of the proposed highway is generally at least five years for all segments. If the highway construction is packaged into segments as stated above, however, the period can be shortened to three years until 2016 as shown in **Table S3-1**, subject to early planning for mitigation measures against possible bottlenecks and unexpected occurrences..

(4) Cost Estimate

- 1) The **total construction cost** is estimated at US\$ 1,396 million as shown in **Table S3-2**.
- 2) The construction cost by sections are: Lamu-Isiolo (530km) US\$ 752 million and Isiolo-Lokichar (350km) US\$ 644 million. The share of the cost is 53.9% for Lamu-Isiolo and 46.1% for Isiolo-Lokichar.
- 3) The unit construction cost of the LAPSSET Highway is US\$ 1.42 million/km (Lamu-Isiolo) and US\$ 1.84 million/km (Isiolo and northwards). In other words, the latter which passes Rift Valley is about 30% higher than the former, or the flat Lamu-Isiolo section.

(5) Economic Evaluation

- 1) **Highway** has an EIRR of 12.9% for the total length of 920km from Lamu to Lokichar. The section-wise EIRRs are 27.9%, 8.2%, and 0.0% for Lamu-Garissa, Garissa-Isiolo and Isiolo-Lokichar, respectively. It is considered that the LAPSSET Highway is feasible from national economic viewpoint.
- 2) **The Rift Valley and Isiolo portions** shows minus Net Present Value (NPV) and, if it is considered locally or evaluated by section, the project for this portion is difficult to be viable economically.
- 3) **LAPSSET Highway** under PPP Scheme has required **toll fee** for trucks of US\$ 22, US\$180, and US\$ 748/ section for Lamu-Garissa, Garissa-Isiolo and Isiolo-Lokichar, respectively. The Isiolo-Lokichar section is financially difficult to manage alone.
- 4) The **lease charges** of the Highway, corresponding to 10% of FIRR, are US\$ 19.9 million/year, consisting of US\$ 7.8, US\$ 6.7, and US\$ 5.4 million/year for Lamu-Garissa, Garissa-Isiolo, and Isiolo-Lokichar sections, respectively.

(6) Investment Plan

- 1) The total initial investment cost is about US\$ 1.4 billion, which is vary large amount and to be borne by **the public sector**, i.e. possibly the government and multi or bi-lateral donors. .
- 2) If necessary, investment can be divided by **priority**, i.e. Lamu-Isiolo first and then Isiolo and northwards.
- 3) Introducing PPP Scheme, the infrastructure should be **owned and maintained** by the public sector, and leased out to a qualified and selected private party entity(s) to **operate** the Corridor by collecting the toll and paying the lease charge.

(7) Institutional and Legal Framework

- 1) Highway plan will be managed also by the LAPSSET Corridor Authority (LCA).
- 2) Initial construction will be executed by the existing **Kenya National Highway Authority** (KeNHA) and **the Kenya Roads Board** (KRB). For Lamu-Garissa section, capital financing by the private sector under an appropriate concessioning can be arranged when the traffic volume increases to a significant level. For the rest of the sections there is room for involving the private sector in Operations and Management (O&M).
- 3) After the traffic will be developed, PPP concession for 20-30 years can be introduced, whereby the concessionaire will collect a toll and operate and maintain the Highway.

26. Master Plan of LAPSSET Oil Pipeline

(1) Pipeline Route Alignment

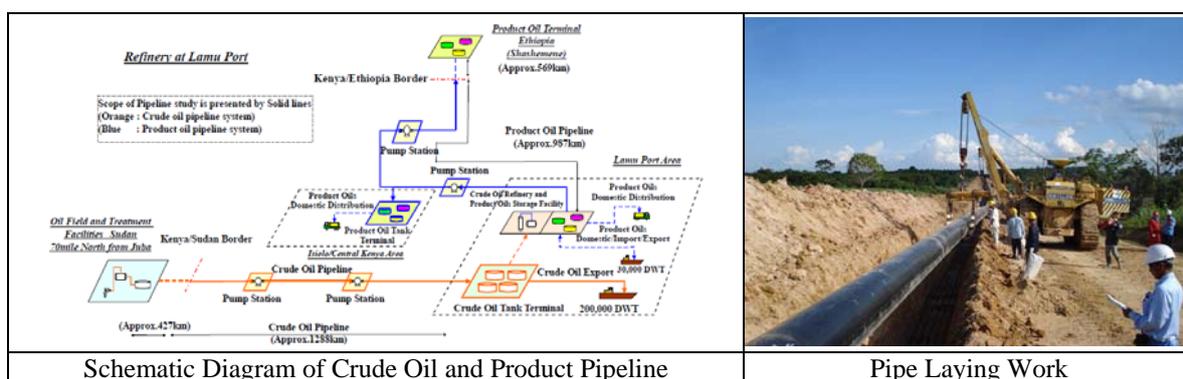
- 1) **Oil Pipeline** for sending crude oil from Southern Sudan to Lamu via Isiolo is planned parallel to the highway routes at flat areas, and independently at precipitous areas (1,288 km long in Kenya, 427km in Southern Sudan) with a capacity of 500,000 barrels per day (bbl/day).
- 2) A part of the crude oil, i.e. 417,600bbl/day, is to be exported from Lamu Port. **Crude oil exporting pipelines** are planned from the *Lamu Tank Terminal* located to the north of the Lamu Port to the two Single Point Mooring Buoys (SPMBs) at the outer channels through Pate Island..
- 3) Another pipeline, which is for refined oil, i.e. diesel 52%, kerosene 29% and gasoline 12%, and called **product oil pipeline**, is planned with a capacity of 97,900 bbl/day. The pipeline is proposed to supply for local demand as well as 30% of consumption of Ethiopia. It extends from Lamu to Isiolo (97,900 bbl/day) and from Isiolo to Moyale (57,700 bbl/day) through the *Isiolo Tank Terminal* (990km in Kenya, 570km in Ethiopia).

