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CONSULTANCY SERVICES FOR THE DESIGN REVIEW OF THE ELWAK – RHAMU (A13) ROAD

FINAL ECONOMIC FEASIBILITY STUDY REPORT

DECEMBER 2020

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EXECUTIVE SUMMARY

Background to the Project

The project road forms part of the 740km Isiolo – Wajir-Mandera road corridor for which detailed engineering design was carried out between 2007 and 2010 under three (3) lots viz.

- Isiolo – Garbatula junction – Modogashe (190km)
- Modogashe – Wajir (156km)
- Wajir - Mandera (388km)

Most of these road sections are still unpaved except the El Wak – Rhamu road section which was recently upgraded under a staged-construction initiative. The Government of Kenya is however committed to improving the road network in the north eastern region and has applied for credit from the International Development Association (IDA) under the North-Eastern Transport Improvement Project (NETIP) to upgrade some of these road sections. Part of this financing package is to be used to study the strengthening of El Wak – Rhamu section so as to be able to support the updated traffic projections.
The El Wak – Rhamu section lies between km 177 and Km 316 with El Wak town located at km 177 and Rhamu town at km 316.

Project Context

The project road lies wholly within Mandera County which has one of the lowest rural access roads in Kenya (<30%) according the 2018 Kenya Roads Board's Road Inventory and Condition Surveys (RICS). The RICS also revealed that the County has a total road network of about 1,884.5km of which only about 3% is paved. The national road network is about 177,800 km while the county's road network is about 1,884.5 km.

The A13 road corridor is expected to provide connectivity to Somalia once construction is completed hence underpinning its regional importance. Locally, it is expected not only to open up the Mandera economy to investors but also to connect it to the rest of the country.

Objectives of the Project

The improvements are expected, *inter alia*, to achieve the following objectives:

- Strengthen the pavement to enable the road to carry the projected future traffic ;
- Improve road safety and minimize negative environmental/social impacts;
- Improvement of the road's geometric features to meet Class A standards;
- Improvement of the road's drainage.

Improvement Interventions

The road will be upgraded to meet Class A road standards and provided with f loop roads around Gari and Rhamu towns to minimise congestion.

. Table E1 below summarizes the existing and proposed drainage structures.

Table E11: Existing/Proposed Drainage Structures

Existing Structures		Proposed Structures	
Type (Dia/ Size)	No. crossing locations	Type (Dia/ Size)	No. crossing locations
CPC - 2x 0.6m dia	58	CPC – 0.9m dia x 1	69
CPC - 3x0.6m dia	1	CPC – 0.9m dia x 2	172
CPC - 1x0.9m dia +1x0.6m dia	1	BC (2mx1.5m) x 1 cell	16
CPC – 0.9m dia x 1	43	BC (2mx1.5m) x 2 cell	76
CPC – 0.9m dia x 2	23	BC (2mx1.5m) x 3 cell	8
CPC – 0.9m dia x 3	1	BC (2mx1.5m) x 4 cell	22
Armco pipe culvert 1.5m dia	1	BC (2mx1.5m) x 6 cell	2
Vented drift 1.2m dia x 2 pipes	1	BC (3mx2.5m) x 2 cell	2
BC (4.5m x 2.5m) x3 cells	1	BC (4mx2.5m) x 4 cell	1
		BC (4mx2.5m) x 8 cell	1
Totals	**159**		**369**

Note: CPC-Concrete Pipe Culverts; BC-Box Culvert

The pavement is to be strengthened to support Traffic Class 2. It will consist of the following layers:

- **Surfacing:** 75 mm AC Type I & single seal surface dressing
- **Base:** 150 mm cement stabilised
- **Subbase:** 175 mm cement improved material
- **Subgrade:** Improved to S5 sub-grade class

Project Costs

The estimated financial costs of the project are tabulated below.

Table E22: Estimated Project Costs (KShs)

Parameter	Amount (KShs)
Total Cost	18,633,261,583
Cost Per Km	130,943,511

Study Methodology

The approach used in carrying out the Feasibility Study entailed:

- Defining the road network in terms of homogenous sections;
- Collection and review of all relevant data;
- Derivation of vehicle fleet characteristics;
- Estimation of project costs for the "without" and "with" project;
- Calculation of economic indicators using HDM – 4 over a 20-year analysis period;
- Determination of whether the economic benefits outweigh the economic costs;
- Computation of switch values and sensitivity analysis for the various alternatives, including undertaking a risk analysis; and,
- Determining the distribution of benefits.

Project Benefits

The main benefits include savings in vehicle operating costs (VOCs) and travel time costs (TTCs) for both motorized and non-motorized transport. Table E3 shows he discounted and undiscounted savings in VOCs and TTCs.

Table E33: Project Net Benefits (KShs Millions)

	Discounted Savings		Undiscounted Savings	
	Savings VOC	Savings TTC	Savings VOC	Savings TTC
Benefits	510.6	143.7	2,484.8	764.1

Economic Analysis Outputs

Table E4 below summarizes the economic indicators of the economic analysis at 12% discount rate.

Table E44: Economic Indicators at 12% Discount Rate

Indicator	Value
NPV (KSh. Millions)	5,132.2
EIRR (%)	16.2
BCR	1.51
FYRR (%) *	0.3%

** Excludes the urban sections*

Risk Assessment

Tables E5 and E6 below summarizes the sensitivity analysis and switch value analysis results for the various project roads.

Table E55: Sensitivity Analysis Findings

Scenario	Outputs		
	NPV (KShs Millions)	IRR (%)	BCR
Increase in Costs (by 20%)	3,123.3	14.3	1.26
Decrease in Benefits (by 20%)	2,096.9	13.9	1.21
Increase in Costs + Decrease in Benefits	88.0	12.1	1.01

Table E66: Switch Value Analysis Findings

Parameter	Change
Increase in Capital & Recurrent Costs (%)	+52%
Decrease in Traffic Growth Rates (%)	-59%

The Table reveals that it would take a 52% increase in cost or 59% decrease in traffic growth rates for the viability of project to be threatened.

Recommendations

A summary of the findings is shown in Table E7 below.

Table E77: Summary of Findings

No.	Theme	Remarks
1	Project Relevance Context	Project in line with SDGs, Agenda 2063, EAC Vision 2050 and Kenya Vision 2030
2	Political and Other Risks	Risk matrix and mitigation measures to be developed
3	Managerial, Administrative and Maintenance Capacity	KeNHA has adequate capacity and proper institutional set-up having successfully handled similar projects. Innovative sourcing of maintenance funds needed.

No.	Theme	Remarks
4	Technical Assessment	Draft designs in line with relevant standards/manuals
5	Environment & Social Safeguards	Mitigation/Enhancement measures developed in Environmental and Social Management Plans (ESMPs), Vulnerable & Marginalized Group Plans (VMGPs), Occupational Health & Safety Management Plans (OHSMPs) and Resettlement Action Plans (RAPs) and the Resettlement Action Plans (RAPs).
6	Economic Assessment	Positive NPV; EIRR>12%; BCR>1.0. Low FYRR means projects may be delayed.
7	Risk Assessment	Acceptable Switch Values & Sensitivity Analysis

The project is expected to have enormous economic and social benefits if implemented. All the identified negative social and environmental impacts are manageable, and suitable mitigation measures have been proposed. It is justifiable to conclude that the proposed road project is viable and should be implemented as proposed.

1 INTRODUCTION

1.1 Objectives of the Project

The objective of this Economic Feasibility Study Report is to provide decision makers at the Government of Kenya and the Kenya National Highways Authority (KeNHA) with sufficient information on the economic costs and benefits of the project to enable them to make a decision on the proposed improvements on the El Wak – Rhamu road section.

These improvements are expected to amongst others achieve the following objectives:

- Strengthen the pavement to enable it to carry the projected future traffic.
- Improvement of road safety and minimising negative environmental/social impacts.
- Improvement of the road's geometric features to meet Class A standards.
- Improvement the road's drainage.

1.2 Alignment with International, Regional and National Objectives

Implementation of this road project will be in line with international, regional and national policies of the government. Thus, it will fulfill Kenya's commitment to improve infrastructure in part fulfilment of the UN's Sustainable Development goals (SDGs) in **"building resilient infrastructure, promoting inclusive and sustainable industrialization and fostering innovation"** along with other goals. At the regional (African) level it will fulfil Kenya's commitment to the achievement of Agenda 2063 in line with the continent's goal of developing, *inter alia*, **"world class infrastructure" crisscrossing Africa"**, among the 20 goals set by the African Union. The project's implementation will also reflect the country's commitment to achieve the sub-regional goals under the East African Community (EAC) Vision 2050 which places infrastructure development as one of its key pillars with emphasis on improved accessibility for increased competitiveness through designated transport corridors. The proposed road section is an international road that provides connectivity to the neighboring country of Somalia.

At the national level improvement of this road will be in line with Kenya's development blueprint, Kenya Vision 2020, "The Big four Agenda" and other key national and sectoral policies and strategies.

1.2.1 Alignment with National and Sectoral Policies

1.2.1.1 Vision 2030 and the 3rd Medium Term Plan (MTP III)

Kenya's Vision 2030 is the country's long-term development blueprint for the period between 2008 and 2030 aimed at transforming the country into a newly industrializing, "middle-income country providing a high-quality life to all its citizens by the year 2030". Vision 2030 lays emphasis on infrastructure, with the country aspiring to be interconnected through a network of roads, railway, ports, airports, water and sanitation facilities, and telecommunications by the end of implementation period.
The Kenya Vision 2030 is to be implemented in successive five-year Medium-Term Plans. The first plan (MTP I) covered the period 2008 – 2012, and the second (MTP II) covers 2013 - 2017. The MTP's are designed to fast-track flagship projects identified under Vision 2030, various programmes and key policies.
Although the current Third Medium Term Plan (MTP III) is consistent with Kenya Vision 2030 and aims at putting the economy on a high growth path, it has a growth target of 7% by 2022/2023 fiscal year, based on the macroeconomic projections for the period.

Major infrastructural projects planned during the MTP III include: -

1. Improvement of 190 km of roads under the East Africa Road Network Project (EARNP).
2. Improvement of 83 km of roads under the Kenya Transport Sector Support Project.
3. Improvement of 350 km of roads under the East Africa Regional Transport, Trade and Development Facilitation Project.

4. Improvement of 47 km of roads under the National Urban Transport Improvement Project (NUTRIP).
5. **Improvement of 344 km of roads under the Northern Kenya Transport Improvement Project (NETIP).**
6. Construction of the 450 km Mombasa-Nairobi six lane highway toll road.
7. Construction/rehabilitation of 7,500 km under the roads 10,000 programme and 176 Kms to low volume seal roads and 298.6 Kms to gravel surface dressing under Roads 2000 programme.
8. Periodic and routine maintenance of 161,456 km of roads.
9. Decongestion of Cities and Urban Areas through the construction of 308 km bypasses, 53.3 km of missing links, and 40 km of Non-Motorized Transport Facilities.
   Transit Systems in Mombasa Gate City and improvement of Mombasa commuter rail.
10. Implementation of a Road Safety Programme including development and implementation of the National Road Safety Action Plan 2018-2022.
11. Development of the 50-Year Transport Master Plan.
12. Development of 20-Year Roads Master Plan.

It can thus clearly be seen that the improvement of the project road is certainly a priority project in line with the MTP III (2018-2022) involving the improvement of 344km of roads under NETIP.

1.2.1.2 The "Big Four" Agenda

In order to fast track the country's development agenda for the 5-year period between 2018 and 2022 in line with the Vision 2030, "The Big Four Agenda" was launched by the Government in December 2017 to be implemented during the MTP III, i.e. up to the end of 2022. The Agenda prioritizes policies, programmes and projects that will support the implementation of the **"Big Four"** initiatives namely, job creation by increasing the share of manufacturing sector to 15 per cent of GDP, ensuring that all citizens enjoy food security and improved nutrition, achieving universal health coverage and constructing at least 500,000 affordable decent housing units by 2022. The implementation of the "Big Four" initiatives is ongoing in collaboration with the national and county governments and other stakeholders.

Improvement of the project road is expected to contribute towards the achievement of the Agenda through boosting livestock production hence promoting food security, improving access to medical facilities and opening up the area for the development of a meat processing facility (with tannery) as envisioned in Vision 2030.

1.2.1.3 Integrated National Transport Policy (INTP)

Kenya's transport policy framework is elaborated in the Sessional Paper on *Integrated National Transport Policy* (MoT, November 2010). The Policy Paper, whose theme is "Transport for Prosperity", identifies a number of challenges inhibiting the transport sector from performing optimally its facilitative role in respect of national and regional economies.

The challenges included: (i) Poor quality of transport services; (ii) Inappropriate modal split; (iii) Unexploited regional role of the transport system; (iv) Non-integrated transport system; (v) Urban environmental pollution; (vi) Lack of an urban/rural transport policy; (vii) Institutional deficiencies; (viii) Inadequate human resource capacity; and, (ix) Lack of a vision for the transport sector.

The Paper outlines several key actions required to address the challenges, including:

(i) Clarification of the key stakeholder roles in the delivery and management of transport infrastructure and services; (ii) User pays and polluter pays principles to facilitate economic efficiency; generation of sufficient revenues to support development; operation and maintenance of transport infrastructure and services; and elimination of transport user choice distortions; (iii) Stakeholder consultation in setting of tariffs and other prices; (iv) Financing of economic infrastructure through user charging or cost recovery, and financing of social and strategic infrastructure through subsidisation on a declining basis over time; and, (v) Strengthening the regulatory framework.

It proposes a new framework for transport sector management that would establish a directorate of transport, and consolidate transport functions under one Ministry, and separation of policy making, regulatory and service provision functions. It also advocates for enhancing the role of the private sector in transport infrastructure development and management, integration of Non-Motorised and Intermediate

Means of Transport as part and parcel of the transport system, and lastly the consolidation of urban public transport through encouraging a shift to high occupancy vehicles.

The framework and actions outlined above have been implemented by the government over the years to various levels. The regulatory framework has been strengthened and separation of roles has been established. Although the challenge of generating sufficient revenues through user charges to support development and maintenance of transport infrastructure has been partially achieved, challenges of enhancing the role of the private sector in financing projects, and encouraging the use of high occupancy vehicles in urban areas largely have not been effectively met.

1.2.1.4 Road Sector Investment Programme (RSIP)

The Kenya Roads Act 2007 stipulates that a Road Sector Investment Programme (RSIP) be prepared every 5 years to guide the development and maintenance of the road sub-sector.
The 1st phase of the RSIP1 (2011-2015), was prepared in the year 2011 by the Kenya Roads Board (KRB) and had three main priorities: (1) Routine and periodic maintenance; (2) Rehabilitation and reconstruction of failed road sections; and, (3) Upgrading, capacity improvements and new construction.
The preparation of the second phase is now complete and shall outline the country's development and maintenance priorities for the road sub-sector for the years between 2018 and 2022. The project road shall then have to be aligned with the programme from RSIP.

