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للهندسة والخدمات الفنية المحدودة

Baseline Study for Sugar Agribusiness in Kenya

FINAL REPORT

Prepared For : Kenya Sugar Board

FEBRUARY 2014

Kenana Engineering and Technical Services

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Preface and Acknowledgement

This report of a baseline study on the sugar agribusiness in Kenya has been prepared by Kenana Engineering and Technical Services (KETS). The study was commissioned by the Kenya Sugar Board (KSB), the entity formed by the Kenyan law to control and lead the sugar subsector, to identify new areas within the Kenyan agricultural sector for expansion of the sugar industry, a move which fits in the overall strategy of the government to develop and improve quality of life in rural areas.

An additional objective by the KSB in commissioning this study was to have a professional review of the existing sugar industry in Kenya and to get recommendations on how efficiency can be enhanced. The findings of this report were discussed with various stakeholders of the Kenyan sugar subsector.

KETS is confident that the report will serve as a framework for the KSB in decision making regarding authorizing of new sugar projects and improving the performance of the existing sugar industry.

The technical team from KETS wishes to acknowledge the considerable guidance and support received from the KSB and other government departments and authorities while visiting Kenya. The technical team also extends its appreciation to local government officials in the various counties for their cooperation.

Mulhim Eltayeb – General Manager

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Reference
$	American Dollars
AHP	Analytical Hierarchy Process
Al	Aluminum
ASAL	Arid and Semi-Arid Lands
ASDS	Agricultural Sector Development Strategy
a.s.l	above sea level
CAACs	Area Advisory Committees
CDM	Clean Development Mechanism
CEC	Cation Exchange Capacity
CERs	Certified Emission Reductions
CET	Common External Tariff
CFSR	Climate Forecast System Reanalysis
CIF	Cost Insurance and Fright price
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Emission
COMESA	Common Market of Eastern and Southern African
DOHSS	Department of Health and Senior Services
DRSRS	Department of Resource Surveys and Remote Sensing
EA	Environmental Audits
EAC	East African Community
EIA	Environmental Impact Assessment
EIA/EA	Environmental Impact Assessment and Audit
EIAAR	Environmental Impact Assessment and Audit Regulations
EMCA	Environmental Management and Coordination Act
ERS	Economic Recovery Strategy for Wealth and Employment Creation
ERU	Emission Reduction Unit
ESIA	Environmental and Social Impact Assessments
ET	Evapotranspiration
FAO	Food and Agriculture Organization
FAOSTAT	FAO Statistics
FDI	Foreign Direct Investment
Fe	Iron
FOB	Free On Board
FTE	Factory Time Efficiency
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GOK	Government of Kenya
Ha	Hectares
hrs	Hours
ICT	Information and Communication Technology
IMF	International Monetary Fund
IPM	Integrated Pest Management
IPPs	Independent Power Producers

Abbreviation	Reference
ISO	International Standardization Organization
ITCZ	Inter-Tropical Convergence Zone
JI	Joint Implementation
JICA	Japan International Cooperation Agency
K	Potassium
KARI	Kenya Agricultural Research Institute
KECATRA	Kenya Cane Transporters Association
KenGen	Kenya Generation and Transmission utility
KeNHA	Kenya National Highways Authority
KESGA	Kenya Sugarcane Growers Association
KESREF	Kenya Sugar Research Foundation
KESMA	Kenya Sugar Manufacturers Association
KETS	Kenana Engineering & Technical Services
Kg	Kilograms
Km	Kilometers
KPLC	Kenya Power and Lighting Company
KRB	Kenya Roads Board
KSB	Kenya Sugar Board
Kshs	Kenyan Shillings
kWhr	Kilowatt-hour
KWS	Kenya Wildlife Service
LASDAP	Local Authority Service Delivery Action Plan
LATF	Local Authorities Transfer Fund
LGP	Low Ground Pressure
MAFAP	Monitoring African Food and Agricultural Policies
MCM	Million Cubic Meter
MDG	Millennium Development Goal
MDGS	Millennium Development Goals
Millionha	Million hectares
Mm	Millimeters
Mn	Manganese
MoH	Ministry of Health
MoL	Ministry of Lands
MoR	Ministry of Roads
MoWI	Ministry of Water and Irrigation
MT	Metric Tons
MW	Megawatt
N	Nitrogen
NCEP	National Centers for Environmental Prediction
NEMA	National Environmental and Management Authority
NES	National Environment Secretariat
NGAC	New South Wales Greenhouse Gas Abatement Certificate
NIB	National Irrigation Board
NPGR	National Parks and Game Reserves
^{o}C	Degree Centigrade
OECD	Organization for Economic Co-operation and Development

Abbreviation	Reference
OGC	Out Growers Companies
OGIs	Out Growers Institutions
OTE	Overall Time Efficiency
P	Phosphorous
PPCSCA	Permanent Presidential Commission on Soil Conservation and Afforestation
PV	Photo Voltaic
REA	Rural Electrification Authority
REC	Renewable Energy Certificate
S&H	Safety and Health
SACCOs	Savings And Credit Co-operative Organizations
SAT	Sugar Arbitration Tribunal
SDF	Sugar Development Fund
SDRN	Natural Resources Services
SDG	Sudanese Geneih
SDL	Sugar Development Levy
SSA	Sub Saharan Africa
SWOT	Strengths, Weaknesses, Opportunities and Threats
TARDA	Tana and Athi River Development Authority
TC	Tons of Cane
TCD	Tons Crushed per Day
TCH	Tons Crushed per Hour
TS	Tons of Sugar
TEUs	Twenty-Foot Equivalent Units
UDD	Department of Urban Development
USAID	United States Agency for International Development
USD	United Stated Dollar
VAT	Value Added Tax
VER	Verified/Voluntary Emission Reduction
VCS	Voluntary Carbon Standard
VCU	Voluntary Carbon Unit
WRMA	Water Resources Management Authority
WCMD	Wildlife Conservation and Management Department
WDI	World Development Indicators
WRUAs	Water Resource User Associations
WTO	World Trade Organization

LIST OF LITERATURE REVIEWED

Year	Type	Title	Source
1972	Act	The Scrap Metal	Laws of Kenya
1986	Act	The Public Health	Laws of Kenya
2000	Act 1	Kenya Gazette Supplement No. 3	Republic of Kenya
2002	Act 9	Kenya Gazette Supplement No. 107	Republic of Kenya
2003	Legal Notice.101	Kenya Gazette Supplement No. 31	Republic of Kenya
2006	Book	Technical Bulletin No.1	Kenya Sugar Research Foundation
2006	Legal Notice.121	Kenya Gazette Supplement No. 37	Republic of Kenya
2006	Act 12	Kenya Gazette Supplement No. 96	Republic of Kenya
2006	Act 19	Kenya Gazette Supplement No. 31	Republic of Kenya
2006	Legal Notice.160	Kenya Gazette Supplement No. 84	Republic of Kenya
2006	Legal Notice.120	Kenya Gazette Supplement No. 36	Republic of Kenya
2006	Report	Kenya National Water Development Report	UN World Water Development
2006	Paper	Climate Variability and Water Resources Degradation In Kenya	World Bank working paper
2006	Book	Basin Identification, Green Water Credits, Report 1	
2007	Book	Annual Report	Kenya Sugar Research Foundation
2007	Book	Atlas For East Africa	Moe, Mineduc
2007	Act .15	Kenya Gazette Supplement No. 111	Republic of Kenya
2007	Legal Notice.73	Kenya Gazette Supplement No. 33	Republic of Kenya
2008		Draft Catchment Management Strategy	Water Resource Management Authority
2008	Report	Strategic Plan 2008 – 2012	National Irrigation Board
2009	Book	Technical Bulletin V.3 No.1	Kenya Sugar Research Foundation
2009	Legal Notice.19	Kenya Gazette Supplement No. 9	Republic of Kenya
2009	Legal Notice.61	Kenya Gazette Supplement No. 31	Republic of Kenya
2009	Magazine	Lake Victoria North, Catchment Management Strategy	Water Resource Management Authority
2009	Magazine	Lake Victoria South , Catchment Management Strategy	Water Resource Management Authority
2009	Magazine	Athi River , Catchment Management Strategy	Water Resource Management Authority
2009	Magazine	Rift Valley , Catchment Management Strategy	Water Resource Management Authority
2009	Publication	Strategic Planning 2009	Kenya Sugar Industry
2009	Publication	Agricultural Sector 2009-2020	
2010	Book	2009 Kenya Population And Book Housing Census V 2	Kenya National Bureau of Statistics
2010	Book	2010 Kenya Population And Book Housing Census V 1a	Kenya National Bureau of Statistics
2010	Book	2011 Kenya Population And Book Housing Census V 1c	Kenya National Bureau of Statistics
2010	Book	2012 Kenya Population And Book Housing Census V 1b	Kenya National Bureau of Statistics
2010	Publication	Strategic Planning 2010-2014	Kenya Sugar Industry
2010	Report	Draft National Emerging Crops Policy	
2010	Report	Research Protocol	KESREF

2011	Book	Sugar Statistic	Kenya Sugar Industry
2011	Magazine	Economic Review Of The Kenyan Sugar Sub-Sector	Kenya Sugar Research Foundation
2011	Magazine	Annual Report	Regional Center for Mapping of Resource for Development
2012	Magazine	Annual Report	Regional Center for Mapping of Resource for Development
2012	Publication	Tana River Data Strategic Environmental Assessment Scoping report	Ministry of Lands
2012	Magazine	Annual report	Tana River District, Livestock Production Department
2012		Research Highlight	Walker Institute
2012	Publication	Weather and Crop Review for Dekad 15, 2012	Kenya Meteorological Department
2012	Publication	Weather and Crop Review for Dekad 17, 2012	Kenya Meteorological Department
2012	Publication	Weather and Crop Review for Dekad 19, 2012	Kenya Meteorological Department
2012	Publication	Weather and Crop Review for Dekad 21, 2012	Kenya Meteorological Department
2012	Publication	Weather and Crop Review for Dekad 23, 2012	Kenya Meteorological Department
2012	Publication	Weather and Crop Review for Dekad 24, 2012	Kenya Meteorological Department
2012	Publication	Weather and Crop Review for Dekad 25, 2012	Kenya Meteorological Department
2012	Publication	Weather and Crop Review for Dekad 26, 2012	Kenya Meteorological Department
2013	Act .16	Kenya Gazette Supplement No. 28	Republic of Kenya
2013	Act .13	Kenya Gazette Supplement No. 25	Republic of Kenya
2013	Act .17	Kenya Gazette Supplement No. 29	Republic of Kenya
2013	Report	Kerio Valley: Draft Diagnostic Report, Integrated Regional Development Master Plan	-

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Executive Summary and Conclusions

Kenana Engineering and Technical Services (KETS) has been assigned by the Kenya Sugar Board (KSB), a government entity mandated to direct and regulate the sugar agri-business in Kenya, to conduct a baseline survey aimed at providing sufficient information and data on potential areas for establishing new sugar facilities in Kenya. Water and soil resources, socio-economic dynamics, and environmental aspects were factored in and evaluated for identifying these potential areas. The report also assessed the existing sugar sub-sector with respect to the past performance and various mitigations were recommended.

In addition to this section, the baseline survey report will include the following chapters:

Chapter 1: Introduction
Chapter 2: Policy Context and Institutional Framework
Chapter 3: Kenya Natural Resources
Chapter 4: Infrastructure in Kenya
Chapter 5: Marketing analysis of Kenya Sugar Industry
Chapter 6: Kenya Business Environment
Chapter 7: Potential Sugar Agro Zones
Chapter 8: Preliminary Environmental Impact and Sustainability Aspect of sugar Agribusiness recommended for detailed Impact Studies
Chapter 9: The Baseline Study Recommendations

SUMMARY ON BASELINE STUDY

THE SUGAR SUB-SECTOR IN KENYA, A LARGE ENTERPRISE

[1] Sugarcane in Kenya ranks top among tea, coffee, maize and horticultural crops which are considered important sources of revenue to the national economy.

[2] Considering the agricultural potential the country enjoys, the Kenyan Government is committed to designing and implementing an expansion program of sugar production in the country as part of its overall objectives in the Vision 2030 to boost national and local economies and develop remote rural areas. Within this context, the Kenya Sugar Board (KSB), the body institutionalized by the government to regulate the sugar sub-sector, has initiated a strategic plan to revive the sugar agribusiness and strengthen it to face the challenges of trade liberalization under the COMESA and the World Trade Organization (WTO) and achieve self-sufficiency in sugar with a surplus for export to the globally competitive market. An integral component of the Kenya sugar strategic plan is to identify new areas of high potential for sugarcane farming to lure local and foreign capital to invest in the sugar agri-business; a process which if realized will appreciably support developing these targeted areas.

[3] The KSB, previously the Kenya Sugar Authority (KSA), was established in 1973 as a government entity with farmers and millers represented on its board. Based on the 2001 Sugar Act, the KSB succeeded the KSA in 2002. The mandate of the KSB is to regulate and develop the sugar industry in Kenya and play a central role in coordinating the activities and interests of stakeholders of the sub-sector.

BUSINESS ENVIRONMENT IN KENYA

[4] Kenya, a multi-party democracy, has a proper and functional government. The major reforms achieved through the new 2010 constitution have laid the ground for political stability that will help remove distortions within the business environment. The peaceful election of 2013 was a major milestone, which will cement the democratic path for the country and promote the national reconciliation. Since 2007, Kenya has attracted many foreign direct investments (FDI), which placed the country among the top African counties for FDI projects in 2012. Investments in

infrastructure are quite visible in Kenya as a strategic objective to attract investments.

[5] Kenya established "KenInvest" as a semiautonomous body responsible for promoting investment under the Investment act of 2004. In a recent World Bank assessment of countries for the ease of doing business, Kenya was ranked 129, higher than the regional average of Sub Saharan Africa (SSA) of 142. Measures and policies have been implemented in this field to attract investments and create an attractive investment environment. Some of these measures include abolishing export and import licensing except for a few items, rationalization and reduction of import tariffs, introducing a free-floating exchange rate and allowing residents and non-residents to open foreign currency accounts in domestic banks. Measures to enhance processes of getting credit and starting businesses and trading across borders have also been formulated.

ASSESSMENT OF SUGAR MARKET IN KENYA

[6] The sugar sub-sector plays a major role in the Kenyan economy and it is a source of income for millions of citizens[1]. Kenya currently produces about 70% of its domestic sugar requirement, running a deficit of about 300,000 MT. The GOK has been taking action to protect the sector by controlling sugar importation and ensuring payment of dues to farmers by the cane factories.

[7] The country's capacity utilization in the industry has a weighted average below 60%. In spite of potential to compete, Kenya's cost of sugar production is the highest among EAC and COMESA sugar producing countries. High costs are attributed to low cane and sugar yields, capacity underutilization, lack of regular factory maintenance programs, poor transport infrastructure and weak corporate governance.

[8] To protect its sugar sector, COMESA in 2003 approved three time extensions for Kenya to secure its sugar sector till 2012. In 2011, the Government of Kenya (GOK) applied for another extension for sugar import safeguards through 2014. Nonetheless, according to the market assessment, the need for sugar will continue to grow outstripping supply by 300,000 MT. Consequently, Kenya's annual imports of sugar from COMESA, and EAC regions and other producing countries will continue to close the gap.

[1] (VAS Consultants 2012)

[9] In 2011 the countries' demand gap in the EAC region, excluding Kenya, stood at 314,000 MT. In the coming decade the EAC countries are looking into adding an additional 700,000 MT of sugar. Excess sugar will target markets outside the preferential regions; hence sugar production costs have to compete with international players.

[10] The combined installed capacity of the operational sugar companies is 30,000TCD, which is not sufficient to produce enough sugar for domestic consumption, currently estimated at 800,000 MT. With current TC/TS ratio and average actual milling time, the country managed to produce almost 500,000 MT of sugar. This largely rose from technical limitations and capacity underutilization with an industry average of 56.63%. However, by improving the capacity utilization to 85%, the country would be able to add an additional 140,000 MT to its production; almost halving the current sugar deficit.

[11] The cost of sugar production in Kenya is more than double compared to neighboring sugar producers and the leeway granted by the COMESA safeguards will expire in less than a year. From a market stand point, the sugar industry needs to focus on rehabilitating its existing facilities, enhancing production, reducing the production costs, considering privatization of sugar factories, and training sugar farmers to embrace modern technology in farming.

[12] Until that happens, it wouldn't be wise for Kenya to expand beyond self-sufficiency since countries in both COMESA and the EAC regions produce sugar at a much more competitive price than Kenya and have major plans to expand their industries in the near future.

[13] Faced with the dual challenge of high production costs and increasing competition, it is imperative that the industry diversifies and ventures into the production of additional high value products as a strategy to enhance its revenue base and income. Using sugarcane as the base, the industry has the potential to produce sugar, ethanol, animal feed and power as revenue sources.

[14] As part of the market assessment, the viability of other crops (maize and rice) was investigated. The crops selection was based on the technical survey for the proposed areas. The analysis was based on opportunity cost for sugar and other crops, comparing the production and import costs (FOB and CIF). The analysis shows the competitiveness of domestically produced maize over imported, while rice cost of production, excluding efficient farms, is higher than international prices (FOB). The CIF price also remains elevated due to tax rates that vary between 35

and 75%. The same case applies to sugar with high cost of production that reaches up to US$1,000.

[15] The analysis for each of the assessed crops for the period 2013-2020 indicates that rice will have the highest deficit due to exceptionally high growth rates and relatively high production costs. With a much smaller deficit, the country has a comparative advantage in producing maize locally.

[16] As for sugar, locally produced sugar will remain unfeasible compared to imported sugar due to inefficiency of the industry and non-utilization of byproducts. A reduction in cost of sugar production by US$100 could equal its production value to import cost (CIF) with tax rate of around 60%.

KENYA INFRASTRUCTURE

[17] Kenya's population and agricultural activities are heavily concentrated in the southern half of the country, along the corridor linking Mombasa to Nairobi and then on to Kisumu up to the border with Uganda

[18] Kenya's infrastructure backbones include the country's principal road arteries and major power transmission lines and the fiber optic systems which have followed this grid route. The northern and eastern parts of the country, by contrast, are less populated and characterized by weak coverage of infrastructure. Kenya's infrastructure networks are largely isolated from those of its neighboring countries. While there are some transport links with Uganda and Sudan, road connections with Ethiopia, Tanzania, and Somalia are of poor quality, while power and information and communication technology (ICT) backbones are not yet integrated across frontiers. The table below summarizes the achievement and challenges of Kenya's key infrastructures.

	Achievement	Challenges
Air Transport	• Leading the region • Major air hub for Africa	• Relieve capacity constraints at Jomo Kenyatta International Airport • Achieve U.S. Category 1 security clearance
ICT Reform	• Very high GSM coverage	• Strengthen competition to bring down prices • Ensure competitive international gateway
Ports	• Major regional shipping hub	• Substantial investment to ease capacity issues • Institutional reform to increase efficiency

	Achievement	Challenges
Power	• Major institutional reform • Cost-recovery pricing	
Railways	• Strategic regional rail corridor	• Revisit design of rail concession
Roads	• Sound road fund in place	• Improve quality of public investment • Major rehabilitation backlog
Urban infrastructure		• Very low levels of access to services • High rates of tenancy and insecure tenure

[19] Conditions of roads and power within the sugarcane farming system needs rehabilitation and improvement to reduce the cost of cane transportation, while extension of roads into new areas will help developing new sugarcane production which will ease the current bottlenecks of cane supply to mills.

MAJOR PROBLEMS FACING THE SUGAR SUB-SECTOR

[20] Low productivity and high cost at farm level

The study has identified a number of factors which are considered the main reasons behind the high cost of sugarcane production in Kenya. These factors include the following:

a) Deteriorating soil fertility due erosion and continued cropping
b) Weakness in the spreading of new high yielding sugarcane varieties and reliance on old low yielding varieties
c) Ineffective weed control strategies resulting in weed pressures and loss of cane
d) Intermittent moisture stresses due to drought spells subjecting the crop to drought conditions which affect both yield and quality of cane
e) Fragmentation of cultivated land to extremely small holdings rendering mechanized field operations, harvesting and transportation unfeasible
f) Lack of and/or untimely application of agricultural inputs
g) Poor management resulting in the inability of farming system to optimize productivity and the ratooning capacity of the sugarcane crop which is a main factor in the economy of the sugar industry
h) Low quality seed cane material for plant crop establishment affecting the crop stand, vigor and the final yield
i) Insufficient and unsustainable technical support to out-growers.
j) Frequent cane shortages which lead to milling of immature cane forcing some mills to operate at a low recovery rate (5%)
k) High harvesting and transportation cost (over 45% of total cane production cost)

l) Millers scramble for cane due to the low volumes of available loading to escalation of cane prices and the subsequent high processing cost of sugar
m) Competition for cane results in millers transporting cane from distant catchment areas which affects cost
n) Dilapidated roads and other infrastructure within cane catchment areas affect transportation costs and loss of cane during transit
o) Lack of sufficient finance for government owned mills to implement rehabilitation programs and meet production targets
p) Lengthy cane harvest to milling time resulting in stale cane and related processing problems
q) Lack of capacity to utilize the by-products of the industry, the molasses and bagasse for the production of ethanol and power generation respectively.

Mitigation Measures

[21] Short term measures:

There is room for improvement and reversing the downturn which depends on strong technical support from KESREF and a more active role by the KSB to organize and enforce regulations enacted in the first place to maintain the viability of the sugar sub-sector in Kenya. The following measures are recommended to rectify the existing situation:

a) Reduction of transportation and harvesting costs
b) Adoption of precision farming techniques to improve yield and save costs
c) Launching programs to test, recommend and release adaptable and high yielding sugarcane varieties to farmers must be a top priority for KESREF to improve cane supply to mills and ease competition between millers in the main cane belt, especially when the new sugar processing facilities are commissioned and rehabilitation of existing facilities is completed
d) With regard to the deteriorating soil fertility, the following measures are recommended:
    - Use of organic manure, which is cheap and available, to improve soil fertility and physical structure
    - Carrying out soil testing to apply the right fertilizer type and dose
e) Improving infrastructure especially roads should be a top priority. Efforts in this respect should involve all stakeholders including the Kenya Roads Board (KRB)
f) Privatization of government owned sugar mills is strongly recommended to inject money into these facilities and improve their efficiency and capacity utilization

Shortly after privatization in 2001, the performance and productivity of Mumias Sugar Company Ltd improved significantly and currently Mumias is now a leading sugar producer in Kenya. The privately run Kibos is reporting profits

g) Utilization of the industry's by-products, the molasses and bagasse, to improve revenues for the sugar companies.

[22] Long term measures

a) Agronomic Practices for Sugarcane Improvement: There is a potential for vertical increase in cane productivity in the western region which could be realized through the introduction of the following measures:
   - Adoption of new variety map: This will require efforts by KESREF to demonstrate to out growers through the establishment of pilot farms the agronomic traits of the new varieties in comparison to the cultivated ones
   - Crop rotation: Sugarcane out growers should be supported to manage crop cycling along the following options:
     - Plant cane to proceed to four ratoons then fallow the land
     - Plant cane to proceed to three ratoons then fallow the land

   It is worth mentioning that sugarcane is a sustainable crop and its economy depends on the number of ratoons which could be harvested which in turn requires proper establishment of the plant cane and the management of the subsequent ratoons

   - Cultivation of soya bean as a break crop is recommended on the fallow land and prior to planting of a new crop. This will improve soil fertility and soil content of organic matter and the soya seeds will generate additional income to farmers.

b) Improving cane quality: The cane quality issue is of vital importance to the sugar industry as improved cane quality will be reflected directly on factory sugar yield. The following measures are recommended to improve cane quality:
   - Cultivation of improved varieties which have high sugar content
   - Optimum age for cane harvesting be observed at12 to 13 months
   - Use of chemical ripeners for cane programmed for harvest early in the crushing season
   - Application of the optimum dose of nitrogenous fertilizers; noting that excessive nitrogen has negative impact on sucrose synthesis and storage
   - Variety mapping to synchronize planting and harvest planning according to maturity characteristics of each variety

- Testing and introduction of shy flowering varieties
- Considering chemical control of cane flowers in zones where the climate is conducive to intensive flowering
- Delivery of fresh cane to factory within the shortest possible time (24hrs cut to crush time)
- Planning harvest schedule to avoid over-aged, immature and dry cane

c) Out growers farm size: Almost all of the sugarcane out growers, the main suppliers of about 95% of the crop to millers, own land plots of areas in the range of one to two hectares, of which one third is cultivated with sugarcane crop. As a result, the land holdings are scattered over a vast land area which renders the adoption of mechanized farming impractical. The solution is to group the plots into fields of 50 to 100 hectares wherever possible. The KSB, KESREF and out growers societies and cooperatives should start a coordinated effort to get the support of out growers to accept such an arrangement. Benefits of large farm size are:
   - Sugarcane planting and variety mapping as well as crop rotation could be scheduled precisely;
   - Enables harvest planning considering cane age, variety maturity traits and distance from farm gate to milling facility

d) Water harvesting and irrigation: The cane growing in West Kenya depends entirely on the bimodal rains, so but the crop frequently suffers water shortage during critical stages of growth leading to stresses which result in suppressed internodes and low cane tonnage per hectare. In fact fluctuating rains are considered one of the main factors behind cane yield decline.

e) Water harvesting plans could be explored in coordination with Ministry of Water and Irrigation (MoWI) as a strategy to supplement the cane crop with water during critical growing periods.

f) Industry Performance: There are eleven sugar factories in Kenya with a total installed capacity of 30,000 tons of cane per day (TCD) which at full capacity for 300 days a year would produce approximately 550,000 tons of sugar which is lower than local demand, currently estimated at 800,000 tons. Further to this, low productivity at the farm level which results in the delivery of immature cane of low quality from distant areas to the mills forcing a number of them to crush as much as twenty tons of cane to process one ton of sugar. The industry is trying to satisfy the local sugar demand despite the low yield and quality of cane through expansion in the crop area. However, the issue of low mill extraction rate, now standing at an average of 90.5%, which is poor compared to the industry's standard minimum of 95%, must be resolved. Serious efforts should be exerted to bring down the high sugar losses in bagasse, filter cake and final molasses.

WATER RESOURCES IN POTENTIAL AREAS

Part of the baseline survey was to explore new potential areas within Kenya for the introduction of sugar crops. Currently facilities are concentrated in western Kenya. Being aware of the positive impacts of the sugar industry on the economies of both remote rural areas and the national level, the KSB is seeking to expand sugar production to other parts of the country.

Kenya is generally a dry country, whereby over 75% of its area is classified as arid and semi-arid with only 25% being viable for agriculture. Inland, rainfall and temperatures are closely related to altitude changes, with variations induced by local topography.

Generally, the climate is warm and humid at the coast, cool and humid in the central highlands, and hot and dry in the north and east. Across most of the country, rainfall is strongly seasonal, although its pattern, timing and extent vary greatly from place to place and from year to year. The country is exposed to alternating cycles of droughts and floods, both inflicting damage especially on the eastern regions.

The relatively wet coastal belt along the Indian Ocean receives 1,000 mm or more rain per year. Most rain falls from April to July as a result of the southeasterly monsoon winds.

Another moist belt, where the traditional sugar sub-sector has developed, is the Lake Victoria basin and its surrounding scarps and uplands, mainly due to moist westerly winds originating over the Atlantic Ocean and Congo Basin. Therefore, venturing out of the traditional sugar zone which depends on rains for the growing of the crop, new potential areas will depend on supplementary irrigation to produce cane of good quality and yield.

Appreciating this, water balance should be considered carefully to ensure sustainable sugar cultivation and processing in the new targeted areas.

Remote sensing data was utilized to evaluate and estimate the water resource, water demand, and water balance.

[23] Water resources

Using the data collected from Water Resource Management Authority, (WRMA), five major basins have been identified as the main Agro Zones. These are the Tana River Basin, Ewaso River North basin, Athi River basin, Western (Lake Victoria) Basin and Rift Valley. Where applicable, some of these Agro Zones were divided into sub-agro zones according to certain parameters that influence and affect sustainable development of the sugar industry. These parameters include, among others, the topography, soil, climate, socioeconomics, and the environmental aspects related to the introduction of the sugar industry in these zones.

Each river basin (agro zone) has been evaluated based on its water availability, rainfall, surface water and groundwater and capacity to irrigate sugar schemes sustainably.

[24] Water demand

A dominant factor on the water demand is the climatic condition. Climate of Kenya has been studied and relevant climatic data has been collected using remote sensing techniques and data from the FAO database and the meteorology department of Kenya. Then geo-statical analysis has been carried out to adjust the data and attain acceptable accuracy. Using geospatial analyses and Penman-Monteith method, the crop evapotranspiration has been estimated for all Kenya as a guide to identify sites for sugarcane cultivation.

[25] Water balance

Water demand per hectare has been estimated for the identified sites to evaluate the total water demand to be utilized from the available water source in the area and a suitable irrigation method was proposed accordingly. Moreover, the rivers' morphologies have been surveyed during site visits to suggest suitable infrastructure (pumps, wires, dams … etc.) required in these particular sites to improve the viability of cultivated potential areas.

For sites proposed as rain-fed areas, drop in crop yield due to water stress has been projected using FAO's Aqua crop.

Following is the water resource and water demand assessment summary for each agro zone/sub-zone and its potential areas:

The Upper Tana sub-zone

Water resource:

- Rainfall is 400-2400 mm
- Small streams in this sub-zone do not have adequate volumes of water to irrigate sugarcane.
- High abstractions of groundwater by other activities are exhausting the aquifer.

- Abstracting water from streams, which feed hydropower dams, for sugarcane irrigation will reduce the capacity of power generation.
- The hilly and undulating land topography doesn't suit surface irrigation.

Middle Tana sub-zone

Water source:

- Water resources evaluation concluded that Tana River is the only reliable source of irrigation water for any site of arable potential.
- River morphology at almost all locations is exposed to either severe bank erosions or developing islands

Water demand:

- Total Irrigation Water Requirement (IWR) for this sub-zone is estimated at **34,000** cubic meters per hectare annually for sugarcane using surface irrigation
- **8,000** ha is the maximum area which can be irrigated from the Tana River, expandable to **30,000** ha through the increase of water storage in the river and optimizing irrigation efficiency through adoption of advanced irrigation methods
- Barrage /weir are the proposed river hydro structures

Lower Tana Sub-zone

Water source: Tana River

Water demand:

- For areas 1, 2, and 3, the total IWR on the sub-zone is estimated at **20,000 m^3/ha annually** for sugarcane using surface irrigation
- **15,500 ha** is the maximum area which could be irrigated from the Tana River within this sub-zone and this area is expandable to **75,000 ha** by increasing the water storage and adopting modern irrigation methods
- Water storage is feasible through establishing more dams upstream and controlling the operational regimes of existing dams
- Proposed Hydro structures: Water lifting pumps

It is important to note that all areas in Tana Agro Zone are sharing the same water source, therefore, water utilized for one of the proposed areas will be at the expense of others.

Ewaso River North Zone

Topographic relief of the river's basin renders options for building dams slim as locating suitable site will be difficult, and if one is found, constructed dam will impact the parks within the area and the swamps downstream.

Athi River Sub-zone

The River's discharge fluctuates from season to season which indicates that its water volume is influenced by alternating cycles of floods and droughts. The average inflow in the river is about 1,350 MCM per annum through 500 MCM has been reported. Furthermore, the river on the downstream side takes a meandering and shallow course and already supports a lot of different activities. In 2010, water demand by the catchment reached 311 MCM while the irrigation schemes' demand was about 920 MCM. Annual rainfall in the area ranges between 200 and 1200mm.

The Sabaki aquifer is strategic as classified by WRMA, therefore, utilizing the aquifer water for irrigation is not advisable.

The Coastal Sub-zone

Water sources:

The area receives high rainfall in the range of 800-1200mm annually with precipitation reaching 1600mm in some places. The average yield of Umba River is about 197 million cubic meters per year.

The ground water in this area is fair as classified by WRMA and can be utilized; however, a comprehensive geo-hydrology study and precautionary measures are required to avoid contamination of aquifer by water intrusion from the ocean.

Water demand:

Annual water requirement for cultivating sugarcane is estimated at **7,700 m^3/ha annually** using drip irrigation. Rain-fed sugarcane can be grown in the area and the projected drop in yield as a result of water stresses is about 10%

on average. Limited supplementary irrigation could be needed and pressurized systems of irrigation are recommended.

Rift Valley South Sub-zone

Water sources for this subzone are:

- Ewaso Ng'iro River and other small streams
- Ground water aquifers within this subzone are generally poor except for some areas which are classified as fair
- Annual rainfall in the area ranges between 200 and 1200mm

Rift Valley Middle Sub-zone (Baringo)

A number of small water streams of low yield cross this sub-zone supplying local communities with water for domestic use as well as other activities such as fishing, recreation and irrigation purposes. Introduction of large irrigated sugarcane projects will consume whatever water that is brought by these streams and put domestic activities at risk.

Rift Valley North Sub-Zone

The main two streams within this zone are Kerio River and Turkwel River which were assessed as follows:

a) **Rift Valley North area 1 (Turkwel) Potential Area**: The water sources include the Turkwel River, Malmalte and other streams besides the rainfall which ranges between 400-600mm per annum.

   The IWR is estimated at **28,600 m^3/ha annually** for sugarcane crop using surface irrigation. Hydraulic structures to facilitate irrigation would be required.

   Turkwel River has the capacity to irrigate up to **6,500** ha of sugarcane possibly expandable by proper management of the dam's operational regime.

b) **Rift Valley North area 2 (Tot) - Potential Area**: The water resources include Kerio River and rainfall ranging between 600 to 800mm per annum. River Aro'LL and other streams in the area can be harvested and managed to be utilized by out growers. Hydraulic structures required to facilitate irrigation are weirs and water lifting pumps.

Environment And Sustainability

[26] The impacts of sugar cultivation and milling operations on the environment will be enormous if not properly assessed, managed, and mitigated.

[27] The Environmental Management and Coordination Act (1999) and subsidiary regulations (2003) mandated new development projects to undertake Environmental Impact Assessments (EIA) before making approval decisions. Relevant environmental laws (national and international) pertinent to sugar production should be thoroughly reviewed. NEMA and the projects' proponents should work closely and consult with concerned stakeholders during project planning and construction. Government agencies such as the wildlife authority, water management agency, regional development authorities, should also be consulted during the EIA study.

[28] A detailed EIA should be conducted for each proposed project to address, at a minimum, the following:

- The affected area should be defined for closer assessment. This includes affected environments such as air, surface water, ground water, soil, vegetation, etc. Based on known and approved practices and techniques, sugarcane plantation and processing should be analyzed to define the areas which could possibly be exposed to hazardous environmental impacts.
- The expected quantities of generated wastes should be determined using international standards and emission rates. Based on the quantified wastes and the affected environment, the appropriate mitigation measures and waste management methods should be recommended to ensure that the construction and operation of the new sugar project is environmentally sound safe and sustainable.
- Clear recommendations should be made with regard to sugar industry by-products utilization to reduce and minimize the wastes.
- Ensure that the projects conserve the natural habitat especially around protected areas.
- Ensure that the new projects in the proposed areas do not cause excessive damage to natural habitat.

[29] It is important to note that the baseline study did not attempt to assess the sustainability of the new sugar projects. The report outlines a number of important elements that need to be considered in future attempts to develop sustainable sugar schemes. The report focuses on the selection of project sites, the plantation, and processing of sugar products from environmental stand point as well as the social aspects.

[30] A holistic approach should be undertaken to select new project sites. The rainfall intensity and distribution in most of the potential areas is not sufficient to support the crop up to maturity which necessitates utilization of river water for supplementary irrigation. The water abstraction for sugarcane irrigation will affect water streams and rivers' discharges which could create water scarcity particularly for livestock and wildlife. Existing and projected water demands should be estimated prior to permitting withdrawal of water for sugarcane cultivation and processing.

[31] New sugarcane projects should take into consideration the potential effects of the project on the existing land uses and ecological functions around project sites. For instance, some of the proposed potential areas are important dry season grazing lands for pastoralists who converge from different and distant places. Other potential areas are surrounded by important biodiversity conservation and wildlife sites, where animals move seasonally through virtual corridors when food sources or other natural resources are lacking in their core habitats.

[32] The dry season grazing areas are important parts of a sustainable grazing cycle as it relieves pressures on the wet season grazing areas, which would otherwise be depleted of pasture during the dry season and subjected to serious environmental degradation. Further, urbanization and developing new projects, especially in the Tana River and coastal regions, could split up habitat areas, causing animals to lose both their natural habitat and the ability to roam freely between regions to utilize resources needed for survival. These issues should be addressed as part of the Environmental Impact Assessment study.

[33] Tana Delta, an area much hailed as a unique bio-diversity enclave and home to a variety of birds, flora and fauna and other endangered animal species, is a fragile and sensitive ecological zone which supports the livelihoods of pastoralists and farmers. Although development is critically needed to alleviate the poverty of the local communities in the delta, mega irrigation projects are sure to impact the environment and threaten the livelihoods of many inhabitants and could risk various elements of the ecology.

[34] The Kenyan government should plan and lead sustainable development programs. The government should promote and support sustainable reform initiatives such as out grower sustainable initiative, sustainable water and land management practices, soil and water conservation practices, etc. At the farm level, the Kenyan government and the sugar sub-sector should work together without growers to develop systems that would enable the identification of natural resource management priorities, activities to address these priorities, and programs to build the capacity to measure, monitor and report on the outcomes of actions towards these priorities.

[35] The National Environment Management Agency (NEMA) and Kenya Sugar Board (KSB) should envisage a future where the industry operates sustainably and in harmony with the environment and the community to grow sugarcane and produce raw sugar, refined sugar, renewable energy and a range of value-added renewable products from sugarcane. Various management approaches should be developed and adopted by the sugar industry (environmental management, pest and weed management, vegetation management, water management, etc.)

Socio-Economic Conditions In Targeted Areas

[36] About 95% of the sugarcane supplied to mills in the traditional sugar belt is harvested from out growers' plots and the revenue generated sustains the lives of thousands of families. Over reliance on money from sugarcane harvest is affecting the living standard of out growers who must be encouraged to give attention to other farming activities such as animal production and the cultivation of food and cash crops in a way that sugarcane becomes a part of the cropping system not the sole activity.

[37] The revision of sugarcane pricing mechanism to include by-products is important to ensure fairness and commitment of stakeholders to honor contractual obligations. In this respect and with the mandate given to it, the Kenya Sugar Board (KSB) should play a more active role in regulating and controlling the performance of the Kenyan sugar sub-sector. Mediating strongly to between out growers and millers to agree on a realistic price of cane should be one of the main targets for the KSB.

[38] The entrenched traditional system of land ownership is almost sacrosanct and represents a sensitive issue particularly in the farming communities of western Kenya and the Rift Valley. Extensions to the sugarcane land in these areas should follow the same pattern of out grower-miller relationship which secures

involvement of land owners as part of the production system. The millers should improve performance of their nucleus farms to inspire out growers to follow suit.

[39] In the other potential areas where the development of a sugar industry based on irrigation of the crop proves feasible, it is advisable that the new investments own sizable nucleus farms to control production targets and balance dependence on out growers as suppliers of raw material. However, the land lease agreements with potential investors should include terms specifying the percent of cane to be delivered by out growers and the technical support to be provided. Corporate social responsibilities to support social infrastructure in local communities should be agreed on with the local community and be provided regularly.

[40] There are socio-economic challenges that are likely to face the introduction of sugarcane and sugar industry in Garissa County and in the potential zones of the Rift Valley. With respect to Garissa and the East in general which is culturally, tribally and religiously distinct, reflecting the diversity of Kenya, there are ongoing efforts to increase the awareness of the pastoralists and the local people to support the development of the sugar industry and to tolerate their brethren Kenyans of different cultures who might be attracted to the area in search of work. But the foundation of a durable civil peace will depend on strong political will and leadership to steer the nation on the basis of citizenship.

[41] With respect to parts of Rift Valley agro-zone, particularly Turkwel and neighboring areas, the latent socio-economic tensions will hinder the introduction of the proposed sugar industry into potential areas if not diffused through a conciliatory approach. Security could be restored and a sense of unity forged through the massive implementation of development projects engaging large segments of the people of different cultural backgrounds to improve their living standard as well as the quality of life in the area. The experience of the Bura Irrigation Scheme in Tana River provides a successful example which could be replicated in other areas.

[42] Historical grazing rights of pastoralists in eastern Kenya should be carefully approached and dealt with when new sugar facilities are developed.

Chapter 1 Introduction to the Baseline Study

1.1. Background of the Study

1.1.1. Overview

Sugarcane in Kenya ranks top among tea, coffee, maize and horticultural crops which are considered important sources of revenue to the national economy.

Considering the agricultural potential the country enjoys, the Kenyan Government is committed to designing and implementing an expansion program of sugar production in the country as part of its overall objectives to boost national and local economies and develop remote rural areas. Within this context, the Kenya Sugar Board (KSB), the body mandated by law to regulate the sugar sub-sector, has developed a strategic plan aimed at reviving and strengthening the subsector to face the challenges of trade liberalization under the COMESA and World Trade Organization (WTO) agreements and achieve self-sufficiency in sugar with a surplus for export to the globally competitive market. An integral component of Kenya Sugar Strategic Plan is identification of new areas of a high farming potential and to lure local and foreign capital to invest in the sugar agribusiness, a process which if realized will appreciably support development in targeted areas.

1.1.2. Rationale of the Preparation of the Baseline Study on Sugar Agribusiness in Kenya

The Sugar Industry Strategic Plan has made recommendations for sugar production expansion through the establishment of new sugar mills in the Coast, Western, Nyando, South Nyanza, Rift Valley and other regions. This plan encourages many investors to set up many sugar projects in these regions.

The Kenya Sugar Board (KSB) has lately been inundated with many applications seeking authorization for new sugar projects all over the country. Such requests have often taken longer than expected to process due to reliance on information from records which are based on outdated data and which are often not easily accessible. This problem is particularly acute for areas considered to have high sugarcane production potential in the country. There therefore emerged a need for collecting and collating data that will provide a general profile of the potential of the sugar industry in Kenya.

It was considered that a baseline study to establish the full potential for the sugar industry in Kenya would provide the required information to guide investors and government in development of specific projects.

1.1.3. Stakeholders Analysis

The sugar sub-sector in Kenya includes a wide spectrum of stakeholders, each having a different role to play. The following represents the major stakeholders:

1.1.3.1. The Government Of Kenya (GOK)

The Ministry of Agriculture has the overall responsibility for the sugar industry development. It has its representatives on the boards of directors of all the sugar mills. The Ministry of Agriculture imposes levies on domestic and imported sugar. It also makes the regulations and appoints the Sugar Arbitration Tribunal (SAT) members in consultation with the Attorney General. Sugarcane research and advisory services to farmers also falls under the Ministry.

1.1.3.2. Kenya Sugar Board (KSB)

KSB, the industry's regulatory body, was established on 1st April 2002 under the Sugar Act 2001. Amongst other duties, it is charged with promoting the efficiency and development of the sugar industry. KSB regulates, develops, promotes, and coordinates the activities of individuals and organizations in the sugar industry and facilitates equitable access to the benefits and resources of the industry by all interested parties. The Board is also involved in policy formulation and implementation. It acts as a technical unit to advise the Ministry of Agriculture on all aspects of production, processing and marketing of sugarcane, sugar and molasses and other by-products. The KSB also advises on pricing and necessary legislation for the industry. KSB has 12 board members on a renewable tenure of three years.

1.1.3.3. Kenya Sugar Research Foundation (KESREF)

The Kenya Sugar Research Foundation (KESREF) was established in 2001 it is the scientific wing of the industry and is mandated to develop and transfer appropriate technology in the sugar sub-sector. It carries out socio-economic studies to enhance the development of sugar as a commercial business. The Foundation is funded mainly through grants from the Sugar Development Fund (SDF).

1.1.3.4. Common Market for Eastern and Southern Africa (COMESA)

In the past, Kenya has taken a protectionist stand on international trade of sugar due to the conjecture that liberalizing the sector would adversely affect the local sugar industry. In 2003, upon Kenya presenting a strong case, COMESA approved a four year safeguard period that expired in 2008. A second extension was sought extending to 2012 and it was granted. Subsequently a third extension was granted which is set to expire in March 2014. The extensions have served as a grace period for the government, millers and other stakeholders to come up with realistic measures for improving sugar production efficiency so as to be able to compete in the COMESA market and beyond without being accorded special favors.

On the lapse of the COMESA safeguard measures, Kenya is expected to grant duty free access to sugar from the COMESA country members under the market opening provisions. The sugar market will open up and the local milling companies will have to compete with more efficient sugar producers.

Currently the country restricts sugar market access through tariffs and non-tariff barriers. Sugar importers are subjected to Value Added Tax (VAT), Sugar Development Levy with exemptions of industrial sugar importers and import duty. Since the extension of the last COMESA safeguard period in 2008, the quota has been enlarging while the tariff applied on import quantities has been reducing in each successive year. In 2008/2009 the size of quota was 220,000MT and tariff rate above quota imports was 100%; in 2009/2010, the quota size was 260,000MT while the tariff above quota was 70%; in 2010/2011, the quota size was 300,000MT and the tariff above quota was 40%; and in the current year 2011/2012, the quota is 340,000MT while the tariff above the quota is 10%.

Non-tariff barriers include registration by KSB of all sugar importers and payment of an annual registration fee, application of an import permit for every consignment granted by KSB, application of intent to import sugar to the government, quarterly and annual import returns for raw sugar to KSB and refined sugar to Kenya Association of Manufacturers (KAM) and Ministry of Finance.

1.1.3.5. Cane Out grower Institutions (OGI)

Sugarcane farmers (out growers) supply 92% of the cane milled. A large number of institutions including out growers Institutions, Societies, Unions and SACCOs represent these farmers. The role of these institutions is to promote, represent and protect the interest of the farmers. The institutions operate under the Kenya Sugarcane Growers Association (KESGA).

1.1.3.6. Cane Transporters

Cane transporters are responsible for provision of cane transportation services in the industry. Transporters operate under the Kenya Cane Transporters Association (KECATRA).

1.1.3.7. Other industry stakeholders include:

- Importers
- Financial institutions
- Consumers
- Special interest groups
- Kenya Society of Sugarcane Technologists (KSSCT)
- Sugar Campaign for Change (SUCAM)

1.2. Study Objectives

1.2.1. General objectives

The general objective of the baseline study is to capture, update and make available information on the potential areas for a sustainable sugar industry in Kenya, which will enable the KSB, the GOK and investors appraise new sugar agribusinesses on a sound basis. To support this general objective the baseline study will:

1. Provide information that may be required by an investor for setting up a new sugar business
2. Establish the Socio-economic-political profile of the project areas in the country
3. Establish products demand and supply conditions in the sugar industry
4. Review agricultural potential, including irrigation

5. Provide an analysis of the potential for sustainable sugar crop businesses
6. Indicate human and other resource requirements, and
7. Provide pointers and references to further study areas

1.2.2. Specific Objective

The objective of this assignment is to conduct a baseline study in the sugar agribusiness potential in Kenya.

1.2.3. Scope of Work

1. Put into perspective potential sugar projects in the current National Development Policies and Strategies, including Vision 2030, Ministry of Agriculture and Sugar Industry Strategic Plan
2. Analyze the physical, political, agricultural, industrial and socio-economic business environments in Kenya
3. Carry out Baseline surveys on the socio-economic attributes of the potential project areas
4. Assess the agricultural potential for a sugar crop industry
5. Identify risks to such sugar projects
6. Identify and analyze options for other competing agro-industries
7. Analyze the benefits of such sugar projects, their attributes and comparative advantages over alternatives projects
8. Identifying large/medium sugar agri-business opportunities
9. Suggest areas of focus for further investor feasibility studies
10. Present Draft baseline study report, and
11. Modify and present final study report in consultation with the Board and other stakeholders in accordance with the work plan prepared by the Consultant.

1.3. Methodology Adopted for this Study

Based on the Terms Of Reference (TORs) and objectives of the baseline study, the methodology adopted for the study included the following:

1.3.1. Data Collection and Compilation

1. Literature Review

Literature relevant to the sugar sub-sector and agriculture in Kenya has been thoroughly reviewed by the assigned KETS team to familiarize with and conceptualize the production environment and the factors which affect the sugar agri-business. The exercise also provided theoretical understanding of the biophysical environment and characteristics of the different regions of Kenya and was a very useful guide in the collection of the secondary data.

2. Geographic Information System (GIS) Mapping Component

The required mapping involved the use of Geographic Information System (GIS) which was utilized to combine aerial photographs and satellite images to develop the base map of the study area. Ground-trusting of the same was done through actual field surveys utilizing Ground Positioning Systems (GPS) and other tools. The updated base map was then used to guide the subsequent field survey stages and served as a platform for further analysis.

3. Field survey

A number of field visits were arranged to the various regions in Kenya to validate the date collected and interact with stakeholders.

1.3.2. DATA ANALYSIS AND PRESENTATION

1. The use of GIS and Remote sensing

GIS was used to overlay and analyze various themes such as soil, hydrology, topography, land use, protected areas, forestry, etc. to assist with the selection of the potential agro zones. The selection involves defining suitability criteria, preparing an inventory of available data, determining suitability based on identified criteria, and combining suitability into hierarchical preferences based on weights proposed by experts. GIS and Multi-Criteria Land Evaluation technique using biophysical, socioeconomic, and demographic variables was employed in selection (Figure1-1).

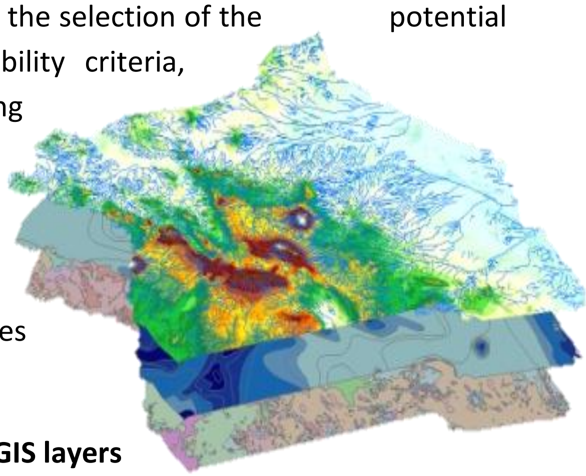

Figure1-1: GIS layers

GIS with Analytical Hierarchy Process (AHP) was used to prioritize and weight each and every parameter within each sector such as soil types. Nine suitability levels with different weights indicated under the soil types and based on effective depths, soil textures, reliefs, drainage, constraints to mechanization, and susceptibility to erosion were considered.

The combination of the different matrices from different geo-spatial data (soil, irrigation, environment, economic and agriculture) facilitated the mapping of the country into sugar ago zones and their attendant characteristics as shown in Figure 1-2.

2. Water modeling tools

Aqua Crop is a crop water productivity model developed by the Land and Water Division of FAO. It simulates yield of crops in response to water and is particularly suited to address conditions where water is a limiting factor for crop production.

Aqua Crop attempts to balance accuracy, simplicity, and robustness. It uses a relatively small number of explicit and mostly-intuitive parameters and input variables requiring simple methods for their determination.

Aqua Crop has been adapted from the revision of the *FAO Irrigation and Drainage Paper No. 33 "Yield Response to Water"* (Doorenbos and Kassam, 1979) which provided a key reference for estimating the yield response to water. Aqua Crop evolves from the fundamental equation of Paper No. 33, where relative yield (Y) loss is proportional to relative evapotranspiration (ET_o) decline, with Ky as the yield response proportional factor. The application was mainly used in areas which primarily depend on rainfall.

Applications of Aqua Crop include

- Assessing water limitation on attainable crop yields at a given geographical location;
- Used as a benchmarking tool, comparing the attainable yields against actual yields of a field, farm, or region, to identify the yield gap and the constraints limiting crop production
- Assessing the long term rain fed crop production
- Developing irrigation schedules for maximum production (seasonal strategies and operational decision-making), and for different climate scenarios
- Scheduling deficit and supplementary irrigation
- Evaluating the impact of fixed delivery irrigation schedules on attainable yields
- Simulating crop sequences
- Carrying out analyses for future climate scenario
- Optimizing a limited available water available considering economic, equity , and sustainability criteria
- Evaluating the impact of low fertility and of water-fertility interactions on yields
- Assessing actual water productivity (biological and/or economic) at the field as well as wider local and regional levels
- Supporting decision making on water allocation and other water policy actions
- Appraising the role of various water-related crop responses in yield determination for ideotype design.

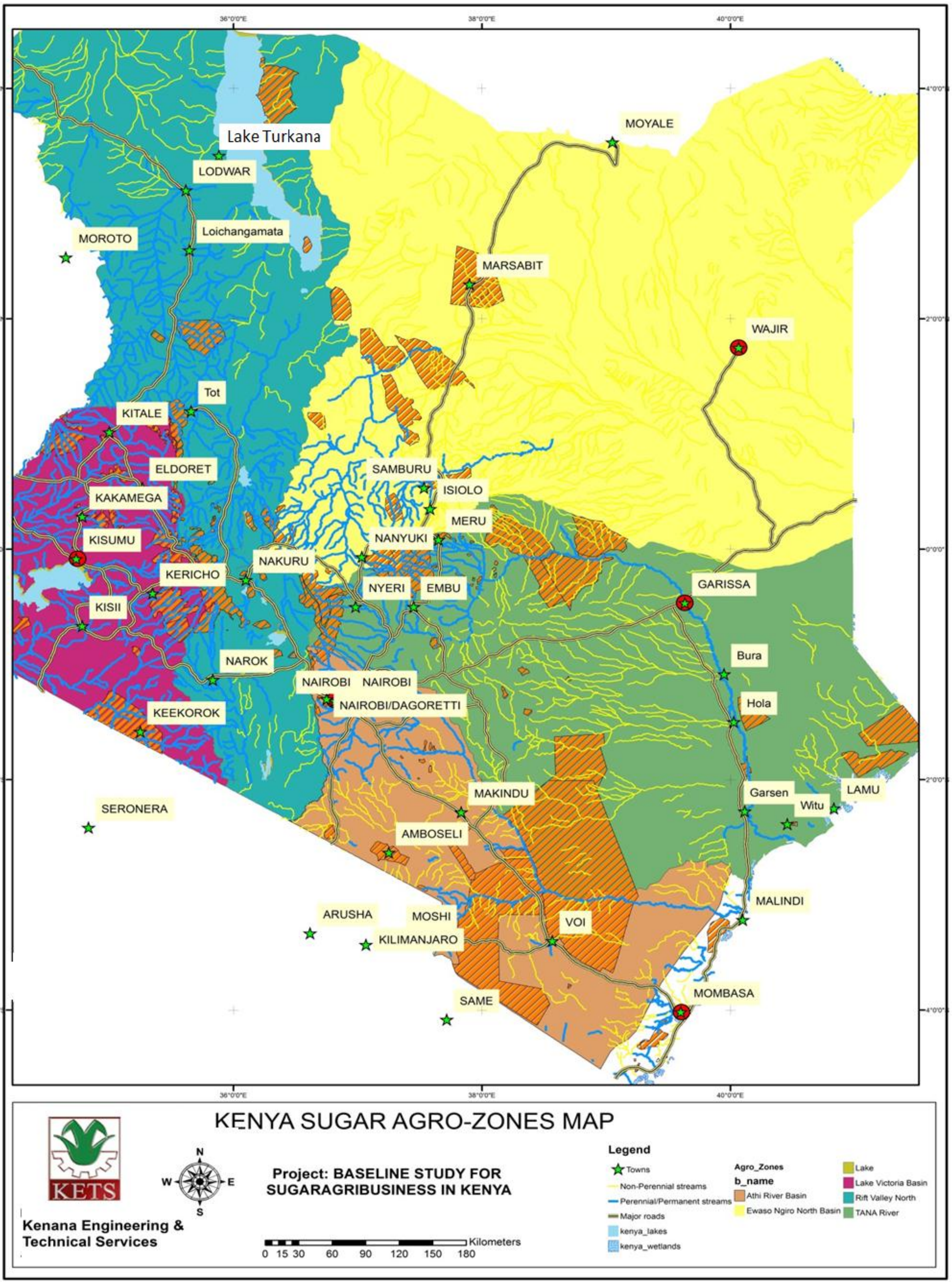

Figure 1-2: Map of Sugar Agro Zones

Chapter 2 Policy Context and Institutional Framework in Kenya

2.1. Policy Framework

2.1.1. Overview

The potential sugar schemes have been recommended in light of Kenya's government current national development policies and strategies including, among others, the Vision 2030, Ministry of Agriculture and Sugar Industry Strategic Plan. This chapter details the institutions, policy and legal framework dealing generally with integrated development in Kenya and specifically development in the sugar industry.

2.1.2. Kenya's Vision 2030

Kenya's Vision 2030 is the Government long-term national planning strategy covering the period 2008-2030. It was developed in the wake of successful implementation of the Economic Recovery Strategy for Wealth and Employment Creation (ERS), which revived the national economy and put it on rapid growth map. The vision is to accelerate Kenya's economic growth and achieve a GDP growth rate of 10% per annum on a sustained basis up to 2030. The Vision 2030 spells out actions to be taken to achieve the Millennium

Development Goals (MDGs) whose deadline is 2015. Some of the goals have already been met.

It is based on 3 pillars – economic, social and political. This economic pillar aims to improve the prosperity of all Kenyans through an economic development programme covering all the regions of Kenya. The economic pillar underscores the need to promote the manufacturing sector, making Kenya a regional trade and service hub, creation of integrated infrastructure and adoption of ICT as an enabler. The key focus sectors are agriculture and agro-industries, business process outsourcing, retail and wholesale trading, financial services, tourism and manufacturing.

The social pillar seeks to build a just and cohesive society with social equity in a clean and secure environment. The political pillar aims to realize a democratic political system founded on issue-based politics that respect the rule of law and protects the rights and freedoms of every individual in Kenyan society.

2.1.3. National Land Policy

The national land policy contains policy recommendations that have been identified, analyzed and agreed upon by various stakeholders. It gives a background to the land issues in Kenya, the New Land Policy Framework and the philosophy behind the National Land Policy.

Other key areas addressed are Constitutional issues, Land Tenure, Land Use Management, Land Administration, Land Issues requiring special intervention and the institutional framework of the National Land Policy.

2.1.4. Agriculture Sector Development Strategy 2009-2020

The agriculture sector accounts for 65 percent of Kenya’s total exports and provides more than 60 percent of informal employment in the rural areas. The sector is therefore not only the driver of Kenya’s economy, but also the means of livelihood for the majority of the Kenyan people. The sector comprises of the following sub-sectors: crops, livestock, fisheries, land, water, cooperatives, environment, regional development and forestry. It also includes the development of arid and semi-arid lands (ASAL). Thus, there are many players and stakeholders in the sector due to its broad nature.

The Agricultural Sector Development Strategy (ASDS) 2009-2020 seeks a progressive reduction in unemployment and poverty aims at spurring agriculture back to growth trends.

The overall development and growth of the sector is anchored in two strategic thrusts:

1. Increasing productivity, commercialization and competitiveness of the agricultural commodities and enterprises, and
2. Developing and managing key factors of production.

Assuming an external environment that is conducive and with support from enabling sectors and factors, the agricultural sector has set the following key targets to be achieved by 2020:

1. Reduction of people living below absolute poverty lines to less than 25 percent to achieve the first MDG
2. Reduction of food insecurity by 30 percent to surpass the MDGs
3. Increase in the contribution of agriculture to the GDP by more than Kshs 80 billion per year as set out in the Vision 2030
4. Divestiture in all state corporations dealing with production, processing and marketing that can be better done by the private sector
5. Reforms in and streamlining of agricultural services such as research, extension and regulatory institutions so as to be most effective and efficient.

2.1.5. National Urban Development Policy

It was envisioned in 2008 by the Department of Urban Development (DUD) to be the roadmap guiding urban development. There were a number of significant challenges faced in urban areas and a policy for urban development was prepared to define strategies and mechanisms to enable the sector respond effectively to these challenges. The policy harnesses the incremental gains achieved by the ongoing initiatives of the Local Government reforms, and translated the same into policy. These include the Local Authorities Transfer Fund (LATF) experiences and the LASDAP (participatory development, decentralization and intergovernmental First Medium Term Plan 2008 – 2012).

2.1.6. Kenya Sugar Industry Strategic Plan 2010-2014

The Kenya Sugar Industry Strategic Plan for 2010-2014 provides a road map of how the sugar industry intends to be a “world class multi-product sugarcane industry.” To enable the Government achieve its strategic objectives of being a middle-income country by the year 2030, this revised strategic plan aims at making the industry more efficient, diversified and globally competitive to contribute to the overall objective outlined in the Agricultural Sector Development Strategy (2009-2020) and the Vision 2030. The Plan provides a framework for setting goals, defining key actions, and mobilizing resources for funding programmes in the industry. It is a unifying instrument at the strategic level for industry stakeholders, who otherwise are autonomous operators. It lays the ground for enhanced performance of the sugar industry premised on a rational utilization of all resources in the sector. The 2010-2014 Strategic Plan is intended to seek a limited but achievable set of goals. These goals are:

- Enhancing competitiveness in the industry in order to transform it to a leaner, lower cost industry
- Expanding the product base to take advantage of opportunities created in the production process and increase factory profitability
- Investing more in infrastructure
- Strengthening the policy, institutional and legal environment

2.1.7. SESSIONAL PAPER NO.2 OF 1997

Kenya's Vision 2030 is the latest development blueprint covering period 2008-2030. It aims at transforming Kenya into an industrialized, middle income country providing high quality life for all its citizens by the year 2030. Specific strategies involve promoting environmental conservation to a better support the economic pillar flagship projects and for achieving the Millennium Development Goals (MDGs); minimizing pollution and improving waste management through design and application of economic incentives; and the commissioning of public-private partnerships (PPPs) for improved efficiency in water and sanitary delivery. In addition, the country will harmonize environment-related laws for better planning and governance.

Environmental concerns have been issues which were raised as early as 1997 in Sessional Paper No. 2 of 1997 on the Industrial Transformation by the year 2020. The paper emphasized planning by the industry for increased production and sound environmental management for the support of social well-being. This meant the industry should have adopted the triple bottom approach of economy, environment and society which would secure "win-win" situations for all stakeholders. This requires a paradigm shift in the way raw materials are extracted, manufactured into goods, consumed and finally disposed of. An understanding of the business value to be gained from efficient use of natural resources and waste reduction is an important step toward sustainability and conceptualization of the policy of managing the resources to meet the needs of Kenyans now and in the future.

In the new constitutional dispensation, greater importance has been attached to the environment. Legislation on the Environment and natural resources is clearly stipulated in Chapter 5, Clause 69. *"The State shall ensure sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensure equitable sharing of the accruing benefits".* The government recognizes the roles played by both non-governmental organizations and the private sector and has provided support and encouragement to their environmental efforts.

Currently there is no comprehensive policy and legislation on waste management. However, there are various pieces of legislations dealing with the management of wastes. The implementation is however not effectively harmonized and thus they do not provide for efficient management.

2.2. Legal Framework

2.2.1. Constitution of Kenya 2010

The constitution of Kenya 2010 contains various provisions that touch on the environment, land and natural resources. These include:

a) The right to a clean and healthy environment.
b) Sets out principles on which land shall be held, used and managed
c) Empowers the state to regulate the use of land in public interest
d) Regulates sustainable exploitation, utilization and management of natural resources.

2.2.2. The Environmental Management and Coordination Act, (1999)

There are about seventy seven (77) statutes which address different aspects of the environment through different bodies. Operating in isolation to manage the environment these bodies were inadequate especially in waste and pollution control and they needed harmonization to be more effective. This led to the formulation and enactment of The Environmental Management and Coordination Act (EMCA 1999) to create synergy and strengthen legal instruments for environmental management.

The Environmental Management and Coordination Act (1999) and the subsidiary legislation, Environmental (Impact Assessment and the Audit) regulations (2003), require operational enterprises to undertake annual environmental audits (EA) while all new development projects which are listed in the second schedule of the Act are subjected to EIA.

The key features of the Act are:

EIA/EA will be administered by National Environmental and Management Agency (NEMA) on behalf of the Ministry of Environment, Natural Resources and Wildlife and will be applicable to both public and private sector development projects.

The projects to be subjected to EIA/EA are specified in the second schedule of the EMCA, 1999. In addition to scheduled activities, the Act also empowers the minister to order EIA appraisal for any activity which he deems as having significant environmental impacts. NEMA will designate environmental committees to oversee implementation of EMCA 1999 at provincial and district Levels [(2)].

A scheduled activity will not be awarded the necessary authorization from NEMA or other government authority to proceed until all EIA/EA requirements have been met and accepted by NEMA and relevant agencies. The EIA/EA license will be granted when NEMA and the Minister are assured that an EIA/EA has been satisfactorily conducted and an Environmental Management Plan of an activity has sufficiently been developed.

All formal submissions under the Environmental Impact Assessment and Audit Regulations, 2003 will be forwarded to NEMA through the relevant county agencies. NEMA will maintain a register of all projects and programs being appraised under their guidelines. The undertaking of all EIA/EA and reporting will be the responsibility of the project proponents. NEMA will, on behalf of the government, provide procedures and technical advice to project proponents on how to comply with the EIA/EA requirements. The Audit (unless it is a self-auditing study), under regulation 34 of The Environmental Impact Assessment and Audit Regulations, 2003, shall be conducted by an independent third party, who shall be an expert or a firm of experts registered in accordance with regulation 14 of The Environmental Impact Assessment and Audit Regulations 2003.

NEMA will have Environmental Inspectors duly designated by the Authority to enter any land premises or facilities to carry out an inspection, examine records and require answers to specific questions.

2.2.3. THE REGISTERED LAND ACT (CAP. 300)

Under this Act, any person may acquire absolute ownership of any land once he has been registered as the absolute owner. On registration, such a person acquires freehold interests on the land. A subsequent buyer of the same land acquires the same rights as enjoyed by the previous owner

[2] In 2013, all provinces and districts were replaced by “counties”. The Counties were subdivided into “Sub-counties”. (See Appendix)

2.2.4. THE PUBLIC HEALTH ACT (CAP 242)

The public health borrows heavily from the common law of nuisance of the English law. Nuisance is broadly understood to mean

- Obstruction
- Smell
- Accumulation of waste or refuse
- Smokey chimneys
- Dirty dwellings
- Premises used without sanitation
- Factories emitting smoke or smell

The law makes it an offence if the landowner or occupier allows nuisance or any other condition injurious to health on his premise. A medical officer or a public health officer satisfied of the existence of the danger can issue a notice for the nuisance to be removed. In case of failure to do so, the medical or a public health officer can take the matter to Court. In this case, the Court may order the occupier to remove the nuisance or put up structures that would lead to muffling of the nuisance. In extreme cases the Court may order that such structure be demolished completely. The Act also empowers local authorities to enact laws with regard to the above in addition to standards for buildings, waste, and sanitation including effluent discharge standards from factories within its jurisdiction. Protection of water supplies is also bestowed on local authorities as undertakers. The Act empowers the Minister of Health to issue rules that mandate Local Authorities to prohibit the following: bathing, washing clothes, watering animals, erecting dwellings, sanitary conveniences, stables and cattle kraals, dipping tanks, factories and other works that may pollute water supply. The haphazard disposal of manure and filth or noxious offensive matter is also covered by the Act. Environmental health is part of the duties of the local authority which is responsible under the Local Authority Act Cap 256 to maintain sanitary services, sewerage and drainage facilities and take measures for the control of rats, vermin, etc.

2.2.5. THE AGRICULTURE ACT (CAP 318) SECTION 184 (3)

The occupier of agricultural land shall be deemed to fulfill his responsibilities to farm it in accordance with rules of good husbandry in respect of manner in which the land is being farmed (as regards both the kind of operations carried out and the way in which they are carried out) such that, maintains a reasonable standard of efficient production, while keeping the land in a condition to enable such a standard to be maintained in future

2.2.6. WATER ACT NO.8 OF 2002

The Water Act protects water bodies and resources. The Act provides a supervisory and precautionary approach and addresses issues of waste management through ensuring issuance of permits for water abstraction and effluent discharges.

The Act requires that any effluent discharged in any water body should contain no poisonous matter or substances that are likely to be injurious directly or indirectly to the public health, or to livestock, crops, orchards and gardens irrigated with such water. It prohibits disposal of effluent, or requires one to obtain a permit before abstracting groundwater and the well shall be constructed in such a manner as to prevent contamination or pollution of groundwater through the well. The Ministry of Irrigation also licenses the drilling of City Council waters. Other relevant Acts governing the water industry include the Local Government Act (Cap 265) and the Workman Compensation Regulations.

2.2.7. ENERGY ACT OF 2006

The Energy Act 2006 was enacted in December 2006 to provide for the establishment of the Energy Regulatory Commission and the Rural Electrification Authority. The Energy Regulatory Commission is responsible for:

- The regulation of importation, exportation, generation, transmission, distribution, supply and use of electrical energy
- Importation, exportation, transportation, refining, storage and sale of petroleum products
- Protecting the interests of consumers, investors and other stakeholders
- Maintaining a list of accredited energy auditors;
- Monitoring and ensuring the implementation of and the observation of fair competition in the energy sector in coordination with other statutory authorities; collect and maintain energy data and prepare indicative national energy plan.

Under this act, the Rural Electrification Authority (REA) is responsible for the management of the Rural Electrification Programme Fund. The REA mandate also includes development and updating of rural electrification master plan and promotion of use of renewable energy sources.

2.2.8. PHYSICAL PLANNING ACT (CAP 286)

Section 36 states that Local Authority Act may if deemed necessary require a submission of Environment Impact Assessment report together with development application if they feel a project is to have some injurious effects on the environment.

2.2.9. Noise Prevention and Control Rules 2005

Section 4(1) *"No worker shall be exposed to a noise level in excess of-the continuous equivalent of ninety dB (A) in eight hours within twenty four hours duration, and one hundred and forty dB (A) peak sound level at any given time"*

(2) *"Where noise is intermittent, noise exposure shall not exceed the sum of the partial noise exposure equivalent continuous sound level of ninety dB (A) in eight hours duration within any twenty four hours duration".*

(3) *"(a) It shall be the duty of the occupier to ensure that noise that gets transmitted outside the workplace shall not exceed fifty five dB (A) during the day and forty five dB(A) during the night and*

(b) Any person who does not comply with this provision shall commit an offence".

2.2.10. The Environmental Management and Co-ordination (Water Quality) Regulations 2006

The regulations protect all water resources. Relevant features of this regulation as far as this audit is concerned include:

- Every person shall refrain from any act which will directly or indirectly cause pollution and it shall be immaterial whether or not the water resource was polluted before the enactment of these regulations
- No person shall throw or cause to flow into or near a water resource any liquid, solid or gaseous substance or deposit any such substance as to cause pollution
- Discharge of effluent from a sewer must be licensed according to the Act
- Water abstraction must only be done after approval of an Environmental Impact Assessment study
- The regulations also set out standards to be followed for effluent discharge to the environment.

2.2.11. The Environmental Management and Co-ordination (Waste Management) Regulations 2006

Relevant parts of this regulation include:

- Prohibition of any waste disposal on a public highway, street, road, recreation area or in any public place except in designated waste receptacles

- The waste generator to collect, segregate and dispose such waste in a manner provided for under these regulations
- All waste generators to minimize waste generated by adopting cleaner production methods
- No person shall be granted a “waste transportation license”- under the Act unless such person operates a transportation vehicle approved by the Authority upon recommendation from the relevant lead agency. Any vehicle used for transportation of waste or any other means of conveyance shall be labeled in such a manner as may be directed by the Authority. The Authority in consultation with the relevant lead agency may designate particular geographical areas as areas of operation for licensed waste transporters..:-A person granted a “mode of transporting waste” license to transport waste shall ensure that:
  - The collection and transportation of such waste is conducted in such a manner that will not cause scattering, escaping and/or flowing out of the waste
  - The vehicles and equipment for the transportation of waste are in such a state that shall not cause the scattering of, escaping of, or flowing out of the waste or emitting of noxious smells from the waste
  - The vehicles for transportation and other means of conveyance of waste shall follow the scheduled routes approved by the Authority from the point of collection to the disposal site or plant, and
  - He or his agent(s) possess at all times during transportation of the waste, a duly filled tracking document as set out in Form III of the First Schedule to these Regulations and shall produce the same on demand by any law enforcement officer.

2.2.12. The Occupational Safety and Health Act 2007

This Act has provisions to ensure that workplaces maintain a safe working environment. Among the requirements are the adequate and sufficient ventilation, lighting and good housekeeping.

Other requirements include:

- Provision of wholesome drinking water
- Provision of suitable personal protective equipment and clothing
- The requirement that workstations suit and fit the worker
- Provision of adequate firefighting equipment and precautions against fire
- Workplaces should ensure machinery safety, chemical safety and electrical safety
- Examination and test of examinable plant

2.2.13. Safety and Health Committee Rules

On April 28th, 2004, the Minister for Labor through Gazette No. 31 promulgated rules for the creation and management of Occupational Health and Safety (OHS) Committees. These Rules require that any project proponent must have in place an OHS Committee if there are a minimum of 20 persons employed in a work place. The Rules require that the proponent complies with the following measures:

- Post an abstract of the Act in key sections of the exchange.
- Provide adequately stocked First Aid Kits in various sections of the service station
- Ensure that there is an appropriate number of certified first aid staff trained by recognized institution such as the St. John's Ambulance or Kenya Red Cross Society
- Provide a general register for recording all incidents and accidents
- Formation of an S&H Committee of five members from management and five from the workers
- All members of the S&H Committee to undergo a DOHSS approved 40 hour induction course
- Nominate and formalize an S&H management representative
- The S& H Committee must meet at least quarterly, take minutes, circulate key action items on bulletin boards and send a copy of minutes to the Directorate of Health and Safety Services (DOHSS) head office in Nairobi
- Appropriate record-keeping including maintenance of all current certificates related to inspection of critical equipment such as air compressors, lifts and pulleys. Such inspections need to be undertaken by a competent person certified by the Director of the DOHSS.

2.2.14. The Chiefs' Authority Act

The Chiefs Authority Act, Cap 128 date is back to the colonial time .The colonial government enacted it for the maintenance of law and order. The Chief was given a wide range of authority to control the cutting of timber and range fires and monitor water pollution.

2.2.15. The Local Authority Act (Cap 265)

The Local Government Act Cap 265 was enacted in April 1963. It gives the Local Authorities wide ranging power to undertake tree planting, garbage collection, provision of clean water and provision of effective sewerage systems. This Act empowers the Municipal Authority to provide and maintain sanitation and sewerage services and to take measures to control or prohibit factories and industries from emitting smoke, fumes, chemicals gases, dust smell, noise, vibrations or any danger, discomfort or annoyance to the neighborhood. The Act also permits the Authority the power to control public contaminations particularly using cyanide.

2.2.16. Lakes and Rivers Act (Cap 409)

Protection of lakes and rivers and estuaries

2.2.17. The Wildlife (Conservation and Management) Act of 1976

This Act amalgamated the then Game Department and the Kenya National Parks to form a single agency, the Wildlife Conservation and Management Department (WCMD), to manage wildlife. Subsequently, through an Amendment to the Act in 1989, the Kenya Wildlife Service (KWS) was established to replace WCMD.

Kenya's wildlife policy is embodied in the Sessional Paper No. 3 of 1975 entitled "A Statement on Future Wildlife Management Policy in Kenya". This policy was a radical departure from the previous approach to wildlife conservation, which emphasized protected areas. The key elements of this Policy may be summarized as follows:

(a) It identified the primary goal of wildlife conservation as the optimization of returns from wildlife defined broadly to include aesthetic, cultural, scientific and economic gains, taking into account the income from other land uses

(b) It pointed out the need to identify and implement compatible land uses and fair distribution of benefits derived from wildlife including from both non-consumptive and consumptive uses of wildlife

(c) It underscored the need for an integrated approach to wildlife conservation and management in order to minimize human–wildlife conflicts, and

(d) The government assumed the responsibility of paying compensation for damages caused by wildlife

2.2.18. Environmental Conventions and Treaties

2.2.18.1. Convention on Biological Diversity (1992)

This was ratified on 11th September 1994. See Section 3. 2. 2.-the Rio Declaration.

2.2.18.2. Montreal Protocol (1987)

The Montreal Protocol on Substances that deplete the ozone layer (1987) was ratified on November 9, 1988. This treaty was designed to protect the ozone layer by phasing out the production of a number of substances believed to be responsible for ozone depletion.

2.2.18.3. United Nations Convention to combat Desertification (1994)

This is an agreement to combat desertification and mitigate the effects of drought through national action programs that incorporate long term strategies supported by international cooperation and partnership arrangements.

2.2.18.4. United Nations Framework Convention on Climate Change (1992)

International environmental treaty produced at the United Nations Conference on Environment and Development (UNCED), informally known as the Earth Summit, held in Rio de Janeiro in 1992. The treaty is aimed at reducing emissions of greenhouse gas in order to combat global warming.

2.2.18.5. Bamako Convention (1991)

This is a treaty of African nations prohibiting the import of any hazardous (including radioactive) waste.

2.2.18.6. Kyoto Protocol (2004)

The protocol details an amendment to the international treaty on climate change, assigning mandatory emission limits for the reduction of greenhouse gas emissions to the signatory nations.

2.3. Institutional Framework

The sugar sub-sector is regulated and supported by a number of parastatal bodies and involves many stakeholders.

2.3.1. Kenya Sugar Board

The Kenya Sugar Authority (KSA) was established in 1973 as a government entity with farmers and millers represented on its board. Based on sugar act of 2001, the KSB succeeded the KSA in 2002. The mandate of the KSB is to regulate and develop the sugar industry in Kenya and play a central role in coordinating the activities and interests of stakeholders within the sub-sector. With such a solid mandate, the KSB is required to function in a number of activities which involve the following:

- Preparation of policies, plans and appropriate programs to develop the industry
- Links various government departments to the sugar industry
- Disseminate research findings to farmers and millers
- Provides information on the local sugar market to the government and recommend appropriate regulatory measures
- Mediate fair pricing system for sugarcane crop and other by-products if industrially utilized by the millers
- Ensures healthy environment the farming and processing components of the sugar industry
- Establish data bases to collect and tabulate statistical data of the industry
- Issues license for new sugar facilities.

2.3.2. Kenya Sugar Research Foundation (KESREF)

Kenya Sugar Research Foundation (KESREF) is a government body founded in the year 2001. It is mandated to:

- Carry out applied research and disseminate recommended research findings on the production of sugarcane or other sugar crops to farmers
- Conduct problem solving research on sugar processing technology to improve efficiency of sugar factories
- Liaise with sugar factories to recommend proposals for the utilization of the industry's by-products to generate additional revenues to factories and improve competitiveness of the sugar industry
- The key role of KESREF is to plan and execute research programs tailored to develop new technologies and services for the sustainable and improved productivity of the sugar industry in Kenya and then transfer these technologies and techniques to both famers and millers

The center and headquarters of KESREF is in Kibos. The site was chosen to locate the research center in the vicinity of the main sugarcane and sugar processing areas of Nyando and other producing area in western Kenya.

2.3.3. Water Resources Management Authority (WRMA)

The Water Resource Management Authority (WRMA) is a state corporation under the Ministry of Water and Irrigation established under the Water Act 2002 and charged with being the lead agency in water resources management.

The key mandates of the Authority include the following:

- Developing principles, guidelines and procedures for the allocation of water resources
- Monitoring, and from time to time reassessing, the national water resources management strategy
- Issuance of permits for water use
- Monitoring and enforcing conditions attached to permits for water use
- Regulating and protecting water resources quality from adverse impacts
- Managing and protecting water catchments

In order for WRMA to undertake its stipulated responsibilities, the Act provides for decentralized and stakeholder involvement. This is implemented through regional offices of the Authority based on drainage basins (catchment areas) assisted by Catchment Area Advisory Committees (CAACs). At the grassroots level, stakeholder engagement is through Water Resource User Associations (WRUAs).