(2) Preliminary Design of Oil Pipeline

- 1) **Design standards** employed are the American Petroleum Institute “Line Pipe” (API 5L) and American Society of Mechanical Engineers i.e. Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquid (ASME B31.4).
- 2) Based on the design pressure of 9.32 MPa, **hydraulic analysis** is made and pipes with diameters of 48 inches and 44 inches are planned for the northern section from Sudan to Rift Valley (570 km) and Rift Valley to Lamu section (715 km), respectively.

Six **Pump Stations** with a power of approximately 2,300kW each are required in Kenyan territory. It is noted that, from Juba to Sudan-Kenya border in Southern Sudan, a pipeline with 48 inch x 427 km and 3 pump stations become necessary. The grade of pipe itself is API 5L-X80.

- 3) The pipeline from the Lamu Crude Oil Tank Terminal to **SPMBs** at offshore for export of crude oil is designed. The pipelines have a length of 42km with a capacity of 4,000 m³/hour x 2 lines with 48-inch pipes (*twin pipelines*) and pipe grade: API 5LX-60.
- 4) Conceptual design of **SPMB** for 200,000 DWT tankers is also shown in the Report
- 5) The **product oil pipelines** are designed. Product oil will be transported in a *single pipeline* (multi-product pipeline) with diameters of 18 inches between Lamu to Isiolo and 16inches from Isiolo to Ethiopia and grade of API 5L X-60 by *batch method*.



(3) Construction Plan

- 1) **Construction** will take three and a half years as shown in **Table S3-1** by separating the total length into several segments which are to be constructed simultaneously.
- 2) The crude oil and product oil pipelines are to be buried with **earth cover** of not less than 1m thickness in consideration of effect of sun heat, security, and others.

- 3) The **undersea pipelines** from Lamu Tank Terminal to offshore SPMBs are also to be buried under the seabed so as not to be damaged by ship anchors.

(4) Cost Estimate

- 1) The **total construction cost** of crude oil and product oil pipelines is estimated at US\$ 3,950 million as shown in **Table S3-2**. The cost for **Crude Oil Pipeline** is US\$ 3,060 million, consisting of Lamu-Isiolo (540km) US\$ 1,480 million, Isiolo-Nakodok (780 km) US\$ 1,240 million, and Lamu Port Area US\$ 340 million.
- 2) The construction cost for **Product Oil Pipeline** is US\$ 885 million, which can be broken down to Lamu-Isiolo (540 km) US\$ 572 million and Isiolo-Moyale (450km) US\$ 314 million.

(5) Economic Evaluation

- 1) **Crude Oil Pipeline** (Lamu-Nakodok) and **Product Oil Pipeline** (Lamu-Isiolo and Isiolo-Moyale) have EIRR of 21.6% and 14.0%, respectively. They can be considered feasible from the viewpoint of national economy.
- 2) **Crude Oil Pipeline** and **Product Oil Pipeline** are assumed under totally private investment. The cut-off FIRR is set at 10%. The **transportation charges** are assessed to be US\$ 2.45/bbl, and US\$ 2.62/bbl, respectively, which are considerably lower than the transport cost by other transport mode such as lorry or railway tanker. Thus, the project can be considered to be financially viable.

(6) Investment Plan

- 1) The project will be undertaken as purely a Private Project. The fund should also be provided by the private party entity.
- 2) Crude oil and product oil pipelines are separately constructed, operated and maintained by their companies.

(7) Institutional and Legal Framework

- 1) Crude Oil Pipeline Company will be created and transport, store and export the crude oil imported from Southern Sudan and possibly from Kenyan sources in the future. The company will own and operate the Single Point Mooring Buoys (SPMB) at Lamu Port.
- 2) Products Oil Pipeline Company will be created which receives the Oil Marketing Company (OMC) products from the Lamu Refinery and possibly from abroad. The product oil will be transported to Isiolo and Ethiopia through the pipelines.

