REPUBLIC OF KENYA

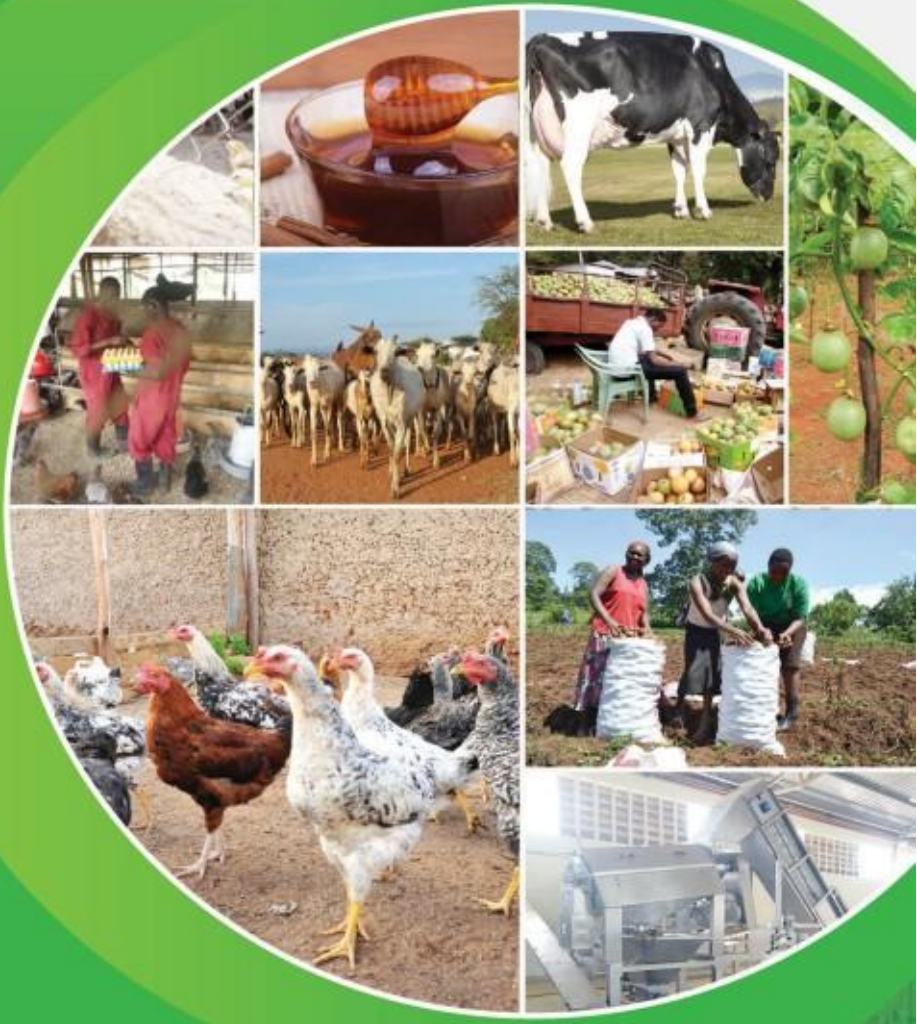
MINISTRY OF AGRICULTURE, LIVESTOCK, FISHERIES AND COOPERATIVES
AND
COUNTY GOVERNMENTS

ASDSP
AGRICULTURAL SECTOR DEVELOPMENT SUPPORT PROGRAMME

AGRICULTURAL SECTOR DEVELOPMENT SUPPORT PROGRAMME II (ASDSP II)

NAROK COUNTY PRIORITY VALUE CHAIN SUITABILITY ATLAS

January 2020



"Transforming Kenya Agriculture Sector"

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"Transforming Kenya Agriculture Sector"

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Agricultural Sector Development Support Programme II (ASDSP II)
Ministry of Agriculture, Livestock, Fisheries & Cooperatives
Along Ngong Road, Community Area, Hill Plaza building, 6th Floor
P. O. Box 30028 - 00100 Nairobi
E-mail: www.asdsp.kilimo.go.ke

Editors: Dr Paul S. Orina

Authors: Shem Okora, Benson Githua, James Wamae, Erastus Mutuku

Disclaimer/Cautionary Note (SP)