2.3.4. National Irrigation Board (NIB)

The National Irrigation Board was established in 1966 through an Act of Parliament (Cap 347) to take over the running of centrally managed irrigation schemes that had been developed by the Government to settle communities. The Board took over the running of Mwea, Hola and Perkerra Irrigation Schemes. Later, the Board developed Ahero, West Kano, and Bunyala Schemes. The first three schemes were developed as pilot schemes in the 1960s and early 1970s and remain so even today. The NIB later expanded the Hola and the Mwea schemes and transferred the control of the Bura Irrigation Scheme to the Ministry of Agriculture. The Board has also facilitated research leading to the development of some public assisted irrigation schemes, such as the Yala Swamp and the South West Kano Schemes.

2.3.5. National Environment Management Authority (NEMA)

The National Environment Management Authority (NEMA) is a government agency responsible for the management of the environment and the environmental policy. NEMA is located in Nairobi with offices through Kenya. The Agency was formed on 1st July 2002 following the merger of three government departments, namely: the National Environment Secretariat (NES), the Permanent Presidential Commission on Soil Conservation and Afforestation (PPCSCA), and the Department of Resource Surveys and Remote Sensing (DRSRS).

2.3.6. Out Grower Associations

The Out Grower Associations (OGIs) have been established in each sugarcane producing area to act on behalf of farmers through executive committees freely elected at grass-roots level.

The OGIs represent farmers in all matters related to production of sugarcane. Their mandate includes assisting farmers to get required loans to carry out field operations and purchase inputs. They also negotiate cane pricing as well as cane harvesting and transportation contracts with millers. The OGIs struggle to secure timely payment to farmers on delivered cane. These services are supposed to be coordinated with the KSB and other stakeholders.

The OGIs link farmers to KESREF to ensure the transfer of research finding and their application by farmers to increase the cane yield and reduce the costs of production at farm level.

Sugarcane farmers (out growers) supply over 90% of the cane milled. A number of other institutions including societies, Unions and SACCOs represent these farmers. The common role of these institutions is to promote, represent and protect the interests of the farmers. The institutions operate under the Kenya Sugarcane Growers Association (KESGA).

Chapter 3 Natural Resources in Kenya

3.1. General overview

Kenya is a sovereign state in East Africa. Its capital and largest city is Nairobi. The country lies on the equator with the Indian Ocean to the south-east, Tanzania to the south, Uganda to the west, South Sudan to the north-west, Ethiopia to the north and Somalia to the north-east. Kenya occupies a land area of 581,309 km^2 (224,445 square miles) and its population is approximately 44 million according to 2009 census.

Lake Victoria also lies to the west of Kenya. The geographical coordinates of the country are Latitude 4 North to 4 South and Longitude 34 East to 41 East.

Kenya's coastline has a total length of 1420 km. Of this, some 650 km, about 45.7 percent of the total is found in Lamu County which, in addition to its very irregular coastline, has several islands within its boundaries. The northern end of the coast, from the Somali border down to the northern coast of Ngomeni is generally characterized by mangroves and tidal flats. Vast tracts of mangroves are again found at the southern end of the coast from Gazi Bay down to the Tanzanian border

The country has a warm and humid climate along its Indian Ocean coastline, with wildlife-rich Savannah grasslands inland towards the capital. Nairobi enjoys a cool climate that gets colder approaching Mount Kenya with its three permanently snow-capped peaks. To the west and south west, the climate is warm and humid particularly near Lake Victoria. Temperate forested and hilly areas are also found in the western region. The northeastern regions along the border with Somalia and Ethiopia are arid and semi-arid areas with desert-like landscapes.

Lake Victoria, considered the world's second largest fresh water lake and the largest within the tropics, is situated to the southwest and is shared with Uganda and Tanzania.

The capital, Nairobi, is a vibrant regional commercial center. Considering GDP as a benchmark, the economy of Kenya is the largest in East and Central Africa. Agriculture is a major employer of the inhabitants and the country traditionally exports tea and coffee, with exportation of fresh flowers to Europe becoming an important source of foreign cash.

3.2. GEOGRAPHY OF KENYA

Kenya has a distinctive topographic profile. The interior is much higher than the rest of the country, and the mountains are roughly in a line running north and south. Its highest mountain, Mount Kenya, is located in approximately the center of the country. The Great Rift Valley runs from north to south through Kenya, separating the Lake Victoria basin to the west from the hills in the east, which slide into the dry grassy lowlands and coastal beaches. Kenya's topography forms complex ecological zones, including one called the highland zone. This is a region of rolling uplands characterized by cool weather, abundant rainfall, rich volcanic soils, and dense human settlement.

3.2.1. TOPOGRAPHICAL FEATURES

. The Kenyan terrain gradually changes from the low-lying coastal plains to the Kenyan highlands. Coastal Kenya is a highly fertile low-lying area. One can find a coral reef over here also. There is a dry coastal plain covered by thorny bushes and savanna grasses. Mount Kenya is the highest point of the country and is 5,199 meters high. Mount Elgon and Mount Kilimanjaro are the other mountain ranges in Kenya.

The Great Rift Valley, located in the western and central part of the country, is one of the striking features of the geography of Kenya. The valley divides the Kenyan highlands into east and west. The highlands are an important agricultural region of the country as they have a cool climate and a highly fertile soil. There are a plenty swamps in the Loraine Plain, on the northeastern part of Kenya.

Several big and small lakes and rivers form part of the geography of Kenya. Lake Turkana is found in the northern part of the country, whereas Lake Victoria lies to the west. Other important lakes include Lake Naivasha and Lake Nakuru.

There are also numerous rivers in Kenya. The rivers Nzoia, Yala and Migori flow across the country before draining into Lake Victoria. Rivers Tana and Athi flows in the southeastern part, while Ewaso Ngiro is found in the northeastern part of the country (Figure 3-1).

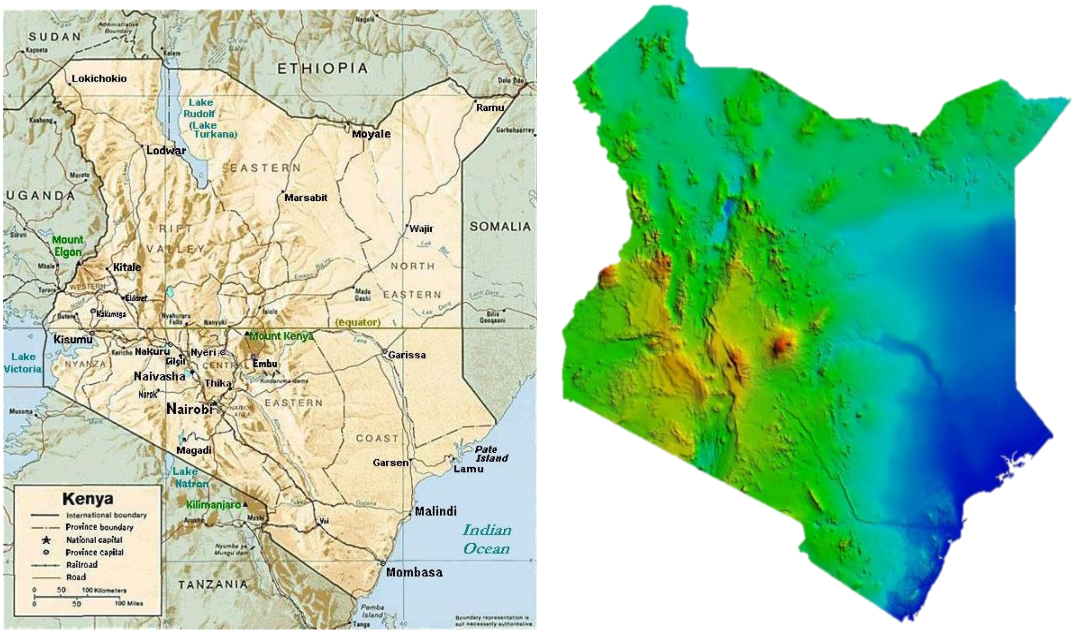

Figure 3-1: Topography map of Kenya

3.3. CLIMATE OF KENYA

Due to the high variation in topography from 4,000m above sea level (a.s.l) in the west and center down to below sea level in the east and water bodies, Kenya's climate is diversified on all parameters that affect evapotranspiration (temperature, wind, humidity and radiation).The climate of Kenya varies from mostly cool, to always warm/hot depending on the location. This variability will lead to different water requirements for sugar production in different agro zones.

3.3.1. TEMPERATURE AND RAINFALL

Kenya's climate is predominantly tropical in nature and highly variable due to the combined influence of altitude and the two monsoon systems. Movements of air masses between the two high pressure belts in the southern and northern hemispheres within the Inter-tropical Convergence Zone (ITCZ) produce rainy and dry seasons around the year. From December to March, Kenya is generally under the northeast monsoon, when the movement of dry air is from the north direction. From March to June eastern wind dominates bringing moist air from the Indian Ocean which results in heavy rains within the area. Between June and September the southeast monsoon is prevalent, and much of the country is influenced by air subsidence which inhibits rainfall and causes low temperatures. From September to November, the wind direction is again from the east, bringing moisture from end of October to the beginning of January, referred to as "short rains" season.

The climate in Kenya is generally hot and humid at the coast, temperate inland and very dry in the north and northeast parts of the country.

The average annual temperatures for some Kenyan towns are: the coastal town of Mombasa (altitude 17 M) is 30.30 Celsius maximum and 22.40 Celsius minimum; the capital city, Nairobi (altitude 1,661 M) 25.20 Celsius maximum and 13.60 Celsius minimum; Eldoret (altitude 3,085) 23.60 Celsius maximum and 9.50 Celsius minimum; Lodwar (altitude 506 M) in the drier north plain lands 34.80 Celsius maximum and 23.70 Celsius minimum (Figure 3-2). There is plenty of sunshine all the year round and summer clothes are worn throughout the year. However, it is usually cool at night and early in the morning. The long rains occur from April to June and short rains from October to December. The rainfall is sometimes heavy and when it does come it often falls in the afternoons and evenings. The hottest period is from February to March and coldest in July to August (Figure 3-4).

The annual migration of wildlife between Serengeti National Park in Tanzania and Maasai Mara National Park in Kenya takes place between June and September. The migration of almost two million wildebeest, zebras and other species is nature's greatest spectacle on earth.

Nine tenths of Kenya is arid, but the highlands and parts of the coastal region receive substantial annual totals of rainfall in two wet seasons each year. The country has seven types of climate, according to the classification of Papadakis. (Papadakis 1966)

1. The southern half of the coastal belt has a humid, semi-hot equatorial climate. The total rainfall is large and exceeds annual evapotranspiration. The mean daily minimum temperature of the coolest month of the year exceeds 18^{o} C. This climate is suitable only for equatorial tree crops such as coconut, oil palm and cocoa, and for such food crops as maize, rice and cassava.
2. A dry, semi-hot tropical climate covers the northern half of the coastal belt and a strip of land west of the humid, semi-hot equatorial region. The mean minimum temperature of the coolest months exceeds 13^{o}C. The temperature regime is too warm for wheat. The principal crops suitable for this climate are maize, groundnuts, cassava, sugarcane, cotton and bananas.
3. A zone of semi-arid tropical climate occurs in the south-west and north of Kenya. Mean daily minimum and maximum temperatures of the coolest month exceed 13^{o} C and 21^{o} C respectively. This climate is too warm for wheat, suitable crops being sorghum, rice, millet groundnuts, maize and sugarcane. (Figure 3-2)
4. A zone of humid tierra templada climate covers a small highland area north-east of Lake Victoria. Mean minimum daily temperatures of the coolest month vary from 8^{o}

C to 13° C. This climate is moderately suitable for wheat, but in-places the winter is dry and irrigation is needed.

5. The plateau and mountain area of south-west Kenya (excluding the high mountains) has a dry Tierra Templada climate. The temperature regime is similar to that of humid tierra templada, which is moderately suited to wheat, but winters are dry and irrigation is needed.
6. A zone of medium tierra fria climate occurs in the tropical highland region in the south-west of Kenya. The temperature regime is quite suitable for wheat. The moisture regime varies from humid to semi-arid monsoon. The possibility of growing wheat without irrigation depends on the length of the wet season.
7. A zone of hot tropical desert climate covers large areas in the east and north-west. The moisture regime is desertic. Wheat is marginally suitable, with irrigation, in areas where winters are cooler (mean daily temperature of the coolest month less than 13° C) (see Figure 3-2).

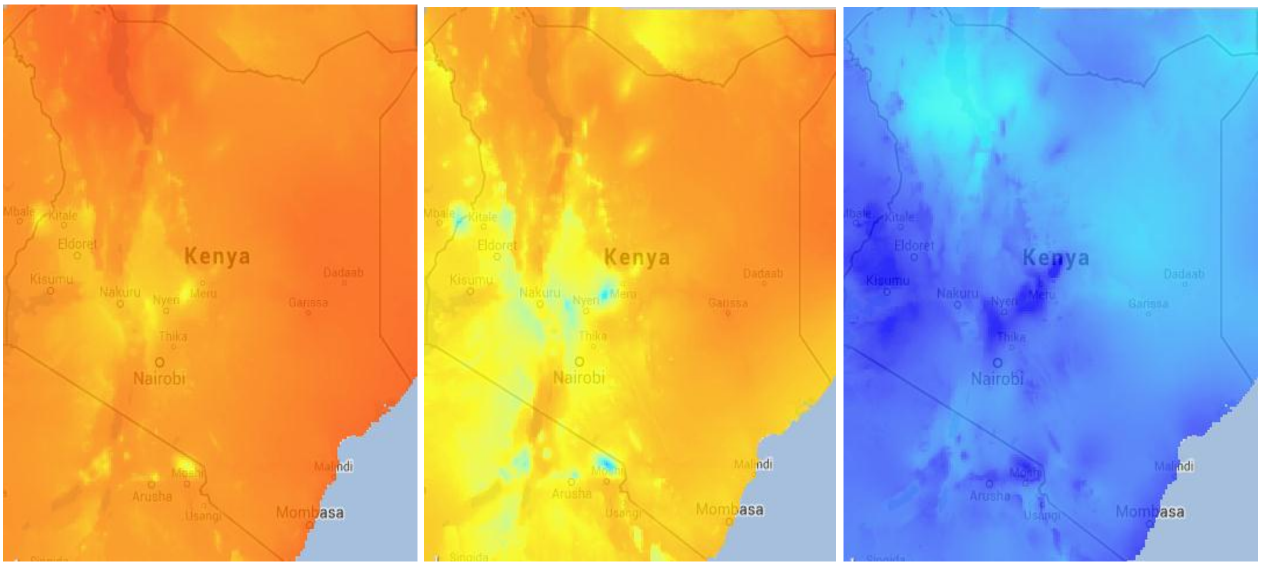

Figure 3-2: Min temperature of the coldest months (left), max temperature for the warmest months (middle) and annual precipitation (right)

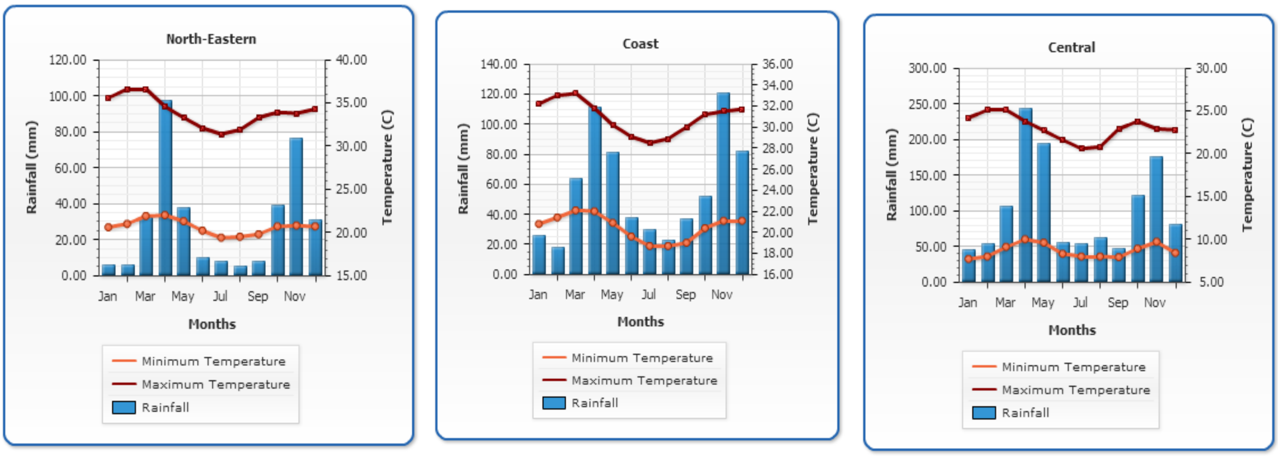

Figure 3-3: Monthly average rainfall and temperature for north-eastern, coast and central areas in Kenya

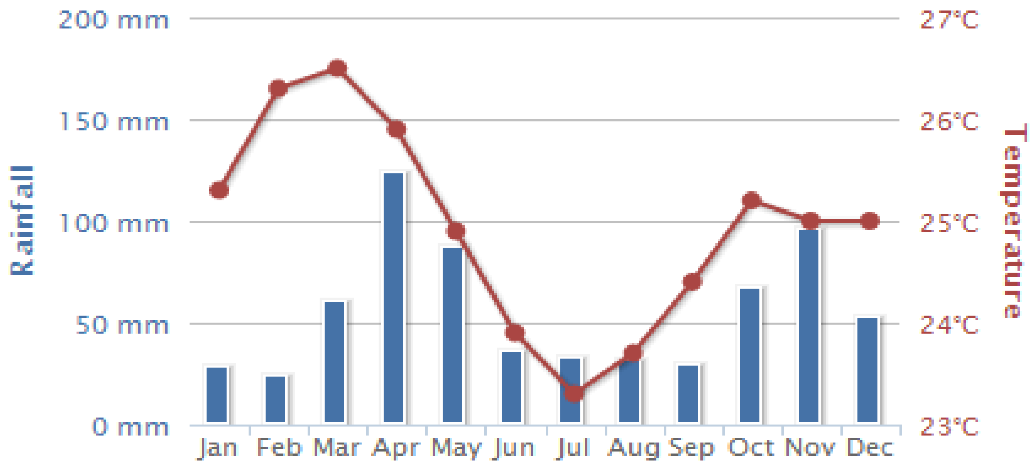

Figure 3-4: Average monthly temperature and rainfall for Kenya from 1990-2009

3.3.2. CLIMATE DATA RESOURCES

The climate data was collected from different sources each source having a different data base regarding the time series, the number of stations, and their distributions in Kenya. The collected data reflected different qualities.

3.3.2.1. FAO DATABASE

Figure 3-5 shows the climate stations locations as provided by Water Resources Development and Management Service (AGLW) and the Natural Resources Service (SDRN) through their Clim-wat application. The data is reported on daily and monthly bases.

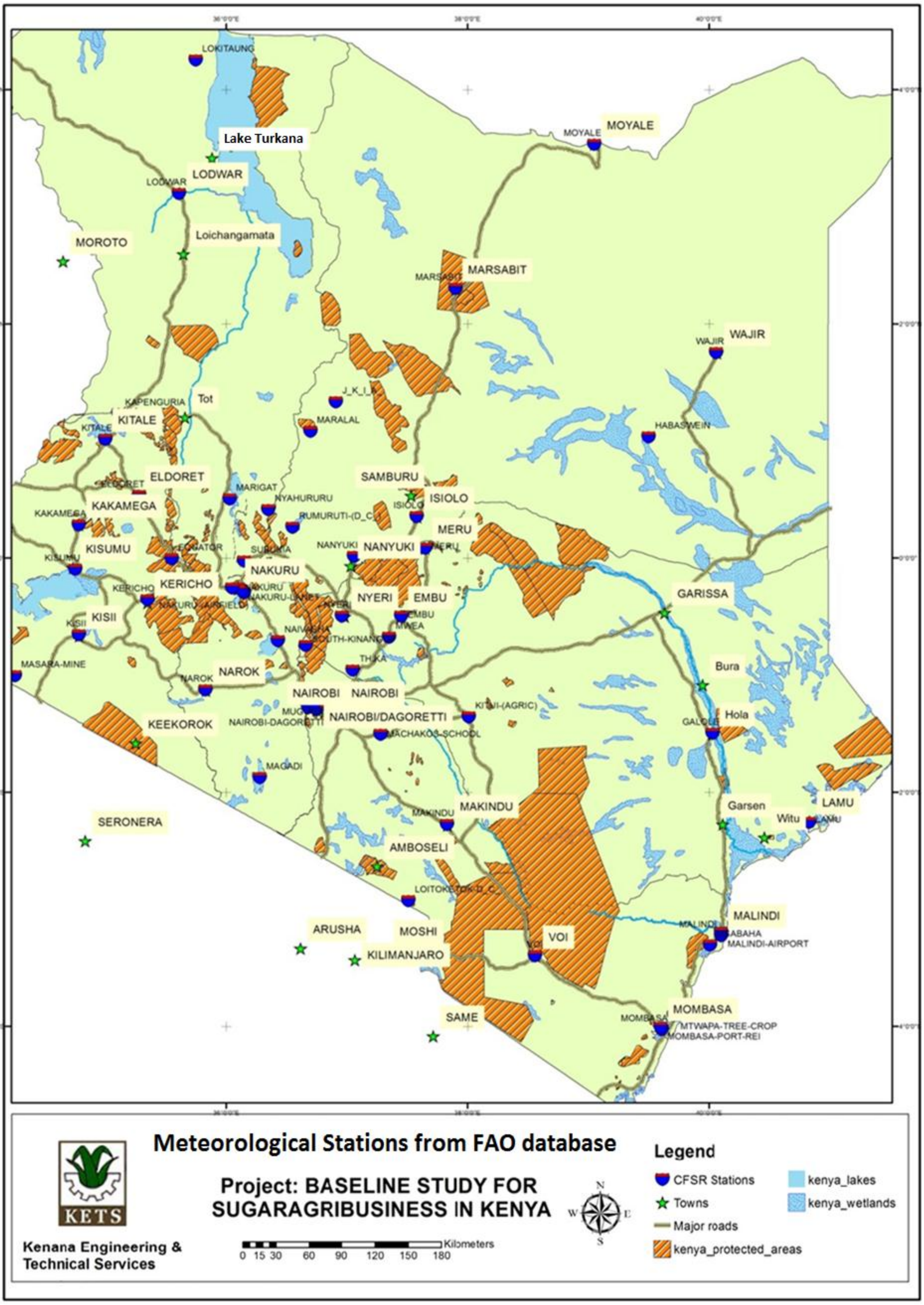

Figure 3-5: Meteorological stations in Kenya (from FAO database)

3.3.2.2. Global Weather Data (CFSR database)

The National Centers for Environmental Prediction (NCEP) and Climate Forecast System Reanalysis (CFSR) was completed over the 31-year period from 1979 through 2010. The CFSR was designed to perform as a global higher resolution, coupled atmosphere-ocean-land surface-sea ice system to provide the best estimates of the state of these coupled domains over this period. Figure 3-6 illustrates the locations of stations grid for Kenya. The data was collected on a daily basis.

3.3.2.3. Kenya meteorological department database

The database of the meteorological department in the Ministry of Environment, Water and Natural Resources has been collected through the following two types of weather stations:

a- Optical stations

They are fully equipped with optical sensors and gauges and under direct supervision of the Meteorological Department. All climatologically parameters are monitored by this type of stations.

b- Volunteer stations

Meteorological Department is responsible for providing the gauges and the necessary equipment to volunteers for governments and companies to observe one parameter or more. Most of these types of stations are collecting rainfall data (Figure 3-6 and 3-7).

Table 3-1 shows the deployment of the two types of stations within some parts of Kenya. The data collected from the stations is utilized for analysis and calibration purposes.

Table 3-1: Types of stations within some parts of Kenya

Station ID	Station Name	Station Type
9039000	Garissa Meteorological Station	optical
9240001	Lamu Meteorological Station	optical
9439021	Mombasa Port Reitz Airport	optical
9034025	Kisumu Meteorological Station	optical
8635000	Lodwar Meteorological Station	optical
8934096	Kakamega Meteorological Station	volunteer
8835031	Kaibuibich - Kapenguria	volunteer
9439001	Kwale Agricultural Department	volunteer
9339078	Tsangatsini Dispensary	volunteer

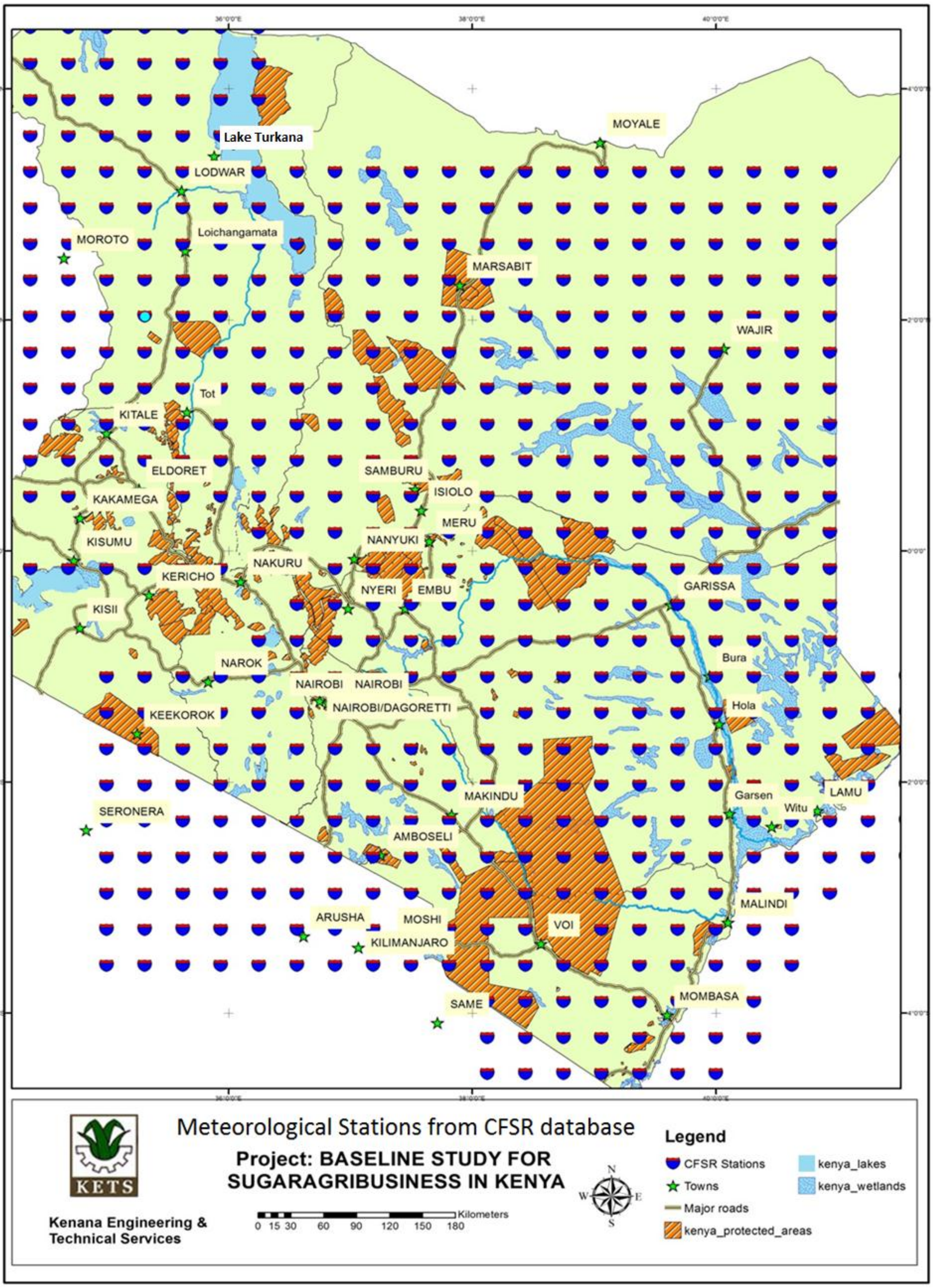

Figure 3-6: Meteorological Stations (from CFSR database)

Figure 3-7: Meteorological stations (from Kenyan Meteorological Department database)

3.3.2.4. Other resources

Additional climatic data was collected from various documents and reports during the site visits which included meetings counterparts in some ministries, factories, development authorities, etc.

3.4. Water Resources

3.4.1. Introduction

Kenya is classified as water scarce country with only 647 cubic meters of renewable freshwater per capita. At the same time it is characterized by high spatial and temporal variability and extremes of droughts and floods.

Under this condition, water resources in view of high demand of sugarcane crop should be carefully balanced when proposing new areas for sustainable introduction of sugar industry in Kenya.

3.4.2. Water resources

3.4.2.1. Renewable water resources

According to WRMA - JICA, the renewable water resources in Kenya are composed of surface water and ground water recharged by rainfall and snow melts. The total quantity of each resource is given in Table 3-2.

Table 3-2: Annual water recharge from different resources

Source	MCM/year
Surface Water	20,637
Groundwater Recharge	55,973
Renewable Water Resources	76,610

3.4.2.2. Surface water

Based on captured information the surface water can be divided into five major river basins (Figure 3-8) and six catchment areas as in Table 3-3.

Table 3-3: Major river basins – surface and ground water

Catchment	Area (km 2)	SURFACE water MCM/year (2010)	Ground water recharge save yield (MCM/year)(2010)
Lake Victoria (North)	18,374	4,626	708
Lake Victoria (South)	31,734	4,773	874
Rift Valley	130,452	2,457	1,402
Athi	58,639	1,198	333
Tana	126,026	5,858	879
Ewaso Ngiro North	210,226	1,725	1,401
Total	575,451	20,637	5,597

3.4.2.3. Rivers Flow

Data on the measurements of rivers flow rates expected to provide the proposed potential areas with supplementary irrigation water have been obtained from 14 river gauges under WRMA supervision on rivers and streams. These stations are listed in Table 3-4.

Table 3-4: Stations in Kenya which provided data on river flow rates

No	Station
1	4F13 Tana Grandfalls
2	4G08 Tana Nanigi
3	4G04 Tana Hola
4	4G01 Tana Garissa
5	4BE10_Tana Rukanga
6	4DC03_Rupingazi
7	4F10 Kazita
8	5ED01 Archers Post
9	5DA05 Likiundu
10	1GD03-Nyando
11	1BD02 Large Nzioa
12	2B26 Malmalte
13	3HA13 -Sabaki
14	3KG01 - Umba

Figure 3-9 shows the locations of the river flow stations.

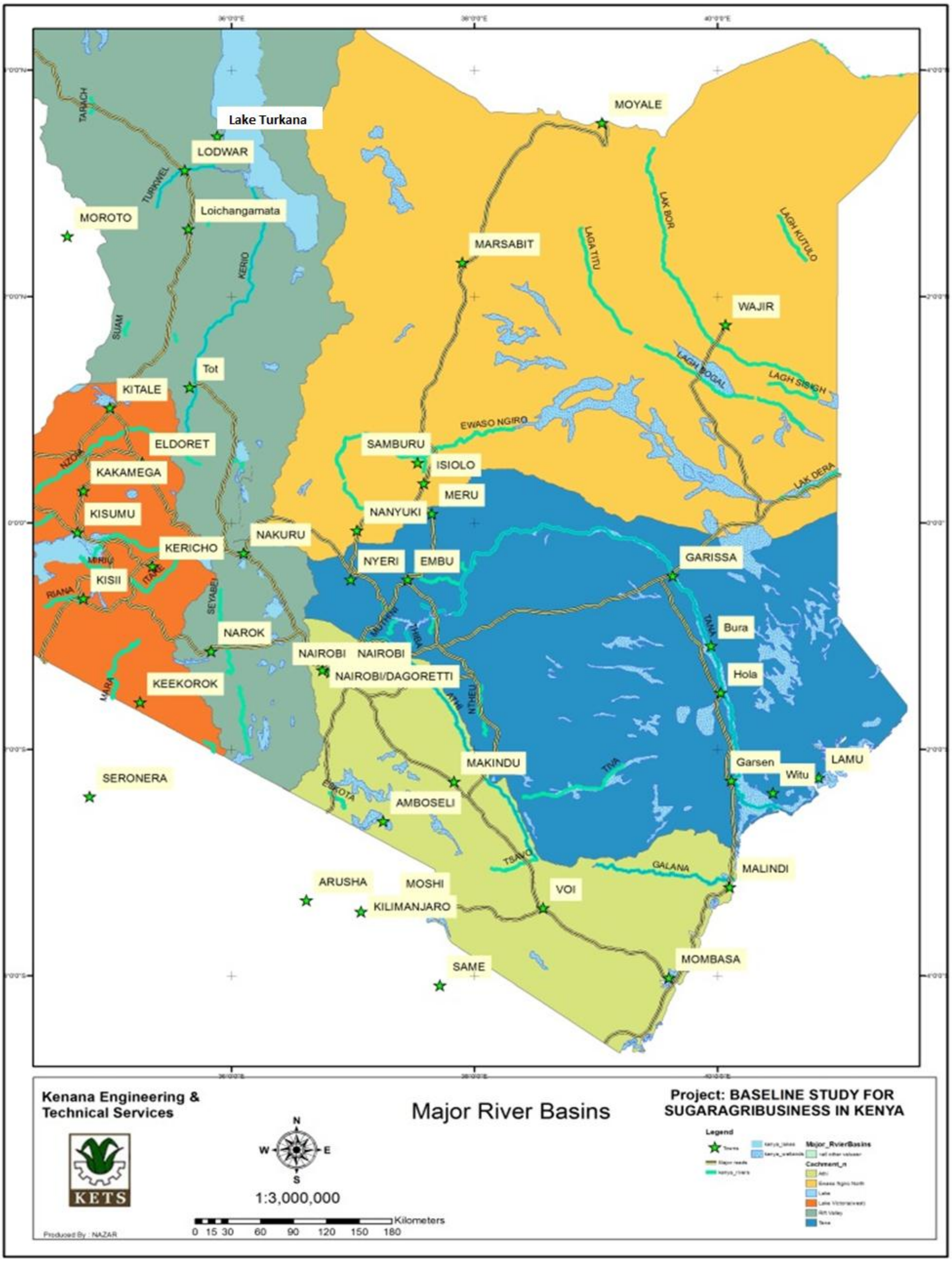

Figure 3-8: Major River Basins

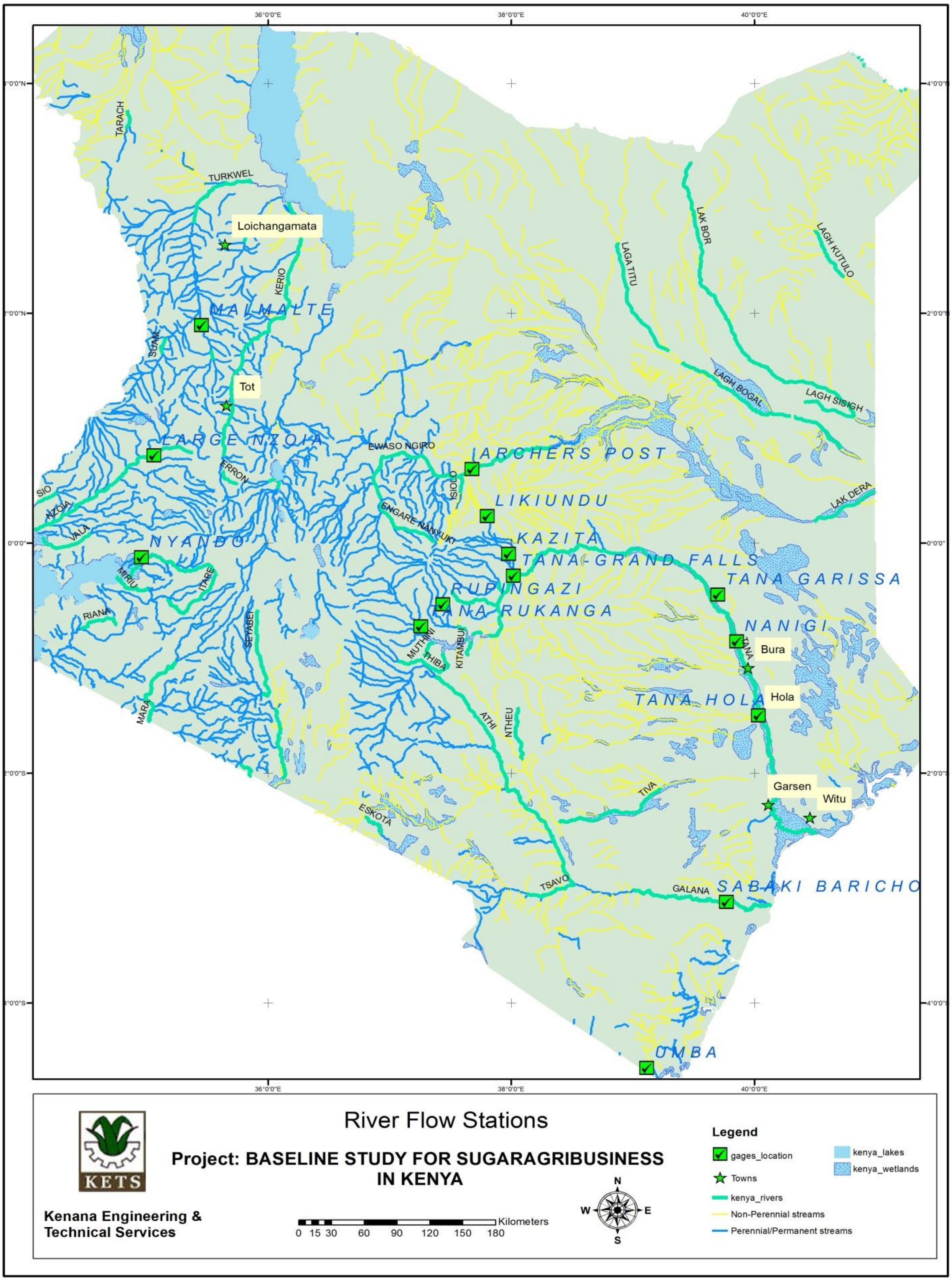

Figure 3-9: River Flow Stations

3.4.2.4. Groundwater

The hydro-geological areas of Kenya can be regarded as simplified geological areas. The main groundwater aquifers are closely linked with the following three major rock systems:

1. Volcanic
2. Metamorphic basement and intrusive rocks
3. Sedimentary rocks

The aquifers potentiality in Kenya can be classified as shown in Figure 3-10 into high, good, fair, poor and low.

Using the groundwater for irrigation in poor and low aquifers should be avoided because of sustainability challenges.

Safe recharge yield:

According to JICA reports the safe yield is estimated to be about 10 % of ground water recharge. Table 3-5 clarifies the safe yield for each catchment.

Table 3-5: Safe yield for each catchment

Catchment	Safe Yield for 2010
Lake Victoria	50,108
Rift Valley	130,452
Athi	58,639
Tana	126,026
Ewaso Ngiro North	210,226
Total	575,451

3.4.2.5. Rainfall

West, central and coastal Kenya enjoy tropical climate with high annual rainfall (more than 800 mm) unlike the east and north where arid and semiarid zones exist with low rainfall (less than 400 mm).

Figure 3-11 shows the general annual distribution of rainfall in Kenya.

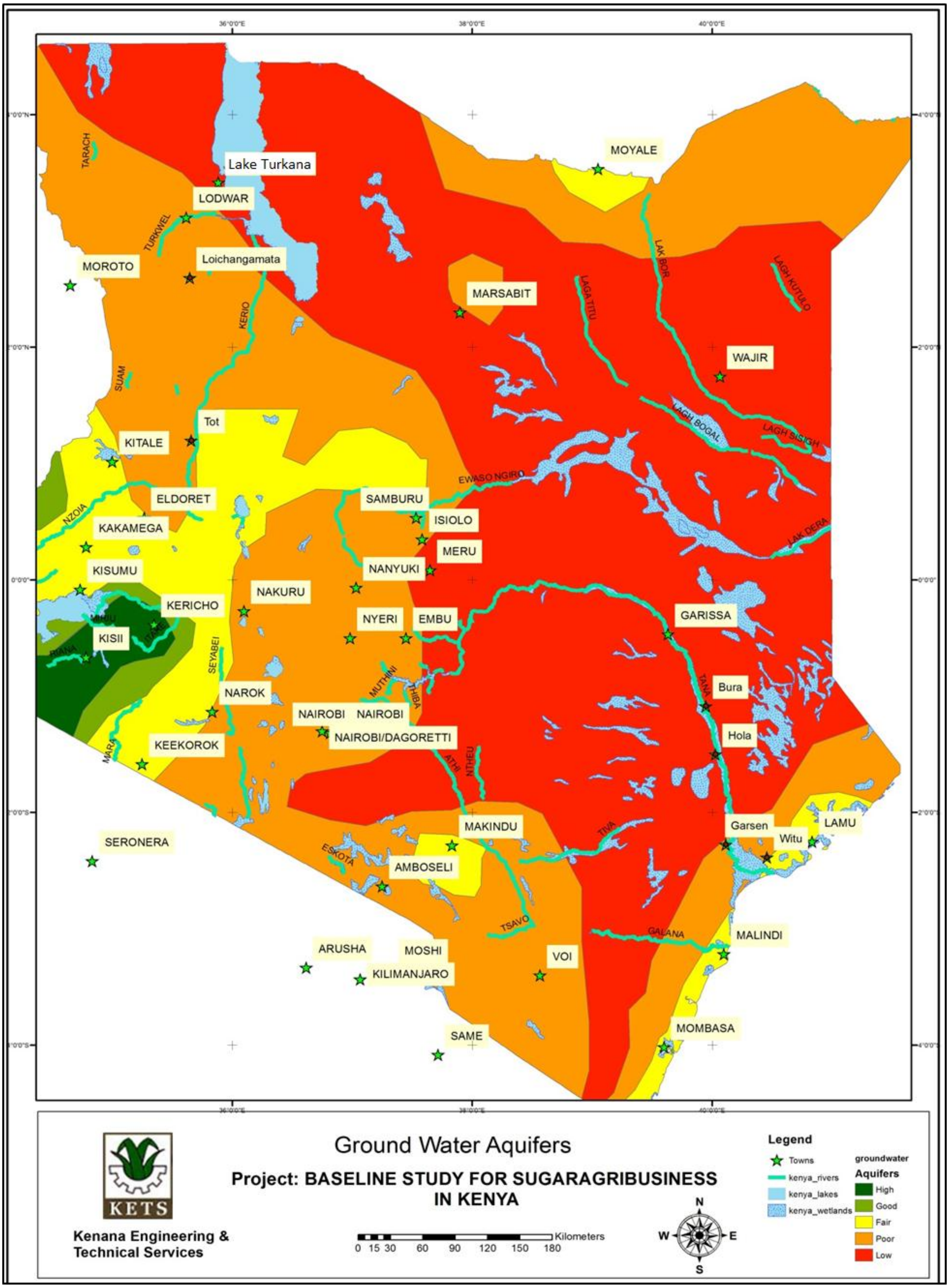

Figure 3-10: Ground Water Aquifers

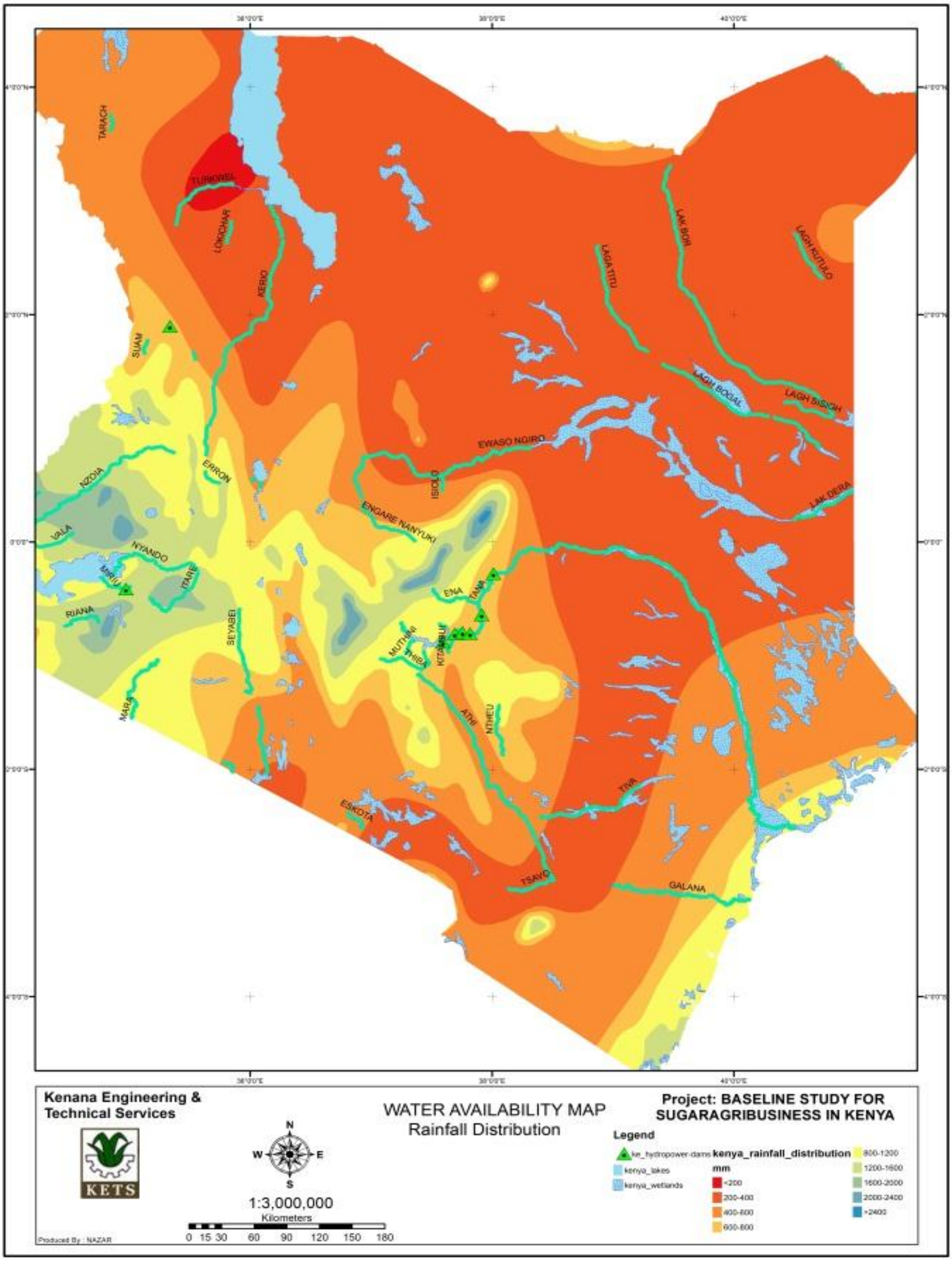

Figure 3-11: Rainfall distribution

3.4.3. Water demand

The Vision 2030 aims to increase the area under irrigation projects by 539,000 ha. Table 3-6 gives the existing and expected water demand for Kenya (as estimated by JICA). Water demand as in 2010 per catchment area is given in Table 3-7.

Table 3-6: Existing and expected water demand for Kenya

Water Demand	2010	2030
Domestic	681	2,556
Industrial	54	250
Irrigation	2,026	7,550
Livestock	351	715
Wildlife	8	8
Fisheries	15	26
Total	3,136	11,105

Table 3-7: Water demand as in 2010 per each catchment

Catchment	Domestic	Industrial	Irrigation	Livestock	Wildlife	Fisheries	Total
Lake Victoria	144	8	182	174	2	5	516
Rift Valley	59	4	119	68	3	2	253
Athi	223	39	920	46	2	1	1,231
Tana	231	3	563	48	0	3	848
Ewaso Ng'iro North	25	0	243	16	1	4	288
Total	681	54	2,027	351	8	15	3,136

3.5. Land Uses

The arable lands in Kenya represent 9.48% of its total area. Permanent crops occupy 1.12% of the land and other uses take up the rest of the land. The various types of land uses are shown in Figure 3-12.

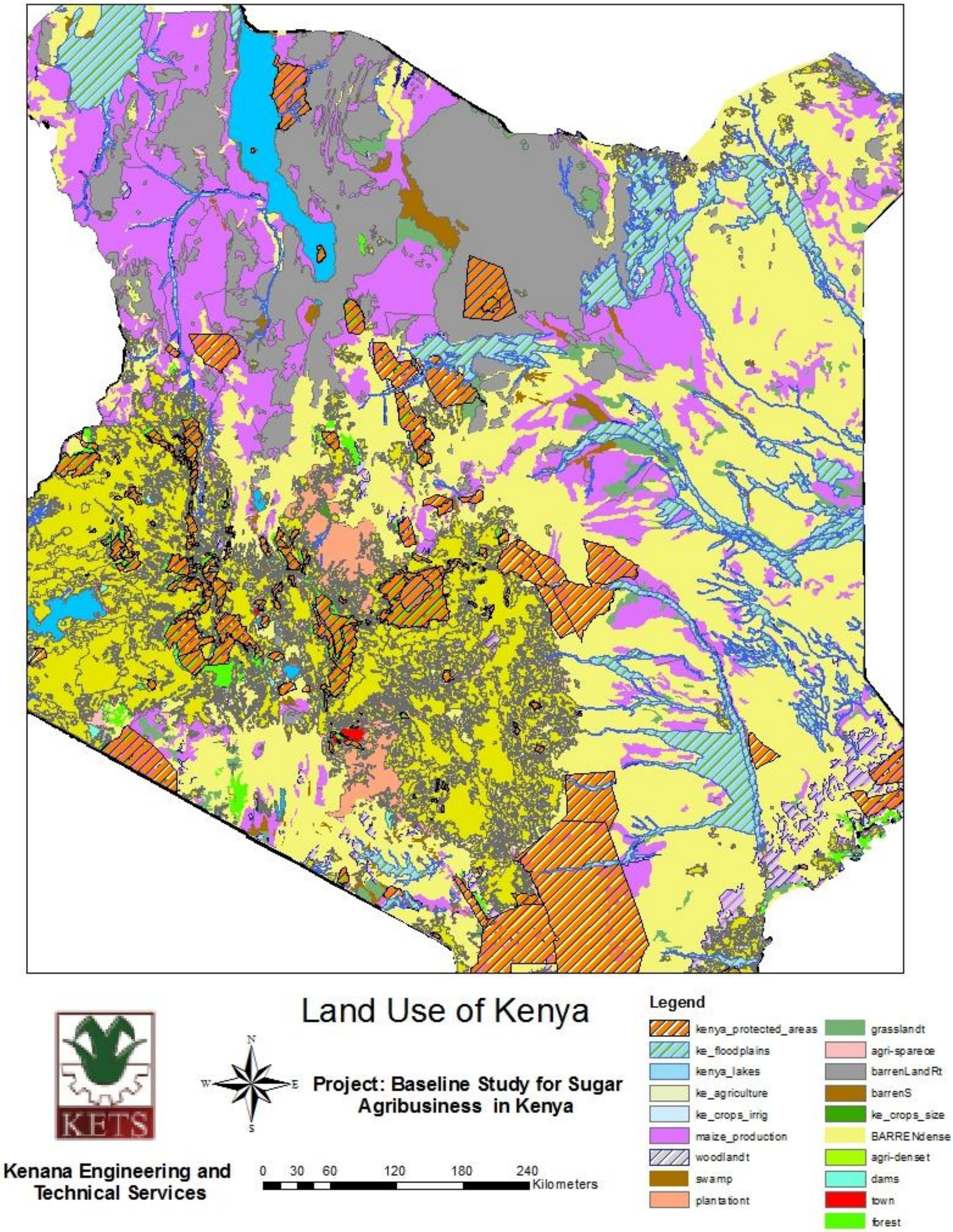

Figure 3-12: Land use In Kenya

3.6. Soils of Kenya

Kenya has a very wide range of soils due to the variations in geology (parent material) in relief and climate. Soil resources vary from sandy to clayey, shallow to very deep and low to high fertility. However, most of them have serious limitations such as salinity/sodicity, acidity, fertility and drainage problems. The major soils used in agriculture are ferralsols, vertisols, acrisols, lixisols, luvisols and nit sols.

Soil consists of solid particles, water and air and serves as a natural medium for plant growth. The solid particles are made up of mineral components such as sand, silt and clay and organic components consisting of decomposed plant and animal residues

Clay and organic matter have the ability of adsorb cations/nutrients, playing a crucial role in plant nutrition. Water and air occupy the pore spaces between the solid particles.

Soils contain microorganisms, which decompose plant and animal residues, and microbes such as Rhizobium bacteria, which help certain plants to fix nitrogen from the air.

Different soils have different profiles with clear horizontal layers, also called horizons. The horizons differ from each other in their physical, chemical and biological characteristics, including color, texture, structure, consistency, presence of organisms, degree of acidity or alkalinity (pH), etc.

3.6.1. Soil types of Kenya

The following details the major soils types of Kenya:

Andosols: Occur in areas with steep slopes and high-rainfall. With rainfall over 1000 mm per year, andosols are exposed to excessive leaching. Andosols are porous, have a high water-storage capacity and a low bulk density. They are also acidic (low pH) due to the high leaching of soluble bases and high levels of Aluminum (Al). These conditions favour P-fixation, making it no longer available to the plants. To improve agricultural production, liming and the use of fertilizers is necessary. Andosols are highly susceptible to erosion as they mostly occur on steep slopes. In these areas, they are mainly used for tea, pyrethrum, temperate crops and dairy farming.

Nitisols: Occur in highlands and on steep volcanic slopes, for example in the central highlands of Kenya, some areas of the Ethiopian highlands and around mounts Kenya and Kilimanjaro. They are developed from volcanic rocks and have better chemical and physical properties than other tropical soils. They have a good moisture-storage capacity and aeration while the organic matter content, cation exchange capacity and percentage base saturation range from low to high. Most nitisols are acidic (pH<5.5) due to the leaching of soluble bases.

Andosols: Occur in areas with steep slopes and high-rainfall. With rainfall over 1000 mm Nitisols have often high clay content (more than 35%). They are the best agricultural soils found in the region. They are intensely used for plantation crops and food production (e.g. banana, tea and coffee).

For optimal agricultural production, nitisols require the use of manure and inorganic fertilizers. To protect these soils from erosion, soil conservations measures are essential

These kinds of soils occur in the coffee zones in the sub-humid areas, on undulating to hilly topography. They show an increase of clay content in the sub-soil (B-Horizon). The sub-soil is often not very porous, impeding root spreading. They have a relatively low water-storage capacity, compared with nitisols. Acrisols and Alfisols in wet areas have a low pH (acid), Al and Mn toxicities and low levels of nutrients and nutrient reserves.

These soils have poor structure and need erosion-control measures. Organic and inorganic fertilizers are needed to improve crop production. The soils respond well to fertilizers (especially N, P and K) and to the use of soil organic matter.

Ferralsols: Occur on gently undulating to undulating topography. They are very old, highly weathered and leached soils, and therefore with a poor fertility, which is restricted to the top soil, as the subsoil has a low cation exchange capacity. Phosphorous (P) and Nitrogen (N) are always deficient. Ferralsols are rich in Aluminium (Al) and Iron (Fe). The nutrient reserves are easily disturbed by agricultural practices. Important management practices include the use of fertilizers (e.g. rock phosphate) and the maintenance of soil organic matter by using green manures, farmyard manures and mulching. Ferralsols have also good physical properties including an excellent capacity to hold moisture.

Ferralsols are used to grow several annual and perennial crops, being particularly suited to tree crops such as oil palm, rubber and coffee.

Planosols and Vertisols: Occur on very gently undulating to flat topography, mostly in rice growing areas such as Mwea in Krinyaga County and Kano Plains in Nyanza Province. They are found in semi-arid and sub-humid environments. Due to the high clay content in the subsoil (higher than in the top-soil), is this layer in the B-horizon that is impermeable resulting in very slow vertical and horizontal drainage and also in an extremely poor workability of the soils. These soils are dark colored and strongly cracking.

3.7. Ecology and Natural Habitats

3.7.1. Biodiversity

Biodiversity refers to the variety of all forms of life on earth, including the different plants, animals, micro-organisms, the genes they contain and the ecosystems they form. It is considered at three main levels including species diversity, genetic diversity and ecosystem diversity. Relative to the variety of habitats, biotic communities and ecological processes in the biosphere, biodiversity is vital in a number of ways including: promoting the aesthetic value of the natural environment, contributing to our material wellbeing through utilitarian values, and promoting the integrity of the environment through maintaining the carbon dioxide and oxygen balance.

Kenya is home to over 6,000 species of higher plants (including 2000 trees and shrubs). Recorded species of butterflies are 875 and there are 1,079 and 379 species of birds and mammals respectively (KIFCON 1994). Most of the fauna species are associated with forest and woody vegetation. Furthermore, the forests contain 50% of the nation's tree species, 40% of the larger mammals and 30% of the birds (KIFCON 1994).

3.7.2. Forests

Kenya's forest cover totals 2.4 million ha or just under 3% of the country (KIFCON 1994). Acacia and *Commiphora spp* dominates the desert thorn-scrub lands. The low montane forests in the ASALs are dominated by tree species and in some cases such trees form closed forest vegetations. The main tree species include *Juniperus procera* (cedar), *Podocarpus gracilior*, *Olea africana*, *Olea hochstetteri*, *Lawsonia inermis*, *Combretum molle*, *Casipourea malosana*, *Diospyros abyssinica* and *Teclea simplicifolia*.

The deciduous woodlands occur throughout the ASALs and is dominated by *Acacia tortilis*. Other notable species include *Hyphaene ventricosa*, *Salvadora persica*, *Acacia nubica* on the northwest and northern Kenya and Commiphora and Acacias in the southern parts.

Deciduous and evergreen thorn bush constitutes another extensive vegetation cover type. The main species in the north include *Acacia reficiens*, *Acacia senegal*, *Euphorbia sp.*, *Pappea capensis* and *Combretum molle*.

The dominant species of the shrub land vegetation are *Acacia mellifera*, *Acacia senegal*, *Acacia reficiens*. *Acacia tortilis* is in the more northerly parts. To the south, *Acacia reficiens* and *Commiphora sp.* are the dominant species.

Of the 210 gazetted forest reserves, 84 are gazetted under government land and cover 1,346,074 ha while 126 under trust lands and cover some 350,427 ha. Within the gazetted natural forest reserves managed by Forest Department on behalf of the Government, some Nature Reserves are located therein.

3.7.3. WILDLIFE RESOURCES

Kenya's wildlife is one of the richest and most diversified in Africa with several of its protected areas and wetlands being internationally recognized and protected as World Heritage Sites, RAMSAR sites and Man and Biosphere Reserves. Kenya's wildlife resource also constitutes a unique natural heritage that is of great importance both nationally and globally.

A number of factors have combined to produce Kenya's biological richness. These include variability in climate and topography and diversity in ecosystems and habitats ranging from mountain ranges to arid areas. Each of these ecosystems requires different conservation priorities and measures.

Wildlife is a valuable resource to the Kenya's economy as it contributes directly and indirectly to the local and national economies through revenue generation and wealth creation. Over 70% of the country's National Parks and Game Reserves (NPGR) are found in the arid and semi-arid lands, which is also home to two thirds of the livestock population. This situation in some instances results in conflicts which threaten the coexistence. The exclusion of the interests of livestock owners when the national and game reserves policies are planned could lead to further complications.

The wealth of biological diversity in Kenya is of significant importance in supporting the lives of many people at the local and international levels. The major threat to the gene pool, species and the ecosystems is the loss of natural habitats due to changes in land use and less comprehensive policies.

3.7.4. AQUATIC ECOSYSTEMS

Aquatic ecosystems provide local communities with natural resources important for sustained livelihoods. These resources and benefits include fisheries, water supply, building materials, pasture and recreation. Aquatic ecosystems are important for ecological and service roles which include among others water storage, flood control, water filtration, recharge and discharge of water systems. The wetlands are important wildlife habitats where nutrients cycling/storage and related pollution controls occur.

Major lakes in Kenya include Lake Turkana, Lake Baringo, Lake Naivasha, Lake Jipe, Lake Chale, Lake Nakuru and Lake Victoria. Some of the swamps include the Yala, Lorian and Shompole. Other swamps which fringe the lakes provide buffering capacities. The lakes secure important ecosystems for the diversity of both floral and faunal species.

Coastal ecosystems, including mangrove forests, coral reefs and estuaries are of prime importance to economic growth and conservation. Marine parks and reserves protect marine life, and are therefore important for biodiversity conservation. They also generate revenue for the local population and support the Kenyan economy.

Kenya has about 500 km^2 of mangrove forest. The largest areas are in Lamu county where protective islands, a gentle relief, and slightly estuarine conditions have favored a lush forest cover of more than 300 km^2. Other important areas are in the Tana River delta and the area north of Ngomeni. The coast between Ungwana Bay and Gazi is too steep and too exposed, and only the creeks of Mida, Kilifi and Mombasa holds significant mangrove stands. To the south, the bays of Gazi, Shimoni and Vanga also hold large and important mangrove areas.

3.7.5. PROTECTED AREAS

Protected areas in Kenya are shown in Figure 3-13, and as part of a global system, they ensure a sustainability of bio-diversity which is beneficial to the planet earth and human welfare. In addition to the protection of wildlife species of immense importance for Kenya's sustainable development and people's wellbeing, these ecosystems also provide critical environmental benefits such as watershed protection, carbon sequestration, pollination, nutrient cycling and soil regeneration.

Currently, national parks and reserves cover 44,562 km^2, which is about 8% of the land area in Kenya. The national parks account for 5% of this area while national reserves and sanctuaries cover about 3%.

Gazetted forest area comprises 1.7 million Ha of which 1.22 million Ha are closed canopy forests including 0.16 million ha of plantations consisting of exotic species established mainly in the high potential areas of the country. Most of the gazetted and the closed forests outside the gazetted areas (0.18 million ha) are located in the wet zones of Kenya.

The highest population density and diversity of Kenya's wild fauna prevails in the dry zones of the country and about 90% of over 50 gazetted national parks, sanctuaries and game reserves are found in the arid and semi-arid lands (ASALs). To date, Kenya has 26 national parks and 30 national game reserves (including one game sanctuary). In addition, there are several private game sanctuaries, primarily licensed for the protection of the endangered black rhinoceros (Diceros bicornis) among other animals and species at high risk.

Kenya has currently demarcated only 7% of its land area for the conservation of terrestrial flora and fauna and protection of the ecological processes that are essential.

The management and control of national parks and a number of reserves is under the Kenya Wildlife Service. Within some parks, special areas have been identified as sanctuaries to ensure maximum protection and management of endangered species.

3.7.6. Marine Protected Areas and Ecosystems

Coastal and marine resources are valuable natural endowments that must be managed for the present and future generations. They offer a range of benefits and opportunities for human use. In nature, the coastal system maintains a dynamic equilibrium with processes that regulate shoreline stability, beach replenishment, and nutrient generation and recycling, all of which are of great ecological and socioeconomic importance.

Coastal and marine ecosystems such as coral reefs, mangrove forests and beach and dune systems serve as critical natural defenses against storms, flooding and erosion. They, also, attract vast human settlements due to the vast oceans' living and non-living resources, marine transportation and recreation. Further, the fishing industry is a major economic activity to supply fish for the local and international markets. Activities that add further value to these ecosystems include recreation and tourism, which have become one of the main sources of foreign exchange in Kenya.

Coastal and marine ecosystems are facing increasing pressures, and it is evident that measures should urgently be taken for a better management of their biological resource base. The principal threats to marine ecosystems include destructive fishing techniques and the associated destruction of habitat, eutrophication and siltation of coastal waters, pollution, urban and tourism development, human settlements, and the effects of climate change.

Kenya was one of the first African countries to establish marine protected areas (MPAs) in 1968. At present, Kenya has 6 marine parks and reserves accounting for about 1% of the entire network of protected areas. There are proposals to establish community-based marine conservation areas in the Tana Delta and the Lamu archipelago.

3.7.7. COMMUNITY WILDLIFE CONSERVATION AREAS AND SANCTUARIES

The areas outside of protected zones have a variety of ecosystems which ranges from those relatively undisturbed such as the semi-arid and arid areas where wildlife is mostly found, to food producing landscapes with mixed patterns of human use, including ecosystems intensively modified and managed by humans, such as agricultural lands and urban sites. The protected areas in Kenya are shown in Figure 3-13.

The issues that affect conservation outside protected areas include space for wildlife, security, human-wildlife conflicts, representation in wildlife management and governance structures, user rights, incentives and benefit sharing, technical and financial capacity to manage wildlife, limited wildlife education and research, and lack of security.

The land outside the protected areas is largely under the control of private owners and communities. Their cooperation is essential for the success of conservation activities, as the majority of these lands are subject to different uses some of which in direct conflict with wildlife conservation (Plate 3-1).

Plate 3-1: Striped Bongo Antelope at Ishaqbini Community Conservancy south of Bura East area

With proper incentives, land use practices such as agriculture which are gradually encroaching on wildlife could be managed or confined to specific areas to minimize impact and support conservation efforts.

Individual or corporate land owners in wildlife areas who develop land use activities that require incentives to promote the establishment of sanctuaries and implement measures that improve sustainable wildlife conservation. They should be part of a protective whole.

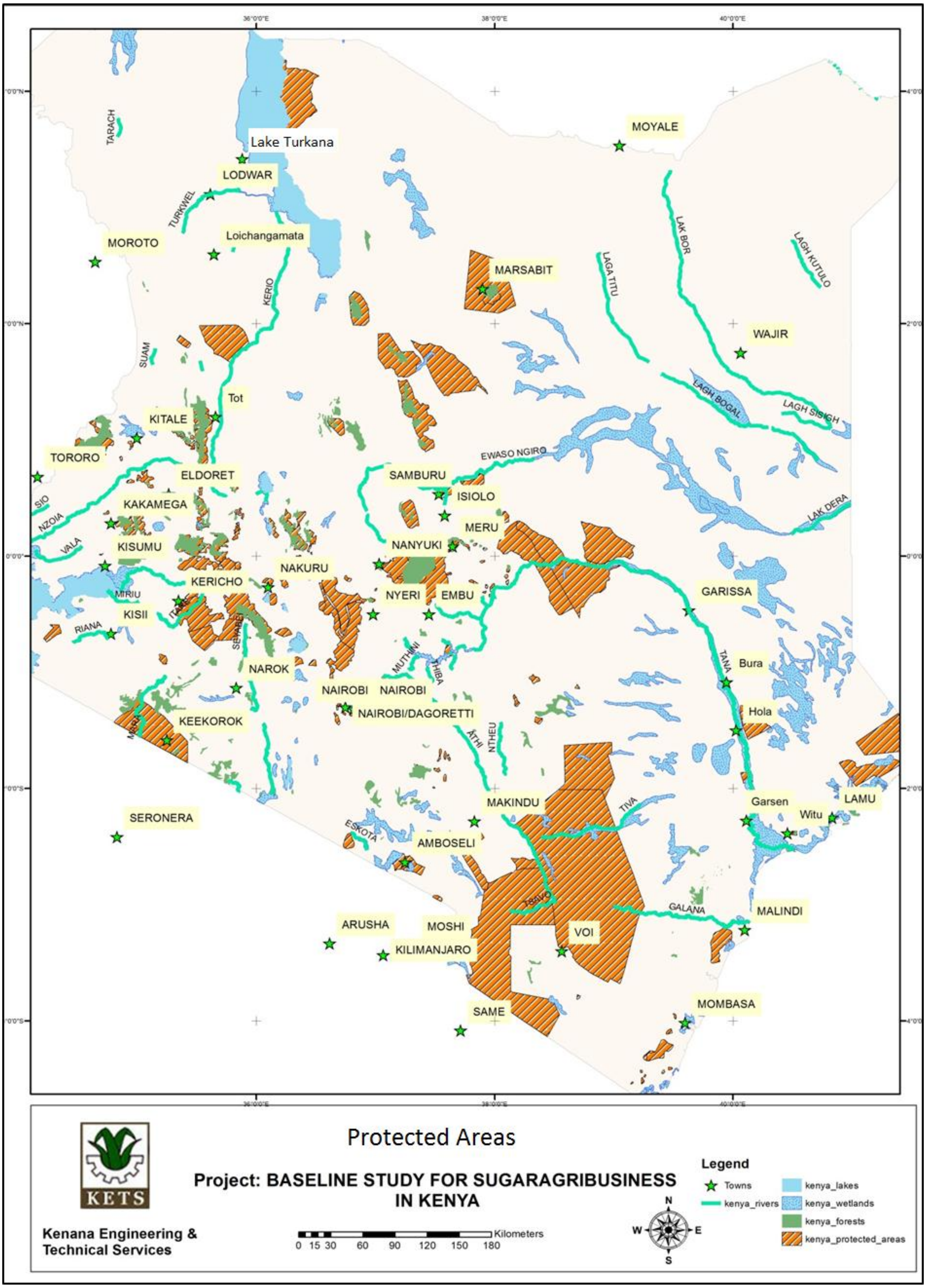

Figure 3-13: Kenya Protected Areas

Chapter 4 Infrastructure in Kenya

4.1. Introduction

Kenya's population and agricultural activity are heavily concentrated in the southern half of the country, along the corridor linking Mombasa to Nairobi and then on to Kisumu and into Uganda. The country's infrastructure backbones, including the principal road artery and major power transmission and fiber optic cables, have followed this route. The northern half of the country, by contrast is sparsely populated and characterized by fragmentary infrastructure coverage. Kenya's infrastructure networks are largely isolated from those of the neighboring countries. While there are some transport links with Uganda and Sudan, road connections with Ethiopia, Tanzania and Somalia are of very low quality, while power and Information and Communication Technology (ICT) backbones are not yet integrated across frontiers.

This chapter provides a quick overview of the key infrastructure networks in Kenya, covering transport, power, and ICT. Table 4-1 summarizes the achievements and challenges of Kenya's key infrastructures.

Table 4-1: Summary of achievements and challenges of Kenya's infrastructure

	Achievement	Challenges
Air Transport	• Leading the region • Major air hub for Africa	• Relieving capacity constraints at Jomo Kenyatta International Airport • Achieving U.S. Category 1 security clearance
ICT Reform	• Very high GSM coverage	• Strengthen competition to bring down prices • Ensure competitive international gateway
Sea Ports	• Major regional shipping hub	• Substantial investment to ease capacity issues • Institutional reform to increase efficiency

	Achievement	Challenges
Power	• Major institutional reforms • Cost-recovery pricing	
Railways	• Strategic regional rail corridor	• Revisit design of rail concession
Roads	• Sound road fund in place	• Improve quality of public investment • Major rehabilitation backlog
Urban infrastructure		• Very low levels of access to services • High rates of tenancy and insecure tenure

Source: AICD.

4.2. ROADS

The responsibility for roads infrastructure is vested in the Ministry of Roads after coming into force under the Kenya Roads Act 2007. The Ministry of Roads is responsible for 178,000 Km consisting of classified and unclassified roads. With the enactment of the Kenya Roads Act 2007, three new Road Agencies were established, namely: the Kenya National Highways Authority (KeNHA) responsible for Class A, B and C roads; Kenya Rural Roads Authority (KeRRA) responsible for Class D, E and other roads; and Kenya Urban Roads Authority (KURA) responsible for urban roads. The Kenya Roads Board (KRB) is now responsible for financing the maintenance of roads and undertaking technical audits (Integrated National Transport Policy 2010).

The length of the trunk network is more than adequate. Even if Kenya's road density indicators look relatively low by some standards, the trunk network provides basic regional and national connectivity, linking the capital to the coast, to international border crossings, and to provincial capitals in the interior (Table 4-2).

Table 4-2: Kenya's road indicators benchmarked

Category	Units	Low-income countries	Kenya	Middle-income countries
Paved road density	km/1000 km^2 of arable land	86.6	152	507.4
Unpaved road density	km/1000 km^2 of arable land	504.7	930	1,038.3
GIS rural accessibility	% of rural population within 2 km of all- season road	21.7	32	59.9
Paved road traffic	Average annual daily traffic	1,049.6	1,108	2,786.0
Unpaved road traffic	Average annual daily traffic	62.6	38	12.0
Paved network condition	% in good or fair condition	80.0	84	79.0
Unpaved network condition	% in good or fair condition	57.6	63	58.3
Perceived transport quality	% firms identifying roads as major	23.0	37	10.7

As shown in Figure 4-1, Kenya has established a sound system for funding road maintenance. The country has made great strides with institutional reforms. The country's road fund meets most of the good practice design criteria. Moreover, the fuel levy is set at a level (around $0.12 per liter) adequate to fund the country's road maintenance requirements, and the associated revenues are indeed being fully captured by the sector.

Beyond the trunk network, accessibility falls off. Only 30 percent of Kenya's population lives within two kilometers of an all-weather road-well above the benchmark for low-income countries, but only half the level found in middle-income countries.

The clustering of Kenya's population along the Mombasa-Nairobi-Kisumu corridor makes it comparatively easy to achieve significant increases in rural accessibility by improving the quality of the existing rural network, without adding hugely to the length of the classified network. When making the necessary improvements, it will be important to ensure that road investments are spatially synchronized with other interventions aimed at raising agricultural productivity. The need to provide a basic level of connectivity for the north of the country should also be considered.

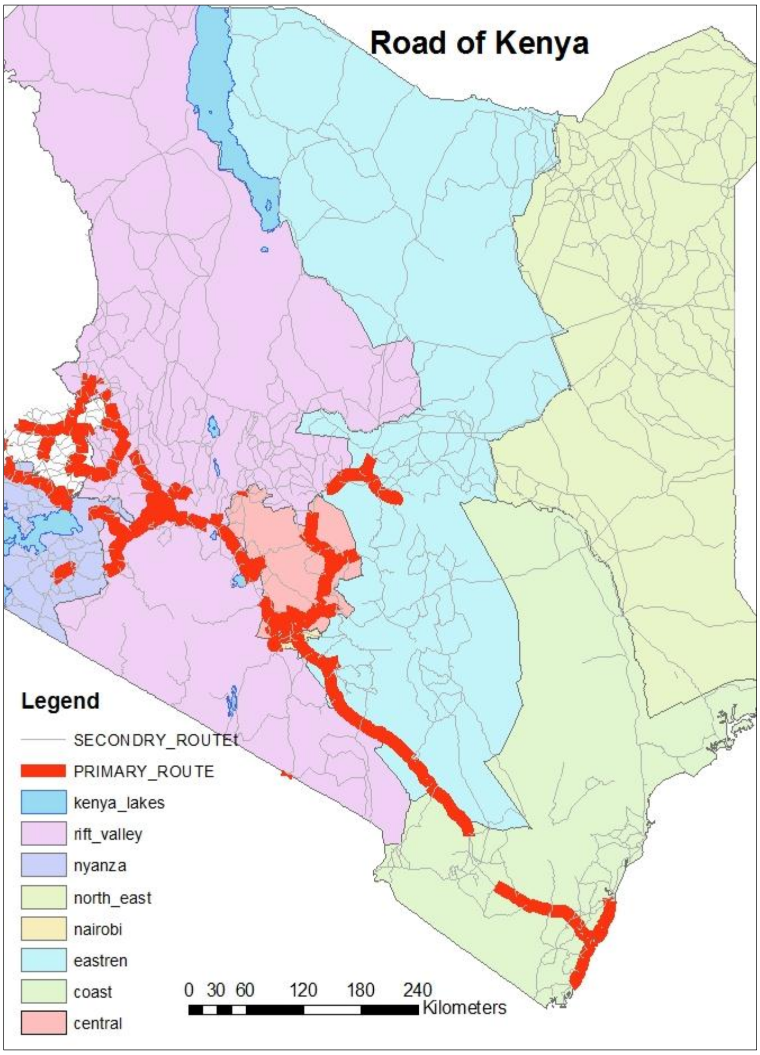

Figure 4-1: Roads in Kenya

4.3. Rail ways

4.3.1. Achievements

Kenya's railway is of strategic importance to the region. Linking the port of Mombasa to Nairobi and continuing onward into Uganda, it is a key conduit for bulk freight, easing pressure and providing additional capacity along the northern corridor (Table 4-3). Owing to deterioration of the infrastructure, freight traffic on the rail corridor has declined to less than 1 million tons per year and handles less than 6 percent of the cargo passing through the northern corridor that links Kenya, Uganda, Rwanda, Burundi, Democratic Republic of Congo, parts of Tanzania, South Sudan, and Ethiopia.

Table 4-3: Railway indicators for Kenya and selected other countries (2000–05)

	Kenya	South Africa	Malawi	Tanzania	Tanzania-Zambia	Uganda	Zambia
	(KRC)	(SPOORNET)	(CEAR)	(TRC)	(TAZARA)	(URC)	(RSZ)
Concession (1)/ state-run (0)	0	0	1	0	0	0	1
Traffic density, freight, 1,000 ton-km/km	690	5,319	112	510	460	815	379
EFFICIENCY:							
Staff: 1000 UT per staff	185	3,037	204	228	300	181	452
Coaches: 1000 passenger-km per coach	1,015	596	1,285	3,157	3,120	NA	2,772
Cars: 1000 ton-km per wagon	200	925	212	692	502	166	180
Locomotive availability in %	44.8	—	89.9	74.2	25.2	69.5	31.2
TARIFFS:							
Average unit tariff, freight, US cents/ton-km	3.8	—	5.8	4.0	3.0	15.2	3.9
Average unit tariff, passenger, US cents/passenger-km	0.6	—	1.0	1.6	1.1	2.3	0.8

Source: Bullock 2009, derived from AICD railways database

Through a combination of track rehabilitation and improved operational performance it should be possible to boost traffic volumes to 5–10 million tons per year, which should be enough to accommodate demand growth during the next decade. Efficiency indicators from the early 2000s show a relatively poor performance compared with other railways of the region.

4.3.2. CHALLENGES

Kenya's rail concession is distressed. In 2006, Kenya together with Uganda awarded a rail concession to the Rift Valley Rail Company. More than half of Sub-Saharan Africa's rail corridors have now been awarded as concessions, and the accumulated experience shows that concessions can have an immediate impact on operational performance. But because of strong competition from road freight railways never seem to generate enough revenue to support private financing of track rehabilitation. As a result, track rehabilitation typically ends up being financed by international financial institutions. In the case of Kenya, however, not even the operational improvements have been forthcoming owing to the absence of an experienced rail operating company in the private consortium (Figure 4-2).

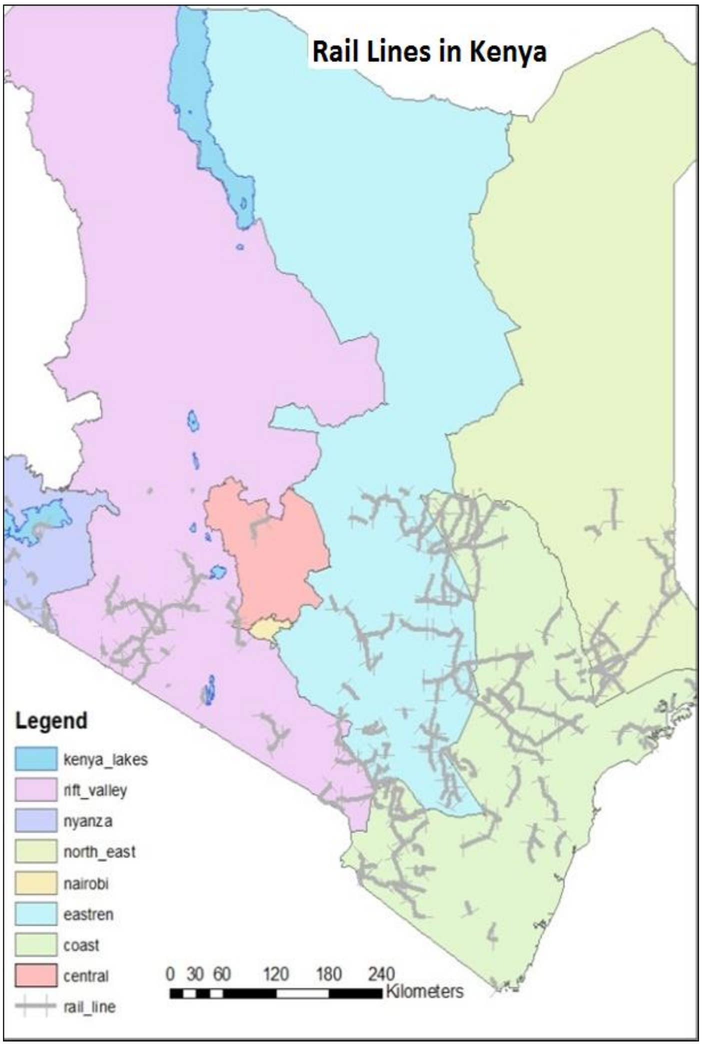

Figure 4-2: Railways in Kenya

There is an urgent need to improve the rail-port interface. In the context of improvements in the rail corridor, particular attention needs to be paid to improving multimodal transfers between the port and the rail corridor, which has become a major bottleneck in the movement of freight. Kenya's major port, Mombasa, handles more than 16 million tons of cargo annually. That number is projected to increase to 30 million tons a year by 2030. The port is congested because of inadequate capacity of rail and road transportation from the port. To relieve the port's congestion, it was proposed that it operates on a 24-hour schedule. Construction of a new terminal is planned. These changes will put even more pressure on traffic on the Mombasa-Nairobi-Kampala corridor. The main highway from

Mombasa to Nairobi and on to Kampala is already clogged with freight transport. Improvements in the Mombasa-Nairobi-Kampala rail network aimed at increasing freight traffic are needed urgently.