27. Master Plan of Lamu Resort City

(1) Allocation of Resort Cities

- 1) Resort Cities are planned at Lamu, Isiolo and Lake Turkana in view of creating new tourism corridor based on group tours. The resort city consists of the *Core Facilities* and the *Satellite Facilities*.
- 2) **Lamu** is proposed to be “**Collaboration City**” located at Mokowe with the core facilities such as water sports, country club, convention center, and amusement. The Satellite Facilities are Eco-tour points include marine and land sports, fishing, market, surfing; nature safaris; archaeological sites. The Collaborated Cities consist of Conventional Center, Fishermen’s Wharf, Cultural Center, and Amusement Center. The eco-villages are proposed at Kipini, Bawayaa, Manda Island, Pate Island, and Kiwaiyu Island.
- 3) **Isiolo** is proposed to be “**Junction City**” of the LAPSET Highway and Railway, and Culture Core of Kenya with nature safari lands, archaeological sites and eco-villages at *Kipsing Gap, Archer’s Post, and Kura Mawe*.
- 4) **Lake Turkana** is proposed as “**Healing City**” with core facilities at Lodwar City and satellite

facilities of fishing, boat building, health care at hot springs, archaeology sight seeing, trekking, etc. at *Kalokoi, Eliye Springs* and *Loiyangalani*.

(2) Preliminary Design and Construction Plan of Facilities

Bird's-eye views paintings and image pictures are drawn and presented for each core and satellite facilities such as Conventional Center, Fishermen's Wharf, Cultural Center, and Amusement Center.



(3) Cost Estimate and Investment Plan

- 1) Costs for development of resort cities at Lamu, Isiolo and Lake Turkana are estimated, as shown in **Table S3-2**, at US\$ 970 million, US\$ 200 million and US\$ 42 million, respectively.
- 2) Investment for all the resort city facilities will be made by private funds or PPP Scheme. In case of PPP, participation/cooperation of authorities which manage the land is essential.
- 3) Maintaining the quality of the present “Tourism Resources” and improvement of potential for development of them are of paramount importance, which can be achieved through active infrastructure improvement by the public sector.

(4) Economic Analysis

- 1) **Resort cities** at Lamu, Isiolo and Lake Turkana have EIRR of 17.1%, 12.8% and 20.8 %, respectively. From national economic point of view, they can be considered as feasible.
- 2) **Resort Cities at Lamu, Isiolo, and Lake Turkana** can be developed and operated by collaboration between public and private sectors. The type of PPP is supposed to be “land lease type”, where lease charge is to be paid annually by the lessee (private resort operator) to the lesser (resort estate owner). The estimated land lease charges are US\$ 22.9, US\$ 7.20, and 0.56 in million/year for Lamu, Isiolo, and Lake Turkana Resort Cities, respectively. The required room charge levels are US\$ 120, US\$131, and \$359 per night, respectively. Lamu and Isiolo can be acceptable, In case of Lake Turkana the room charge is very high, in other words, it must be a very special type resort city, e.g. short stay for rich individual tourists.

(5) Institutional and Legal Framework

- 1) The main implementing agencies will be a combination of private party, i.e. a **Master Developer** (MD) and public bodies, i.e. the Ministry of Tourism, the Ministry of Lands, the National Land Commission (NLC), and the relevant county authorities.
- 2) The MD will be competitively sourced by the Ministry of Tourism.
- 3) The public sector will be responsible to provide trunk infrastructure such as piped water, grid electricity and roads. A head lease for each resort site will be issued by NLC to the MD for 99 years at a price that reflects market value.