1.2.1.5 Annuity Programme

The programme was launched by the government in June 2014 with the aim of attracting private sector financing to the infrastructure so as to improve some 10,000km of roads. Under the programme, the contractors design, finance and construct roads within a stipulated time not exceeding three (3) years and guarantee construction quality. The contractors are also tasked with raising at least 70% of the total construction cost of the project before signing the contract. Upon completion of construction, the contractors are to maintain the roads for a maximum period of 8 years during which they are to be paid fixed annual payments (i.e. annuity). The government is meanwhile tasked with negotiating loans and payment terms with the banks on behalf of the contractors and also providing guarantees to the banks.
The annuity programme was later suspended by the government owing to concerns about the inflated construction costs that were submitted by the bidders but has since been revived.

Some of the projects undertaken by KeNHA under this programme include: -

- 25 km Kwale – Kinango (B92) road;
- 41 km Mariakani – Kinango (B91);
- 50 km Modogashe – Habaswen – Wajir (Modogashe – Samatar Section) (A13) road;
- **75 km Rhamu – Mandera Section, which is part of the Elwak -Rhamu – Mandera Road of the A13;**
- 19 km Kilgoris – Lolgorian (B3) road;
- 29 km Kehancha – Lolgorian (B1) road;
- 22 km Bomas – Kiserian – Magadi (Dualling Bomas – Kiserian Section) (B19) road;
- 9 km Bomas – Karen – Dagoreti – Ruiru (Bomas – Dagoreti Market section) (B19);
- 70 km Nanyuki – Gwa Kungu (B22) road;
- 133 km Laisamis – Ngurunit – Nursaery (South Horr) (B74) road;
- 67 km Illasit –Njukini – Taveta (B55) road;
- 33 km Ngong – Kiserian – Isinya (B50) road; and
- 43 km Kajiado – Imaroro (B52) road.

The El Wak - Rhamu road has recently been upgraded to bituminous standards by KeNHA under the Low Volume Sealed Roads (LVSR) annuity programme. This involved staged-construction where the road has been constructed up to the subbase layer and then sealed using a double-surface dressing layer.

1.2.1.6 KeNHA Strategic Plan 2018/2019 – 2022/2023

Some of the planned targets for KeNHA's current 3rd Strategic Plan (SP) include the following:

i. Construction and rehabilitation of 3,820 km of roads;

ii. Acquisition of titles for 9,000 km of road reserve and 40 road camps;
iii. Preservation/maintenance of 50,000 km under routine maintenance (10,000 km annually), 5,000 km under periodic maintenance (1,000 km annually) and 30,000 km under PBC (6,000 km annually);
iv. Planting of 60,000 trees for environmental preservation to act as carbon sink;
v. Rehabilitation of 100% of all quarries and borrow pits after construction works;
vi. GIS mapping of 18,101km of KeNHA's network; and,
vii. Implementation of at least 4 road projects under the PPP financing framework.

According to the SP, the project road form part of the Isiolo – Modogashe – Wajir – El Wak – Rhamu – Mandera (A13) road corridor and is amongst those slated for improvement so as to enhance regional integration and trade facilitation.

1.2.1.7 Mandera County Integrated Development Plan

The planned priority interventions by the Mandera County government during the 2018 – 2022 period in Roads, Public Works and Transport section are aimed at enhancing national and regional connectivity for sustainable socio-economic development.
Main projects outlined in Mandera's CIDP for the road sector include:

i. Upgrading of 38km of roads to bitumen standards;
ii. Paving of Kutulo-Elwak, Elwak-Rhamu, Rhamu-Mandera, Mandera-Lafey, Danaba-Takaba-Wargadud and Danaba-Dandu-Kukub-Banisa in partnership with relevant agencies;
iii. Gravelling of 975km of roads;
iv. Rehabilitation of 1,000km of gravel roads; and,
v. Construction of 20 No. bridges/box culverts and 50 No. drifts.

2 ASSESSMENT OF DEMAND

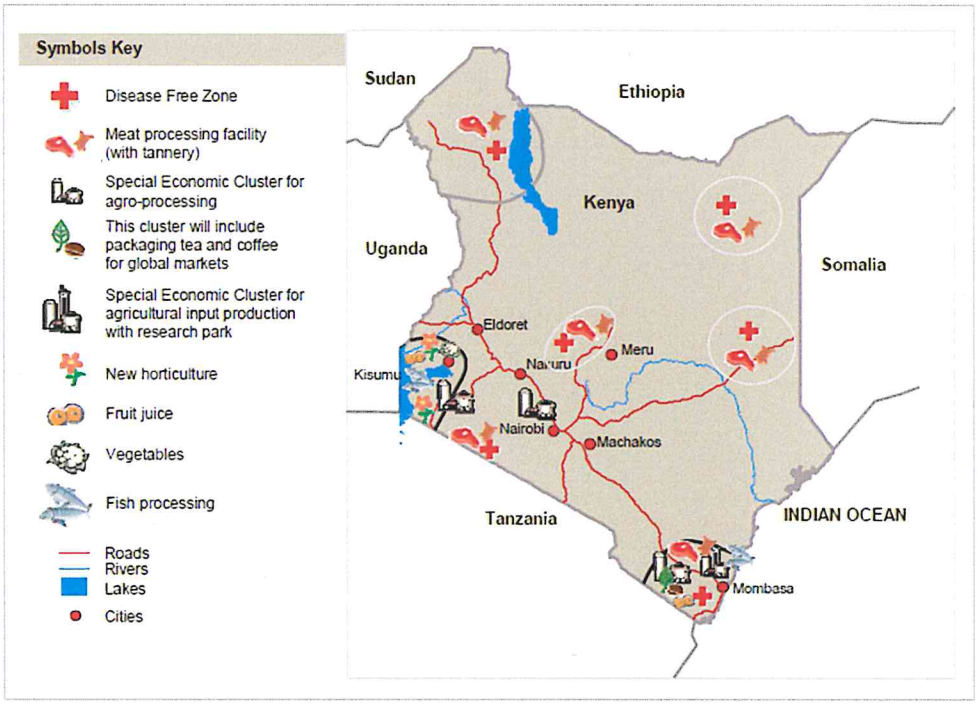
2.1 Project's Area of Influence

Presently, the project road section predominantly serves local traffic owing to poor connectivity both upstream and downstream. Improvement of the entire corridor from Isiolo to Mandera is however likely to change this narrative by opening up a completely new corridor to the north eastern parts of Kenya and providing a critical link to Somalia.

This new corridor is projected to boast trade across the country by facilitating faster movement of agricultural products and livestock from the north-eastern region to the rest of the country.

Additionally, the new road corridor shall facilitate the proposed establishment of a disease-free zone and a meat processing facility (with tannery) as envision in Vision 2030 (see Figure 2.1 below).

Figure 2.1: Possible Regional Industrial and Manufacturing Clusters (Vision 2030)



Source: Republic of Kenya (October 2007). Kenya Vision 2030 (Figure 3.5.5, Page 96)

3 REVIEW OF KENYAN ECONOMY

3.1 Overview

Performance of the Kenyan economy since the beginning of this millennium has been moderate. High growth rates were recorded during the period 2003-2007 when the economy recorded steady growth rates from 5.1% in 2004 to 7.1% in 2007. Due to post-election violence of 2008 and effects of global financial crisis on remittances from abroad and on exports as well as unreliable weather, growth of Gross Domestic Product declined to 2.7%in 2009. Thereafter, the country's GDP has been fluctuating below 6.3 % p.a. Table 3.1 below gives the trends in GDP growth rates between 2015 and 2019.

Table 3.1: Trends in Kenya's GDP Growth (%)

Year	2015	2016	2017	2018	2019*
GDP Growth at Constant 2009 Prices (%)	5.7	5.9	4.9	6.3	5.4

Source: *Economic Survey 2020 – Table 0, KNBS.*

** Provisional*

The country's economy is still dominated by agriculture which contributed an average of 32.9% to GDP during the period 2015-2019, followed by the manufacturing which averaged 8.4% of GDP, followed by transport and storage sector which accounted for an average of 8.0 % of GDP during the period. Each of the other sectors accounted for less than 8% of GDP over the last 5 years. It may be noted that the share of manufacturing to GDP has been declining steadily over the last 5 years from 9.4% in 2015 to 7.5% in 2019. High average growth rates were recorded in several sectors during the period, namely Accommodation and Food Services (10.6%), Information and Communication (9.7%), Electricity Supply (9.7%), Construction (9.1%), Transport and Storage (7.6%) and Real Estate (6.3%). Low average growth rates of the agricultural sector, the mainstay of Kenya's economy) and the manufacturing sector at only 4.2% and 3.0%, respectively are worrying trends, considering their importance to the economy.

3.2 Policy Context of the Project Road

Following the formulation of Kenya's long term development in 2008, through the *Kenya Vision 2030*, it is important to review the performance of the economy in the context of the policies, goals and strategies aimed at achieving the objectives of Vision 2030 and in the context of other appurtenant government policies that complement the long term policy and in the context of regional and international policies. Vision 2030 established the planning and development framework aimed at transforming the country's economy into a "globally competitive and prosperous country with a high quality of life by 2030." Its implementation is intended to transform Kenya into

> "a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment"[1]

The development framework sets an average economic growth rate of 10% per annum during the period 2008-2030 and provides for five-year Medium Term Plans starting from 2008.

This road project will be implemented during the Third Medium Term Plan (MTP III) 2018-2022 which builds on the performance and achievements of the Second MTP, 2014-2017. Thus the first and second MTPs have already been implemented. Currently the government is implementing the Third Medium Term Plan (208-2022). The El Wak-Rhamu road project will be

[1] Government of Kenya (GOK), *Kenya Vision 2030*, p. vii.

implemented during the Fourth Medium Term Plan (MTP IV) 2022-2026 and will thus be influenced by the performance of the economy based on the policies and strategies under the MTP III (2017-2022).

In view of the above, it is fitting to review the performance of the economy under the two Medium Terms that have been implemented.

3.2.1 Performance under the Second Medium Term Plan (MTP) 2013 – 2017

The second Medium Term Plan for the period 2013-2017 was consistent with Kenya Vision 2030 and aimed at putting the economy on a high growth path, to ensure that double digit growth was realized by the end of the plan period.
The framework laid emphasis on infrastructural developments. Major projects planned during the period for the road subsector included:

- Expansion of the Roads Programme by constructing and rehabilitating approximately 5,500 km of roads comprising of 3,825 km national trunk roads and 1,675 km of county roads;
- Development of Public, Private Partnership (PPP) arrangements such as concessioning, Build Operate Transfer, Design Build Operate, Design and Build. This would be applicable to road construction and/or maintenance on Nairobi bypasses and other major roads including sections of Mombasa - Nairobi - Malaba, Mau - Summit - Kisumu - Busia and Nairobi - Thika highway;
- Implementation of the Northern Corridor Transport Improvement Project (NCTIP);
- Implementation of the East Africa Road Network Project (EARNP);
- Implementation of the Kenya Transport Sector Support Project (KTSSP);
- Rehabilitation and upgrade of the 600-km Eldoret – Kitale – Lodwar – Nadapal; road;
- Decongestion of Cities, Urban Areas and Municipalities through Construction of Bypasses, Construction of Missing Links and improvement of roads in Nairobi and other Cities and Municipalities; and,
- Development of the Lamu Port - South Sudan - Ethiopia Transport (LAPSSET) Corridor which will involve the provision of a reliable transport corridor for Ethiopia and Southern Sudan encompassing a standard gauge railway line; a new road network; and an oil pipeline, amongst others.

Modernization of Kenya's infrastructure has had a positive effect in stimulating growth, and in opening up areas that were hitherto outside the reach of Kenyan markets;
Mobilization of investment funding for large scale infrastructure projects posed challenges to debt levels, and the Government is exploring different ways of accessing such funds including PPP and long-term infrastructure.

3.2.1.1 GDP and Sectoral Growth Rates, 2013-2017

Table 3.2 below summarizes trends in the growth of GDP during the period 2013-2017.

Table 3.2: Trends in Kenya's GDP Growth 2013-2017

Year	2013	2014	2015	2016	2017
GDP Growth at Market Prices (%)	5.9	5.4	5.7	5.9	4.8

Source: Kenya National Bureau of Statistics (KNBS), *Economic Survey 2018, 2019, 2020*

During the period total GDP growth rate averaged 5.5% p.a. mainly due to a stable macroeconomic environment and major investments in the infrastructure sector. Agriculture forestry and fishing, the mainstay of economic activity in the country averaged a growth rate of only 4.3% during the period while manufacturing growth averaged only 3.0%. Sectors that recorded high growth rates were: Information and Communication (11.0%), Construction (10.3%), Electricity Supply (9.4%), Mining and Quarrying (7.4%), Financial and Finance Activities (7.1%), Real Estate (6.4 %) Transportation and Storage (5.7%) and Wholesale and retail, trade and repairs (5.1%).
The poor performance of agriculture and manufacturing is of concern given their importance to sustainable development of the economy..

4.2.3 Third Medium Term Macro–Fiscal Framework and Growth Strategy Prospects, 2018-2022

As alresdy mentioned, MTP III endeavours to move the economy towards a high growth trajectory to achieve a 7 per cent economic growth by the end of the Plan period.[2]" and will support the implementation of the **"Big Four" (Agenda IV)** initiatives namely

3.2.3.1 Projected Macro-economic Framework, 2018-2022

Table 3.3 below summarizes projected macro-economic indicators for the Third Medium Term Economic Framework for the period 2017/2018-2022-2023. It reveals that real Gross Domestic Product (GDP) will grow from 5.9% in 2017/2018 to reach 7.0% in 2022/2023. Improved performance of the economy and indeed the achievement of the "Big Four Agenda" will be based on sound macro-economic management, including maintenance of low inflation rates, stable interest and exchange rates, and maintenance of sustainable debt through a robust fiscal discipline.
The Table shows the macro-economic indicators underlying the Medium Term Economic Framework for development during the Third Medium term Plan. Within the framework, the consumer price index will be maintained at an average of 5.0% between 2018/2019 and 2022/2023, while gross national savings will rise steadily from 13.6% of GDP to 21.2% of GDP during the period. Through prudent fiscal management, the proportion of public debt to GDP will be steadily reduced during the Plan period from 7.9% in 2018/2019 to 3.4% in fiscal year 2022/2023. The Table also reveals that the volume of gross foreign exchange reserve coverage is expected to rise steadily from 6.7 months in 2018/2019 to 3 months in 2022/2023 fiscal year.

[2] Third Medium Term Programme, p. 1.