4.4. Seaports

4.4.1. Achievements

Mombasa is one of the largest and busiest seaports in Africa. With almost 0.5 million Twenty-Foot-Equivalent Units (TEUs) and 3.7 million tons of cargo handled each year, Mombasa is the second-largest port in Sub-Saharan Africa after Durban in terms of tonnage and containers handled. With Dar Es Salaam, it is one of the key trading centers for the East Africa region. The port is also a natural transshipment center for East Africa, with 27,288 TEUs of inbound transshipment and approximately the same amount outbound per year. However, Mombasa is straining to maintain that role because of significant capacity constraints. In terms of performance indicators, Mombasa fares relatively well compared with other ports in eastern and southern Africa. However, its container crane performance, at 10 containers per hour, is far behind Dar Es Salaam (20) and Durban (15).

4.4.2. Challenges

Easing Mombasa's capacity constraints will require substantial investments. Additional berths and terminals can be accommodated at the Mombasa site, and construction is already underway. In order to make fullest use of the site, however, and to reduce bottlenecks on the landside of the port, improvements on the local road network should be undertaken simultaneously.

Institutional reforms can also contribute significantly to easing capacity constraints. The more efficiently a port is operated, the more throughputs can be accommodated within the physical capacity of its infrastructure. It is therefore critical to accompany investments with institutional reforms that increase the efficiency of port operations. A first key step would be to move toward the adoption of the internationally preferred landlord model of port management, whereby the public sector provides port infrastructure while the private sector provides port services. A second step would be to seek greater private participation in port operation and investment. One possibility would be to try and adapt the strategic investor model successfully used by Kenya Airways, to the port sector. Further, given the expected development of new grain and container terminals at Mombasa, it will be very important to allow these facilities to compete with each other to create pressure for service improvements.

4.5. AIR TRANSPORT

4.5.1. ACHIEVEMENTS

Kenya is a regional leader in air transportation. Kenya Airways is one of Africa's top three international carriers, with an extensive network across the continent and a safety record of up to international standards (Figure 4-3). The success of the company is in large measure due to an innovative public- private partnership with a strategic investor, KLM, which has a minority stake in the company but is nonetheless fully responsible for management. Linked to the ascendancy of the national airline, Jomo Kenyatta International Airport in Nairobi has become one of the three main international gateways in Sub-Saharan Africa. Beyond its role as an international hub, Kenya has a domestic air transport market that is the fourth-largest in Sub-Saharan Africa (following South Africa, Nigeria, and Mozambique).

4.5.2. CHALLENGES

JKIA needs to address capacity constraints and security issues. While runway capacity at JKIA is adequate, there are shortages of terminal capacity and so-called airside infrastructure, such as taxiways and aprons that allow the runway to be utilized to its fullest potential. Indeed, the airport is currently operating well beyond its design capacity in numbers of passengers. While the airport's terminal capacity equals 2.5 million seats, actual passenger traffic is much higher, reaching 4.3 million seats in 2005 and an estimated 6.3 million seats in 2007.

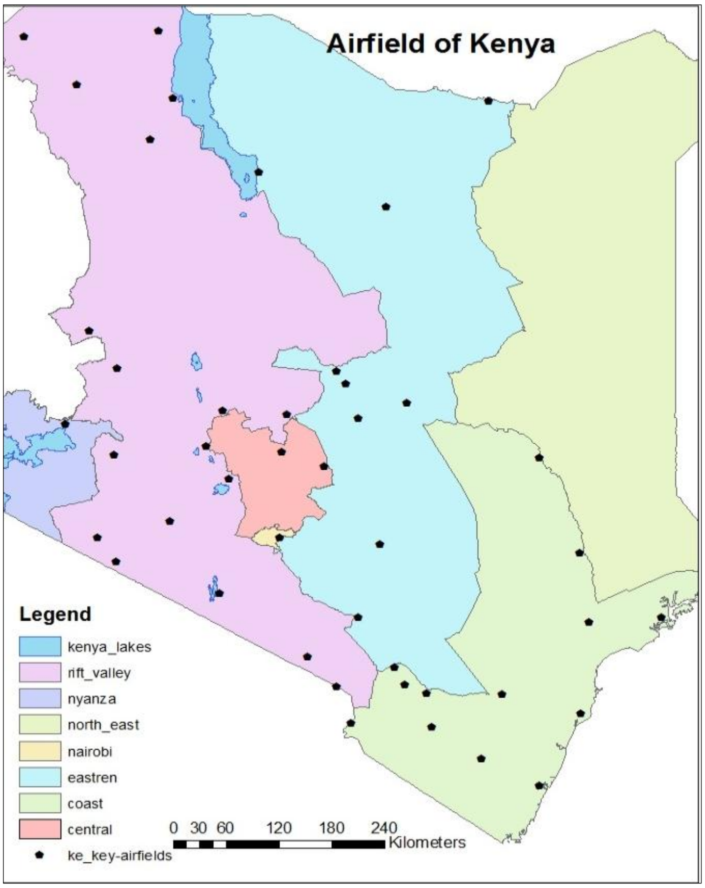

Figure 4-3: Airfields in Kenya

Investments already underway will add a new terminal to the airport and upgrade the airside infrastructure, increasing the capacity of the airport to more than 9 million passengers per year. For Nairobi to fully capitalize on these investments and strengthen its position as an international gateway for Africa, it is desirable to obtain U.S. Category 1 security clearance, which would allow direct flights to the United States. Obtaining that level of clearance will require further work on security arrangements at the airport.

It is important to leverage the benefits of the new regional regulatory framework. The East African Civil Aviation Authority was recently formed as a regional approach to strengthening regulation of the aviation sector, and the regulatory frameworks of the member countries have already been harmonized. One of the key motivations for tackling regulation at the regional level was to allow countries to pool scarce human resources in particular areas of expertise needed for oversight. To make this a reality, it will be important for countries to share responsibilities for training and for providing specialized services.

4.6. Urban Infrastructure

4.6.1. Challenges

More attention needs to be paid to urban infrastructure, particularly in slum areas. A two-way comparison between the slums of Nairobi and Dakar provides some important insights. In Nairobi, slum residents have substantially higher levels of education and employment than in Dakar, but this does not translate into better living conditions. Only 3 percent of Nairobi's slum residents have access to a home with solid walls and a power and water connection, compared with 74 percent in Dakar. Taking a closer look at all aspects of infrastructure provision, coverage for Dakar residents was found to exceed 70 percent versus only 20 percent for Nairobi residents. The only exception was drainage services, where Nairobi residents were significantly better off. The explanation lies in contrasting tenure arrangements in the two cities: 92 percent of Nairobi's slum residents are tenants, and turnover is high.

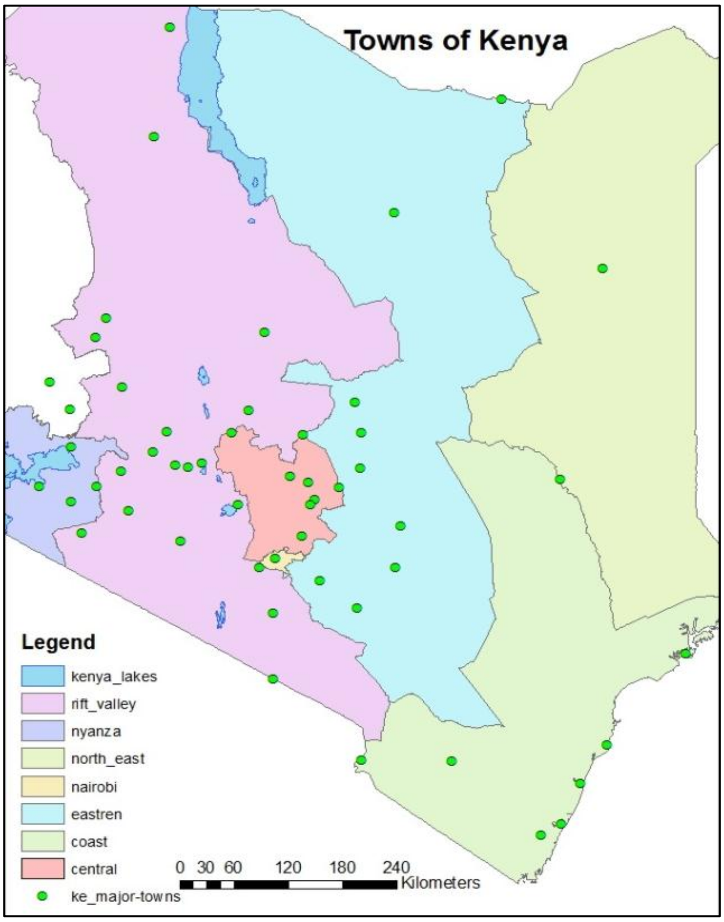

Figure 4-4: Towns in Kenya

Because settlements are informal, neither landlord nor tenant has much incentive to invest in housing improvements. In Dakar, on the other hand, tenants are just 25.8 percent of the residents, while ownership of buildings (without land) is 13.7 percent and ownership of both land and buildings is 57.6 percent, making the population more stable over time and providing residents with the possibility of gradually investing to improve the quality of their homes.

4.7. Information and Communication Technologies

4.7.1. Achievements

Kenya has made substantial progress with ICT reforms. As of 2006, the country scored around 50 percent on an index of institutional reform, which is close to the African average. More recently, Kenya has privatized its fixed line incumbent, taking the reform process one step further.

The country has achieved one of the highest rates of GSM coverage in Africa. Over 90 percent of Kenya's population lives within range of a GSM signal. This is one of the highest rates in Africa. It is likely that another seven percent could be profitably served by private operators. Only about one percent of the population would not be commercially viable to serve and would probably require some degree of public subsidy. Furthermore, about 30 percent subscribe to the service with a further 2 percent of the population being added each year.

4.7.2. Challenges

Prices for ICT services in Kenya remain relatively high. Charges for fixed-line, mobile, and international calling and for Internet access are significantly higher in Kenya than in comparable African countries.

The recent award of a fourth mobile license is beginning to exert some downward pressure on prices, however. Given the size of Kenya's market, it may be desirable to consider introducing competition in the fixed-line services, as well. Nigeria has done so with considerable success and today is the only country in Africa where fixed-lines services are not in decline.

The Nigerian experience also illustrates the willingness of private providers to invest significantly Submarine cables could substantially reduce costs as long as access is competitive. Based on experience elsewhere in Africa, the imminent completion of three submarine cable projects—EASSy, SEACOM, and TEAMS—has the potential to cut Kenya's Internet and international telecom charges at least by half. But these benefits will materialize for the economy only if there is more than one operator providing a physical point of access to the submarine infrastructure, . Countries in which international gateways remain under monopolistic control do not experience full price reductions from increases in international connectivity, essentially because the benefits of the technology are retained as monopoly profit in inter-urban telecommunications backbones.

4.8. Power

4.8.1. Achievements

Institutional reforms have led to efficiency gains of 1 percent of GDP. Kenya's power sector has gone through a number of important institutional reforms in recent years. The national power utility was unbundled into a generation and transmission utility (KenGen) and a distribution utility (KPLC). As of the early 2000s, the hidden costs associated with the distribution utility—in the form of underpricing, collection losses, and distribution losses—were as large as 1.4 percent of GDP. In the run-up to the adoption of a management contract, revenue collection improved substantially—from 81 percent in 2004 to 100 percent in 2006. Distribution losses also began to fall, though more gradually, reflecting the greater difficulty experience in its function. Power-pricing reforms also allowed tariffs to rise in line with escalating costs, from $0.07 per kilowatt-hour in 2000 to $0.15 in 2006 and to $0.20 cents in 2008. As a result of these measures, the hidden costs of the power sector had fallen from 1.4 percent of GDP in 2001 to 0.4 percent of GDP in 2006 and were largely eliminated by 2008, reaching one of the lowest levels in Africa. This has saved Kenya more than 1 percent of its entire GDP and helped to place the sector on a firmer financial footing.

4.8.2. Challenges

Kenya's power supply remains unreliable because generation and transmission are stretched too thinly. The country's installed generation capacity is a meager 33 megawatts per million of population— about one-tenth the average in Africa's middle-income countries. Growing demand, combined with recent droughts that have reduced the supply of hydropower, has led to frequent power interruptions, even more than in other low-income African countries. The private sector has suffered as a result, with 70 percent of firms feeling the need to install backup generators and 3 percent of turnover lost to power outages. It is estimated that the burden of power outages on the economy is as high as 2 percent of GDP. To overcome the problem, Kenya will need to install an additional 1,000 megawatts of generation capacity over the next decade - a near doubling of current installed capacity. About 300 megawatts of coal and geothermal capacity are already in the pipeline.

The country will also need to develop or reinforce cross-border transmission links with Ethiopia, Tanzania, and Uganda to provide access to relatively inexpensive hydropower and improve overall system security. As new capacity comes on stream, prices of power will eventually fall. Power tariffs in Kenya, currently at $0.20 per kilowatt-hour, are comparatively high. This is entirely appropriate at present, given that the country is able to meet current demand only by relying on emergency generation that costs around $0.25 per kilowatt-hour. Fortunately, however, the high present tariff does not represent the long- run marginal cost of power sector development in Kenya. As long-term investments are put in place, the country will secure access to more cost-effective power sources, and the costs of supply could gradually come down to around $0.13 per kWhr. Table 4-4 shows the existing ongoing and approved infrastructure projects in Kenya.

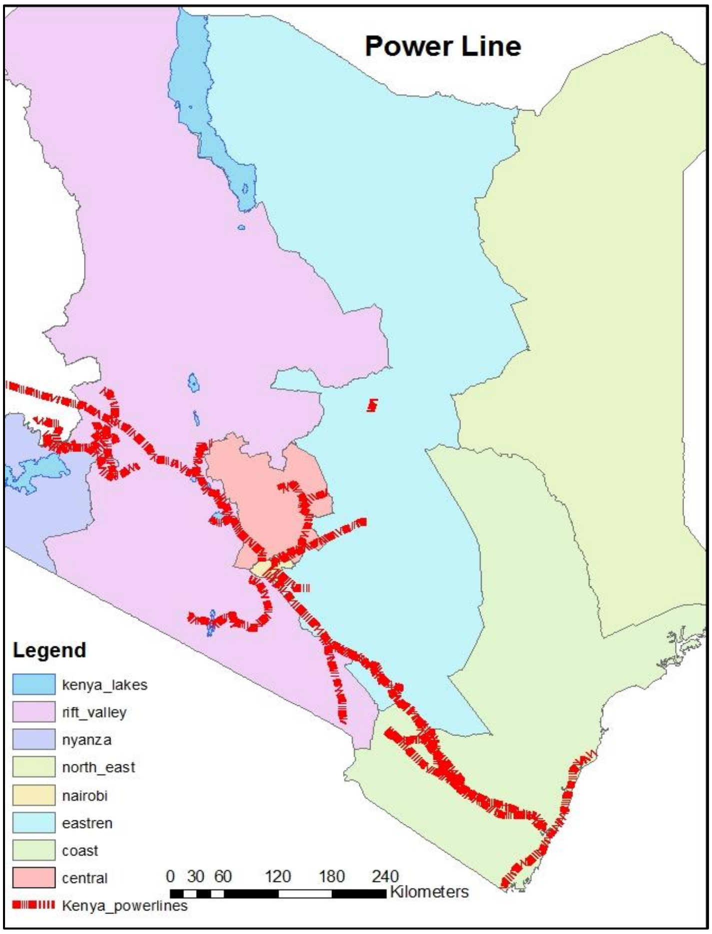

Figure 4-5: Power lines in Kenya

Table 4-4: Ongoing and approved infrastructure projects

African Development Bank				
Sector/Project Title	**Status**	**Approval Date**	**Completion Date**	**Net Loan**
Mombassa Nairobi Transmission Line	Ongoing	06May09	31Dec13	50,000,000.00
Nelsap Interconnection Project - Kenya	Ongoing	16Jun10	31Dec14	39,770,000.00
Power Transmission Improvement Project	Ongoing	06Dec10	31Dec13	46,700,000.00
Thika Thermal Power Project	Ongoing	07Dec11	01Jun26	24,439,883.11
Menengai Geothermal Development Project	Ongoing	14Dec11	31Dec17	80,000,000.00
Menengai Geothermal Development Project	Ongoing	14Dec11	31Dec17	4,976,775.05
Menengai Geothermal Development Project	Ongoing	14Dec11	31Dec17	11,612,475.12
Ethiopia-Kenya Electricity Highway (Kenya)	Approved	19Sep12	31Dec18	75,000,000.00
Arusha - Namanga-Athi River Road Development Project	Ongoing	13Dec06	31Dec12	49,241,000.00
Mombasa-Nairobi-Addis Corridor Ii - Kenya	Ongoing	01Jul09	31Dec15	125,000,000.00

African Development Bank				
Rehabilitation Of Timboroa Eldoret Road	Ongoing	24Nov10	31Dec16	35,000,000.00
Ethiopia - Mombasa -Nairobi-Addis Ababa	Ongoing	30Nov11	31Dec18	120,000,000.00
Arusha - Holili Voi Taveta	Approved	16Apr13	31Dec18	75,000,000.00
Rift Valleykenya-Uganda Railways Concess	Ongoing	13Jul11	15Jul26	26,620,878.76
African Virtual University (Phase 2)	Ongoing	12/16/2011	06/30/2017	10,000,000.00
World Bank				
Kenya Infrastructure Finance/PPP Project	Ongoing	2012-11-15T00:00:00Z		40.00
Nairobi Metropolitan Services Improvement Project	Ongoing	2012-05-10T00:00:00Z		300.00
Kenya Informal Settlements Improvement Project (Kisip)	Ongoing	2011-03-24T00:00:00Z		100.00
Northern Corridor Additional Financing	Ongoing	2009-04-02T00:00:00Z		253.00
Electricity Expansion	Ongoing	2010-05-27T00:00:00Z		330.00

Chapter 5 Marketing Analysis of Kenya Sugar Industry

5.1. Demand And Supply Trends in Kenya and Regional Markets up to 2020

5.1.1. Domestic Market

5.1.1.1. Overview

The sugar sub-sector plays a major role in the Kenyan economy and is a source of livelihood for millions of citizens[3]. Kenya currently produces about 70% of its domestic sugar requirement. The supply and demand gap is narrowing down, as the existing factories are being rehabilitated and expanded while proposals have been made to set up new factories. Yet still as of 2011, the country ran a deficit of almost 300,000 MT [(4)] (Figure 5-1). Consequently, the government has been working to put in place measures to protect the sector such as controlled importation and payment of dues to farmers by sugar factories. Moreover, capacity utilization in the industry has a weighted average of below 60%. In spite of a potential to compete, Kenya is among the highest cost sugar producers among the EAC

[3] (VAS Consultants 2012)
[4] (Kenya Sugar Board 2012)

and COMESA countries. High costs are due to capacity underutilization, lack of regular factory maintenance, poor transport infrastructure and weak corporate governance.[5]

To protect its sugar sector, and upon presenting a strong case in 2003 COMESA approved three extensions of time for Kenya to protect its struggling sugar sector till 2012. In 2011, the Government of Kenya (GOK) applied for another extension for sugar import safeguards through 2014. COMESA agreed to the request in October, paving the way for the GOK to retain a COMESA Member import tariff-rate quota of 340,000 tons at zero tariff and ten percent above-quota tariff. Reportedly, with immense pressure to improve the industry's competitiveness, the GOK has pledged to reduce sugar production costs by about 40 percent to approach the costs of Swaziland, Malawi and Zambia[6]. In addition the GOK, through the Ministry of Agriculture resolved to privatize five Government-held sugar refineries by 2014.

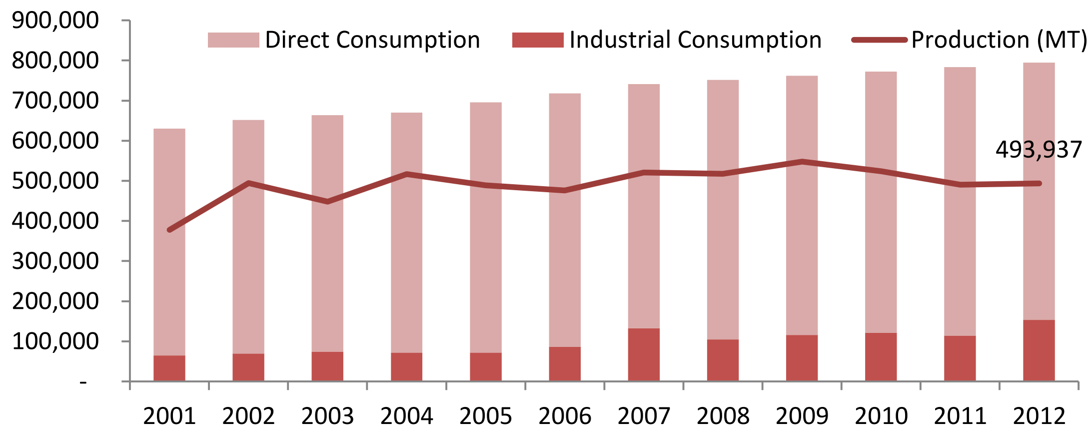

Figure 5-1: Production and consumption of Sugar, 2001-2012

Source: Year Book of Sugar statistics, 2013; Kenya Sugar Board and KETS computations

5.1.2. PROJECTED DEMAND TRENDS OF SUGAR IN KENYA TO 2020

Projected supply and demand for sugar in Kenya was determined through a regression analysis having independent variables being adopted from KSB's Study on National Supply and Demand. Data were collected from World Development Indicators and Kenya Sugar Industry's Year Book of Sugar Statistics.

[5] (Kenya Sugar Board 2012)
[6] (United States Department of Agriculture (USDA) 2012)

5.1.2.1. Gross Domestic Product

The economy of Kenya registered slow growth in 2012, estimated at 4.6%, compared to 5.8% in 2010, and 4.4% in 2011.[7] Nominal GDP data was collected from the World Development Indicators data bases, and forecasts till 2020 were calculated using a polynomial model.

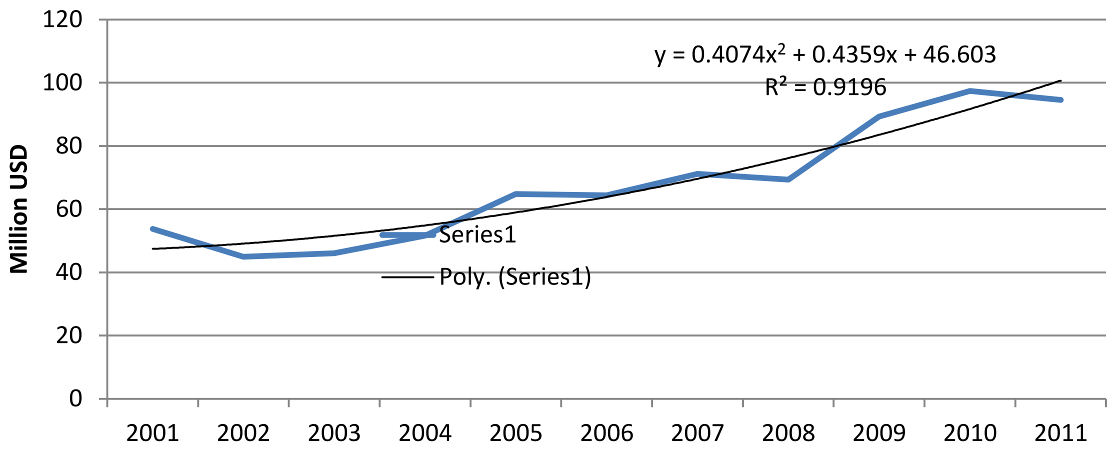

Figure 5-2: Nominal GDP (in millions USD), 2001-2011

Source: World Development Indicators and KETS calculations

Table 5-1: GDP forecasts, 2012-2020

Year	Nominal GDP in USD
2012	41,100,000,000
2013	46,100,000,000
2014	51,800,000,000
2015	57,600,000,000
2016	64,200,000,000
2017	71,100,000,000
2018	79,000,000,000
2019	88,085,000,000
2020	98,214,775,000

Source: KETS calculations.

[7] (ADB; OECD; UNEC; UNDP 2012)

5.1.2.2. Population

As of 2013, population levels in Kenya stood at 43.18 million according to the latest publications by the World Bank and KETS estimates. The average growth rate in the period from 2001-2011 was 2.7%. A linear model was set for population whereby projections till 2020 were made.

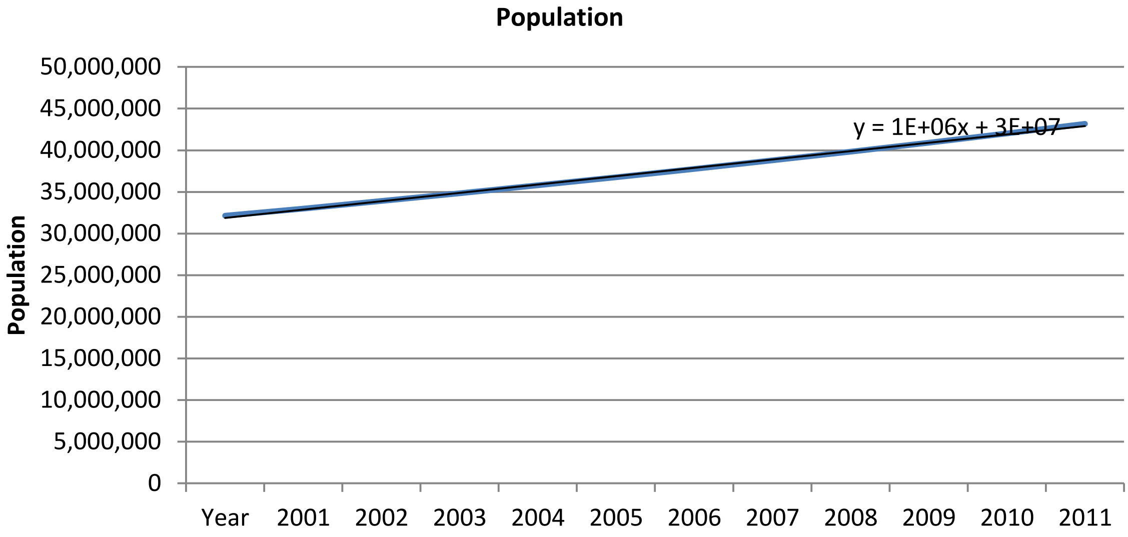

Figure 5-3: Population levels, 2001-2011

Source: World Development Indicators

Table 5-2: Population projections

Year	Population
2013	43,923,393
2014	44,975,785
2015	46,028,174
2016	47,078,892
2017	48,125,982
2018	49,167,295
2019	50,200,926
2020	51,226,039

Source: KETS Calculations

5.1.2.3. Prices

The latest figures for sugar prices reveals at 95 ksh/kg and a polynomial model was used to project prices up to 2020.

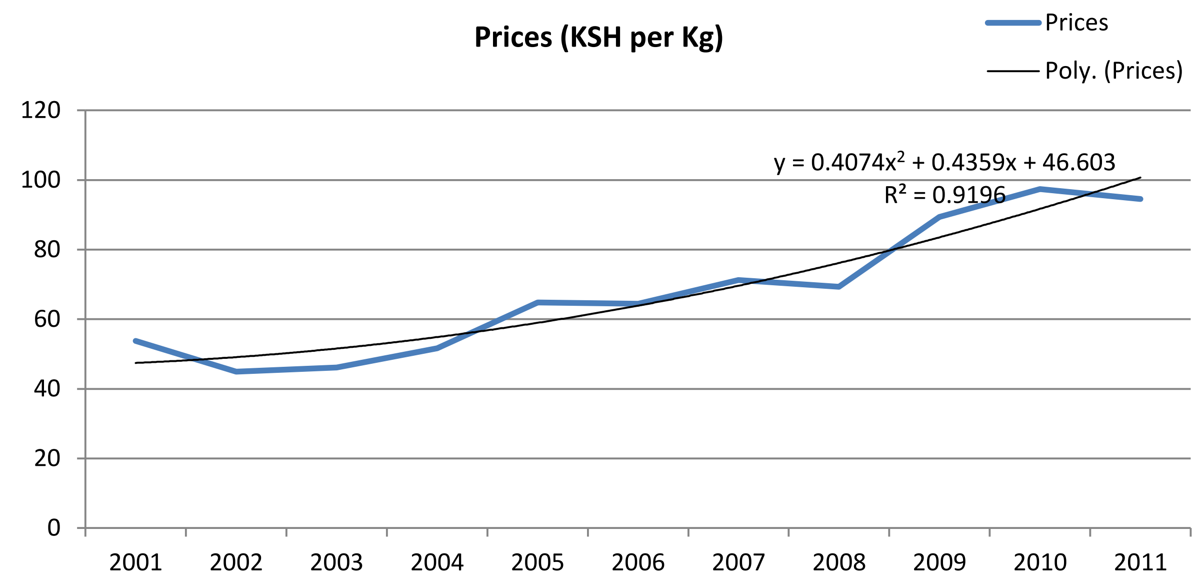

Figure 5-4: Sugar Prices (KSH per Kg)

Source: Sugar yearbook and KETS calculations.

Table 5-3: Sugar Prices (KSH per Kg), 2012 - 2020

Year	Sugar Prices
2012	110
2013	121
2014	133
2015	145
2016	158
2017	172
2018	186
2019	202
2020	218

Source: KETS computations

5.1.2.4. Production and Consumption

Data for coefficients was collected using World Development data base and Kenya's Yearbook of sugar statistics. Projections for the coefficients were done based on linear and polynomial models.

Table 5-4: Demand, regression function

Regression Equation: 3.37E06GDP+.009POP+-641.3Price+333928.5				
	Coefficients	T stat	P-value	Forecast Equation
Intercept	333928.4891	2.689171	0.016125571	NA
GDP	3.37262E-06	2.106267	0.051322243	y = 3E+09x + 8E+09
Population	0.009273174	-1.77082	0.095636084	y = 1E+06x + 3E+07
Prices	-641.2588596	2.083404	0.053610977	y = 0.4074x2 + 0.4359x + 46.603

Source: WDI, and Year Book of sugar stats, 2012.

Data for the coefficients was collected using World Development online data-base and Kenya's Yearbook of sugar statistics. Projections for the coefficients were done based on linear and polynomial models. Coefficients in our model indicates an increase of (3.4*10^-6) in consumption for every dollar increase in the GDP. For every unit increase in the population consumption would increase by 0.0092, and for every unit increase in prices consumption would decrease 641 units.

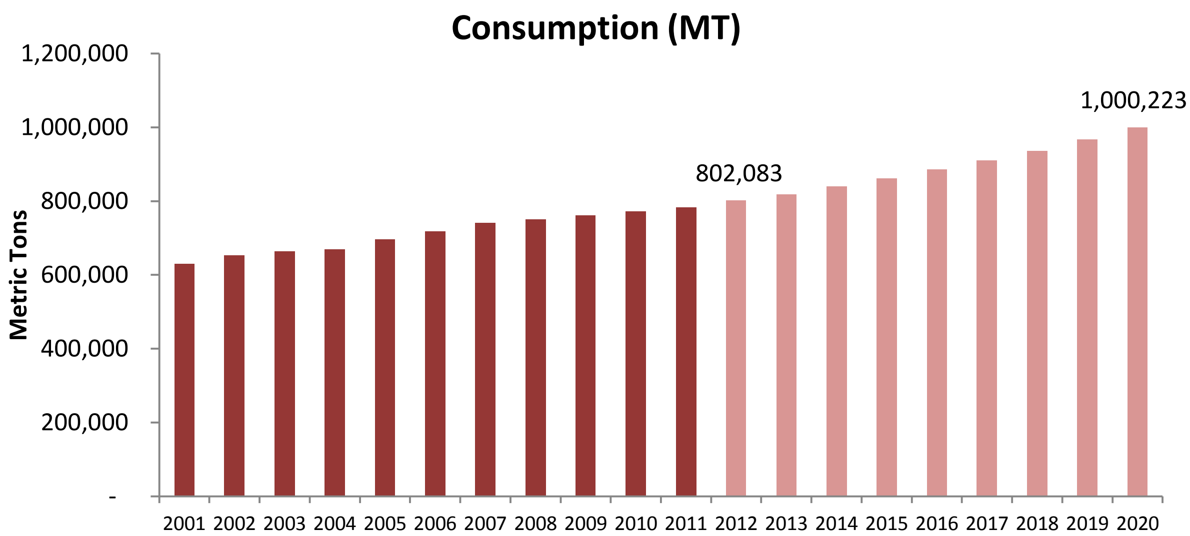

Figure 5-5: Current and forecasted consumption levels (Metric Tons)

Source: KETS calculations

5.1.3. PER CAPITA DOMESTIC SUGAR CONSUMPTION IN KENYA

The sugar consumption for each county was extracted from the "Study on National Sugar Supply and Demand for the period 2010-2014." Based on the break down illustrated below, Rift Valley constitutes the largest cluster of individuals estimated at 26% of total population levels, followed by the Eastern region (15%), Nyanza (14%), Western (11%), Central (11%), Coast (9%), Nairobi (8%), and North Eastern (6%) regions.

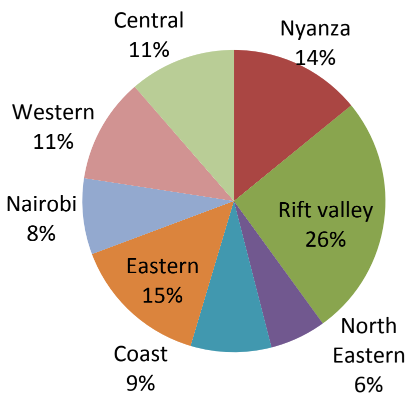

Figure 5-6: Population breakdown by Region (former provinces)

Source: Study on national sugar supply and demand for the period 2010-2014

Using this population breakdown, and assuming that the study's per capita sugar consumption holds true, we have updated consumption figures by region using the latest projections for population.

Total population estimate for 2013 is **43,923,393**; by applying the breakdown above to the existing per capita consumption, we get the following estimates for the region.

Table 5-5: Consumption by region, 2013

	Population Estimates 2013	Percapita Consumption (Kg)	Total Consumption
Nyanza	6,191,689	15.8	97,828,685
Rift valley	11,383,853	23.9	272,074,093
North Eastern	2,628,743	14.4	37,853,899
Coast	3,782,906	9.9	37,450,774
Eastern	6,448,120	17.2	110,907,666
Nairobi	3,570,244	9.6	34,274,339
Western	4,930,843	15.7	77,414,228
Central	4,986,995	7.9	39,397,261

As per the "Study on National Demand and Supply" Rift Valley regions has the highest per capita consumption of 23.9kgs, followed by Eastern counties Nyanza, Coast, Nairobi, western and central regions each with 17.2kg, 15.8, 15.7, 14.4, 9.9, and 7.9 respectively.

5.1.4. Sugar Supply

Sugar in Kenya is available from two primary sources: local production and importation. A model which constitutes sugarcane crushed by milling factories, conversion rate of sugarcane to sugar (TC/TS), overall time efficiency (OTE) and factory time efficiency (FTE) was adopted [8]. The coefficients column gives the values for the regression equation for predicting the supply from cane crushed, FTE, OTE, and conversion rate.

5.1.4.1. TC/TS Conversion rates

TC/TS conversion rates demonstrate how efficient the process of sugar crushing is. Table 5-6 tracks the changes on the industry conversion rates in the last 11 years. A simple average for the years 2001-2011 was used for the period until 2020.

Table 5-6: TC/TS conversion rate, 2001-2011

Year	TC/TS conversion rate
2001	9.75
2002	9.35
2003	9.66
2004	9.37
2005	9.86
2006	10.29
2007	10.03
2008	9.97
2009	10.23
2010	10.7
2011	10.74
2012	11.6
Average	10.1

Source: Yearbook of Sugar Statistics, 2012

5.1.4.2. Factory and overall time efficiency

Factory and overall time efficiencies have an impact on how much sugar is produced. Factory time efficiency refers to actual grinding time (the numbers of hours of sugarcane processing) while overall time efficiency takes into account stoppages in processing due to breakdowns, maintenance and availability of cane. Table 5-7 shows the past Overall Time Efficiency and Factory Time Efficiency. Projections till 2020 for FTE and OTE were calculated using a three year moving average.

[8] (VAS Consultants, Ltd 2012)

Table 5-7: Factory and overall time efficiency, 2001-2020

Year	Factory Time Efficiency (%)	Overall Time Efficiency	Proj. Years… Moving Average	Factory Time Efficiency (FTE %)	Overall Time Efficiency (OTE %)
2001	80.21	60.19	2012	78.31	68.55
2002	77.06	70.84	2013	79.18	67.42
2003	81.14	67.69	2014	79.00	66.37
2004	83.23	73.01	2015	78.83	67.45
2005	81.87	71.97	2016	79.01	67.08
2006	79.58	73.07	2017	78.95	66.96
2007	78.03	70.16	2018	78.93	67.16
2008	74.91	66.23	2019	78.96	67.07
2009	75.69	71.95	2020	78.95	67.07
2010	79.72	70.58			
2011	79.52	63.13			

Source: Yearbook of Sugar Statistics, 2012

5.1.4.3. Sugarcane crushed

The tons of sugarcane crushed have a high influence on the tons of sugar produced. Data on the actual amounts of cane crushed was collected from the yearbook of sugar statistics, projections of cane available for crushing was calculated using trend analysis. (Equation = 159491x + 4E+06; R^2 = 0.8426).

Table 5-8: Levels of sugarcane available for crushing

Year	Level of sugarcane available for crushing	Proj. Years	Level of sugarcane available for crushing
2001	3,689,571	2012	5,873,936
2002	4,576,335	2013	5,931,798
2003	4,312,991	2014	6,101,151
2004	4,805,887	2015	6,195,909
2005	4,845,384	2016	6,344,091
2006	4,889,529	2017	6,479,673
2007	5,202,360	2018	6,593,244
2008	5,165,786	2019	6,735,321
2009	5,622,175	2020	6,844,550
2010	5,591,678		
2011	5,385,224		

Source: Yearbook of sugar statistics, 2012 and KETS calculations.

5.1.5. PROJECTED SUPPLY

To project the supply of sugar in Kenya, a regression model was run. Factory time efficiency proved insignificant and thus was omitted from the model. Results are presented in Table 5-9 and Table 5-10.

Table 5-9: Regression, supply function

	Coefficients	Standard Error	t Stat	P-value
Intercept	506594.72	34890.85066	14.51941442	1.75E-06
TC/TS conversion rate	-54816.46796	3080.715748	-17.7934196	4.37E-07
Overall time efficiency (%)	629.3723473	281.6736367	2.234402746	0.060576
Level of sugarcane available for crushing	0.099446121	0.002732749	36.39050357	3.07E-09

Table 5-10: Supply projections, 2011-2020

Year	Production (MT)	Year (proj)	Proj. Production (MT)
2001	377,438	2012	493,937
2002	494,249	2013	590,757
2003	448,489	2014	606,936
2004	516,803	2015	617,039
2005	488,997	2016	631,543
2006	475,670	2017	644,954
2007	520,404	2018	656,374
2008	517,667	2019	670,443
2009	548,207	2020	681,303
2010	523,652		
2011	490,210		

Source: Yearbook of sugar statistics, 2011 and KETS computations.

5.1.6. SUPPLY AND DEMAND GAP

According to the above analysis, the need for sugar will continue to grow outstripping supply by 300,000 tons by 2020.

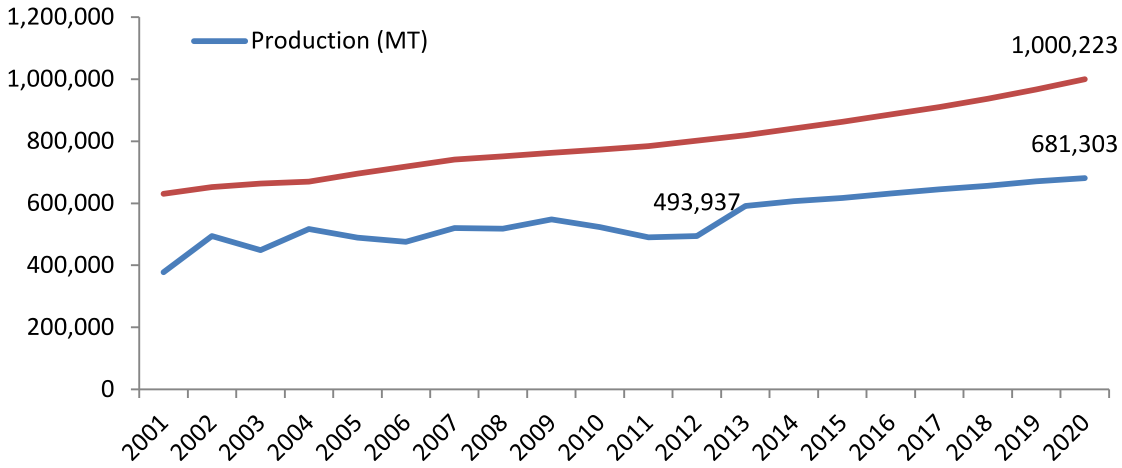

Figure 5-7: Production and Consumption projections till 2020

Source: Yearbook of sugar statistics; Study on the supply and demand; KETS computations.

5.1.7. SUPPLY AND DEMAND TRENDS IN INTERNATIONAL MARKET TO 2020

To satisfy its growing demand, Kenya imports in excess of 300,000 MT of sugar annually from the COMESA region and other sugar producing countries. In 2011, Saudi Arabia, Egypt, and South Africa provided 37%, 21%, and 18% of total sugar imported, respectively (Figure 5-8). International competition from low cost sugar producers poses a big challenge to the local sugar industry. Illegal and uncoordinated importations of sugar are major contributors to the sub-sector problems.

Figure 5-9 shows historical imports by Kenya from non-COMESA countries (2002-2011).

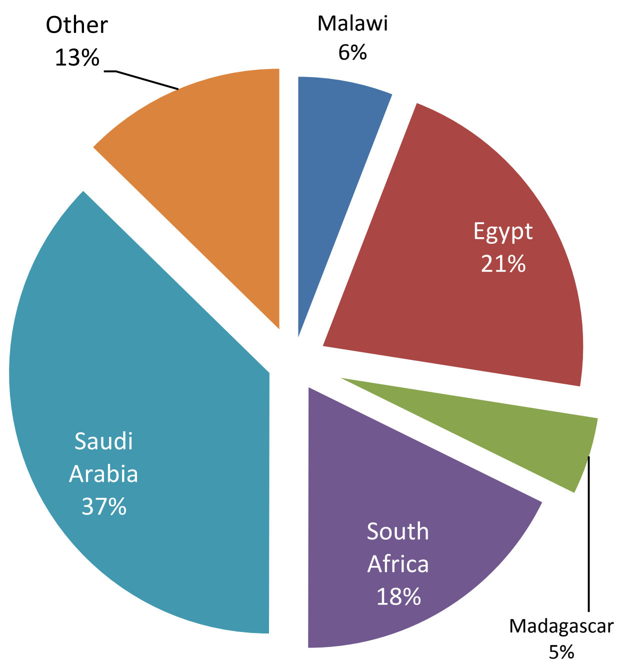

Figure 5-8: Import breakdown, 2011
Source: Yearbook of sugar statistics, 2012

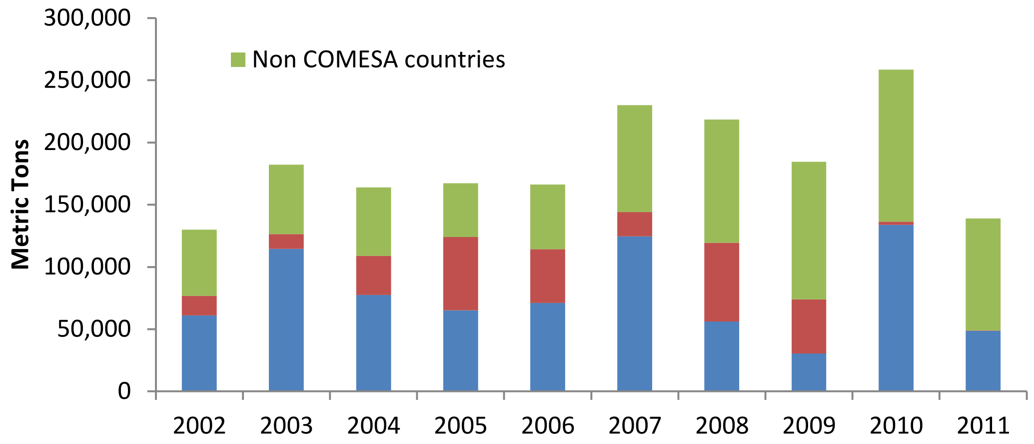

Figure 5-9: Historical imports by Kenya from non-COMESA countries, 2002-2011

Source: Yearbook of sugar statistics, 2011

The East African Community (EAC) is a regional intergovernmental organization that was established in 1999 consisting of the Republics of **Burundi**, **Kenya**, **Rwanda**, the United Republic of **Tanzania**, and the Republic of **Uganda.** The broad objective of EAC is to develop policies and programmes aimed at widening and deepening cooperation among the Partner States in political, social and cultural fields, research and technology, defense, security and legal and judicial affairs.[9] Based on 2011 figures, the current demand gap for sugar in the EAC region, excluding Kenya, is around 314,000 MT. In the coming decade, the EAC countries are looking at adding 700,000 MT of sugar (Figure 5-10). Excess sugar will target markets outside the preferential regions, hence sugar production costs have to compete with international players.

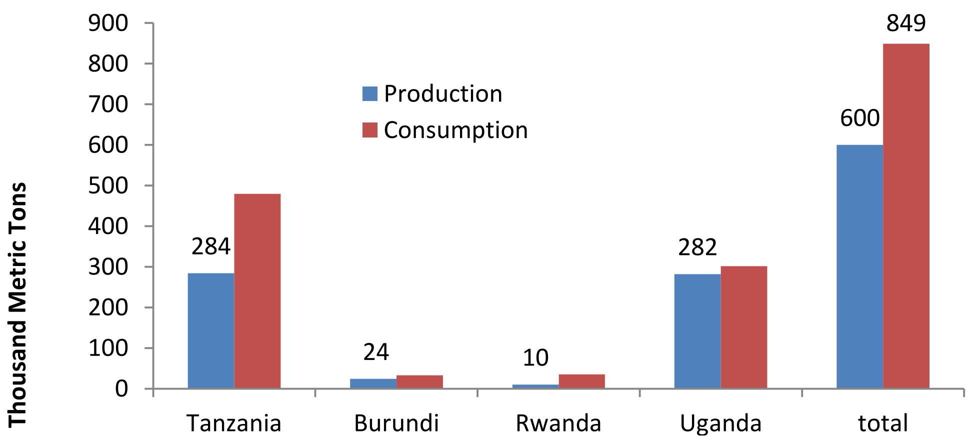

Figure 5-10: Sugar production and consumption in selected countries

Source: Sugar Yearbook, 2011

[9] (East African Community Portal 2013)

The Common Market for Eastern and Southern Africa (COMESA) is a free trade area with twenty member states stretching from Libya to Zimbabwe. Nine of the member states formed a free trade area in October 2000 (Djibouti, Egypt, Kenya, Madagascar, Malawi, Mauritius, Sudan, Zambia and Zimbabwe), with Rwanda and Burundi joining the FTA in 2004 and the Comoros and Libya in 2006. This was the first FTA in Africa under the African Union. Membership in the FTA is now 13 Member States trading on a full duty free and quota free basis. The FTA has boosted intra COMESA trade, increasing it nearly six-fold from $3.1 billion in 2000 to $17.4 billion in 2011.[10] Under this agreement, Kenya can export sugar to FTA countries duty free and quota-free (Figure 5-11).

Excess sugar will target markets outside the preferential region since Kenya's prospective market in this region is limited. Now, as shown above, the cost of sugar production in Kenya is the highest among the two aforementioned regions. Before any further expansion, Kenya needs to bring its cost down to those of its competitors in order to exploit opportunities availed by the global market.

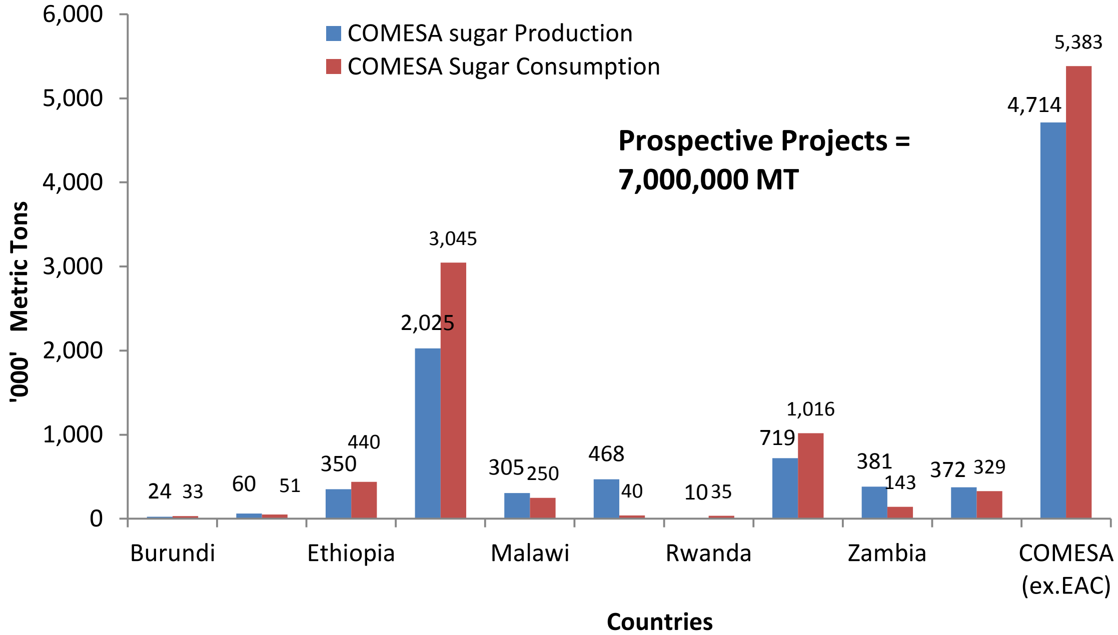

Figure 5-11: Sugar production and consumption within COMESA

[10] (COMESA Secretariat n.d.)

5.2. Market Strategies and Competitor Analysis

5.2.1. Domestic Market Analysis

Kenya's sugar consumption is growing steadily outstripping supply. The combined installed capacity of the operational sugar companies is 29,890, which is not sufficient to produce enough sugar for domestic consumption currently estimated at 800,000 MT (Table 5-11). Now, with TC/TS ratio of 10.76 (2011), current and average actual grinding time of 4,945 hrs. (206 days), the country managed to produce almost 500,000 MT of sugar. This is largely due to the technical limitations and capacity underutilization with an industry average of 56.63%. However by improving the capacity utilization to 85% the country will be able to add 140,000 MT to its production, reducing the current sugar deficit by nearly 50%.

Table 5-11: Production, consumption and capacity utilization in major production areas, 2012

Factory	county/sub-county	Production	Capacity utilization %	Current Capacity (TCD)	Population	Percapita Consumption (kg)	Consumption (MT)
Muhoroni	Nyanza	30,536	42.36	2200			
Chemilil	Nyanza	15,977	28.53	3360			
South Nyanza	Nyanza	52,470	59.71	3120	6,191,689	15.8	97,828
Kibos	Nyanza	26,179	74.15	800			
Sukari	Nyanza	17,781	Na	1500			
Total		142,943					
Mumias	Western	181,372	64.51	9200			
Nzoia	Western	61,291	69.67	3360			
West Kenya	Western	49,565	69.97	2500	4,930,843	15.7	77,414
Butali	Western	42,671	75.19	2500			
Total		334,889					
Soin	Rift Valley	2,551	25.61	100			
Transmara	Rift Valley	16,457	Na	1250	11,383,853	23.9	272,074
Total		19000					

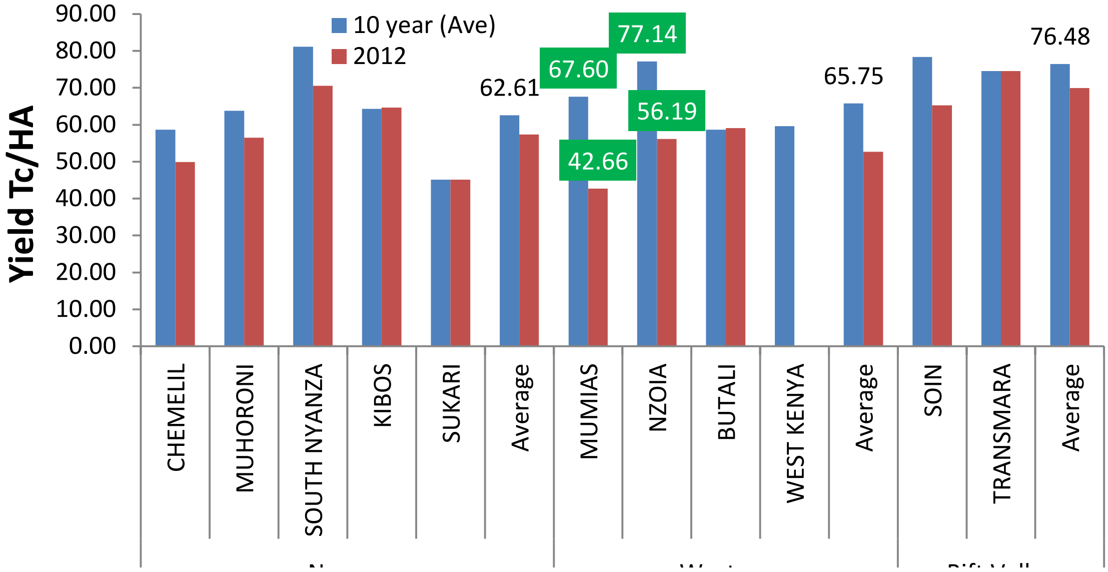

Figure 5-12: Yields by region, 2012

Source: Yearbook of Sugar Statistics, 2012

As evident from Figure 5-12, the productivity in Kenya experienced major deterioration in the past decade with the yield measured by the tonnage of cane produced for every hectare. Mumias and Nzoia experienced major hits each experiencing 58% and 36% declines in TC/H when compared to their ten year averages.

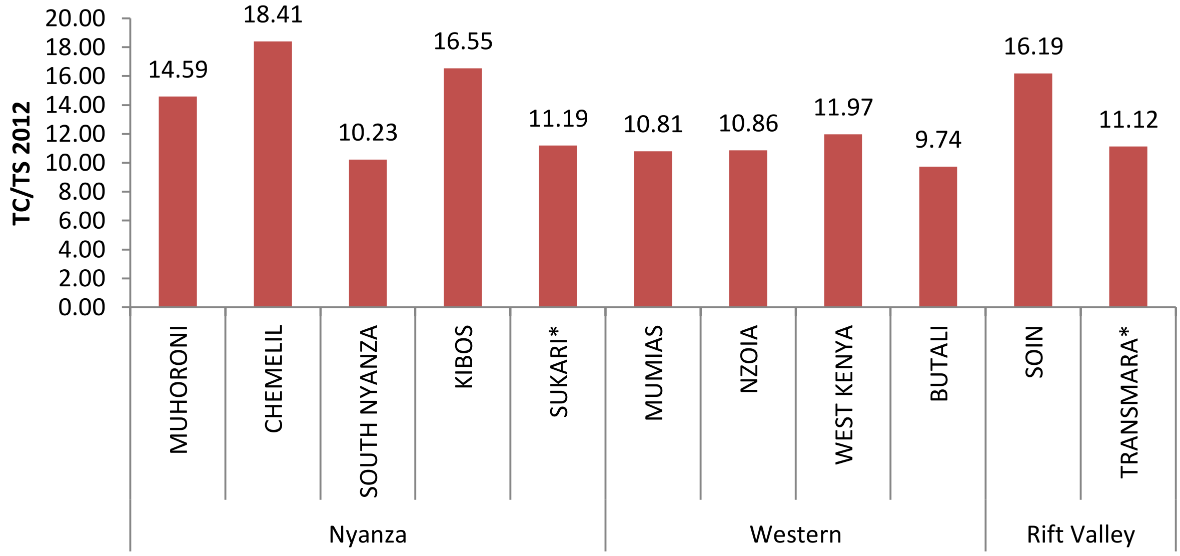

Figure 5-13: Sugar yields TC/TS, 2012

Source: Yearbook of Sugar Statistics- Database

In 2012, the TC/TS ratio was lowest in Butali sugar company (9.74), and highest in Chemelil (18.41). This implies that Chemelil requires an additional 9 tons or 90% more cane in order to realize 1 ton of sugar.

5.2.2. INTERNATIONAL MARKET

The cost of sugar production in Kenya is currently estimated at $870[11] per ton which is twice that of other COMESA competing countries as suggested in Figure 5-14. Due to high production costs, Kenya's sugar industry is threatened by cheap imports from efficient sugar-producing countries. As a result, Kenya has to restrict access to its domestic market using tarrif and non-tariff barriers. Non-COMESA countries must go through a number of obstacles to gain access to the Kenyan sugar market as discussed in previous sections[12]. "They are required to pay a 100 percent ad-valorem Common External Tariff (CET), apply for permission from the KSB, pay VAT and development levies and submit extensive quarterly and annual records"[13]. On the other hand, COMESA member countries fall under a duty free quota-tariff regime, which limits sugar imports to a set amount each year and applies a tariff to imports exceeding that amount.

Figure 5-14: Cost of production of 1 ton of sugar in selected COMESA countries

Source: Kenya Cost Study (2012); Business Daily (2013)

[11] (Kenya Sugar Board 2012)
[12] (FAO; OECD; USAID 2013)
[13] (USDA GAIN Report 2012)

Table 5-12: Import Access Costs for Sugar (KSH/Ton), 2005-2011

	2005	2006	2007	2008	2009	2010	2011
Imports declaration Fee 2% CIF	484.09	577.12	633.3	631.47	784.67	1,031.83	1,404.43
Value Added Tax: 16% of CIF	3,872.69	4616.98	5,066	5051.78	6277.33	8254.68	11235.45
Sugar Development Levy 7% ('05, '06, '07) and 4% ('08, '09, '10, '11)	1,694.30	2,019.93	2216.54	1262.94	1,569.33	2,063.67	2,808.86
Cleaning charges: US$ 15/25T container	32.22	32.61	31.75	37.55	46.41	49.48	63.24
Delivery Order Fees: US$ 1.82/25T container	3.91	3.96	3.85	4.56	5.63	6.00	7.67
Drop Off Charges: US$ 30/25T container	64.45	65.21	63.49	75.1	92.82	98.96	126.48
Terminal Handling Charges: US$90/25T container	193.35	195.64	190.48	225.3	278.47	296.89	379.44
Container Freight station THC: US$ 90/25T container	193.35	195.64	190.48	225.3	278.47	296.89	379.44
Wharfage: US$ 60/25T container	128.9	130.43	126.98	150.2	185.64	197.93	252.96
Container Freight Station Handling Charges varies. In this case at Consolbase it is $350/25T	751.9	760.84	740.74	876.15	1,082.93	1,154.57	1,475.60
Clearing Agency Fees: US$ 80/25T container	171.86	173.91	169.31	200.26	247.53	263.90	337.28
Transport CFS-Warehouse: US$ 160/25T container	343.73	347.81	338.62	400.53	495.05	527.81	674.56
Letter of Credit Costs: 3% of CIF value	726.13	865.68	949.95	947.21	1,177.00	1,547.75	2,107
Total Import Costs	8660.88	9985.76	10721.87	10088.35	12521.28	15790.36	21252.05

Source: MAFAP: SPAA 2013

Before liberalization of the sugar industry in 1992, marketing and distribution was controlled by the government through the Kenya National Trading Corporation, which regulated producer and consumer prices and imports[14]. Today, processed sugar reaches the end consumer through an integrated network of private wholesalers, retailers, importers and distributors. The ex-factory price paid by wholesalers incorporates the cost of the sugarcane (raw material inputs), milling, processing, packaging, factory operations, the factory's margin, and government levies, which include a 16 percent Value Added Tax (VAT) and a 4 percent Sugar Development Levy (SDL) imposed by the KSB (KSB, 2010).

[14] (KSB 2010)

According to the KSB's 2010 sugar value chain analysis, the main factor hindering sugar marketing is the high cost of transportation due to large distances traveled and poor road conditions, a distribution system controlled by few players and inadequate packaging and branding. Even though sugar imports in Kenya are regulated through quotas and tariffs, the insufficient administration of the quotas and high local retail prices have enabled importer entities to obtain major profits. Currently, domestic sugar prices are inflated and are well above the international price for sugar due to tariffs and quotas applied to Kenya's raw sugar imports (Figure 5-15). While these high prices benefit local producers, they make raw sugar and sugar products more expensive for consumers[15].

Table 5-13: Tarrifs and quotas applicable to Kenya's raw sugar imports

Year	Quota (1000 tonnes)	Tariff Rate (%)
Before 2008	200	100
2008/09	220	100
2009/10	260	70
2010/11	300	40
2011/12	340	10
2012/13	340	10
2013/14	340	10
2014/15	Free market	0

Source: MAFAP: SPAAA, 2013

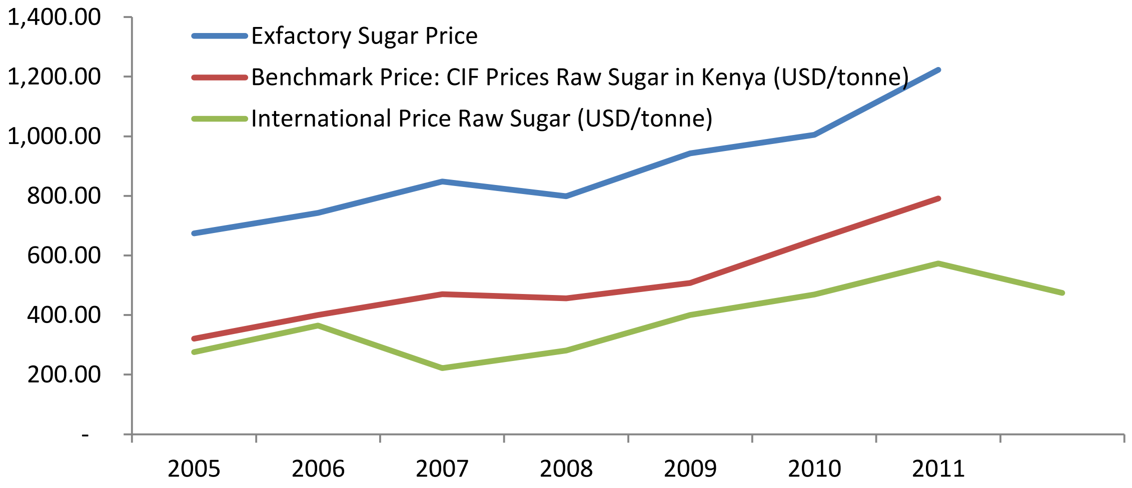

Figure 5-15: Domestic sugar prices in Kenya compared to the international price for sugar, 2005-2011

Source: MAFAP: SPAAA, 2013; WDI data-base

[15] (FAO; OECD; USAID 2013)

5.2.3. Summary

The Kenyan sugar industry is faced by several constraints escalating its costs of production and putting the viability of the sugar industry into question. Cost of production is more than double that in neighboring sugar producers yet the leeway granted by the COMESA safeguards is due to expire in less than a year. As previously stated COMESA safeguards expired in February 2008, and were extended to February 2012 by the COMESA Council under the condition that the GOK make a concerted effort to reduce Kenya's sugar industry production costs and gradually remove all trade barriers (KIPPRA, 2010).

By 2012, a free trade regime was supposed to be in full operation between COMESA member countries. However, in 2011, the GOK petitioned to extend Kenya's COMESA safeguards until 2014 (USDA-GAIN Report, 2012). The petition was granted, maintaining the 2012 quota and tariff conditions until 2014.

From a market stand point, the sugar industry needs to focus on rehabilitation of its existing facilities, enhancing production and reducing the production costs vis-a-vis privatization of sugar factories and training sugar farmers to embrace modern technology in farming. In the short to medium term, if Kenya effectively utilized its existing mills' capacities, the country's existing capacities would add 140,000 MT to the market without developing new projects. After that, Kenya can work on producing additional sugar to satisfy the local market (so an additional 160,000 MT). The regions whereby new projects are proposed are Rift Valley, Coast and Eastern. Total consumption in Rift Valley region alone exceeds 270,000 MT (Table 5-14), thus strategically, it would be wise to focus in placing new sugar facilities in that region.

Table 5-14: Proposed regions for sugar production

	Population Estimates 2013	Percapita Consumption (Kg)	Total Consumption	Current Production
Rift valley	11,383,853	23.9	272,074	19,000
Coast	3,782,906	9.9	37,451	0
Eastern	6,448,120	17.2	110,908	0

From a market stand point, producing sugar for the international market is unadvisable. Kenya should focus on satisfying its sugar needs by improving its efficacy in the cultivation and production of sugar and adding new facilities in the proposed regions.

5.3. Sugar Comparative Advantages and Potential Benefits

As a result of its diverse nature, and through years of experience, the sugar industry has the potential to accumulate extensive assets and infrastructure in the form of agricultural equipment, irrigation systems, power generating units and boilers as well as a deep knowledge and expertise in diverse fields. Since inception, Kenya's sugar industry has depended on the sale of sugar as the main product line to generate revenue (KSB 2010). Over-reliance on a single product undermines the very survival of the industry particularly in the face of increasing regional and global competition. Moreover, the cost of sugar production has been rising over time and cannot be offset from the revenues generated from sugar sales alone. Faced with the dual challenge of high production costs and increasing competition, it is imperative that the industry diversifies and ventures into the production of additional high value products as a strategy to enhance its revenue base and income. Using sugarcane as the base, the industry has the potential to process sugar and produce ethanol and power from molasses and bagasse respectively.

5.3.1. The Use of By-products

Through the effective utilization of its by-products, the sugar industry has the potential to be a successful and profitable business, one that exemplifies the industrialization of the agricultural sector where streams of high value products are generated. As a result, the sugar industry adds a value of not less than 4000% to the sugarcane, substantially higher than any other competing crop.

5.3.1.1. Bagasse generation and Molasses

Bagasse, a residual product from cane milling could be used to make briquettes, charcoal, chipboards, paper, mulch, bagasse concrete and most importantly to generate power. Blending molasses, bagasse, and other ingredients produces highly nutritious and desirable animal feed. Using molasses (Figure 5-16), a prime by-product of the sugar industry, the sugar sector has the opportunity to produce ethanol as a bio-fuel.

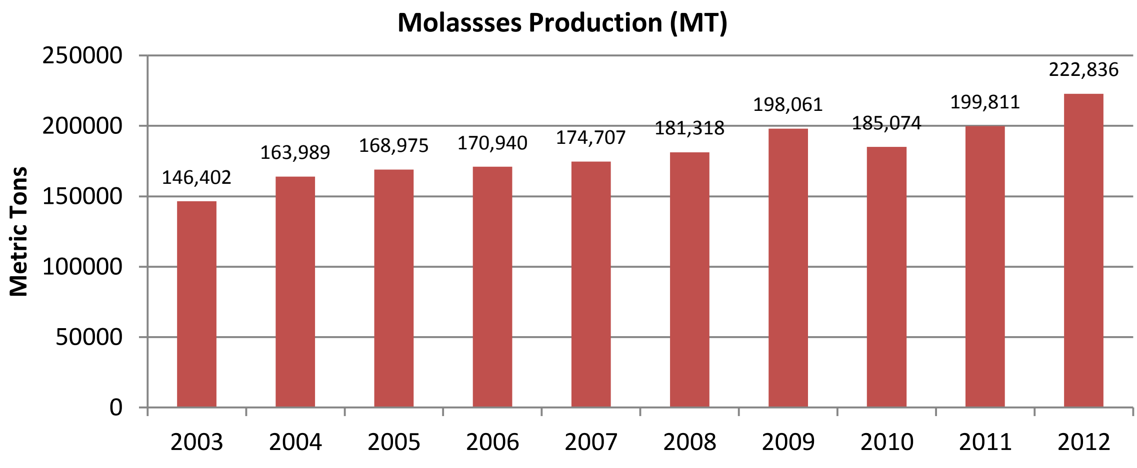

Figure 5-16: Molasses production in Kenya (MT)

Source: Yearbook of sugar statists

5.3.1.2. Power generation

Kenya has, in the recent past, experienced severe power shortages, putting pressure on the country's economic growth and its efforts to improve the day-to-day lives of Kenyans. Only 25 percent of the population has access to electricity, and rural grid access is only about 5 percent[16]. Increasing the access to electricity and ensuring reliable power supply are key elements of Vision 2030 with the goal to achieve 40 percent energy access. This is to be achieved by increasing electricity generating capacity to 11,510 MW by then from the current installed capacity of 1,473MW [17] (Table 5-15).

Kenya plans to add new generation capacity of about 2,000 MW, developed by the public sector as well as by the private sector through Independent Power Producers (IPPs), and utilizing low-carbon resources[18]. It is estimated that the industry has potential to generate up to 190 MW of electricity from this source, which is currently under-exploited. This co-generated power is enough for the industry's needs with a surplus for export to the National Grid. The estimated exportable power is 120 MW, none of which is currently being utilized.

The lack of a supportive pricing mechanism and limited funding for cogeneration are the main hindrance to investment in this promising area. Though the current factory capacities and technology are limiting, this could be resolved during rehabilitation and expansion.

Table 5-15: Installed capacity and generation of electricity, 2008-2012

	Installed Capacity MW[2]					Generation GWh[2]							
	Hydro	Thermal Oil	Geo thermal	Cogeneration	Total	Thermal oil				Geo Thermal	Co generation	Wind	Total
						Ken Gen	IPP	EPP	Total				
2008	719	418.9	128.0	2.0	1,267.9	52.4	883.0	741.0	2,145.4	1,039.0	4.0	0.2	6,455.6
2009	730	421.5	158.0	2.0	1,311.5	654.0	1,208.0	1135.0	2,997.0	1,293.0	5.0	7.2	6,507.2
2010	728	469.2	189.0	26.0	1,412.2	291.0	1370.0	540.0	2,201.0	1,442.0	92.0	16.8	6.975.8
2011	735	582.7	190.6	26.0	1,534.3	903.0	1538.8	358.7	2,800.5	1,443.7	80.9	17.6	7,559.9
2012	769.9	610.6	199.6	26.0	1,606.1	682.5	1,208.9	309.0	2,2004	1,515.9	104.7	14.4	7,851.3

Source: Economic survey 2013

5.3.1.3. Animal feed production

Feed manufacturing play a critical role in the livestock sub-sector in Kenya. Generally, the number of millers has grown over the years with an installed capacity of 843,567 tons (in 2008) of which only 44.8%[19]. Though Kenya has the potential to produce most of the plant-

[16] (World Bank Group 2012)
[17] (World Bank Group 2012)
[18] (World Bank Group 2012)
[19] (Olala, Gihinji and Maritim 2009)

based protein supplying raw materials, over 60% of these raw materials are imported either from Tanzania or Uganda.

Table 5-16: Animal feed production, 2003-2008

Region	Installed Capacity (Tons)	Actual Production (Tons)					
		2008	2007	2006	2005	2004	**2003**
Nairobi	405,068	151,138	194,095	168,032	1,460,612	133,180	**125,230**
Thika	160,940	59,695	70,919	60,648	47,657	46,415	**44,777**
Kiambu	50,160	17,507	15,677	11,934	8,220	1,760	**0**
North Rift	37,030	18,235	23,142	16,658	15,621	12,536	**4,249**
Nyanza	19,537	8,756	12,691	12,962	11,200	10,000	**12,000**
Nakuru	69,362	32,841	33,693	34,394	33,243	31,593	**23,967**
Mt. Kenya	25,320	3,880	3,733	4,240	4,056	1,990	**1,840**
Coast	76,150	19,087	19,410	9,723	6,950	6,900	**7,400**
TOTAL	**843,567**	**311,140**	**373,259**	**318,591**	**273,009**	**244,374**	**219,463**

Source: Feed milling Industry: The missing data (2009)

Table 5-17: Products from the Feed Milling Industry in 2007

Category / Quantity	Cattle	Poultry	Pigs	Others[20]	Totals
Quantity (tons)	104,412	251,861	12,521	4,598	**373,259**
Total %	**28**	**68**	**3**	**1**	**100**

Source: Feed milling Industry: The missing data (2009)

The Kenyan sugarcane industry comprises a total of 154,298 Ha dedicated to sugarcane for sugar production. There is great potential in sugar-livestock integration in Kenya. A new emphasis should be placed on the use of sugarcane and its derivatives, soybeans, and multi-nutritional blocks for feeding livestock.

5.3.1.4. ETHANOL PRODUCTION

Using molasses, a prime by-product of the sugar industry, the sugar sector can produce ethanol for use as fuel for vehicles. Ethanol is globally gaining ground and being blended with benzene; flexi-cars, which use a blend of ethanol and bagasse, are now being produced in many countries.

A potential product from distillation of molasses is power alcohol. This product can be successfully blended with petrol or diesel at a rate of 5-10% by volume in case of petrol and 3% when mixed with diesel. At these ratios, no modification is required in the current petrol

[20] Dog Meal–1599.92; Horse Meal– 1966.86; Bone Meal –800; Breeder feeds –165; Minerals– 46.25; Rabbit ratio –8.12; Sheep and Goat ration– 4.76; Tilapia Pellets –7.

and diesel engines. However, with a few modifications on the vehicles, as happened in the case of Brazilian Flexi-cars which is designed to have up to 100% power alcohol can be used.

Energy Act of 2006 mandates the government to pursue and facilitate the production of biofuels though the government is yet to adopt a biofuels policy in response to its mandate under the Energy Act. Production of ethanol was undertaken for some time at the Agro-chemical and Food Company for blending with petrol. "This programme however could not be sustained because there was no policy and legal framework to regulate its use"[21]. In addition, there was resistance from the multi-national petroleum companies who feared a reduction in their market share[22].

Production of ethanol for blending with petroleum can provide additional income for the sugar industry. Use of this "green fuel" would also be in tandem with worldwide trends where countries are striving to reduce their reliance on petroleum and other non-renewable sources of energy. At the current capacity of 24,280 TCD, the industry has the potential to produce in excess of 100 million liters of ethanol a year.

"…the industry disposes off the final molasses at a nominal value for onward utilization in the manufacture of cattle feed, fuel ethanol, rectified spirit and industrial ethanol. Molasses is also used in production of local brews"[23].

5.3.2. SUGARCANE RETURN COMPARED WITH OTHER CASH CROPS

The yield, production cost and selling price of sugarcane and other cash crops are shown in Table 5.18.

Table 5-18: Crops' yield, production cost, and wholesale prices

USD/Ton	sugar	maize	rice	Coffee	Tea
Yield (ton/ha)*	58.78/5.82	1.94	1.25	0.35	2.2/0.52
cost of production/ton	870	221	767	-	1330
cost of production/ha	5063.2	428.7	958.8		688.5
wholesale price/ton	1378	281	628	6580	621.3

* Sugar extraction is 10.1%. Tea is processed at a conversion rate of 4.2

Table 5-19 shows a comparison of return per hectare between sugarcane crop and other cash crops including added value of sugarcane (ethanol, animal feed, cogeneration, etc.).

[21] (KSB 2010)
[22] (KSB 2010)
[23] (KSB 2010)

Table 5-19: Comparison of return/hectare between sugarcane and other cash crops

	sugar cane	maize	rice	Coffee	Tea
Revenue without added value (USD)/ha	8022.3	546.1	784.4	2303	1367
Revenue with added value (USD)/ha*	9470	2184.4	1255.04	3684.8	1663.4

* The added values for sugarcane were estimated based on ethanol and animal feed. Maize was assumed to have 400% added value, while rice and coffee were assumed to have 60% added value.

5.4. Comparative Analysis of Alternative Crops

Table 5-20 shows a suitability matrix indicating the optimum growing conditions for sugarcane and other cash crops in Kenya. The study approach and selection criteria excluded current areas known for cash or food security crops such as coffee, tea, and maize from further consideration as potential areas for sugarcane.

Based on climate suitability, maize could compete with sugarcane in the new potential areas. However, the study avoided converting existing maize farms into sugarcane and, for new areas, selected flat lands to allow mechanized farming, which makes sugarcane more profitable compared with maize. The study have not recommended certain areas, where could be suitable for sugarcane or sugar beet, in the Rift valley and other areas (Baringo and Kitale) because these areas have better potential for other cash and food security crops such as horticulture, maize, and commercial forest. Tea could compete with sugar beet, but the study took into consideration the application of intercropping system, as maize or tea could be incorporated in the sugar beet areas.

The top consumed stable crops in Kenya are Maize and Rice. In the following section, the potential cultivation for these alternative crops will be assessed from purely market perspective. Through the assessment of:

- Consumption and production trends for Maize, Rice and Sugar
- Import cost and the cost of production for each.

Table 5-20: Suitability matrix for sugarcane and comparative cash crops

Crop	Climate	Soil	Topography	Maturation	Optimum Rainfall	Competing Crop
sugarcane	Sun loving plant, greater incident radiation favors sugar yields	Sandy loam to clay loam, deep and well-drained soil	relatively flat lands from sea level up to 1700 m	12-18 month	1000 - 1200 mm	maize, coffee (in the central region)
sugar beet	more of a winter crop with temperature raining between 20 to 30c	sandy loamy to loamy clay with good texture		short duration crop	500-700 mm	tea, horticulture,
maize	dry and semi hot climate, daily minimum temperature of the coolest month of the year should not exceeds 13o C.	well-drained, well-aerated, deep soils containing adequate organic matter and well supplied with available nutrients	hilly areas and steep slopes	4-5 month	short rain period of rain ranges between 600 - 900 mm depending on the verities	competing with sugarcane
rice	humid and semi hot climate, daily minimum temperature of the coolest month of the year should not exceeds 18o C.	Rice thrives on land that is water saturated or even submerged during part or all of its growth	lowlands and delta with slope level 0-2%,	1-3 month		
coffee		deep porous soil with relatively low storage capacity	undulating to hilly topography			
tea	well distributed rainfall with long sunny day	volcanic red soil	Highlands altitude between 1,700 to 2,700 m above sea level, steep slopes	All round the year production with two main peak seasons of high crop between March and June and October and December which coincide with the rain seasons	1200 - 1400 mm	sugar beet

5.4.1. KENYA FOOD BASKET

According to FAO Stat, 55% of caloric needs for Kenyans come from 6 main staples: maize, wheat, beans, potatoes, plantains, and rice. Among these, Maize is the main staple food has an average per capita consumption of 86 kg, accounting for 54% of total staple food intake. Wheat is the second most important staple, food nationally, accounting for 14% of staple food consumption in Kenya, followed by potatoes (14%), plantains (9%), beans (6%), and rice (3%).