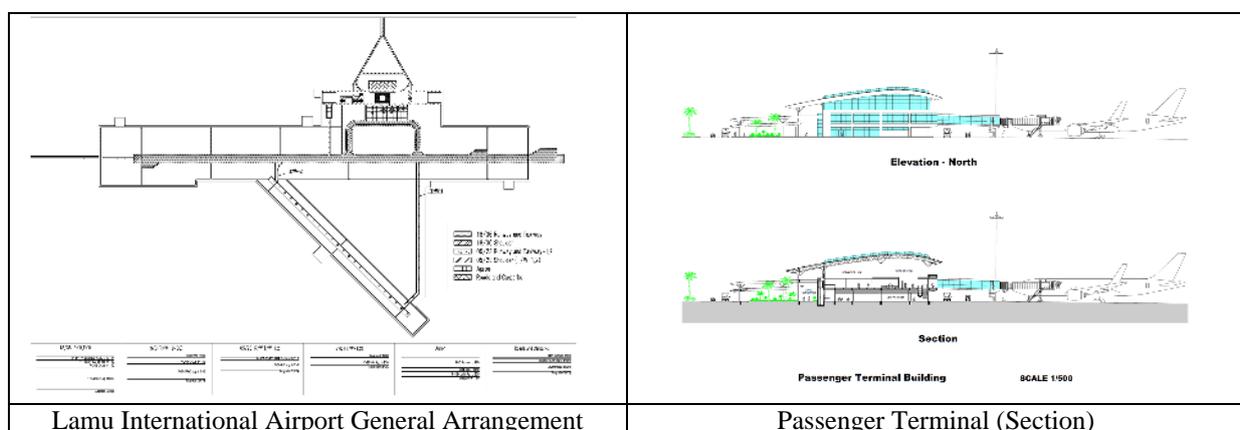
28. Master Plan of Airports

(1) Allocation of LAPSSSET Airports

- 1) **Airports** are planned at Lamu, Isiolo and Lokichokio in this Study. At **Lamu**, three alternative locations of an **international airport** (planned runways with 2,500m and 1,300m long) are compared at Bargoni, Mkunumbi, and Witu. **Mkunumbi** is considered to be best. This evaluation is made based on i) Accessibility and distance from Lamu, ii) Adequacy in land area and geography for airport development, iii) Development cost implication, iv) Harmonization with the present and future land use of surrounding areas, and v) Environmental considerations.
- 2) The existing domestic **airport at Isiolo** (existing runway: 1,500m long) is proposed to be utilized until further expansion will become necessary in the future. When the number of passengers will further increase and larger airplanes will be introduced, a new airport should be planned to the north of Isiolo city.
- 3) The existing **airport at Lokichokio** (existing runway: 1,800 m long) is considered to be rehabilitated for further use. In fact, the existing airport is under rehabilitation by the government.

(2) Preliminary Design for New Lamu Airport

- 1) It is estimated that, in 2030, the traffic is estimated at 1.2 million passengers, including international 0.35 million and domestic 0.85 million; and 2,000 tons of cargos in total including 1,000 tons each for international and domestic.
- 2) Preliminary design is carried out for *Airside facilities* (Runways, Taxiways, etc.) and *land-side facilities* (Terminal Building, Cargo Building, Administration and Operation Building, etc.)



Design data for civil works (earthwork, pavement, and drainage, etc.), and building works for passenger terminal and cargo terminal are described and their drawings are presented.

(3) Construction Plan

Construction schedule is discussed. The construction period is expected to take three years.

(4) Cost Estimate

Costs for civil works, building, utilities, equipment, navigation aides, and aviation fuel supply systems are estimated at US\$ 188 million in total for 2030.

(5) Economic Evaluation

- 1) **Airport at Lamu** has an EIRR of 20.7%, which indicates economic viability.

Airports at **Isiolo** and **Lochichokio**, however, need rehabilitation and maintenance of the existing airports. The maximum allowable costs are assessed to maintain the cut-off EIRR of 12%, i.e. US\$ 175 million and US\$ 143 million, respectively.

- 2) **Lamu International Airport** can be constructed and operated all by the public sector as the Airport Owner, or by PPP of terminal lease type. FIRR is estimated at 5.4% for the former case. In case of PPP, “the Airport Owner” owns and maintains the runway and appurtenant facilities. A qualified and selected private operator builds and operates the Passenger Terminal. The cut off rates of FIRR are 4.0% for the owner and 10.0% for the operator.

It is assessed that the necessary level of Aircraft Landing Charge and Aircraft Parking Charge are US\$ 1,500 and US\$ 800 per aircraft, respectively. The terminal operating right charge is 8.4 million/ year. The passenger facility use charge is US\$ 12 per pax. The car parking charge is US\$ 4.0 per car, terminal tenants charge is US\$ 15,000 per tenant per year and advertisement fees is US\$ 20,000 per user. These unit rates can be accepted by the airport users and the operator. Hence, the Project of Lamu Airport can be considered as financially viable.

(6) Institutional and Investment Plan

- 1) The executing agency is assumed to be **Kenya Airport Authority (KAA)** under MOT.
- 2) In consideration of public nature of an international airport, the basic civil facilities should be constructed, owned, and maintained by the public party. It is necessary to consider **PPP Scheme** also. The passenger and cargo terminals are better to be constructed, owned and operated by qualified private entities.

29. Master Plan of New Lamu Oil Refinery

(1) Basic Oil Refining Plan

- 1) An Oil Refinery development plan is formulated at **Lamu Port** next to the *Lamu Crude Oil Tank Terminal*.
- 2) The plan takes account of several preconditions, i.e. the refinery plan in Southern Sudan, probable construction of refineries at Uganda, possible sources of crude oil (from Southern Sudan), and expansion of the existing Mombasa Refinery. It is assumed that crude oil is **sourced** via the LAPSSSET pipeline at a 5% transport/incentive discount on *Nile Blend* Port Sudan cost.
- 3) **Production plan** has a design capacity of about 125,000 barrel per day. The possible consumers and sales areas are discussed, including central Kenya (about 40,000 bbl/day) and Ethiopia (about 58,000 bbl/day).
- 4) The **products** (diesel oil, Kerosene, and Gasoline) will be mostly sent by Products Oil Pipeline. The non-pipeline products (fuel, oil, LPG, bitumen) will be evacuated via corridor railway and the highway.