Table 3.3: Macroeconomic Indicators Underlying the MTEF Framework, 2018/19 - 2022/23

Indicators	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
	Actual	Projection	Projection	Projection	Projection	Projection	Projection
	Annual Percentage Change						
Real GDP	5.3	5.3	5.9	6.3	6.8	6.9	7.0
CPI Index	6.6	5.6	5.0	5.0	5.0	5.0	5.0
CPI Index (avg)	6.9	6.3	5.0	5.0	5.0	5.0	5.0
As % of GDP							
Investment	17.5	19.7	21.9	22.6	22.8	23.4	25.4
Gross National Saving	12.4	13.6	16.5	17.1	18.0	19.2	21.2
Total Revenue	18.3	19.0	18.9	19.0	19.2	19.4	19.6
Total expenditure and net lending	27.6	26.8	25.5	23.8	22.9	22.5	23.1
Overall balance (commitment basis) and grants	-9.3	-7.9	-6.5	-4.8	-3.8	3.4	-3.4
Overall balance (commitment basis) incl. grants	-9.1	-7.2	-6.0	-4.3	-3.3	-3.0	-3.1
Nominal Public Debt, net	51.9	53.0	52.8	51.0	48.2	43.6	42.0
Current external balance, incl. official transfer	-5.0	-6.1	-5.4	-.5.5	-4.8	-4.2	-4.2
Gross international reserve coverage in months	6.5	6.7	6.8	6.9	7.0	7.1	7.2

Source: *Third Medium Term Plan 2018-2022,* Table 2.8, p. 12.

In order to achieve these targets, the government will introduce legal and institutional reforms to maintain and underpin macroeconomic stability and create an environment conducive to investment, employment generation and socio-economic development through the implementation of "Agenda IV".

3.3 Further Outlook

The medium-term GDP growth forecasts by the Government of Kenya, International Monetary Fund and the World Bank range between 5% and 7% which are still below the 10% growth rate targeted to enable the realization of Vision 2030, but nevertheless achievable. Based on the past and projected performance of the economy, it is considered that the country will easily accommodate the rehabilitation and maintenance of the project road.

The above projections were made before the onset of the worldwide pandemic, Covid-19 (Corona Virus) the devastating economic effects of which will negatively affect performance of Kenya's economy. It is hoped, though, that by the time the road project will be under implementation the country will have sufficiently recovered from the pandemic to ensure its implementation along with other government projects.

3.4 Mandera County Economic Profile

3.4.1 GCP

Mandera County 's recorded a Gross County Product (GCP), grew steadily from KShs 22,969 million in 2013 to KShs 35,301 million in 2017 at current prices. The County's GCP was the lowest in the country. Her contribution to the total GCP during the period averaged a paltry 0.5%.

Table 4 below, however shows that the County's GCP per capita has been growing during the period from KSh 17,418 in 2013 to KSh 20,725 in 2017, translating into a marginal improvement in the standard of living as revealed

Table 3.4: GCP at Constant Prices (KSh million)

	2013	2014	2015	2016	2017
GCP	17,418	18,230	19,044	19,889	20,725

Source: Gross County Product Report 2019, KNBS.

by the GCP per capita in the Table 5 below.

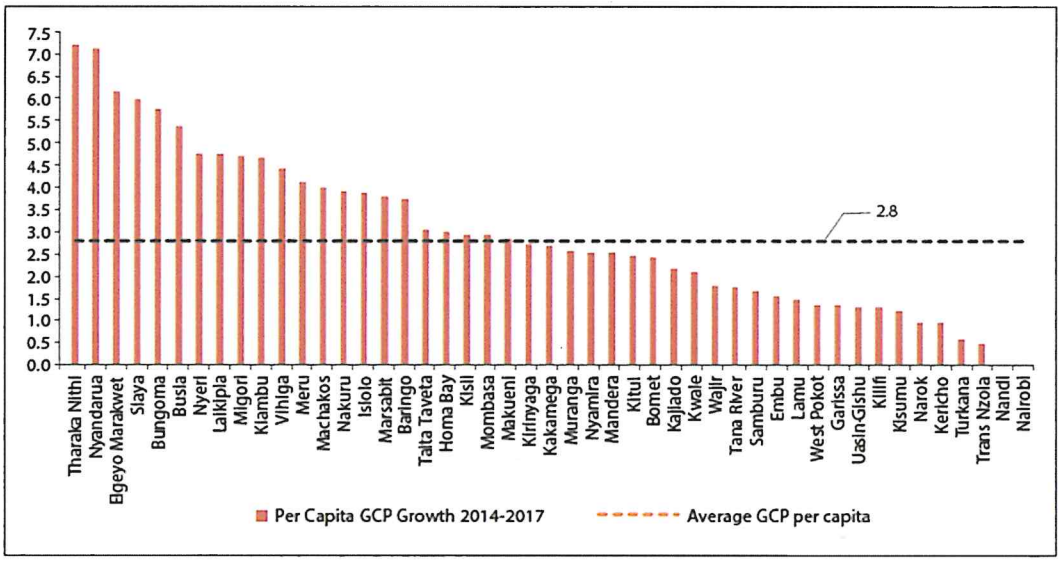
Table 3.5: Per Capita GCP at Constant Prices (KSh)

	2013	2014	2015	2016	2017
GCP per capita	25,867	26,594	27,287	27,968	28,602

Source: KNBS, Economic Survey 2019

On the average, Mandera County has been growing at a rate below the overall average County growth rate of 2.8% during the period (See Figure 3.1 below). This highlights the urgent need for investment in the county in a bid to shore up its economic prospects.

Figure 3.1: Per Capita GCP Growth Relative to Average Per Capita GCP in all Counties (%)



Source: Gross County Product Report 2019, KNBS

It is therefore expected that improvement of the roads will further improve the fortunes of Mandera County given its huge potential in agriculture and services as depicted below. Good infrastructure will hasten the integration of region with the national economy and with ASAL regions which account for 67% of the red meat and 12% of the milk consumed in Kenya.

3.4.2 Population

Table 3.6 shows the population density of Mandera County during the 2009 and 2019 censuses. The total population of Mandera County in 2019 was 867,457. In 2009 the census recorded a population of 1,02,756 persons. That figure was among those considered anomalous by the government during the release of the census results, although it has been used in the preparation of various documents, including the County Integrated Development Plans (CIDPs) 2013-2017 and 2018-2022. It may be noted however that results of the 2019 Population and Housing Census reflects the correct population of the County. The County has a low population density of 33 persons per km^2, which is far below the national population density of 82 persons/km^2.

Table 3.6: Population Density of Mandera County

County	**Population**			Population Density (No. per km^2)	
	2009	2019	Growth Rate (%)	2009	2019
Mandera	1,025,756[3]	867,457		39	33
National Population	38,610,097	47,564,296	2.2	66	82

Source: KNBS: *Statistical Abstract 2017 Tables 3.1 and 2019 Population and Housing Censuses, op. cit*

[3] As counted.

.According to the 2019 KPHC, Kenya's population stood at about 47.6 million translating to an average population growth rate of about 2.2% per annum between 2009 and 2019. Meanwhile Mandera's population stood at 867,457 during the 2019 census representing a 15% decline compared to the 1,025,756 people registered during the 2009 census.

The 2019 population segregated by sub-county is as shown in Table 3.7 below.

Table 3.8: Mandera's 2019 Population Breakdown by Sub-County

Sub-County	Population	Population Density	Av. Household Size
Mandera West	98,300	24	6.9
Banisa	152,598	39	6.3
Kutulo	72,394	29	7.6
Lafey	83,457	22	7.2
Mandera Central	157,220	39	7.4
Mandera East	159,638	64	6.1
Mandera North	143,850	28	7.4
Total	**867,457**	**33**	**6.9**

Source: KNBS: 2019 Kenya Population and Housing Census. Volume 1

The current County Integrated Development Plan had estimated the population as at 2017 to be 1,399,503 with projections of the population increasing to 1,699,437 people by 2022. This was, however, prior to the release 2019 official census results – which were criticised by the County after revealing its population had indeed been declining. With KNBS yet to produce new forecasts, it is difficult to predict future population trends for the County. However, as with other infrastructure projects, most notably the Isiolo – Moyale road,3. improvement project road corridor is likely to translate into exponential transport demand.

3.5 Traffic Survey

3.5.1 Traffic Survey Locations

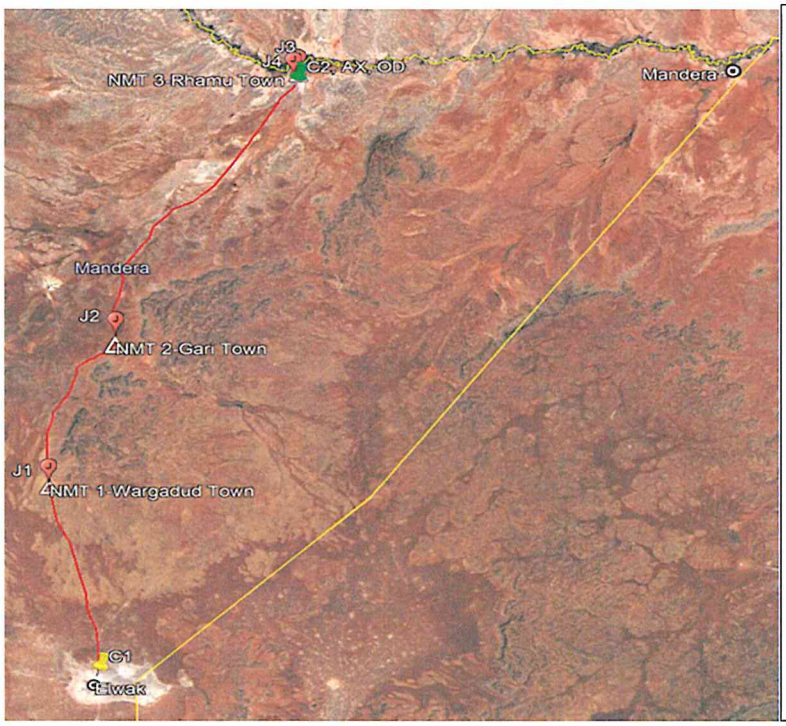
Traffic surveys were carried out between 30th July 2019 and 7th August 2019 at various locations as detailed in Table 3.8 and Figure 6 below

Table 3.9: Traffic Survey Details

Location	Chainage	Type of survey	Date	Remarks
El wak Town	Km 4+500 (El wak Spur Road)	• Classified link counts	30th July – 5th August 2019	4-day 12hr counts & 3-day 24hr counts
Wargadud town	Km 217+525	• Junction counts • NMT	31st July, 1st & 3rd August 2019	3-day 12hr counts
Gari Town	Km 251+250	• Junction counts • NMT	31st July, 1st & 3rd August 2019	3-day 12hr counts
Rhamu Town	Km 311+925	• Classified link counts	30th July – 5th August 2019	4-day 12hr counts & 3-day 24hr counts
		• NMT • O-D	31st July, 1st & 3rd August 2019	3-day 12hr counts
		• Axle Load	30th July – 7th August 2019	7-day 12hr counts

Location	Chainage	Type of survey	Date	Remarks
Junction to Malka Mari (Rhamu Town)	Km 1+150 (Rhamu Spur Road)	• Junction counts	31st July, 1st & 3rd August 2019	3-day 12hr counts
Junction to Garissa (Rhamu Town)	Km 3+050 (Rhamu Spur Road)	• Junction count	31st July, 1st & 3rd August 2019	3-day 12hr counts

Figure 3.3: Traffic Survey Location



SURVEY LOCATIONS:

C1 - Classified Counts Elwak town (Km 4+500 Elwak Spur Road)

C2 - Classified Counts RhamuTown (Km 311+925)

J1 - Junction to Takaba near Wargadud (Km 217+525)

J2 - Junction to Lafey near Gari (Km 251+250)

J3 – Junction to Malkamari (Km 1+150 Rhamu Spur Road)

J4 – Junction to Girissa (Km 3+050 Rhamu Spur Road)

NMT 1 – Wargadud Town (Km 217+050)

NMT 2 – Gari Town (Km 249+700)

3.5.2 Vehicle Classification

During the surveys, the following vehicle classification was adopted (Table 9).

Table 3.10: Traffic Survey Details

Category	Description
1	Motorcycle/ Tuk-tuk
2	Private Car (≤5 Seats)
3	Large Car, 4WD, Utility Vehicle
4	Pick - Ups, Vans
5	Minibus/ Matatu (≤ 14 seats)
6	Small Bus (14 -29 seats)
7	Large Bus (> 29 seats)
8	Light Trucks – 2 axles (single rear wheel)
9	Medium Trucks (2 axles, double rear wheel)
10	Heavy Trucks (3 - 4 axles)
11	Articulated/ Draw-bar Trucks
12	Other vehicles including agricultural tractors, graders etc.

• 3.5.3 Classified Link Counts

Traffic flow data was obtained by continuously recording passing traffic by manual tally counting. The 12-hour counts were carried out between 6.00 am and 6.00 pm while 24-hour counts were carried out from 6.00 am to 6.00 am. Traffic from each direction was recorded in 15-minute intervals by trained enumerators

• 3.5.4 Origin-Destination Surveys

OD surveys were conducted simultaneously with the traffic volume counts data. The roadside interview technique was used for the OD survey. The method involved traffic police officers stopping the vehicles at the Rhamu Town barrier for the enumerators to interview the drivers. OD survey provided information on the travel pattern of vehicles carrying freight and passenger traffic within the road network. It also provided information regarding the purpose and frequency of travel, and commodity movement

3.6 Traffic Survey Results

• *3.6.1 Average Daily Traffic (ADT)*

To determine the ADT, the 12-hour flows had to be converted to 24-hour flows using the "night factor" i.e. 24/12-hour factor, which is the ratio of the full 24-hour traffic and the 12-hour traffic. The 12-hour counts were then expanded for all the days of traffic count and accordingly the ADT was determined. The ADT was calculated as the average flow for the 7 days in which traffic counts were carried out.

The 2019 ADTs are as summarised below (Table 3.10).

Table 3.11: 2019 ADTs

Location	Motorcycle	Private Cars	Large car, 4WD	Pick-ups/ Vans	Matatu	Small Bus	Large Bus	Light Trucks	Medium Trucks	Heavy Trucks	Articulated Trucks	Others	Total
Elwak	428	105	65	112	18	1	6	12	57	188	57	11	**1,057**
Rhamu	174	104	120	44	41	6	12	11	28	77	113	0	**730**
J1 Elwak Arm	281	42	39	65	3	3	14	27	24	50	9	0	**558**
J1 Rhamu Arm	232	63	47	70	5	1	9	23	29	49	13	0	**541**
J2 Elwak Arm	339	91	54	84	23	4	14	27	43	48	19	0	**747**
J2 Rhamu Arm	360	96	82	98	45	16	17	47	48	57	21	0	**887**
Average	**302**	**84**	**68**	**79**	**23**	**5**	**12**	**25**	**38**	**78**	**39**	**2**	**753**

A seasonal variation factor of 1.0 was then used to convert the ADT to AADT.