Due to the urbanization trends in Kenya over the past decade, the market for maize has narrowed, being substituted by wheat, and consumption of rice has registered massive growth. Maize has "inferior good" characteristics meaning its share in staple food expenditures is highest among the poor. Maize accounts for nearly 20% of total food expenditures among the poorest 20% of urban households, and 1% of total food expenditures among the wealthiest 20%[24].

Since the national cereal production is not keeping pace with the growth in national demand, imported wheat and rice are increasingly filling the residual food needs gap. For this reason, the share of wheat and rice in staple food expenditures are rising, leading to a more diversified basket of staples over time. Table 5-21 shows the average per capita consumption and share of total staples consumed from 1990 to 2009.

Table 5-21: Average per capita consumption and share of total staples consumed, 1990-2009

	Average per capita consumption (1990-2009)	Share of total staple food consumed
Maize	86	54%
Wheat	23	14%
Potatoes	22	14%
plantains	15	9%
Beans	10	6%
Rice	4	3%
Total	160	100%

Source: FAO-State (2013)

5.4.2. MAIZE

Maize production in Kenya has, by and large not kept up pace with national demand requirements. Maize production is mostly dominated by small-scale producers, who account for 70% of total production Figure 5-17. These small scale producers are known to consume

[24] (Staple food prices in Kenya January 2010)

the vast majority of what they cultivate. Maize is mainly cultivated in Rift Valley, Nyanza and Western counties. Maize production in years 2007-2012 reached 3.1 million tons, while consumption varies between 2.4 to 3.7 million with an average of 3.2 million.

Kenya kept oscillating between deficit and surplus in maize production, with deficit reaching record highs in 2009 of 608,000 ton due to relatively low rainfall rates, and a surplus of 232,000 and 194,000 in 2010, and 2011 respectively.

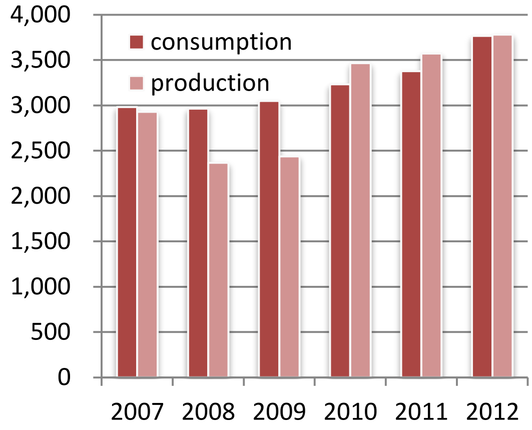

Figure 5-17: Maize production and consumption, 2007-12

Source: Tegemeo Institute figures

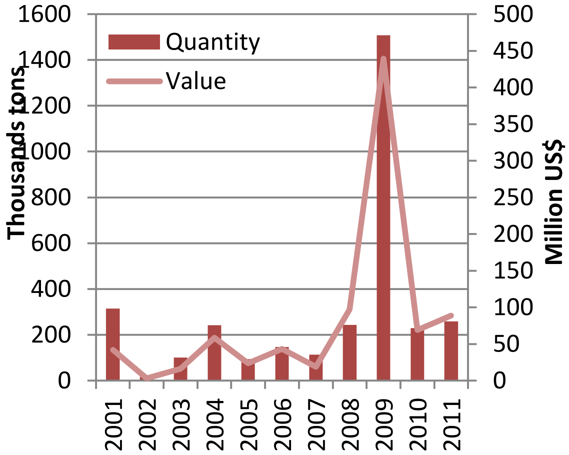

Figure 5-18: Maize import quantities and value, 2001-11

Source: FAOSTAT

From 2007 to 2012, Kenya imports around 7.7% of its maize consumption at an average import value of 41.2 million dollars with international maize prices in the range of $162 - 275 (FOB price) (Figure 5-18). In 2009, Maize imports rose drastically to reach 1.5 million and that's mainly due to imports ban lifting by government to allow businessmen to supplement the local produce that was short of the minimum required to satisfy the local market.

CIF prices for maize imports have ranged from 2500-4800 KES/90 kg (CIF-MSA) for 2011-mid 2012, according to the Tegemeo Institute of Agricultural Research and Development. Cost of production, registered an average of 1696 KSh/bag for 2012/13 season. Wholesale prices increased to 3396 KSh/100kg in 2012 from 2500 KSh/100kg in 2011.

In terms of determining consumption by region, the population of the region was used as the main independent variable. Surplus producers of maize are the Rift Valley with an excess of 930,000 tons followed by Nyanza and Western regions all representing the highest yields in Kenya (Table 5-22 and Table 5-33).

Table 5-22 : Region Maize production, consumption and surplus-deficit in 2012

	Rift Valley	Nyanza	Eastern	Western	Coast	Central	North-Eastern	Nairobi
Consumption	979,682.2	532,850.1	554,918.3	424,343.0	325,552.8	429,175.4	226,226.8	307,251.4
Production	1,910,175.8	652,657.1	452,445.1	506,614.7	64,508.8	178,363.8	542.3	851.5
surplus/deficit	930,493.7	119,807.0	(102,473.2)	82,271.6	(261,044.1)	(250,811.6)	(225,684.5)	(306,399.8)

Table 5-23: Average yield by county, 2009-12

Region	Yield (Bag 50 kg/ha)
Rift Valley	24
Western	19
Nyanza	16
Nairobi	12
Coast	9
Central	9
Eastern	8
North-Eastern	4

Maize projections

In the past two decades 1990-2012, the consumption of maize registered a 2.7% growth and is expected to reach 3.7 million tons by 2020. In the same period, production grew at an average annual rate of 2.3. For the purposes of this study, it was assumed that production will grow linearly with the same trend affected by consumption levels and it is expected to reach 3.4 Million tons by 2020. This will result in a deficit of 306,249 tons by 2020 (Figure 5-19). The cost of filling this deficit can be estimated at US$ 76 million (port value), with a price for ton equal to US$248 (FOB price) based on OECD projections in 2020[25].

[25] Tegemeo Institute Maize records

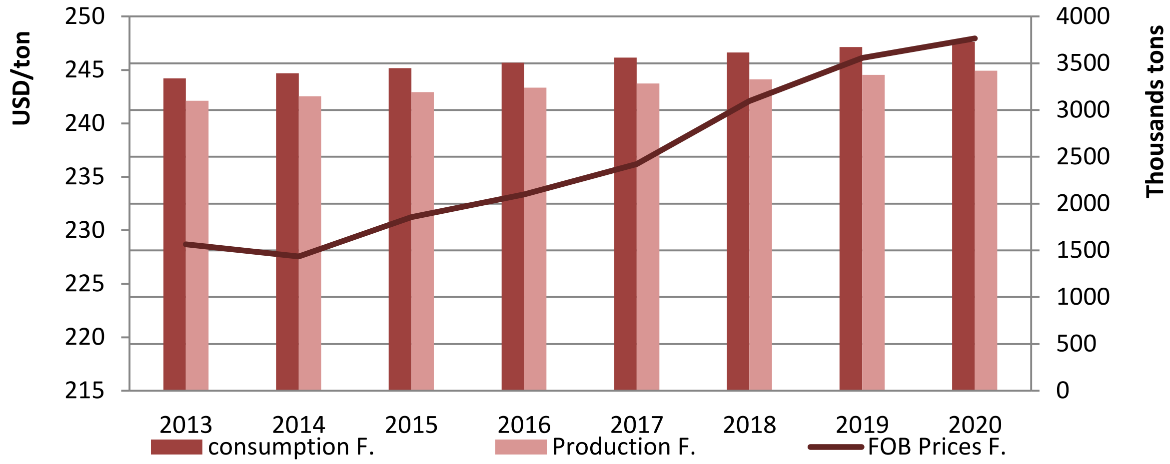

Figure 5-19: Forecasted production, consumption and International prices

Source: Tegemeo Institute, KETS calculations

According to Tegemeo Institute records, the cost of production per bag for last season in different counties averaged 1696 KSh, equivilant to 221.2 US$/ton, while the FOB price was equivilant to 246 US$ as per OECD report. In the same period, total import cost per ton (CIF) for maize reached KSh 31,954 (US$375.5), which shows the competitiveness of domestically produced maize over imported maize (Table 5-24).

Table 5-24: Maize production and cost vs. imports

Maize	KSh /Ton 2011
Cost of production	18,848
Import cost CIF	31,954
International price FOB	20,952

5.4.3. Rice

Rice was considered the third grain crop and the sixth staple food consumed in Kenya throughout the period of 1990-2009. Rice consumption has been growing at an average of 12% throughout last decade, which can be attributed to changes in eating habits and urbanization. Rice production hasn't kept pace with consumption, having grown at less than 1% according to FAOSTAT records, leading to an average deficit of 344,941 tons (2007-2012) as shown in Figure 5-20.

Rice is cultivated in lowlands of Kenya. Irrigation schemes cultivate about 95 percent of all the rice produced while the rest grow under rain-fed conditions, according to the National

Irrigation Board (NIB). Recently Kenya was only able to meet around 11-23% of its rice consumption needs due to production inefficiencies and increased demand.

Kenya imports its entire rice deficit, on average more than 300,000 thousand tons annually. Imports in 2012 peaked at 399,000 tons[26]. The main import partners are Pakistan, Vietnam, Thailand, and India, through Tanzania also supplies a substantial amount through unrecorded cross border trade. The value of rice imports doubled in 2011 to reach US$ 191 million from 2008 level (Figure 5-22).

Figure 5-20: Rice production and consumption, 2007-12

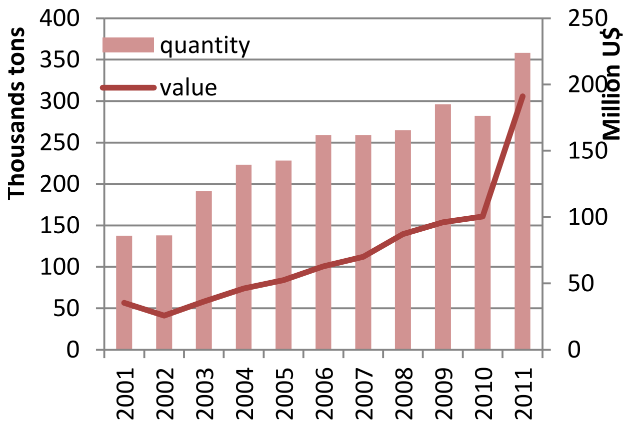

Figure 5-21: Rice import quantities and value

Rice producing regions in Kenya are Central, Coast, Nyanza and Rift Valley i with a total cultivates of 5,700 ha in 2012, and an average yield of 30 bags/ha. North Eastern in 2012 had the highest yield reaching 80 bag/ha, followed by Central and Nyanza with 53 and 48 bag/ha yield respectively.

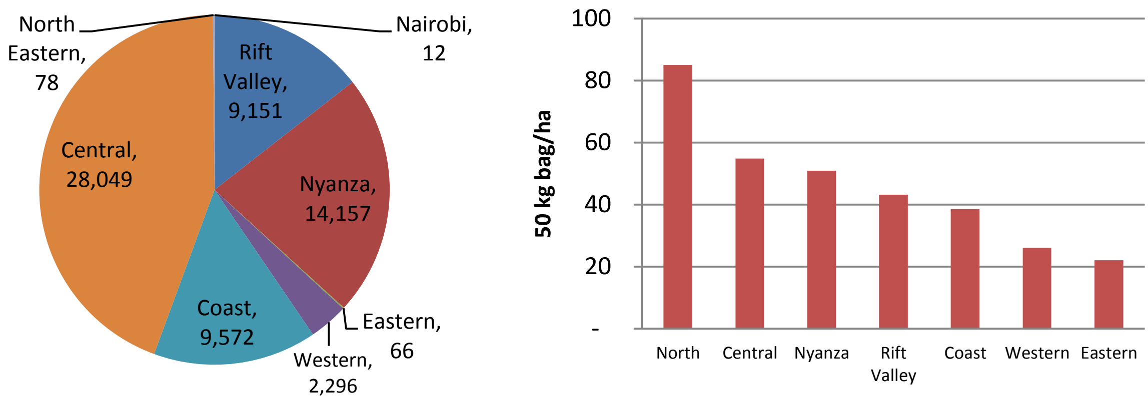

Figure 5-22: Rice production quantities (ton) and percentage, 2008, -2012

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[26]Economic Survey 2013 , Kenya National Bureau of statistics http://gain.fas.usda.gov/Recent%20GAIN%20Publications/EAC%20Rice%20Import%20Tariffs%20and%20Food%20Security%20Update_Nairobi_Kenya_4-26-2012.pdf

Rice is one of the crops that are dependent on income and for projecting future consumption a regression analysis was run using population and GDP as independent variables. This resulted in a forecasted consumption of 940,422 tons by 2020. GDP projections are based on IMF report published in April 2013, while population growth rate assumed was 2.68%. The formula resulting from regression to project rice consumption based on GDP and Population is illustrated below:

Consumption Y= (8.13E-6 * GDP) + (0.004874 * Population) – 117,722

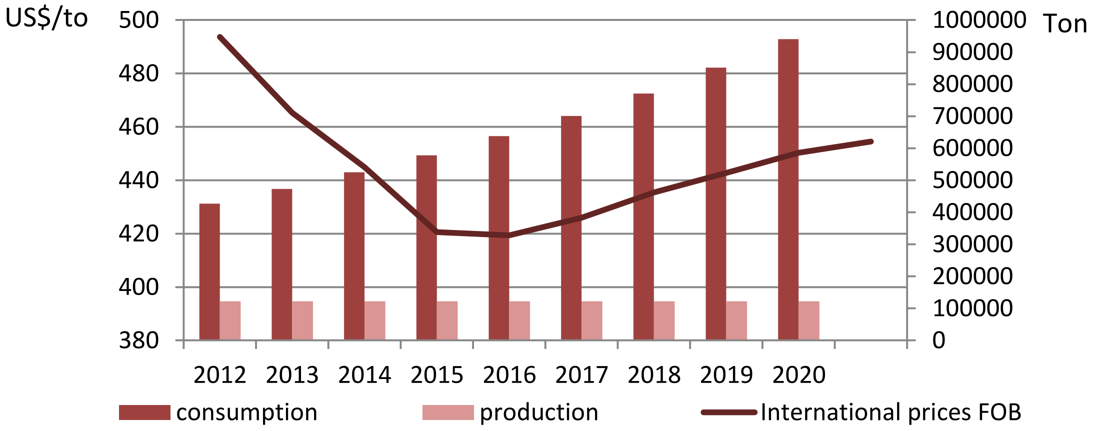


Figure 5-23 : Forecasted production, consumption and international prices of rice 2012-2020

We can see how consumption is forecasted to increase with a high annual rate of around 9.5%, with population growth rate of 2.6%. On the other hand and for the reason of inconsistency of production trends and for the purposes of the study, production was assumed constant on 2012 level of 122,465 tons. Based on these assumptions, the deficit will be growing to reach around 818,000 by 2020 and the cost of covering this deficit over 2013-2020 period will vary from US$150-US$368 million, port cost (FOB price)[27].

The cost of rice production is relatively high due to labor-intensive nature of production, high input costs and poor irrigation infrastructure. Cost of production depends on how efficient farming is and in one of the published surveys in 2010, cost of production at farm level, varied between 2,259-3,487 KSh/50kg for efficient and inefficient farms. While cost of imported rice (Pakistani) landed in Mombasa with 35% duty was equal to 3,014 KSh/50 kg, it can reduce to 2,445 KSh/bag with no duty[28].

[27] OECD agriculture and food outlook 2012-2021 , price projections
[28] (Gitau, Muburu and Mathenge n.d.)

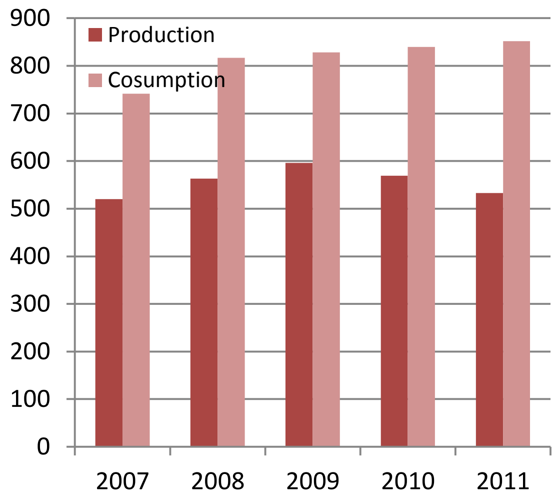
Table 5-25: Rice cost comparison - production vs. import

Rice	KSh /ton 2011*
cost of production	65,276
Import cost CIF	68,719
International price FOB	40,341

Figures in the table above are calculated based on 2010 figures inflated to 2011, with the assumption of average efficiency farm for cost of production, and import duty rate of 35%.

5.4.4. SUGAR

Sugarcane in Kenya is mainly cultivated in Western Kenya comprising Nyanza, Rift Valley and Western provinces, feeding sugar factories that have total production of 556,000 tons on average (Figure 5-24). Consumption varies within the range of 817-852 thousand tons, leaving a deficit of around 259,000 on average that is covered by imports mainly from South Africa, Malawi and Egypt with a total import value of US$93 Million (KSh 7.91 Billion).



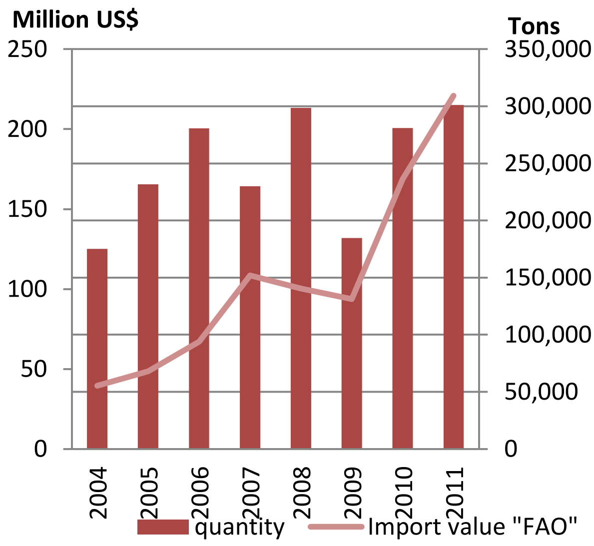


Figure 5-24: Sugar production and consumption 2007-2011 **Figure 5-25: Sugar imports quantities and value**

Source: FAOSTAT

Sugar production is projected to grow annually at 4.1% up to 2020 to reach 681,303 tons (Figure 5-26), and that's when assuming that production is dependant on three factors TC/TS conversion rate, overall time efficiency and level of sugarcane available for crushing with consumption projected to grow with 2.7% to reach a million tons in 2020, this will leave a deficit of 318,920 tons. Assumption is made that consumption will be dependent on three variables GDP, population and average sugar prices. Satisfiyng this deficit over the outlook period will cost within a range of 120-150 Million USD (port price), using OECD projections for 2012-2020.

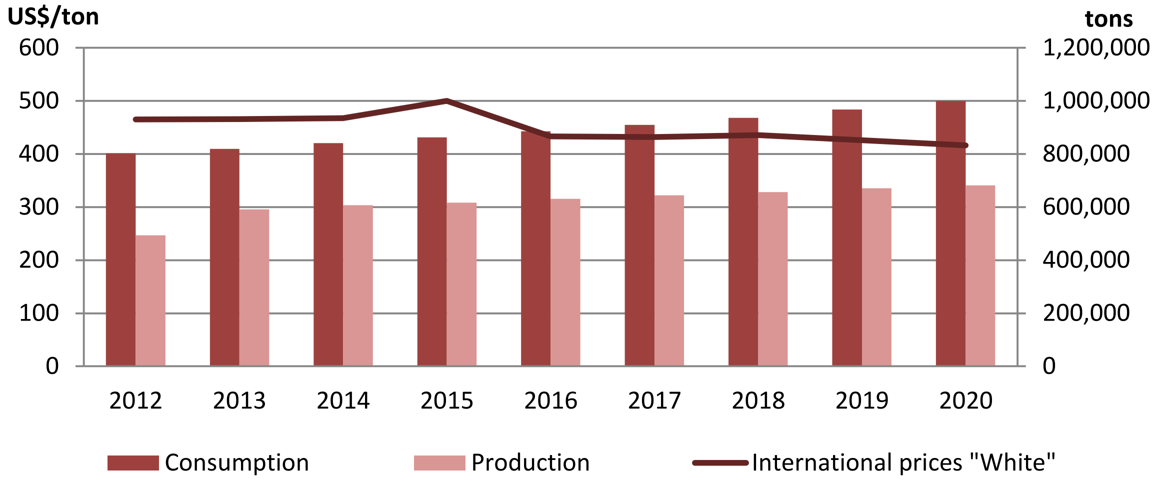


Figure 5-26 : Forecasted sugar production, consumption and international FOB price

Domestic sugar prices in Kenya are relatively high varying within a range of 1,033.2-1,212 US$/ton (3,916-5,160 KES/50kg) in the period 2009-2012 since the industry is protected by government. As described earlier, the Kenya Sugar Industry will, from 2014, be force to compete with cheaper sugar from COMESA countries, necessisitating improvement in industry efficiency.

Nevertheless sugar industry can provide set of diversified by products such as baggasse and mollasses which can be used for production of ethanol,animal feed and fuel to generate electricity. For example, one ton of sugar can provide 0.364 ton of molasses which have factory price of 5,674 KSh/ton according to KSB annual book for 2012[29].

Table 5-26: Sugar cost comparison - production vs. import

Sugar	KSh/ton 2011
cost of production	74,037
Import cost CIF[30]	*70,371
International price FOB	43,316

[29] This calculation is based on the assumption that sugar extraction rate from cane is 11% and molasses is 4%
[30] Sugar Year Book by KSB 2011

5.4.5. SUMMARY

In this section, we are evaluating the opportunity cost, for either cultivating or importing each of the crops above. The cost of imports and production were calculated for the average projected deficit of outlook period of 2013-2020.

Due to data availability issues and for the sake of consistency, year 2011 was considered the reference year for all prices and cost figures. The following assumptions were made to attain future costs of import and costs of production:

- The cost of production in USD remains fixed since 2011
- Import cost per unit used is CIF price projected into future was done using OECD projected price (FOB) 2013-2020, while fixing tariff rates at 2011 values (53% maize, 49% rice and 62% sugar)
- CIF prices used are for imports landed in Mombasa stores

Moreover, it is highly feasible cost wise to cultivate maize with the current cost of production set at US$221 over the CIF price of US$375 per ton and this status is most likely to remain the same in the future granted the assumptions above. In terms of rice in 2011, locally produced rice has a competitive advantage over imported rice given the level of tariff rates, and this is expected to change in the future with rice prices expected to remain flat (nominal rates) accompanied by a comfortable supply and slowing demand[31]. Therefore, local suppliers will need to increase their efficiency even further in the future in order to reduce their cost of production.

Table 5-27: Sugar, Maize and Rice comparison matrix

	Maize	Rice	Sugar
Projected average deficit in tons 2013-2020	271,673	533,502	270,073
International prices FOB US$/ton 2011	246	566	509
Import cost CIF - US$/ton 2011	375	808	827
Cost of production US$/ton 2011	221	767	870
Cost of Importing future deficit Million USD	98.7	338.2	207.8
Cost of producing future deficit Million USD	60.0	409.2	235.0

Finally, the sugar industry in Kenya has faced the challenges of elevated production costs and lack of utilization of byproducts resulting in costs of production that struck $1,000 in some factories. According to table above, the cost of importing sugar is less than producing it locally. Nevertheless, increasing industrial efficiency, lowering the current cost of production by more than $100 by full utilization of the by-products mentioned previously may lead to a situation where locally produced sugar becomes cheaper than imported sugar.

[31] (OECD-FAO Agriculture outlook (2012-2020) 2012)

Chapter 6 Business Environment In Kenya

6.1. Economic Factors

Population: **43.18 million**
GDP (current US): **$37.34 billion**
GDP per Capita (Current US): **$865**

Kenya had been one of the leading economics in Africa with an average GDP growth of 4.6 percent in the past decade, higher than the 1990's which had an average growth of 2.2 percent. However, low GDP growth was registered in 2008 which was the time of the country experienced post-election violence in January-February.

Kenya, as a business environment, has been surrounded by concerns regarding corruption, governance and political instability. The change of regime in 2002 brought changes as the new government started rooting out corruption and encouraging donor support.

Recent political and economic developments have stimulated development opportunities for Kenya, but concerns remain in some areas including youth unemployment, poverty and vulnerability to climate change. Of critical concern are food security, governance and corruption.

Kenya has a proper and functional government and has undertaken with major reforms brought about by 2010 constitution that allowed for smooth political transition as evidenced by the peaceful elections of March 2013.

The economy of Kenya has remained resilient and has successfully overcome the post 2011 Eurozone crisis (considering that Europe is the main market of Kenya products) as well as the severity issues triggered by the crisis in Somalia. The discovery of oil and gas [32] further blasted the economy Projections by the IMF indicate an average of 6.1% for real GDP growth up to 2018 and inflation to remain single digit with an average of 5.7% (Figure 6-1).

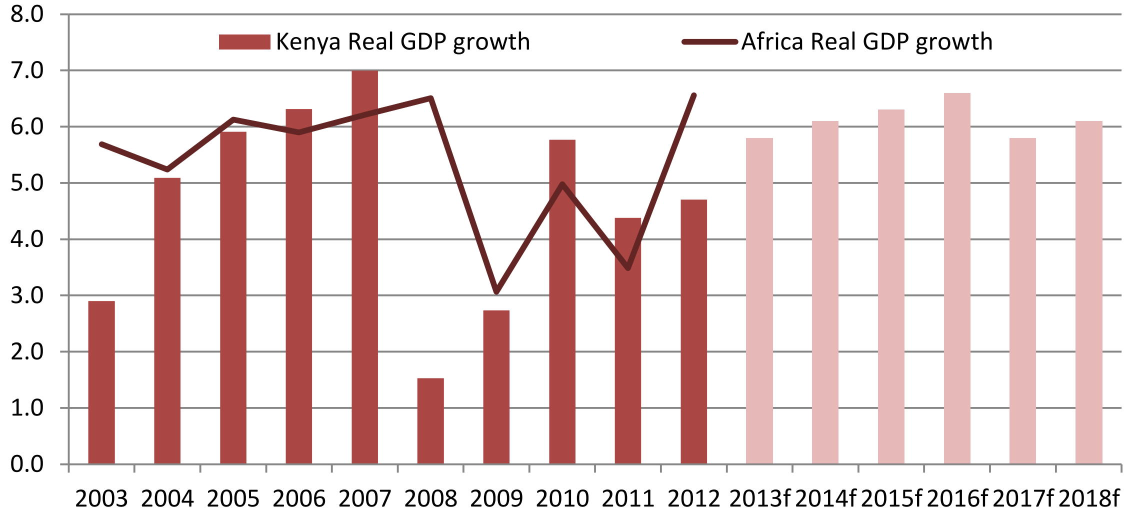
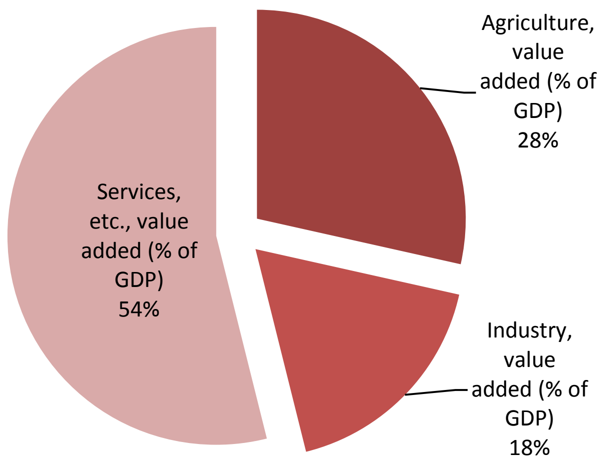


Figure 6-1: Kenya real GDP growth, actual and forecasted

Source: Kenya African Economic Outlook Report, IMF Country Report

Kenya is heavily reliant on public debt, and the debt- to-GDP ratio remained above 43% for the past three years (of which 22% was external debt). According to a report by Global Lenders published in 2013, Kenya ranked third biggest borrower of the World Bank loans in Africa over the past five years, coming after Nigeria and Ethiopia. Kenya received Sh53 billion World Bank loans since July 2008, indicating the country's heavy reliance on the institution for development and infrastructure funding. [33]



Kenya's economy is mainly dominated by services, which represent 54% of GDP, followed by agriculture representing 28% of GDP

[32] IMF report April 2013
[33] http://www.businessdailyafrica.com/Kenya-ranked-third-largest-recipient-of-World-Bank-loans/-/539552/2030434//8ql4nu/-/index.html

and industry with 18% of GDP. In 2011 the agricultural sector was the highest contributor to Kenya's GDP at 24% followed by wholesale and retail trade, hotels and restaurants with 13.9%, followed by finance, real estate and business services of 12.3%, then transport, storage and communication, and following was manufacturing with 10.7% of GDP.

Kenya has an average inflation rate in the past decade of 10.5%, reaching a peak of 26% in 2008 due to international food and fuel crisis (Figure 6-2). After that, the Kenya inflation has been varying between 4-14%, and in 2012 inflation registered 9.6 %, estimated to drop to 6.3 % in 2013, with projections that it will remain single digit up to 2018 as per IMF scenario.[34]

Figure 6-2: Kenya inflation rate

Kenya has a negative trade balance over the past decade with average import value of 13.8 billion for the past five years reaching 16.6 billion in 2012 with crude oil constituting a major portion of these imports. With the discovery of oil in northern Turkana region in 2012, Kenya has an opportunity to boost the economy, even in the short term because of the indications of a vast oil reserve there but the commercial viability of the find is yet to be determined.[35]

Kenya is striving to improve its private sector competitiveness, through introduction of new policies and measures such as single window system to facilitate trade. According to the World Bank report on Kenya economic update published June 2013, Kenya's private sector grew by 21 % beginning of 2011, 28% in 2012 and 12% in 2013. In 2012, the sector was hindered by the issue of massive credit squeeze post 2011 Euro zone crisis, but in 2013 the

[34] http://www.imf.org/external/pubs/ft/scr/2013/cr13107.pdf
[35] Africa economic outlook 2013

private sector credit growth picking up as bank lending conditions eased. The Small and Medium Enterprises (SMEs) sector contribute significantly to economic development, will 9.2 million people engaged in the informal sector as of 2011. Meanwhile for the same year the SMEs created 445,900 jobs equivalent to 5.1% increase.

6.2. INVESTMENT ATTITUDE

Kenya ranks as one of the top FDI destinations in Africa, primarily due to ongoing investments in infrastructure and judicial reforms. During the period 2007-2012, Kenya ranked third in terms of growth rate in new FDIs, attaining a compound rate of 43.1%, according to Ernst and Young Attractiveness Survey, Africa 2013 (Figure 6-3). Since 2007, FDI projects into Sub Sahara Africa have grown significantly at a compound rate of 22%, during which investment into North Africa has stagnated largely due to political dynamics.

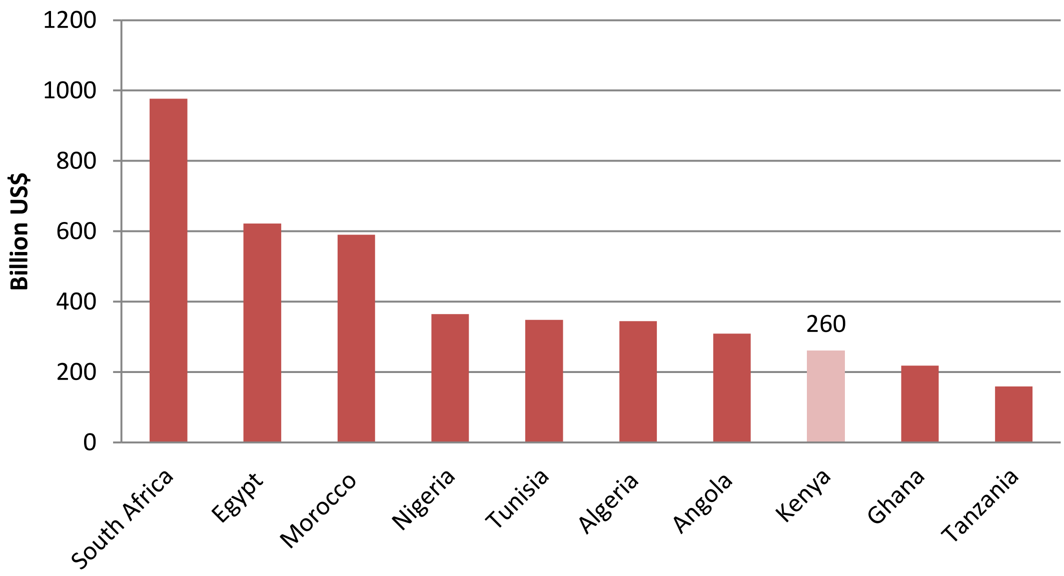


Figure 6-3: FDIs for African countries since 2003

To attract and facilitate the flow of FDIs into the country, the government of Kenya has established "KenInvest" as a semi-autonomous agency in 2004. Nevertheless, Kenya still needs to work on strengthening judicial institutions and stabilizing the political situation. In 2013, Kenya ranked among the top ten African countries for investment projects in infrastructure with total sum of invested capital of 32.85 billion USD[36]. Moreover, expansion in the energy sector -including oil, gas, geothermal, coal, wind, solar, biomass is a prominent axis in the Vision 2030. This led to heavy investments by FDIs in the energy sector, especially

[36] Africa attractiveness report 2013

in 2012, driven by the discovery of oil in Northern Kenya, and offshore natural gas in exploration blocks near Malindi.

Kenya is also becoming an important outward investor in manufacturing, finance and service activities to EAC countries and the wider region given its industrial base which is relatively advanced[37]. In 2011, Kenya attracted 58 new projects in several sectors, ranking it as the forth in Africa's top FDI destinations, with South Africa being the top attracting 154 for same year.

In the past decade Kenya had average FDIs of US$149.8 million, reaching a peak in 2007 which had an increase of more than fourteen-fold from the previous year. In 2006 the level of FDI's attained was set at US$51 million (0.2% of GDP) and increased to US$729 million (2.7%) in 2007. However, FDIs dropped to US$96 million (0.3%) in 2008 then increased once again to US$116 million (0.4%) in 2009. Between 2010 and 2011, FDI's increased from US$178 million (0.6%) to US$335 million (1.0%). The figure below illustrates an overall high compound growth rate for FDIs between 2008 and 2011 of 51% (Figure 6-4).

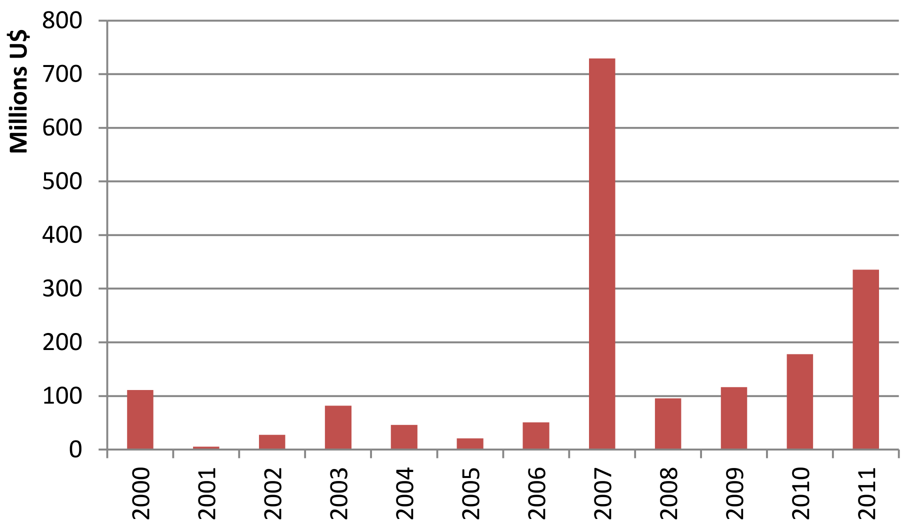


Figure 6-4: Kenya Foreign Direct Investments (FDI)

6.3. FOREIGN INVESTMENT GUIDE

Kenya established a semiautonomous authority in 2004 namely "KenInvest" with the main objective of promoting investments in Kenya. It was a successor to Investment Promotion Centre (IPC). Established under the Investment Promotion Act No.6 of 2004, "KenInvest" authority was given autonomy in 2007.

[37] http://www.state.gov/e/eb/rls/othr/ics/2013/204669.htm

Foreign investors according to the Act 2004 are required to obtain an investment certificate. Local investors are not obliged to obtain certificate but still have to register with "KenInvest". To obtain a certificate, an investor is obliged to have a minimum of 100,000 US$ or equivalent. Investors must also show that the potential business is beneficial to Kenya judged by criteria such as positive impact on employment, upgrading skills, transfer of technology, foreign exchange generation and tax revenue enhancement.

The benefits offered by investment certificate are points:

a. The holder of investment certificate is entitled to issuance of 71 licenses for carrying on business
b. Entitlement to entry permits for expatriates

6.3.1. Investment incentives

Services provided to investors include investment facilitation, investment promotion, investor tracking, after care services and policy advocacy. Further incentives offered include:

- 100% to 150% investment allowance depending on location
- Capital goods are zero rated
- Duty exemption and VAT waiver for machinery and equipment
- Export Processing Zones program (Special Economic Zones) which enjoy the following incentives:
  - 10-year Corporate Tax holiday and 25% tax rate on profits thereafter (except for commercial activities)
  - 10-year Withholding Tax holiday
  - Duty and VAT exemption on inputs
  - Stamp Duty exemption.

6.4. Doing Business in Kenya

Kenya was ranked as the 129th out of 189 countries in World Bank doing business report of 2014, lower by 7 degrees than the previous years' evaluation report (Figure 6-5). Nevertheless, Kenya still recorded higher rank than the regional average of Sub Sahara Africa (SSA) that stood at 149.

To attract investment, the Kenyan government enacted several reforms, including:

- Abolishing export and import licensing, except for a few items listed in the Imports, Exports and Essential Supplies Act

- Rationalizing and reducing import tariffs; revoking all export duties and current account restrictions
- Introducing a free-floating exchange rate
- Allowing residents and non-residents to open foreign currency accounts in domestic banks; and removing restrictions on borrowing by foreign as well as domestic companies

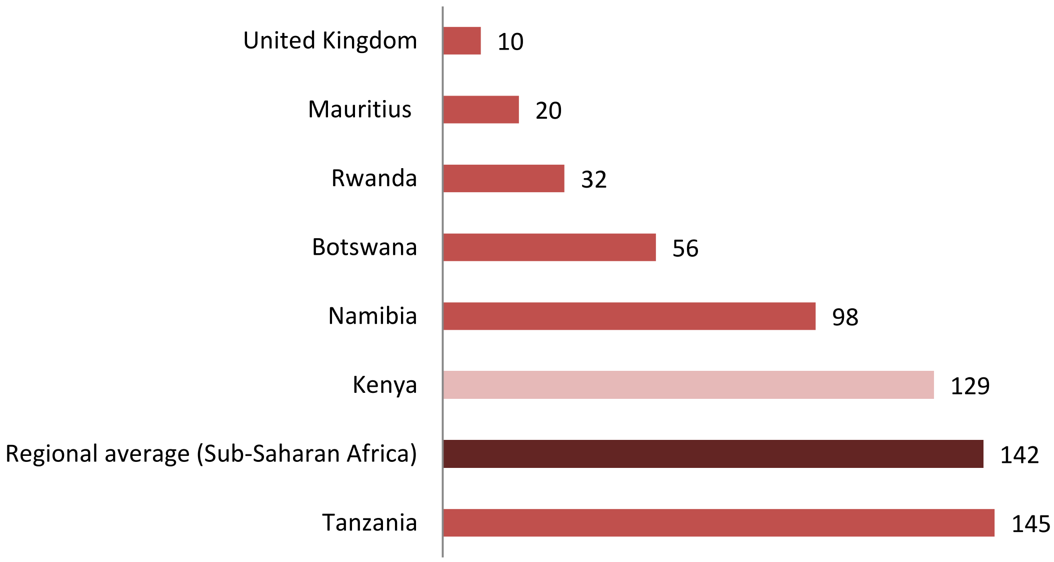


Figure 6-5: Ranking of Kenya Business report 2014

Currently, according to the doing business report 2014, starting a business in Kenya requires 10 procedures and takes around 32 days and costs 38.2% of income per capita.

With regard to access to credit, Kenya was ranked 13 of 189 economies. This came as a result of implementation of laws, of that provide a framework for regulated and reliable system of credit information sharing in 2010. Others aspects where Kenya scored high relative to regional average included dealing with construction permits where the process requires nine procedures and takes 125 days and costs 191.3% of per capita income.

Kenya ranked higher at 98 compared to regional average of SSA of 114 in the area of protecting investors.

Areas where Kenya scored low relative to other countries of the region include:

- Getting electricity ranked on 166 out of 189, with procedures that take around 158 days and costs 1,090.7% of per capita income for 6 procedures process.

- Registering a property, ranked 163 against SAA range of 121, requires 9 procedures and takes around 73 days with cost of 4.3% of property value
- Paying taxes,“ ranked 166 out of 189
- Trading across borders, ranked 156 as exporting a standard container, requires 8 documents and takes 26 days and costs $2,255, while importing the same container requires 9 documents and takes 26 days with a cost of $2,350. [38]

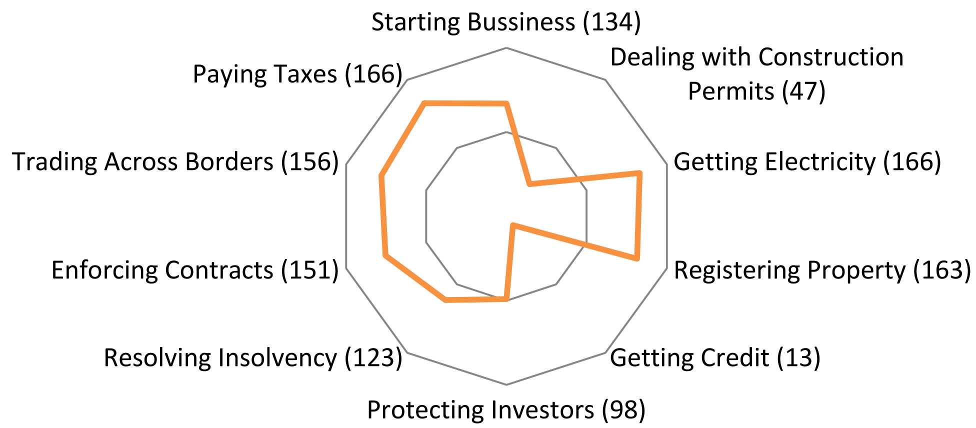


Figure 6-6: Ranking of Kenya in Doing Business topics

[38] (Doing Business , Economy profile Kenya 2014)

Chapter 7 Potential Sugar Agro Zones in Kenya

7.1. Overview

This baseline study has divided Kenya into five major Agro Zones (Figure 7-2) based on the water catchment areas. These Agro Zones were analyzed in greater details based on certain parameters that influence and affect the sustainability of sugarcane production and processing. These parameters include land topography, water availability (Figure 7-1), climatic conditions, soil suitability, socioeconomic, environmental and ecological factors which could impact the introduction of sugarcane crop.

As deemed pertinent, some of these Agro Zones were further divided further into sub-zones (Figure 7-3) based on the same parameters described above.

The potential Agro Zones in Kenya will be discussed in details in the following sections. The selection process of Agro Zones in Kenya was based on their suitability to fit into:

1- A sugarcane matrix
2- Sugar beet matrix

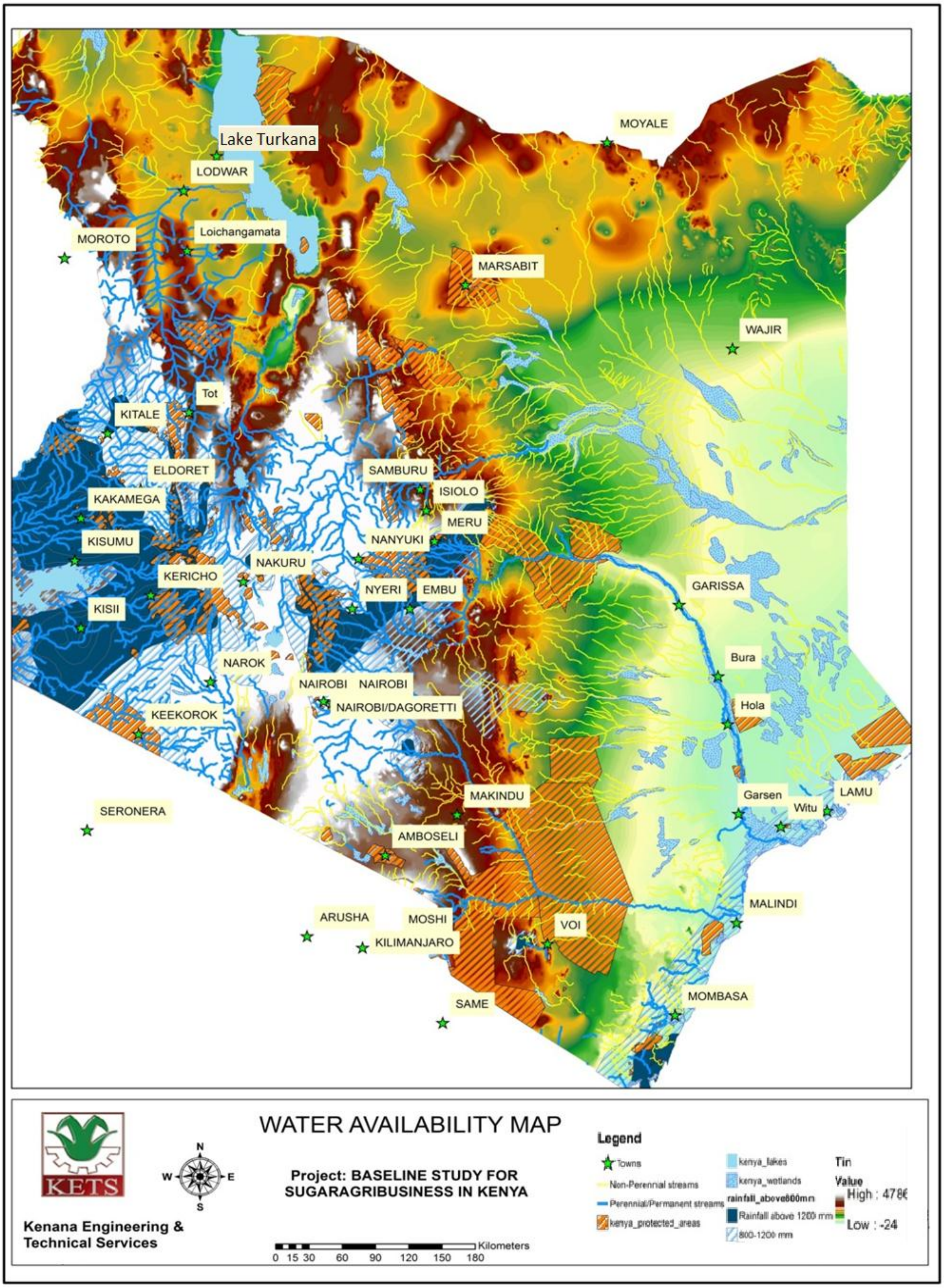


Figure 7-1: Map of Water Resources in Kenya

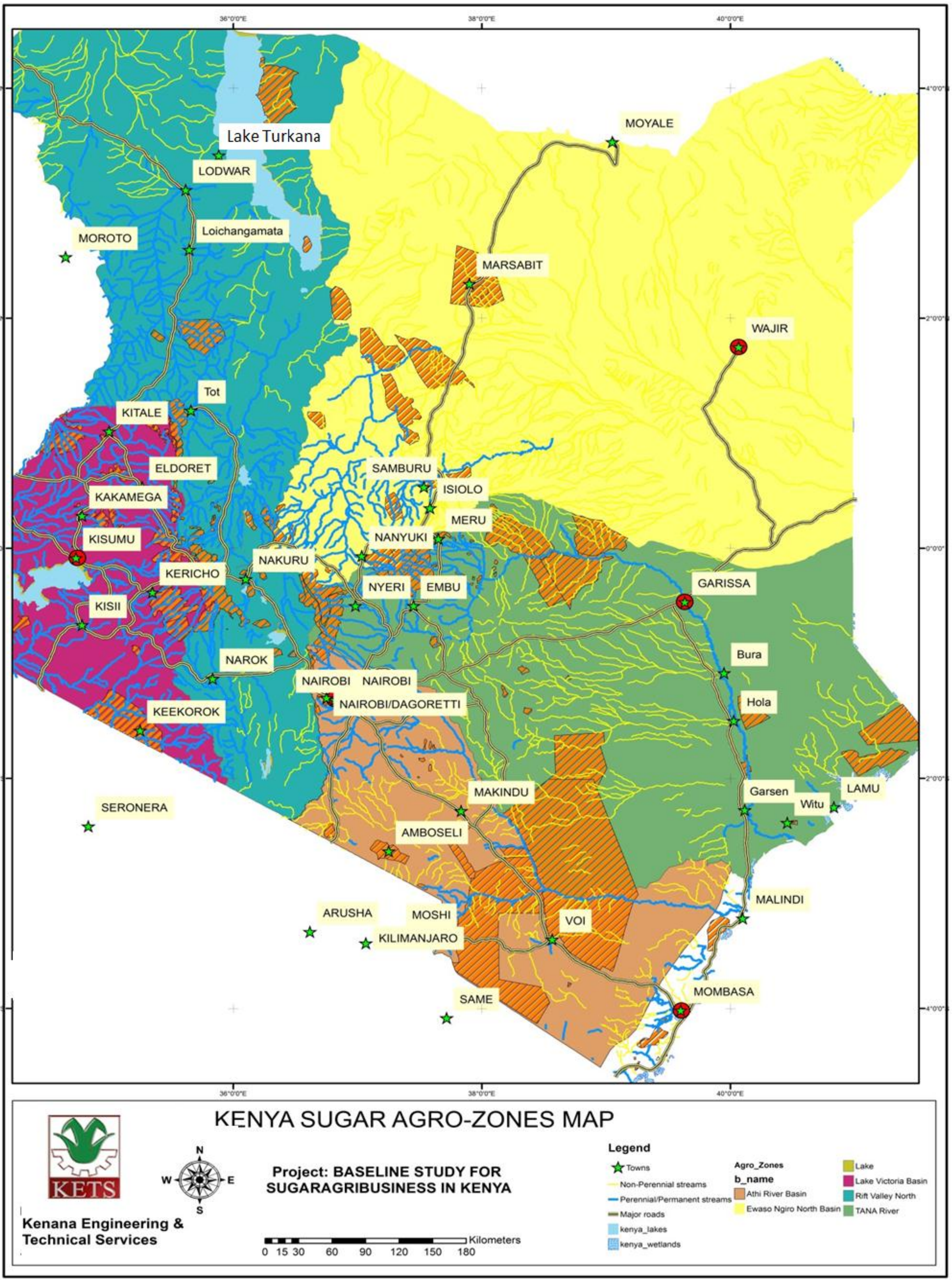


Figure 7-2: Map of Kenya Sugar Agro Zones

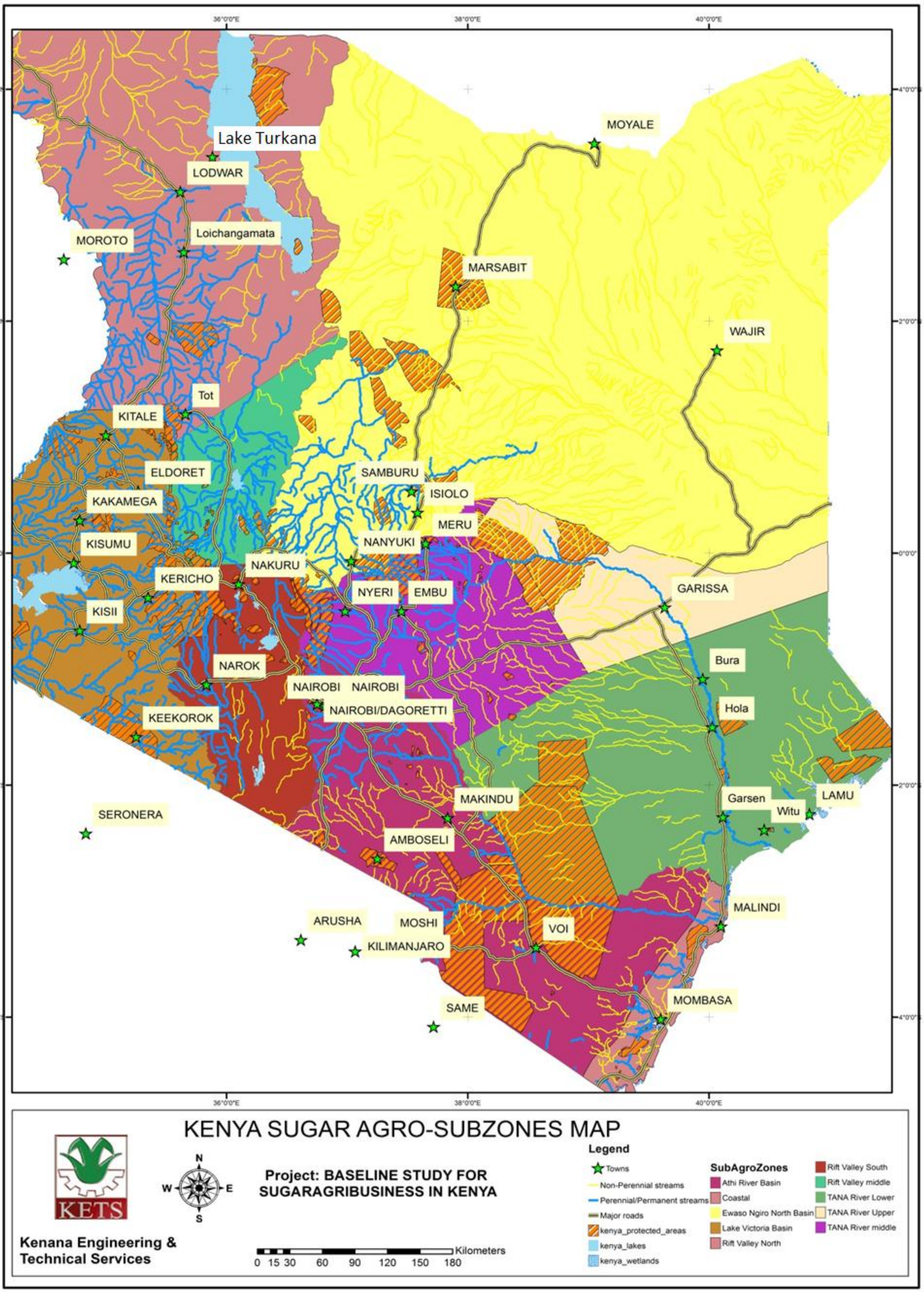


Figure 7-3: Map of Kenya Sugar Agro Sub-zones

7.1.1. SUGARCANE MATRIX

It is well known that sugarcane, as a crop, is affected by many biotic and abiotic factors which ultimately influence productivity per unit area. The suitable ranges of temperatures, sunshine, humidity, and elevation required for optimum cane development, from germination to the stage of ripening, are listed in Table 7-1. The matrix was used by KETS team to assist in selecting the Agro Zones in the different regions of Kenya.

Kenya is characterized by a suitable climate which supports sugarcane growth and development in the selected Agro Zones especially in the, flat, deep and well drained soils. Based on soil physical and chemical properties, loamy soils was rated as the most suitable soil type for sugarcane cultivation due to its easy workability by machines. Clay soil is also favorable for sugar cultivation, but characterized by some limitations at wet conditions, in contrast to loamy soil, and it is has a high Cation Exchange Capacity (CEC) that could support sugarcane into advanced ratoons as reported in Australia and Kenana Sugar Company in Sudan. For instance, at Kenana and for more than thirty years, nitrogen and phosphorus are the main elements which are added as inorganic fertilizers to vertisols under a mono-cropping system with no signs of soil deterioration in spite of the high obtained cane yields per Ha (Table 7-2).

In both loamy and clay soil long furrow irrigation could easily be practiced for getting high crop yields. Sandy soil is less favorable for sugarcane cultivation due to its poor chemical properties, but addition of adequate fertilizers under a drip irrigation system can support excellent sugarcane growth and yields. KETS team had the chance to see good growth of sugarcane farms of Kwale International and Allied Sugar Company. The detailed soil suitability map (Figure 7-6) shows the different Agricultural and sub-agricultural zones.

Table 7-1: Sugarcane matrix

No.	Parameter	Level/type	Remarks
1	Water - rains	1200 - 1500 mm	Sugarcane grows best in warm sunny, frost free weather. It needs fertile soils at least 1500 mm of rains annually supported by supplementary irrigation
2	Sunshine	7 to 9 Hrs	Sun loving plant , greater incident radiation favours sugar yields
3	Winds	60 Km/hr	High winds exceeding 60Km/hr are harmful to growing cane and causing lodging
4	Optimum temperature/Cane growth		
	A. Germination	27 - 33 C^{o}	Optimum
	B. Tillering	26 - 32 C^{o}	Optimum
	C. Photosynthesis	24 - 30 C^{o}	Optimum
	D.Mobilization ripening	16 - 26 C^{o}	Optimum
5	Soil PH	6 - 8 ph	Optimum
6	Soil type	▪ Sandy loam to clay loam - the best is well drained /loamy soil. ▪ Heavy clays with proper drainage & addition of organic matter. ▪ Saline/alkaline and acidic soils are not suitable for sugarcane.	Loamy soils are the ideal best soils for growing sugarcane
7	Elevation	From sea level up to 1700 m	
8	Altitudes	35° N 35° S	

Table 7-2: Soil Criteria

	Class			
Soil Characteristics	**Good**	**Average**	**Restricted**	**Unfit**
Effective depth	Deep	Medium	Shallow	Too shallow
Soil texture	Clayey	Medium to clayey	Sandy	Too sandy
Relief	Flat	Rolling	Too rolling	Hilly
Fertility	High	Medium or low	Too low	Too low
Drainage	Good	Medium to accentuated or incomplete	Incomplete	Excessive or deficient
Restraints to mechanization	Absent	Medium	Strong	Too strong
Susceptibility to erosion	Low	Medium	High	Too high
Source: Kofeler and Bonzelli (1987)				

Source: Kofeler and Bonzelli (1987)

As shown in the table above, Kenya soils were assessed and rated based on different soil characteristics.

7.1.1.1. CLIMATIC CONDITIONS

Global data was used and calibrated using Geo-statistical methods of analysis to fill the gaps and make the necessary adjustments using more accurate data from optical stations and FAO data.

Geo-statistical techniques assumed that at least some of the spatial variation observed in natural phenomena could be modeled by random processes with spatial autocorrelation. These require the spatial autocorrelation to be explicitly modeled. Geo-statistical techniques can be used to describe and model spatial patterns (variography), predict values at unmeasured locations (kriging), and assess the uncertainty associated with a predicted value at the unmeasured locations.

7.1.1.2. WATER RESOURCES ASSESSMENT

a) Water demand

Reference Evapotranspiration

As detailed in Chapter Three, meteorological data was used to estimate the reference evapotranspiration denoted as ET_o.

The FAO Penman-Monteith method (equation no.1) was used to calculate the reference evapotranspiration which is considered an indicator for crop water requirement.

$$\lambda ET = \frac{\Delta(R_n - G) + \rho_a c_p \frac{(e_s - e_a)}{r_a}}{\Delta + \gamma\left(1 + \frac{r_s}{r_a}\right)}$$

Where:

- Rn is the net radiation
- G is the soil heat flux,
- (es - ea) represents the vapour pressure deficit of the air
- ρa is the mean air density at constant pressure
- cp is the specific heat of the air
- Δ represents the slope of the saturation vapour pressure temperature relationship
- γ is the psychrometric constant; and
- rs and ra are the (bulk) surface and aerodynamic resistances.

The Penman-Monteith approach as formulated above includes all the parameters which govern energy exchange and corresponding latent heat flux (evapotranspiration) from uniform expanses of vegetation. Most of the parameters are measured or can be readily calculated from weather data. The equation can be utilized for the direct calculation of any crop evapotranspiration as the surface and aerodynamic resistances are crop specific. (FAO 56)

Figure 7-4 illustrates the distribution of annual reference evapotranspiration within Kenya.

From ET_o and the general annual rainfall distribution, the crop water requirement (CWR) was roughly estimated as shown in Figure 7-5. The calculation took into consideration effective rainfall of 80 % out of the minimum values of rainfall ranges and assumed the average of sugarcane crop factor (K_c) to be (1.15).

The green spots in Figure 7-5 could be recommended for rain-fed sugarcane projects needing minor supplementary irrigation and these areas will be the most suitable for sugar cultivation considering only water requirements and irrigation cost parameters.

In the same figure, as the color changes from green to red, more irrigation supplement will be required. However, the irrigation will incur more cost and will be limited by the capacity of the water resources and water balance in each catchment.

Water resource layers and irrigation requirements layers were analyzed and processed with other parameters in the selection criteria and the outcome from this analysis constituted the proposed potential areas for sugarcane cultivation. More detailed analysis has been applied for each proposed location as needed.

b) Water balance

Water balance for each zone will be discussed. Generally the available data indicated good opportunity for cultivating sugarcane and establishing a sugar industry in the costal, Tana and Rift Valley areas and to support the existing sugar cultivation in the west zone.

7.1.1.3. Soil analysis

As shown in Figure 7-6, nine suitability levels with different weights were indicated under the soil types and based on effective depths, soil textures, reliefs, drainage, constraints to mechanization, and susceptibility to erosion.

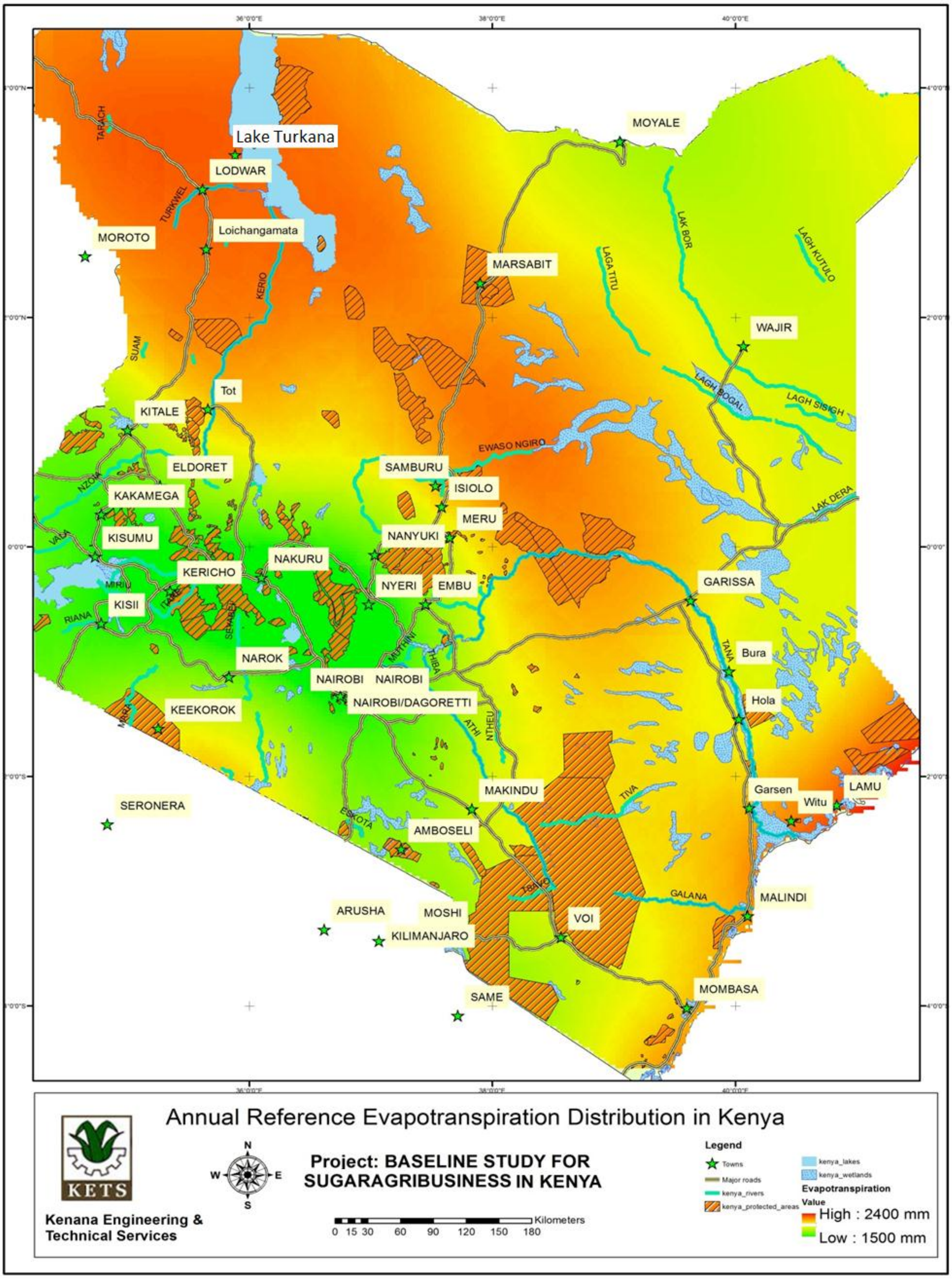


Figure 7-4: Estimated Annual Reference Evapotranspiration in Kenya

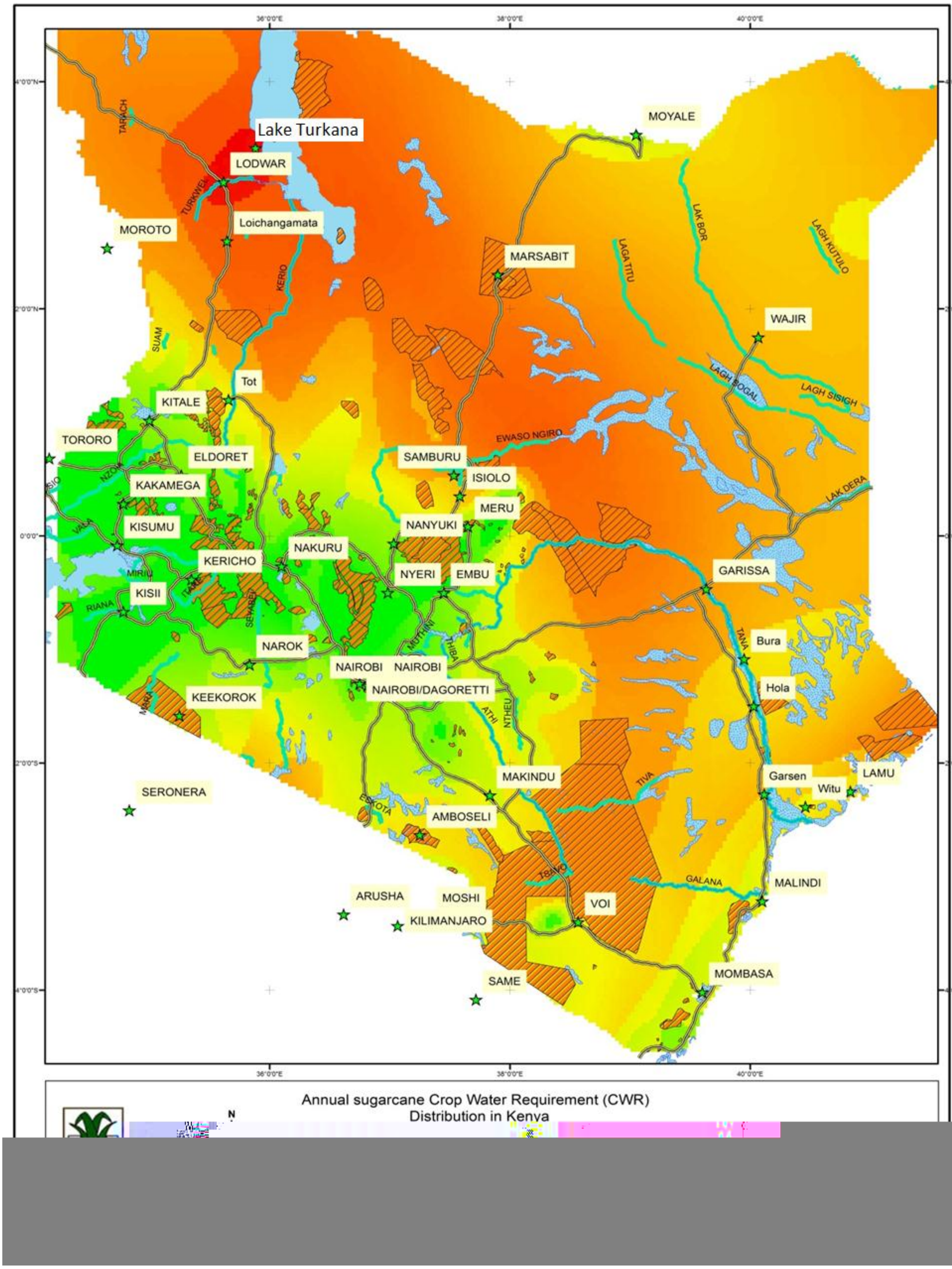


Figure 7-5: Estimated Annual Sugarcane Crop Water Requirement (CWR) distribution in Kenya

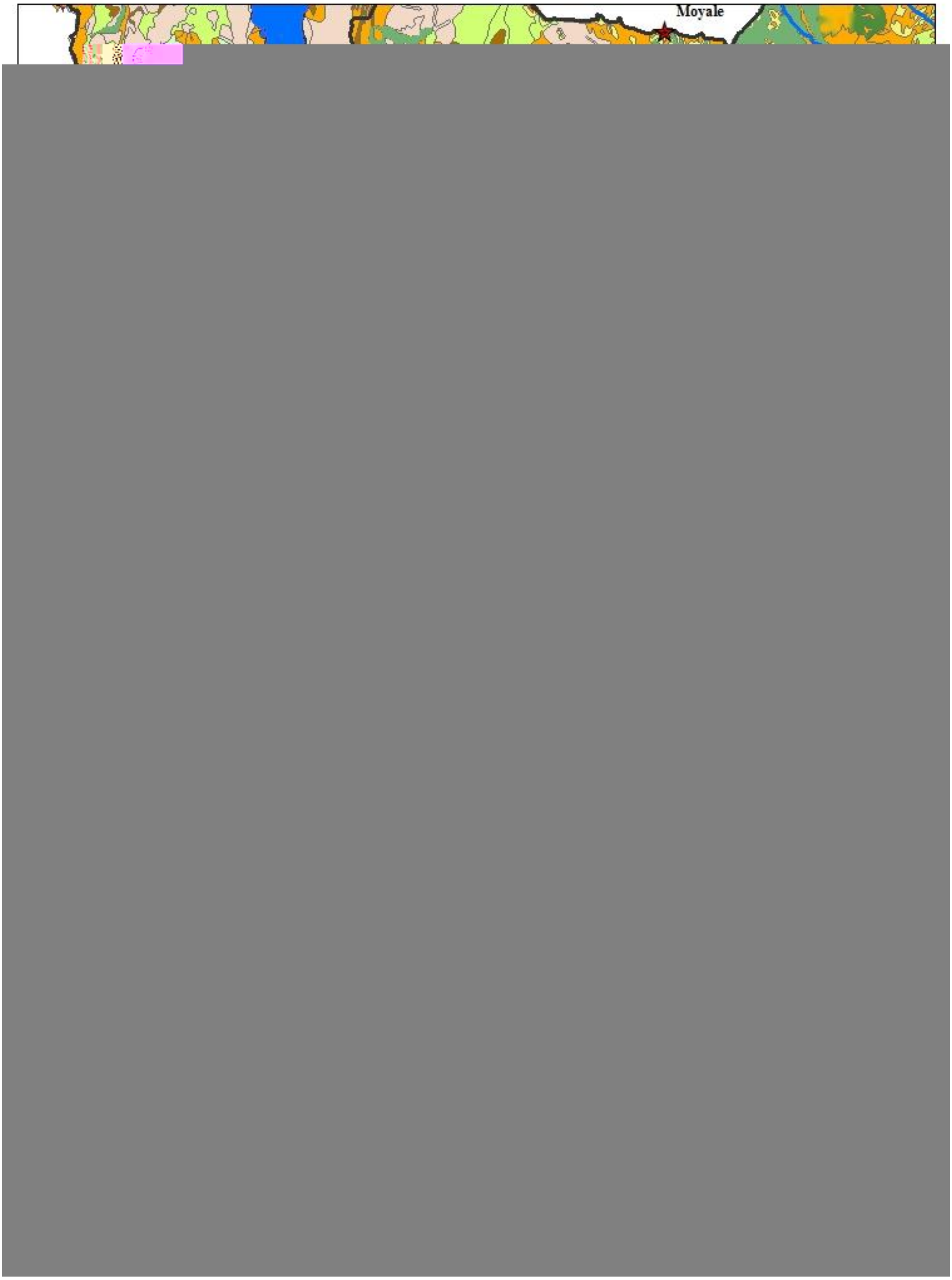


Figure 7-6: Soil Map of Kenya

7.1.1.4. Socio economic and environmental factors

The baseline study analyzed and presented data on existing socio-economic characteristics and the factors that reflect positive behavior and attitude and challenges to ensure the successful introduction or impediments to the introduction of the sugar industry into the potential areas.

Environmental factors were also factored in to improve the selection process and to ensure the sustainability of the sugar projects when established.

The factors of biodiversity and endangered animal and plant species were high on the list of criteria. Supplying sustainable water and the issue of land degradation were ranked second and third respectively. The economic and social dimensions which will be discussed later in the report were regarded critical aspects of sustainable development.

7.1.2. Sugar Beet Matrix

7.1.2.1. Overview on Sugar Beet

Sugar Beet (*Beta Vulgaris*) is the most important member of the family *Chenopodiaceae* which includes several other crops such as spinach, table beet and fodder beet. Sugar Beet is a biennial plant which grows in the first season to produce vegetative and root parts and in the second season and under suitable climatic conditions it produces the seeds. Beet seed is a fruit containing 2-5 embryos is called multi-germ seed. Commercial beet was bred from high sugar content fodder beet. Botanically it is characterized by broad, green, and veined leaves and a large tap root system tapering into smaller and longer roots which penetrate the soil. The mature beet is composed of the crown, the neck and the root. Depending on the variety, crop stand and the growing conditions the weight of the sugar beet root ranges from 0.5 kg up to 3 kg.

Extraction of sugar from beet was one of the major agricultural developments of nineteenth century in Northern Europe. The crop was acclimatized and got adapted as a temperate crop despite the fact that the natural habitat of its ancestors is the Mediterranean and North Africa.

Experimental work in Germany laid the foundation of the beet sugar industry while the Napoleonic wars enhanced its development as an alternative to cane sugar introduced from the tropical areas. Nowadays, sugar beet is responsible for about one third of the total world sugar output, mainly in the temperate regions, while the remainder comes from sugarcane grown mainly in the tropical regions of the world.

Breeders were able to evolve some high yielding and disease resistant sugar beet varieties adaptable to the tropics. The introduction of mono-germ cultivars allowed sowing the crop without the need for the expensive thinning operation. The potential for large scale cultivation of the crop offers good opportunities for agro- industrial investments. In addition to the sugar production, the crop residues and its by-products such as tops, pulp and molasses are useful for livestock feeding and the production of the bio-fuel ethanol.

7.1.2.2. ADVANTAGES AND DISADVANTAGES OF SUGAR BEET

Sugar beet is relatively a short duration crop which gives room for other rotational field or vegetable crops. It is thus maximizing on land utilization, unlike the mono-cropping system of sugarcane cultivation. Sugar beet consumes only about one third of the water and one half of the fertilizer applied to sugarcane in the same unit area. It is tolerant to salts and to a certain degree, it is non-sensitive to micro element deficiency which allows cultivation in marginally suitable soils. However, beet after beet cultivation which encourages nematode and other soil pests is not recommended, that is, the land should not be replanted with beet for at least two seasons; other rotational crops could be grown instead.

Sugar beet is known to be susceptible to a wide range of pests and diseases unlike sugarcane which is less susceptible to attacks of pests and diseases. Sugarcane seed material is abundantly available as cuttings from the same crop while sugar beet seeds have to be imported every sowing season. Lack of bagasse as a by-product of sugar beet industry is a b0g disadtge 3ns cge 3bagasse 34�s)-32(a)-33(f)-4(re)-2ge 3of 3-53(en)-eql(c)(ge 3)-5ourat ibl5-3(t)-4(

thermal induction is necessary lo bring about climate as a winter crop. In general, sugar beet grows well with satisfactory sugar accumulation at temperatures ranging between 20 and 30^0C. Sugar beet has successfully been introduced in the last thirty years far south into the subtropical region. In North Africa, Egypt and Morocco are leading beet sugar producers, both cultivating the crop in winter in considerable areas.

The ideal soil type which suits the growing of sugar beet ranges from sandy loam to loamy clay, with good texture, aeration and water permeability. Soil pH in the range of 6.0 to 8.0 is to be optimal.

As a new sugar crop into the farming system, research on the crop should be planned and carried out to address the following:

- Selection program to release sugar beet varieties of high root yield and sucrose content
- Identifying the sowing date and planting rate which gives the highest root and sucrose yields
- Recommending effective weed control strategies
- Closely monitoring and Identifying the pests and diseases which might affect the crop under the humid conditions and recommend control measures
- Cercospora Leaf Spot (CLS) should be given attention
- Recommending packages of land and field operations and harvesting techniques which optimize yield

7.1.2.4. CLIMATE

According to climate suitability the potential areas for sugar beet were divided into the following three classes:

Class 1: fits into the required climate for sugar beet to meet different growth stages and harvesting from April to September.

Class 2: less fitting than Class 1 whereby the minimum temperature is slightly lower than required) or higher than the temperature required for pre-harvesting stage as less than 10^oC is required.

Class 3: the climate is marginally matching the required climate for sugar beet for different growth stages and beyond the optimum temperature for pre-harvesting stage.

7.1.2.5. RAINFALL

Water required for sugar beet in Kenya is within the range between 500-750mm per season/cultivation period (April to September). In the sugar beet areas where the rainfall is more than 550mm, no supplementary irrigation is required. The suitability for rainfall intensity to cultivate sugar beet is shown in Table 7-3. Figure 7-7 shows the total rainfall for the expected cultivation period as well as proposed areas for sugar beet.

Table 7-3: Total rain fall per season (April to September)

Total rainfall per season (April to September)	Suitability for sugar beet
0-450 mm	Irrigation is Required
451-550 mm	Marginally sufficient /Supplementary irrigation
550-750 mm	Optimum
751-1000 mm	Good
1001-1250 mm	Excessive rain causes water logging , raising humidity and difficulties in field activities

7.1.2.6. SOIL SUITABILITY

In the analysis of this survey, unsuitable soils have been excluded from the potential areas. Unsuitable soils included areas of poor drainage, steep, rapid percolation, very slow infiltration, high/low pH, etc.

The five identified Agro Zones will be discussed in greater details in the following sections.

Figure 7-7: Sugar Beet Potential Areas

7.2. WESTERN ZONE (LAKE VICTORIA BASIN)

7.2.1. OVERVIEW

This Agro Zone represents the existing sugar industry in Kenya. Comprehensive assessments of the Kenyan sugar industry, mills' performances, sugarcane production, reasons behind low yields, and challenges will be discussed in greater details in the upcoming sections. The potential for the expansion of the existing sugar industries horizontally and vertically will be discussed. Additionally and regarding the future development of Kenyan sugar business, strategic recommendations have been made to KSB.