(2) Preliminary Design of Refinery Facilities

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- 1) *Linear Programming* (LP) is introduced to establish the most optimum configuration of various process unit and the most optimum crude oil selection and yield pattern. The Nile Blend with TGU/MHC/VDU cracking process is considered best in view of, fuel oil production, kerosene deficit and surplus gasoline.
 - 2) Tanks in the refinery are crude storage tanks, intermediate tanks for secondary feedstock and products tanks for shipping product oil.
 - 3) The products will be sent mostly by “product oil pipeline” to Isiolo and Ethiopia, and a part of the product oil will be shipped from “the Liquid Bulk Berth” in Pate Island by 30,000DWT class tankers. The berth will handle imbalance deficit chemicals to be imported. Tank rollies and rail
 - 4) The refinery has approximately 100 ha area. Power requirements are 25-30 MW. The cooling system is “*recirculation system*” which does not take cooling water from the sea, but fresh water of 2,500 ton/day is proposed to be taken from the Tana River.

(3) Construction Plan

- 1) Refinery area is assessed to be about 53 ha in total, consisting of Crude and Products Tank Farm (16.4 ha), Primary and Secondary Processing Units (6.5 ha), Administration Services (7.5 ha), Construction Yards (6.5 ha), and others.
- 2) Construction works will take about three years.

(4) Cost Estimate

The construction cost of Lamu Refinery is estimated at about US\$ 2.8 billion.

(5) Economic Analysis

- 1) **Oil Refinery at Lamu** has an EIRR of 18.4%, which can be considered feasible from national economic viewpoint.
- 2) Financial analysis is not made in this report, because it is assumed to be a purely private project.

(6) Investment Plan

- 1) The Refinery should have no problem attracting interests from private or PPP investments.
- 2) The business model assumed is “**a merchant refinery**” with revenues from refining margins, i.e. buying crude oils, refining, and selling products. Competition would be mainly from products imported from Middle East and also products from other regional refineries.
- 3) Refinery development at Lamu would take a minimum of five years for financing arrangements, detailed designs, contracting and construction.

(7) Institutional and Legal Framework

- 1) A purely private company, e.g. Lamu Refining Company, will construct, operates and maintain the Refinery.
- 2) Buys crude oil from Southern Sudan or any other sources, refines and sells products to oil marketing company (OMCs) for local and export markets.
- 3) The refinery company makes its return out of refining margins.

30. Associated Infrastructure Development Plan for LAPSSET Projects

- 1) **Demand for electricity** for the LAPSSET Transport Corridor and the New Lamu Port Projects is assessed at 2030 stage to be about 1,100 MVA, including New Lamu City 860 MVA, Oil Pipeline 160 MVA, Lamu Resort 38 MVA, Lamu Port 28 MVA, Oil Refinery 18 MVA, and Airports 7 MVA. Supply of electricity for these demands is planned to be made by

new thermal power plants at Lamu, possibly coal fired and LNG fired plants.

For the Urgent Development Plan of New Lamu Port, two generators of 3,500 kVA will be installed in the Port Management Area.

- 2) **Demand for water** for the New Lamu Port and Lamu Metropolis will be quite high and by far outstretching any locally available sources of supply in the vicinity of Lamu. The greatest challenge will in the long term (2030 and beyond) when the port will be fully industrialized and with population figures of between 450,000 and 1.25 million people in 2030 and 2050, respectively. In the long term, a supply of 181,550 – 296,750 m³/day is anticipated.

The current water demand for Lamu town (Island) is estimated at about 3,000 m³/day. This is met by supply from the Shella well field located within the Island and reached its limit. For the **Urgent Development Plan of the New Lamu Port**, considering the water requirements for the port (350 m³/day), it is planned that water be obtained from **the HIMWA Water Supply** (about 5 km from the port) that can sustain a supply of about 500 m³/day; this if joined together with the LAWASCO's Magogoni supply mains which can supply an additional 30 m³/day can meet the urgent demand. The two transmission pipeline mains, if linked, will have an estimated combined pipeline length of about 6-7 km.

For **2030 and beyond**, this study has looked at the following three sources as the most feasible solutions for the long-term water supply opportunities: Option-1: Conveying water from the Tana River to the Project Area. Option-2: Obtaining water from the **High Grand Falls Dam (HGFD) project** with an uptake at the Nanighi Barrage (weir) and pumping to Lamu, approximately 185 km away. And Option-3: Desalination. At this moment, Option-2 is considered most suitable, and its pipeline system is designed in this Study at master plan level.