3.6.2 Turning Movement Counts

The junction ADT TMCs are summarised in Table 3.11 below.

Table 3.12: Junction TMCs

Junction	Arm	Motorcycle	Private Cars	Large car, 4WD	Pick-ups/ Vans	Matatu	Small Bus	Large Bus	Light Trucks	Medium Trucks	Heavy Trucks	Art. Trucks	Other	Total
Takaba	Rhamu	232	63	47	70	5	1	9	23	29	49	13	0	541
	Elwak	281	42	39	65	3	3	14	27	24	50	9	0	558
	Takaba	234	53	53	64	6	2	7	32	14	22	16	0	504
Lafey	Elwak	339	91	54	84	23	4	14	27	43	48	19	0	747
	Rhamu	360	96	82	98	45	16	17	47	48	57	21	0	887
	Lafey	340	100	69	48	41	13	5	31	6	11	2	0	666
Malkamari/ Bulla Dana	Malkamari	1,045	364	192	345	96	122	15	24	55	33	64	1	2,356
	Rhamu	1,130	392	262	505	207	242	48	46	38	55	116	2	3,043
	Bulla Dana	1,130	375	185	359	174	112	38	35	57	51	74	1	2,591
	Elwak	1,090	398	244	413	95	157	78	45	52	65	127	1	2,765
Girissa	Mandera	1,655	783	509	975	354	200	77	153	166	274	900	3	6,050
	Elwak	1,904	976	521	1,067	451	245	87	194	203	376	1,090	3	7,116
	Girissa	1,896	927	479	1,008	221	75	15	111	149	291	339	0	5,511

The data shows that majority of traffic at these junctions is composed of motorcycles. The Malkamari/Bulla Dana Junction and the Girissa Junctions are located in Rhamu Town hence the high traffic volumes.

Medium trucks are used to transport water from Wargadud to areas such as Gari, Quorhanmadhow and Elwak. Vehicles transporting animals use the Takaba Junction to access the Takaba-Wajir route as a better alternative route to the Elwak-Wajir route due to insecurity and presence of police. The high number of heavy vehicles using the Takaba junction may be due to the quarry located in Takaba.

At the Lafey Junction, higher traffic was experienced on Thursday and Saturday. This can be attributed to the higher number of light trucks and medium trucks which travel to Lafey as a convoy, for security purposes, to transport goods such as sugar and flour to areas such as Bambo, Gari and Wargadud every Thursday, Saturday and Sunday.

3.6.3 *Non-Motorized Traffic (NMT) Findings*

The average 12-hr 3-day NMT findings at three (3) of the main towns are as tabulated below.

Table 3.13: 2019 NMT Findings

	Pedestrians	Bicycles	Handcarts & Animal Drawn Carts	Total
Wargadud Town	8,088	8	232	**8,328**
Gari Town	7,182	2	344	**7,528**
Rhamu Town	37,183	2	2,076	**39,262**

Animal-drawn carts are used in Rhamu Town to mainly ferry sand, firewood and water while the high number of pedestrians are market traders. Suitable NMT facilities have been proposed to handle these high NMT flows.

3.6.4 *O-D Survey Findings*

OD surveys were used to determine the traffic dispersal patterns, trip purposes, occupancy levels and goods carried by the vehicles using the project road.

Table 3.14: OD Matrix

		DESTINATION														
		1	2	3	4	5	6	7	8	9	10	11	12	13	Total	%
ORIGIN	1-Wajir-Tarbaj	0	0	0	0	0	3	0	0	0	0	0	0	0	3	**0%**
	2-Tarbaj-Kotulo	0	0	0	0	0	1	0	0	0	0	0	0	0	1	**0%**
	3-Kotulo-Elwak	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
	4-Elwak-Lafey	0	0	0	0	0	38	0	0	0	0	0	0	0	38	**5%**
	5-Lafey-Rhamu	0	0	0	0	0	23	0	0	0	0	0	0	0	23	**30**
	6-Rhamu-Mandera	3	0	0	5	18	2	1	0	4	2	4	0	0	34	**44**
	7-Takaba	0	0	0	0	0	29	0	0	0	0	0	0	0	29	**4%**
	8-Buna	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
	9-Malka-Mari	0	0	0	0	0	53	0	0	0	0	0	0	0	53	**7%**
	10-Moyale	0	0	0	0	0	11	0	0	0	0	0	0	0	11	**1%**
	11-Nairobi & its environs	0	0	0	0	0	65	0	0	0	0	0	0	0	65	**8%**
	12-Uganda, Ethiopia, Sudan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
	13-Eastern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0%**
	Total	3	0	0	5	18	43	1	0	4	2	4	0	0	78	**10**
	%	**0**	**0**	**0**	**7**	**23**	**56**	**2**	**0**	**6**	**0**	**6**	**0**	**0**	**10**	

The OD data shows that 30% and 44% of all trips originated from Lafey-Rhamu and Rhamu-Mandera respectively while 23% and 56% of the trips were destined from Lafey-Rhamu and Rhamu-Mandera respectively. This shows that majority of the traffic along the project road are local traffic. 8% of all trips originated from Nairobi, Mombasa, Meru and Thika. Miraa is transported from Meru to Rhamu and Mandera due to the high demand in these areas. Petrol is transported from Nairobi/Mombasa to Rhamu and Mandera using 6 axle trucks.

In terms of trip purposes, 57% of the trips surveyed were work trips while 32% were business trips hence revealing the economic significance of the project road.

57% of the intercepted trips were ferrying either agricultural, livestock or food products. The main agricultural products were fruits emanating from Rhamu and Mandera and also livestock.

3.5.5 Vehicle Occupancy Rates

Vehicle occupancy rates are a key input in assessing the total travel time savings. Estimated occupancy rates from the OD surveys are as presented below (Table 3.14).

Table 3.15: OD Matrix

Vehicle Type	Average Occupancy
Motorcycle	2.2
Car/Taxi	4.3
Jeeps/4wd	6.9
Van/Pickup	6.4
Minibus/Matatu	12.3
Small bus	14.3
Large Bus	47.1

3.7 Base Year and Design Year

The traffic surveys were carried out in July/August 2019. It has been assumed that the design review and documentation shall be completed by 2020. Further it has been estimated that procurement process of a Contractor and a Consultant shall take approximately 1-year and the commencement of construction shall be in 2022. An additional 36 months has also been allowed for construction. The earliest time of opening of the road shall, therefore, be 2025.

The year 2025 is therefore the assumed base year, with 2034 and 2044 assumed as the design years for geometric traffic and pavement loading analysis respectively.

3.8 Historical Traffic Data

Using the 2007 and 2019 traffic survey data, the average historical traffic growth rates over this period are as shown in Table 3.15 below.

Table 3.16: Historical Traffic Growth

Station	Year/ % Change	Motorcycle	Private Cars	Large cars/4WD/Pick-ups	Matatus & Small Buses	Large Bus	Light Trucks	Medium Trucks	Heavy Trucks	Articulated Trucks	Others	Total
Elwak	2007	4	6	51	12	2	11	19	14	8	0	127
	2019	428	105	177	19	6	12	57	188	57	11	1,057
	% Change	10600	1650	247	58	200	9	200	1243	613	10900	732
Rhamu	2007	0.1	12	30	3	4	5	6	10	6	0	75
	2019	174	104	164	47	12	11	28	77	113	0	730
	% Change	173900	767	447	1467	200	120	367	670	1783	0	873

The findings reveal exponential growth in traffic during the intervening period most probably due to the improvement of the project road in 2019. The exponential growth rates are, therefore, likely to be an indicator of suppressed demand.

3.9 Traffic Growth Scenario

Traffic growth rates have been derived from historical GDP growth, new registration for motor vehicles, fuel sales and population growth. The adopted annual growth rates segregated into low, medium and high bands is as shown in Table 3.16 below.

Table 3.17: Traffic Growth Scenarios (Low, Medium & High)

Vehicle Category	Low (%)	Medium (%)	High (%)
Motorcycles	4.9	10.4	21.2
Cars	3.3	8.4	10.9
Pickup/Vans	2.7	6.3	10.4
Matatu/Minibus	2.9	7.5	11.4
Buses	2.9	7.2	11.4
Trucks	2.7	5.6	11.6
NMT	-	4.3	-

Medium growth rates have been adopted in the economic analysis with low and high growth rates being used for sensitivity analysis.

3.10 Normal, Diverted and Generated Traffic

Normal traffic comprises traffic which uses the road even without the project while diverted traffic refers to traffic that changes from an alternative route to/from the project road, but still travels between the same origin and destination. Generated traffic on the other hand is the additional traffic due to improvement of the road and can either be induced or converted traffic.
Generated traffic is expected to be mainly from increased farming activities of watermelons, onions, mangoes and lemons around Daua River in Rhamu while diverted traffic is expected to be insignificant given the fact that the project road is a trunk road with no major competing routes.
The estimated normal, diverted, generated and induced traffic are as presented in Table 3.17 below.

Table 3.18: Normal, Diverted and Generated Traffic

	Motorcycle	Private Cars	Large car/4WD	Pick-ups/ Vans	Matatu	Small Bus	Large Bus	Light Trucks	Medium Trucks	Heavy Trucks	Articulated Trucks	Others	Total
Normal traffic	302	83	68	79	22	5	12	25	38	78	39	2	753
Diverted Traffic	0	0	5	0	0	0	2	0	0	0	0	0	7
Generated Traffic	3	4	0	0	3	0	0	0	0	2	0	0	11
Induced Traffic	0	0	0	0	0	0	0	0	0	1	1	0	2

The base year (2025) traffic is as summarised below.
Table 3.19: Base Year (2025) Traffic

	Motorcycle	Private Cars	Large car/4WD	Pick-ups/ Vans	Matatu	Small Bus	Large Bus	Light Trucks	Medium Trucks	Heavy Trucks	Articulated Trucks	Others	Total
Base Year traffic	427	110	87	96	30	6	17	35	48	97	48	-	1,001

3.11 Geometric Capacity Design

Geometric design capacity has been assessed using Tables 4.2.1 and 4.2.2 of the RDM Part I. The forecast AADT PCUs for the 10-year geometric design year are as summarized in Table 3.19 below.

Table 3.20: 10-year Traffic Forecast in PCUs

Growth Rates	10-year AADT (pcu)	Cross Section Type	Possible Cross Section Type
Low	1,977	III or IV	II or III
Medium	3,068	II or III	
High	9,074	II	

From the findings, cross-section Type II (7 m carriageway and 2.0 m shoulders) is recommended.

3.11.1 Pavement Loading Analysis

For pavement loading design, axle load surveys for heavy traffic were carried out as part of the traffic surveys. The findings were used to determine the Equivalence Factors (EFs) as provided below (Table 3.20).

Table 3.21: Sample Size and Vehicle Equivalent Factors

Vehicle Type	Northbound		Southbound	
	No.	EF	No.	EF
Large Bus	16	1.44	19	4.35
Medium Truck (2axles)	18	0.95	37	2.05
Heavy Truck (3 axles)	40	3.17	48	3.73
Articulated truck (>5 axles)	5	5.95	16	6.38

Using the southbound EF factors and the growth rates, the forecasted 15-year and 20-year cumulative equivalent standard axles are as shown in Table 3.21 below.

Table 3.22: Cumulative Standard Axles (CSA)

Period	Design Life	Low	Medium	High
15-years (2039)	CSA	5,846,894	7,465,237	19,844,368
	Traffic Class	T3	T3	T2
20-years (2044)	CSA	8,251,521	10,979,122	37,360,398
	Traffic Class	T3	T2	T1

The road has therefore been designed to traffic class T2.

4 ENGINEERING DESIGN ASPECTS

4.1 Pavement Type

The El Wak – Rhamu section was recently upgraded to bituminous standards up to Km 313 using the staged-construction approach. The pavement structure comprises of 275mm thick sub-grade and 200 mm thick sub-base with a double seal surface dressing.
Improvement shall involve strengthening this pavement to support Traffic Class 2. The proposed pavement is to consist of the following layers:

- **Surfacing:** 75 mm AC Type I & single seal surface dressing
- **Base:** 150 mm cement stabilised
- **Subbase:** 175 mm cement improved material
- **Subgrade:** Improved to S5 sub-grade

4.2 Road Sections

The homogenous road sections have primarily been derived based on homogeneity in traffic flows, urban influence and pavement type. The homogenous road sections are as presented in the Table 4.1 below.

Table 4.1: Road Sectioning Data

Approx. Chainage	Length (km)	Surfacing Type	Alignment Soil CBR
Km 177 to Km 228	51	Bituminous	14
Km 228 to Km 308	79.4	Bituminous	7
Gari Town (Km 250 to Km 251)	0.6	Bituminous	7
Km 308 to Km 313	5	Bituminous	29
Rhamu Town (Km 313 to Km 316)	3	Gravel	

4.3 Project Costs

Tables 4.223 and 4.3 below summarises the estimated financial costs of the project and unit cost of maintenance works.

Table 4.2: Estimated Project Costs (KShs)

Parameter	Amount (KShs)
Total Cost	18,633,261,583
Cost Per Km	130,943,511

For the maintenance works considered in the analysis, the unit costs are as tabulated below.

Table 4.3: Road Maintenance Costs

	Intervention	Units	Financial Costs (KSh)
Paved Sections	50mm Overlay	Per m^3	1,500
	Drainage Works	Per km	50,000
	Edge Repair	Per m^2	3,200
	Pothole Patching	Per m^2	3,000
	Routine Miscellaneous Works	Per km per year	32,000
Unpaved Sections	Light Grading	Per km	50,000
	Spot Re-gravelling	Per m^3	2,500
	Routine Miscellaneous Works	Per km per year	22,400
	Drainage Works	Per km	20,000

Source: Calibrated Kenyan HDM-4 Workspace

5 ASSESSMENT OF BENEFITS

5.1 Appraisal Methodology

The appraisal methodology has been premised on the Cost-Benefit Analysis approach and further hinged on the Consumer Surplus Approach given the fact that the traffic volumes exceed 250 vehicles per day. The adopted approach is summarized below: -

1. Defining the road network whereby homogenous sections within the road network are identified and classified together based on traffic volumes, surface condition, pavement strength, geometric properties, alignment soil properties etc.
2. Collection and review of all relevant data including traffic volumes, traffic growth rates, existing and proposed pavement structures, alignment soil characteristics, future pavement maintenance regimes, climatic conditions, and geometric characteristics amongst others;
3. Derivation of basic and economic vehicle fleet characteristics;
4. Estimation of project costs for the "without" and "with" project;
5. Calculation of Net Present Value (NPV), Economic Internal Rate of Return (EIRR), Benefit – Costs Ratio (BCR) and First Year Rate of Return (FYRR) using HDM – 4 over a 20-year analysis period;
6. Determination of whether the economic benefits outweigh the economic costs;
7. Computation of switch values and sensitivity analysis for the various alternatives, including undertaking a risk analysis;
8. Identification of intangible (i.e. non-quantifiable) benefits for secondary justification of the project; and,
9. Determining the distribution of benefits.