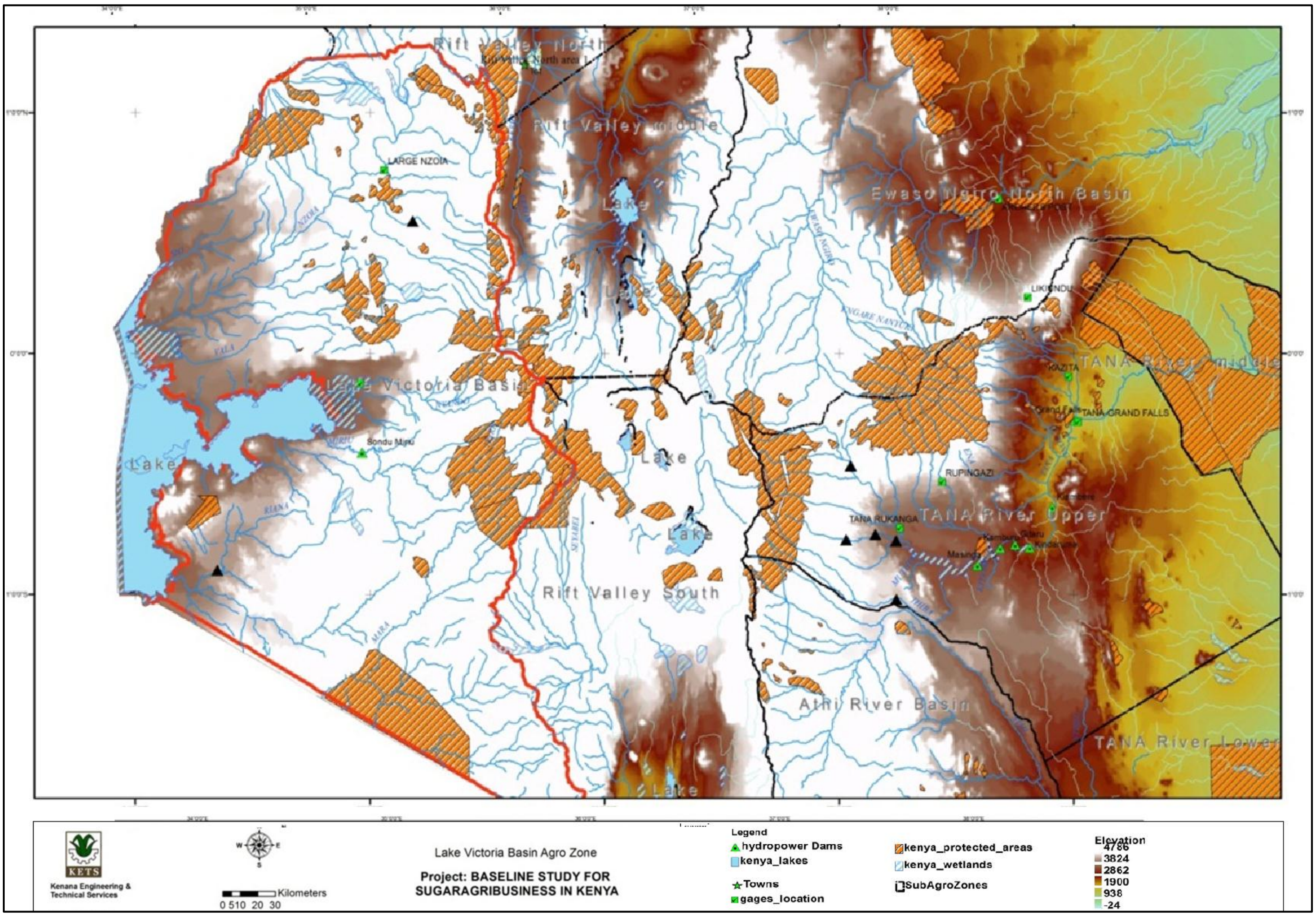


Figure 7-8: Western Agro Zone

7.2.2. STATUS QUO OF SUGAR INDUSTRY IN WESTERN KENYA

The existing sugar agro business in Kenya (Figure 7-9) includes 11 sugar mills with a combined crushing capacity of approximately 30,000 tons of cane per day (TCD) and a total production of 500,000 tons of raw sugar annually. The supply of cane to mills mainly depends on an out- growers system with limited cane volumes harvested from nucleus farms owned by sugar companies. Unlike the other Agro Zones, the rainfall intensity and duration allows sugarcane farming to rely solely on rainfall with very minimal supplementary irrigation. This zone, being the main sugar producing area in Kenya, faces a variety of technical, operational and management challenges which fortunately don't seem insurmountable as there is room for improvement and production expansions if the problems are well identified and addressed as explained in the report.

7.2.1.1. INDUSTRY PERFORMANCE

The average figures of all factories for years as illustrated in the Yearbook of Sugar Statistics, the KSB, 2011 and Table 7-4 indicate the following:

1. Total cane crushed is about 5.8 million tons per year
2. Pol% cane decreased from 13.28% to 11.35% (poor cane quality)
3. Sugar recovery decreased from 10.7% to 9.3 (Poor sugar recovery)
4. Mill extraction about 90.5% (very poor compared to 95%min mill extraction)
5. Overall time efficiency decreased from 70.9% to 63% (very poor compared to 90% min efficiency)
6. High losses in bagasse filter cake, and final molasses

It is clear that the Kenyan sugar industry is facing challenges of cane quality and industry performance over the decades. The following account will give a brief assessment of the main sugar companies individually and give recommendations in each case.

It is to be noted that the new sugar factories (Butali, Transmara and Sukari) are limited by the cane availability and quality (Table 7-5).

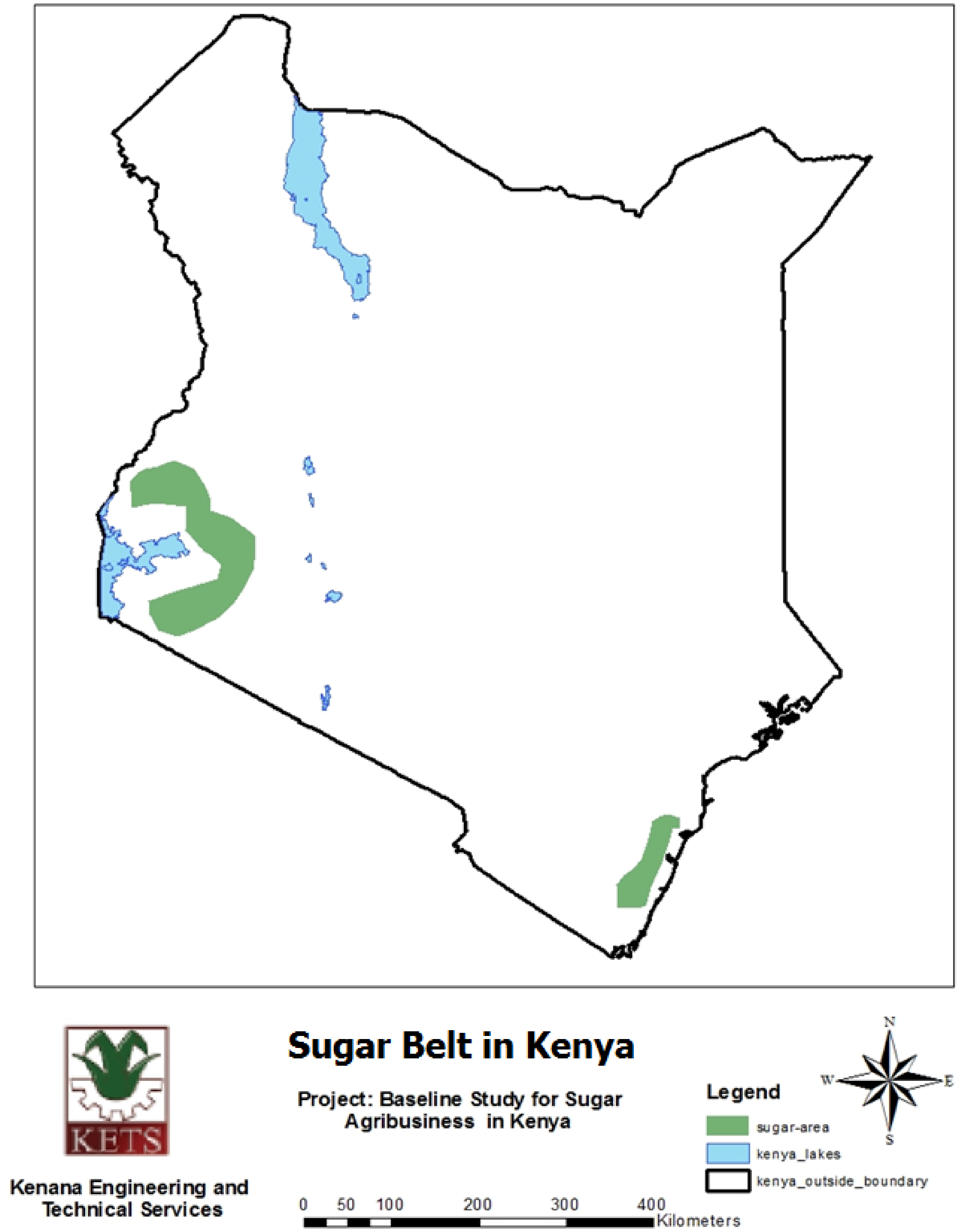


Figure 7-9: Existing Sugar belt in Kenya

Table 7-4: Installed capacity of sugar mills in Kenya

Factory	Year Built	Installed Capacity (TCD)
Miwani Sugar Company Ltd (currently closed)	1927	1,500
Chemelil Sugar Company Ltd	1968	3,500
Mumias Sugar Company Ltd	1973	8,400
Nzoia Sugar Company Ltd	1978	3,250
South Nyanza (Sony) Sugar Company Ltd	1979	2,400
West Kenya Sugar Company Ltd	1981	3,000 (Up rated)
Muhoroni Sugar Company Ltd (operating under receivership)	1966	2,200
Kibos Sugar & Allied Industries	2008	1,800
Butali	2011	1,500
Transmara	2011	1,500
Sukari	2011	1,500
TOTAL		30,550

Table 7-5: Cane milled, sugar made, TC/TS ratio and sugar recovery by factory

Factory	Cane Crushed (Mt)		Sugar Made (Mt)		Cane:Sugar Ratio (Tc/Ts)		Sugar Recovery (%)	
	Jan - Dec 2011	Jan - Dec 2012	Jan - Dec 2011	Jan - Dec 2012	Jan - Dec 2011	Jan - Dec 2012	Jan - Dec 2011	Jan - Dec 2012
Muhoroni	370,099	445,438	26,279	30,536	14.08	14.59	7.10	6.86
Chemelil	344,880	294,088	21,501	15,977	16.04	18.41	6.23	5.43
Mumias	1,964,063	1,960,258	194,714	181,372	10.09	10.81	9.91	9.25
Nzoia	635,920	727,921	61,291	67,003	10.38	10.86	9.64	9.20
South Nyanza	689,389	536,838	72,346	52,470	9.53	10.23	10.49	9.77
West Kenya	635,394	593,329	59,234	49,565	10.73	11.97	9.32	8.35
Soin	25,217	41,297	1,564	2,551	16.12	16.19	6.20	6.18
Kibos	391,886	433,291	28,781	26,179	13.62	16.55	7.34	6.04
Butali	322,718	415,546	35,354	42,671	9.13	9.74	10.96	10.27
Transmara*	3,838	183,059	227	16,458	16.91	11.12	5.91	8.99
Sukari*	1,820	198,993	182	17,781	10.00	11.19	10.00	8.94
Total	5,385,224	5,830,058	501,473	502,563	10.74	11.60	9.31	8.62

*Transmara and Sukari Industries began operations in December 2011

A brief account on the performance of the sugar mills is given below:

1) ***Chemelil Sugar Company***
   - Total cane crushed decreased from 602,304 tons in 2002 to 294,088 tons in 2012
   - Pol% cane decreased from 12.34% to 10.54% which indicates poor cane quality
   - Sugar recovery decreased from 10.0% to 6.2 which is very poor compared to standards
   - Mill extraction of about 90.5% is very poor compared to standard of minimum 95%
   - Capacity utilization deteriorated from 60.8% to 28.5%
2) ***Muhoroni Sugar Company***
   - Total cane crushed was 445,438 tons in 2012
   - Pol% cane decreased from 12.28% to 9.97% indicating poor cane quality
   - Sugar recovery decreased from 8.81% to 7.10 which is very poor compared to standards
   - Mill extraction of about 92.0% is very poor compared to standard of a minimum of 95%
   - Capacity utilization decreased from 51% to 42.4%
3) ***Mumias Sugar Company***
   - Total cane crushed about 1,960,258 tons in 2012
   - Pol% cane decreased from 13.44% to 11.18% which is poor compared to standards
   - Sugar recovery decreased from 11.65% to 9.91 which could be rated as good
   - Mill extraction of about 96% is very good compared to minimum standard of 95%
   - Capacity utilization of about 67% is rated as very good
4) ***Nzoia Sugar Company***
   - Total cane crushed was 727,921 tons in 2012
   - Average pol% cane of 13.0% is rated as good
   - Sugar recovery of about 9.9% could be rated as good
   - Mill extraction of about 91.0% is very poor compared to the minimum standard of 95%
   - Capacity utilization increased from 51% to 70.0% which is very good
5) ***South Nyanza (SONY) Sugar Company***
   - Total cane crushed was 536,838 tons in 2012
   - Average Pol% cane is 13.0% which is good
   - Sugar recovery of about 10.0% is good
   - Reduced mill extraction about 92.0% (very poor compared to 95%min mill extraction)
   - Capacity utilization decreased from 67% to 60%

6) ***West Kenya Sugar Company***
   - This factory has been uprated from 210,000 ton cane/year to about 650,000 ton cane/year and in 2012 it processed 593,329 tons of cane
   - Pol% cane deteriorated from 13.9% to 11.0% which is low compared to standards
   - Sugar recovery of about 9.5% could be rated as average
   - Mill extraction of about 94% could be rated as good
   - Capacity utilization increased from 56% to 70%
7) ***Kibos Sugar & Allied Industries (2008)***
   - Total cane crushed about 433,291 tons in 2012
   - Pol% cane dropped from 11.58% to 9.15% indicating poor cane quality)
   - The sugar recovery of about 8.5% is poor
   - Mill extraction of about 95% is very good compared to standards
   - Capacity utilization decreased from 88% to 74%
8) ***Soin***

Total cane crushed was about 41,297 tons and the percent of sugar recovery was poor at about 6% probably due to the milling of immature cane. Other factory operational parameters were not reported by this factory for lack of laboratory equipment. Currently, this factory contributed only 0.51% of the total industry production.

9) ***Butali***

Butali Sugar Mills has completed its second year of operation to produce 42,671 tons of sugar in 2012, a jump of 21% over production in 2011. Similarly, the volume of cane processed rose by 29% to 415,546 tons in 2012 from 322,718 tons in 2011.

The factory reported a drop in sugar recovery with a TC/TS conversion ratio increasing to 9.74 in 2012 from 9.13 in the previous year. However, this factory recorded the best sugar recovery for the industry during the year under review.

10) ***Sukari***

Sukari Industries Ltd started operations in December 2011. The factory has a rated capacity of 62.5 TCH. In 2012, the factory crushed 198,993 tons of cane and produced 17,781 tons of sugar at a TC/TS conversion ratio of 11.19.

The low capacity utilization of 39% was attributed to stoppages caused by lack of cane. The Company is however addressing the cane availability situation through an aggressive program to contract farmers.

11) Transmara

The sugar mill started operations in December 2011 with an installed capacity of 52.1 TCH. In 2012, Transmara milled 183,059 tons of cane to produce 16,458 tons of sugar at a TC/TS conversion ratio of 11.12. Cane shortages resulted in low capacity utilization of 39%.

Factories with good track records should maintain productivity while the following measures are recommended to improve the productivity of the other low performing sugar mills:

- Mechanical efficiency of the mills to be revisited
- Cane issues to be assessed and resolved
- Reasons for low sugar recoveries to be assessed

7.2.2.2. SUGARCANE PRODUCTION IN WESTERN KENYA

It is quite clear that the Kenyan sugar sector functions through three main stakeholders, these sectors are the regulatory bodies, the millers, and the out-growers. The out-growers represent the back bone of the sugar industry as the community is responsible for the growing of the sugarcane crop and supplying the factories with approximately 95% of their crop requirements. Shouldering this task, the out-growers are in need of much support, motivation, and incentives in terms of getting easy to repay credits, direct and continuous on-farm backup based on technology transfer and assistance in planning and management of field operations. Capacity building programs are thus needed to promote performance of the farming community. However, this was not tangible to KETS mission when it toured some cane areas of west Kenya. The average cane yield in the Agro Zones of all the eleven factories was reported to be 51 TCH which is below the world average of 64.4 TCH.

Table 7-6 shows farm and mill yields in some sugar producing countries. Although a number of Kenyan sugar factories scored high cane in some years, the trend of cane yield decline was observed to have persisted from 2009 and continued till 2012 as shown in Figure 7-10, something which seriously impacted the Kenyan sugar industry.

The reviewed historical sugarcane production data showed that the productivity per hectare for the last two decades is lower than the cane yields obtained during the eighties of the last century and that Kenyan sugar sector maintained production as a result of expansions in cultivated land rather than output increase of farm lands.

Table 7-6: Sugarcane and sugar yields in main sugarcane growing countries

Country	Cane yield (t/ha)	Sugar recovery (%)	Sugar yield (t/ha)
Australia	100.4	13.8	13.85
Egypt	110.8	11.5	12.74
Brazil	68.4	14.5	9.91
U.S.A.	80.2	11.7	9.38
Colombia	80.5	11.5	9.26
Mexico	79.5	11.6	9.22
India	66.9	9.9	6.62
Pakistan	50.3	9.2	4.63
World Avg.	64.4	10.6	6.82

Source: FAO Production Yearbook, 1998; Sugar and Sweetener, USDA, June 1997.

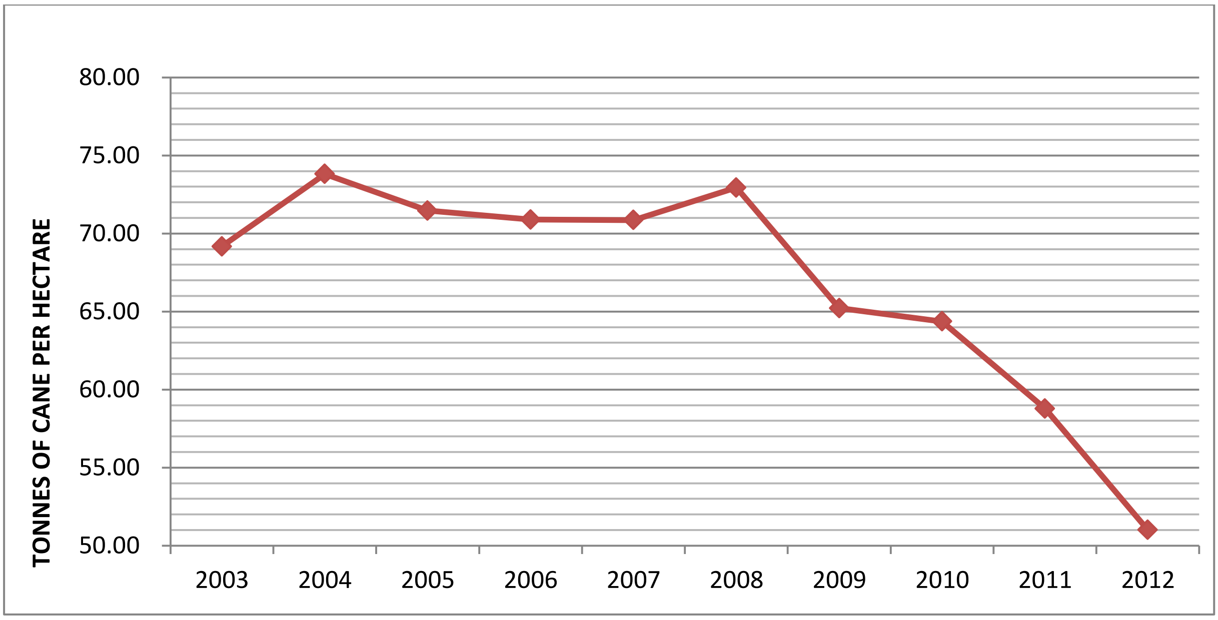


Figure 7-10: Sugarcane Yield TCH in Kenya (2003 - 2012)

7.2.2.3. Reasons behind low cane yields

The low cane yields and high cost of production could partially be attributed to:

1. Deteriorating soil fertility
2. Weakness in spreading high yielding sugarcane varieties
3. Ineffective weed control strategies
4. Intermittent moisture stress
5. Fragmentation of cultivated land
6. Lack of /or untimely application of inputs

7. Poor management
8. Low quality seed cane material for plant crop establishment
9. Failure to manage to proceed to late ratoons
10. Insufficient sustainable technical support to out-growers
11. Frequent cane shortages which led to the milling of immature cane
12. High cost of cane harvesting and transportation (over 45% of total cane production cost)
13. Millers are exposed to pressures from farmers which escalates cane price;
14. Millers' competition to get the raw material illogically increase its price;
15. Competition for cane results in millers transporting cane from distant catchment areas which affects cost;
16. Dilapidated roads and other infrastructure
17. Cane losses during transportation
18. Lack of sufficient finance for government owned mills to meet its production targets
19. Lengthy off-loading time at factories
20. Poor factory maintenance due to cash flow challenges
21. Lack of capacity to utilize the by-products of the industry, the molasses and bagasse for the production of ethanol and power generation

Plate 7-1 shows the poor vigor of sugarcane in some fields in the West Kenya.

Plate 7-1: Poor vigor of sugarcane

7.2.2.4. MILLS AND CATCHMENT AREA IN WESTERN KENYA SUGAR BELT

High cost of production is partly attributed to limited amount of cane which leads to competition between millers each trying to capture the cane volumes to secure its production target. The competition gives rise to:

- Cane being transported from distant catchment areas which increases the cost
- Mill receiving stale cane due to long cycle from harvesting to loading to off-loading at factory
- Harvesting of immature cane forcing some mills to crush as much as twenty tons of cane to produce one ton of sugar
- Mills hungry for the raw materials and scrambling to get it succumb to pressures from out growers and pay high price per ton of cane

Whereas less than a decade back the problem was the low milling capacity which resulted in cane standing for two and sometimes for three years in many farms, the reverse to the other extreme is now happening and the two situations negatively impact the industry and cause a lot of distortions.

Sugar mills establishment which started after independence and continued up to the early 80s of the last century as a commitment of the Kenyan government to develop rural areas, was planned to cover, in a balanced fashion, the area termed today as the sugar belt. Factories were deployed to each utilize the cane crop in a catchment area that practically would be poached by another factory and to keep farmers inextricably linked to one mill. However over the last decade, new factories have been erected without much consideration to the Sugar Act which defined the buffering distance of (40 Km) between one mill and the other. For instance, the distance between West Kenya and Butali is far much less and both went to court to settle a dispute over the matter. Chemilil and Mumias sugar also battled in courts over cane disputes while Sony, which had opposed licensing of Sukari and Transmara sugar companies in the first place, is now complaining the new facilities are collecting cane from its catchment area.

The current crowding of mills (Figure 7-11) which are competing within the same farming system to get a share of the limited cane, pushed some millers to follow ways, considered by other millers as violating their cane rights, to achieve that end, and at the same time, gave some out growers room to breach their contracts. This is a reality and the fallout requires strong measures and actions to curb. The KSB should use its mandate to enforce important measures such as:

a. Payment to out growers must be immediately upon cane delivery which will motivate them to optimize productivity
b. The KSB should monitor and mediate realistic cost items particularly the transport of cane to ensure out growers are fairly paid and motivated
c. Millers, with the involvement of the KSB and out grower's societies, should allocate an agreed upon percent of their proceeds to tangibly support local communities within their catchment areas to cement their relationships. Honoring commitments and maintaining a link of this nature could be much stronger than signed contracts.
d. Lobby with appropriate government departments to extend roads and other services to new areas to encourage establishment of new sugar facilities out of the jammed zone
e. Licenses for new facilities should be issued on condition the miller is capable of developing a new sugarcane zone
f. The Sugar Development Fund (SDF) which is a 7% levy charged on all sugar sales is allocated as follows:
    - Cane Development 2%
    - Infrastructure 1%
    - Factory Rehabilitation 3%
    - Grants to Research 0.5%
    - KSB Administration 0.5%

The percent of the fund earmarked for the cane development, infrastructure, factory rehabilitation and grants to research should be made available to financing these essential activities to speed up the privatization process.

g. The privatization process which is planned by the government to divest part of its shareholding to generate reasonable capital to modernize and expand capacity can’t takes off easily under the current financial situation of targeted sugar companies. Noting that Soin is heavily indebted, Miwani and Muhoroni are under receivership and Chemilil struggles with immature cane supplies and a high TC/TS ratio. To attract investors, efforts have to be exerted to promote the efficiency and put these factories on track. Installing capacities to utilize the by-products must be planned to improve revenue and cash flow.
h. As stakeholders, the out growers should be partners when privatizing government owned factories. Out growers in Mumias Sugar, the largest sugar producer in Kenya own 30% of the facilities.
i. To minimize competition, the feasibility of the acquisition of two or three adjacent factories by one holding company should be explored.

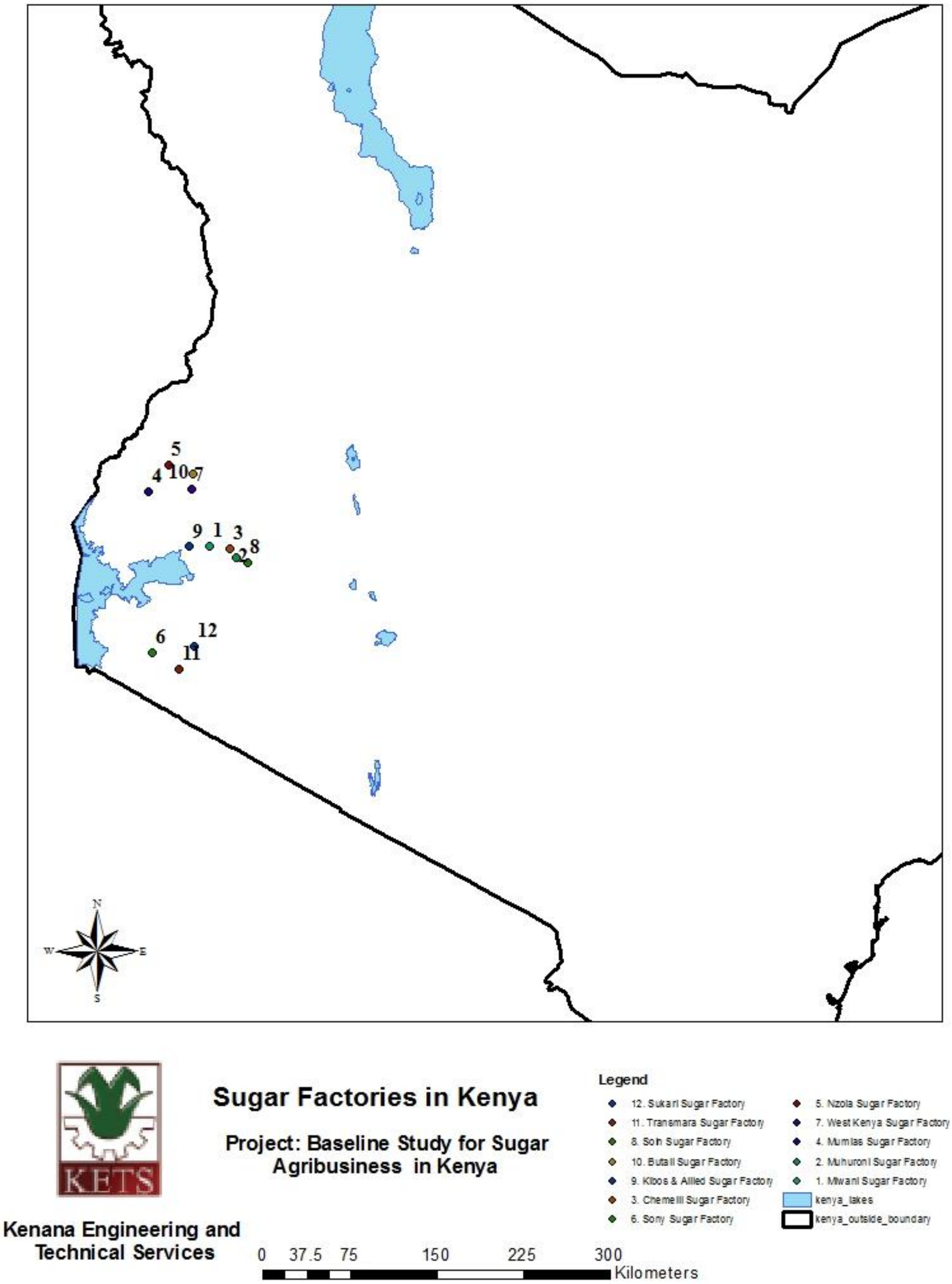


Figure 7-11: Concentration of Sugar mills in western part of Kenya

The situation as it now stands could further be improved by:

- The current catchment zones for each mill should be redefined in proportion to a mill's actual capacities. The following table gives the estimates of cane areas harvested for each mill in 2011/2012 season based on actual volume of cane crushed and an average yield of 55 tons per hectare.

Table 7-7: Estimates of cane areas harvested for each existing mill in Kenya

Mill	Area (ha)	Percent of total
Muhoroni	8,000	7.6
Chemilil	5,300	5.0
Mumias	35,600	33.7
Nzoia	13,200	12.5
SONY	9,760	9.2
West Kenya	10,700	10.1
Soin	750	0.7
Kibos	7,800	7.4
Butali	7,555	7.2
Transmara	3,320	3.2
Sukari	3,600	3.4
Total	**105,585**	**100**

- Based on the defined catchment area, the KSB together with millers and Kenya Cane Transporters Association (KECATRA) should set a realistic benchmark for transport cost
- The KSB should take all measures necessary to ensure millers abide with the guidelines.
- A package of incentives, e.g. grants to up-rate or rehabilitate could be proposed to committed millers as well as punitive measures against violators. The KSB should stand at an equal distance from all millers.

A main approach which will ease the bottlenecks of cane supplies to mills within a short period of time is to increase the cane productivity per unit area. KESREF will be expected to play a major role in this aspect through the spreading of competent and short maturing varieties as well as encouraging farmers and millers to strengthen the package of field operations and husbandry practices. Total sugar produced in 2012 was 502,563 tons compared with 501,473 tons in 2011. The increase in milled cane was 8.3% while sugar was increased by a mere 0.22% mainly due to the reduction in sugar recovery with TC/TS ratio rising from 10.74 in 2011 to 11.60 in the year 2012 (Kenya Year Book, 2012)

Improving cane quality by increasing pol% cane to 13% and overall recovery by 1% will result in an increase of 53,852 tons of sugar based on 2012 total cane production. Accordingly, emphasis should be placed on improving both cane and sugar yield. Decreasing productivity is considered one of the potent solutions to ease the existing competition between millers for cane. Therefore, the core objectives of KESREF should be geared toward the following:

- To generate and promote demand driven sugar processing technologies, products and innovations
- To strengthen effectiveness and sustainability of institutional capacity for implementing integrated agricultural and sugar processing research for development. (KESREF, Research Protocol 2010)

KESREF needs to play a more effective role in technology transfer to out growers through well scheduled extensions services in all catchment areas and should concentrate on the spreading of new high yielding varieties along with packages of recommended agronomic practices. It is worth mentioning that KETS teams found locally bred varieties with outstanding traits which are products of patient research carried out by dedicated staff of KESREF. But still remaining is the challenge to transfer technology and demonstrate the positive impact to out growers.

7.2.2.5. Critical issues

1. Cane Quality

With the exception of Nzoia and South Nyanza Sugar Companies, the quality of cane is dropping in the other milling facilities during the last two seasons. The weighted average pol % cane as a measure of cane quality achieved was 11.16, slightly less than11.35 in 2011 and 11.76 in 2010. Cane quality has shown a downward trend over the last five years.

The weighted average fiber% cane rose slightly from 17.09 in 2011 to 17.18 in the year under review. The industry target for fiber is 15.50%.

None of the factories is supplied with very good quality cane as the best pol% cane achieved was 12.48 at South Nyanza Sugar Company followed by 12.34 at Nzoia. Chemelil, Muhoroni and Kibos had been supplied with low quality cane of an average pol% cane of 10.21, 10.38 and 8.68 respectively. Even worse for these three factories was the fiber content in cane within Nyando sugar zone which was high measured against industry standards (Production Year Book 2012). In Kenana Sugar Company the fiber% cane reported annually is in the range of 15 to 16%.

The cane quality issue is of vital importance to the sugar industry as improved cane quality will be reflected directly on factory sugar yield. The following measures are recommended to improve cane quality:

- Cultivation of improved varieties with high sugar content
- Optimum age for cane harvesting (12 to 13 months)
- Use of chemical ripeners for cane destined for harvest early in the crushing season
- Application of the optimum dose of nitrogenous fertilizers; excessive nitrogen has negative impact on sucrose synthesis and storage
- Variety mapping to synchronize planting and harvesting according to maturity characteristics of each variety
- Flower control in zone where the climate is conducive to intense flowering
- Delivery of fresh cane to factory within the shortest possible time (cut-crush, 24hrs)
- Planning harvest schedule to avoid over-aged, immature and dry cane

2. Out growers Farm sizes

Sugarcane in Kenya is mainly cultivated by small-scale farmers amounting to 95%. The remaining 5% comes from large scale growers and factory nucleus farms. The sugar sub-sector is the third most important contributor to the GDP ranking third behind tea and coffee. It's a source of livelihood for about 170,000 farmers and the sugar sub-sector supports directly or indirectly almost 6 million Kenyans.

Almost all farmers own land in the range of one to two hectares of which one third is cultivated with sugarcane crop. The land holdings are scattered over a vast land area which renders the adoption of mechanized farming a difficult task unless plans to group the plots into fields of 50 to 100 hectare are made.

An important aspect related to the adoption of larger farm sizes and long furrow system is that it allows crop planning with respect to:

- Sugarcane planting and variety mapping as well as crop rotation could precisely be scheduled
- Harvest planning considering cane age factor, variety maturity trait and distance from farm gate to milling facility
- To get the buy-in of farmers, other stakeholders such as the KSB, KESREF, out-growers unions and societies and Extension Service at local governments
- Coordinate campaigns to enlighten farmers and increase their awareness on the benefits of mechanization as a tool to boost cane productivity and profitability

3. Water Harvesting and Irrigation

The cane growing in Western Kenya depends entirely on the bimodal rains, but the crop frequently suffers water shortage during critical stages of growth leading to stresses which result in suppressed internodes and low cane tonnage per hectare which. Insufficient rains are considered one of the main factors behind cane yield decline.

Water harvesting plans could be explored in coordination with Ministry of Water and Irrigation (MoWI) as an approach to supplement the cane crop with water during critical growing periods. Barrages on the numerous water streams within the existing sugar belt could be built to store water and irrigate the crop when erratic rainfall or drought spells coincide with important growth stages.

7.2.2.6. THE WAY FORWARD

1- Short term mitigation measures

There is room for improvement and reversing the downturn which depends on technical support required from KESREF and a more active role of the KSB to organize and enforce regulations enacted in the first place to rectify and maintain the viability of the sugar sub-sector in Kenya. The following measures are recommended to rectify the existing situation:

A. The reduction of cost of cane transportation and harvesting which entails:

   - Use of proper cane haulage units
   - Minimizing off-loading time cycle at factories
   - Adoption of good agronomic and field practices to increase cane yield vertically which will bring down cost of transportation
   - Farmers with small farming units could bring their produce to cane assembly points using cheaper means (as the case in India)

B. Adoption of precision farming techniques to improve yield and save cost;

C. Programs to test, recommend and release adaptable and high yield sugarcane varieties to farmers must be high on the agenda of KESREF to improve cane supply to mills

D. With respect to deteriorating soil fertility the following measures are recommended

- Use of organic manure which is cheap and available, to improve soil physical structure
- Soil should be monitored to apply the right fertilizer type and dose

E. Improving infrastructure especially roads should be a top priority, and efforts in this respect should involve all stakeholders including Kenya Roads Board (KRB)

F. Privatization of government owned sugar mills is strongly recommended to inject money into these facilities and improve their efficiency and capacity utilization. Shortly following privatization in 2001, the performance and productivity of the company improved significantly. Currently Mumias is a leading sugar producer in Kenya and while privately run Kibos reported profits since inception. Kwale International Co., an allied company, which planning to start milling next year, is establishing excellent sugar farm and drip irrigation system (Plate 7-2).

Plate 7-2: Sugar farm and irrigation system at Kwale International

G. Utilization of the industry's by-products, the molasses and bagasse to improve revenues of the sugar companies.

2- Medium and long term measures

<u>Agronomic Practices for sustainable Sugarcane production</u>

There is a potential for vertical increase in cane productivity in the Western region which could be realized through the introduction of the following measures:

A. Adoption of new variety map

Efforts by KESREF to test, recommend and release new and adaptable sugarcane varieties must be maintained as a strategic objective to ensure the viability of the sugar sector.

During the frequent field visits by KETS teams and from the data they have captured, it was concluded that there is a resistance to the cultivation of the new varieties released by KESREF in most out growers' zones and this was confirmed in a study conducted by KESREF in Nyando Sugar Zone.

As reported, a limited number of farmers cultivate only a few of the improved cane varieties while the majority is sticking to old varieties for reasons of inadequate information on the source of the planting materials or lack of funds to purchase the new seed cane material.

The new potential varieties include KEN 82-808, KEN 83- 737, EAK 73-335 and KEN 82-216 while the old commercial and mostly grown varieties are Co 617, Co 331, Co 421 and CB 38-22.

Despite the information some farmers have about the new improved varieties, only KEN 82-808 is gaining popularity. The utilization of the improved varieties is estimated at 46% as compared to 54% utilization of old commercial varieties.

The study recommends that KESREF establishes more demonstration plots in sub-locations for farmers to appreciate the attributes of new varieties.

To develop a suitable variety map which spreads high yield varieties according to their maturity characteristics over the milling season will require establishing seed cane farms close to out growers' lands to facilitate speedy distribution of healthy seed cane. The process also needs extension services to persuade farmers to take up the new varieties; and package of recommended husbandry practices from planting operation to harvesting should be offered alongside the new varieties to optimize their potential and benefits to farmers.

B. Crop rotation

Sugarcane out growers are recommended to manage a crop cycle along the following options:

- Plant cane to proceed to four ratoons then fallow the land
- Plant cane to proceed to three ratoons then fallow the land fallow

It is worth mentioning that sugarcane is a sustainable crop and the number of ratoons which could be harvested depends on the proper establishment of the plant cane and the management of the subsequent ratoons.

C. Soya bean as a break crop

It was observed that land undulation and steepness affect some farm lands and expose them to water erosion and removal of fertile top soil which partially explains the current decline of cane yields. To ameliorate soil fertility and in addition to the application of organic manure, soybean is recommended to be cultivated as break crop on the fallow land and prior to planting a new cane crop (**Error! Reference source not found.**). The measure will improve soil fertility and soil content of organic matter and the soya seeds will generate additional income to farmers. Introducing soya bean as a break crop should be based on adaptive research for selecting the most suitable varieties and strain to reduce the cost of inorganic fertilizer.

Plate 7-3: Soya bean in KSC

The cultivation of soya bean as a break crop is practiced in Australia where cane yield considerably improved following many years of decline. Kenana Sugar Company (KSC) has recently started cultivation of soya bean in fallow cane fields and the results obtained so far are promising. A leguminous crop, soya bean reclaims chemical, physical and biological properties of soil through fixation of atmospheric nitrogen which will save cost as less amounts of synthetic fertilizers will be needed (Alan 2005/06).

7.2.2.7. ENVIRONMENTAL STATUS OF THE WESTERN AGRO ZONE

For the operating sugar factories in the western zone, approximately 85% of the sugarcane is supplied by out growers and only a small amount of the cane is supplied by nucleus farms owned by the sugar companies. Some of the existing mills have ISO 14001 (Environmental Management System) and ISO 9001 (Quality Management System) certification. However, the western sugar belt faces a number of environmental challenges and the out growers farming system lacks the basic knowledge of occupational health and safety norms, which indicates the wide gap between out growers and the mills. The existing gap could be bridged by strengthening the capacity of farmers through intensive awareness programs and specialized training courses.

Environmental aspects of existing sugar industry land degradation can be considered a common problem, stemming from erosion and surface runoff especially during the rainy season and the poor management of agro-chemicals application which led to soil acidification. Furthermore, insufficient cane supply to meet mills' capacities created competition among farmers to harvest under wet conditions which resulted in soil compaction and loss of soil organic matter.

Poor watershed management has led to excessive soil erosion, which resulted in the accumulation of massive silt volumes in the receiving water bodies. Furthermore, uncontrolled use of fertilizers, pesticides, herbicides, insecticides, and fungicides together with runoff from rains has accelerated the eutrophication problem. Untreated mills' effluents contaminated downstream rivers and streams which are the main sources of potable water supplying rural areas.

The absence of a rotation system due to land limitations and poor land management exhausted the soil and possibly resulted in the over application of agricultural inputs which led to the pollution of water streams and small rivers.

The Kenyan sugar agribusiness is hampered by the low productivity of the cane crop per unit area. To overcome this problem farmers usually tend to expand horizontally and removing the tree covers to develop new farming lands. This leads to the destruction of habitat, creating competition on land use and consequently resulted in serious conflicts. In fact the increase in the sugar output in Kenya is due to more land being utilized for cane cultivation.

7.2.2.8. Socioeconomic Aspects of the Western Agro Zone

Population

The Western Agro Zone includes Nyando, Nyanza, South Nyanza, Migori and Busia counties. Sugarcane is the second largest contributor to Kenya's agricultural growth after tea. The population of Western Kenya has increased from about 1.33 million in 1969 to about 4.33 million in 2009, while that of Nyanza has increased from 2.122 million to 5.44 million during the same period. The population annual growth rate of western Kenya has declined from 3.5% during 1969-1979 to 2.5% during 1999-2009, while that of Nyanza has almost maintained the same level of 2.2% during the whole period. Western Kenya and Nyanza are densely populated with f 470 persons per km^2 and 372 persons per km^2 respectively.

Education

School enrollment at different levels in rural areas of Western Kenya was about 2.67 million while the number of people who never attended school was about 0.44 million. About 72% had primary education, 17% had secondary and 0.6% had university education.

Animal wealth

Livestock population in Western Kenya is composed of 1.06 million heads of cattle, 0.233 million of heads of sheep, 0.264 million heads of goats and 0.037 million heads of camels. Nyanza has more cattle (1.7 million), more sheep (0.495 million) and more goats (0.961 million) and more camels (0.048 million heads). However, in total, the livestock population in this area is considered relatively less than those in the eastern and north eastern provinces.

Socioeconomics

The socioeconomic pattern found in the western sugar industry is mostly composed of sugar out-growers who cultivate and grow sugarcane crop as individuals or as members of an authorized group either in the form of cooperatives and or companies. Despite the existence of a number of cooperatives and companies of sugarcane out-growers, most of the sugarcane out-growers are not sufficiently motivated to accept the communities' proposal to pool land to facilitate large areas of plantation which would render the harvesting and transportation of cane a bit easier and less costly. In fact the existing cooperatives and companies provide pooled production and marketing services to their members but charge each member on individual accounts basis. Each out-grower makes his own decision when planning production and marketing activities of his sugarcane crop. The sugarcane out-growers companies are currently replacing the cooperatives and although they are getting the blessing of the public sugar mills they are still unable to convince the majority of out-growers to join in.

Production Relationships

The production relationship between out growers and millers is controlled by a business contract which defines the responsibilities of each party. The out growers cultivate and tend the crop until it is ready to be harvested and the miller provides seeds, machinery, supervision and funding for harvesting and transportation of cane to the milling facility. The relationship between out growers and millers is reasonable on hypothetical basis but in reality it is complicated by a number of challenges.

From an organizational and management point of view, the main stakeholders including the sugar millers are supposed to ensure the spread of healthy planting material, follow up the application of inputs and the cultural practices and monitor the crop to maturity and harvest, and to pay out growers dues immediately upon cane delivery. Failure to do this, which is the norm rather than the exception, results in poor productivity at farm and factory levels and inflame competition between millers for the raw material which lead to harvesting immature cane at a high price. Some out growers, on their part, don't honor their contractual obligations and deliver cane to the miller who offers the highest price and as a result, the cane that should be delivered to a certain mill leaks to another which disrupts harvesting schedules and extends the milling season unnecessarily. In many instances, the disputes over cane delivery issues are taken to courts.

Sugar Sector

This scenario of an undisciplined sugar sector explains the abnormally high cost of sugar production in Kenya. As stakeholders, the millers should agree to and honor a code of ethics to ensure fair competition and the out growers should meet their obligations in clearly drafted contracts. There is room for vertical increase of the crop which requires effort by all stakeholders to reinforce the regulations which have been formulated to organize the sugar sector in Kenya.

Socially responsible millers are able to build trust and build a team of loyal out growers. This could be realized if millers allocate small fractions of their proceeds to support social services in villages within their areas of activities which are in dire need of clean water, electricity, good schools and health care. It is unfortunate that the concept of corporate social responsibility is weakly conceived by public and private millers and only a very few private millers mature this concept, as result of which they are building trust, respect and loyalty among villagers.

Farming system and land tenure

On average, out growers own five acres of land of which only 0.5 to 1 acre is allocated for sugarcane production. As for the rest of the area, one acre is cultivated with maize, the main staple crop, and the remaining area is cultivated with cassava, beans, bananas, vegetables and fodders. The farmers also keep cows, whose milk is used by the family. Surplus milk is marketed to provide cash for items needed by the household. Some out growers raise oxen and rent them to farmers in the neighborhood to drag ploughs for land preparation.

The expansion of the nucleus farms to meet production targets will require the sugar millers to purchase land from owners, something which will not be easy as land owners stick to their land to secure food to their families since the land is the only source of income to the poor rural farmers.

Although the percentage of households who have legal title over land they hold is low, the majority of households hold their land under usufruct norms which gives the household the rights to utilize and rent the land which can be inherited upon death of original holder to direct family members. However, this type of land tenure doesn't allow land owners to utilize the property as collateral to obtain credit. Over the decades, the land has been fragmented to sizes which are economically unfeasible for crop production. Amalgamation of the fragmented lands must be encouraged and land owners could be incentivized to join the process which will result in improving the quality and quantity of cane provided and thereby increase the income for the farmers..

7.2.3. WATER RESOURCES

Lake Victoria North

Lake Victoria North (LVN) catchment area lies on the western part of Kenya. The LVN is bordered by Mountain Elgon (4,321 m height) and Cherengani Hills to the north and east respectively, by Uganda to the west and Lake Victoria to the south-west. Its total area is 19,012 km^2, which is 3.3% of the land area of Kenya. According to the Census of 2009, population in the catchment is 7.23 million, or about 19% of the total population of Kenya and the population density is 380 persons per km^2. The major cities in the LVN catchment are Eldoret, Kakamega, Kitale, Bungoma, Kapenguria, Busia, Siaya, Vihiga and Kapsabet. The LVN Catchment area includes the whole area of Busia, Bungoma, and Kakamega counties, the larger parts of Siaya, Vihiga, Nandi, Uasin Gishu, and Trans-Nzoia counties, and small part of Elgeyo Marakwet and West Pokot counties. The whole area lies in the highlands that are more than 1,000m above sea level. Major rivers are Nzoia, Yala, Malaba, Malikisi, and Soin rivers. Nzoia River is a representative river with a drainage area of 12,853 km^2 that covers about 2/3 of the LVN catchment. Yala River flows in the southern part of the LVN catchment to the west and discharges into the Lake Victoria. The drainage area is 3,259 km^2 which is 17% of the LVN catchment. Soin River flows along the border with Uganda into the Lake Victoria.

Malaba and Malikisi rivers flow across the border with Uganda. Total drainage area of these three international rivers is 2,301 km^2 which is 12% of the LVN Catchment. (JICA 2012)

Lake Victoria South

Lake Victoria South (LVS) catchment area lies on the south-western part of Kenya, and encompasses the basins of four major rivers which originate from Cherangani Hills and flow westward or south-westward. The LVS catchment is bordered by the LVN Catchment to the north, Lake Victoria to the west and Tanzania to the south. Its total area is 27,389 km^2, which equals 4.7% of Kenya's total land mass. According to the 2009 census, population in the catchment is 7.26 million, or about 19% of the total population of Kenya. Population density is as high as 265 persons per km^2. The major cities/towns in the LVS catchment are Kisumu, Kisii, Migori, Kericho, Homa Bay, Molo and Kehancha.

The LVS catchment includes the whole area of Kisumu, Kericho, Homa Bay, Nyamira, Kisii, Bomet and Migori counties, and a part of Siaya, Vihiga, Nandi, Nakuru and Narok counties.

Most of the major rivers originate from the 3,000 m-Class Mountain in the Mau forest which occupies the western part of Cherangani Hills. Major rivers are Nyando, Sondu, Kuja and Mara rivers. Nyando (3,604 km^2), Sondu (3,474 km^2) and Kuja (6,843 km^2) rivers flow into Lake Victoria.

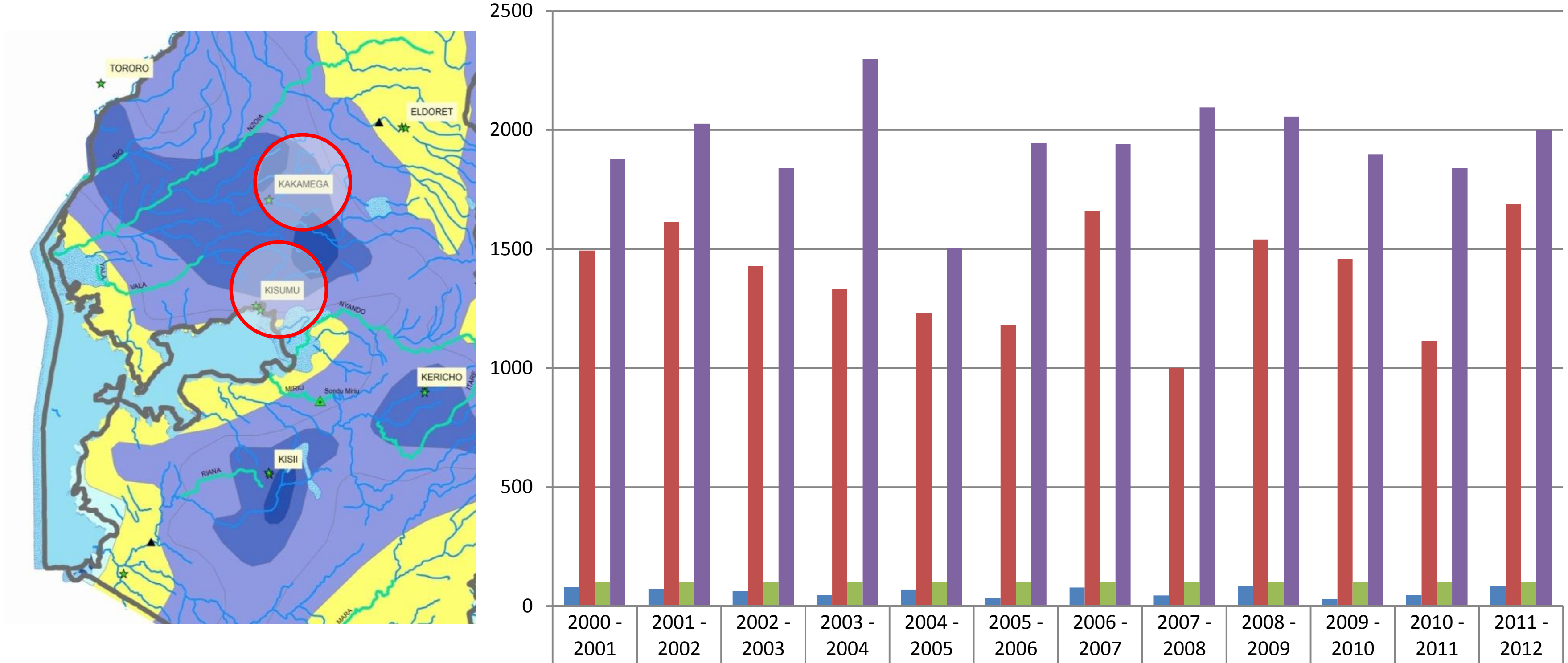
The basins of these three rivers account for 51% of LVS catchment. The drainage area of Mara River (9,107km^2), accounts for about one-third of the total catchment of LVS. It flows through Masai Mara National Reserve across the border with Tanzania and discharges into the Tanzanian side of Lake Victoria. The four major rivers account for about 84% of the total area of LVS catchment and the remaining 16% area is composed of small catchments along the Winam Gulf in Lake Victoria. (JICA 2012)

As for crops in the LVS catchment area, maize is widely grown in the whole area, cotton is grown along the Winam Gulf of the Lake Victoria, cassava, sorghum and millet are grown on the northern shore of the Winam Gulf and tobacco and beans are grown in the middle to lower reaches of Kuja River. In the middle to upper catchment areas that are 2,000m above sea level, tea, sugarcane, coffee and pyrethrum are widely grown. Areas around Kericho, Bomet, Nyamira and Kisii are famous for tea plantation, which accounts for more than 40% of the total tea production of Kenya.

Kisumu, the largest city in the LVS catchment, is home to different industries such as cement, construction material, brewing and beverages, food processing, timber and timber products, textiles, printing and light engineering. Around Kericho, tea processing industry is famous.

Rainfall

Rainfall amount and distribution are highly significant for sugarcane cultivation in this zone. The AquaCrop model was used to simulate the changes in biomass of sugarcane as a result of water stress. Figure 7-12 illustrates the relationship between the biomass, water stress and the attainable yield in optimum conditions. The results are based on data acquired from Kisumu and Kakamega stations 12 years' rainfall records (2000-2012), and show that supplementary irrigation would be required to increase yield, especially in areas of lower rainfall.



	2000 - 2001	2001 - 2002	2002 - 2003	2003 - 2004	2004 - 2005	2005 - 2006	2006 - 2007	2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012
kisumu relative biomass ratio to optimal conditions %	79	73	64	47	70	35	78	44	85	29	46	84
kisumu Rainfall mm	1493.6	1614.7	1428.6	1331	1230.3	1179.2	1661.8	1001.6	1540.6	1458.4	1113.4	1688
Kakamega relative biomass ratio to optimal conditions %	100	100	100	100	100	100	100	100	100	100	100	99
Kakamega Rainfall mm	1878	2026.4	1840.6	2297.8	1504.2	1945.5	1940.5	2095.1	2056.9	1898.9	1840.1	1998.9

Figure 7-12: Model simulation result for relative biomass production (optimum conditions) and annual rainfall

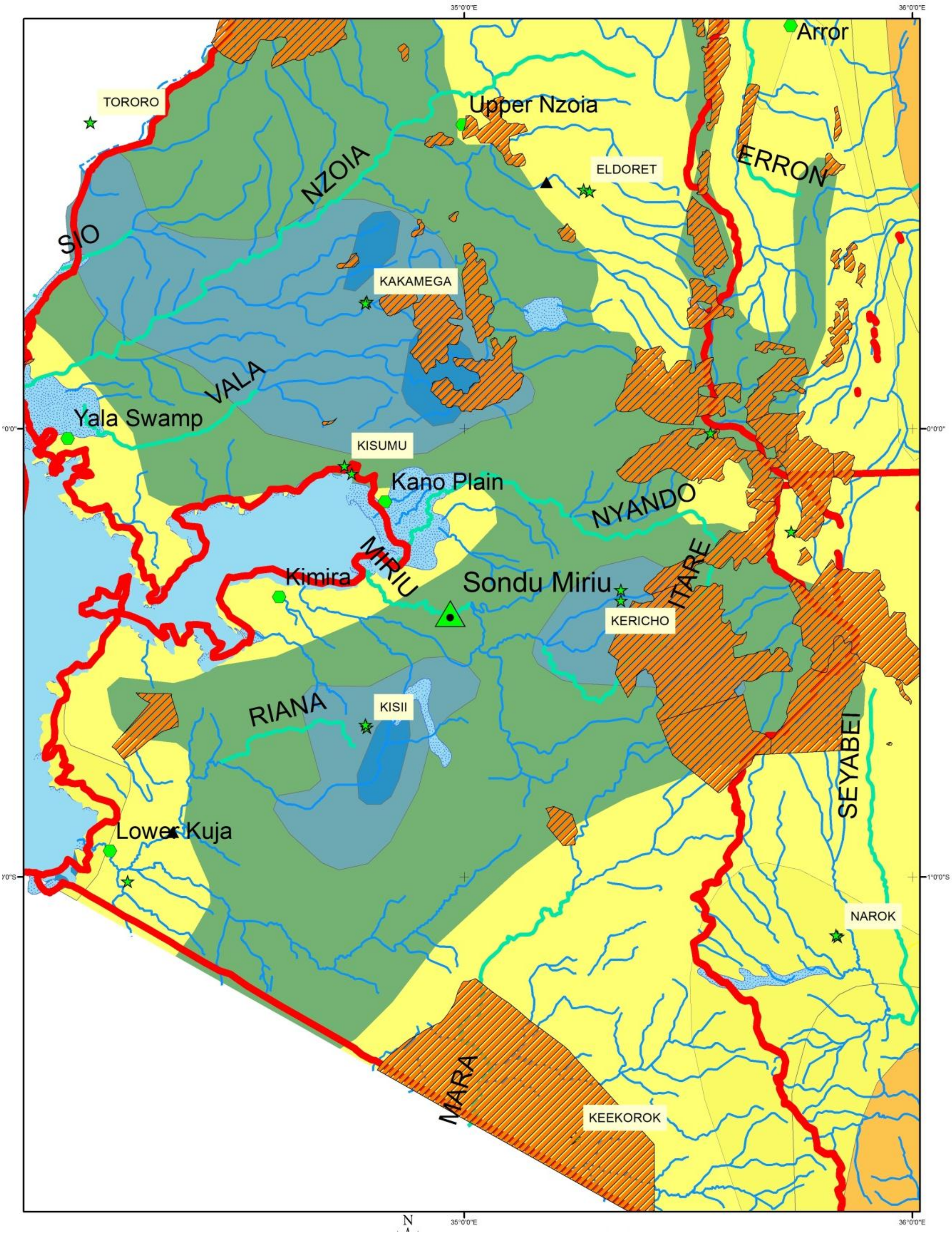


Figure 7-13: Rainfall distribution in the West Agro Zone

Figures (7-12) and (7-13) indicate the following:

- Supplementary irrigation would not be required for areas with in the same rainfall range of Kakamga Station (blue color)
- Minor supplementary irrigation for the areas which with in the same rainfall range of Kisumu Station (green color) will increase the yield up to 35 %
- Supplementary irrigation would be required for the areas shaded in yellow color (see Figure 7-13)
- The model of Aqua Crop needs calibration by actual field data to get more accurate results
- Installment of well distributed rainfall gauges is important to monitor/study the rain fed areas to assess the need for supplementary irrigation.

7.2.4. SUGARCANE POTENTIAL IN THE WESTERN ZONE

Based on available land, soil suitability, proximity to existing factories and climatic conditions, a number of areas were identified as possible locations for sugarcane cultivation as shown in Figure 7-14.

7.2.5. SUGAR BEET POTENTIAL AREAS IN WESTERN ZONE

The suitability of potential areas for sugar beet in this sub-zone is classified as high and medium.

For some areas where the rainfall ranges between 550 mm and 750 mm per season, supplementary irrigation is not needed (Figure 7-15).

For supplementary irrigation, groundwater or water harvesting could be utilized.

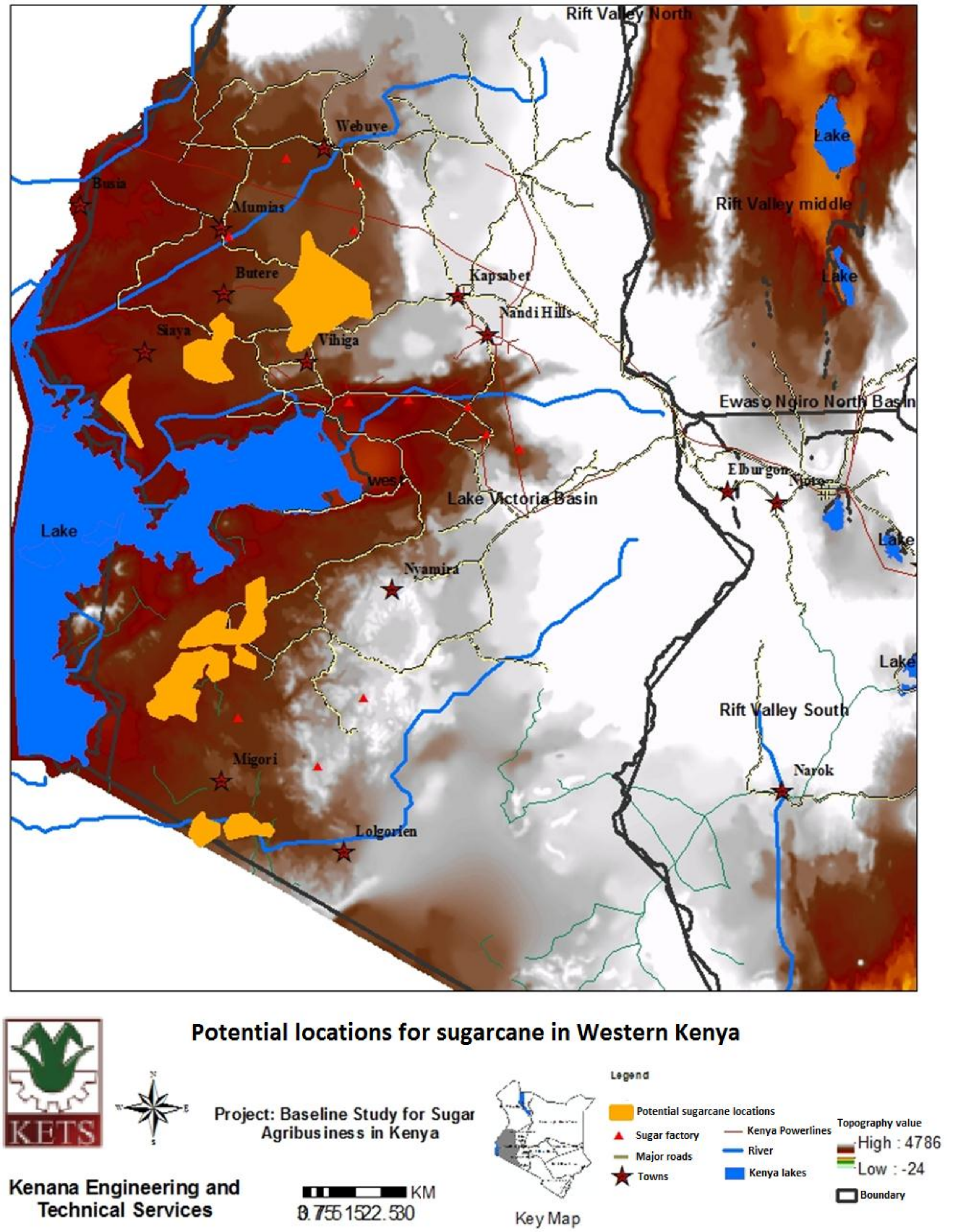


Figure 7-14: Potential areas for sugarcane in the Western Zone

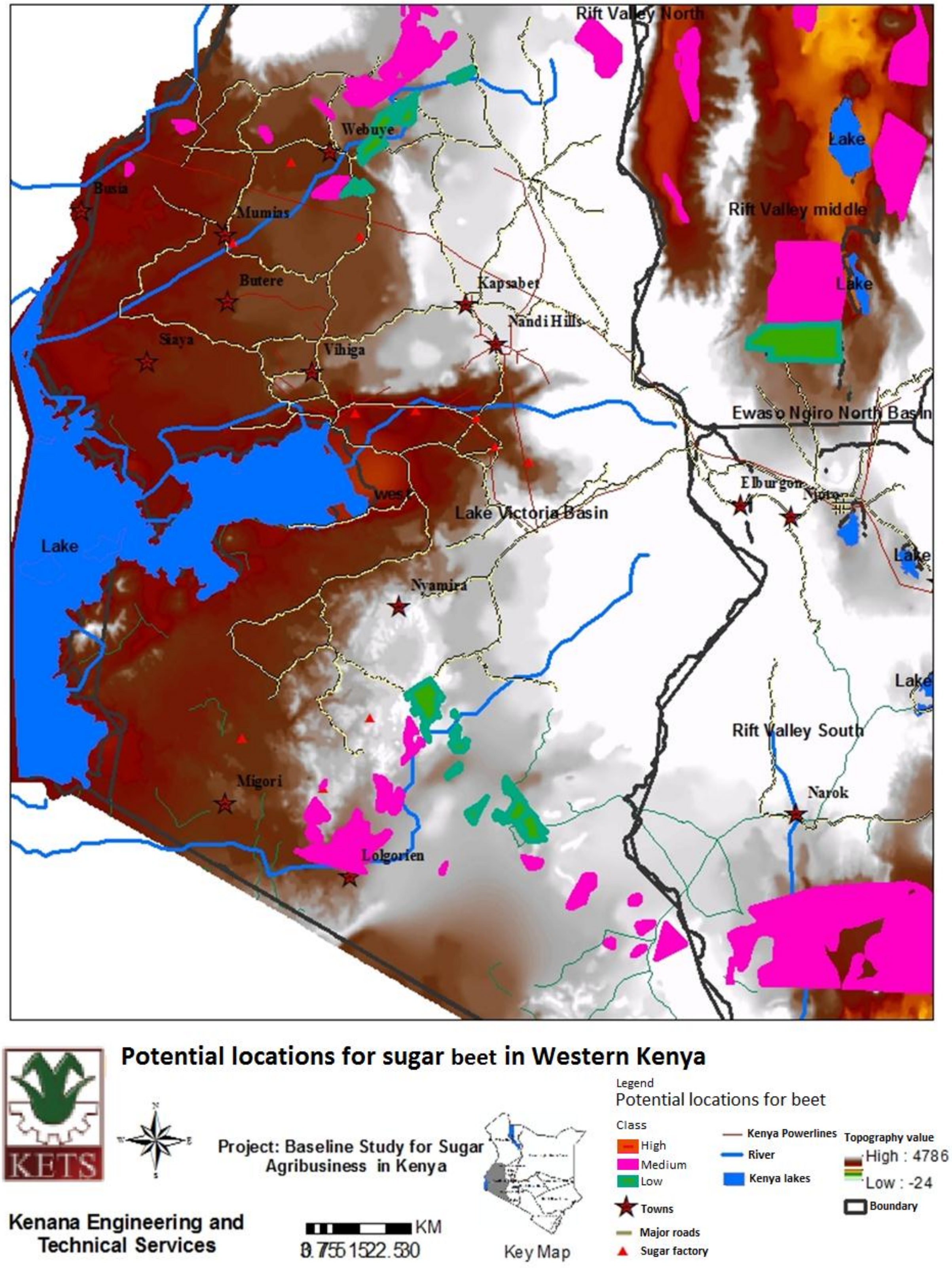


Figure 7-15: Potential areas for sugar beet in the Western Zone

7.3. TANA RIVER AGRO ZONE

7.3.1. OVERVIEW

The Tana River catchment area is bounded by latitudes 0˚ 30’ north and 2˚ 30’ south, longitudes 37˚ 00’ east and 41˚ 00’ east. It borders the crests of Mt. Kenya, the Aberdare Ranges and the Nyambene Hills to the north the Indian Ocean to the south the Yatta Plateau to the west, and the Kenya-Somali border to the east. The catchment area covers an area of approximately 126,000 km^2.

Mount Kenya and the Aberdare Ranges, which are both gazetted and protected areas, are the main water sources of the region providing 49% and 44% of the region’s waters respectively. The remaining 7% is provided by Nyambene Hills and other minor catchments. The Region provides about 80% of Kenya’s hydropower and 80 % of the water consumed in Nairobi City, the Kenyan capital. The Tana River catchment area also includes four National Parks and eight Game Reserves, the major ones being the Aberdare Forest, Mt. Kenya Forest, Meru National Park and Tsavo East National Park.

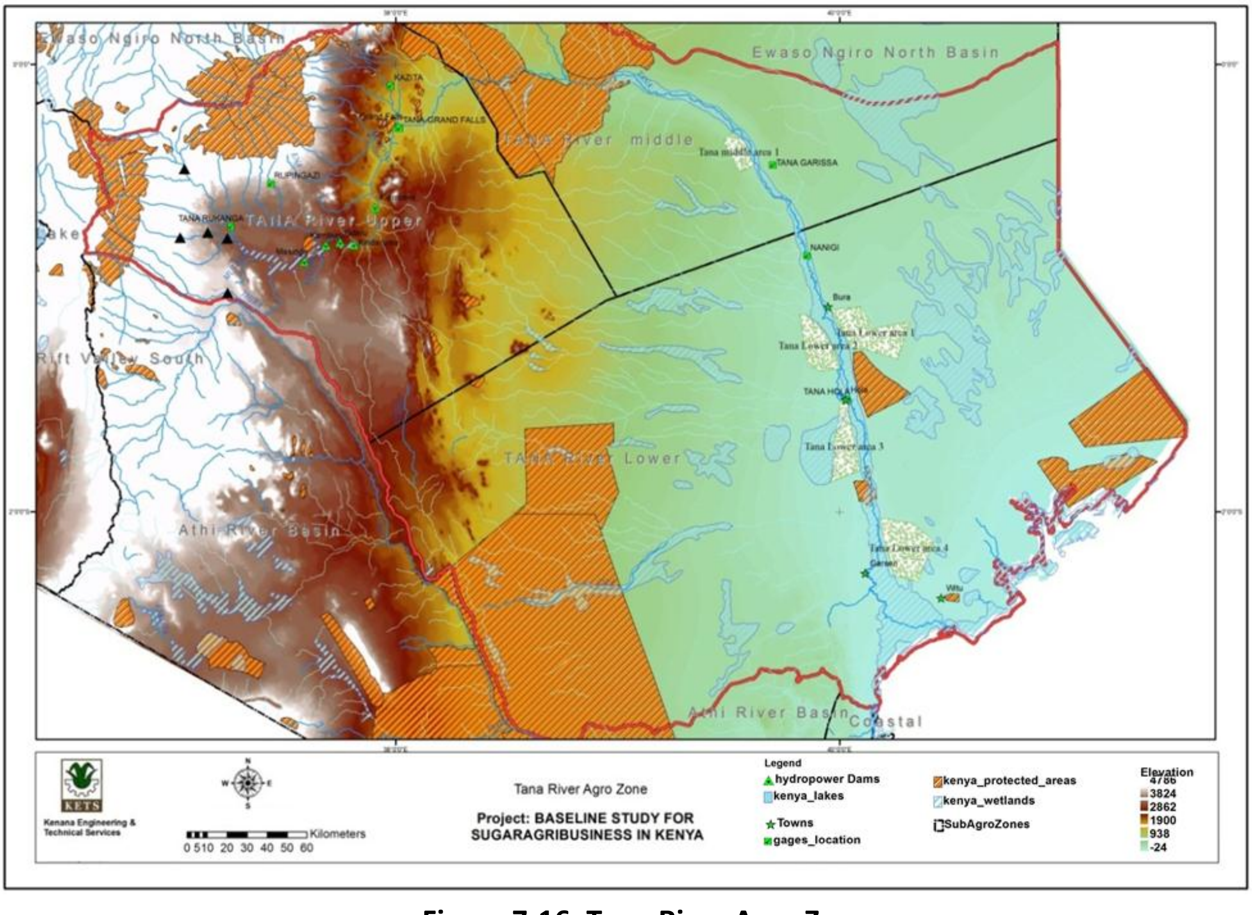


Figure 7-16: Tana River Agro Zone

The Tana River, the longest in Kenya, runs about 1000 kilometers before it drains into the Indian Ocean. Tana River Zone represents a more homogenous area as the basin is commonly used by pastoralists and farmers practicing scattered and small scale farming

In addition to available land and sufficient water recourses, the Tana River Zone is rich in wildlife and biodiversity which can be promoted to attract tourism and generate revenue. The Tana River area also has a rich riverine forest belt flanking its two banks as well as scattered, woodland cover towards the hinterland which are dense in many locations.

Tana River Agro Zone comprises three counties namely Garissa, Tana River, and Tana River Delta basin. Garissa county encompasses four administrative units of Central, Sankuri, Balambala and Danyere. Tana River County is divided into 5 administrative Sub-Counties namely Bangale, Madogo, Bura, Galole and Wenje. Tana Delta is divided into three Sub-Counties of Garsen, Tarassa and Kipini and it covers a total area of 16013.4 km^2, of which the Tsavo National Park covers 1300 km^2 (19% of the county total land area).

7.3.2. WATER RESOURCES

The water management in this catchment is very critical due to variability in climate, catchment characteristics, droughts, river morphology in addition to different water uses by human beings, livestock, wildlife, irrigation, etc.

Fresh water availability in this catchment has been steadily declining to a current value of about 647 m^3 per capita per annum.

7.3.2.1. CATCHMENT CHARACTERISTICS

Most of Tana River catchment is semi-arid implying high levels of water scarcity. Consequently, conflicts over water use have been quite common in this region. Furthermore, variable weather conditions and erratic rainfall result in frequent droughts and floods which, under extreme conditions, lead to loss of life for both human beings and livestock. In addition, due to the low investment in water storage infrastructure, the national per capita storage of surface water has declined from 11.4 cubic meters in 1969 to 4.3 cubic meters in 1999 (Tana District Report REF).

The drainage system of the catchment is mainly the Tana River and its tributaries. Tana River is a permanent river with a number of perennial tributaries such as Nairobi, Amboni, Gura, Ragati, Chania, Mathioya, Thiba, Kazita, Mutonga, Sabasaba, Maragwa, Thika, Ena, Ura and Runjeweru. The seasonal tributaries include Tiva, and LagaKokani. The tributaries emanate from Mt. Kenya, the Aberdares and the Nyambene Hills forming a dendritic drainage system dominated by Tana River, which is the largest river in Kenya. The fresh water Lake Kenyatta at the coast is the only lake in the region. Table 7-8 shows certain aspect of Tana River basin Agro Zone compared to general Kenya.

Table 7-8: Aspects of Tana River Basin Agro Zone compared to Kenya

Parameter	Kenya	Tana	Units
Catchment area	580,370	126,026	**km^2**
Population.	28,686,607	5,100,800	**inhabitants**
Annual average rainfall	621	679	**mm**
Annual average runoff	13	29	**mm**
Renewable fresh water	647	726	**m^3/capita/year**
SW abstractions rates.	1071.7	595.4	**million m^3/year**
GW abstractions rates.	57.21	4.79	**million m^3/year**
Average borehole yield	6.25	6.58	**m^3/hr**
Borehole specific capacity	0.20	0.17	**m^3/m**
Hydropower production	599	477	**MW**
Irrigation potential	539,000	205,000	**ha**

Source: National Water Master Plan 1992 [2]Population Census 1999

7.3.2.2. WATER SOURCES

A. Surface water sources

The 1,000 kilometers Tana River is the longest river in Kenya, and gives its name to the Tana River County. The annual flow is above 5,000m^3 on average, but varies substantially within and across years. It floods twice a year.

Dams

Tana River catchment area is home to the largest dams and reservoir capacity in Kenya. Most of these dams were built for hydropower generation as well as other uses indicating supply of drinking water and irrigation.

The dams built on Tana River are the Kindaruma Dam in 1968, the Kamburu Dam in 1975, the Gitaru Dam in 1978, the Masinga Dam in 1981, and the Kiambere in 1988). Three-quarters of Kenya's electrical needs are supplied by these dams (as shown in Table 7-9). Table 7-10 shows a number of dams and hydraulic structures proposed by WRMA and NIB.

Table 7-9: The existing dams in Tana River Basin

Name of the Dam	Year Constructed	River	Catchment Area km²	Gross Storage (Mm³)	Remarks
Sasumua	1956	Chania	65	16	**Water Supply to Nairobi City**
Ndakaini	1993	Thika	71	70	**Water Supply to Nairobi City**
Masinga	1981	Tana	7,335	1,560	**Hydro-power 40 MW**
Kamburu	1975	Tana	9,520	150	**Hydro-power 94.4 MW**
Gitaru	1978	Tana	9,525	20	**Hydro-power147 MW**
Kindaruma	1968	Tana	9,807	16	**Hydro-power44 MW**
Kiambere	1988	Tana	11,975	585	**Hydro-power144 MW**

Table 7-10: The Proposed Water Resource Management Infrastructure in the Tana Catchment

No	Activity to be funded	Period (year and size)	Implementing agency	Lead role	Key partners	Bil-lion Ksh	Source of funds
1	2 major river dams	5 year 1 Mm³	NWCPC	WRMA	NEMA, NIB, WSBs	1	**GOK, Donors**
2	Dams (1 of 7 forks)	10 year 4-5 B m³	NWCPC	KENGEN	TARDA, WRMA, NEMA	30	**GOK, Donors**
3	5 Small WRUA dams (stream based)	5 years 0.2Mm³	NWCPC	WRMA	NEMA, NIB, WSBs, WRUAs	0.1	**GOK, CDF, LATF,WSTF Donors**
4	5 Sand dams/ check dams/ pans/rock catchment	5 year 100-1000m³	WRUAs WRMA	WRMA	NEMA, WSBs	0.1	**GOK, CDF, LATF, Donors**
5	Ground water surveys, mapping	5 year 1 Map	WRMA	WRMA	Survey of Kenya, Kenya Soil Survey, TI	1.5	**GOK, Donors**
6	Rain water harvesting	5 year 1000 households/Institutions	WRMA	WRUA	WSBs,	0.1	**WRMA, Donors, NGOs**

Tana River flow (Hydrograph)

Figure 7-17 shows the average monthly flow of River Tana which has been extracted from the daily records of the following stations:

1. Grandfalls for the period of (1962-2012)

2. Garissa for the period of (2000-2012)
3. Hola for the period of (1949-1991)
4. Nanigi for the period of (1974-1988)

Despite the discrepancies in the stations records for the same period of time and some missing data, Figure 7-17 confirmed the fluctuation of the river yield for the past 50 years.

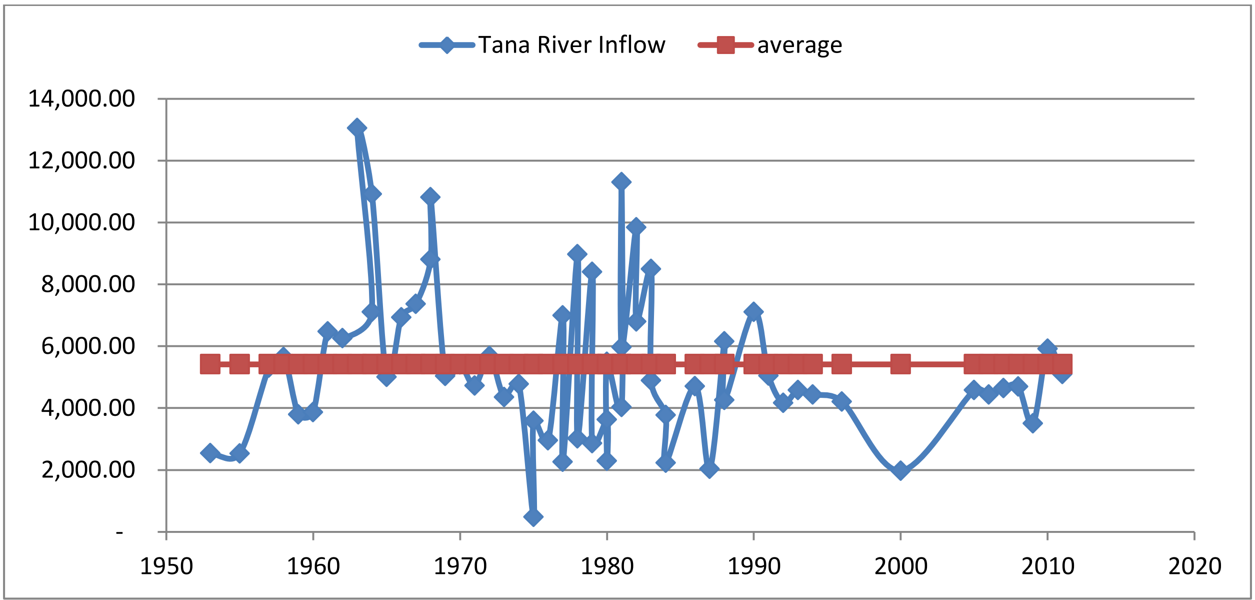


Figure 7-17: Monthly average flow of Tana River

For calculating Tana River safe yield, Graissa station was considered as a reference.