- 3) For the **communications systems** for LAPSSET Corridor, **Fiber Optics Cable network (FOC)** is considered as the basis for the development of the communications infrastructure. FOC is becoming less expensive, is easy to install and not prone to interference as compared to other technologies. FOC is suitable for LAPSSET Corridor to be arranged in the 200m Corridor width simultaneously with construction works of the components.

It is noted that FOC also offers very high bandwidths which is a prerequisite for the deployment of advanced services and applications. The use of FOC will also facilitate the integration of existing services and other planned projects viz, the **National Single Window System**, a project by *the Kenya Ports Authority and Kenya Revenue Authority*.

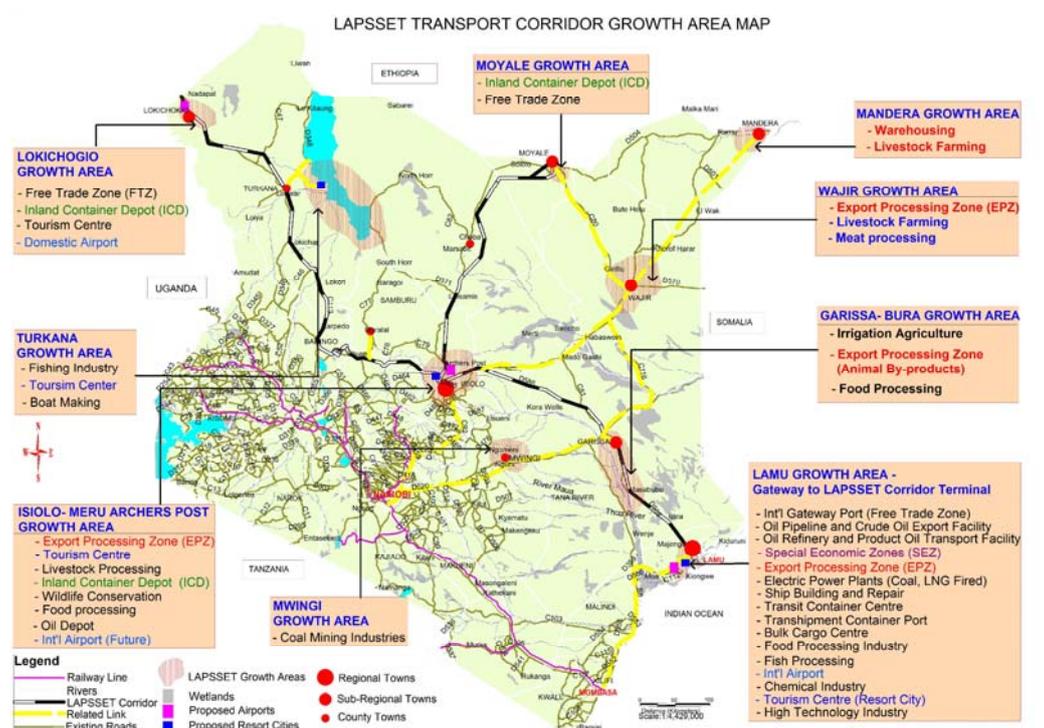
For the **New Lamu Port** at Manda Bay, introduction of the **Electronic Data Interchange (EDI)** as the communication systems for port management and operations, and the **Vehicle Mounted Terminal (VMT)** communication system in the cargo terminals are taken into account as the method for controlling the cargo terminal operations. Other than these two basic systems, individual terminal operation systems are supposed to be introduced by operators.

31. Regional LAPSSET related Development Master Plan

- 1) The LAPSSET Corridor is expected to connect the major centers and sub regions of economic significance, thereby creating new opportunities and more effective land uses that will help in generating more jobs and wealth in the northern regions of Kenya. Beyond. LAPSSET corridor therefore can be visualized as a **development corridor concept** that can elevate a region to a certain level of development. This concept maximizes on a strategy that identifies areas with inherent growth potential for purpose of concentrating investment to stimulate growth .
- 2) The harnessing of the expected newly created opportunities will depend on how mechanisms to facilitate effective planning and development at the local and regional level are evolved. The study identifies **key growth areas** along the corridor with the aim of unlocking potential in specific locations. It has identified the interface between the LAPSSET corridor and the

hinterland social economic potential and the key growth strategy that can be put in place to realize this full potential.

The key growth areas identified as indicated in below map, include the **Lamu Metropolis Area**, **Isiolo Growth Area**, **Garissa-Wajir-Mandera Corridor**, **Lokichogio Growth Area**, **Lake Turkana Growth Area** and **Moyale Growth area**.



- To realize the full potential of LAPSSET Corridor and its full economic impact on the underdeveloped regions of Northern and North-eastern Kenya, the Government will be expected to put in place **funding mechanism** for development of infrastructure to enable the establishment of investments that will assist these identified growth areas reap from their potential.