5.2 Vehicle Operating Characteristics

The basic vehicle fleet characteristics as provided in the calibrated and configured workspace for Kenya and, updated using field surveys are as provided in Tables 5.1 and 5.2 overleaf.

Name	Base Type	PCSE	No. of Wheels	No. of Axles	Tyre Type	Tyre Base Recaps	Tyre Retread Cost (%)	Annual Km	Annual Work Hours	Avg Life	Private Use (%)	Pass-engers	Work Related Trips (%)	ESALF	Oper. Weight (t)	Life Model
Articulated Trucks	Articulated Truck	2.20	22	6	Radial ply	0.60	12.00	75,000	2,000	10	0	0.0	0.00	6.38	42.30	Optimal
Heavy Truck	Heavy Truck	1.80	10	3	Radial ply	0.60	12.00	75,000	2,000	10	0	0.0	0.00	3.73	24.60	Optimal
Medium Truck	Medium Truck	1.50	6	2	Radial ply	0.60	12.00	75,000	2,000	10	0	0.0	0.00	2.05	10.50	Optimal
Light Truck	Light Truck	1.40	6	2	Radial ply	0.60	8.00	55,000	1,400	10	0	0.0	50.00	0.18	6.53	Optimal
Large Bus	Medium Bus	1.60	6	2	Radial ply	0.60	12.00	100,000	2,200	8	0	47.1	50.00	4.35	10.80	Optimal
Small Bus	Light Bus	1.40	6	2	Radial ply	1.30	8.00	75,000	1,750	10	0	14.3	50.00	0.14	6.48	Optimal
Mini-bus (Matatu)	Mini Bus	1.20	4	2	Radial ply	1.30	8.00	85,000	1,850	6	0	12.3	50.00	0.14	6.48	Optimal
Pick-up Utility	Light Delivery	1.00	4	2	Radial ply	0.60	8.00	45,000	1,000	8	50	6.4	50.00	0.03	2.47	Optimal
4 Wheel Drive	Four Wheel Drive	1.00	4	2	Radial ply	1.30	8.00	25,000	425	10	50	6.9	50.00	0.01	2.20	Optimal
Car	Medium Car	1.00	4	2	Radial ply	0.60	8.00	20,000	370	10	95	4.3	50.00	0.00	1.50	Constant
Motorcycles	Motorcycle	0.50	2	2	Radial ply	1.30	8.00	10,000	2,000	5	50	2.2	50.00	0.00	0.20	Optimal

Table 5.1: Basic Vehicle Fleet Characteristics (MT)

Name	Base Type	Wheel Type	No. of Wheels	Wheel Diameter (m)	Op. Weight (kg)	Payload (kg)	Avg Life	Work Hours	Annual Km	Passengers
Pedestrians	Pedestrian		0	0.00	80	15	0	0	0	1.00
Cyclists	Bicycle	Pneumatic	2	0.70	100	35	10	150	2,500	1.00
Carts	Animal Cart	Pneumatic	2	1.00	500	300	3	600	3,000	0.00

Table 5.2 Basic Vehicle Fleet Characteristics (NMT)

5.3 Vehicle Operating Cost Inputs

5.3.1 Conversion of Financial Costs to Economic Costs

A Standard Conversion Factor (SCF) has been used to convert financial costs into economic costs for carrying out economic analysis. This was necessary so as to exclude transfer of payments within the economy and provide for distortions between international and domestic prices caused by application of duties and taxes on traded items.

The following were considered in computing the economic costs;

i. All taxes, duties and subsidies are excluded
ii. Imports and exports more highly priced where the exchange rate is overvalued/there is a shortage of foreign exchange
iii. The opportunity cost of labour is used in case of under employment

The SCF formula for converting financial costs into economic costs is as summarized below: -

The S.C.F was computed using average data for the years between 2014 and 2018 as shown in the Table 5.3 below.

Table 5.3: Computation of S.C.F

		2015	2016	2017	2018	2019*	Average
1	Total Imports - CIF (M)	1,581,273	1,438,806	1,736,472	1,764,472	1,806,335	1,665,472
2	Total Domestic Exports – FOB (X)	503,023	510,042	534,393	542,857	520,787	522,220
3	Export Subsidies (S_x)	-	-	-	-	-	-
4	Taxes on International Trade Transactions (T_{m1})	121,881	131,830	138,476	153,187	142,374	137,550
5	VAT on Imported Goods & Services (T_{m2})	128,897	144,800	150,599	182,586	171,907	155,758
a	X+M	2,084,296	1,948,848	2,270,865	2,307,329	2,327,122	2,187,692
b	$M+T_{m1}+T_{m2}$	1,832,051	1,715,436	2,025,547	2,100,245	2,120,616	1,958,779
c	$X-S_x$	503,023	510,042	534,393	542,857	520,787	522,220
d	$(M+T_{m1}+T_{m2}) +(X-S_x)$	2,335,074	2,225,478	2,559,940	2,643,102	2,641,403	2,480,999
e	SCF = $(X+M)/ (M+T_{m1}+T_{m2}) +(X-S_x)$	0.89	0.88	0.89	0.87	0.88	**0.88**

*Source of Data: Economic Survey 2020, KNBS. * Provisional*

Note:
Amounts are in KSh Millions
CIF: Cost, Insurance and Freight
FOB: Free on Board

The financial costs have been converted into economic costs by applying an S.C.F of **0.88**.

5.3.2 Value of Travel Time

One of the primary drivers for road transport investments is often to have savings in passenger working and non-working time. The resulting reduced time taken to travel is often referred to as journey time savings and constitutes a major project benefit.

Since the savings in travel time can be easily quantified, the main task in appraisals, therefore, always involves establishing the VOT. VOT basically represents the opportunity cost of time and involves establishing an exchange rate between time (in hours) and money (KShs).
The social equity approach has been adopted in estimating the VOT in line with the recommendations postulated in the World Bank OT-5[4] paper: -

i. A single national value of time should be used if poverty alleviation and regional redistribution of income are national objectives.
ii. Working time should be valued at an augmented rate to account for extra costs associated with employment of labour such as social security, taxes, administration costs etc.
iii. Where unemployment rates are high, a shadow wage rate (SWR) that is lower than the actual wage rate may be justified.
iv. Business travel time should be treated in the same way as other working time savings.
v. A common value of time should be used for all non-work journeys, with a default value of 30% of the average hourly income being used for the valuation of non-work time.
vi. The value of time should be treated as increasing over time, proportional to expected increases in per capita GDP.

Due to the absence of stated preference or revealed preference data, VOT has been estimated using the wage-based approach. This approach requires determining the median monthly wages and no. of working hours.

For the estimation of median wages, the following 2018 percent distribution of the monthly salary ranges has been used.

Table 5.4: Percent Distribution of the 2018 Monthly Salaries

Monthly Salary Range (KShs)	No. of per Group	Frequency
0 - 9,999	23,188	1%
10,000 - 14,999	23,465	1%
15,000 - 19,999	91,673	3%
20,000 - 24,999	183,333	7%
25,000 - 29,999	329,746	12%
30,000 - 49,999	1,093,073	40%
50,000 - 99,999	888,162	32%
100,000 +	132,519	5%
Total	**2,765,159**	**100%**

Source: KNBS- Statistical Abstract 2019

The median worker's wage in Kenya was about **KShs. 43,000** per month based on the above data.

For determination of hourly wages, the assumptions tabulated below have been adopted in computing the working hours.

Table 5.5: Computation of Working Hours

	Item	Number
1..	Annual Gross No. of Working Days	

[4] K. Gwilliam (1997). World Bank paper OT-5: The Value of Time in Economic Evaluation of Transport Projects, Lessons from Recent Research.

	Item	Number
a.	Total Weeks Per Year	52
b.	Average No. of Working Days Per Week	5
c.	Gross Total No. of Working Days Per Year	**260**
2..	Annual Leave & Public Holidays	
a.	Total Leave Days Per Year	21
b.	Total Sick Leave Days Per Year	7
c.	Total Public Holidays Per Year	10
d.	Total Annual Leave & Public Holiday Days	**38**
3..	Net Total No. of Working Days Per Year (1.c - 2. d)	**222**
4..		
a.	Average No. of Working Hours Per Day	8
b.	Average Total No. of Working Hours Per Year (3 * 4.a)	**1,776**

Employment overhead cost is estimated as 15% of the wage, rather lower than the European figure given above by Gwilliam (World Bank, OT-5) since a large proportion of workers in Kenya are self-employed.

Based on the foregoing, the estimated VOTs are as tabulated below.

Table 5.6: Calculation of Working and Non-Working VOT

Item	Value
Average wage (KShs per year)	516,000
Working hours per year	1,776
Average wage (KShs per hour)	290.5
Employment overhead (%)	15%
Working VOT (KShs per hour)	334.1
Non-working VOT (KShs per hour)	100.2

Note: No corrections for shadow wage rate factors applied

An average of about **KShs. 334.1** per hour and **KShs. 100.2** per hour for Working and Non-working VOT respectively. The average cost of cargo delay in KShs per hour has estimated to be around 1.5 to 2.0 times the passenger working travel time cost translating to about **KShs. 584.7** per hour.

The economic vehicle fleet characteristics as provided in the calibrated and configured workspace for Kenya and, updated using field surveys are as provided in Tables 5.7 and 5.8 below.

Table 5.7 Vehicle Fleet Cost Characteristics for MT (in KShs)

Name	Base Type	New Vehicle	Replace Tyre	Fuel (per litre)	Lubricating Oil (per litre)	Maintenance Labour (per hr)	Crew Wages (per hr)	Annual Overhead	Annual Interest (%)	Passenger Work Time (per hr)	Passenger Non-Work (per hr)	Cargo Holding (per hr)
Articulated Trucks	Articulated Truck	10,700,000	56,330	56.0	221.6	420.0	413.0	1,708,000	18.0	0.0	0.00	584.7
Heavy Truck	Heavy Truck	9,900,000	56,330	56.0	221.6	420.0	325.0	1,240,448	18.0	0.0	0.00	584.7
Medium Truck	Medium Truck	4,950,000	43,000	56.0	221.6	420.0	155.0	1,240,448	18.0	0.0	0.00	584.7
Light Truck	Light Truck	3,000,000	12,797	56.0	221.6	420.0	100.0	1,112,224	18.0	0.0	0.00	584.7
Large Bus	Medium Bus	11,736,000	56,330	56.0	221.6	420.0	150.0	2,701,000	18.0	334.1	100.2	0.0
Small Bus	Light Bus	4,821,000	37,133	56.0	221.6	420.0	100.0	1,205,000	18.0	334.1	100.2	0.0
Mini-bus (Matatu)	Mini Bus	5,150,000	35,000	56.0	221.6	420.0	0.0	1,762,187	18.0	334.1	100.2	0.0
Pick-up Utility	Light Delivery	4,066,714	16,057	49.8	204.4	420.0	0.0	1,089,666	18.0	334.1	100.2	0.0
4 Wheel Drive	Four Wheel Drive	5,600,000	12,797	49.8	204.4	420.0	0.0	2,560,123	18.0	334.1	100.2	0.0
Car	Medium Car	1,871,667	7,894	49.8	204.4	420.0	0.0	757,507	18.0	334.1	100.2	0.0
Motorcycles	Motorcycle	119,350	3,000	49.8	204.4	420.0	0.0	85,500	18.0	334.1	100.2	0.0

Table 5.8: Vehicle Fleet Cost Characteristics for NMT (in KShs)

Name	Base Type	Purchase Cost	Crew Wages (per hr)	Passenger Time (per hr)	Cargo Holding (per hr)	Annual Interest (%)
Pedestrians	Pedestrian	0	0.00	60.80	91.1	0.00
Cyclists	Bicycle	6,000	25.00	60.80	91.1	18.00
Carts	Animal Cart	15,000	25.00	0.00	91.1	18.00

5.4 Road Accident Analysis

HDM-4 allows users to describe the expected accident rates for different road and traffic conditions such as road type and geometry, traffic flow pattern and other conditions.

The three accident severity types are:

i. Fatal – If death occurs within a fixed period (e.g. 30 days) following the accident;
ii. Injury – No fatalities occur, only injuries; and,
iii. Damage Only – Only damage to property occurs but no personal injuries.

Accident rates in the HDM-4 model are usually expressed based on the concept of exposure. Exposure rate is calculated in terms of 100 million veh-km using the equations shown here.

$$EXPOSINT = AADT \times 365 / 10^6$$

whereby: -

AADT = Annual Average Daily Traffic
EXPOSINT = Exposure

The accident rate per 100 million veh-km is then established as the number of accidents per year divided by the exposure.

$$ACCRATE = ACCYR / EXPOSURE$$

whereby: -

ACCRATE = Accident Rate per 100 million veh-km
ACCYR = Number of Accidents Per Year
EXPOSURE = Exposure Rate

It is generally agreed that the nature and incidence of accident rates can change with road improvements. For instance, constructing a dual carriageway with faster speeds, may mean that less accidents will occur but may, however, increase the severity of the accidents.

In Kenya, there are no explicit studies examining the impact of changes in the accident rates whenever a road improvement is undertaken making it extremely difficult to forecast how any given road improvement will impact the accident rates.

The various components to accident costs include amongst others: -

i. Loss of earnings of individuals directly involved in accidents;
ii. Opportunity cost to a displaced member of society;
iii. Welfare costs associated with family bereavement (grief);
iv. Welfare loss of dependents' reduced life chances;
v. Damage to property;
vi. Costs of health services and emergency services involved; and,
vii. Traffic disruption.

Like in most countries across the globe, there are no agreed national guidelines to costing accidents in Kenya due to the little consensus in assigning "value to the human life".

Due to its complexity and uncertainty, accident savings has been excluded from this economic analysis due to lack of data and consensus regarding the models, dependent variables, costing and even analysis methods to adopt.
A road safety audit is proposed to be undertaken during the design process to enhance the safety of the project.

6 ECONOMIC ANALYSIS

6.1 Cost Benefit Analysis

Economic Cost Benefit Analysis involves calculating the likely costs and benefits of a project and using the results to make recommendations regarding the viability of an investment decision. It helps to answer a range of pertinent investment decisions such as: -

1. Is the project viable? (i.e. benefits must be greater than costs).
2. Which is the best optimal alternative from the set of project alternatives?
3. When is the optimal year for construction and opening of the project?
4. How should the mutually exclusive projects be prioritized/ranked in case funds are limited?
5. Should the project be implemented in stages?
6. What is the best work and maintenance standard to be adopted?