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ABBREVIATIONS

AHP	Analytical Hierarchical Process
ASDS	Agriculture Sector Development Strategy
ASDSP II	Agriculture Sector Development Support Programme Phase 2
CI	Consistency Index
CIDP	County Integrated Development Plan
CR	Consistency ratio
DEM	Digital Elevation Model
ESP	Economic Stimulus Program
ILWIS	Integrated Land and Water Information System
IPM	Integrated Pest Management
KCC	Kenya Co-operative Creameries
KES	Kenya Shillings
KFA	Kenya Farmers Association
KMS	Kenya Meteorological Services
KNBS	Kenya National Bureau of Statistics
KSS	Kenya Soil Survey
MLND	Maize Lethal Necrosis Disease (
NRM	Natural Resource Management
PVCs	Priority Value Chains
QGIS	Quantum Geographic Information System
RCMRD	Regional Centre for Mapping of Resources for Development
RCI	Random Consistency Index
SAGA	Systems for Automated Geo-Scientific Analysis
THI	Total Heat Index
VC	Value Chain
VCAs	Value Chain Actors

FOREWORD

Agricultural sector growth and development is crucial to Kenya's overall economic and social development. In particular, agriculture significantly contributes to the county economy; ensures the county is food secure; generates incomes and provides employment both directly and indirectly for the population. Sustained agricultural growth is therefore critical to uplifting the standards of living of our people. The county however faces a number of challenges that need to be overcome for this growth to occur. These challenges include high levels of poverty, food insecurity and the negative effects of climate change.

Kenya's development blue print, Vision 2030 recognizes the agricultural sector as one of the vehicles that will aid the achievements of the targets. The sector's Agricultural Sector Transformation and Growth Strategy (2019 - 2029) focuses on increasing the income of 3.3 million small scale households; significantly improving sector contribution to the national GDP through enhancement of land productivity and agro-processing to improve agricultural outputs and value addition and boosting household food resilience against environmental and fiscal shocks through cost reduction of nutritious foods and well-targeted support in terms of subsidies and social protection. The county government of Narok in collaboration with other development partners and specifically with initial support from the government of Sweden has brought the realization of this goal a step closer through the Agricultural Sector Development Support Programme (ASDSP II) that is being implemented at both the national and county governments' levels.

In order to make informed decision on priority value chains (Maize, Beef and cow milk) for the county, it was necessary to establish the scientific generated resource and suitability maps. It is my strong believe that value chain actors and stakeholders will use this information in addressing the challenges that the sector faces in food security, productivity and natural resource management. The development of these maps was therefore timely and critical for this county as the basis for planning and setting priorities of adaptation intervention in the sector.

The exercise integrated biophysical (climatic and soil factors), economic (population, road network and market outlets), social (agrarian characteristics) and political (framework conditions) parameters to classy the county into regions that are highly and moderately suitable. The moderately suitable areas require attention by both levels of governments and stakeholders in order to address constraints that affect productivity of the priority value chains. The adaptations, innovations and technologies proposed to improve value chain performance, require resources that require multi sectoral and multi-disciplinary approach to address.

I wish to encourage all stakeholders to not only study the reports but also utilize the data and information for evaluating their activities and improving their implementation profiles to achieve realistic goals. As a department, we are committed to use the findings to inform the process of county domestication of policies and guide current and future programs actions that will lead to realization of food and nutrition secure and wealthy households.

Dr. David Ole Letuati
Chief Officer Department of Agriculture
County Government of Narok

ACKNOWLEDGMENT

The ASDSP II is implemented at national and county level in the 47 counties through the National Programme Secretariat (NPS) and the County Program Secretariat (CPS). The purpose of the nationwide resource mapping was to provide information to be used in making key decisions in intervening to improve value chain productivity as guided by the suitability maps. The intensive and highly technical resource map development exercise at the county was undertaken from June 2019 by the technical multi-disciplinary teams who concluded the exercise in January 2020 across the 47 counties in the country. The specific objectives of the surveys were to identify the suitability levels of the ASDSP II value chains and develop adaptation methods innovations and technologies which best fit a particular value chain The joint exercise between the County, NPS and the service provider was to enable the counties to own the suitability maps, understand the base maps and be able to interpret the parameters used so as to define innovations and technologies for use in the value chain moving towards commercialization

Further, the value chain resource maps are intended to avail data to be shared with other stakeholders to guide them in planning and making key decisions. The survey considered the three priority value chains namely maize, beef and cow milk, being implemented by the programme. The exercise involved value chain actors and organizations.