Figure 7-18 shows annual River Hydrograph at Garissa Station. Table 7-11 shows the average and minimum monthly flow reported by the Garissa Station from 2000 to 2012.

The safe yield is estimated at 2400 MCM per year and is considered as the baseline for water supply.

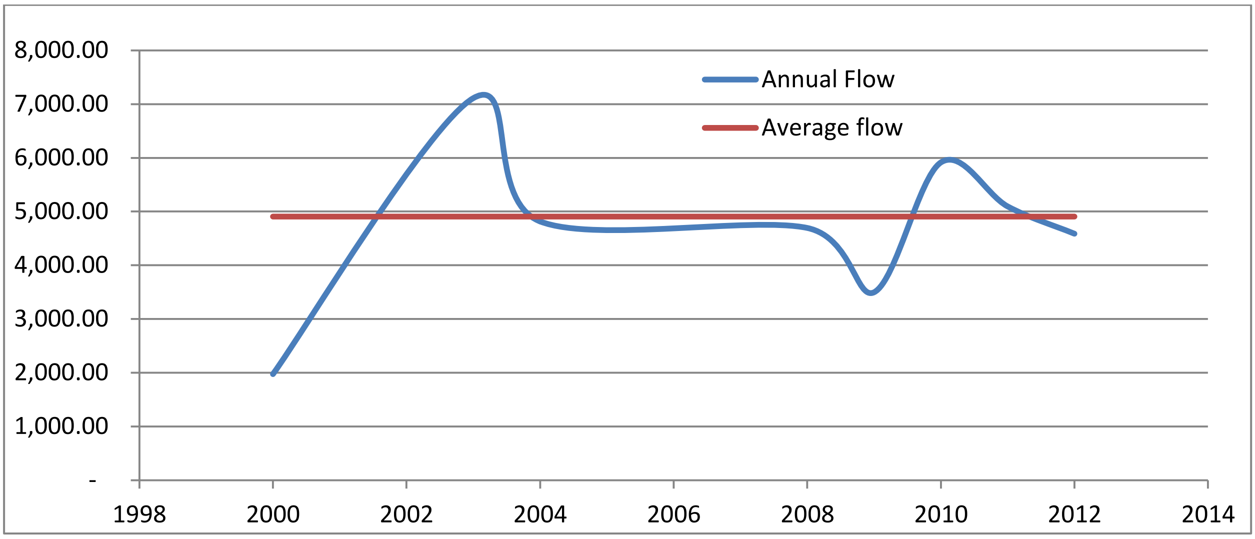


Figure 7-18: Annual River Hydrograph at Garissa Station

Table 7-11: Tana River Inflow (Mcu.m)-Garissa Station

Month /year	2000	2001	2002	2003	2004	2008	2009	2010	2011	2012	Average Inflow (Mcu.m)	Standard Deviation	safe yield 80 %
Jan	365	125	201	385	524	476	291	332	351	484	356	120	237
Feb	187	114	135	305	348	355	225	166	269	330	250	88	162
Mar	196	120	318	456	328	377	278	409	263	333	305	95	210
Apr	230		539	1,294	538	651	391	756	311	369	564	321	244
May	213			1,331		535	313	1,157	463	1,239	750	474	276
Jun	88			1,171	293	328	196	730	312	704	478	361	117
Jul	49	147	239		223	295	161	394	282	424	246	119	127
Aug	42	156	256		217	257	129	365	259	368	228	106	121
Sep	19		252		215	198	91	332	235	337	210	110	100
Oct	15		277	380	327	349	263	331	487		304	135	168
Nov	360	400	648	1,005	1,062	557	572	550	948		684	248	437
Dec	210	294	576	783	739	315	586	393	914		532	232	300
Annual	1,974			7,112	4,816	4,695	3,498	5,914	5,095	4,588	4,907	2,409	2,498

A- Groundwater

The subsurface geology is composed of the Archaean age Mozambique belt basement system rocks which are mostly metamorphic rocks, the Miocene and Pleistocene volcanic rocks, the Tertiary and Quaternary sediments followed by the recent alluvium deposits along river flood plains.

- The Upper Tana Region

This region comprises of the volcanic areas of the eastern and southern slopes of Mt. Kenya, the eastern slopes of Aberdare Ranges and Nyambene Hills, all at an altitude higher than 1300m. Different recharges, transit and discharge zones characterize the regional aquifer system. The good inter-granular and fractured-type aquifers in this region generally produce good quality water and the yields vary between 5 to >30 m^3/hr.

- The Middle Tana Region

This region lies at an altitude below 1300m and drops down to about 500 m. Generally, the region's climate is semi-arid to arid. The aquifers are localized and typically poor. The region extends over Tharaka, Kitui counties and Mwingi and parts of Yatta sub-county.

- The Lower Tana Region

This region lies below 500m and encompasses the coastal zone. It has complex local and semi-regional aquifers found within Tertiary Sediments and Quaternary alluvium deposits. (JICA 2012)

B. Rainfall

Rainfall in this catchment is bimodal falling during the long rains of March – May, and short rains of October – November.

- Water quality

The main sources of pollution in Tana River Zone are:

- Agro-based industries (coffee and tea factories)
- Livestock based industries (slaughter houses, milk plants, tanneries)
- Sewerage works in large towns
- Car washing sites in towns

7.3.2.3. WATER DEMAND

According to WRMA-JICA the water demand allocations and source of water for each subsector in the Tana River catchment are shown in Table 7-12.

Table 7-12: Tana River Catchment Area Water Demands Units in MCM

Sector	Water Demand	Surface water	Groundwater
Domestic	297	150	147
Industrial	14	6	8
Irrigation	3, 987	3, 749	238
Livestock	105	64	41
Total	4, 403	3, 969	434

7.3.3. SOILS, CLIMATE AND LAND SUITABILITY

Soils

Generally the soils are classified as Fluvisols, and are divided into two subgroups: eutric and vertic Fluvisols. The floodplain consists of chromic Vertisols that is, silt clay with no salinity or alkalinity. In the meander belt (river levee land) and taking into consideration old and new river courses, the soils are yellowish brown, often stratified, sand to clay rich in Micas. The textures of topsoil vary from sand to clay while the sub-soil is firm clay. Infiltration of such soils will thus vary with texture being slow in areas with clay as topsoil and fast where sand forms the top soils. Such soils have been described for the area between Lango la Simba and Abarfarda River where the topography is flat to gently undulating. On the fringes of levee land is river basin land, an area with different soil types depending on levels of sedimentation. Typically, these soils consist of heavy to very heavy clay. The top soils (up to 100 cm) are non-saline but salinity increases with depth. The soils have slow infiltration especially when saturated and can be classified into three subtypes. i) On flat, moderately high lying and weak Gilgai areas where the soils are deep with 10-20 cm of very dark gray clay overlying dark brown clay. ii) On moderately low lying areas, top soils are very dry dark gray clay over dark grayish brown, cracking clay. iii) On areas of shallow depressions on gullies, the dark gray topsoil overlies dark gray cracking clay.

Climatic condition

The climatic condition of the Tana River catchment area was based on 28 years of reported records as illustrated in Table 7-13. The average atmospheric temperature is about 27°C throughout the year with an average minimum of 22°C and an average maximum of 32°C with diurnal range rarely exceeding 10°C. The average annual rainfall is about 520mm while the average annual evaporation is 2480mm. The high moisture deficit (evaporation minus rainfall) indicates that agriculture in the Tana Delta would require irrigation for optimum production

Table 7-13: Average climate data in Tana Delta (Garsen Met. Station)

Item	Jan	Feb	Mar	Apr	may	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total/ Average
Rainfall (mm)	14.5	9.2	34.4	84.6	94.4	50	31.6	32	22.1	28.6	82	41.9	525.3
Temp mean °C	28.3	28.7	29	28.6	26.7	25.7	24.9	24.9	25.7	27.1	27.6	27.6	27.1
RH %	77	75	75	77	79	77	77	75	73	73	75	78	76
Wind speed (m/s)	1.9	2	2.2	2.5	2.7	2.9	3	3.1	3	2.7	2	1.7	2.5
Sunshine (hrs)	8.8	8.9	8.8	8.2	7.4	7.6	7.5	8.4	8.9	8.9	8.8	8.9	8.4
Solar radiation (cal/cm^2/day)	614	621	610	566	483	488	456	536	596	617	598	604	566
Pan evaporation (mm/day)	6.6	7.4	7.3	6.8	5.7	6.4	6.1	6.7	7.1	7.2	6.4	6.3	6.7

Source: TARDA, 1988

The soils in the river basin are heavy clays which are suitable for the establishment of irrigated sugarcane with the yield results of limited research conducted in the area showing high sugarcane yields per hectare (TCH). Cane yields as high as 104 and 189 TCH were reported, which supports sustainable sugar production in the region. Soils in river levee are less suitable.

Generally there are three major physiographic units which are the flood plain, terrace land and former beach ridges. The latter two are considered unsuitable for crop production as their soils were developed on recent fluvial sediments in the river basins and river levee lands and soils developed on sub-recent marine sediments.

7.3.4. Tana River Agro-sub-zones

Based on the factors described above, this zone has been subdivided into three sub-zones namely upper, middle and lowers Tana sub-zones, as shown earlier in Figure 7-16.

7.3.4.1. Upper Tana Sub-zone

The Upper Tana sub-zone is characterized by catchment degradation leading to higher and faster runoff flows. Moreover, high population densities in these areas have caused excessive water abstraction. Intensive agro-based factories and urbanization contribute to substantial pollution of the water source. In this zone, water quality is affected by pollution from tea factories, and sanitation from Tea zone dwellers.

A number of natural streams run through this sub zone which drains into the main Tana River. All the hydropower dams in the Tana River basin are located in this sub-zone.

Annual Rainfall in this sub-zone ranges between 400-2400 mm and the groundwater aquifers are classified as poor and low classes, which do not allow for sustainable irrigation use. Plate 7-4 shows portion of Tana River catchment area

Plate 7-4: Portion of River Tana catchment area

The Upper Tana Sub-zone starts from the uphill of Mt. Kenya and goes up to the Meru National Park area. The hilly, undulated land topography and climatic factors will not support sugarcane cultivation in the area.

This sub-zone could however suit sugar beet production according to the low climatic suitability criteria as explained above, but requires supplementary irrigation. Potential areas suitable for sugar beet are shown in Figure 7-19.

The Upper Tana Sub-zone is an extensive upland area (all above 1,300m above mean sea level) of moderate seasonal rainfall, which comprises the southeastern slopes of Mount Kenya and the eastern slopes of the Aberdare and Nyambene Hills. Geologically, it is predominantly volcanic terrain with steep slopes, but with naturally good infiltration characteristics, resulting in both plentiful direct and streambed recharge to the complex underlying volcanic aquifer systems. However, where the more fractured or partly cemented volcanic rocks are at the surface, not only will there be excellent recharge conditions but vulnerability to groundwater pollution will also be very high.

Sedimentation is a key issue – especially during seasons of high rainfall. Soil erosion is particularly severe in the coffee and maize producing areas on the Upper Catchment due to poor vegetation cover. Water and land conservation measures to retain moisture are particularly important in these areas.

Though there are several known wetlands in this sub-zone, none falls under the Ramsar Convention as they are mainly small in size, with only a few with an area of 10 km^2 or above.

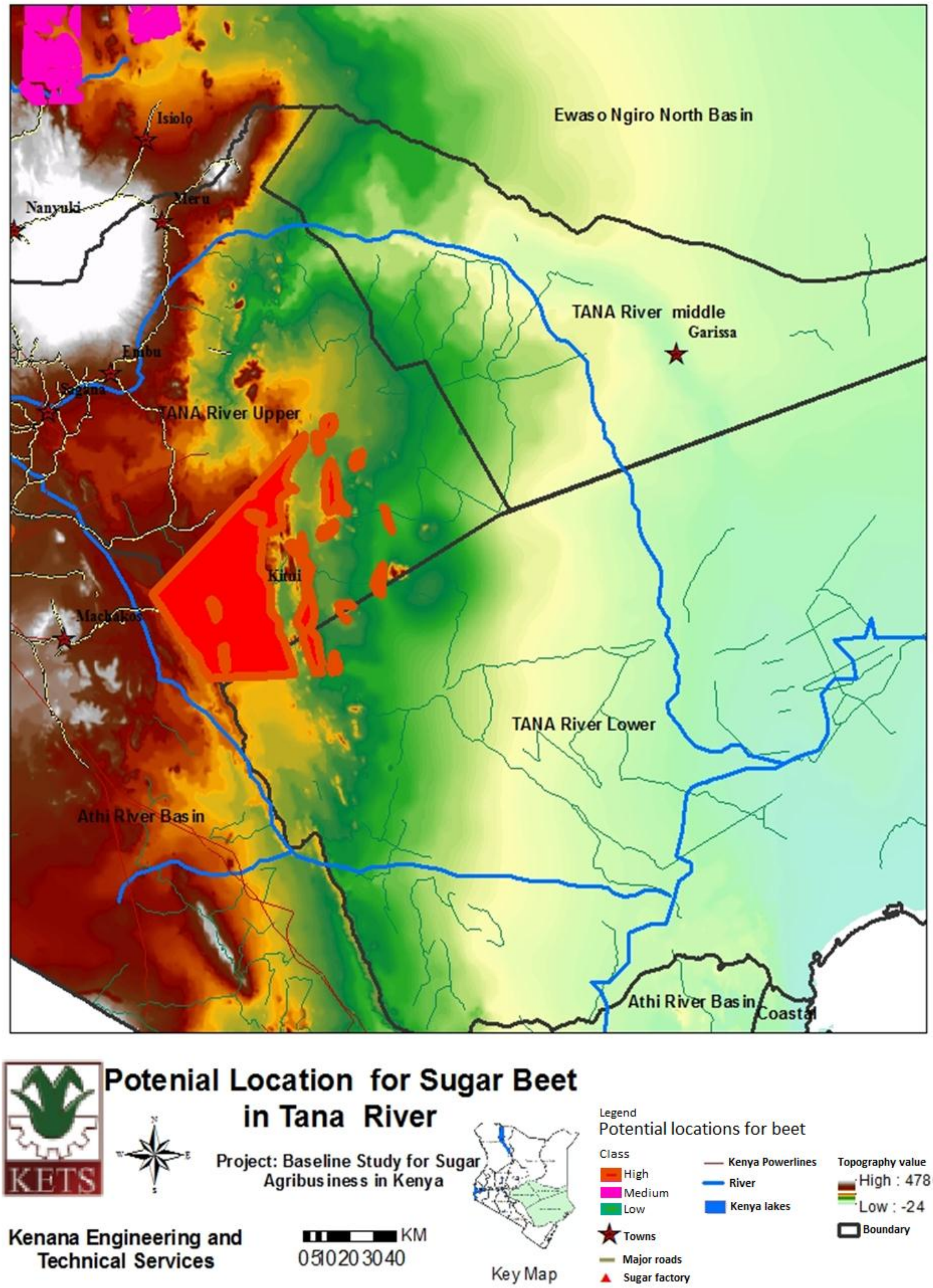


Figure 7-19: Potential areas for sugar beet in Tana River

Wetlands are important for ground water recharge, regulating water flow, temporary storage and later release of water to receiving water bodies, and act as sinks for wastes and pollutants. However, wetlands in the area are threatened, mainly through conversion to agricultural use.

Included in this sub-zone is Meru National Park which has a total area of 870 Sq.km. The Park has diverse scenery from woodlands at 3,000 feet on the slopes of Nyambeni Mountain Range, northeast of Mount Kenya, to wide open plains with wandering riverbanks dotted with doum palms. Large prides of lions can be seen as well as some of Kenya's largest herds of buffalo. In the mid 1980's, the Park suffered from poaching. The Kenya Wildlife Service and armed wildlife security patrols have driven out the poachers and the elephant population has stabilized.

Environmental challenges in the Upper Tana sub-zone include catchment degradation from systematic deforestation, conversion of land and wetlands into human settlements and farmlands, soil erosion, human encroachment, excessive and illegal logging, livestock incursions into the forest, charcoal burning, and forest fires.

7.3.4.2. Middle Tana Sub-zone

This sub-zone starts at the Meru National Park and extends up to Garissa town area. The Tana River is the only perennial water course crossing this sub-zone as shown in Figure 7-20.

Tana River segment at this sub-zone drops from high to mild slopes, which leads to erosion and development of islands due to sedimentation of the meandering river, (Plate7-6).

Several locations as demarcated in yellow in Figure 7-20 were visited to check river morphology and there are severe bank erosions at most of the locations and newly developing islands were spotted as shown in Plate 7-5 and 7.6.

Figure 7-20: Locations visited to check river morphology

Finding suitable segments in Middle Tana Sub-zone for pump locations will be quite difficult and costly. Further, more than 50 meters head is needed to lift the water from the river up to the targeted lands on the upper terraces. Therefore, constraints which might limit water supply could be eliminated by introducing a weir or barrage upstream of the targeted lands and at the steep constricted area of the river (Figure 7-22) to divert the water from a higher elevation to targeted lands. Diverting the water from upstream location can offer 50m command for the downstream flat areas on both sides of the river which can be irrigated by gravity.

Plate 7-5: Developing islands **Plate 7-6: Severe bank erosion**

On other hand, the conveyor will cross through protected lands (Kora and Rahole) and the environmental and social impact should be assessed carefully to lessen impact and ensure sound and sustainable development (Figure 7-22).

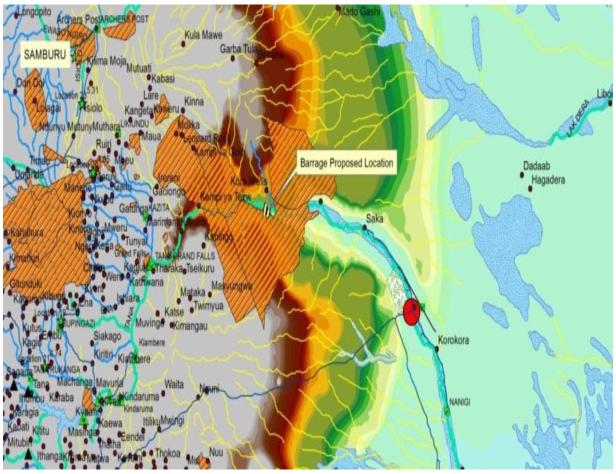


Figure 7-21: Barrage location **Figure 7-22: Barrage/weir location**

On other hand, the conveyor will cross through protected lands (Kora and Rahole) and the environmental and social impact should be assessed carefully to lessen impact and ensure sound and sustainable development (Figure 7-22).

The Middle Tana sub-zone starts at an altitude below 1300m and gradually drops to about 500m extending over the Tharaka, Kitui counties and Mwingi and parts of Yatta sub-counties. The region's climate is semi-arid to arid and because of the low rainfall the water demand is considerablity high rendering the region less attacrive for sugarcane cultivation. It is, nevertheless, utilized intensively for livestock and agriculture without considering proper management of resources e.g. , controlled grazing, forest managemengt or water harvesting programs.

Aquifers in this Sub-zone are localized and typically poor. In some areas water quality is an issue because of quarrying, sand harvesting and chemical wastes from farms. Towns and settlements in these zones are sources of pollution because they lack functional sewerage systems. There are pockets in these zones where there are excessive fluorides, irons, manganese etc. in groundwater. (UNEP 2012)

The main issues within Middle Tana sub-zone are:

- Water scarcity – rainfall ranging between 200 m to 400m
- High water demand compared with lower Tana subzone
- The groundwater aquifers are poor and low classes, which do not allow for sustainable irrigation use
- Uneven distribution of available groundwater and seasonal variation of shallow groundwater
- Salinity of groundwater in several areas;
- Uncontrolled sand mining
- Illegal logging
- Lack of management of grazing areas
- Extensive spreading of invader tree species, particularly *Prosopis juliflora*

The above issues render this sub-zone less attractive compared to the lower Tana sub-zone.

7.3.4.2.1. Potential areas in Middle Tana Sub-zone

The nearest metrological station for this area is Garissa Station which was used for the calaculation of water demand. Table 7-14 shows the sugarcane Irrigation Water Requirement for this sub-zone is estimated as 34,000m^3 per ha per annum.

Table 7-14: Middle Tana Subzone Water Demand

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Days	31	28	31	30	31	30	31	31	30	31	30	31
ET0 mm/day	4.9	6.0	6.5	6.7	6.6	6.5	6.5	6.9	7.6	6.7	5.4	5.1
Kc	0.40	0.62	1.05	1.27	1.27	1.27	1.27	1.27	1.27	1.18	1.01	0.84
Etc mm/day	2.0	3.7	6.9	8.6	8.4	8.3	8.2	8.8	9.7	7.9	5.4	4.2
Etc mm/month	61	104	213	257	259	249	255	273	290	246	162	131
Rain mm/month	5.1	1.1	21.9	59.9	14.3	3.4	2.9	3.3	6.3	31.9	96.2	40.7
Effective rain	4.1	0.9	17.5	48.0	11.5	2.7	2.4	2.7	5.0	25.5	76.9	32.5
Overall efficiency	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
IWR cu.m/month	86	158	295	303	377	378	387	415	436	330	102	139

8,000 ha is the maximum area which could be irrigated from the Tana River, expandable to 30,000 ha through the increase of water storage in the river and optimizing irrigation efficiency by the adoption of advanced irrigation methods. Potenial areas in this sub-zone are shown in Figure 7-23.

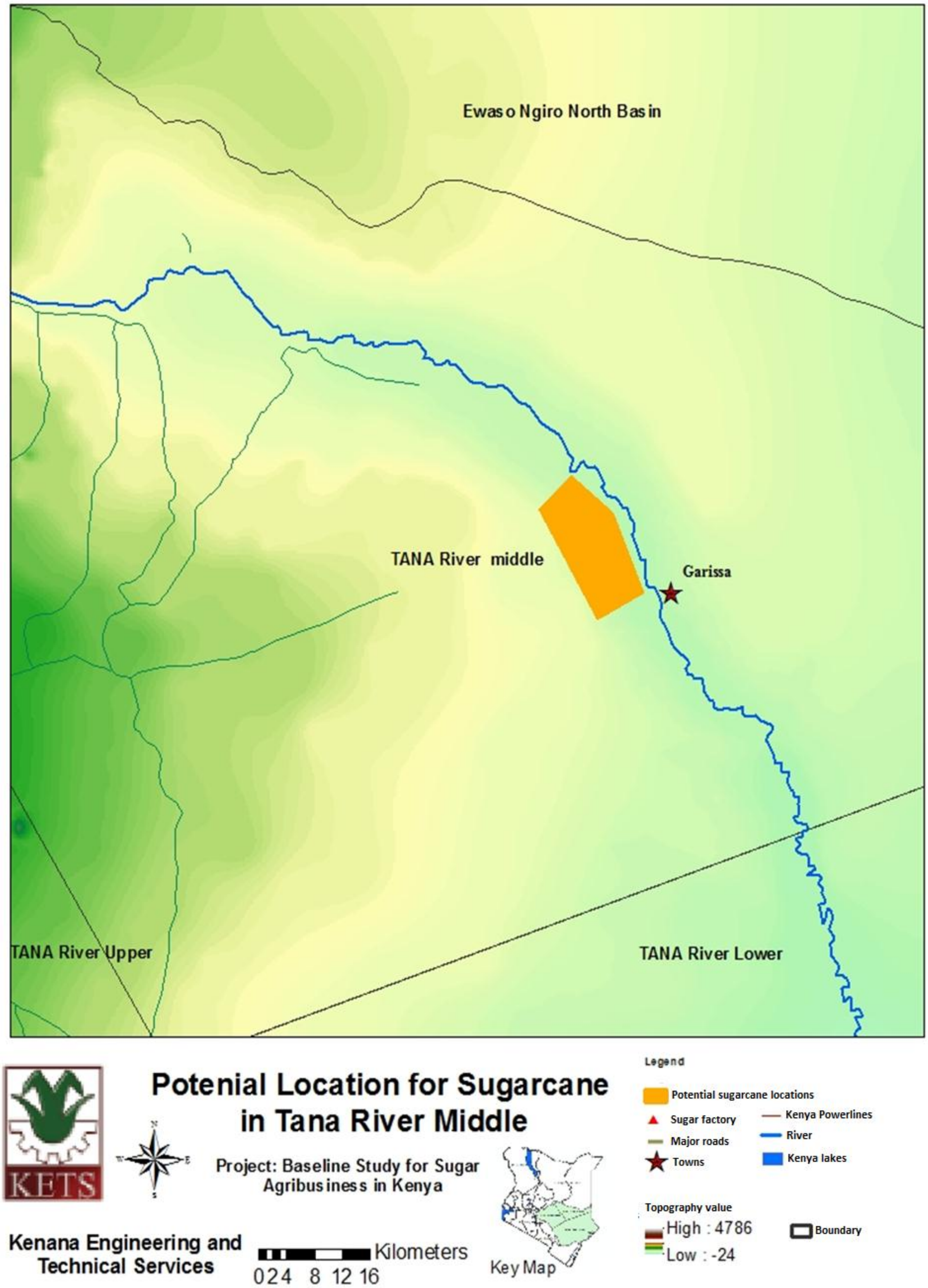


Figure 7-23: Potential area for sugarcane in Tana River Middle Sub-zone

7.3.4.3. Lower Tana Sub-zone

The Tana River in this sub-zone has a lower energy and water velocity than the middle Tana zone and the banks are more stable. and so, suitable locations for pumping stations could be identified in this sub zone.

This sub-zone contains four potential areas for sugarcane (1,2,3 and 4). Records of Galole FAO station which is in the middle of first three areas were used to estimate the crop water requirement. Tana Lower area 4, which falls in Tana Delta area, has been disregarded due to a number of environmental and socioeconomic issues as will be discussed later in this section.

Using surface irrigation, sugarcane irrigation water requirement is estimated at 20,000 m^3 per hectare per annum, the maximum consumption being is in August and May. Notably, minimum flow in the river occurs in September and February.

Figure 7-24 shows the possibility of irrigating 15,500 ha by surface irrigation from Tana River considering the monthly minimum (safe yield ,>80% depedancy) flow of the river and other current consumptions (the existing irrigation schemes which are estimated at 30,000 ha in Bura, Hola, Tana Delta and others in addition to other domestic, industrial and livestock water uses).

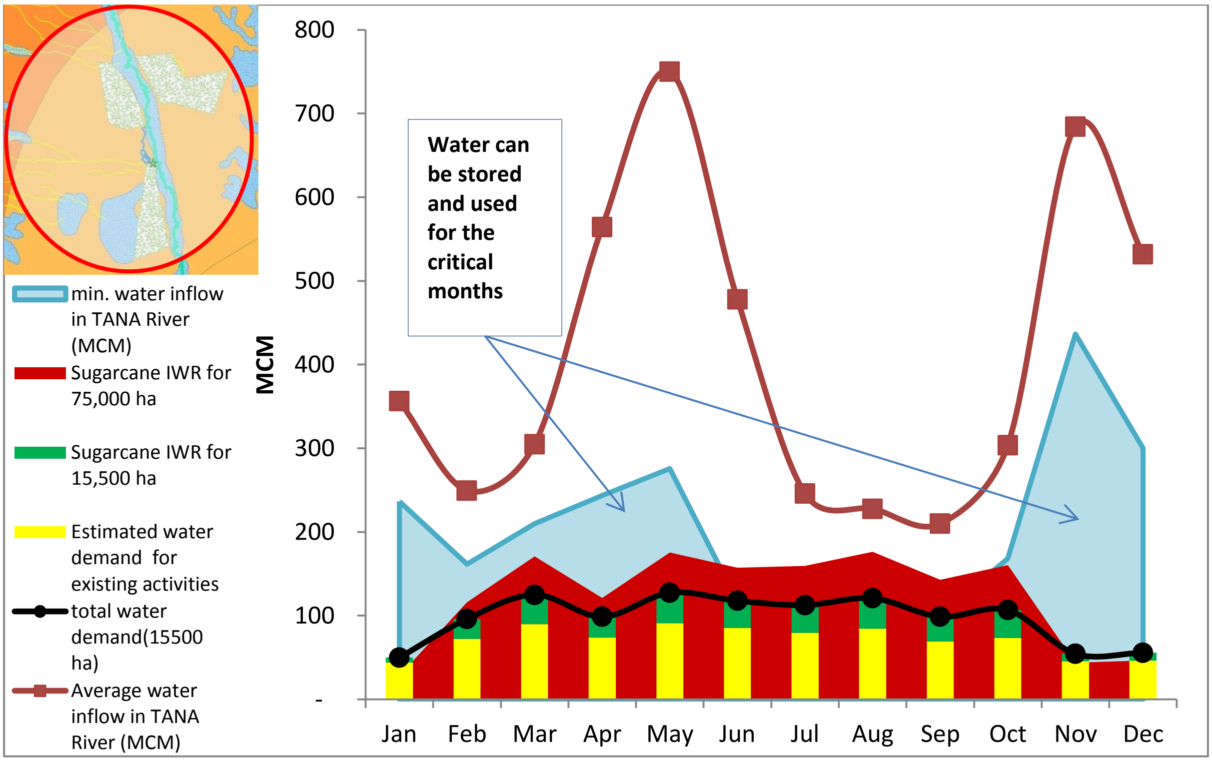


Figure 7-24: Estimated monthly water demands and Tana River monthly flows

Figure 7-23 also shows the possibility of supplying 15,500ha from Tana River considering the average monthly flow of the river and the current consumption. This area (15,500 ha) can be extended up to 75,000 ha (50% dependancy) by storing water during the flood seasons and changing the irrigation method. The expected shortage in the water supply will be about 1,250 MCM distributed in the critical months. Further, as perviously shown in Figure (7-17), the critical months are from June up to October and February. Water storage can be realized by establishing more dams upstream or changing the operational regime for existing dams for project benefit.

Table 7-15: Water demand calculations and assumptions in Lower Tana areas 1,2 and 3

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET_0 mm/day	4.8	5.3	5.3	4.9	4.7	4.2	4.1	4.3	4.6	4.6	4.6	4.7
Kc	0.4	0.8	1.1	1.1	1.3	1.3	1.3	1.3	1.3	1.3	1.0	0.7
Etc mm/day	2	4	6	5	6	5	5	5	6	6	4	3
Etc mm/month	60	120	182	161	182	156	159	166	173	177	132	101
Rain mm/month	35	19	34	56	30	20	21	13	49	38	94	61
Overall efficiency	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65	.65
Total IWR (mm)	38	155	228	162	234	210	213	235	191	214	58	62

A number of factors support the prospects of rapid growth in the cultivation of irrigated sugarcane and other crops. These factors include:

- Large swaths of flat lands
- Soils of good quality
- Adequate rainfall

The presence of pastoralist tribes who utilize the area for animal grazing during the dry season who include theOromas and Wardi and the Pokomos, (the latter being involved in the rice plantation in Tana Dalta area) will require detailed social surveys as part of the projects detailed feasibility studies.

The upper part of this sub-zone remains the most suitable area for developing large scale irrigated sugarcane projects as it enjoys adequate water and land resources. Supportive local community and commitment from the government could motivate investors and developers. This sub-zone is characterized by flat land and loamy soils which are ideal for irrigated and mechanized cultivation of sugarcane. It is worth mentioning that this sub-zone includes the existing irrigated schemes of Bura and Hola. The Bura project was financed by the World Bank in 1977, with a total net area of about 6,700 ha for settling approximately 5,150 families (36,000 persons). The Hola project is irrigated from the Tana River and the project soil is fairly suitable. The project introduces new crops, mostly legumes to compliment what has been traditionally grown in this area such as cotton and maize.

Few soil samples were collected from the areas targetd for cane cultivation by KETS experts during the agricultural team mission to Kenya and analyzed at the Land and Water Resource Centre – Medani, Sudan. Results of the chemical and physical properties are shown in Table 7-16, and 7-17 respectively. The results revealed that all levels of ECs and ESP are below the critical levels (ECs 4 dS m-1 and ESP 15%). It could be concluded that there will be no hazards of sodicity and salinity for sugarcane cultivations in those potential areas. With regard to nutrients, results showed low levels of total nitrogen and available phosphorous which entails the addition of those elements as inorganic fertilizers based on experimental work to be conducted at the fore-mentioned locations. The analysis showed that the levels of Ca, Mg and Kwere adequate for sugarcane cultivation except for East Tana and Garsen areas. The organic carbon (OC) in all analyzed samples is very low and it is important to incorporate leguminous crop in the rotation to increase the O.C and Nitrogen. However, research demonstrated clearly that cultivation of sugarcane over years will improve O.C of soils (Ali, A.1998). Further, the results of physical properties tests showed moderate to high levels of clay at 46%, 47% and 67% at Hola, Bura and Garsen respectively as shown in Table 7-17 in mixture with reasonable percentages of coarse sand which renders the areas suitable for irrigated and mechanized farming. Further detailed soil analyses will be required to generate a comprehensive soil map for each region.

Table 7-16: Chemical Properties of soils in Lower Tana River Zone

Location	pH paste	E.C dS m^{-1}	C/N	$CaCO_3$	N	O.C	Soluble Cations			Soluble Anions			Exch. Cations		CEC	SAR	ESP	Av. P mg kg^{-1} soil
				---------------%------			Na	Ca	Mg	Cl	HCO_3	SO_4	Na	K				
							me l^{-1}						cmol(+) kg^{-1} soil					
Bura	7.9	0.7	5	6.00	0.090	0.437	4.5	2.5	1.0	0.7	0.3		1.2	1.03	43	3	3	**2.0**
Hola	7.6	0.8	6	5.40	0.120	0.663	4.0	3.5	2.0	4.0	2.5		0.32	1.16	30	2	1	**5.4**
E.B of Tana	8.3	1.2	5	5.20	0.140	0.663	0.7	2.5	1.0	1.0	2.0		0.32	1.01	20	1	1	**8.0**
E.Tana	8.1	1.9	6	6.00	0.100	0.624	0.8	3.0	1.0	1.2	3.0		0.31	0.08	17	1	2	**8.6**
Gazura Farm Bura	7.4	1.8	7	5.00	0.080	0.577	5.0	11.0	2.0	5.1	4.5		1.99	1.38	30	2	6	**2.0**
Garsen	**7.8**	**0.7**	**3**	**6.00**	**0.220**	**0.577**	**3.6**	**3.5**	**1.5**	**2.6**	**4.5**		**2.12**	**0.84**	**53**	**2**	**4**	**3.8**

Table 7-17: Physical Properties of soil in Lower Tana Rive Zone

Mechanical Analysis				
Location	CS	FS	Si	**C**
Bura	38	5	10	**47**
Hola	39	7	8	**46**
E.B of Tana	92	1	1	**6**
E.Tana	52	10	26	**12**
Gazura Farm Bura	60	6	8	**26**
Garsen	**17**	**4**	**12**	**67**

Results of limited research conducted at Tana Delta (Kebeney, et al., 2007) by KESREF were promising as shown in Table 7-18. The yield of the KEN varieties was very high ranging from 135 to 189 TCH for plant cane harvested at 12 months, but with respect to Pol% cane, some varietes scored moderately while others were low and this could possibly be attributed to young cane age at harvest; had it been harvested at 13 or 14 months the pol% cane could have been optimized.

Trials should continue to proceed to at least two crop cycles to test the ratooning capacity of the different varieties. Being carried out under furrow irrigation system in Tana Delta, the testing of KESREF new varieties should have shown advantages regarding low cost of installation, operation and maintenance as water flow by gravity. Also, the furrow irrigation requires minimum specialized skills and farmers can speedily acquire needed skills.

Table 7-18: Quality parameters and yield components of 10 KN varieties at the Tana Delta

variety	Fiber%	POL%	cane yield (t/ha)	Sugar Yield (t/ha)
N14	12.58	11.59	176.30	20.44
KEN 83-737	16.93	14.13	134.55	19.01
KEN 82-808	14.63	11.41	175.80	20.06
KEN 82-401	14.35	13.3	160.15	21.39
KEN 82-247	15.08	12.1	160.15	19.38
KEN 82-216	14.4	10.04	188.65	18.94
D8530	12.93	11.42	153.35	17.51
D8484	11.25	13.99	104.95	14.68
D15841	13.33	13.44	154.20	20.73
CO421	13.43	12.85	149.95	19.77

Environment status of Tana River Lower Area

This sub-zone is considered a unique biodiversity and sanctuary area for various types of wildlife and natural habitats. Additionally, the area has a high potential for tourism activities. Ishaqbini Hirola Community Conservancy is one of North Rangelands Trust's newest community conservation initiatives located in the Masalani Division of the Garissa County. The conservancy surrounds the eastern sector of the Tana River National Primate Reserve and is managed by and represents local Somali pastoralist communities from Hara, Korissa and Kotile whose members come from the Abdullah clan of the Ogaden community. The most important feature of this conservancy initiative is that it encompasses an area of land inhabited by the endangered Hunters Hartebeest, commonly called Hirola, with an estimated population of 100 Hirola within the conservancy area. Hirola are Africa's most endangered large antelope with a total population estimated at merely 400 individuals, having declined from over 14,000 in the 1970s.

The Kenya Wildlife Services (KWS) has raised the possibility of incorporating the eastern sector of the Tana River National Primate Reserve under conservancy management through a co-management agreement. This would be a major development for a community conservancy in Kenya and provide added importance and potential for wildlife and tourism development at Ishaqbini.

The Tana River Primate Reserve was established to protect the Tana riverine forest and the two endangered primates, Mangabey and the red colobus monkey. The two primate species are the major wildlife attraction in the reserve. The ecosystem consists of riparian forests, dry woodlands and savannah habitats on the east and west of the lower Tana River. The ecosystem is also a stronghold for birdlife with over 200 species recorded in the area. These include the White-winged Apalis, African Open-bill Stork, Martial Eagle, Bat Hawk, African Pygmy-falcon, African Barred Owlet, Scaly Babbler, Black-bellied Glossy-starling, and the Golden Pipit.

Socioeconomic Status of Tana Lower Sub Zone

The population of the Tana River Basin is estimated at 5.7 million. Within Tana and Lamu Counties there are around 240,008 people with females comprising 120,190 and males accounting for 119,818 (National Census of 2009). This figure implies an inter-censual population growth rate of 3.4% which is higher than the national average of 3.0%. The estimated population within the 130,000 ha of the delta is 96,664 while the total number of households is 12,457, giving a mean household size of 8 persons.

The lower Tana area falls in Tana River County. The trading centers of Hola and Madogo provide a cosmopolitan society of the different tribes. The total area of the Tana River County is 22,452.9 km^2, with 90% considered as usufruct land.

The main tribes of the county are the Pokomo, Orma, Wardei, Somalis, Malakote, Munyoyaya and Wata and other small tribes also settle in the county.

The Pokomos, Munyoyaya and Malakote are farmers while the Orma, Wardei and Somalis are pastoralists. The Pokomos and the Malakote live in villages of 500 households in average with most of the villages established on the banks of the River Tana where they cultivate their small plots of land.

The pastoralists prefer the hinterland where they live in villages known as Manyattas with the average number of 150 households in each village. Water points are centers of settlement for pastoralists as they move in search of pasture. This pattern of land use followed over decades has resulted in overutilization of water points and over grazing of the surrounding pastures. The pastoralists are forced to cover long distances in search for water and pasture, and their movement is getting more frequent as dictated by severity of droughts. They start moving from the northern divisions of Bangale, Madogo, Bura and Galole up to the Tana Delta and camp there before moving back again to the northern areas with the onset of the rains.

Agriculture and pastoralists

The arable land is estimated to cover an area equal to 1,361 square kilometers while the average farm size holding is disproportionally small at about 1.5 hectares per household. The total number of farming households was estimated at 14,978 in 2008 and the ratio of dedicated agricultural staff to household farming is 1:788. The main horticultural trees and plants and food crops grown along the rivers' banks include mangoes, bananas, cowpeas, millet, and green grams. Most of the farmers depend on rains and the residual moisture following flood recession; only few farmers lift irrigation water from the river using pumps. The area under irrigation accounts for only 6.25% of the potential irrigable land in the county.

Due to poor marketing infrastructure and facilities, part of the mango harvest is lost and the yield of crops in the area is generally low for being exposed to frequent spells of drought.

The types of livestock raised by pastoralists in the county include the Ormabaran cattle, Galla goats, black-head Persian sheep and other cattle breeds and camels. The marketing of milk is carried out by women while men are involved in livestock marketing as the main economic activity. The development animal wealth is hindered by a number of challenges in the area such as the erratic cycles of floods and, droughts as well as the incidence of diseases and tribal conflicts.

The Tana River county is more experienced in agriculture than Garissa county and it is home to a number of irrigated projects producing cotton, maize and other food and cash crops. Development of irrigated projects which attract labor from different localities and ethnic backgrounds could proof successful in the settlement of the nomadic tribes and could also provide a melting pot to reconcile different cultures and forge a sense of unity. An example is the irrigated farm in Hola which attracted a number of pastoralists to settle as farmers and integrate their animals into the new system.

The irrigation authority provides water to the farmers at a nominal fee while other governance departments offer technical and financial services so as to improve crop production which is currently weak due to low farmers' capacity.

Resources in the area offer an ideal opportunity for investment in large scale production utilizing labor and machine. The possibility of attracting newcomers from other areas of Kenya is welcomed in this county.

The expansion of the present scheme into a second phase has been approved whereby an extra 5000 acres are to be added for production of cotton and maize and other crops. However, based on doubts by supporting departments about the viability of the present small farmers system, the administration is contemplating the idea of distributing the new land to private investors who will be expected to efficiently manage the scheme and control production.

learning from this irrigation project, we are convinced that the optimum approach for sugarcane production in this area would be large scale farms using labor and machinery. The sugar mill authority should assume the responsibility of producing the crop technically and financially. The people of the Tana River County can provide the needed labor for the various sugarcane and sugar milling activities.

This study established that is a problem created by a law which enacted in 1930 gives the authority of Tana River County control of available agricultural land on banks of the river including parts of Garissa County on the eastern bank of the river. This is considered a violation under the current demarcation of county borders. The solution to this could be declaration of both banks communal land under the mandate of the Tana and Athi River Development Authority (TARDA), and giving it authority to plan development strategies together with the loca communities.

7.3.4.3.1. Potential areas in Lower Tana Sub-zone

Tana Lower area 1

The potenial areas in this sub-zone are shown in Figure 7-25.

The annual irrigation water requirement for the potential area was estimated as 20,000 cubic meters per hectare using surface irrigation. This is equivalent to about 1,060 MCM annually for the whole area.

Plate 7-7: Tana River in lower area 1

Tana Lower area 2

The potenial areas in this sub-zone are shown in Figure 7-25

Water demand:

The annual water requirement is about 20,000 cubic meters per hectare which is equivalent to about 584 MCM annually for the whole area.

Plate 7-8: Tana River in lower area 2

TANA LOWER AREA 3

The potenial areas in this sub-zone are shown in Figure 7-25

The annual water requirement is about 20,000 m^3 per hectare, which means about 640 MCM annually for the whole area.

Plate 7-9: Tana River in lower area 3

Table 7-19: Water demand calculations and assumption in Lower Tana area 4

Month	Jan	Feb	mar	Apr	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET0 mm/day	5.1	5.4	5.4	4.8	4.1	4.2	4.5	4.8	4.9	4.9	4.9
Kc	0.4	0.8	1.1	1.1	1.3	1.3	1.3	1.3	1.3	1.0	0.7
Etc mm/month	64	122	184	158	155	161	175	182	190	139	107
Rain mm/month	14	9	28	104	101	57	35	44	46	56	34
overall Efficiency	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
IWR mm /month	71	161	222	78	77	148	200	196	206	118	105

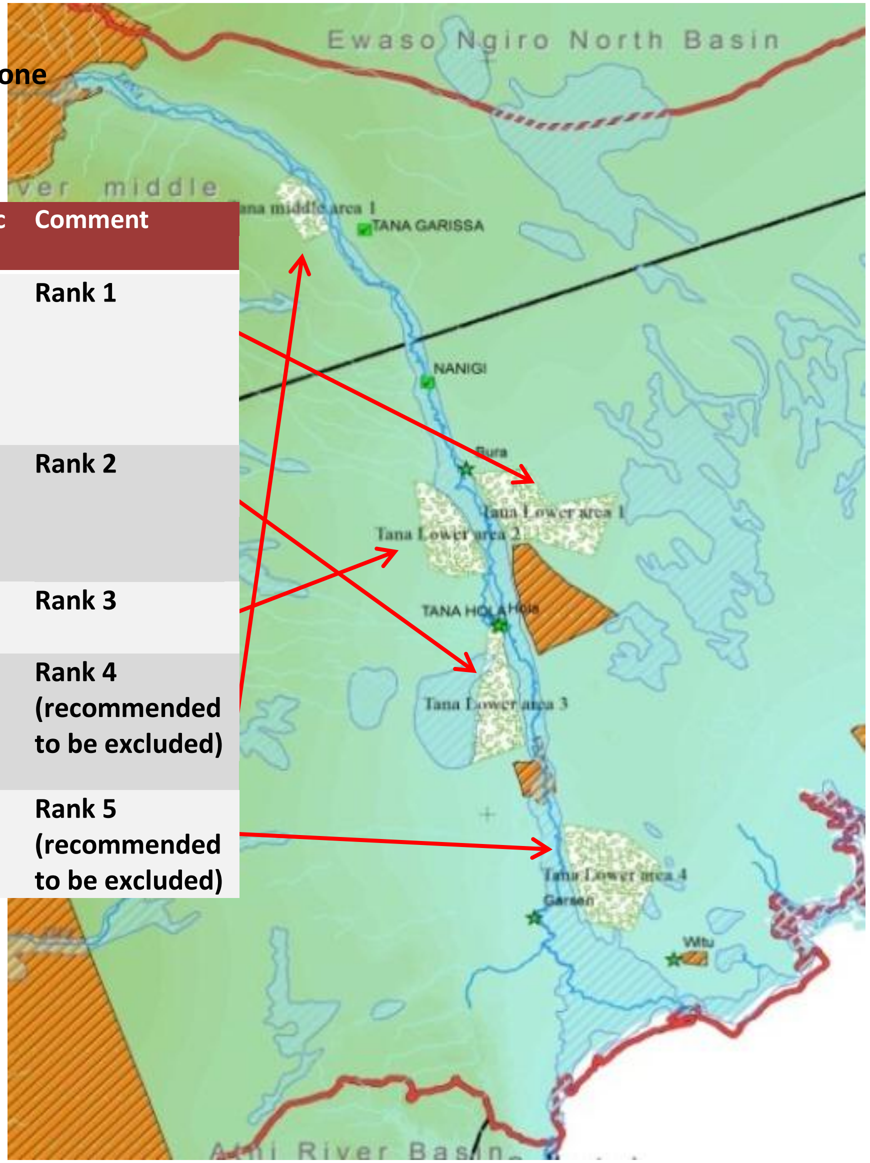
Table 7-19 showed that the annual water requirement is about 15,400 cubic meters per hectare per annum which is equivalent to about 832 MCM annually for the whole area.

Demand summary

It is important to note that all areas in Tana River Agro Zone are sharing the same water source therefore; water utilized for one of the proposed areas will be at the expense of others.

Table 7-20: Summary of potentioal areas in Tana River Agro Zone

Potential area	Water demand	Sub zone	Soil suitability	Climate	Environment	socioeconomic	Comment
1	**Reasonable**	**Lower**	**Loamy (high)**	**Suitable**	**Low risk (nearby protected areas)**	**Conflict between farmers and pastoralists (medium)**	**Rank 1**
3	Reasonable	Lower	Clay (medium)	Suitable	Low risk nearby protected area	Low risk (farmers)	**Rank 2**
2	Reasonable	Lower	Sand (low)	Suitable	No risk	No risk	**Rank 3**
1	Very high compared to lower Tana	Middle	(clay) medium	Suitable	Low risk	Low risk	**Rank 4 (recommended to be excluded)**
4	Reasonable	Lower	Loamy clay (high)	Suitable	Very high risk Ramsar site	High risk conflict with nomads	**Rank 5 (recommended to be excluded)**



Sugar Beet areas in Tana River Lower Area

This sub-zone could be suitable for sugar beet according to the low climatic suitability criteria as explained above, but requires supplementary irrigation (see Figure 7-19). Ntheu and Athi Rivers could be sources to irrigate potential sugar beet areas basedon on detailed water balance studies.

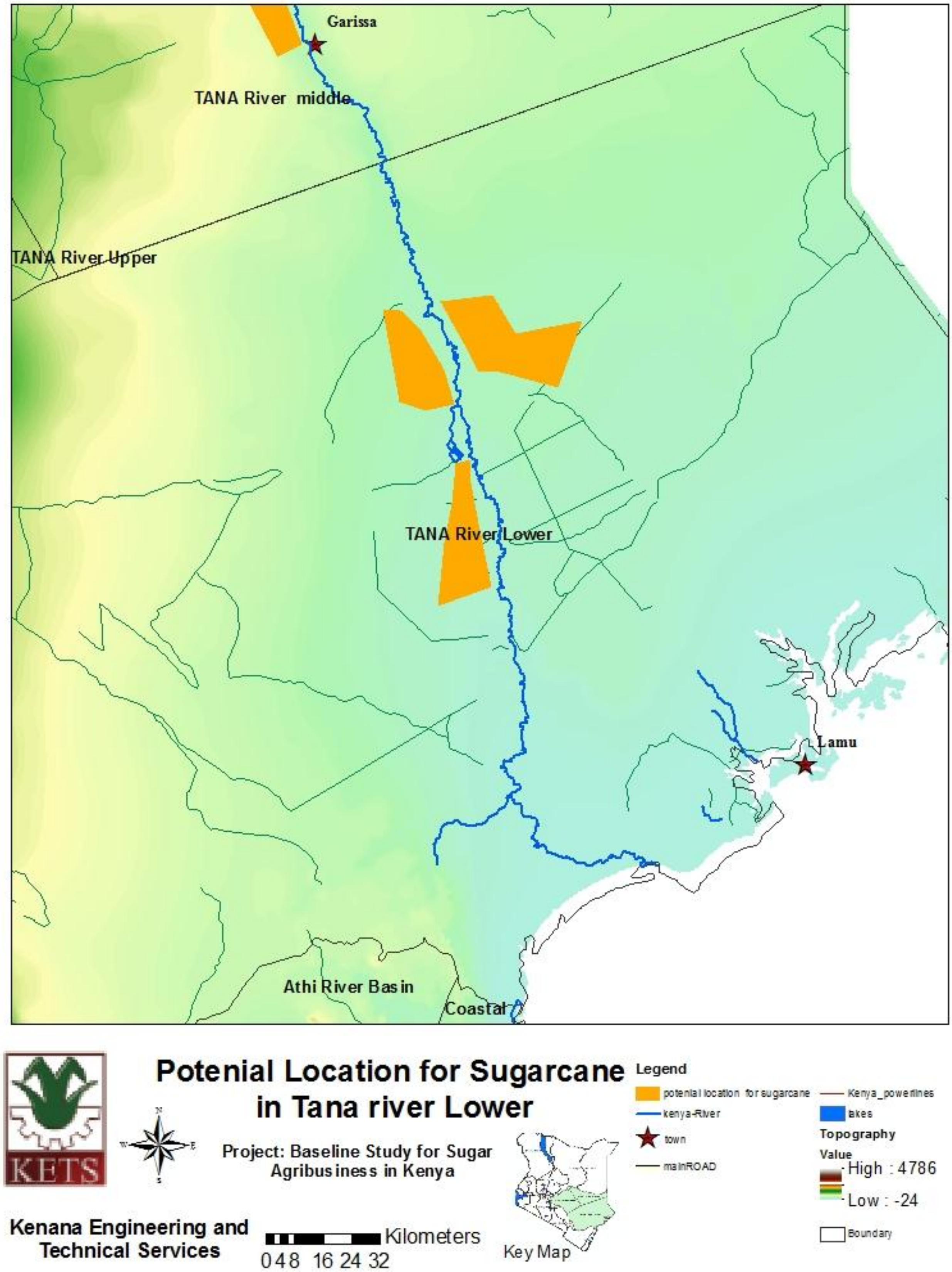


Figure 7-25: Potential areas for sugarcane plantation in Tana River Lower Zone

The Tana Delta Area

Initially, four areas were selected in Tana River Lower Sub-zone. One of these areas is located in the Tana Delta Area, namely, Tana River Lower Area 4 which excluded as a potential area for both sugarcane and beet plantation. This because of a number of environmental and social factors as described below.

Environment of Tana Delta Area

Tana River Lower Area 4 falls in Tana Delta area and there are numerous social and environmental issues which will hamper the introduction of irrigated sugarcane plantation in this sub-zone. The delta has many shallow lakes and wetlands created within former channels and meanders of the river which are recharged through ground water seepage or by the periodic flooding. As such any development in this area should be avoided to preserve the natural habitat. This area is home to highly threatened remnants of indigenous vegetation, rare plant communities and species of wildlife and birds, whose survival depends upon protecting the diminishing habitats and expanding them (Plate 7-10, 7-11). These are not only unique habitats, they also provide food, livelihoods and social benefits to local communities. The basins of oxbow lakes and the deeper parts of dammed lakes where water remains for most of the year include the Lakes Bilisa, Shakababo, Kongolola, Kitumbuini, Harakisa, Moa, Mnuji and Kenyatta.

Plate 7-10: Garissa giraffes' sanctuary

Plate 7-11: Antelopes and water bucks at the south of Bura East area

The Tana Delta forms an area of rich biodiversity for sea species including fish, prawns, and five species of marine turtles. There are a host of terrestrial animals such as the African Elephant, Tana Mangabey, Tana River Red Colobus, and White Collared monkey. In addition to more than 600 plant species, the Tana Delta is a home for many bird species and is a critical transit point for migratory water birds such as waders, gulls and terns. Therefore, the Tana Delta is an important ecosystem not only for Kenya but also for the East African coast.

On 12th October 2012 the Tana Delta Ramsar Site was announced as Kenya's 6th Ramsar site. This comes as a result of a lot of hard work by Kenya Wildlife Service which has taken the lead in the process with significant support from KenWeb and the Kenya Wetlands Forum amongst others (Figure 7-26).

The Tana Delta is the second most important estuarine and deltaic ecosystem in Eastern Africa. It comprises a variety of freshwater, floodplain, estuarine and coastal habitats with extensive and diverse mangrove systems. (source- KWS website)

Further, the Tana Delta is vital for the herders who depend on its water and grasslands during the dry season, the farmers who cultivate rice, mangoes and other crops and the fishermen who fish its lakes and watercourses and for tourism and research activities.

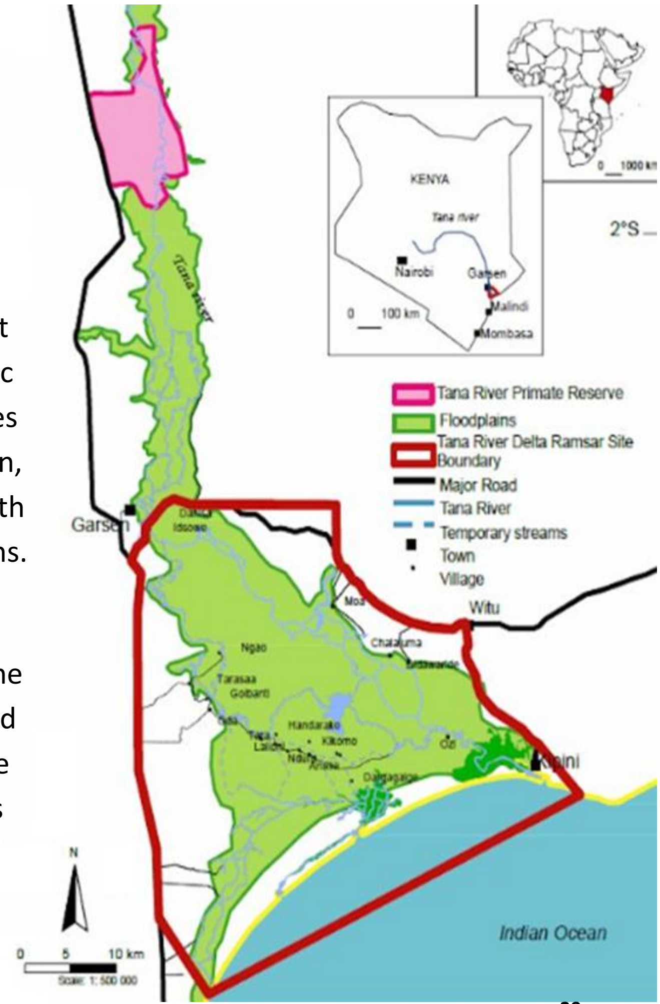


Figure 7-26: Tana Delta Ramsar Site [39]

According to the Ramsar Secretariat, the Tana River Delta Ramsar Site is the second most important estuarine and deltaic ecosystem in Eastern Africa, which supports a variety of coastal and marine plant and animal species. The site also provides feeding and wintering ground for several migratory water birds.

Socioeconomics of Tana Delta Area

The land downstream of Tana River is utilized by pastoralists and scattered farmers practicing small scale agricultural production. The area enjoys land availability, sufficient water resources and thriving wildlife which could form basis for tourism industry. There is

[39] Source: http://africanature.or.ke/index.php/news-updates1/125-tana-river-delta-becomes-the-6th-ramsar-site-in-kenya

also a rich forest belt along the river's banks as well as frequent pockets of woodland cover deep to the east and west.

The baseline study has indicated the availability of potential land area for the establishment of sugarcane projects downstream of Tana River. Suitability of soil and climate, availability of water to provide supplementary irrigation, approving local community and supportive county government are encouraging factors.

Given the diversified land use and the wild life factor, the introduction of a sugar industry in the area must be preceded by appropriate studies to identify the possible impacts on the local environment and enumerate the measures needed to mitigate them.

Tana River Lower Area 4 is located in the Tana Delta. The Delta is home to diverse human settlements, ranging from nucleated to sparse settlements. The communities living in the delta are Pokomo - 44%, Orma - 44% and Wardei - 8%, while other ethnic groups, including the Luo, account for the remaining 4% (Tana Delta County Development Plan, 2008-12). These communities earn their livelihoods as farmers, pastoralists, fishermen and tourism guides. The Wardei and Orma are pastoralists. The Pokomo are mainly subsistence farmers who cultivate lands along parts of River Tana. The Delta has a high rate of poverty, estimated at 76% compared to the national average of about 50%. The unemployment rate is high at 33%, in comparison with the national average of 20%.

Tana Delta supports commercial irrigation farming of rice and other grains and provides a dry season's grazing area for livestock emigrating from regions outside the delta. Over the past decade, conflicts have increased in the delta due to factors of increasing population, competition for land, declining natural resources, encroachment into fragile ecosystems, poverty and changing climatic conditions.

The upper part of this sub-zone has the highest potential for the development of large scale projects of irrigated and mechanized cultivation of sugarcane as it has potentially adequate water and land resources. Supportive local community and commitment from the government could motivate and incentivize investment and development.

7.4. Rift Valley Agro Zone

7.4.1. Overview

Most of the Rift Valley region consists of low lying plains with isolated mountains and hill ranges. The south is generally high and rugged. Prominent features include Cherangany Hills (3500 m), Keiyo Escarpment, Tugen Hills and isolated mountain ranges in Turkana County. The Great Rift Valley runs north–south though not well defined in Turkana County.

The region has diverse and spectacular land forms ranging from highlands to plains. Land forms can act as either a hindrance or a catalyst for development. Moreover, climatic conditions are related to altitude. Temperature in the region is generally high but varies with altitude.

The Rift Valley region has a mean annual rainfall ranging from over 1000mm in the highlands to between 200mm to 800mm in the dry lowlands. The highlands are in the modified tropical zone with soils generally well drained and fertile. They have high potential for agricultural and livestock development. The lowlands are in a semi-arid climatic zone and have complex soils with various textures and drainage capacities.

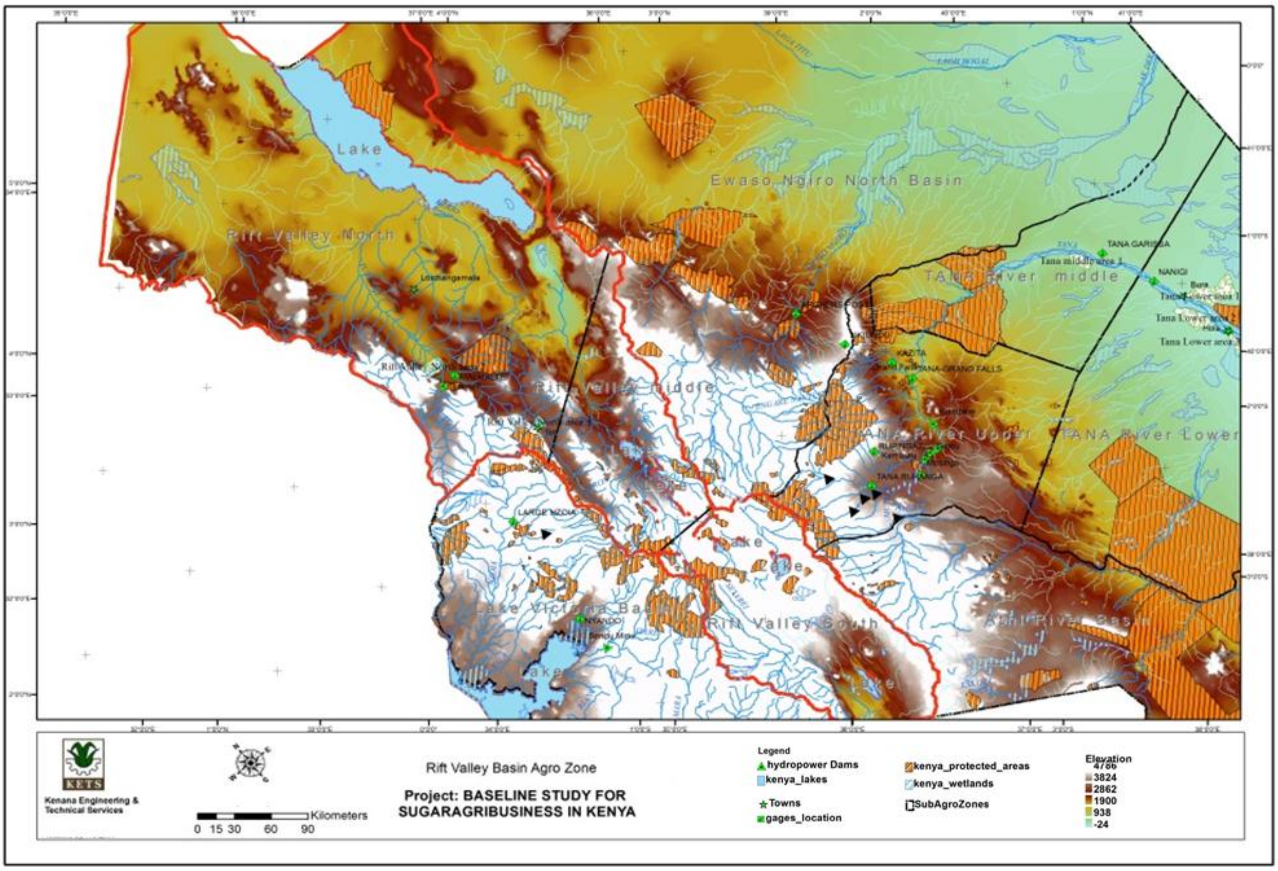


Figure 7-27: Rift Valley Agro Zone

The Rift Valley has 14 couties distributed in the North, Middle and South regions. The Rift Valley total area is 182,505 km^2 and , the total population of the counties, according to 2009 Census, was 10,006,205 million. For the purpose of this baseline study, the Rift Valley has been divided into three sub-zones.

7.4.2. WATER RESOURCES

Rift Valley (RV) catchment area covers the central-western part of Kenya, which includes a number of rivers flowing in the Rift Valley. The Rift Valley catchment is bordered by South Sudan and Ethiopia to the north, Uganda to the northwest and Tanzania to the south. It has a long and narrow shape approximately 800 km long in the north-south direction and 100 to 300 km wide in the east-west direction.The total catchment area is 128,907 km^2 which is 22.3% of Kenya.

There are seven lakes within the Rift Valley, namely, Turkana, Baringo, Bogoria, Nakuru, Elementeita, Naivasha and Magadi. Only Naivasha and Baringo are fresh water lakes. Additionally, there are a few other lakes with saline waters. Rivers in the Rift Valley catchment originate from the Mount Elgon, Mau Range, Cherangani Hills and Abadere Range, and most of them drain into one of the seven lakes.

The water demand, MCM/year, as at 2010 in the Rift Valley Catchment is shown in Table 7-21.
The irrigation potential of the region is estimated to cover an area of 64,000 hectares of which only 5,477 hectares are currently developed. Table 7-22 lists irrigation projects under execution in the area.

Table 7-21: Rift Valley water catchment

Domestic	59
Industrial	4
Irrigation	119
Livestock	68
Total	250

Table 7-22: List of irrigation projects under execution in Rift Valley area

Project	Cultivated land (ha)	Outputs	County/Sub-County
Wei Wei project (phase I and II)	275, using sprinklers	Farmers earned Ksh30 million KDVA earned Ksh 2 million 300 ha degraded land reclaimed	Central Pokot
Tot project	18 ha, under furrow	Food self sufficiency and horticultural cops	Marakwet
Arror Integrated project	40 ha, under sprinklers	Food self sufficiency and horticultural cops	Marakwet
Elelea/Turkwel project	Envisaged to provide 540 ha of irrigated scheme	Carry preliminary studies	Lokori
Salawa/Kolowa project	42 ha, under crops	Dry land hybrid maize under cultivation	Baringo

7.4.3. Soils, climate and land suitability

The Rift Valley Agro Zone has been divided into three sub-zones, namely south, middle, and north sub-zones.

Rift Valley north land, climate, and soils have high potential for sugarcane cultivation. The other two sub-zones are not suitable for sugarcane plantation and could have potential for sugar beet, specially the south sub-zone. The land suitability for the north zone will be discussed in more details in the north sub-zone.

7.4.4. Rift Valley Sub Agro zones

7.4.4.1. Rift Valley South Sub-zone

The South sub-zone starts from the southern boundary of the Rift Valley up to Nakoru town. The annual rainfall in this area ranges between 200 and 1200mm. A considerable number of natural streams run through this sub-zone and drain into Ewaso Ng'iro and Kerio Rivers. However, the sub-zone includes protected areas, undulated land topography, tourism activities and enjoys a relatively cold climate, which makes it unfavorable for sugarcane production. Therefore, this sub-zone has been excluded from further assessment for sugarcane plantation. However, it could potentially be suitable for sugar beet plantation.

The potential areas of sugar beet in this sub-zone are classified as medium cliamte suitability and irrigation is required for all the potential areas (Figure 7-28). Water harvesting is the only source to provide supplementary irrigation.

7.4.4.2. Rift Valley Middle Sub-zone (Baringo)

This sub-zone includes most of the Baringo County. A number of protected areas and national parks fall within this sub-zone. The Hell's Gate National Park, south of Lake Naivasha, and the forest reserves known as the Cherangani Hills Forests, are some of these reserved areas.

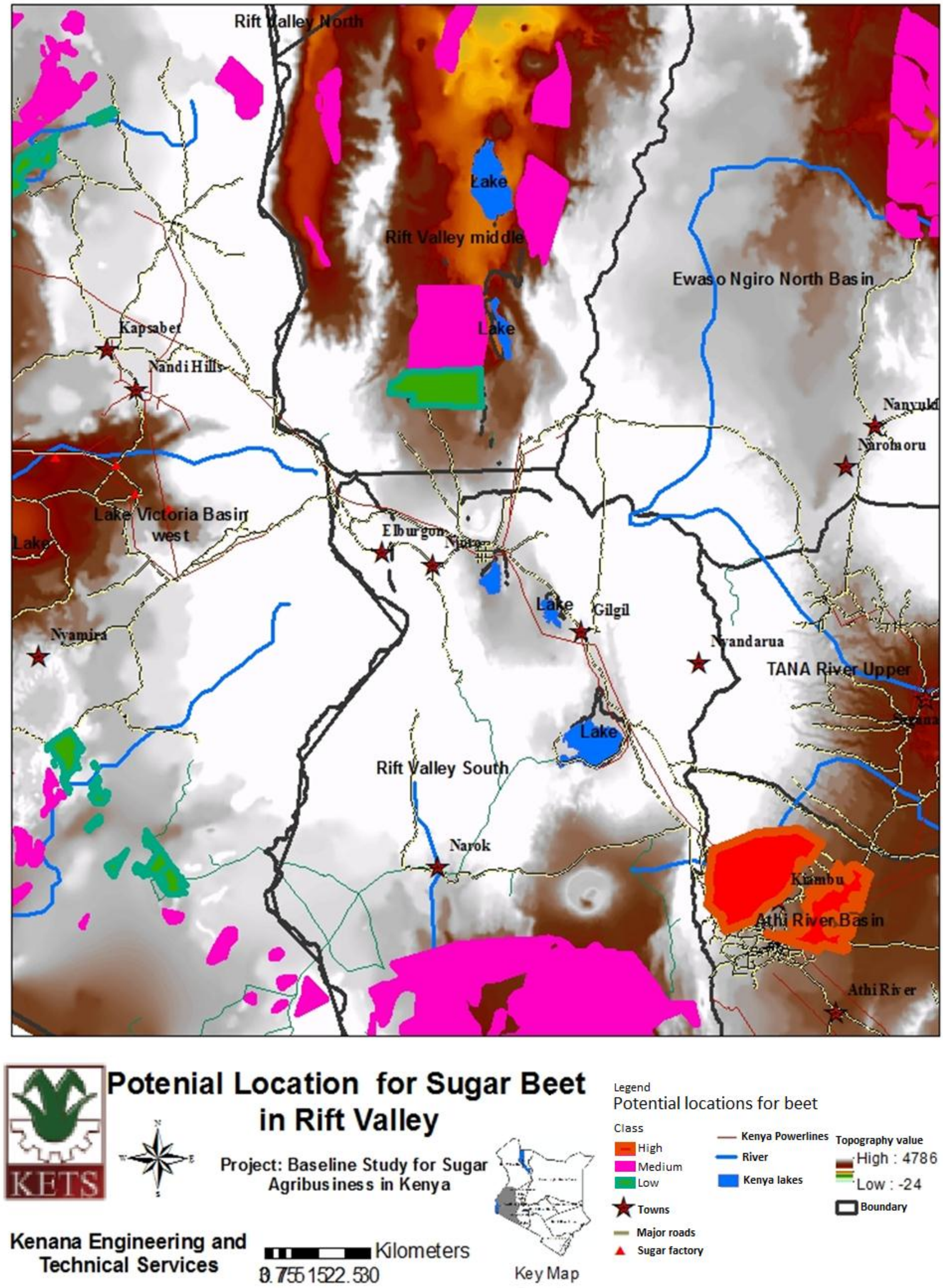


Figure 7-28: Potential areas for sugar beet in Rift Valley South

Water resources - Rift Valley Middle Sub-zone

The annual rainfall in the area ranges between 200 and 1200mm and the groundwater aquifers in this sub-zone are classified in the range of fair to poor. This sub-zone contains many small streams with miniscure water yields which are used by communities for various purposes such as fishing, tourism, drinking, and irrigation. The Kerio Valley Development Authority (KVDA) is proposing 24 small dams to be distributed across the various counties with a total storage capacity of 5.5 million m^3 for flood control, generation of energy, and irrigation. KVDA is anticipating a total of 12,900 ha wil be irrigated after implementation of these dams.

The crop water requirements for sugarcane will be about 180,000,000 cubic meters per annum with an average of 14,000 cubic meters per hectare per annum, the peak demand being in January - February and September-October periods. This means that the dams should secure 10,000,000 cubic meters per annum for the crop in each period as shown in Figure 7-29.

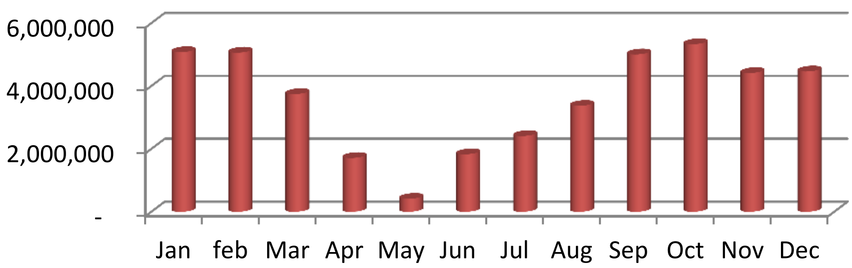


Figure 7-29: Monthly crop water demand in Kerio Area (m^3/month)

Challenges of cultivating sugarcane at this area:

- The sugarcane water requirement is high, which implies that the total irrigable area would have to be less than 5000 ha considering a runoff factor of 0.3 for all the streams
- The proposed areas are small and scattered around the region and this will lead to complications regarding field operations, transportation and management
- Other activities are also demanding water including other competitive crops, which farmers normally grow (food crops and cash crops)

Given the above mentioned challenges, this agro-sub-zone has been excluded as a potential area for sugarcane.

The potential areas for sugar beet in this sub-zone are classified as medium climate suitability. Irrigation is required for all the potential areas and water harvesting is the only source to provide supplementary irrigation.

7.4.4.3. Rift Valley North Sub-zone

Water Resources

The two main streams within this sub-zone are Kerio and Turkwel Rivers. Rainfall in this sub-zone ranges from as low as 200 up to 1,600mm per annum.

Groundwater aquifers in this sub-zone are classified as poor and low classes which are not variable for irrigation use. However, based on recent information, massive groundwater has been discovered by a french company called Radar Technologies International (RTI) located in Lotikipi in Turkana county. The reserved water in the acquifers is estimated at much as 200 billions cubic meters. These aquifers are linked by small lakes and underground streams and the verfication and caculation of water recharge depth are inprogress. Further studies and researches are strongly recommended before considering it as a viable water source for sugarcane projects.

Land forms and Soils

Kerio Valley floor is located in the north western region of Kenya. It lies between latitude 0^{o} 10’ S and 10^{o} 30’ N and longitude 34’ and 37’ E. This region includes the counties of Baringo, Marakwet, West Pokot, Turkana and sub-counties of Koibatek, Keiyo and western parts of Samburu. Total area covered by the valley is approximately 15,904 Km^2 and all of it is being classified as arid and semiarid. Area by county is given in Table 7-23. The region has great contrasts in land form and physical features and is characterized by three topographical zones namely: Highland plateau (2500-3500m.a.m.s.l), steep escarpment (1200-2400m.a.m.s.l) and the valley floor (300-1100m.a.m.s.l). Soils in the region can be broadly classified into lava borders and shallow stony soils, clay soils, loamy soils and alluvial soils, according to matrix of soil suitability for sugarcane cultivation. Loamy soils, which are characterized by flat topography, proper drainage and good machine performance under wet conditions are given priority for cane cultivation followed by clay soils which have high fertility due to high cation exchange capacity (CEC).

Table 7-23: Rift Valley North Sub-zone area by county*

county /subcounty	Area – Km^2
Keiyo	352
Marakwet	378.9
West Pokot	5686
Turkana	9487
Total	15,903.9

Source: Kerio Valley Development Authority, Investment Plan

Climatic conditions

The lowlands experience a bi-modal rainfall pattern with two peaks in March-April and September-October. The average rainfall varies between 300-600mm per year and the mean daily temperature ranges between 24 to 38°C. The mean daily temperatures are suitable for sugarcane growing. However, the annual rainfall is inadequate since sugarcane requires over 1500mm of well distributed rainfall per year. The high mean temperatures and low rainfall promotes high evapo-transpiration. Therefore, for successful sugarcane growing in the low land areas, there is need for supplementary irrigation over in the order of 900mm (60%).

The potential areas for sugar beet in this sub-zone are classified as high and medium.

Some sugar beet areas, where the rainfall ranges between 550 mm and 750mm per season, will not require supplementary irrigation (see Figure 7-7).

There are two potential sugarcane areas in this sub-zone which will be discussed in greater details in the following sections:

7.4.4.3.1. POTENTIAL AREAS IN RIFT VALLEY NOTH SUB-ZONE

RIFT VALLEY NORTH AREA 1 (TURKWEL)

Potential areas in this sub-zone are shown in Figure 7-31. Plate 7-12 shows the existing dam at Turkwel which could provide irrigation water for limited areas in this sub-zone. Table 7-24 shows the monthly rainfall in Turkel dam area. Figure 7-30 shows the river's flow before and after Turkwel dam construction.

Plate 7-12: Turkwel Dam

Table 7-24: Monthly rainfall in Turkwel Gorge

Month	Rainfall
JAN	13.40714
FEB	17.07143
MAR	41.70357
APR	82.55714
MAY	68.30714
JUN	36.56786
JUL	54.65357
AUG	38.81429
SEP	33.55357
OCT	45.13077
NOV	63.44231
DEC	16.98148

Based on the nearest FAO climatic station (Lodwar station) which represents a more arid area than the proposed site, the river could irrigate up to 6,500ha of sugarcane using surface irrigation considering that the sugarcane irrigation requirement is 28,600 cubic meters per hectare per annum (Table 7-25).