The purpose of road investment appraisal is to select projects with high economic returns i.e. determine how much to invest and what economic returns to expect. The size of the investment is determined by the costs of construction and annual road maintenance. The economic returns are mainly in the form of savings in road user costs due to the provision of a better road facility. These three costs constitute what is commonly referred to as the total (road) transport cost or the whole life cycle cost.

The primary benefits of road rehabilitation and upgrading projects derive from:

1. Savings in maintenance expenditures;
2. Savings in vehicle operating costs;
3. Reduction in travel time to passengers and goods;
4. Reductions in the number and severity of accidents;
5. Salvage value of the road structure at the end of the analysis period;
6. Reduction in negative environmental effects; and,
7. Increase in value of goods moved

The secondary benefits include:

1. Induced economic development, such as agricultural or tourist activities that were previously constrained by poor access; and,
2. Social benefits arising from the increased mobility of the population and improved accessibility to health, education and other services.

Economic analysis, as this, has been designed to give maximum coverage of costs and benefits. However, it is important to avoid double counting, that is, do not add primary and secondary benefits (e.g. increases in land values added to changes in transport costs). Secondary benefits are usually ignored. The consumer surplus approach should be adequate for carrying out economic analysis.

6.2 Estimation of Benefits

6.2.1 HDM-IV Analysis Tool

The Highway Development and Management (HDM-4) model has been used for estimation of benefits. HDM-4 is a software used to appraise both technical and economic aspects of road investment projects. It's the most commonly used software for appraisal of road investment projects due to 1) an internationally accepted analysis framework; 2) transparency in its analysis; and 3) ability to be calibrated to local conditions. It has therefore been used for this economic analysis.

The approach used for the economic analysis is the cost-benefit analysis of "with" or "without project" case. The economic analysis is based on homogenous road sections, in terms of physical characteristics, traffic and road condition.

The HDM-4 analytical framework is based on the concept of pavement life cycle analysis, which is typically 15 to 40 years. This is applied to predict road deterioration, road works effects, road user effects and socio-economic and environmental effects, Odoki and Kerali (2000).

To ensure accurate prediction of pavement performance and vehicle resource consumption, the configured and calibrated HDM-4 workspace for Kenya has been adopted in this analysis

The main data sets required as inputs for HDM-4 analyses are categorized as follows:

1. **Road Network Data:** include inventory, geometry, pavement type, pavement strength, road condition.
2. **Traffic Data:** include details of traffic composition, volumes and growth rates, speed-flow types and traffic flow pattern.
3. **Vehicle Fleet Data:** include vehicle physical characteristics, tyres, utilization, loading and performance.
4. **Road Works Data:** include a range of construction and maintenance work items together with their unit costs.
5. **Economic Analysis components and parameters:** include discount rate, analysis period, salvage value, standard conversion factors etc.

The sources of data used in this study included the following: field surveys carried out by the Consultant, KeNHA, Kenya Roads Board (KRB), previous studies conducted in the study area, internet literature review and HDM-4 parameter default values. The *Economic Appraisal Guidelines for Road and Transport Projects* prepared by the Ministry of Transport and Infrastructure have also been adopted.

6.2.2 Economic Analysis Parameters

Discount Rate

Discount rate refers to the opportunity cost of capital in the public sector. It is recommended to use the planning discount rate and not the financial market rate in conducting economic analysis.

The planning discount rate used in the calculation of the NPV was taken as **12%**, in line with the recommendations of the Road Sector Investment Project II (2018 – 2022). The World Bank also recommends the 12%[5] discount rate since most research have shown that the cost of capital for developing countries is higher than 10%.

[5] The World Bank (1998), Handbook on Economic Analysis of Investment Operations. Washington DC: The World Bank.

Annual Cost Stream

The project cost has been phased over a 3-year construction period taking cognisance of the prepared work programmes. It's been assumed that 30% shall be invested in the first year, 30% in the second year and the remaining 40% in the terminal year of the project.

The Salvage Value

Whenever an asset's life lasts longer than the analysis period, its residual value (i.e. value of the remaining life) at the last year of analysis should always be discounted and then included as a project benefit.

Amongst the various project elements, bituminous components have been assumed to have a life of about 20-years or less depending on periodic treatment with a zero-salvage value. The formation layers below the bituminous layer on the other hand has been assumed to have a 30-year life since they are most often recoverable, while the structural elements have been assumed to have a life of more than 50-years. Other residual values incorporated includes the cost of land acquisition, social displacement cost etc.

A salvage value of about 20% of capital cost of construction has been adopted for this economic analysis based on estimates from the straight-line depreciation method. The method involves deducting the residual value of an asset form the original cost and dividing the balance equally by the number of years of estimated life.

6.3 Analysis Scenarios

Two alternatives have been considered in this analysis, viz.

i. The *"without project"* – Maintaining the existing road with the aim of preserving the existing asset using the present practice; and,
ii. The *"with project"* – Improving the road to a higher design class e.g. stronger pavement, improved drainage, widened cross-section etc.

The road work standards for each project alternative is as tabulated below.

Table 6.1: Project Alternatives

"Without Project" Activities		"With Project" Activities
Paved Sections	**Unpaved Sections**	**Paved/Unpaved Sections**
• Edge repair every year • Patching potholes ≥ 5 no. potholes/km • Drainage works every year • Routine Miscellaneous works every year • 50mm overlay after at least 7 years and 4≤IRI≤9	• Light grading every year • Spot re-gravelling when gravel thickness≤100mm • Routine Miscellaneous works every year • Drainage works every year	• Upgrading the road to a stronger pavement with widened shoulders and improved drainage.

The trigger mechanisms for the work standards are those adopted in the calibrated HDM-4 workspace for Kenya.

6.4 Multi Criteria Analysis

Traditionally, appraisal has often been based on the concept of the cost-benefit analysis (CBA) with little or no consideration to other impacts including social concerns, political concerns, safety concerns, environmental impacts, energy concerns and comfort amongst others. This has often been attributed to the difficulty in quantification, valuation and forecasting of these other impacts in monetary terms using the current techniques and tools.

Unlike the traditional CBA method, MCA allows for the integration of both quantitative and qualitative costs and benefits, and monetised and non-monetised costs and benefits in a single analytical framework.

MCA analysis is based on the *Analytic Hierarchy Process (AHP)* method which allows for the conversion of subjective assessments of relative importance to a set of overall scores or weights.

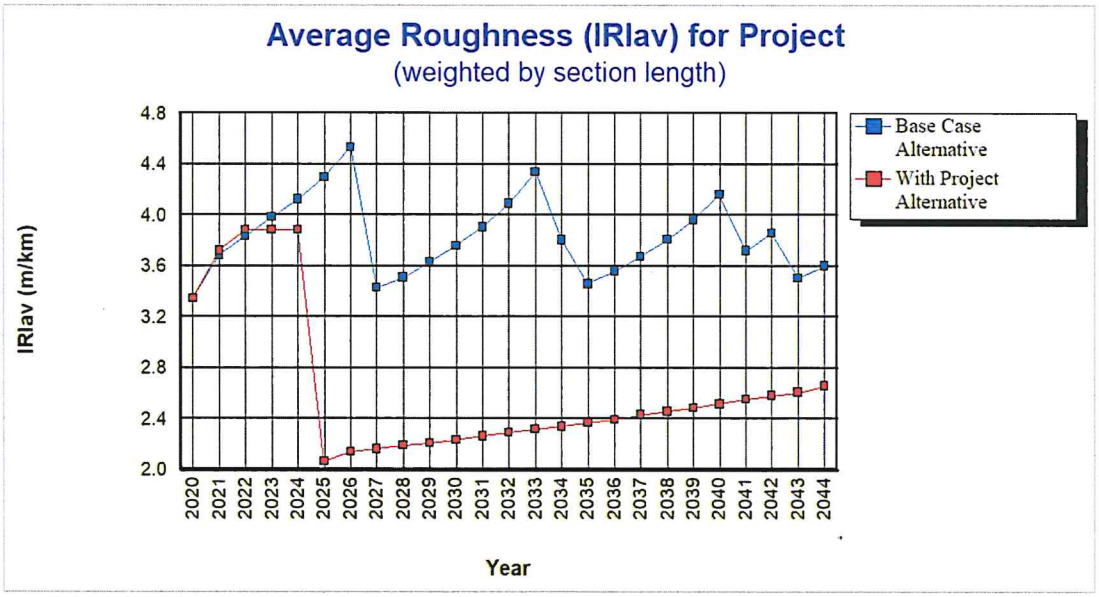
The procedure[6] for inclusion of these other impacts often involves: -1) the definition of a decision criteria; 2) identification of the costs and benefits; 3) estimation of the relative weightings of the costs and benefits; 4) calculation of individual attributes and combined scores of alternatives; and, 5) investment decision making based on the rank/score outcomes.

To determine the relevant criterion and the perceived weightings, it's often essential to conduct stakeholder surveys which involves comparing impacts (i.e. benefit/cost) against one another and using the findings to derive the corresponding relative weights. The benefits/costs weightings are then incorporated into the HDM-4 to assist in making investment decisions.

For this study, MCA field surveys were not conducted as this was not part of the scope of works. Furthermore, the economic costs and benefits have been captured in their totality in estimating economic indicators.

6.5 Road Deterioration Trends

Figure 6.1: Road Deterioration Trends



[6] Jennaro B. Odoki, Farhad Ahmed, Gary Taylor & Sunday A. Okello (April 2008). Towards the Mainstreaming of an Approach to Include Social Benefits within Road Appraisal: A Case Study from Uganda. The World Bank Group

These condition trends represent the engineering performance of the project over the entire life cycle and are premised on the assumption that the defined maintenance standards shall be adhered to.

The average initial roughness is above 3.3 IRI m/km. After upgrading the road sections and following strictly the specified maintenance activities and intervention criteria, the average annual roughness over the analysis period doesn't exceed around 3 IRI.

6.6 Project Benefits

The main benefits include savings in vehicle operating costs (VOCs) and travel time costs (TTCs) for both motorized and non-motorized transport. The discounted and undiscounted savings in VOCs and TTCs is as tabulated below.

Table 6.2: Project Net Benefits (KShs Millions)

	Discounted Savings		Undiscounted Savings	
	Savings VOC	Savings TTC	Savings VOC	Savings TTC
Benefits	510.6	143.7	2,484.8	764.1

In overall, the discounted savings in VOC and TTC would amount to KShs. 510.6 million and KShs. 143.7 million respectively discounted over the analysis period, while the undiscounted savings would amount to KShs. 2,484.8 million and KShs. 764.1 million for VOC and TTC respectively.

6.7 Economic Indicators

6.7.1 Net Present Value (NPV) Criterion

This refers to the present value of the net benefits of a project. For a project to be economically justifiable, the NPV must be positive when discounted at an appropriate rate. Usually, the larger the NPV the better the project and that it can be used to choose between mutually exclusive projects.

NPV is computed using the expression below: -

$$NPV = (B_1 - C_1)/(1 + r) + (B_2 - C_2)/(1 + r)^2 + \ldots + (B_n - C_n)/(1 + r)^n$$

Whereby: -

$B_1, B_2 \ldots B_n$	=	*Benefits in years 1, 2 …. n*
$C_1, C_2 \ldots C_n$	=	*Costs in years 1, 2 …. n*
r	=	*Planning discount rate*
n	=	*Planning time horizon*

6.7.2 Economic Internal Rate of Return (EIRR) Criterion

This is the discount rate that results into an NPV of zero for a given project. For a project to be economically justifiable, the EIRR must be equal or greater than the planning discount rate. Usually, the higher the EIRR the better the project but it cannot be used to decide between mutually exclusive projects.

EIRR is computed using the expression below: -

$$0 = (B_1 - C_1)/(1 + r) + (B_2 - C_2)/(1 + r)^2 + \ldots + (B_n - C_n)/(1 + r)^n$$

Whereby: -

$B_1, B_2 \ldots B_n$	=	*Benefits in years 1, 2 …. n*
$C_1, C_2 \ldots C_n$	=	*Costs in years 1, 2 …. n*
r	=	*EIRR*
n	=	*Planning time horizon*

6.7.3 Benefit-Cost Ratio (BCR) Criterion

The BCR is the ratio of discounted benefits divided by discounted costs. A positive BCR signifies a viable project. The ratio gives an indication of the profitability of investment option relative to base option at a given discount rate. It helps eliminate the bias of NPV towards larger project options but, like the IRR, gives no indication of the size of the costs or benefits involved.

The BCR of investment option m, relative to base option n, is calculated as follows:

$$BCR_{(m-n)} = \frac{NPV_{(m-n)}}{C_m} + 1$$

Whereby: -

$BCR_{(m-n)}$	=	*Benefit cost ratio of investment option m relative to base option n*
$NPV_{(m-n)}$	=	*Discounted total net benefit of investment option m relative to base option n. This is the NPV at discount rate r*
C_m	=	*Discounted total road agency costs (RAC) of implementing investment option m*

6.7.4 First Year Rate of Return (FYRR)

FYRR is used as an indicator of the optimal project timing. It is computed using the expression below: -

$$FYRR\ (\%) = (B_1 - C_1) / C_i$$

Whereby: -

B_1 *and* C_1 = *Benefits and Costs in year 1 after construction*

C_i = *Road investment costs*

Normally if a computed FYRR is greater than the planning discount rate, then the project should have commenced earlier, if equal to the planning discount rate, then the project is timely and should go ahead, but if less than the discount rate, then the start of the project should be deferred. It may also call into consideration the adoption of a lower-cost upgrading method.

6.7.5 Economic Indicator Outputs

The Table 6.3 below summarizes the economic indicators of the economic analysis at 12% discount rate.

Table 6.3: Economic Indicators at 12% Discount Rate

Indicator	Value
NPV (KSh. Millions)	5,132.2
EIRR (%)	16.2
BCR	1.51
FYRR (%) *	0.3%

** Excludes the urban sections*

The results show that strengthening of the pavement, improving the drainage and widening of the cross-section is viable as proposed. The low FYRR however show that these improvements do not need to be undertaken immediately and that they can be delayed without losing project benefits. Improvements within the urban sections should however be prioritised as they yield very high FYRRs.

6.8 Sensitivity Tests

Sensitivity analysis involves identifying and quantifying the variables that greatly influence a project's net benefits. Sensitivity analysis is normally carried out by increasing or decreasing cost and benefit variables in order to measure their impact on the project's IRR and NPV results. It serves to indicate the robustness of the project in the event of changes in key parameters.

Sensitivity analysis to evaluate the impact of changes in key factors to the project's viability was undertaken.