32. Consolidated Corridor Environmental Plan

- Development of the proposed corridor to ensure **environmental protection** and sustainable development will be the execution of **EIA and AIA studies** for every phase of development. Issues dealing with **land acquisition** should also be addressed.
- In **Lamu Port area** key items of environmental consideration include impacts on *marine life* (Sea Turtle, Dugong, etc), *fishing industry*, *world heritage site*, and *terrestrial floral and faunal species*, *land acquisition* and impact of construction on *HIV/AIDS prevalence*.
- Isiolo area** poses a special case due to *the wildlife migration* corridors which will require to be protected with the development of the corridor. This is due to the existence of surrounding national parks and reserves. EIA and AIA studies will be necessary.
- Development of corridor components around **Turkana and Lokichokio area** should take into consideration impacts on Lake Turkana as a world heritage site and the nearby national reserves. EIA and AIA studies will also be necessary.

PART III. CONCLUSIONS AND RECOMENDATIONS

C1. CONCLUSIONS

Until 2030, the short, middle and long-term plans of **LAPSSET Corridor Projects** are formulated for seven components, including Lamu Port; LAPSSET railway; highway; oil pipeline; oil refinery at Lamu; resort cities at Lamu, Isiolo and Lake Turkana; and airports at Lamu, Isiolo and Lokichokio.

In this Report, the Master Plans for LAPSSET railway; highway; oil pipeline; oil refinery, resort cities and airports are presented, excluding the new Lamu Port and Lamu Metropolis which are described in Volume Two separately.

The **feasibility** is analyzed from technical, economic, financial and other aspects for each component and confirmed that LAPSSET railway; highway and oil pipeline; as well as Lamu oil refinery; Lamu resort city; and Lamu International Airports are all feasible in terms of EIRR, B/C ratio and NPV as well as FIRR and lease costs, etc..

Airports at Isiolo and Lokichokio are under operation and considered that the airport expansion is not needed urgently for the time being. **Resort cities** at Isiolo and Lake Turkana are premature to make large-scale investment for infrastructure.

Institutional and legal arrangements are discussed. Alternatives for LAPSSET Corridor management body are presented, and establishment of *the LAPSSET Corridor Authority (LCA)* is proposed.

Environmental considerations are discussed for development of both the Corridor. The Corridor does not pass any National Parks and Reserves except Marsabit National Park where the new Railway route crosses. Passage of wildlife is taken into consideration throughout the Corridor.

C2. IMPORTANT ISSUES AND SUBJECTS TO BE TAKEN INTO CONSIDERATION

Major issues to which attention is to be paid in the LAPSSET Corridor and Lamu Port Projects at this stage can be summarized as follows:

(1) Prerequisite of the Project

This LAPSSET Transport Corridor Development Project as well as new Lamu Port Construction Project predicts a sound and sustained economic growth not only of Kenya but also of the neighboring countries, i.e. Kenya, Southern Sudan, Ethiopia, Uganda, and others.

It is recognized that, in general, development potential is high in Sudan. **Independence of Southern Sudan**, which will be realized possibly on 9th of June as the result of the Referendum carried out from 9th to 16th January, 2011, is the prerequisite for the Projects, especially for the Pipeline Project.

(2) Coordination with Southern Sudan and Ethiopian Governments

Existence value of the LAPSSET Corridor depends heavily on users in Southern Sudan, especially cargoes including crude oil. In view of start of operations of the Corridor, **cooperation with the Southern Sudanese government** and the Kenyan Government is very essential in creating sustained demand and supply as well as constructing and completing the transport corridor in the both countries. **Coordination with the Ethiopian government** is also indispensable, for example, to connect the railway and successful management of its operation.

(3) Fund Arrangement for Corridor Development Projects

Realization of the LAPSSET Corridor Project, including development of New Lamu Port, Railway, Highway and Lamu Airport, needs enormous fund, e.g. US\$ 3.5, 8.6, 1.4, and 0.2 billion, respectively, in total US\$ 13.7 billion until 2030. Costs for Oil Pipeline, Oil Refinery and Resort City, which are to

be funded by private party, amount to US\$ 7.8 billion. The total amount is US\$ 21.5 billion, excluding costs for electricity and water supply.

Possibility of undertakings of the public infrastructures depends entirely on fund and budget availability and **proactive involvement of the government of Kenya**. Furthermore, as the cost is comparatively large compared with current GDP and the national budget of Kenya in the past, **cooperation of neighboring countries** are indispensable, or share of cost for Port, Railway and Highway by the governments of Southern Sudan and Ethiopia.

Oil Pipeline, Oil Refinery and Resort City developments have been usually made through **private investment**. A part of the costs can be borne by the neighboring countries as the direct beneficiaries such as Southern Sudan for Crude Oil Pipeline, Southern Sudan and Ethiopia for Oil Refinery, etc., which can be coordinated by *the LAPSET Corridor Authority*.

(4) Coordination with Related Ministries in the Governments

It is important to coordinate and cooperate with **related Ministries and/or stakeholders** in promoting and executing the other projects components. An example is the Resort City planning at Isiolo, which is demarcated to the Ministry of Tourism.