Table 7-25: Evapotranspiration from Lodwar station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Eto	6.23	6.72	6.78	6.53	6.61	6.42	6.2	6.71	7.36	7.53	6.5	6.11

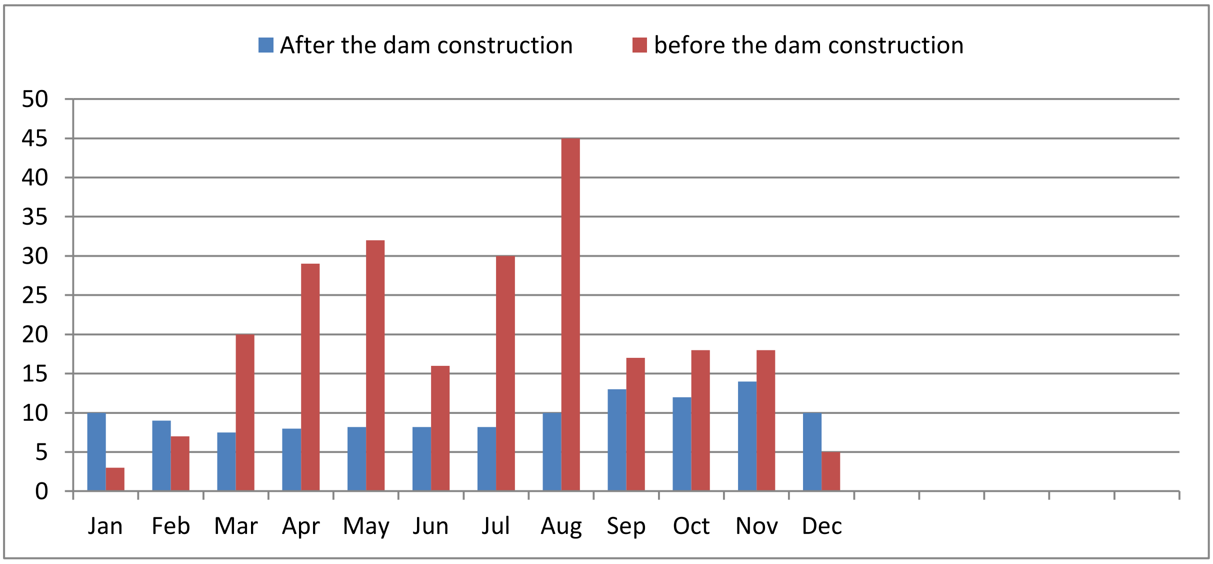


Figure 7-30: Flow rate at Turkwel Dam

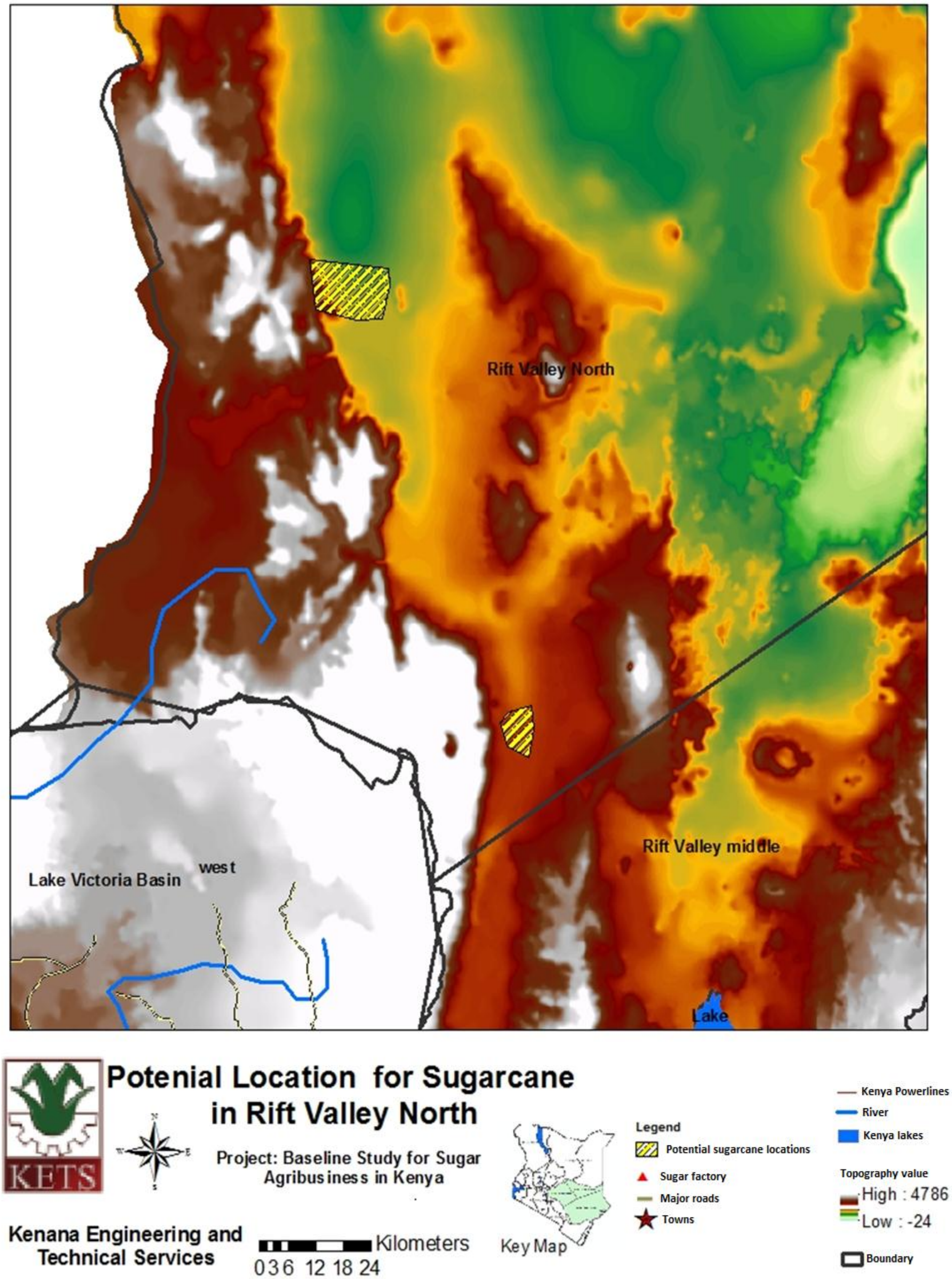


Figure 7-31: Potential area for sugarcane in Rift Valley North

To increase sugarcane crop potential area, dam filling/emptying programs must be modified.

Socio-economics

The average size of cultivated land is two acres per household. The land tenure system includes communally owned land, government owned land, free holdings and privately owned lands. Crops grown include maize, sorghum, beans, pulses, sweet potatoes, Irish potatoes, mango trees, bananas, cabbage and pyrethrum in the highlands.

The land use systems in the region include agricultural production, grazing and forest products harvesting. Most of the arable land is found in Koibatek, Keiyo, Marakwet, each with 60% of its total land area, and to a lesser extent in West Pokot with 40%, in Baringo and Turkana each with 20% while Samburu has the least arable land of about 4%. Most of the pastures are found in Samburu (90%), Baringo and Turkana (each with 70%), west Pokot (50%), Keiyo (39%), Koibatek (30%) and Marakwet (20%). The forest cover is as low as 0.02% in case of Baringo and as high as 8% in Koibatek (KVDA Strategic Plan 2008-2012).

Pastoralism and livestock production are the main activities in the region. The types of animals raised include the Zebu cattle, red Masai sheep, Galla goats, East African goats, and Turkana camels. The incidence of drought spells which has recently increased in frequency is one the factors affecting pastoralism and animal production and the general welfare of the population at large.

As shown in Table 7-26 and according to 2009 census, the number of animal heads was 3.71, 5.2, 9.1, and 0.94 millions of cattle, sheep, goats and camels respectively. The region has a fishing potential in Lake Turkana and Lake Baringo. The last estimated catch of fish reported in 2002 was 4135 tons. The region has high potential for bee honey production which is estimated at 700 metric tons using both modern and traditional systems. The forest area accounts for 2900 km^2.

Table 7-26: Livestock population in the region

County	Sub-county	cattle	sheep	goats	Camels
Baringo	Baringo central	68595	72260	168852	13
	Baringo north	38143	30446	128364	28
Nakuru	Koibatek	96952	67988	100644	6
	Molo	182243	149906	37724	2
Elegeyo Marakwet	Marakwet	99969	202260	108093	17
Baringo	Keiyo	97350	89881	64177	4
West Pokot	West Pokot	129475	114050	173693	294
	Pokot north	377688	199977	377903	29273
	Pokot central	179212	146300	213141	1050
	East Pokot	787209	380125	1474617	67036
Samburu	Samburu central	78213	175415	148360	3544
	Samburu east	37350	69422	131840	7212
Turkana	Turkana central	196492	560671	1273445	150700
	Turkana north	652288	1274062	1874668	269185
	Turkana south	685832	1682418	2846748	412577
	total	3707011	5215181	9122269	940941

Source: KNBS Census 2009

Conflicts in the area

Socio-economic factors and climate change are causing conflicts over resources between farmers, pastoralists and the fishing groups. The increase in population and livestock exposes forests and grazing areas to mounting pressures leading to competition among various stakeholders. Climate change and its impacts of drought cycles and erratic rainfall fan tensions and conflicts.

The zone is plagued with conflicts over water and pastures and the once rampant cattle rustling. The conflicts occur in the zone itself and across boundaries with neighboring countries of Uganda, South Sudan and Ethiopia. Conflicts over water resources are reported around Lake Turkana due to the construction of the Turkwel Dam which flooded an estimated 66 Km^2 of land originally utilized for pastures, beehives, agriculture and mining purposes. The conflicts brought to a halt the execution of irrigation projects in the area. Other conflicts were reported around River Molo, River Rongal and River Waseges where abstraction of water by upstream farmers for the irrigation of horticultural crops reduced water supply downstream causing conflicts among pastoralists.

Conflicts over land use are experienced on the Turkana and the Pokot border, and the Pokot and Marakwet border. The conflicts occur due to the conversion of communal land into wild life protectorate area and disputed border lines. In Pokot and Marakwet, conflicts caused by conversion of pastures into farms by former pastoralists. Theese conflicts interrupted the development of a number of projects in the area, including the establishment of the cement factory at Ortum, West Pokot.

Conflicts driven by tradition and culture were reported in Marakwet and West Pokot. The traditions in this area don't incriminate raids to rob cattle and attacks have been escalated by bandits using sophisticated weapons. Incidences are rising as the role of the elders, who used to reconcile differences within and across communities, diminishes.

The challenges in the Lake Turkana and Turkwel area seem more complicated and require well thought out plans to address. But examples of the gradual melting of cross cultural differences in other parts of Kenya gives hope that the same could be inspired in this area. The development of irrigation projects in Tana River county which encouraged the settlement of pastoralists and attracted immigrants from other areas of Kenya is a good example that different cultures can co-exist and respect the rights of others to available resources.

Security must be restored in the area and improved through the development of projects to create job opportunities and uplift the living standards of the local people. Development of infrastructure and the establishment of commercial centers, schools, health services, supply of electricity and clean drinking water are essential for changing social attitude and behavior in this area. Development plans should give priority to improve livestock production and processing as well as marketing and trade system.

Development of pastures with improved fodders and providing drinking water supplies should be part of the arrangements to compensate pastoralists for the grazing areas which will be utilized for sugarcane production. Demarcated routes to water sources and grazing areas should be considered when planning areas for cane development.

According to KVDA, the best land for crop production is mostly found in Keiyo and Marakwet with 28.6% out of 2810 km^2, West Pokot with 13% out of 9100 km^2, Baringo with 8% out of 10642 km^2, and Turkana with 1% out of 6400 km^2. The distribution of the moderate land potential is found in Keiyo and Marakwet (49.5%), Baringo (10%), West Pokot (12%) and Turkana (5%). Most of the marginal land is found in Turkana (94%), Baringo (82%), West Pokot (75%) and in Keiyo and Marakwet (25.5%).

Table 7-27 shows the area under crops and the average farm size per household. More land is under food crops production especially in Marakwet. The average farm size ranges between 0.5 acres in Turkana and 4.2 acres in West Pokot. Most of cash crop land is found in Marakwet and Baringo.

Table 7-27: Area under crop production in North Rift Valley zone

County	Koibatek	Turkana	Marakwet	Baringo	Keiyo	Samburu	West Pokot
Area under food crops (ha)	16000	11939	76675	18000	26963	4900	27520
Area under cash crops (ha)	580		3160	1900	445.5		637
Average farm size (acres)	1	0.5	2	3.5	3.6	3.5	4.2
Area under food crops (ha)	16000	11939	76675	18000	26963	4900	27520

Source: KVDA report

RIFT VALLEY NORTH AREA 2 (TOT)

Figure 7-31 shows potential areas in this sub-zone which have been identified based on available water supply, soil sutiablity, and cliamtic condtions.

Rainfall ranges between 600 and 800mm per annum as shown in Table 7-28.

The waters of Kerio River, Arror River, and other streams in the area could be harvested to supply potential cane out growers. The Hydrualic structures that are required to facilitate irrigation are weirs and water lifting pumps. It is important to note that for this study, no records were found for Kerio River flow gauges within WRMA database.

Table 7-28: Monthly rainfall in Tot area

Month	Rainfall
JAN	23.345
FEB	27.24
MAR	54.165
APR	124.6619
MAY	101.045
JUN	80.96667
JUL	99.28182
AUG	89.79
SEP	57.29091
OCT	94.38636
NOV	76.28333
DEC	46.38571

7.4.5. LAND SUITABILITY

The region varies widely in land form and physical features and is characterized by three topographical zones namely: Highland plateau (2500-3500m.a.s.l), steep escarpment (1200-2400m.a.s.l) and the valley floor (300-1100m.a.s.l). The valley floor covering Keiyo, Marakwet, West pokot and Turkana counties is suitable for sugarcane cultivation as explained in the report based on trials conducted by KESREF at Arror and Tot.

In 2005, KESREF in collaboration with Kerio Valley Development Authority (KVDA) and Kenya Sugar Board (KSB) conducted trials to test 12 sugarcane varieties in areas of Arror and Tot. The reported results reflected only the quality data for crop ages starting from 11 to 17 months. All varieties had reached maturity at 13 months at Tot site (Table 7-29), with acceptable purity levels of over 84%. Yield data was unavailable for both plant cane and different ratoon cycles. Results of the study (Table 7-28) indicated a potential for sugarcane and sugar production in Kerio Valley. However, limitations of water and pockets of saline and sodic soils especially in the Turkwel area need to be addressed and resolved.

Wherever feasible, infrastructure for sugarcane supplementary irrigation has to be developed and to rationalize water consumption, modern irrigation techniques like drip, linear and center pivot systems could be utilized.

Table 7-29: Results of Cane Quality Tests at Arror and Tot Sites

	Arror site-14 months			Tot site-13 months		
Variety	Plo % Juice	Brix% Juice	Purity % Juice	Plo % Juice	Brix% Juice	Purity % Juice
N14	18.03	20.67	87	19.05	21.17	89.96
KEN82-808	17.28	20.17	85.64	17.8	19.8	89.89
KEN82-216	18.17	21.05	85.54	19.51	21.3	90.32
CB38-22	18.28	20.55	88.88	19.26	21.55	89.28
KEN82-472	18.02	20.55	87.6	19.01	21.17	89.83
CO11-48	18.23	21.05	86.53	17.6	20.17	87.23
KEN83-737	19.62	22.17	88.38	19.91	22.3	89.23
CO945	17.22	20.42	84.2	16.6	19.8	83.8
EAK70-97	18.44	21.05	87.58	17.01	19.17	88.2
CO617	18.64	21.17	88.09	17.57	19.67	89.2
D8687	16.6	19.42	85.29	*	*	*
EAK73-335	18.66	21.3	87.48	20.27	22.17	91.44
CO421	*	*	*	17.34	19.8	87.38

The lowland areas experience a bi-modal rainfall pattern with two peaks in March-April and September-October. The average rainfall varies between 300-600mm per year and mean daily temperature ranges from 24 to 38°C. The mean daily temperatures are suitable for sugarcane growing. However the annual rainfall is in adequate since sugarcane requires over 1500mm of well distributed rainfall per year. The high mean temperatures and low rainfall promotes high evapo-transpiration, and so, for successful sugarcane growing in this region there is need for supplementary irrigation in the order of 900mm (60%).

7.4.6. ENVIRONMENTAL STATUS

One of the most prominent features of the Rift Valley system is the so-called the “Gregory Rift Valley” in Kenya. Flanked by scarp lines like the Nyandarua Range (Aberdares) on its eastern side and the Mau Escarpment on its western side, it reaches relative altitude of 1,000m or more. The distance between east and west escarpments varies from 48 to 64km.

In this study the Rift Valley zone has been divided into three sub-zones based on different parameters, as mentioned earlier, namely, the North, Middle and South sub-zones. The environment of most of these sub-zones experience stresses and pressures such as flash floods, soil erosion, droughts and pollution caused by the existing activities.

Flash floods are a common in the north and middle sub-zones, especially in the plains. The Turkwel plain, which stretches from Kaputir to Lake Turkana, has seasonal flows in the form of flash floods of considerable volume. The Lotikipi Plain is a flood plain composed of young soils which have been developed on alluvium of recent origin.

Also soil erosion is widespread in this area. Soil erosion in Baringo County is severe and widespread. The major causes are overgrazing and tramping by livestock. There is visual evidence of severe erosion in parts of West Pokot and Turkana Counties as well. Soil erosion in Elgeyo Marakwet County is not very widespread (Cappon 1986). The eroded sections of West Pokot are on the escarpment and in areas with steep slopes. Overgrazing is reported in all cases as the major cause of soil erosion.

Spells of drought in Baringo, Turkana and Samburu counties are less frequent. These regions experience dry weather conditions causing pressure on the existing pastures and water resources on which the communities depend for survival. The extreme climate and weather conditions are associated with variations in the general circulations of the seasonal northward and southward movement of the Inter-Tropical Convergence Zone (ITCZ). Nomadic life and pastoralism are the most efficient forms of land use for these parts of arid and semi-arid lands, where crop production is very risky due to high climatic variability (Kilby, 1993; Scoones, 1995).

The invasive *Prosopis* tree species, commonly known as ‘Mathenge’, can be found in most of the arid and semi-arid lands of Kenya. It was introduced to control desertification but has become a major environmental issue especially in Baringo. The worst hit locations include Salabani, Ngambo, and Lobo.

The South Rift Valley Zone spans a wide area covering a range of topographic and ecological conditions and hosts one of the richest and largest mammalian populations in the region. The productivity and survival of wildlife and livestock in this area depend on a common ecological strategy based on mobility and feeding efficiency. This has made it possible for wildlife and pastoral livestock to co-exist for over 3,000 years without significant degradation of the environment. This area comprises arid and semi-arid lands. Due to its rich culture, wildlife, ecology and landscape the potential for diversification of land use and livelihood generation, particularly through tourism, is high.

One of the major socio-economic impacts in the Rift Valley is the outbreaks which results in financial losses with respect to livestock production and marketing chains. This disease has caused serious impacts on rural food security and household nutrition, as well as direct and indirect losses to livestock producers.

Wildlife Resources

The tourism industry has been one of Kenya's three largest foreign exchange earners. Tourism is also a major source of employment, and is a leading sector in achieving the goals of the Vision 2030.

The Vision's economic pillar is targeting to place the country among the top 10 long-haul tourist destinations in the world, offering high-end, diverse, and distinctive visitor experiences that few competitors can offer. Preserving the environment is essential if this goal is to be realized. The economic contribution and variety of wildlife can be analyzed through the various wildlife reserves in the region which include:

- Kerio Valley National Reserve: Elephants, crocodiles and birdlife,Lake Kamnarok National Reserve: Bush pigs, waterbuck, buffalo, elephant, Rothschild's Giraffe, dik dik and warthog
- South Turkana National Reserve: Elephant, giraffe, buffalo, eland, oryx, impala, bush-buck, greater kudu, grants and Thompson's gazelle, lion, leopard, cheetah, spotted hyena jackal, crocodiles in ,and birdlife.
- Lake Baringo Reserve: Marine life and bird species. It offers an extraordinary variety if bird life.
- Lake Bogoria National Reserve: 135 species of birds recorded, and is Flamingos
- Cherangany Forest: home to the rare De Brazza's Monkey And is an t Important Bird Area (IBA) with over 73 forest-dependent species
- Sibiloi National Park: Common zebra, giraffe, hippos, crocodile and numerous bird species such as flamingos, pelicans and ducks
- Nasalot National Reserve: Elephants, Monkeys, Lions, antelopes, cheetahs and Dikdik

South Rift area links two of Kenya's most important parks, Maasai Mara National Park and Amboseli National Park. Maasai Mara National Reserve is the most important protected area in Kenya, accounting for 25% of Kenya's wildlife and nearly three quarters of the population of the protected area. The Amboseli landscape covers an area of approximately 5,700 Km^2 stretching between Mt. Kilimanjaro, Chyulu Hills, Tsavo West National Park and the Kenya/Tanzania border.

Land Potential and Land Use

Land use and land potential are closely related in income generation. Development of land in the Northern Rift Valley as an ASAL area has been hindered by poor land use planning, rapid growth of population as well as inadequate provision of both physical and social infrastructure. Hence, there is an urgent need for proper planning which will, in essence, provide for well-coordinated development of this fragile region in terms of resource mapping and tapping and equitable distribution of county resources for balanced regional development in all sectors of the economy. This includes housing, commercial, industrial and infrastructural development to accommodate changes in lifestyle and economic activities in the long term.

Land

The total land area covered under KVDA is approximately 112,867.63 Km^2 which represents 16.5% of Kenya's land mass. About 80% of this area is either arid or semi-arid. This area has been divided into six agro-climatic zones, namely, humid, sub-humid, semi-humid, semi-arid, arid and very arid. Humid and sub-humid zones fall within the highlands with altitudes ranging from 2000 to 3500 meters above sea level with high agricultural potential. It forms the main watershed to many rivers in the area. Rainfall is bimodal with peaks in March-April and October- November with a mean annual ranging from 1,000 to 1,300mm.

Land Characteristics of the KVDA Region

The land within KVDA mainly falls within Arid and semi-arid or sub-humid zones. These are characterized by low and erratic rainfall of up to 700mm per annum, periodic droughts and different vegetative cover and soils. Rains fall mostly as heavy showers and are lost to surface run-off especially in the mountainous steep/hilly areas in Elgeyo Marakwet and Baringo. Due to high solar insolation in the area, high rate of potential evapotranspiration causes further reductions in crops yields.

High erosion occurs in counties like West Pokot and Elgeyo Marakwet due to configuration and highly sloping nature of the land. There are high population densities in counties like Elgeyo Marakwet and Baringo on valley bottoms and hill tops where people practice farming. Due to availability of huge amounts of rangelands within the KVDA region, pastoralism is the extensively practiced. The defining features are livestock mobility and the communal management of natural resources. Generally, livelihood systems are of light pastoral activity in the arid areas of Turkana with rain-fed agriculture being almost impossible. In the semi-arid areas such as West Pokot and Baringo Counties, agricultural harvests are likely to be irregular, although grazing is satisfactory.

Land Potentials

The area under the KVDA jurisdiction is not among the prime agricultural lands in Kenya due to its ASAL nature. According to the Vision 2030, the ASAL region covers a total of about 57.6 million hectares of land which is approximately 84% of Kenya's land area. The remaining 16% is considered to be of High and Medium potential. Thus there are high agricultural prospects as 48.4 million hectares is considered to be potentially productive. Of this 19% has potential for cropland if irrigated, 31% livestock keeping and 50% nomadic Pastoralism. This information is significant as it implies that this area has a high pastoralism and livestock raising potential and minimum irrigated cropland prospects.

Arable land occupies 39% of the region. Land use patterns and practices are closely related to the conservation of agricultural biodiversity and minimizing soil erosion occurring mainly on hillsides due to cultivation. Erosion is considered one of the major threats to the environment in the region particularly when associated with monoculture farming.

Intensive crop farming is practiced in the high potential areas of Elgeyo Marakwet and Baringo c with schemes like Pekerra Irrigation in Marigat. Small pockets of isolated farming takes place in the ASAL county of (Samburu North,Maralal and Purra) areas where wheat and barley farming is practiced. In the arid and semi-arid areas of this sub-zone, forests develop in water catchment areas. The forests are found in the ecological zone areas of Cherangany Hills, Turgen Hills and Mau Complex (Londiani, Tinderet, Kaptagat, Marmanet).

The valley has a number of shallow lakes; five of them are registered as Wetlands Ramsar sites; (Lakes Nakuru, Baringo, Elementaita, Bogoria and Naivasha). These lakes are important feeding sites for numerous migratory water birds including the endangered Lesser Flamingo (*Phoeniconaias minor*) which scavenges on the dense water algae.

7.5. THE ATHI RIVER BASIN AGRO ZONE

7.5.1. OVERVIEW

The Athi River Basin includes parts of Nairobi, Kiambu, Thika, Kajiado, Machakos, Kitui, Makueni, Malindi, Kilifi, Mombasa, Kwale, and TaitaTaveta counties. This Agro Zone has been subdivided into two sub-zones: the Athi River Sub-zone and Coastal Sub-zone. This division is based on a number of factors including, climate variability, rain fall intensity, environment, and socioeconomics.

7.5.2. ATHI RIVER SUB-ZONE

This Sub-zone is part of the Athi River system, which is given the name of Galana River in its middle reaches and the Sabaki River in its lower reaches.

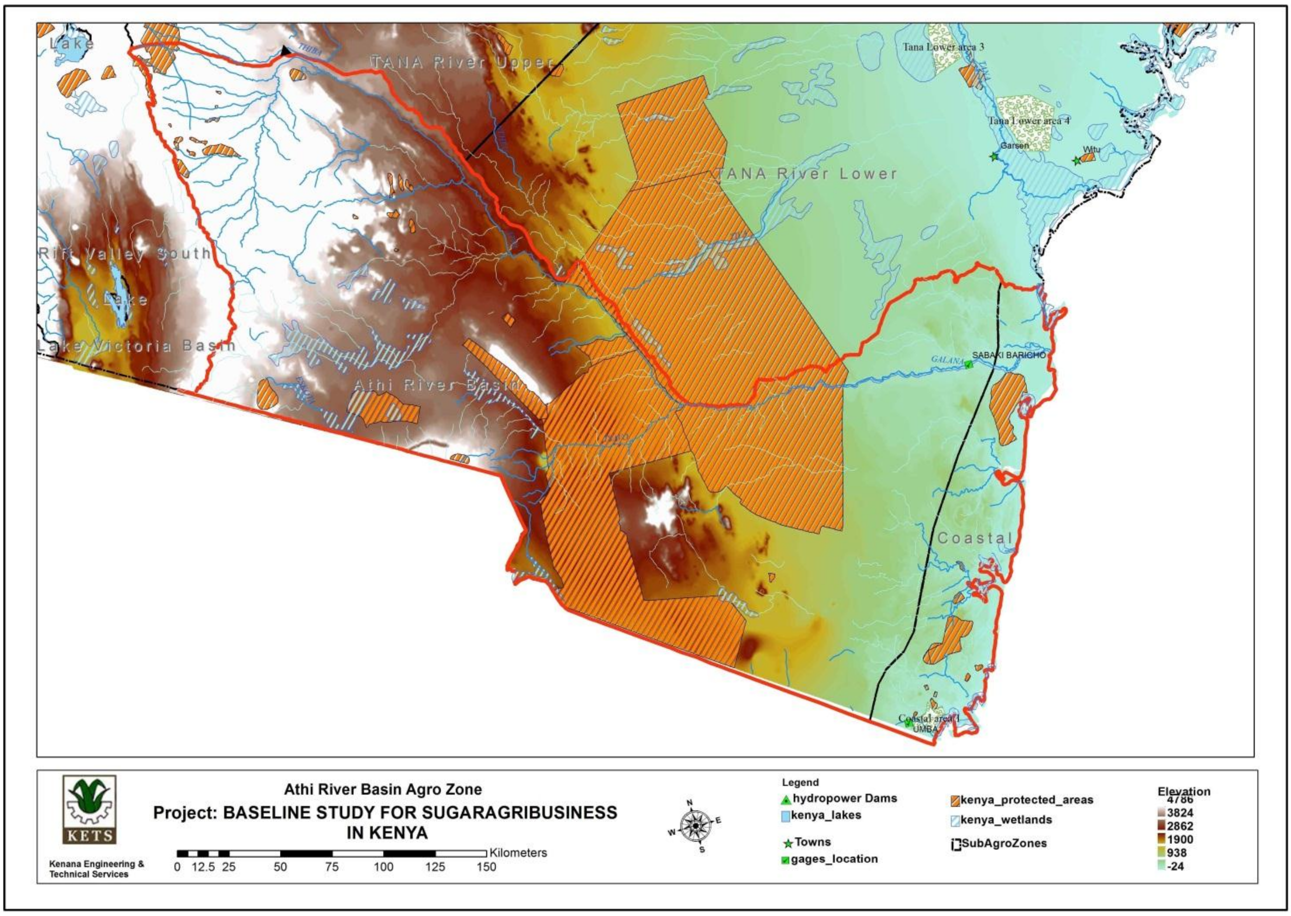


Figure 7-32: Athi River Basin Agro Zone

7.5.2.1. WATER RESOURCES

The Athi River Basin covers an area of 66,837 km² divided between arid and semi-arid zones with a mean annual rainfall of 535 mm.

Water sources

A. Surface Water

Annual rainfall in the area ranges between 200 and 1200mm.

Athi River is the second longest river in Kenya (540 km). Significant lakes in the catchment include Lakes Jipe, Challa and Amboseli.

Figure 7-33 and 7-34 show the hydrograph of Sabaki River annual and monthly flows respectively using information from Sabaki Station Gauge.

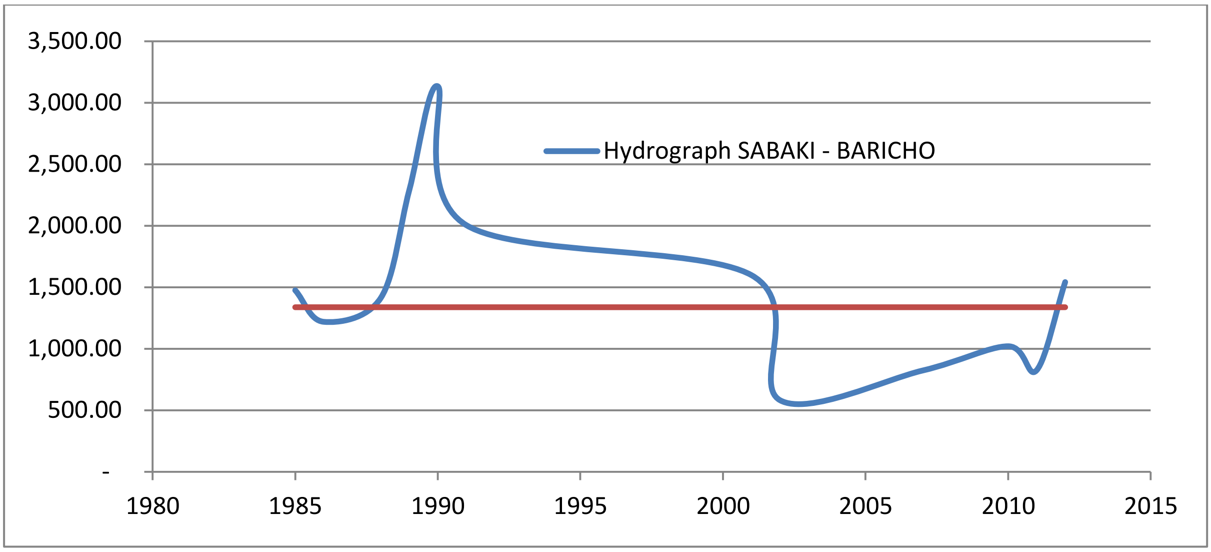


Figure 7-33: **Annual inflow of Athi River at Sabaki-Baricho Station**

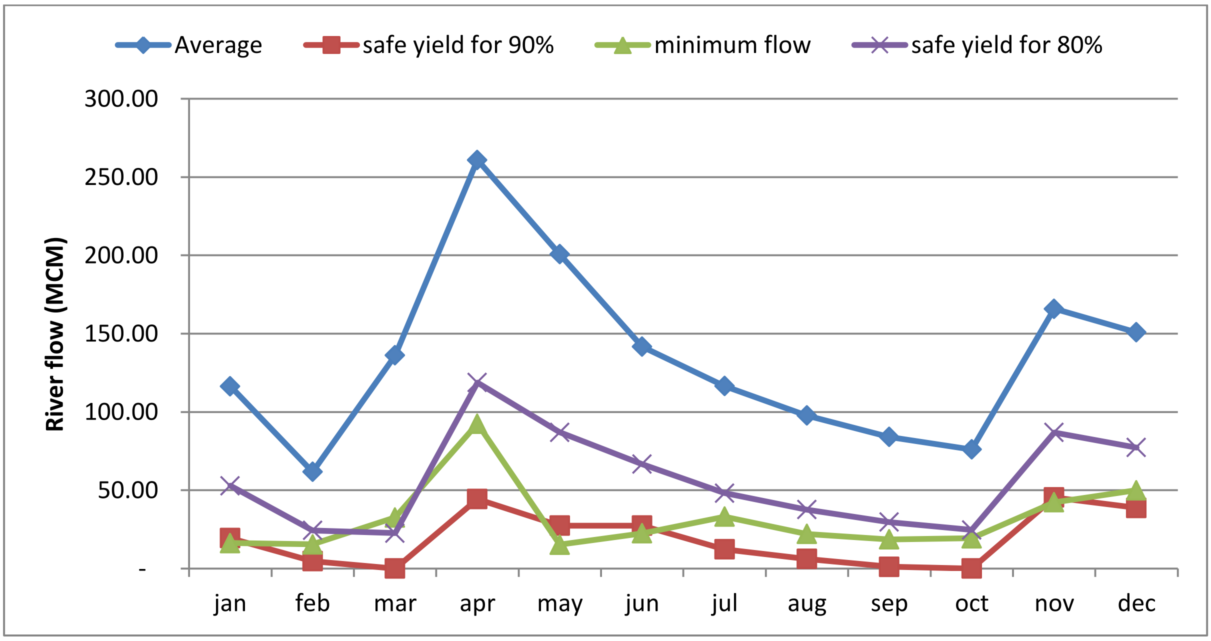


Figure 7-34: **Monthly inflow of Athi River at Sabaki – Baricho station**

From Figure 7-33, it was clear that the inflows are not stable, which indicates that the river faces alternating floods and droughts problem. The average flow in the river is about 1,350 MCM per annum, though 500 MCM has been reported. Figure 7-34 shows that the river flows in the critical months are not sufficient to support sugar cane production and other critical activities on the river. Further, the downstream areas of the river are relatively shallow, wide and meander, as shown on the side photo.

To utilize Athi River, the establishment of water storage infra-structures will be required which will render the subzone as less attractive for investors.

B. Ground water

Athi River Catchment Area is characterized by carrying hydro- geological conditions which lead to different aquifers. The upper zone, which is predominately volcanic, has relatively good water yielding aquifers (over 10 m^3/hour), of considerable value for domestic, community and commercial water supply. The middle zone has localized aquifers in the fractured and weathered zones of the Basement system, with alluvial aquifers being locally important. The Chyulu Hills host the aquifer that supplies the Mzima Springs, as well as the spring units that flow from the eastern side of the range (Kiboko in the North and Umani further South). Volcanic aquifers on the northern flank of Kilimanjaro source a number of springs that support water supply, irrigation and tourism (Nolturesh, Kimana, and Entonet).

The coastal zone is susceptible to seawater intrusion and pollution from domestic and industrial sources. Where abstraction is limited, the coastal coral limestone and sand aquifer is of considerable commercial importance. Tiwi Aquifer is a typical example and a key water supply source. The coastal hinterland aquifers are generally poor and often brackish.(WRMA)

The main aquifer in this sub-zone is Sabaki aquifer which is considered a strategic aquifer, currently used to supply significant amounts of water in the absence of other sources.

The Middle Athi Zone is a low potential area and the inappropriate livestock practices (overstocking) are leading to catchment degradation and consequently high erosion rates. Other human activities such as quarrying, sand harvesting and poor waste management lead to poor water quality and quantity. Rural settlements in these zones are a source of pollution because they lack conventional sewerage systems.

The quality of ground water in this zone has high salinity and excessive hardness. The lower Athi River zone is characterized by water scarcity in time and space and high evapo-transpiration rates, leading to heavy reliance on groundwater which suffers from salinity due to the nature of geological formations and low recharge rate. (WRMA)

7.5.2.2. Soils and land suitability

Land in the Athi River Basin is characterized by soils with low fertility. Vegetation cover is mostly bushes and thicket.

The upper portion of the Athi river basin is a high potential agricultural and industrial zone and covers major urban centers like Nairobi. Most of the soils are Alfisols (red soils) and the land is very undulated and subjected to continuous annual erosion by rains, leading to substantial loss of soil fertility and deep water percolation. This limits the potential of cultivating sugarcane in this region.

7.5.2.3. Environmental status

The majority of the seven million people living in the Athi River Basin are engaged in agriculture and pastoralism to sustain their livelihoods. Crop production in the Basin is mainly rain-fed and is unstable due to erratic and fluctuating rainfall. Recurrent drought spells in almost all of the counties in the basin affect crop production and income.

A major portion of the water allocated for irrigation in the Athi River Basin is utilized by the county of Kiambu and Thika in the upper reaches of the Athi/Galana/Sabaki river system. According to the Kenya's National Water Master Plan, only 23,000 of about 44,000 hectares of irrigable land in the Athi River Basin are developed

In the Athi River Basin, the sustainable expansion of irrigated lands remains a goal of food security and poverty alleviation programs. However, several factors severely restrict the prospects of rapid growth of irrigated agriculture in the Athi River Basin, which include low and variable rainfall, poor quality of soils and weak infrastructure.

Water in the agricultural sector in the Athi River Basin is also important for livestock, especially in the vast arid and semi-arid rural areas. The south-east Kenya rangelands constitute one of the principal "beef sheds" in Kenya, supplying Nairobi, Mombasa and other urban centers. Water sources are therefore shared by animals and both the pastoralists and agro-pastoralists. Water sources include rivers, springs, boreholes/wells, dams/ponds and rainwater, all under communal use (Mwacharo 2005: p. 639). Livestock water demand in all the counties of the Athi River Basin was estimated at 52,511 m^3 per day (about 19.2 million m^3 per year) in 1990 (National Water Master Plan 1992).

Increased human water abstractions and occurrences of droughts threaten the ecological stability and proper functioning and survival of national parks such as the Tsavo National Park which contain more than 41 different species including the big five plus hippopotamus and crocodiles. The combined area of Tsavo West and Tsavo East National Parks forms one of the largest National parks in the world and covers a massive 4% of Kenya's total land area. Tsavo East, the larger of the two, lies to the east of the Nairobi-Mombasa road, equidistant between Nairobi and Mombasa, and offers a vast and untapped arena of arid bush which is watered by the azure and emerald meandering of Galana River. It is guarded by the limitless lava reaches of Yatta plateau and patrolled by some of the largest elephant herds in Kenya.

7.5.2.4. Socioeconomic Survey

Most of the 7 million people who live in this sub-zone are farmers and pastoralists. Specific county information in this sub-zone indicates that Nairobi is largely urban with no major agricultural activities while Kiambu has good soils and infrastructure basis to qualify as an economic farming region. The county produces tea, and coffee in small farms. Small farms in wet parts of Kiambu also produce Pyrethrum plants. The Kajiado county is part of the ranching zones while Machakos (Makueni) have a thriving livestock business as the main economic activity. The poor soils and unsuitable climate renders small scale farming under rainfall risky. Kitui and Mwingi counties have low and unreliable rainfall and poor soils unsuitable for farming. The counties are more suited for ranching and subsistence livestock production as a mainstay activity of the population. About two thirds of the land in Kilifi and Malindi counties is unsuitable for small scale farming due to poor soils and unfavorable climate. The Mombasa County is an urban area and has no major agricultural activities, whereas large parts of the Kwale County outside the Tsavo National Park are allocated to horticultural trees such as coconuts and cashew nuts. The Taita Taveta County is a dry area suitable for ranching and sisal production. Agriculture can be successful toward the higher rain catchment areas (Taita Hills) and their foothills, with some valley bottoms suitable for vegetables. The Tsavo National Park would allow the introduction of land cultivation.

Despite of the existence of the Athi River Basin, crop production system in this sub-zone largely depends on the erratic rains which lead to yields fluctuations. The recurrent droughts and poor soil in the sub-zone are part of the factors behind low production of food crops and low incomes. This situation limits the possibility of introducing sugarcane, a water loving crop, which is bound to affect water availability for food crops and livestock. According to the National Water Master Plan of 1992, the Athi River Basin was expected to supply livestock with more than 52,511 m^3 per day (about 19.2 million m^3 per year) for drinking in 1999.

Further, the zone has elevations that reach high of 1650 m.a.s.l. which is not suitable for sugarcane growing. Additionally, very distinct land undulations, large reserved areas for forests, wildlife and park all make the basin unfavorable for sugarcane.

SUGAR BEET AREAS

The sugar beet climate suitability in this sub-zone is classified as low and the crop will need to be supplemented by irrigation (Figure 7-35). The groundwater aquifers within these sugar beet potential areas are poor. Athi River and water harvested from the other streams in the area could provide the water required.

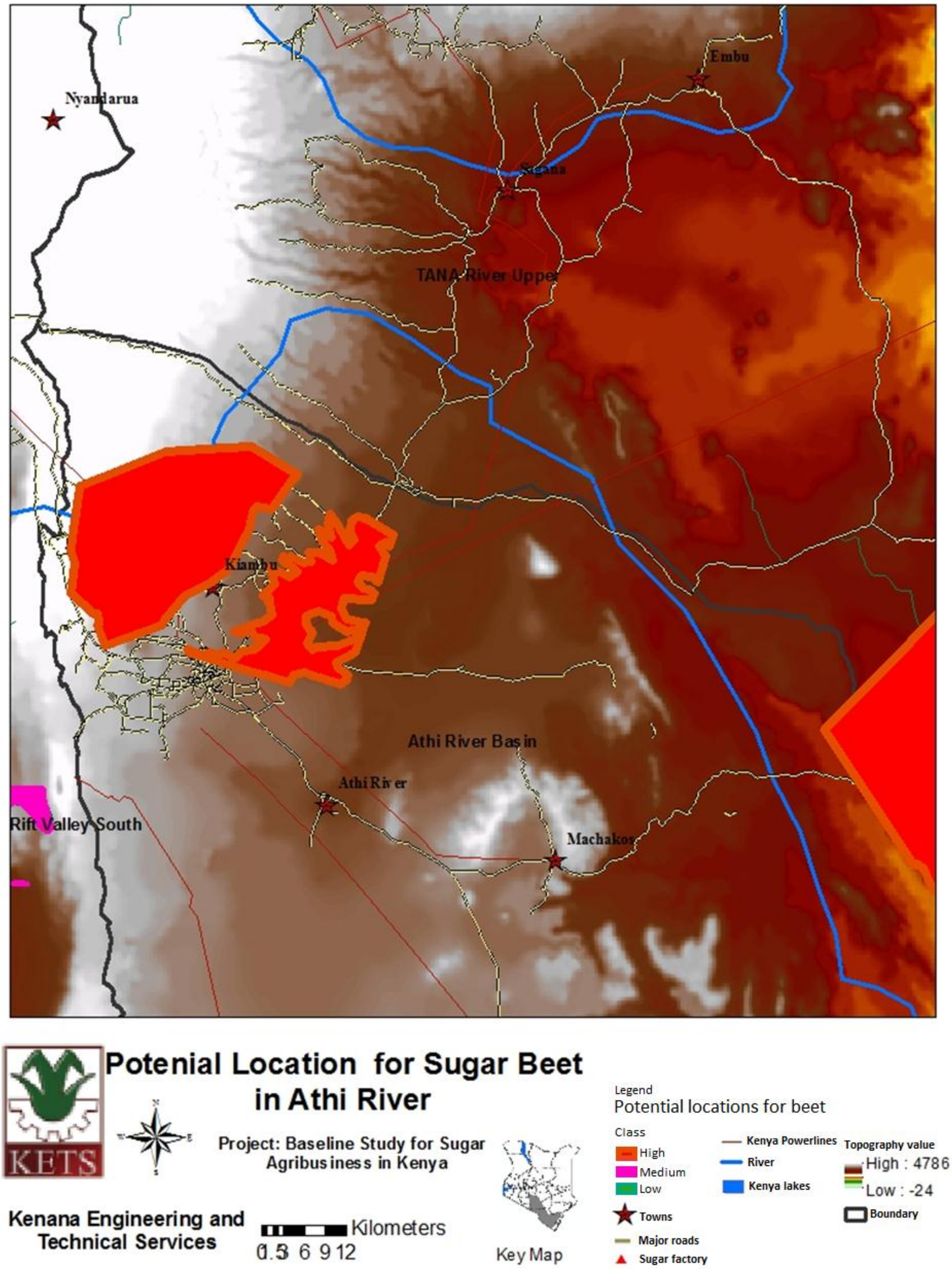


Figure 7-35: Potential areas for sugar beet in Athi River Basin

7.5.3. THE COASTAL SUB-ZONE

7.5.3.1. WATER RESOURCES

This sub-zone enjoys high rainfall between of 800-1200mm annually and currently there are fields under sugarcane in the area which are rainfed with limited supplementary irrigation.

Water sources

A. Surface water

Water harvesting techniques could be used to supplement irrigation, with the relevant structures being established on the streams which come from upper hills. One of these rivers that can serve is Umba River (Plate 7-13). Table7-30 shows the monthly inflow of the Umba river.

B. Umba River

Figures 7-36 and 7-37 show the Hydrograph of Umba River whose average yield is about 197 MCM per year.

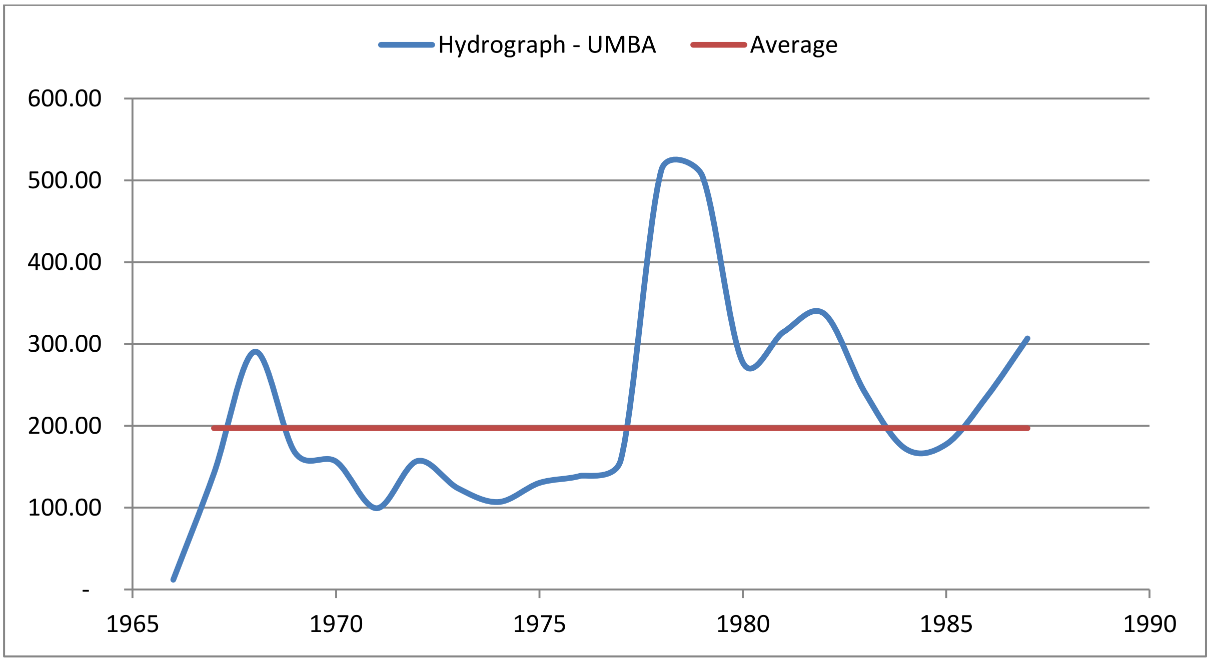


Figure 7-36: The Hydrograph of Umba River

Plate 7-13: Umba River

Table 7-30: The monthly inflow of Umba River

Month	Average	Standard deviation	Minimum flow
Jan	24.15	20.31	0.89
Feb	14.03	15.46	2.20
Mar	17.05	16.48	3.85
Apr	21.11	18.15	6.34
May	17.70	14.97	7.43
Jun	13.80	11.79	4.86
Jul	10.68	9.04	1.38
Aug	8.46	7.76	0.60
Sep	8.02	6.68	1.37
Oct	10.25	8.29	1.06
Nov	14.09	8.09	2.59
Dec	37.83	23.35	3.67
Annual	197.17	160.36	36.27

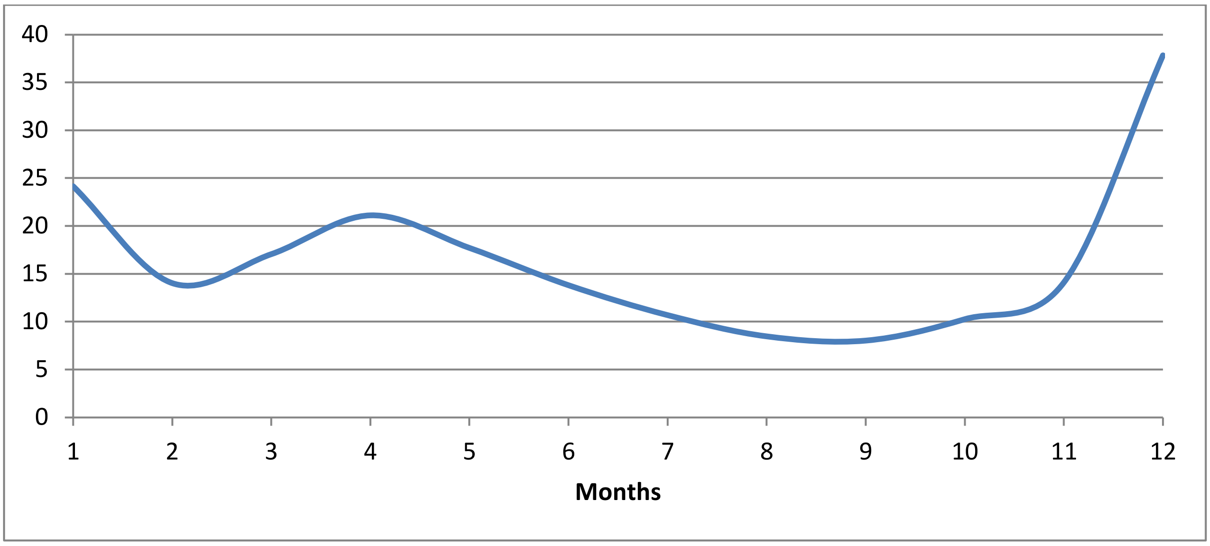


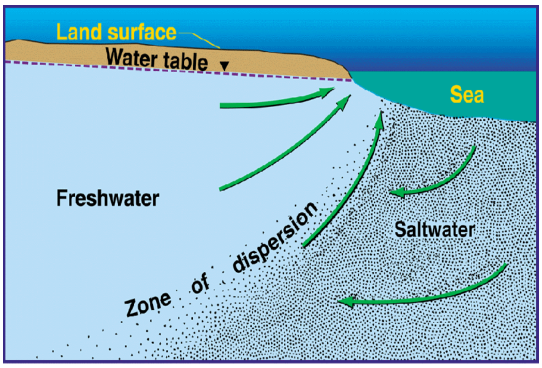
Figure 7-37: Monthly Average Inflow of Umba River (MCM)

C. Ground water

It is important to note that ground water in this area could be utilized only after preparing a comprehensive geo-hydrology study and taking the necessary precaution to avoid sea water intrusion.

Sea water intrusion: Aquifers near the coast have a lens of freshwater near the surface and denser seawater under.

High rate of fresh water abstraction can cause lateral and vertical intrusion of the surrounding saltwater (Figure 7-38, 7-39).



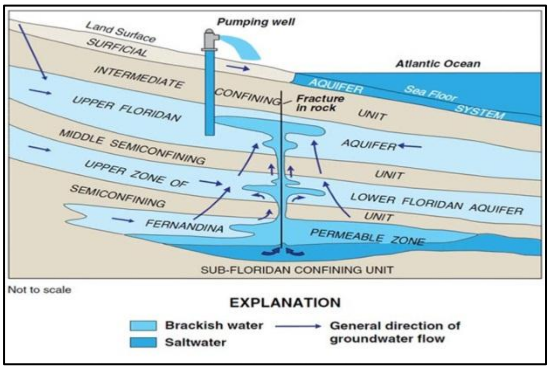


Figure 7-38: Saltwater bordering the fresh water

Figure 7-39: High rate of abstraction can cause lateral and vertical intrusion of the surrounding saltwater

A. Rainfall

The rainfall in this sub-zone varies from 800 up to 1600 mm, which is adequate for rain-fed cropping (Figure 7-40).

7.5.3.2. WATER DEMAND

Mombasa Meteorological Station is the nearest and it was used in the analysis by Crop-Watt and Aqua Crop models.

In this area, the soil is classified as light soil (loamy sandy, loamy, clay loamy) so the irrigation method advisable is to be either drip or sprinkler.

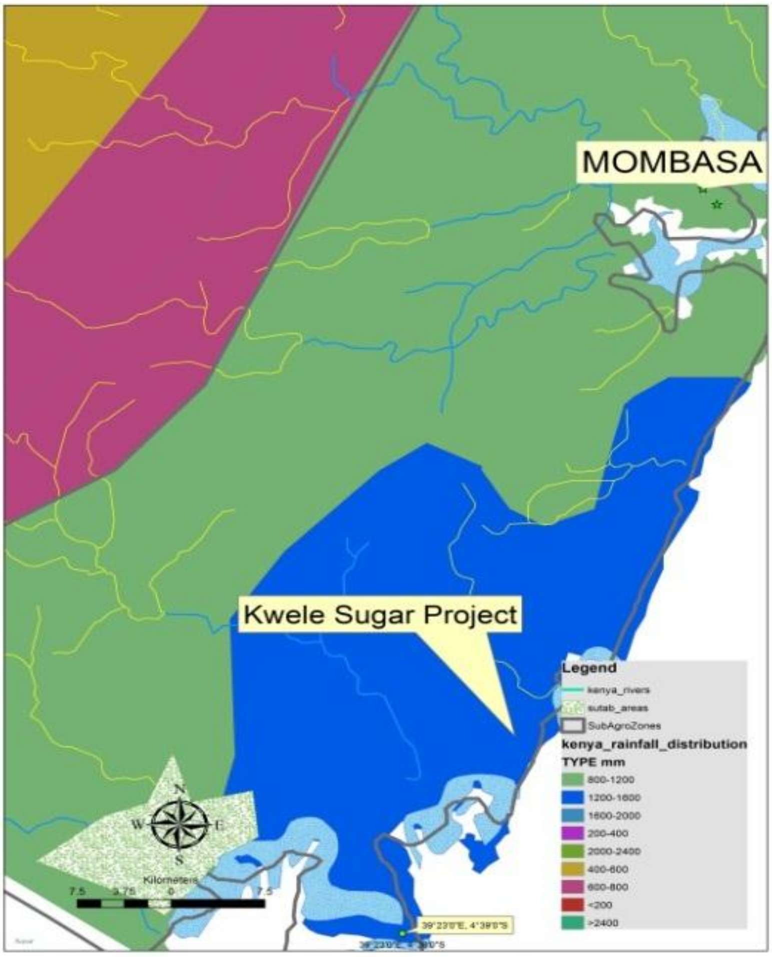


Figure 7-40: Rainfall distribution for Kwale Region

As illustrated in Table 7-31, annual irrigation water requirements for cultivating sugarcane is about 7,700 cubic meters per hectare using drip irrigation system which is equivalent to about 85 MCM for the whole proposed area in the coastal sub-zone.

Table 7-31: Water demand for supplementary irrigation

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ET0 mm/day	4.6	5.2	5.1	4.3	3.5	3.4	3.2	3.6	4.1	4.4	4.7	4.6
Kc	0.7	0.4	0.8	1.1	1.1	1.3	1.3	1.3	1.3	1.3	1.3	1.0
Etc mm/month	100	58	127	142	120	128	124	139	152	169	174	134
Rain mm/month	34	14	56	154	236	88	72	68	67	103	105	76
Overall efficiency	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
total IWR	78	50	85	3	0	54	66	86	102	85	89	73

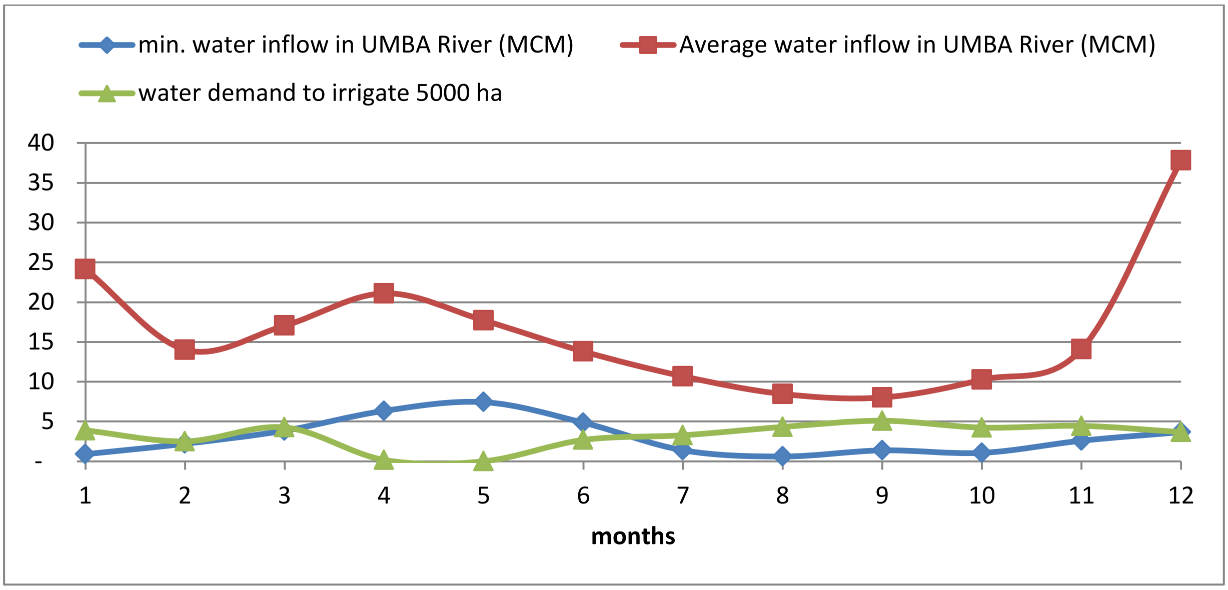


Figure 7-41: Water demand (5000 ha) and Umba stream water flow

Figure 7-41 shows how the water can be utilized from UMBA River for supplementary irrigation of 5000 ha.

The area to be supplemented by irrigation can be extended up to 15,000 ha by securing 117 MCM annually from other sources such as groundwater and water harvesting projects on the water streams within the area.

The AquaCrop model was used to simulate sugarcane growth in the area depending only on the rains (Figure 7-42). The model uses water stress as the only variable and considers no limitations for the other parameters.

Figure 7-43 shows that rainfall is well distributed and the effective rains are very high (95 %).

The model result (Figure 7-41), shows that the crop production depending on the rain will be less by 10% on wet years average due to water stresses. For areas within the range of 1200mm – 1600 mm rainfall, the sugarcane growth will be much better. The model must be calibrated with more accurate meteorological data and field observation data in the feasibility study.

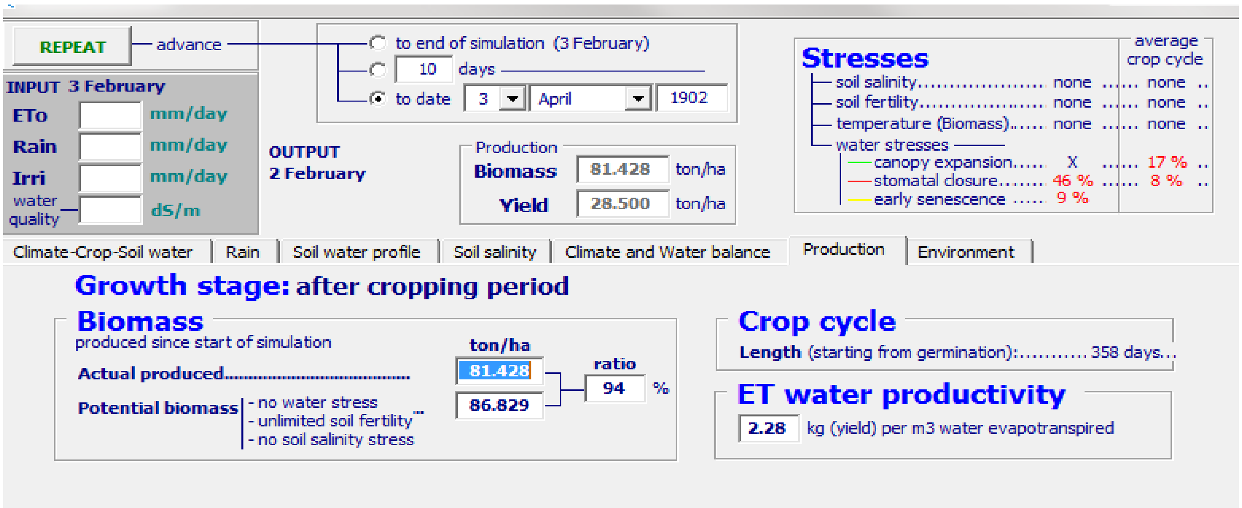


Figure 7-42: Aqua Crop Model Result Caption (FAO Mombasa Meteorological Station data)

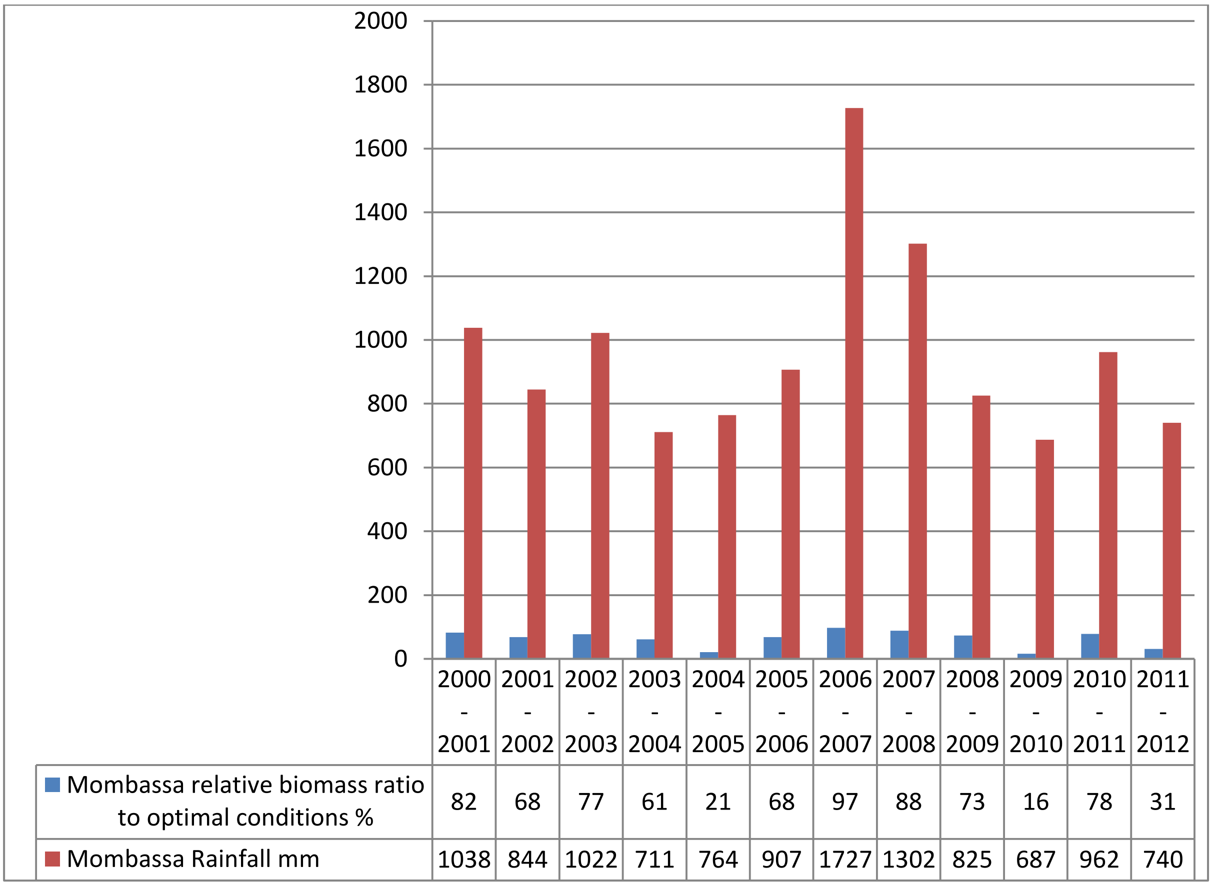


Figure 7-43: Model simulation result for relative biomass production (optimum conditions) and the annual rainfall Base on Mombasa meteorological station monthly rain records from 2000-2012

Although there are some water stresses in the last few years, as shown in the results of the model simulation (Figure 7-43), out growers can cultivate sugarcane depending on rainfall only and they can get a reasonable yield (Plate 7-14).

The setup in the Kwale project (Plate 7-14) can be followed where water harvested from groundwater is held in reservoirs. The reservoirs then refresh intermediate ponds which provide water for drip irrigation.

Plate 7-14: Kwale project using the three components of ground water and rainfall and water harvesting project

7.5.3.3. Soils and land suitability

To the south of Kwale, where the new project is being developed, the soils are sandy loam and clays and are deep, flat, and fertile with good drainage capacity. These are suitable for sugarcane cultivation. KETS team witnessed good performing cane that had high vigor and plant population in an area of 1000ha. The plan at this phase is to develop 5,000 hectares and there is additional area which could be added to accommodate out growers (3500 hectares). There is a sugar mill under construction with crushing capacity of 3,000 TCD. Local climate characterized by two periods of rainfalls March to July, and Aug to Oct with an average annual total of 1,300mm. Supplementary irrigation is available through water harvested by two small dams.

Data obtained from this area on performance of sugarcane showed very high cane yields approximated at 160 tons cane per hectares with Pol% cane of 13%.KESREF has availed 6 new varieties which need to be further screened.

7.5.3.4. Potential area

Based on climatic condition and soil suitability, the potential areas in this sub-zone are shown in Figure7-44.

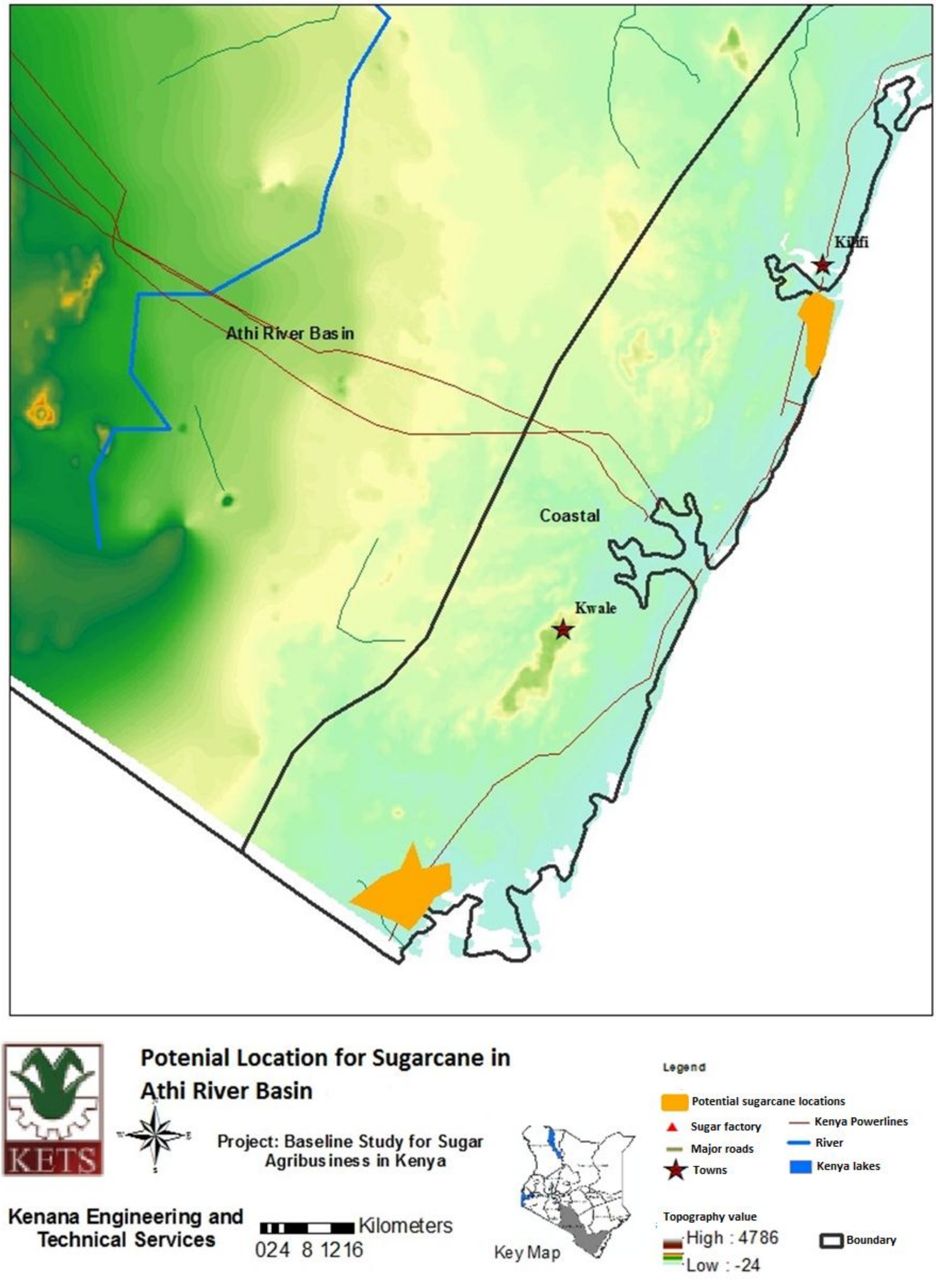


Figure 7-44: Potential area for sugarcane in Coastal Sub-zone

7.5.3.5. ENVIRONMENTAL STATUS

The coastal sub-zone runs in a south-west direction from the point where Sabaki River discharges its freshwater into the Indian Ocean north of Malindi and down to the border with Tanzania. This sub-zone lies in the hot tropical region where the weather is influenced by the great monsoon winds of the Indian Ocean.

Rainfall distribution, climate suitability and the flat landscape make this sub-zone one of the most suitable areas for sugarcane cultivation. The area is already experiencing sugarcane production with the plantations under development by the Kwale Sugar Company.

There are a number of semi-perennial and seasonal rivers such as the Mwache, Kombeni, Tsalu, Nzovuni, Umba, Ramisi, Mwachema and Voi, all of which start from arid and semi-arid catchments and drain into the coastal region. The Ramisi River, which arises in the Shimba Hills forested area (Plate 7-15), discharges it's freshwater and tons of sediments annually into Funzi - Shirazi Bay in the southern part of the Kenya coast.

Plate 7-15: Herd of buffalos at Shimba Hills National Park

The Kenyan coastal region is generally low-lying and characterized by the extensive fossil reef which lies a few meters above present sea level. The coastal plain is lined in the interior by a series of hills which rarely exceed 300m in height except in southern parts where the Shimba Hills reach an altitude of around 1,000m above sea level. Further inland, the Taita Hills rise to a height of 1,500m above sea level. Soils of the coastal region are considerably variable.

Living coral reefs occur along most of the Kenyan coast. A fringing reef colonizes the shallow parts of the continental shelf along most of the Kenyan coastline to a depth of around 45m and at a distance of between 500m and 2.0 km offshore, except where river systems create conditions of low salinity and high turbidity which limit coral growth. Estuaries and deltas are another part characterized by extensive mangrove forests.

7.5.3.6. SOCIOECONOMIC STATUS

This sub-zone includes several potential counties of which Kilifi,Malindi, Taita, Taveta, and Kwale are described below.

Kilifi County

The Kilifi County covers a total area of 3870.2 km^2 and its population was 488,384 according to 2009 census. Agriculture is the main economic activity in the county, and the main produce include maize, coconuts, cashew nuts, and mango trees. The crops are grown in small holdings of an average of 5.4 hectares per household. The agricultural challenges, are unorganized land tenure, crop diseases, post-harvest losses, small acreage holdings, traditional farming technology and droughts.

Livestock is another source of wealth and a significant economic driver of the district's economy. The main livestock are cattle, sheep, goats, and poultry. There is a private dairy processing plant in the district.

Taita County

The county covers a total area of 16,482.9 km^2 and its population was projected to be 247,922 as indicated in 2009 census. Agriculture is the main economic activity characterized by small land holdings of 0.4 hectare per household. The main grown crops are maize and coffee beans, potatoes, bananas, macadamia, sunflower, pigeon peas, cowpeas, cotton, sisal, cassava, mango trees, custard apple and green grams. Agricultural challenges are unreliable rainfall, frequent droughts and attacks by wild animals. Livestock sector is important encompassing 160,610 heads of cattle, 128,900 heads of goats, and 30,070 heads of sheep. The county has 26 ranches, and is targeted to be a Disease Free Zone by the Vision 2030.

Lamu County

The county covers an area of 6,474.7 km^{2}and the population in the county was projected to reach 109,831 based on the 2009 Census. The county is divided into: i) the rich agricultural and livestock zone in the mainland in the form of settlement schemes, and ii) the fishing and marine zone. The county has 3 rainfall zones: the arid areas along the northern borders, the semi-arid areas covering Amu division and the islands, and the sub-humid zone covering Witu and Mpeketoni.

Agricultural land is estimated at 959,000 hectares with an average farm size of 4 hectares per household. Only 20 percent of the local farmers had land title certificates. The main crops are maize, sorghum, cow peas, cotton, cassava, green grams, bananas, mango trees and coconuts. About 30% of the population depends directly and indirectly on livestock production. The agricultural challenges are unreliable rainfall and frequent droughts.

Taveta County

The county lies in the arid and semi-arid lands (ASAL) covering an area of 4,205.63 km^2 and its population was projected to be 66,166 by 2012. About 90% of the population lives on subsistence farming growing maize, beans, cotton, sisal, cassava, cow peas, green grams, millet, mango trees, bananas, vegetables (tomatoes, water melon, sweet pepper and onions), rice, kales, and coconuts. The livestock include dairy and beef cattle, goats and sheep, poultry, pigs and rabbits.

The challenges to development are multiple including poor base of infrastructure (roads, power, and communication services), food insecurity, low tourism revenues, high population growth rate, human encroachment on wild life, floods, fluctuating rainfall and land tenure issues. The erratic rainfall in the county has driven farmers to supplement their crops with irrigation water to improve yields and so, there are 15 operating irrigation schemes in the County covering an area of 7,000 acres.

Kwale County

Kwale County has a population of 649,931 based on 2009 census. This county has experienced the sugarcane industry through the establishment Ramisi Sugar Factory which collapsed in the 1980s. Kwale International Sugar Company is replacing the old Ramisi Sugar Company and is expected to kick off with production of 3000 TCD in 2014.

Kwale International Sugar Company has already started registering farmers in the vicinity as potential sugarcane out-growers which reflects the willingness of the farmers to be part of the sugarcane production system.

The Coastal Plains Counties and Sub-counties are home to a farming community and pastoralists who will provide labor required for the introduction of sugar industry into the area. The two approaches of sugarcane production can be followed:

- The out-growers system through the integration of the existing farmers, who can allocate part of their cropland as out growers for sugarcane production.
- The corporate large scale sugarcane production system through the hiring of labor and use of machinery.
- The pastoralists and farmers who have large areas can rent part of their land for large scale sugarcane production activity. The crop producers and pastoralists

households can supply the bulk of the waged labor as needed by the sugar industry in the area.

The new sugar industry has to consider compensating land owners who shift to sugarcane production through the supply of agricultural and extension services and technical support. The cropping system should better encourage the production of food, fodder and cash crops along with sugarcane. The new corporates should be socially responsible to support the surrounding community and contribute to basic services of education, health, and clean drinking water. A fair sugarcane pricing system and remunerative wage incentives are critical for the success and sustainability of the sugar industry in the new potential areas.

7.6. EWASO RIVER AGRO ZONE

7.6.1. OVERVIEW

Ewaso Ng'iro North catchment area is located in arid and semi-arid areas in the north eastern part of Kenya. The catchment is bordered by Ethiopia in the north, Somalia in the east, the Rift Valley catchment area in the west, and by Tana catchment area in the south. The catchment area is the largest among the five catchment areas. The total catchment area is 210,573 km^2, which is 36.4% of Kenya. According to the 2009 Census, the total population of the area is 3.6 Million with an average density of 14 persons per km^2. The population and the density were projected to reach 850,080 and 19 persons per km^2 respectively by 2017. The lowest density of about 7 persons per km^2 is in Fafi constituency.

Major cities and towns in the catchment are Nanyuki, Nyahururu, Isiolo, Marsabit, Moyale, Mandera and Wajir. The catchment area includes the whole area of Mandera and Wajir counties, most part of Marsabit, Samburu, Isiolo and Laikipia counties, and a part of Nyandarua, Nyeri, Meru and Garissa counties.

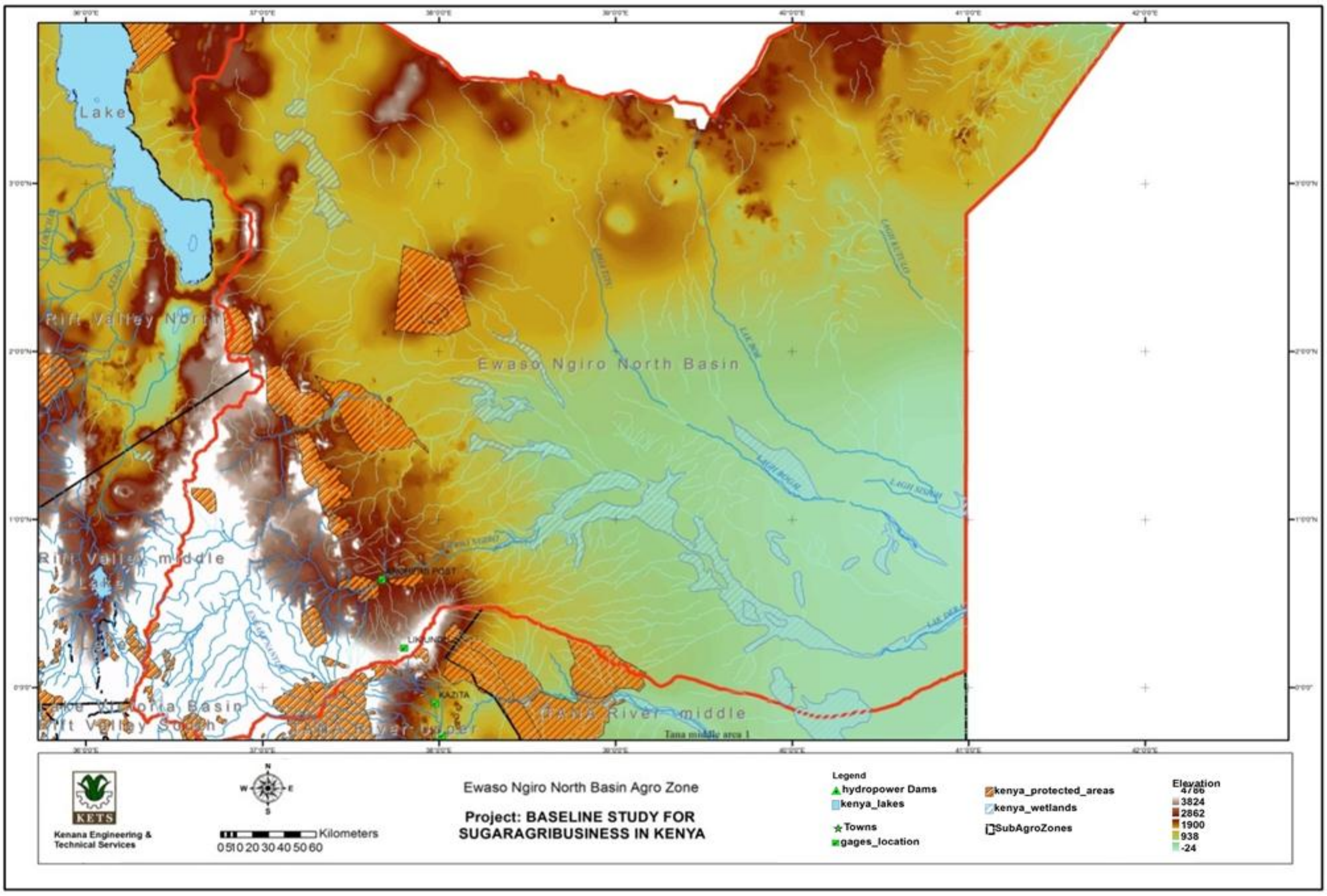


Figure 7-45: Ewaso River Agro Zone

7.6.2. WATER RESOURCES

Annual Rainfall in the zone ranges between 200-800mm. Groundwater aquifers are classified as poor and fair.

Ewaso Ng'iro North River is the major river in the Ewaso River Catchment area. It originates from Mt. Kenya (5,199 m) and flows in the central part of the country eastward and disappears underground near the Lorian Swamp. The underground flow pours into Somalia. The drainage area of Ewaso Ng'iro North River is 81,749 km^2, which account for about 39% of the whole Catchment Area.