The scenarios considered were:

i. A 20% increase in costs;
ii. A 20% decrease in benefits; and,
iii. A combination of a 20% increase in costs and a 20% decrease in benefits.

The table below summarises the sensitivity analysis results for the various project roads.

Table 6.4: Sensitivity Analysis Findings

Scenario	Outputs		
	NPV (KShs Millions)	IRR (%)	BCR
Increase in Costs	3,123.3	14.3	1.26
Decrease in Benefits	2,096.9	13.9	1.21

Increase in Costs + Decrease in Benefits	88.0	12.1	1.01

For the scenarios analysed, the viability of the project is more threatened by a decrease in benefits than changes in costs. This could be attributed to the low baseline traffic.

6.9 Switching Tests

The switch value of a cost or benefit is that value at which the project's NPV becomes zero (or the IRR equals the opportunity discount rate). It's usually expressed in terms of the percentage change in say the cost, AADT or traffic growth rates needed for the project's viability to be threatened. Switching values gives an indication of the variables that will affect the project outcomes the most.

The Table 6.5 below summarises the switch values for the project road.

Table 6.5: Switch Value Analysis Findings

Parameter	Change
Increase in Capital & Recurrent Costs (%)	+52%
Decrease in Traffic Growth Rates (%)	-59%

It would take a 52% increase in cost or 59% decrease in traffic growth rates for the viability of project to be threatened.

6.10 Distribution of Benefits

Accrued benefits in HDM-4 can be segregated into various categories including time savings attributable to passengers; cargo holding costs attributable to freight operators; vehicle operating cost (VOC) savings attributable to vehicle owners; operation costs savings attributable to NMT users; and, road maintenance costs attributable to the Government.

These benefits are clearly defined outputs of HDM-4 and are summarised below.

Table 6.6: Distribution of Benefits

Benefit Category	Proportion (%)
Passengers	26
Freight Operators	4
Vehicle Owners	70

Most benefits are expected to be derived from VOC savings to vehicle owners (70%) and time savings to passengers (26%). The low benefits being accrued to the freight operators (4%) could be due to low proportion of trucks plying the project road.

7 INTANGIBLE BENEFITS

7.1 Accrued Benefits

Accrued benefits in HDM-4 can be segregated into various categories including time savings attributable to passengers; cargo holding costs attributable to freight operators; vehicle operating cost (VOC) savings attributable to vehicle owners; operation costs savings attributable to NMT users; and, road maintenance costs attributable to the Government.

7.2 Growth of the Local Economy

This is expected to be derived from amongst others local purchases of sand, gravel, hardstones etc. Better access shall also boast earnings from tourism within the northern tourism circuit which covers amongst others the Malkamari National Park

7.3 Creation of Employment Opportunities

Creation of employment opportunities for the local populace during the construction period for both semi-skilled and unskilled labour (e.g. messengers, secretaries, drivers, cleaners, watchmen, labourers etc.). This is projected to inject billions of shillings into the local economy and in the process improve the living standards. During the construction period, there shall also be training and technology transfer to local communities.

7.4 Improved Security

This likely to be due to better access and response by the police whenever conflicts flare up. Improved security may further reduce the cost of doing business by eliminating the need for police escorts and even allowing for night trips as was again witnessed along the adjacent Isiolo - Moyale road.

7.5 Increase in Value of Land

Improved access is expected to result into an increase in the value of land within the vicinity of the project road. This was the case in Marsabit town after upgrading of the Isiolo – Moyale road where there was tenfold[7] increase in value of land.

7.6 Reduced Cost of Living

This is likely to be deduced from the reduced cost of transportation of goods and services for essential commodities including fresh produce.

[7] H.P. Gauff Consulting Engineers (Sept. 2016). Supervision of Construction of Merille River–Marsabit Road (A2). Socio-Economic Report Impact of Upgrading. Report No. 3. Page 15.

7.7 Improved Access to Social Services and Amenities

These include hospitals, schools, government services, extension services etc. leading to improved living standards.

8 CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

At 12% discount rate, the total net present value of benefits has been estimated at KShs. 5.132 billion with an economic rate of return of 16.2% and benefit-cost ratio of 1.51. The positive NPV, an EIRR which is greater than the planning discount rate and BCR which is greater than one shows that the project is viable. However, a first-year rate of return lower than the planning discount rate shows that the implementation of the project can be delayed without losing benefits.

The results from the sensitivity analysis showed that for the scenarios analyzed, the viability of the project is threatened most by changes in benefits than changes in costs, and that even if the costs are increased by 20% and benefits reduced by 20%, the project is still viable.

Switch values on the other hand have revealed that it would take a 52% increase in costs or a 59% decrease in traffic growth rates for the viability of the project to be threatened. This shows that the project is robust given the high percentages by which the traffic growth rates need to decline or the costs need to increase for the project's viability to be threatened.

In terms of distribution of benefits, most benefits are expected to be derived from VOC savings to vehicle owners (70%), time savings to passengers (26%) and cargo holding cost savings to the freight operators (4%).

8.2 Recommendations

The project is expected to have enormous economic and social benefits if implemented. All the identified negative social and environmental impacts are manageable, and suitable mitigation measures have been proposed. It is justifiable to conclude that the proposed road project is viable and should be implemented as proposed.

9 REFERENCES

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Appendices

Appendix A: Average Roughness

Appendix B: Economic Indicators Summary

Appendix C: Work Standards

Appendix A: Average Roughness

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HIGHWAY DEVELOPMENT & MANAGEMENT

Average Roughness by Project (Graph)

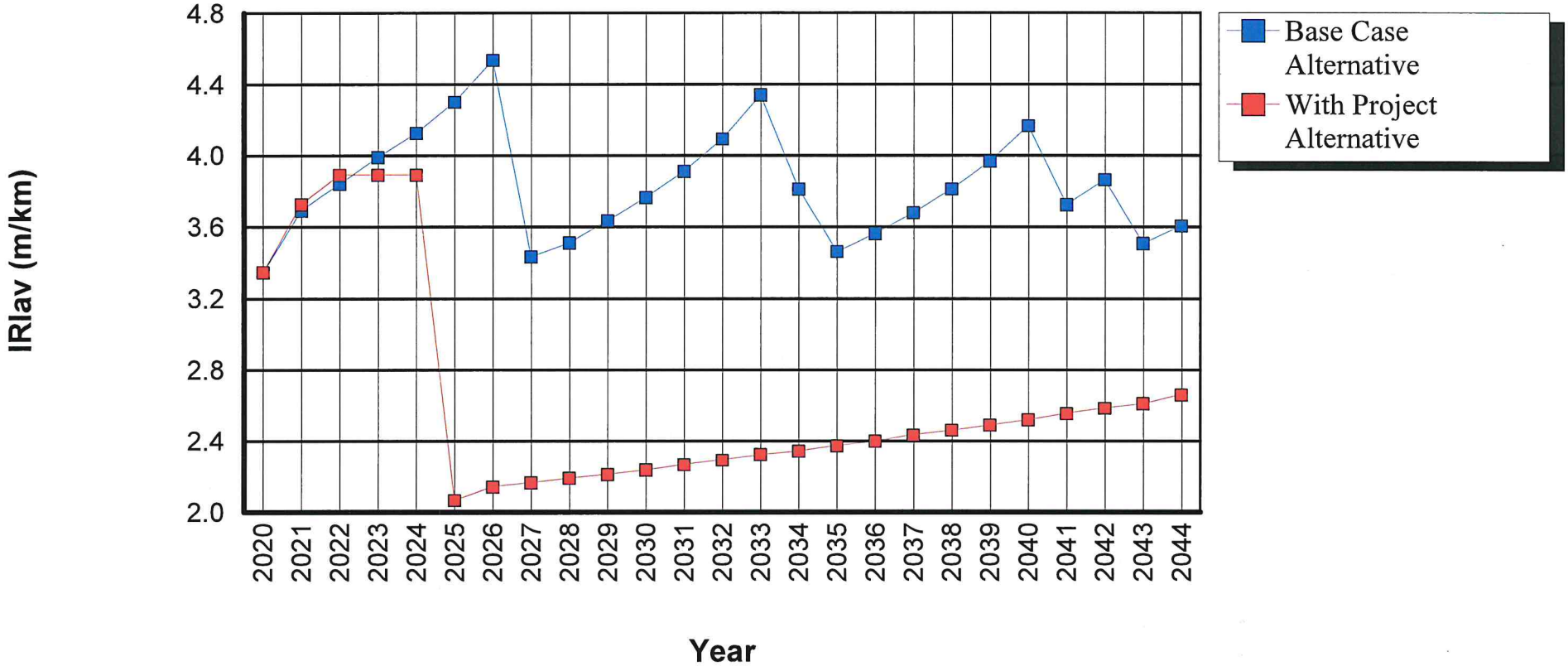
Study Name: **Upgrade El Wak - Rhamu Road**

Run Date: **22-06-2020**

Sensitivity: No Sensitivity Analysis Conducted

Average Roughness (IRIav) for Project

(weighted by section length)



Appendix B: Economic Indicators Summary

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HIGHWAY DEVELOPMENT & MANAGEMENT

Road Sections - Basic

Study Name: **Upgrade El Wak - Rhamu Road**
Run Date: **22-06-2020**

ID	Name	Speed Flow Type	Traffic Flow Pattern	Road Class	Climate Zone	Surface Class	Calibration Item	Length (Km)	Width (m)	Shoulder width (m	ELanes
ER001	Km 177 to Km 228	Two-Lane	Inter-Urban A	Class A	CZ I_Arid	Bituminous	CZ I_STGB	51.00	7.00	1.50	2
ER002	Km 228 to Km 308	Two-Lane	Inter-Urban A	Class A	CZ I_Arid	Bituminous	CZ I_STGB	79.40	7.00	1.50	2
ER003	Km 308 to Km 313	Two-Lane	Inter-Urban A	Class A	CZ I_Arid	Bituminous	CZ I_STGB	5.00	7.00	1.50	2
Gari Town	Km 250 to Km 251	Two-Lane	All Urban	Class A	CZ I_Arid	Bituminous	CZ I_STGB	0.60	7.00	1.50	2
Rhamu Town	Km 313 to Km 316	Two-Lane	All Urban	Class A	CZ I_Arid	Unsealed	CZ I_Gravel	3.00	6.50	0.00	2

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HIGHWAY DEVELOPMENT & MANAGEMENT

Vehicle Fleet - Economic

Study Name: **Upgrade El Wak - Rhamu Road**
Run Date: **22-06-2020**
Currency: **Kenya Shilling**

Motorised Vehicle Types:

Name	Base Type	New Vehicl	Replac Tyre	Fuel (per litre	Lubr. Oi (per litre	Maint Labour (per hr	Crew Wages (per hr	Annual Overhead	Annual Interes (%)	Passenge Work Time (per hr	Passenge Non-Worl (per hr	Cargo Holding (per hr
Articulated Trucks	Articulated Truck	10,700,000	56,330	56.00	221.60	420.00	413.00	1,708,000	18.00	0.00	0.00	584.70
Heavy Truck	Heavy Truck	9,900,000	56,330	56.00	221.60	420.00	325.00	1,240,448	18.00	0.00	0.00	584.70
Medium Truck	Medium Truck	4,950,000	43,000	56.00	221.60	420.00	155.00	1,240,448	18.00	0.00	0.00	584.70
Light Truck	Light Truck	3,000,000	12,797	56.00	221.60	420.00	100.00	1,112,224	18.00	0.00	0.00	584.70
Large Bus	Medium Bus	11,736,000	56,330	56.00	221.60	420.00	150.00	2,701,000	18.00	334.10	100.20	0.00
Small Bus	Light Bus	4,821,000	37,133	56.00	221.60	420.00	100.00	1,205,000	18.00	334.10	100.20	0.00
Mini-bus (Matatu)	Mini Bus	5,150,000	35,000	56.00	221.60	420.00	100.00	1,762,187	18.00	334.10	100.20	0.00
Pick-up Utility	Light Delivery	4,066,714	16,057	49.80	204.40	420.00	0.00	1,089,666	18.00	334.10	100.20	0.00
4 Wheel Drive	Four Wheel Drive	5,600,000	12,797	49.80	204.40	420.00	0.00	2,560,123	18.00	334.10	100.20	0.00
Car	Medium Car	1,871,667	7,894	49.80	204.40	420.00	0.00	757,507	18.00	334.10	100.20	0.00
Motorcycles	Motorcycle	119,350	3,000	49.80	204.40	420.00	50.00	85,500	18.00	334.10	100.20	0.00

Non-Motorised Vehicle Types:

Name	Base Type	Purchas Cos	Crew Wages (per hr	Passenge Time (per hr	Cargo Holding (per hr	Energy Used (per MJ	Annual Interes (%)
Pedestrians	Pedestrian	0	0.00	60.80	91.10	0.00	0.00
Cyclists	Bicycle	6,000	25.00	60.80	91.10	0.00	18.00
Carts	Animal Cart	15,000	25.00	60.80	91.10	0.00	18.00

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HIGHWAY DEVELOPMENT & MANAGEMENT

Vehicle Fleet - Basic

Study Name: **Upgrade El Wak - Rhamu Road**
Run Date: **22-06-2020**

Motorised Vehicle Types:

Name	Base Type	PCSE	No. of Wheels	No. of Axles	Tyre Type	Tyre Base Recaps	Tyre Retread Cost (%	Annual Km	Annual Work Hours	Avg Life	Private Use (%)	Passengers	Work Related Trips (%	ESALF	Oper Weight (t)	Life Model
Articulated Trucks	Articulated Truck	2.20	22	6	Radial ply	0.60	12.00	75,000	2,000	10	0	0.00	0.00	6.38	42.30	Optimal
Heavy Truck	Heavy Truck	1.80	10	3	Radial ply	0.60	12.00	75,000	2,000	10	0	0.00	0.00	3.73	24.60	Optimal
Medium Truck	Medium Truck	1.50	6	2	Radial ply	0.60	12.00	75,000	2,000	10	0	0.00	0.00	2.05	10.50	Optimal
Light Truck	Light Truck	1.40	6	2	Radial ply	0.60	8.00	55,000	1,400	10	0	0.00	50.00	0.18	6.53	Optimal
Large Bus	Medium Bus	1.60	6	2	Radial ply	0.60	12.00	100,000	2,200	8	0	47.10	50.00	4.35	10.80	Optimal
Small Bus	Light Bus	1.40	6	2	Radial ply	1.30	8.00	75,000	1,750	10	0	14.30	50.00	0.14	6.48	Optimal
Mini-bus (Matatu)	Mini Bus	1.20	4	2	Radial ply	1.30	8.00	85,000	1,850	6	0	12.30	50.00	0.14	6.48	Optimal
Pick-up Utility	Light Delivery	1.00	4	2	Radial ply	0.60	8.00	45,000	1,000	8	50	6.40	50.00	0.03	2.47	Optimal
4 Wheel Drive	Four Wheel Drive	1.00	4	2	Radial ply	1.30	8.00	25,000	425	10	50	6.90	50.00	0.01	2.20	Optimal
Car	Medium Car	1.00	4	2	Radial ply	0.60	8.00	20,000	370	10	95	4.30	50.00	0.00	1.50	Constant
Motorcycles	Motorcycle	0.50	2	2	Radial ply	1.30	8.00	10,000	2,000	5	50	2.20	50.00	0.00	0.20	Optimal