(5) Co-funding for Multi-sector Projects

For sustained development of the LAPSET Corridor and the new Lamu Port, it is essential to incorporate related projects such as electricity supply and water supply, or construction of electricity plants and water pipeline from the Tana River. This type of **multi-sector projects** should also be sought in this Project.

C3. RECOMMENDATIONS

Based on the above study results and discussions, the recommendations of the Consultant to the government of Kenya are as follows:

(1) Authorization of Master Plans for LAPSET Corridor, Lamu Port and Lamu Metropolis

Prior to commencement of construction works of the new Lamu Port, the Master Plans proposed in this report shall be authorized by the government of Kenya administratively, legally, and financially. The urgent subjects for these Master Plans are as follows:

1) LAPSET Corridor Master Plan

- a. Authorization of the entire Master Plan by the Kenyan Government, and confirmation of coordination and cooperation among the Ministries concerned.
- b. Formation of international agreements on the Plan between the government of Kenya and the governments of Southern Sudan and Ethiopia.

2) Lamu Port Master Plan

- a. Authorization and confirmation of the Master Plan among the parties concerned, including the central and local governments and relevant authorities.
- b. Definition and legal authorization of LAPSET Corridor, Lamu Port area, Port Limit, Free Port Area, Special Economic Zone, Bonded area, etc.

3) New Lamu City Development Plan

- a. Authorization of **new Lamu City Development Plan**, including interim arrangement for planning and urban management,
- b. Land management by prescription of **“Urban Area.”**
- c. Designation of Port-related Industrial Area, **Special Economic Zone (SPZ)**, Export Processing Zone (EPZ), etc.

- d. Authorization of location and area for **New Lamu International Airport** and **Resort Cities**.
- e. Other infrastructure development plans such as **Electricity Supply Projects** with an order of 1 GW for 1.25 million citizens and factories anticipated in the future..

(2) Establishment of LAPSSET Corridor Authority

The LAPSSET Corridor Project involves many domestic implementing organizations as the service providers, and several countries internationally as the users alongside Kenyan organizations. Coordination among Kenyan implementers is essential for execution, management and operation of the Corridor, and for this purpose, “the LAPSSET Corridor Authority” should be established in the government of Kenya to plan and coordinate the Projects. At the international level, a LAPSSET Corridor International Coordination Organization is recommended.

(3) Consideration on Environmental Conservation

From the viewpoint of environmental conservation, the LAPSSET Corridor, or railway, highway and pipeline must have remedial measures against the impacts on wildlife and livestock. An example is the influence of their construction works to migration/movement of these animals across the facilities. The corridor shall not block them completely. It is necessary to construct culverts and/or other appropriate passages across the corridor bank.

(4) Consideration on Electricity Supply System

For LAPSSET Corridor projects, electricity supply could become a serious bottleneck. According to “Kenya Electricity Access Investment Prospectus 2009-2014” by the Ministry of Energy, electricity supply will be increased by import of surplus electricity from Ethiopia, geo-thermal power generation, and wind power generation.

In case of the LAPSSET Transport Corridor, the Crude Oil Pipeline from Southern Sudan to Lamu, for example, requires nine booster pump stations from Juba to Lamu with a capacity of about 200MW in total. Thus, the pipeline project will not be realized unless a Power Supply Project will be implemented parallel.

(5) Priority of the Corridor Components

The Corridor consists primarily of Railway, Highway and Pipeline. Although the construction schedules of these components are simultaneous, the highway had better be executed first so that the railway and pipeline projects can use the road for their construction works.

(6) Access Road Construction to Connect LAPSSET Corridor and New Lamu Port

It is necessary to construct an access road from the port to the existing Hindi Junction of Route C112, which has a distance of about 7km. There is a private land on this access road, of which acquisition needs to be undertaken early enough to avoid delay of the project implementation.

(7) Link Road for New Lamu Port Construction

It is prerequisite to improve the present Route C112 road at least before opening of the new Lamu Port. It is desirable to complete it before start of construction works, or even during the port construction works, to utilize the road for construction and logistic works for new Lamu Port. For this purpose, discussions between the owner of the Lamu Port Project and the Kenya National Highways Authority should start as soon as possible.

(8) Electricity and Water Supply to Lamu Port and Lamu Metropolis

In the Urgent Plan, electricity and water supply to the first three berths and the related facilities and equipment is planned to be done by two generators of 3,500 kW to be newly installed in the port, and through the existing water pipeline. It is apparent that, following the development of the port, their capacity will not be enough and new sources shall be exploited. For this purpose, the planned extension project of 220kV power supply line from Kilihi to Lamu by the Kenya Power and Lighting Company, Ltd. (KPLC), and water supply projects by the Ministry of Water and Irrigation and the Ministry of Regional Development Authorities.