Implementation of dams will be difficult because there are no suitable locations to construct such dams. Additionally, building of dams if found possible, would have negative impacts on the parks and the swamps downstream of the river.

Ewaso River North Hydrograph

Ewaso River Hydrograph (MCM) from Archers Post station which has daily records for the period from 1949 up to 2011 is shown in Figure 7-46. Table 7-32 shows the average monthly flow and the monthly minimum flow for the whole period.

Table 7-32: Average monthly and minimum flows as at Archers Post Station

Month	Average	Minimum flow
Jan	28.89	1.01
Feb	14.47	0.19
Mar	30.52	0.54
Apr	87.59	0.41
May	63.90	5.14
Jun	29.35	0.41
Jul	26.90	0.20
Aug	42.44	0.66
Sep	39.40	0.77
Oct	43.21	0.41
Nov	121.34	14.78
Dec	86.49	5.52
Annual	614.50	30.03

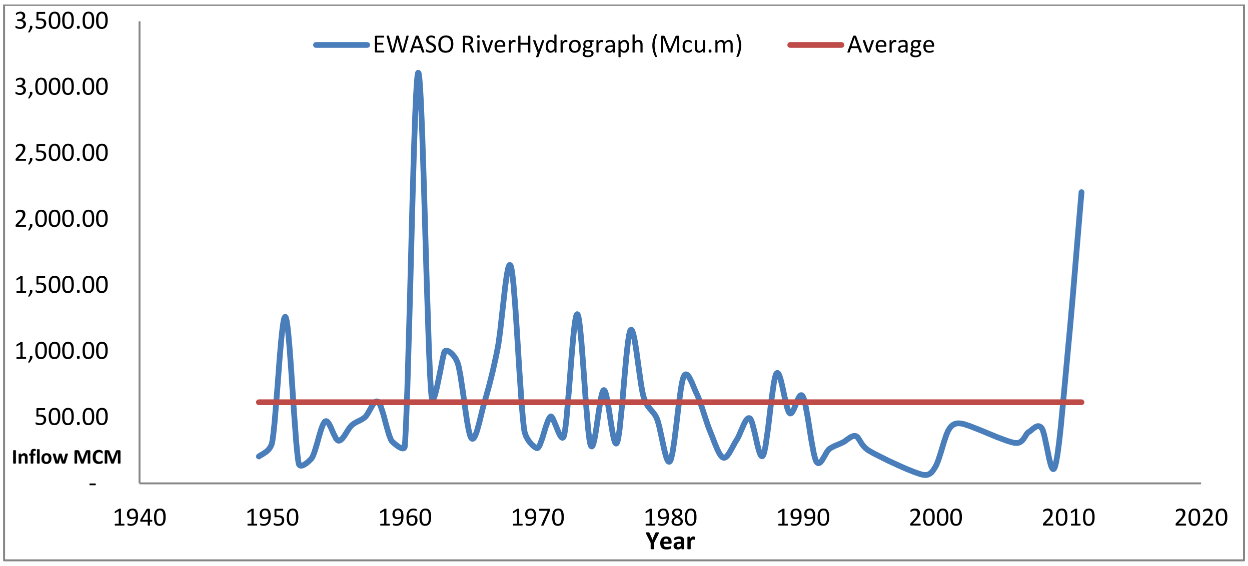


Figure 7-46: Ewaso River Hydrograph (MCM) in Archers Post Station

7.6.3. SOILS, CLIMATE AND LAND SUITABILITY

The preliminary studies and remote surveys conducted for the study area indicated that the Ewaso River North Zone falls deeply in wetland areas with rocks and stones as part of features. The area is subjected to continuous erosion. The Ewaso Ng'iro North Catchment encompasses an area of 210,573 km^2 with a population of 3.6 Million. The Catchment is the largest of six catchment areas, but due to its fragile resources, has the lowest population; the catchment falls in semi-arid areas, which constitute more than 70% of the entire catchment area. Forests cover approximately 1,655 km^2, which is less than 1% of the area. Concerted effort is therefore required to improve the forest area and minimize land degradation.

The spatial distribution of rainfall varies from 800 mm/year in the highlands to 400 mm/year in the ASAL areas. The renewable surface water in this catchment area is 1,725 MCM/year while that for groundwater is 18,197 MCM/year giving a total of 19,922m^3/year renewable water resources as per NWMP 2030 interim report. Accordingly, the per capita water resource in this catchment area is 5,534m^3. In this, surface water is about 9% and groundwater is about 91%. The per capita is more than 5 times higher than the global benchmark of 1000 m3. Ewaso Ng'iro North area falls in the category of areas with 'moderate problems', which indicates that the area has occasional water supply and quality problems, particularly during droughts. However, this issue could be mitigated by focusing more on developing groundwater resources rather than continued reliance on surface water sources. Therefore, the region is unable to provide sustainable water supply for sugarcane farming.

7.6.4. ENVIRONMENTAL STATUS OF THE EWASO RIVER AGRO ZONE

Studies and remote surveys conducted for this zone indicated that the Ewaso River North Zone falls deeply in wetland areas. It has limited water supplies that might not be adequate to sustain the existing fauna and flora, especially during the dry seasons, or supply irrigation water for new sugar schemes. Moreover, this Agro Zone secures the existence of a wealth of wildlife and supports tourism industry through attractions such as Kenya National Reserve. Herds of livestock roam the area in search of pasture and water and their lives could be at risk if more pressure is placed on the existing water resources by developing new irrigated schemes. Based on its fragile resources this Agro Zone could be rated as unsuitable for sugarcane irrigation.

The Ewaso River flows into the Lorain swamp where it forms a seasonal wetland that contains water for only short period and represents a critical water resource for people, livestock, wildlife and plants. This is beside its important role of recharging the groundwater in the area.

The availability of fresh water, pasture and other useful products attracts humans and could render the wetlands focal points for economic development and indeed urbanization. The introduction of large scale agro-industry will enhance changing lifestyles of local communities who could settle and be more focused on subsistence and commercial agriculture.

Ewaso-Ngiro North Catchment area has gone through extensive degradation in the past as a result of deforestation, encroachment into water catchment areas, cultivation in wetlands and over-grazing. These activities destroy surface cover and result in increased surface run-off and soil erosion. The eroded soils are carried by surface flow and deposited in the water streams resulting in reduced storage capacity and water quality. The increased surface run-off causes flooding and its associated consequences. Pollution from agro-industries, effluent discharges and solid waste from urban areas continue to affect water resources.

7.6.5. SOCIOECONOMIC ASPECTS OF THE EWASO RIVER AGRO ZONE

A large part of the Garissa County falls in this zone. The county covers an area of 44,174.1Km^2 and administratively has been divided into seven constituencies, namely, Fafi, Garissa, Ijara, Lagdera, Balambala, Dadaab, and Hulugho. According to the 2009 Census, the total population of the County is 623,060 with an average density of 14 persons per km^2. The population and the density were projected to reach 850,080 and 19 persons per km^2 respectively by 2017 (Table 7-33).

The land use in this zone is communally based and dominated by nomadic-pastoralists. The main livestock resources are cattle, goats, sheep and camels.

The zone is not recommended for sugarcane production due to water supply limitations and the existence of the Kenya National Reserve for wildlife.

Table 7-33: Population Distribution and Density by Constituency – Garissa County

Constituency	2009 (Census)		2017 (Projections)	
	Population	Density/ (Km^2)	Population	Density/ (Km^2)
Garissa Township	116,953	173	159,566	236
Balambala	73,109	15	99,747	20
Lagdera	92,636	14	126,389	19
Dadaab	152,487	22	208,048	37
Fafi	95,212	6	129,904	8
Ijara	92,663	9	126,426	13
Total	623,060	14	850,080	19

Source: KNBS, 2013

Sugar Beet areas

The potential areas for the cultivation of sugar beet in this zone are classified as medium climate suitability and irrigation is required for all the potential areas. (Figure 7-47).

Supplementary irrigation for sugar beet could be established following conduction of detailed water balance for water harvesting projects. Geo-hydrology studies are also required to assess capacity of groundwater aquifers to supply irrigation for beet crop within areas where suitability for the crop was rated as fair.

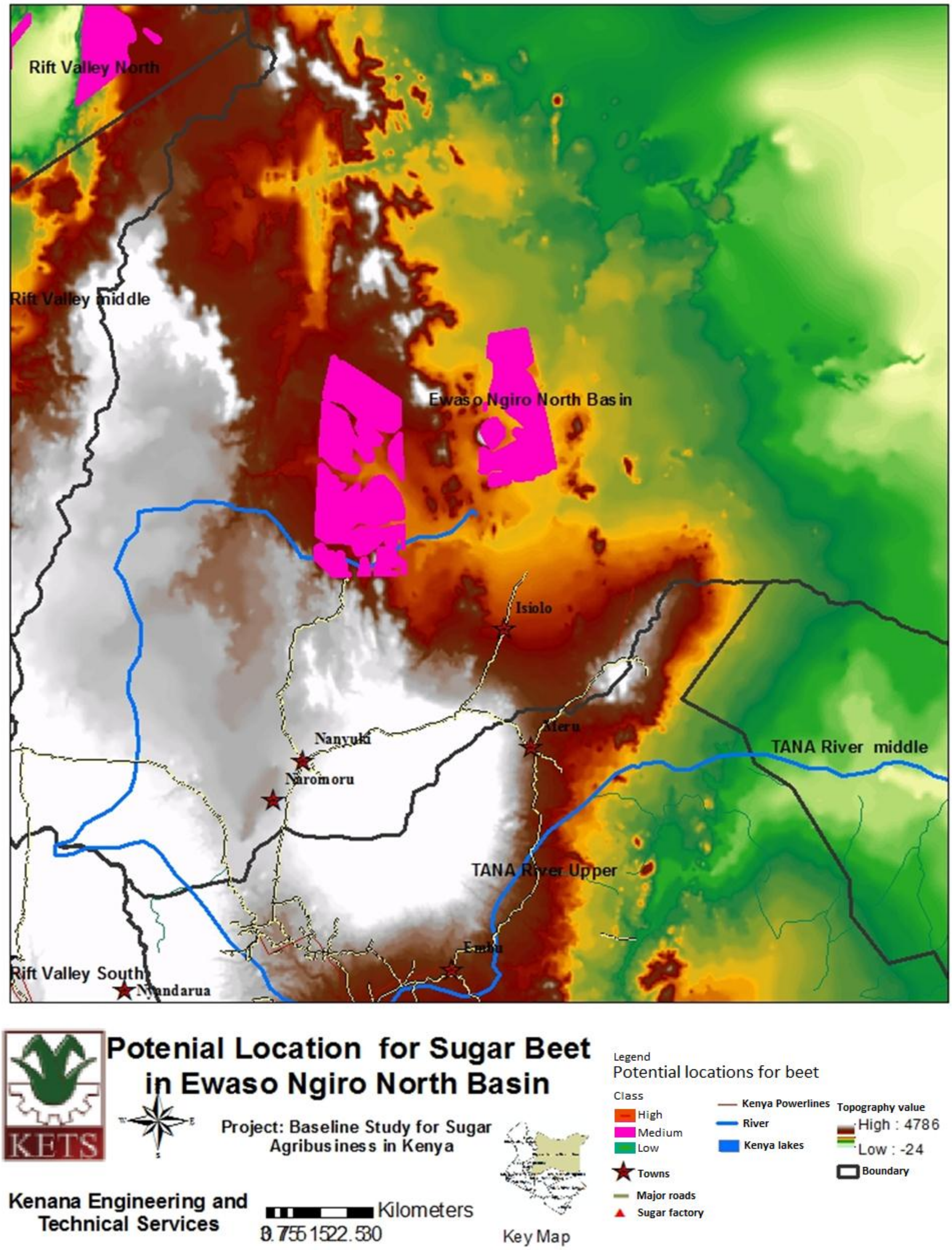


Figure 7-47: Potential sugar beet areas in Ewaso Ng'iro Agro Zone

7.7. SWOT KENYA SUGAR SECTOR ANALYSIS

Based on the analysis of Kenya's sugar industry and the study recommendations to expand sugar production in the Coast, Rift Valley, and Tana River, KETS has assessed the Strengths, Weaknesses, Opportunities and Threats (SWOT) involving internal and external industry environment. The results are outlined on the following page.

STRENGTHS

Environment and Socio-economic
1. Strong agronomic research capacity
2. Available processing capacity
3. Experienced farmers with sugar cultivation (Western Belt)
4. Stakeholder commitment to promote the sugar industry

Natural resources
1. Available land and water resources for (sustainable) sugarcane production
2. High rainfall and good distribution allow for rain-fed cultivation (Western and costal regions)
3. Different soil types and water to develop irrigation systems according to climatic zones

Infrastructure
1. Status of National Urban development Policy (Vision 2030)
2. Air transport (facilities) is one of the most important airline in the world
3. ICT: 90% covered by GSM signal
4. Mombasa Seaport is the second largest seaport in Africa

Business environment and Market
1. Political stability as evidences by2013 election
2. Reforms in business sector (single window trade system, getting credit, protecting investors)
3. Investment incentives (Export processing zones program, duty exemption, investment allowance)
4. The sugar sub-sector is source of livelihood for millions of citizens.

Sugarcane and sugar production
1. Abundant available labour
2. Established industry
3. Available technologies & recommended Agronomic practices
4. Well established Sugar research facilities (West & East of Kenya)

WEAKNESSES

Environment and socioeconomic
1. By products of industry not fully utilized
2. Lack of experienced farmers in sugar crops in new areas
3. Inadequate and uncoordinated funding
4. Lack of awareness and poor capacity of farmers (Health Safety and Environment, pest control, pest management practices).
5. Conflicts between farmers and millers
6. The crowding of existing sugar mills resultingin disputes over catchment areas
7. Cane production management

Natural resources
1. Water scarcity especially in the East, North, and Rift Valley regions
2. No supplement irrigation in the Western region
3. High supplement irrigation cost
4. Low soil fertility

Business environment and market
1. High cost of transportation due to long distances traveled and poor road conditions
2. A distribution system controlled by few players covered with inadequate packaging and branding
3. Insufficient administration of quotas and high local retail prices allowing importer entities to obtain major profits at the expense of the consumer
4. High prices of sugar due to tarrifs which benefits local producers but make raw sugar exensive for consumers.

Infrastructure
1. Poor roads for cane transportation
2. Airport infrastructure is weak
3. ICT is very expensive
4. High rates of tenancy and insecure tenure
5. Rail ways network does not cover the whole country
6. Poor feeder roads in sugarcane areas

8. Mombasa sea port capacity constraints will require substantial investments
9. All type of transportation(air, sea, road) need improvement in quality and quantity
10. Urban infrastructure is weak

Sugarcane and sugar production
1. Generally outdated and poorly maintained factory equipment
2. Debt burden of government mills
3. Lack of distribution map for new sugarcane varieties
4. Lack of crop rotation
5. Low pol% cane or high fiber% cane
6. Very many farm-factory transport cycles for out grower's cane
7. Lack of well-planned planting and harvesting schedules

S W O T

OPPURTUNITIES

Environment and Socio-economic
1. Agronomic potential
2. Government/stakeholders goodwill
3. By-product utilization (co-generation, ethanol, animal feed, drinking water … etc.)
4. Increasing farmers income through increasing sugarcane yields
5. Introducing best management practices
6. Application of different types of production relationships

Natural resources
1. Different climatic zones relevant to sugarcane and beet plantation
2. Potential for mechanized irrigated schemes

Business Environment and Market
1. Trend for biofuel market (Ethanol)
2. Need for power generation (cogeneration)
3. Gap in animal feed market
4. Growth in private sector, along with privatization policy carried out
5. Attractive destination for FDIs (specifically infrastructure)
6. Growth of FDI projects into SSA-since 2007
7. Discovery of oil in north Turkana
8. GOK has been working to put in place measures to protect the sector such as controlled importation and payment of dues to farmers by cane factories.
9. The government is planning to complete rehabilitation of existing facilities, enhance production and reducing the production costs
10. Privatization of sugar factories and training of sugar farmers to embrace modern technology in farming
11. The domestic need for sugar will continue to grow outstripping demand by 300,000 tons by 2020
12.

Infrastructure
1. Air transport: Kenya Airways is one of Africa's top three international carriers, with an extensive network across the continent and a safety record up to international standards
2. Seaport: Mombasa is one of the largest and busiest seaports in Africa.

Sugarcane and sugar production
1. Opportunity for expanding the land and application of advanced irrigation systems
2. High potential for higher cane yields by implementation of proper technologies
3. Pricing of sugarcane on sucrose content
4. Investment in suitable Agro Zones for new sugarcane projects
5. Water harvesting to increase cane production (western and coastal)
6. Optimization of available factories and increasing efficiency

THREATS

Environment and Socio-economic
1. Insecurity in some of the potential areas (East, Rift Valley)
2. Conflict between wildlife and sugar industry
3. Uneconomic farm sizes
4. Conflict between farmers and pastoralists
5. Insolvency of some producers
6. Food insecurity
7. Slow adoption of new technologies
8. Political interference in affairs of the industry
9. Environmental degradation (overgrazing, erosion and habitat destruction)
10. Malaria and HIV/AIDS
11. Pollution by the sugar industry
12. Cultural differences

Infrastructure
1. High cost of power
2. Air transport: Kenyatta airport needs to address capacity constraints and security issues.

Business Environment and Market
1. High cost of sugar production at $870/ton which renders Kenyan sugar in competitiveness
2. Expiry of COMESA safeguards in 2014
3. International sugar real prices remaining below $500/ton up to 2020
4. Expansion in sugar industry in EAC region will limit export market
5. High debt to GDP ratios (above 40%)
6. Kenya's sugar industry is threatened by cheap imports and/or smuggling from efficient sugar-producing countries.

Piracy at East Coast

Sugarcane and Sugar production
1. High prices paid for sugarcane
2. Slowness in adoption of advanced technology
3. COMESA sugar imports from low cost producers
4. Further fragmentation of land
5. History of mistrust between out growers and sugar companies
6. Present situation of land ownership (Culture of tribes)

Natural resources
1. Climate change (floods, droughts and rainfall distribution)

7.8. Risks associated with Potential Sugar Projects in Kenya

Introduction

The risk assessment attempts to quantify and measure the potential risks that could threaten Kenya business environment and the development of new sugar projects in the country. The matrix which will be shown later in this section highlights the risks and impacts and proposes mitigation measures to reduce these risks to an acceptable level.

7.8.1. Risk Analysis Methodology

7.8.1.1. Probability and impact rate

The rating of probability and impact consist of fives bands graduated from very low to very high. The table below illustrates the rates, their color code, and their numerical value for probability and impact.

Probability & Impact Rate	Description	Color Code	Numerical probability	Numerical Impact
VH	Very High		5	5
H	High		4	4
M	Medium		3	3
L	Low		2	2
VL	Very Low		1	1

7.8.1.2. Risk degree

Risk degree is based on compensation of probability and impact by multiplying probability times the impact for each risk. The risk degree shows the risk exposure for each individual risk and the average of overall risks degree used to figure out overall risk exposure for the proposed sugar industry.

Probability							
	VH	5	5	10	15	20	25
	H	4	4	8	12	16	20
	M	3	3	6	9	12	15
	L	2	2	4	6	8	10
	VL	1	1	2	3	4	5
			1	2	3	4	5
			VL	L	M	H	VH
			Impact				

This chart of Probability Impact matrix (PI) shows a probability and impact matrix adapted for scale from 1 to 5 for both probability and impact.

The Risk degree of the above PI matrix is illustrated below:

Risk degree	Rating Criteria	
	Minimum	Maximum
VH	20	25
H	12	19
M	6	11
L	3	5
VL	1	2

7.8.2. Risk Assessment Matrix

Risks Identification			Risks Analysis			Risks Response Strategy	Risks Analysis After applying Responses		
#	Category	Risk Description	Probability	Impact	Risk Degree (P * I) From 1 to 25		Probability	Impact	Risk Degree (P * I) From 1 to 25
1	Business Environment and Market	Abolishing safeguards of COMESA in 2014, which will result in zero import tariff for sugar from COMESA countries the local sugar prices cannot compete with imported sugar	VH	H	20	• Apply for another extension for COMESA safeguards • Reduce cost of production to compete with COMESA cost of production	L	M	6
2	Business Environment and Market	International real Sugar prices remaining below 500 US$ and the Kenyan sugar prices cannot compete with international prices	H	VH	20	• Applying tariff rates on imports from countries other than COMESA	L	L	4
3	Business Environment and Market	Expansion of sugar industry in some of EAC region countries (Ethiopia, Tanzania) and sugar supply will exceed demands and with prices lower than Kenya prices	M	H	12	Reduce the cost of production relatively to compete with these countries	L	L	4
4	Business Environment and Market	Hesitation in foreign investment due to speculations of security associated with Somalia Islamic groups and ethnic conflict in production areas will discourage investors	M	M	9	• Expand enforcement of security by police in production areas • More manifestation and emphasis on security image via media channels	L	M	6
5	Business Environment and Market	High production cost due to low yields, inefficient industry operations, lack of byproducts utilization, and mismanagement of facilities will imply that Kenya sugar prices cannot compete with other countries prices	VH	VH	25	• Regulate out growers/facilities relations to reduce cost of production • Efficient utilization for byproducts and regulate its market • Enhance the management process • Hindering the efficient running for facilities • Seek privatization	L	L	4
6	Business Environment and Market	Production cost in new sugar areas in north and east is expected to be much lower than existing sugar factory and the western factory will not compete with new sugar areas	H	VH	20	Lower the cost in existing sugar industry to compete with new sugar factories	L	L	4
7	Environment and Socio-economic	Insecurity in some of the potential areas could delay project implementation and discourage investors	H	VH	20	• Government presence and effectiveness • The involvements of the elders and community leaders in the decision.	VL	L	2
8	Environment and Socio-economic	Conflicts between wildlife and sugar industry could negatively disrupt or hinder the project process	M	H	12	• The involvement of Kenya Wildlife Services (KWS) in the ESIA studies • The designation of corridors for wildlife movement	L	M	6
9	Environment and Socio-economic	Conflicts between farmers and pastoralists could lead to disputes over land and obstruction of work	H	VH	20	Government presence and effectiveness, holistic approach, and consultation and the involvements of community leaders in the decision	L	L	4
10	Environment and Socio-economic	Food insecurity could increase poverty among farmers	H	H	16	Mandating sugarcane farmers to grow other cash crops in their farms as part of the crop rotation	L	M	6
11	Environment and Socio-economic	Environmental degradation could lead to destruction to natural habitat and loss of soil fertility	H	H	16	• The involvement of Kenya Forest Services and NEMA in the decision making and in the pre projects studies (ESIA) • The designation of corridors for wildlife movement	L	L	4
12	Environment and Socio-economic	Malaria and HIV/AIDS could have impact on laborers, which could reflect in poor performance of staff	H	VH	20	Awareness programs, protection means, etc.	L	L	4
13	Environment and Socio-economic	Pollution from the sugar industry could harm the environment and lead to opposing the project from communities and environmental groups	H	H	16	• Efficient industry • Green technology • Policy and Regulations	VL	M	3
14	Environment and	Sugar industry waste could harm the environment and	H	H	16	• Utilize some waste in profitable by-product	L	M	6

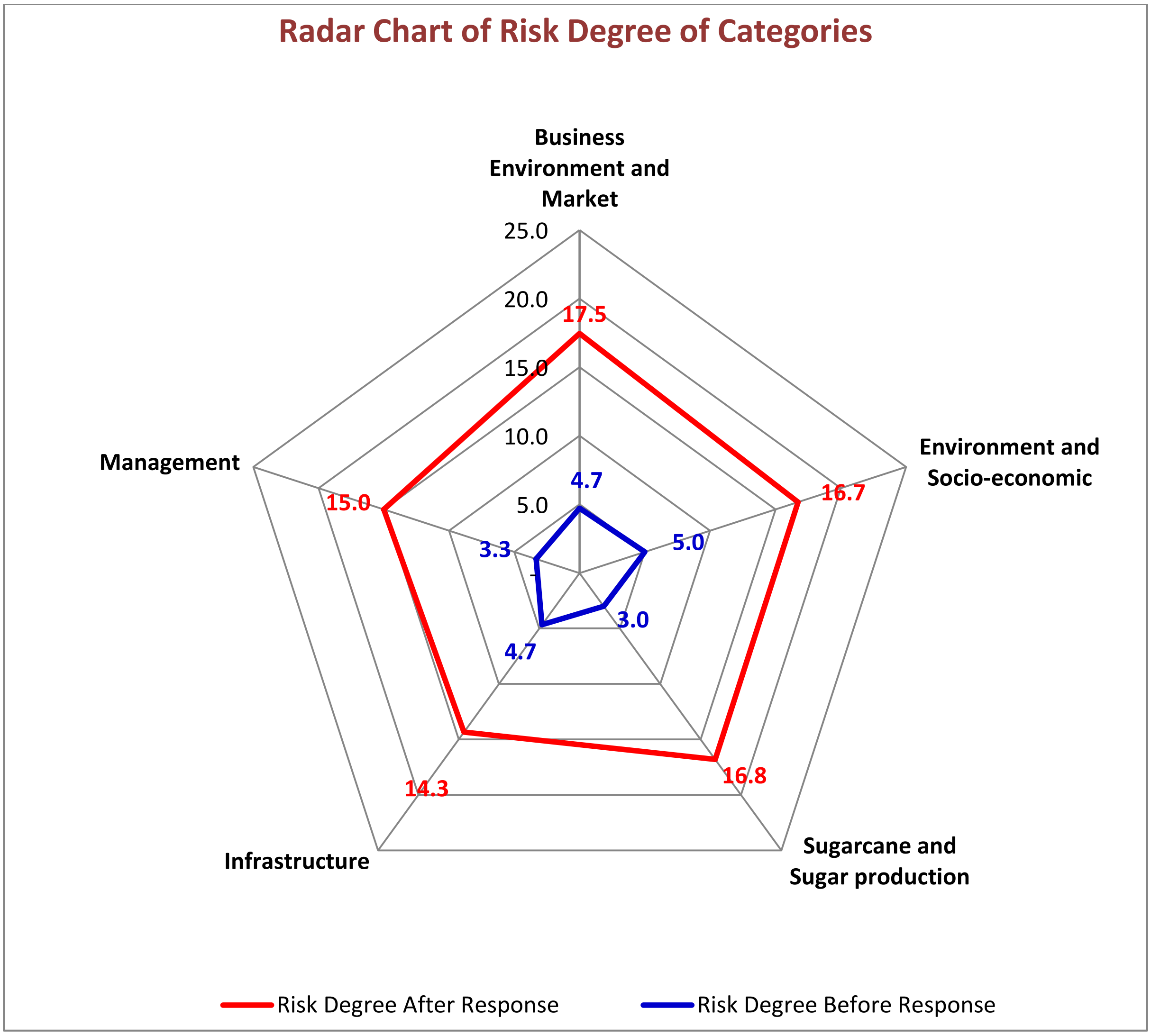
Risks Identification			Risks Analysis			Risks Response Strategy	Risks Analysis After applying Responses		
#	Category	Risk Description	Probability	Impact	Risk Degree (P * I) From 1 to 25		Probability	Impact	Risk Degree (P * I) From 1 to 25
	Socio-economic	lead communities opposing the project				• Efficient industry • Green technology • Policy and Regulations			
15	Environment and Socio-economic	Water scarcity (east) could prevent project establishment and create conflict	H	VH	20	• Storage reservoirs • Strategy for more effective water management and measurement to reduce water use • Improved irrigation efficiency and scheduling	L	H	8
16	Environment and Socio-economic	Climate change could cause floods, droughts and variability in rainfall distribution and could increase the project costs when mitigating for such impacts	H	VH	20	Adaptation measures, mitigation, and policy reforms, Enhanced planning and risk assessment	L	M	6
22	Infrastructure	Poor road conditions and lack of feeder road increases cane transportation cost and leads to high production cost	VH	H	20	Government invests in new roads and other infrastructure, especially in cane growing areas	L	L	4
23	Infrastructure	Security constrains of air and sea ports will lead to work interruption and incur additional costs	L	H	8	Obtaining level of clearance that requires further work on security arrangements at the ports	L	M	6
24	Infrastructure	Kenya's power supply shortages in generation and transmission affect expansion of sugar businesses	VH	M	15	Government should invest in power generation and sugar factories should utilize by products to generate power	L	L	4
25	Management	Insufficient attraction and retention of key skills and having caliber staff will impact negatively project operations	M	VH	15	• Active capacity development • Remuneration policies focused on attracting, motivating and retaining high caliber employees • Employee retention strategy • Investment in skills development programs • Succession planning and talent management programs	VL	L	2
26	Management	Due to insufficient or defects in the design, there is a threat of increasing the time and cost of project to rework and redesign, which would generate a funding gap.	M	VH	15	• All concerned parties have to collaborate in preparing the design • Cross check the design by the project team or third parties • Give the design the required amble time and numbers of revisions • Expert consultation (consultant involvement)	L	L	4
27	Management	Poor implementation will result in uncontrolled cost escalation, risk of non-completion, as well as sub-optimal production.	M	VH	15	• Support from local and international reputable consulting firms • Insure clear scope • Apply quality measures & assurance and best project management practices, and follow-up of their implementation.	L	L	4
28	Environment and Socio-economic	Unenforced regulation and policies will interrupt the work process and impose additional cost	L	H	8	strengthening sound policies and establishing a monitoring body for enforcement	L	M	6
29	Sugarcane and Sugar production	Inadequate supply of cane to meet production requirements in respect of quantity, quality and timing	H	VH	20	• Cane grower development strategies and programs • Collaboration with government Programs for the development of claimant communities (mentorship programs) • Irrigation, planting cane varieties, weather forecasting • Cane supply agreements.	L	L	4
30	Sugarcane and Sugar production	Fluctuation of river stream could reduce planted areas and impact sugar germination	VH	H	20	Water harvesting	VL	L	2
31	Sugarcane and Sugar production	Lack of adoption of new technology will reduce factory efficiency and sugar extraction	H	H	16	Modern technologies	VL	VL	1

Risks Identification			Risks Analysis			Risks Response Strategy	Risks Analysis After applying Responses		
#	Category	Risk Description	Probability	Impact	Risk Degree (P * I) From 1 to 25		Probability	Impact	Risk Degree (P * I) From 1 to 25
32	Sugarcane and Sugar production	Bad management and operation of existing dams will lead to reduction in the planted area and could create conflicts	M	H	12	Improve dam management and supervision	L	L	4
33	Sugarcane and Sugar production	Some beet varieties are fragile and cannot tolerate many diseases and this could impact yield and germination	H	H	16	Strong research and development supported with pilot farm	L	L	4
		Overall Threat Risks Degree			**16.3**				**4.4**

7.8.3. RISK DEGREE ASSESSMENT

The overall calculated risk degree of the quantified risks is **16.3** which is High and after applying risk response strategy to control these risks it will be expected to shrink to 4.4 which is Low .

The risk degree for the five categories before and after applying risk response strategy are calculated and mapped into a radar chart (See Below). The chart illustrates the existing risk degree and the expected decline of risk degree to an acceptable level as result of controlling the risk for each category. The chart shows that the business environment and market has the highest risk degree of 17.5 which falls to 4.7 after applying the risk response.



Chapter 8 Preliminary Environmental and Sustainability Aspects for Sugar Business in Kenya

8.1. Preliminary Environmental Aspects of Sugar Industry

As concerns are growing worldwide about the threats the environmental degradation poses to both human wellbeing and economic development, many industrialized and developing nations, as well as donor agencies, have mandated new projects to undertake environment impact assessments before making decisions on the release of funds. Therefore fully-fledged Environmental and Social Impact Assessments (ESIA) should be undertaken for the prospective sugar investments in the recommended new areas and mitigation measures should be incorporated into the projects' design to eliminate or reduce adverse environmental impacts.

The following section highlights possible environmental impacts of sugar cultivation and milling operations and recommends general mitigation measures to ensure the new sugar projects will be environmentally sound and sustainable. Further to this, the fundamental nature of the sustainability of sugar projects and their impacts on natural resources and other businesses will also be highlighted.

8.1.1. AGRICULTURAL IMPACTS

Environmental impacts of sugar production can be reduced by adopting good management practices at both the farms and the mills levels. Farming operations could be improved by adopting alternative cultivation systems (e.g. Integrated or precision methods) to provide more efficient use of chemicals, and introducing efficient techniques of irrigation such as subsurface drip irrigation to save on water and agro-chemicals such as fertilizers.

Impacts of the sugarcane cultivation are significantly influenced by local conditions, such as soil types and climatic factors. Therefore, appropriate planning and good management techniques are important factors to reduce these impacts. Possession of clear data from high quality soil analysis is essential in formulating specific soil management guidelines. The challenge to the grower community would be to protect biodiversity through the maintenance of natural habitat fragments within the farming landscape, and adopting a more diversified cropping system which includes leguminous crops to avoid the problems associated with the monoculture.

8.1.2. SUGARCANE CULTIVATION IMPACTS

Land use planning and zoning: Biodiversity conservation and maintenance of ecosystems needs to be addressed on a landscape level, as well as on individual fields. Without effective conservation measures, farm lands can quickly deplete the dry regions' water supplies which will negatively impact the habitat and biodiversity in general.

Crop establishment: Specific guidelines need to be followed when soil is utilized for planting and the cultivation operations should follow recommended practices to protect the fragile soil ecology particularly under high rainfall and steep terrains. Sloping terrain could increase loss of nutrients, accelerate soil erosion and weaken the balanced ecology of soil organisms.

Planting on fallow lands*:* Planting on fallow land is less labor intensive and requires less machinery and agricultural inputs compared to planting on new extension of lands. Expanding into new lands remains a major threat to biodiversity and the environment in general and it should be curtailed by rigorous policies and tough regulations.

Maintaining soil fertility*:* Fertilizer recommendations should be based on leaf tissue and soil analyses to determine type and dose of fertilizers to be added and recommendations in this respect should be strictly adhered to. Regular leaf sampling and recycling of mill organic wastes such as filter mud as soil conditioner or boiler ash for silicon and Vinasse as NPK fertilizer.

Reducing inputs usages: Integrated Pest Management (IPM), elimination of prophylactic use of agrochemicals and following precision agriculture are accepted methods to reduce application of inputs.

Efficient water use: Optimizing water use by adopting innovative irrigation practices, improving irrigation scheduling to enhance water use efficiency, recycling of drainage water and mulching or trashing to reduce evaporation are recommended techniques for efficient water use.

Improving soil quality: Controlled traffic of infield mechanical operations to minimize soil compaction and damage to sugarcane stool and the use of 'Low Ground Pressure (LGP) running gear' to control tire pressure are important to maintain the physical properties of the soil.

Reducing air pollution from pre-harvest cane burning: Adoption of green harvesting method is increasingly becoming standard in the global sugar industry. In Brazil, the biggest sugar producer in the world, the burning of cane will be terminated by the year 2014.

8.1.3. HARVESTING IMPACT

Good planning for farm layout, including headlands, roads, slopes and drainage, and row width, length and profile should be followed to ensure standard harvesting operation. The following should be considered:

Green Harvesting of cane: Harvesting green cane and utilizing the large quantities of trash to the boilers will provide more biomass for energy generation. The harvest of 90-100tons of cane/ha will leave behind 10-15 tons of trash which will approximately double the amount available to boilers from bagasse. Many sugarcane producing areas in the world have moved from cane burning to green harvesting and reaped advantages which include protection of top soil, conservation of moisture, reduction of erosion, reduced cost of weed control and low emissions of CO_2.

8.1.4. PESTS CONTROL

Sugarcane could harbor a number of insects, nematodes and vertebrate pests and diseases which could result in significant losses in productivity if appropriate control measures are not taken. Stem and root borers and nematodes and white grubs are perceived to be the most important pests of sugarcane. Smut and ratoon stunting disease are considered major diseases.

While the breeding of resistant varieties lessened dependence on pesticides, agrochemicals are still widely used in a number of sugarcane growing areas. The use of pesticides especially in poor countries represents the greatest risk to the wellbeing of farmers, farm workers and rural communities. Uncontrolled use of pesticides also poses risk to non-target organisms and to the environment.

There are a number of management practices which can be used to control sugarcane pests and diseases with little or no risk to the well-being of people or the environment. They include:

- Use of biological controls
- Use of benign chemicals and biopesticides – e.g. tebufenozide, neem based products and formulations of Metarhizium spp.
- Adoption of various agronomic practices – e.g. planting pest free seed cane; using resistant and tolerant varieties, management of planting or harvesting dates to the detriment of certain pest species, adopting green cane harvesting with a trash blanket and replanting using minimum tillage, use of organic amendments in the planting furrow to enhance early plant growth and reduce damage caused by nematodes, avoiding moisture stress through irrigation, intercropping and crop rotation to include cash crops (including rotation with soybean that favors beneficial bacterium)
- Pests capturing, hand picking and the use of trap crops, light traps and pheromone traps.
- Most of the chemicals registered for pest control in sugarcane are classified as hazardous and control of their use with respect to optimum dose, timing and method of application should adhere to manufacturer’s guidelines
- To reduce the risk of poisoning and environmental contamination, and until more safer control options are available, greater emphasis has to be placed on:
    - Training of farm workers
    - Provision of appropriate safety clothing, and
    - Use of improved application technology

A responsible country like Kenya should impose a ban on itself regarding highly hazardous pesticides if audit reports indicate lack of guarantees that they can be handled within the margins of acceptable risk to the user (FAO 2010).

8.1.5. PROCESSING IMPACTS

Measures to be adopted by various mills include:

a) Efficient processing

- Minimizing effluent quantities by recycling and re-using both water and condensate
- Ensuring the best quality condensate is returned to the boilers as feed water
- Using only condensate for process water requirements, that is, imbibition, filter wash water, centrifugal spray water, dilution water and chemical make-up water
- Using lower quality reject streams such as cooling tower overflow and boiler blow-down in the boiler scrubber circuit
- Minimizing wash down in the mill
- Collecting and re-using water where appropriate
- Replacing cane washing with dry cleaning to remove sand and leaves
- Recycling used condenser cooling water for irrigation
- Managing the factory water balance to use less than 1 m3/t cane

b) Air quality

Air pollution could be controlled by reducing stack emissions, mainly particulates, through strict enforcement of new emission standards for bagasse-fired boilers and substitution of old boilers for more efficient units. Greater use of Life Cycle techniques to establish the carbon footprint of both factory and agricultural operations, and to develop strategies for lowering the footprint based on reforestation of fragile areas with indigenous trees. Other measures include recycling organic mill wastes back to fields as added value compost, implementation of environmental awareness for staff and the community, and use of sustainability metrics for meeting all the requirements of sustainable production.

c) Energy conservation

Measures to be adopted by various mills include:

- Energy generation from bagasse must be measured and controlled for optimization
- Replacing old boilers with more efficient high pressure boilers
- Use of renewable supplementary fuels such as woodchips instead of coal
- Attention to be given to factory steam and energy balance
- The use of cane leaves and tops as fuel is receiving widespread attention
- Utilization of wasted heat
- Potential for biogas generation and use

d) Energy Management

- The sugar industry is fortunate in having bagasse available as an energy source. As mills are able to configure the thermal economy of the operation to be independent of other fuel sources under most conditions, plans to achieve the following targets should be formulated:
    - All mills should adopt a sustainable operation policy, and consider being certified to ISO 14001
    - Any new project or expansion must take into account the sustainability of the project, encompassing not just economic but also social and environmental factors
    - The thermal economy of the factory should be designed so that the mill does not need supplementary fuels or create a bagasse surplus
    - If waste biomass is to be used as a supplementary fuel, its suitability for use should be assessed based on chemical analysis to ensure freedom from boiler fouling and slagging problems
    - If the mill can profitably export bagasse to a downstream use (e.g. for by-products), the thermal economy of the mill is most important

- Likewise if the mill intends to export power, the factory should be set up to be energy efficient, and/or the distillery should employ a steam saving configuration, to maximize export revenue
- Good energy efficiency is achieved by using high efficiency electric drives instead of turbines on plant and equipment and minimizing process steam usage
- High pressure boilers are necessary if substantial export of power is envisaged
- Good boiler efficiencies are achieved by incorporating air heaters and economizers, and through good maintenance and operation
- Bagasse driers can deliver efficiency benefits, but the correct design and integration of the plant is vital if the benefits are to outweigh the additional operating costs
- The existing legal framework and the prevailing electricity market rules can have a huge influence on an energy export project and should be thoroughly investigated before investing
- The generation of biogas from vinasse when available can profitably contribute to energy production
- Exporters of ethanol to developed countries need to get certified sustainability for their products
- Sugar mills can produce products with a small carbon footprint because of the availability of bagasse as a fuel source
- The effect on GHG emissions should be thoroughly considered in arriving at a final project design
- New projects involving expansion onto virgin land should not be undertaken without a comprehensive study of the effect on land carbon stocks
- The Clean Development Mechanism (CDM) process provides an opportunity for sugarcane projects to benefit from carbon credits, even though the process involved can be drawn out
- Sustainability certification provides the most promising avenue to have sustainable production certified

8.1.6. ELECTRICITY GENERATION (CO-GENERATION)

When cane is crushed and the juice separated for crystallization, the remaining dry matter - called bagasse - is burnt to provide energy. The bagasse resulting from the crushing of cane can be used to raise steam for driving turbines for co-generation. The process of generating energy avoids the need to use fossil fuels to generate electricity and therefore avoids the emission of greenhouse gasses, notably carbon dioxide. In Kenya, the aspect of generating energy from bagasse is not well developed. It is only Mumias Sugar Company that has a very small scale capacity in this respect.

Historically, many sugar mills deliberately designed low efficiency boilers/generators to avoid the problems of surplus bagasse, as there was no incentive to export electricity. Leal (2007) describes how the design of sugar factories has changed dramatically in the past 20 years, through the use of high pressure boilers and high efficiency turbo alternators together with minimizing power consumption in the factory. New factory design considerations need to include the prices payable for electricity, ethanol and sugar so that outputs can be optimized according to economics.

The 'ball park' potential for export of bagasse-based power is 100 KWh/t of cane processed. This figure is already being attained and exceeded in the more efficient sugar factories in Brazil, Guatemala, Reunion, Mauritius, and India where the price being paid for electrical power from sugar mills is economically attractive (Avram-Waganoff et al. 2010).

8.1.7. RECOMMENDATION FOR DETAILED ENVIRONMENTAL IMPACT ASSESSMENT

The impact of sugar cultivation and milling operations on the environment will be severe if not properly assessed, managed, and mitigated. The Environmental Management and Coordination Act, (1999) and Subsidiary Regulations (2003) mandated new development projects to undertake Environmental Impact Assessment (EIA) before making approval decisions. To ensure compliance, relevant environmental laws (national and international) pertinent to sugar production should be reviewed. NEMA and the project's proponent should work closely and consult with concerned stakeholders during project planning and construction. Government agencies such as the wildlife authority, water management agency and regional development authorities should also be consulted during the EIA study.

A detailed EIA should be conducted for each proposed project to address, at a minimum, the following:

- The affected area should be defined for closer assessment. This included affected environments such as air, surface water, ground water, soil, vegetation, etc. Based on known and approved practices and techniques, sugarcane plantation and processing should be analyzed to define the areas with possible hazardous environmental impacts

- The expected quantities of generated wastes should be determined using international standards and emission rates. Based on the quantified wastes and the affected environment, the appropriate mitigation measures and waste management methods should be recommended to ensure that the construction and operation of the new sugar project is environmentally sound and sustainably
- Clear recommendations should be made with regard to By-products utilization to reduce and minimize the wastes
- Ensure that the project conserves natural habitats especially around protected areas, and
- Ensure that the new project does not cause excessive damage to natural habitat

8.2. Sustainability of Sugar Projects

A new sugarcane estate, cogeneration of electricity, and/ or ethanol production would have local, national, and global benefits. The primary local benefits would be the stimulation of rural economic development through creating jobs, improving livelihoods, and improving social services (such as schools, water supply, and clinics) to the local population. The national benefits include filling the deficits in the domestic sugar demand, reducing sugar imports thereby saving foreign exchange, and the provision of a renewable energy resource that would diversify Kenya's electricity supply system. This section does not to attempt to assess the sustainability of the new sugar projects. However, a number of important elements that should be considered in any future attempts to develop sustainable sugar schemes will be highlighted. A holistic approach should be undertaken to select new project sites.

Sugarcane farming requires more water for irrigation compared to other traditional cash crops such as maize and millet. The rainfall intensity and distribution in most of the potential areas would not allow sugarcane farming to rely solely on rainfall, necessitating abstraction of massive volume of water from rivers to supplement irrigation. The water abstraction for sugarcane irrigation will reduce streams and river flows which could lead to water scarcity particularly for livestock and wildlife. Existing and projected water demands should be estimated prior to granting withdraw of any massive water volumes for sugarcane cultivation and processing.

New sugarcane projects should take into consideration the potential effect of the project on the existing land uses and ecological functions around projects' sites. For instance, some of the proposed potential areas are important dry season lands for pastoralists who converge from different and distant places. Other potential areas are surrounded by important biodiversity conservation and wildlife sites, where wildlife moves seasonally through virtual corridors when food sources or other natural resources are lacking in their core habitat. The dry season grazing areas are an important part of sustainable grazing cycle as they relieve pressure on the wet season grazing areas, which would otherwise be depleted of pasture during the dry season and get subjected to serious environmental degradation. Furthermore, urbanization and developing new projects, especially in the Tana River and the coastal Regions, could split up habitat areas, causing animals to lose both their natural habitat and the ability to move freely between regions to use the resources they need to survive. These issues should be addressed as part of the Environmental Impact Assessment study.

The Kenyan government shall play a positive role in sustainability of the sugar industry. In addition to regulating the sugar industry, the government should promote and support sustainable reform initiatives such as out grower sustainable initiative, sustainable water and land management practices, soil and water conservation practices, etc. At the farm level, the Kenyan government and the sugar industry should work together to develop a system that facilitates the identification of natural resource management priorities, activities to address these priorities, and programs to build the capacity to measure, monitor and report on the outcomes of actions towards these priorities.

The National Environment Management Agency (NEMA) and the Kenya Sugar Board (KSB) should envisage a future where the industry operates sustainably and in harmony with the environment and the community to grow sugarcane and produce raw sugar, refined sugar, renewable energy and a range of value-added renewable products from sugarcane. Various management approaches should be developed and adopted by the sugar industry which includes environmental management, pest and weed management, vegetation management, water management, etc.

8.3. Carbon Credit

8.3.1. International Context - Kyoto Protocol (KP) And The Carbon Markets

The United Nations Framework Convention on Climate Change (UNFCCC), signed in 1992, forms the basis of today's international climate change framework. The Convention's ultimate aim is to reduce greenhouse gases (GHG) emissions to levels that would prevent "dangerous anthropogenic interference with the climate system". In 1997, the Kyoto

Protocol was signed as an instrument to pursue this goal more aggressively by imposing binding emission reduction targets on industrialized countries. During the Protocol's first commitment period, from 2008-2012, industrialized countries (so-called Annex I countries) have committed themselves to reduce their emissions by about 5% below 1990 levels. Developing countries have no binding emissions targets under the Protocol.

One of the Kyoto Protocol's innovative features is the inclusion of flexible mechanisms. These allow industrialized countries to purchase emission reduction credits in other countries where the marginal abatement cost of reducing greenhouse gas emissions is lower. The Clean Development Mechanism (CDM) is one such tool, allowing transactions to take place between developing countries (like Kenya) and Annex-I countries with binding emissions targets. A project that reduces greenhouse gas emissions in a developing country is, if it follows the guidelines and procedures set out by the CDM, eligible to sell Certified Emission Reductions (CERs) to buyers in Annex-I countries. The additional revenue generated by this sale can improve the profitability of such projects and help to introduce technology transfer to developing countries.

The Kyoto Protocol's flexible mechanisms essentially produce a commodity – emission reductions – that can be bought and sold on the global market place. Two events in particular have helped to stimulate emerging carbon markets. The first is the actual entry into force of the Kyoto Protocol, following Russian ratification, in February 2005. The second is the inauguration of the EU Emissions Trading System (ETS) on 1 January 2005. The system covers over 12,000 installations in various industrial sectors, and accounts for about 45% of EU GHG emissions. A crucial factor for the global carbon markets is the Linking Directive, which permits the use of emission credits from CDM projects within the trading system. As a result, many of the future buyers of such credits will be private entities located within the EU ETS.

Kenya currently has relatively low emissions of greenhouse gases and has already introduced a range of low carbon options across many sectors. These include renewable energy in the electricity sector, more efficient use of biomass and sustainable land use management.

In 2005, Kenya ratified the Kyoto protocol, paving the way for the country to engage with developed countries in CDM projects.

8.3.2. THE KENYAN ELECTRICITY SYSTEM AND POWER GENERATION

The Kenyan electricity system has one grid system which serves the entire country. It is in a deficit situation, especially during the dry periods when thermal plants are used to fill power gaps. All generating companies feed their power to this grid which is owned by the Kenya

Power and Lighting Company (KPLC), the sole distribution company. However, not all parts of the county are served by this grid since some are powered by isolated fossil fuel generators owned by KPLC.

The Kenyan electricity system comprises of around 1,155.0MW of installed capacity, with an effective capacity of 1,066.9MW. For example in 2004/2005, Kenya Power and Lighting Company purchased 5,347.7 GWh from power producers, and out of this 53.6% was from hydro sources, 25.1% from petro- thermal sources, 19.4% was from geo-thermal sources, 0.01% was from wind sources and 1.9% was imported. The proportion of the fossil fuel based thermal component increases substantially during dry seasons and it is this portion that will be significantly replaced because cogeneration electricity is available during the dry season while the mills normally shut down during the rainy season, when hydroelectricity happens to be readily available.

Besides, the feature of electricity generation from bagasse during the dry months when the hydroelectricity (the most important type of electricity in Kenya) is stressed provides complementary energy and makes the bagasse cogeneration electricity attractive to the whole country, in general, and to the potential purchasers in particular.

Currently, all the sugar companies in Kenya use low pressure (21 bars maximum) cogeneration technology except Mumias Sugar Company Limited that uses a high pressure boiler (89bar) with main objective of satisfying the ever increasing demand for electricity in Kenya with a clean alternative to the more fossil-fuel based electricity component of the Kenyan national grid. This proposed Clean Development Mechanism (CDM) project, (35 MW Bagasse-Based Cogeneration Project by Mumias Sugar Company Limited), is a power capacity expansion project involving the generation of electricity using sugarcane bagasse on site. The project will export to the national grid 25 MW as green energy.

The bagasse cogeneration projects are a stable, renewable and local supply of electricity that should permit displacement of carbon-intensive power generation and/or expansion which is not only adversely affecting the environmental but also expensive and slows down overall economic growth in Kenya. The energy sources for the country would be more diversified and secured by the domestic energy supply.

In addition, bagasse cogeneration project will save the country significant foreign exchange that would have been used for the importation of fossil fuels for the thermal plants which are used to address marginal power shortfalls. The savings can then be channeled to other economic activities leading to economic growth of the country. These projects will make positive contribution to the country's implementation of its energy strategy which aims to reduce energy from thermal sources and increase energy from renewable areas.

These carbon credit projects will provide sustainable benefits through the diversification of revenue streams where the farmer will not only be producing sugarcane for sugar production and get sucrose content compensation, but also electricity and CERs which will be able to attract a fiber content compensation for the farmer.

The environmental benefits not only include GHG emission reductions, but also reduced steam generation with higher efficiency resulting in twice the amount of power generated. The project design will also eliminate the occasional release of ash and related-carbon particles into water streams. The elimination of particulate matter in the boiler exhaust, which will be fitted with an electrostatic precipitator under the project, will result in improved air quality in the area.

These projects will play an important role the country's economic development, as more power will be available for use to offset the deficit of power supply. The provision of renewable electricity is a major factor contributing to sustainable development. Rural electrification which would result from these projects would have far reaching impacts on livelihoods in the rural communities where the factories are located and where more jobs would be created.

8.3.3. POTENTIALS FOR CARBON CREDITS

The utilization of bagasse in cogeneration is one of the main sources of revenue generation in sugar industry. The amount of bagasse generated is calculated from the cane equation:

Cane + Water = Mixed Juice + Bagasse

As about 37% of the crushed cane is bagasse, it is quite obvious the huge amount of biomass that could be used for green power generation. The total carbon credit potential from the existing 11 factories plus the factories to be developed in the potential areas is quite significant, for example, displacing grid electricity with GHG-neutral biomass (bagasse) electricity generation. This component of the project activity is expected to achieve GHG emission reductions of 1245652 t CO_{2e} over the 10 year period (2008-2018). Methane abatement through avoiding dumping of bagasse and using it to generate electricity which is expected to achieve GHG emission reductions of 50,262 tons of Co_2 over 10 year period. The overall GHG emission reductions expected from the project is therefore 1,295,914 tons of Co_2 over the period (2008-2018). (Source: Project Design Document Form (CDM PDD) - Version 13, 28th January 13. UNFCCC, CDM – Executive Board).

8.3.4. INDUSTRIAL OPTIONS

A technology upgrade in the currently proposed cogeneration system would be by far the largest source of carbon credits (accounting for about 2/3 emission reductions by industrial options). The new system would be based on the introduction of a high-pressure boiler, an increased supply of biomass fuel through the utilization of additional biomass waste, and improved energy efficiency in the sugar production process. The implementation of this improved system would generate enough energy to meet not only the plant's requirements, but also to sell a significant amount of clean electricity to the grid.

The net financial result of this option would therefore be an additional annual income, 90% of which would come from direct electricity sales and 10% of which would be generated by the sale of carbon credits.

Other proposed industrial options include:

- Ethanol production by adding a distillery to the factory in order to process molasses. This addition, which was not envisaged in the original project design, has almost become the industrial standard in leading sugarcane producing countries like Brazil. The processing of ethanol would allow the use of residual steam in the sugar production process, thereby reducing energy costs
- Charcoal production through the conversion of wood products from additional afforestation, using modern kiln technology that eliminates GHG emissions. The use of biomass charcoal would also alleviate pressure on natural dry forests which are currently harvested unsustainably by traditional charcoal producers
- On-site lime production, which would substitute for lime currently imported from abroad. Production would be based on local calcareous rocks that would be calcined with on-site produced charcoal.
- Other technological options that could be implemented at a later stage such as production of biogas by vinasse bio-digestion which would be a complementary activity to the distillery, while bi-carbonate production would eventually be the beginning of biomass-based chemical products

8.3.5. AGRICULTURAL OPTIONS

Three of these options are strongly linked to the proposed cogeneration system:

- Elimination of sugarcane burning would be necessary to produce biomass fuel additional to bagasse
  a) Increased soil carbon storage would be one of the co-benefits of the elimination of cane burning and a reduction in mechanical operations. The resulting carbon credits

are currently not eligible under the CDM, but could be sold on voluntary carbon markets at a discounted price

b) Afforestation and windbreakers would result in water savings by reducing evapotranspiration, thereby lowering energy demand from pumping stations. The other two options have specific features

- Fertilizer savings represent a win-win low-cost proposition that reduces operational costs while at the same time generating carbon credits. It is therefore recommended to incorporate this option into the project design.
- Fuel switching from conventional to high energy crops seed bio-diesel would be an interesting combination of industrial and agricultural options.

8.3.6. Mechanisms under the Kyoto Protocol

Countries with commitments under the Kyoto Protocol to limit or reduce greenhouse gas emissions must meet their targets primarily through national measures. As an additional means of meeting these targets, the Kyoto Protocol introduced three market-based mechanisms, thereby creating what is now known as the “carbon market.”

The Kyoto mechanisms are:

- Emissions Trading
- The Clean Development Mechanism (CDM)
- Joint Implementation (JI)

The Kyoto mechanisms:

- Stimulate sustainable development through technology transfer and investment
- Help countries with Kyoto commitments to meet their targets by reducing emissions or removing carbon from the atmosphere in other countries in a cost-effective way
- Encourage the private sector and developing countries to contribute to emission reduction efforts

JI and CDM are the two project-based mechanisms which feed the carbon market. JI enables industrialized countries to carry out joint implementation projects with other developed countries, while the CDM involves investment in sustainable development projects that reduce emissions in developing countries.

8.3.6.1. Types of Carbon Credits

Essentially, carbon credits can be split into two forms: those within the voluntary market and those within the compliance market. Each type of carbon credit adheres to a particular standard or certification.

1. Compliance Carbon Credits

a) Certified Emission Reduction (CER) units

The most common type of compliance credit is a CER (Certified Emission Reduction unit) which originates from projects in developing counties. Certification and overall approval of these abatement projects and their credits is known as the Clean Development Mechanism (CDM).

b) Emission Reduction Unit (ERU)

Like CER in developing nations, within developed nations, a mechanism known as Joint Implementation or JI, produces compliance credits referred to as Emission Reduction Units or ERUs.

c) New South Wales Greenhouse Gas Abatement Certificate (NGAC)

The New South Wales Greenhouse Abatement Certificate (NGAC) certification process is comprehensive. It includes Kyoto Protocol measures, but goes beyond these.

2. Voluntary Carbon Credits

The credit types below are just a sample of the most commonly used products in Australia and globally. Many more types exist overseas.

a) Voluntary Carbon Unit (VCU) or Voluntary Carbon Standard (VCS) credit

The VCS Programme provides a robust, global standard for approval of credible voluntary carbon credits. VCS credits or Voluntary Carbon Units (VCU) must be real, the abatement must have occurred, they must be additional by going beyond business-as-usual activities, be measurable, permanent, and not temporarily displace emissions. The findings need to be independently verified and unique so they cannot be used more than once to offset emissions. The VCS is the most widely known and chosen standard in the voluntary market due to its Kyoto compatibility as well as its ability to manage a wide range of project types and methodologies.

b) Verified (or Voluntary) Emissions Reduction (VER) and Gold Standard VER

The most popular type of carbon credit used to offset emissions around the world voluntarily is a VER, a Verified or Voluntary Emission Reduction unit and there are many different types. Before CDM or JI projects deliver credits used for Compliance purposes such as CERs and ERUs they can produce VERs. These credits can be verified to a number of specific standards, including the Gold Standard. Not all projects go on to register within the CDM or JI, often due to the size of the project and the inhibitive costs associated with compliance registration, so their choice of one or more of these voluntary standards is made based on its overall viability and compatibility to them.

c) Renewable Energy Certificate (REC)

A REC is not a carbon credit that represents one ton of CO_2e emissions but rather a unit that relates to how much CO_2e is saved by the adoption of renewable energy and how efficiently one megawatt hour (MWh) of electricity can be produced. This can vary from as little as 500 kilos of Co_2e, to as much as almost two tons from older, less efficient power stations. Like carbon credits, in an attempt to phase out and replace traditional, emission intensive activities, RECs provide financial subsidies for the power sector to help renewable energy projects become more viable around the world.

New technology and innovations to existing technology are rapidly being realized in areas such as; solar Photo Voltaic (PV) cells, wind farms, subterranean geothermal power plants, wave collection technology, hydroelectric, tidal power, renewable biomass and more. Depending on their location, these projects can produce RECs but as they also displace CO_2e they can often be a more viable project if a choice was made in favor of producing carbon credits instead, for example VCUs, VERs or CERs.

8.4. Climate Change

Climate change is not only an environmental problem, it is also clearly a development problem since its adverse effects will disproportionately affect poorer countries with economies predominantly based on natural resources and related economic sectors such as agriculture, forestry and fisheries. An analysis of the trends in temperature, rainfall, water levels in lakes and extreme events points to clear evidence of climate change in Kenya. Studies indicate that temperatures have generally risen throughout the country, primarily near large water bodies (King'uyu et al 2000, GOK 2010). Other projections also indicate increases in mean annual temperature of 1 to 3.5° C by the 2050's (SEI 2009). The country's arid and semi-arid lands (ASAL's) have also witnessed a reduction in extreme cold temperature occurrences (Kilavi 2008). All these have combined and resulted to severe droughts, flooding and other natural hazards. Livestock dynamics in the arid and semi-arid lands (ASAL's) of Kenya have been widely researched (McCabe 1987). Droughts particularly hit the ASAL's hard because they reduce the availability of forage, increase disease incidences and lead to a breakdown of marketing infrastructure.

Wild fires as a result of drought and high temperature are a common occurrence in the northern districts. They have thus played a big role in environmental degradation rendering the area even more vulnerable to drought as the vegetation is depleted.

Overstocking is leading to reduced grass cover exposing the soil to agents of erosion.

Reducing water levels in lakes and rivers and diminishing of wetlands can be traced from climate change.

8.4.1. Opportunities of Climate Change

Kenya is endowed with diverse and abundant climatic resources which include solar insolation, sunshine, wind, rainfall and air. These resources which provide life-supporting goods and services are however not evenly distributed throughout the country with some regions being better endowed with more of a particular resource than others. Solar insolation provides natural light and energy while sunshine and wind can be used to generate electricity.

The ASALs regions, which constitute 80 percent of the country's land mass, experience long periods of sunshine which typically amount to over 7 hours a day. They therefore have enormous potential for solar energy generation with the highest potential being in north western Kenya in Lodwar. High speed winds are generally common in northern Kenya (around Marsabit), the coastal zone, Maralal, Keiyo, Eldoret and Ngong Hills with these areas being ideal for wind power generation.

Floods associated with excessive rainfall can be harvested in dams and used during the dry seasons. The waters can also be used in hydro power generation

Conservation agriculture Conservation agriculture is one of the approaches that are envisaged to climate-proof agriculture. Given the significant role that agriculture plays in the country's economy, in Kenyans' livelihoods and in the attainment of Vision 2030, conservation agriculture is an important climate change adaptation method. It involves minimizing soil disturbance (no-till), ensuring permanent soil cover (mulch) and using a blend of crop rotation or inter-cropping (FAO 2006). The synergy of these factors leads to improved agricultural productivity and food security, increased incomes and enhanced carbon sequestration. The government, with the support of the COMESA Secretariat, has concluded the design of an Investment Framework for up-scaling conservation agriculture. The framework is anchored on both the NCCRS and the Agricultural Sector Development

Strategy. Clean energy Clean and renewable energy sources, such as wind and solar, can power small-scale rural industries and hence improve livelihoods. Harnessing them can also help to reduce reliance on hydroelectric power whose generation is particularly prone to climate change stressors.

Chapter 9 Baseline Study Recomme-ndations

9.1. RECOMMENDATIONS HIGHLIGHTS

In the Vision 2030, Kenya aims at building an agricultural sector that is innovative, business oriented and modern by increasing productivity in the sector and expanding irrigation in arid and semi-arid lands. The sugarcane industry accounts for about 15% of agricultural GDP. The existing sugar industry is located in the Western Kenya areas of Nyando, Migori, Rongo, Mumias and Busia where climate allows for rain-fed cultivation of the crop.

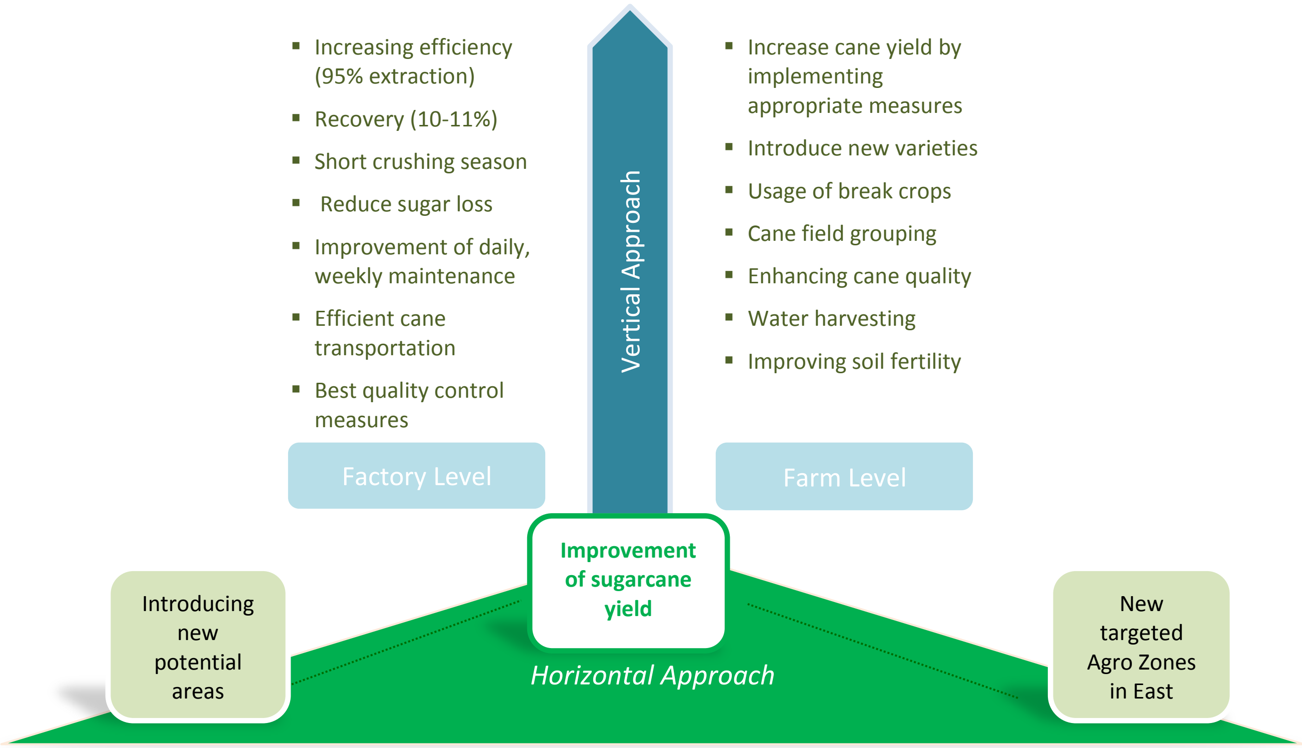
Consistent with the Vision 2030 and the sugar industry strategic objectives (2010-2014), the study recommended sugar production expansion in the Coast, Rift Valley, and Tana River regions where irrigation is possible to achieve self-sufficiency in sugar and to export the surplus to the regional market. The study also recommended preliminary areas suitable for sugar beet, which need further assessment. There is also room for expansion in the Western belt. However, the sugar industry faces a number of challenges including, among others, capacity underutilization, poor transport infrastructure, and weak corporate governance. Additionally, the cost of sugar production in Kenya is more than double the cost in neighboring sugar producers. The sugar industry needs to focus on rehabilitating its existing facilities, enhancing production, reducing the production costs, and considering privatization of government owned sugar factories. A number of measures have been recommended to tackle these challenges and until the full implementation of these measures, Kenya is strongly advised to focus on closing the gap in its local sugar production as the COMESA and EAC countries produce sugar at a much more competitive price than Kenya.

The baseline study provided a recipe and road map to guide the GOK generally, and the KSB specifically to address these challenges and to reduce the production costs to enhance the industry's competitiveness. The study findings and recommendations are summarized below:

9.2. Business Strategy

1. **Introducing vertical expansion approach** by focusing on the existing sugar industry and improving the farm and mill level operations as shown on the flow chart below.

2. **Introducing horizontal expansion approach** by introducing sugarcane in new areas in Kenya as shown on the flow chart below.



3. **Use of By-Products:** Sugar is still the core commodity produced from sugarcane in Kenya. Diversification to other by-products such as power co-generation, ethanol production, animal feed production, etc, as revenue sources is still very limited and largely unexploited. Using the valuable by-products of the industry namely bagasse and molasses, the Kenya sugar industry will add considerable economic value.

a. ***Power Generation:*** Generating electricity from bagasse enables sugar factories to cover most of their requirements and generate revenues by selling surplus power to the National Grid system. Additional revenue could be generated through the carbon credit window by selling certified emission reduction (CERs).
b. ***Animal Feed Production:*** Blending molasses and bagasse together with other ingredients to produce highly desirable animal feed for the animal production sector will create much needed synergy amongst the various economic sectors in Kenya.
c. ***Ethanol Production:*** Using molasses, one of the prime byproducts of sugar processing the sugar sector can produce Ethanol to be used as fuel for vehicles. Ethanol is now gaining ground when blended with benzene worldwide for use without modifications to engines. Flexi-cars that use both types of fuels are now being produced in many countries.

Fertilizers Production: Industries should start using filter mud as a biological fertilizer for sugarcane cultivation. This would allow factories and out growers to save more than 1,000 tons of chemical fertilizer annually, with substantial cost savings.

d. ***Vinasse***: (ethanol production byproduct), could also be used, after treatment, as biological fertilizers with additional savings on the use of other chemical fertilizers.

4. Strengthening Policy and Legal Framework

a) Support emergence of Ethanol Industry through
   - Passing of the Ethanol Bill enable the use of ethanol as a fuel in blend of a minimum of 10% with benzene
   - Grant tax concessions to the emerging industry at the introductory stage
   - Encourage importation of Flexi-engine cars through custom concessions and reduced registration fees with an objective to increase the share of flexi-engine cars in the domestic market to 50% by 2015

b) Develop a comprehensive policy on co-generations and exploitation
c) Enforcement of existing policies (establishing a monitoring body within KSB)
d) Improve management of sugar import policy

9.3. INVESTMENT MAP FOR POTENTIAL SUGAR INDUSTRY

Based on water availability, topography, and climatic conditions, soil and land suitability the potential sugarcane and sugar beet areas in Kenya are shown in Figure 9-1 and Figure 9-2, respectively. Detailed feasibility studies will be required for each of the recommended potential area.

Table 9-1 shows the potential areas, maximum areas that could be utilized as a corporate farm, sugarcane water demand and expected white sugar production.

Table 9-1: Potential areas for sugarcane production and expected sugar production

Potential area	Agro Zone	Water Demand M3 /ha/annum	Maximum area (corporate farm) ha	Yield (T/H)	White Sugar Production (tons)
Tana Lower	Tana	20,000	15,000	90	135,000
Coastal (supplement irrigation)	Athi	7,700	5,000	90	45,000
Coast (rain fed)	Athi		50,000	70	400,000
Turkwel	Rift Valley	28,600	6500	90	58,500
Tot	Rift Valley		5000	90	45,000

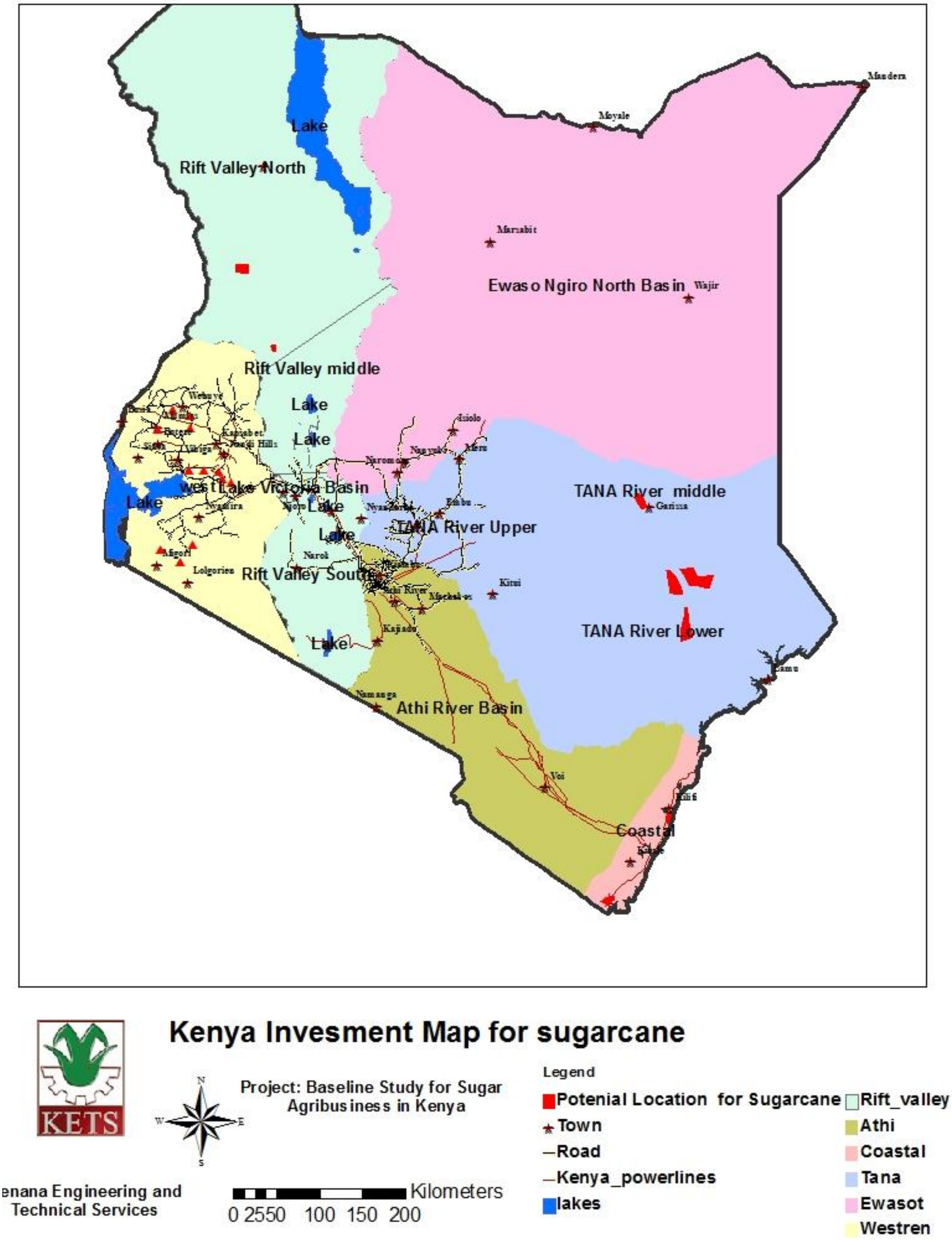


Figure 9-1: Investment map for potential sugarcane in Kenya

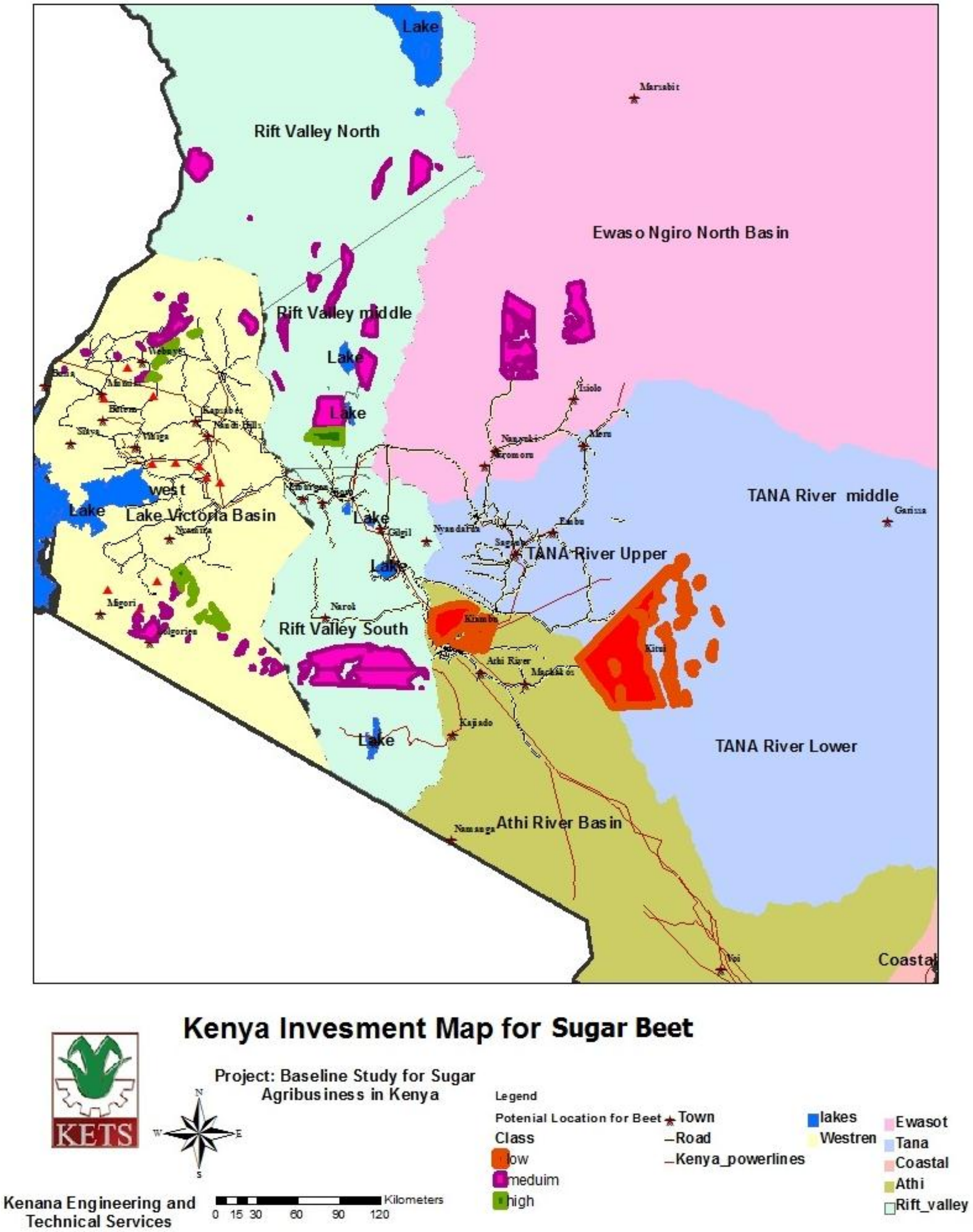


Figure 9-2: Investment map for potential sugar beet in Kenya

10. BIBLIOGRAPHY

ADB; OECD; UNEC; UNDP. *Kenya African Economic Outlook.* Paris: African Economic Outlook, 2012.

Alan, G. et al. *Soybeans in the Sugarcane Cropping System.* BSES LTD and QDPI & F, Australia , 2005/06.

Analysis for incentives and disincentives for sugar in Kenya , Monitoring African Food and Agricultural Policies . FAO, July 2013.

Cappon. 1986.

COMESA Secretariat. *Common Market For Eastern and Southern Africa.* n.d. http://www.Comesa.int/ (accessed October 29, 2013).

East African Community Portal . *East African Community.* 2013. http://www.eac.int/index.php (accessed October 30, 2013).

FAO; OECD; USAID. *Analysis of Incentives and Disincentives for Sugar in Kenya.* MAFAP-SPAAA, 2013.

Gitau, Raphael, Samuel Muburu, and Mary K Mathenge. *Trade and Agricultural competitiveness for growth , food security and poverty reduction , A case of wheat and rice production;.* Tegemeo.org, n.d.

JICA. *WRMA Progress Report no. 4.* 2012.

Kenya Sugar Board. "Kenya Cost Study." 2012.

KSB. "The Kenya Sugar Industry Value Chain Analysis: Analysis of the Production and Marketing Costs for Sugarcane and Sugar Related Products." Nairobi, 2010.

OECD-FAO Agriculture outlook (2012-2020). OECD, 2012.

Olala, Monica, Vincent Gihinji, and Wesley Maritim. *Feed Milling Industry: The Missing Data.* Nairobi: Ministry of Livestock, 2009.

Papadakis. 1966.

Staff, FAS/Nairobi. *Kenya Sugar Annual Report.* Nairobi: USDA Gain Report, 2012.

"Staple food prices in Kenya ." *Joshua Ariga , T.S Jayne and Stephen Njukia* , January 2010 .

UNEP. *Securing Water and Land in the Rana Basin, a resource book for water managers and practitioners.* 2012.

United States Department of Agriculture (USDA). "Kenya Sugar Annual Kenya Sugar Annual Report." 2012.

USDA GAIN Report. "Kenya Sugar Annual Report." Nairobi, 2012.

VAS Consultants. *Study on National Sugar Supply and Demand for the Period 2010-2014.* Nairobo: Kenya Sugar Board, 2012.

VAS Consultants, Ltd. *Study on National Sugar Supply and Demand for the Period 2010-2014.* Kenya Sugar Board, 2012.

World Bank Group. *The Workd Bank: Working for a World Free of Poverty Kenya's Power Shortage Problem Meets Innovative Finance.* April 5th, 2012. http://www.worldbank.org/ (accessed October 30, 2013).

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