Non-Motorised Vehicle Types:

Name	Base Type	Wheel Type	No. of Wheels	Wheel Diameter (m	Op. Weight (kg	Payload (kg	Avg Life	Work Hours	Annual Km	Passengers
Pedestrians	Pedestrian		0	0.00	80	15	0	0	0	1.00
Cyclists	Bicycle	Pneumatic	2	0.70	100	35	10	150	2,500	1.00
Carts	Animal Cart	Pneumatic	2	1.00	500	300	3	600	3,000	0.00

HDM - 4
HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Indicators Summary

Study Name: **Upgrade El Wak - Rhamu Road**
Run Date: **02-06-2020**
Currency: **Kenya Shilling (millions)**
Discount Rate: **12.00%**

Sensitivity: Base Sensitivity Scenario

Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase i Agency Cost (C)	Decrease i User Cost (B)	Net Exogenous Benefit (E)	Net Presen Value (NPV = B+E-C	NPV/Cos Ratio (NPV/RAC	NPV/Cos Ratic (NPV/CAP	Internal Rat of Returr (IRR
Base Case Alternative	1,154.942	1,028.822	0.000	0.000	0.000	0.000	0.000	0.000	0.000
With Project Alternative	11,199.232	11,111.438	10,044.289	15,176.470	0.000	5,132.180	0.458	0.462	16.2 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

Sensitivity: Decrease in Benefits

Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase i Agency Cost (C)	Decrease i User Cost (B)	Net Exogenous Benefit (E)	Net Presen Value (NPV = B+E-C	NPV/Cos Ratio (NPV/RAC	NPV/Cos Ratic (NPV/CAP	Internal Rat of Returr (IRR
Base Case Alternative	1,154.942	1,028.822	0.000	0.000	0.000	0.000	0.000	0.000	0.000
With Project Alternative	11,199.232	11,111.438	10,044.289	12,141.176	0.000	2,096.887	0.187	0.189	13.9 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

Sensitivity: Increase in Cost

Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase i Agency Cost (C)	Decrease i User Cost (B)	Net Exogenous Benefit (E)	Net Presen Value (NPV = B+E-C	NPV/Cos Ratio (NPV/RAC	NPV/Cos Ratic (NPV/CAP	Internal Rat of Returr (IRR
Base Case Alternative	1,154.942	1,028.822	0.000	0.000	0.000	0.000	0.000	0.000	0.000
With Project Alternative	11,199.232	11,111.438	12,053.148	15,176.470	0.000	3,123.322	0.279	0.281	14.3 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

Sensitivity: Increase in Cost+Decrease in Benefits

Alternative	Present Value of Total Agency Costs (RAC)	Present Value of Agency Capital Costs (CAP)	Increase i Agency Cost (C	Decrease i User Cost (B	Net Exogenous Benefit (E	Net Presen Value (NPV = B+E-C	NPV/Cos Ratio (NPV/RAC	NPV/Cos Ratic (NPV/CAP	Internal Rat of Retur (IRR
Base Case Alternative	1,154.942	1,028.822	0.000	0.000	0.000	0.000	0.000	0.000	0.000
With Project Alternative	11,199.232	11,111.438	12,053.148	12,141.176	0.000	88.028	0.008	0.008	12.1 (1)

Figure in brackets is number of IRR solutions in range -90 to +900

Appendix C: Work Standards

Improvement Standards

Study Name: **Upgrade El Wak - Rhamu Road**
Run Date: **22-06-2020**
Works Currency: **Kenya Shilling**

Upgrade Km 177 - Km 313 Paved Rural Section

Short code:	UPPV	Operation type:	Upgrading	Feature type:	Carriageway
Existing surface class:	Bituminous	Duration (years):	3		

Design

Speed flow type:	Two-Lane	Length adj.	1.00
Accident class:	2-4 Lane Roads_Low Traffic	Iditional NMT lanes:	2
Pavement type:	AMSB (Asphalt Mix on Stabilised Base)	After works width (m)	11.00
Road class:	Class A	New construction:	0.50
Traffic Flow Pattern:	Inter-Urban A		

Costs

Economic unit cost:	115,231,000.00	Financial unit cost:	130,944,000.00	Cost units:	per km
% cost stream year 1:	30.00	% cost stream year 2:	30.00	% cost stream year 3:	40.00
% cost stream year 4:	0.00	% cost stream year 5:	0.00		
Salvage cost:	20.00 %				

Unit Costs of Preparatory Works (per m2)

Economic resurfacing:	0.00	Economic patching:	0.00	Economic edge-repair:	0.00
conomic crack sealing:	0.00	Financial resurfacing:	0.00	Financial patching:	0.00
Financial edge-repair:	0.00	Financial crack sealing:	0.00		

Pavement

Dry season struct num:	3.40	Surface thickness (mm):	75.00	Relative compaction (%):	97.00
Base thickness	150.00	Base modulus:	15.00		

Construction - Quality Indicators

uminous surfacing, CDS	1.00
Base, CDB	0.00

Construction - Resurfacing

Resurface exisiting carriagewa	No	Resurface thickness	150.00 mm
		Strength coefficient:	0.40

Geometry

Rise + Fall:	10.00 m/km	Rises + Falls:	2.00 no./km	Curvature:	15.00 deg/km
Superelevation	2.50 %	adral (m/s2):	0.10	Speed limit (km/h):	100.00
Enforcement factor:	1.10	XNMT:	1.00	XMT:	1.00
XFRI:	1.00				

Asset Valuation

	Proportion of Cost	Residual Value	Useful Life	
Road Formation& subgrade:	0.00 %	0.00 %	0.00 years	Proportion of exisiting ass to decommisio 0.00 %
Road Pavement layers:	100.00 %	0.00 %	0.00 years	
NMT lanes:	0.00 %	0.00 %	0.00 years	

Calibration - Surface Distress

	Initiation	Progression		
All structural Cracking:	1.00	1.00	Crack retardation time:	0.00/ears
Wide structural Cracking:	1.00	1.00	Ravelling retardation factor:	1.00
Transverse Thermal Cracking:	1.00	1.00		
Ravelling:	1.00	1.00		
Pothole (Cracking initiated):	1.00			
Pothole (Ravelling initiated):	1.00			
Pothole (all):		1.00		
Edge Break:	1.00			

Calibration - Surface Texture

Texture Depth:	1.00
Skid Resistance:	1.00
kid Resistance - speed effects:	1.00

Calibration - Structural Defects

RUTTING		STRUCTURAL NUMBER	
Initial densification:	1.00	Seasonal effects:	1.00
Structural deterioration:	1.00	Structural no. due to	1.00
Plastic deformation:	0.00	ROUGHNESS	
Surface wear:	1.00	Environmental coefficient:	1.00
Standard Deviation:	1.00	Progression (structural):	1.00
Vehicles with studded tyres:	0.00%	Progression (cracking):	1.00
Is salt used on the road:	No	Progression (rutting):	1.00
		Progression (potholing):	1.00

Calibration - Drainage

Drainage factor:	1.00
Drain life calibration factor:	1.00

Upgrade Km 250 to Km 251 Paved Urban Section

Short code:	PVUR	Operation type:	Upgrading	Feature type:	Carriageway
Existing surface class:	Bituminous	Duration (years):	3		

Design

Speed flow type:	Two-Lane	Length adj.	1.00
Accident class:	2-4 Lane Roads_Low Traffic	Iditional NMT lanes:	2
Pavement type:	AMSB (Asphalt Mix on Stabilised Base)	After works width (m)	15.00
Road class:	Class A	New construction:	0.50
Traffic Flow Pattern:	Inter-Urban A		

Costs

Economic unit cost:	115,231,000.00	Financial unit cost:	130,944,000.00	Cost units:	per km
% cost stream year 1:	30.00	% cost stream year 2:	30.00	% cost stream year 3:	40.00
% cost stream year 4:	0.00	% cost stream year 5:	0.00		
Salvage cost:	20.00 %				

Unit Costs of Preparatory Works (per m2)

Economic resurfacing:	0.00	Economic patching:	0.00	Economic edge-repair:	0.00
conomic crack sealing:	0.00	Financial resurfacing:	0.00	Financial patching:	0.00
Financial edge-repair:	0.00	Financial crack sealing:	0.00		

Pavement

Dry season struct num:	3.40	Surface thickness (mm):	75.00	Relative compaction (%):	97.00
Base thickness	150.00	Base modulus:	15.00		

Construction - Quality Indicators

uminous surfacing, CDS	1.00
Base, CDB	0.00

Construction - Resurfacing

Resurface exisiting carriagewa	No	Resurface thickness	150.00 mm
		Strength coefficient:	0.40

Geometry

Rise + Fall:	10.00	m/km	Rises + Falls:	2.00	no./km	Curvature:	15.00 deg/km
Superelevation	2.50	%	adral (m/s2):	0.10		Speed limit (km/h):	50.00
Enforcement factor:	1.10		XNMT:	1.00		XMT:	1.00
XFRI:	1.00						

Asset Valuation

	Proportion of Cost	Residual Value	Useful Life		
Road Formation& subgrade:	0.00 %	0.00 %	0.00 years	Proportion of exisiting ass to decommisior	0.00 %
Road Pavement layers:	100.00 %	0.00 %	0.00 years		
NMT lanes:	0.00 %	0.00 %	0.00 years		

Calibration - Surface Distress

	Initiation	Progression		
All structural Cracking:	1.00	1.00	Crack retardation time:	0.00/ears
Wide structural Cracking:	1.00	1.00	Ravelling retardation factor:	1.00
Transverse Thermal Cracking:	1.00	1.00		
Ravelling:	1.00	1.00		
Pothole (Cracking initiated):	1.00			
Pothole (Ravelling initiated):	1.00			
Pothole (all):		1.00		
Edge Break:	1.00			

Calibration - Surface Texture

Texture Depth:	1.00
Skid Resistance:	1.00
kid Resistance - speed effects:	1.00

Calibration - Structural Defects

RUTTING		STRUCTURAL NUMBER	
Initial densification:	1.00	Seasonal effects:	1.00
Structural deterioration:	1.00	Structural no. due to	1.00
Plastic deformation:	0.00	ROUGHNESS	
Surface wear:	1.00	Environmental coefficient:	1.00
Standard Deviation:	1.00	Progression (structural):	1.00
Vehicles with studded tyres:	0.00%	Progression (cracking):	1.00
Is salt used on the road:	No	Progression (rutting):	1.00
		Progression (potholing):	1.00

Calibration - Drainage

Drainage factor:	1.00
Drain life calibration factor:	1.00

Upgrade Km 313 - Km 316 Unpaved Urban Section

Short code:	UPTYP3	Operation type:	Upgrading	Feature type:	Carriageway
Existing surface class:	Unsealed	Duration (years):	3		

Design

Speed flow type:	Two-Lane	Length adj.	1.00
Accident class:	2-Lane Roads_Low Traffic	Iditional NMT lanes:	2
Pavement type:	AMSB (Asphalt Mix on Stabilised Base)	After works width (m)	15.00
Road class:	Class A	New construction:	0.50
Traffic Flow Pattern:	Inter-Urban A		

Costs

Economic unit cost:	115,231,000.00	Financial unit cost:	130,944,000.00	Cost units:	per km
% cost stream year 1:	30.00	% cost stream year 2:	30.00	% cost stream year 3:	40.00
% cost stream year 4:	0.00	% cost stream year 5:	0.00		
Salvage cost:	20.00 %				

Unit Costs of Preparatory Works (per m2)

Economic resurfacing:	0.00	Economic patching:	0.00	Economic edge-repair:	0.00
conomic crack sealing:	0.00	Financial resurfacing:	0.00	Financial patching:	0.00
Financial edge-repair:	0.00	Financial crack sealing:	0.00		

Pavement

Dry season struct num:	3.40	Surface thickness (mm):	75.00	Relative compaction (%):	97.00
Base thickness	150.00	Base modulus:	15.00		

Construction - Quality Indicators

uminous surfacing, CDS	1.00
Base, CDB	0.00

Construction - Resurfacing

Resurface exisiting carriagewa	No	Resurface thickness	150.00 mm
		Strength coefficient:	0.40

Geometry

Rise + Fall:	10.00	m/km	Rises + Falls:	2.00	no./km	Curvature:	15.00 deg/km
Superelevation	2.50	%	adral (m/s2):	0.10		Speed limit (km/h):	50.00
Enforcement factor:	1.10		XNMT:	1.00		XMT:	1.00
XFRI:	1.00						

Asset Valuation

	Proportion of Cost	Residual Value	Useful Life	
Road Formation& subgrade:	0.00 %	0.00 %	0.00 years	Proportion of exisiting ass to decommisio 0.00 %
Road Pavement layers:	100.00 %	0.00 %	0.00 years	
NMT lanes:	0.00 %	0.00 %	0.00 years	

Calibration - Surface Distress

	Initiation	Progression		
All structural Cracking:	1.00	1.00	Crack retardation time:	0.00/ears
Wide structural Cracking:	1.00	1.00	Ravelling retardation factor:	1.00
Transverse Thermal Cracking:	1.00	1.00		
Ravelling:	1.00	1.00		
Pothole (Cracking initiated):	1.00			
Pothole (Ravelling initiated):	1.00			
Pothole (all):		1.00		
Edge Break:	1.00			

Calibration - Surface Texture

Texture Depth:	1.00
Skid Resistance:	1.00
kid Resistance - speed effects:	1.00

Calibration - Structural Defects

RUTTING		STRUCTURAL NUMBER	
Initial densification:	1.00	Seasonal effects:	1.00
Structural deterioration:	1.00	Structural no. due to	1.00
Plastic deformation:	0.00	ROUGHNESS	
Surface wear:	1.00	Environmental coefficient:	1.00
Standard Deviation:	1.00	Progression (structural):	1.00
Vehicles with studded tyres:	0.00%	Progression (cracking):	1.00
Is salt used on the road:	No	Progression (rutting):	1.00
		Progression (potholing):	1.00

Calibration - Drainage

Drainage factor:	1.00
Drain life calibration factor:	1.00

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FORM MP180 / B

Project Name and Number	2055 – Design Review of Elwak - Rhamu (A13) Road
Title of the Report	Final Economic Feasibility Study Report
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REVISION	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

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