I take this opportunity to extend special recognition and appreciation to the following, whose contribution led to the success of this exercise: members of NPS, VCO (respondents), CPS, value chain chairpersons.

Vincent Ireri Kinyua
Narok County Programme Coordinator
Agricultural Sector Development Support Programme II (ASDSPII)

EXECUTIVE SUMMARY

The value chain resource/suitability maps development is an important exercise that has generated scientific data and information for the priority value chains for Narok County. The results of the maps have showed the suitability of each value chain. Considering the biophysical parameters (temperature, rainfall, soil and slope) economic factors (population, roads coverage and access to the market) social and political factors on the Narok county priority value chain being implemented by Agriculture Sector Development Support Programme (ASDSP) II different maps have been developed.

The analysis of biophysical, economic and social characteristics of Narok show that the county is generally highly suitable for the commercialization of beef, moderately suitable for maize and marginally suitable for cow milk value chains. Narok County offers a good opportunity for the improvement of value chain performance. Most of Transmara West sub county and central areas of Narok South are highly suitable for maize value chain, while the midlands are marginally suitable. All the midland areas of the county around Ewaso Nyiro, Narok Town, Ntulele, Suswa, Mulot, Lolgorian and Loita are suitable for beef value chain. However, interventions such as rangeland pasture and water resources must be improved. In lowland areas such as Mosiro, Narosura, Maji Moto, rotational grazing must be practiced to avoid overgrazing of these rangelands. The areas around the Mau such as Sogoo, Kisiriri, Nairegie Enkare and northern areas of Transmara West are highly suitable for dairy production while the midland areas such as Ololunga, Mulot, Emurua Dikirr, Ogwedhi are marginally suitable.

Adaptation measures, the use of innovations and technologies have been suggested to improve or make the value chains more suitable as follows ;- modification of temperature through Agroforestry and improved range management practices, establishment of beef cattle collection centres, improvement of dairy cow shelter , improvement of maize storage, soil erosion control, improving grazing management, adhering to the right livestock carrying capacities, water harvesting, feed lot improvement, capacity building efforts on entrepreneurial skills and commercialization of the enterprises, market structure improvement, improvement of market access through better road conditions, strengthening linkages of market players, provision of timely market information, passing legislations that safeguard and attract investments in the value chains, agroforestry, rain water harvesting, development of water infrastructure, planting cover crops and contour farming are some of the adaptation recommendations aimed at improving the performance of the three value chains.

The use of **innovations** that improve value chain performance have also outlined in the report. They include agroforestry, use of solar powered coolers, use of refrigerated tracks to transport meat and milk, terracing , use of contour bands, use of cut off drains, supplementary feeding, paddocking, ranching, breed improvement, value addition, beef animal auction campaigns, expansion of market segments, establishment of livestock collection centres, contractual agreement, establishment of market info sharing platforms, use of shade nets, run-off water harvesting, roof catchment , value addition, solar drying, the use of improved varieties, and formulation of suitable policies have been suggested as key innovations that will result into improved performance of the value chains. The use of innovation is strongly backed by technology in order to make the innovations more successful. The report has identified some key technologies, which include the rehabilitation of degraded areas with indigenous and other improved fodder tree/grass varieties. The others are: - the use of cold chain storage system, the use of suitable package information, the use of trapezoidal bunds, negarims, terracing, contour bunds, the sinking of boreholes/wells, strip fodder and forage production, the use of gabions, dams and feed formulation/processing, branding, mass media advertisements, the use of e-apps and information sharing through the county website, soil testing, shed nets and mulching.

The suitability analysis reveals that the priority food value chains of maize, beef and cow milk vary from marginal to highly suitable in Narok County. The maps and the statistical analysis of ranking and weighting provided factual understanding for decision-making. This model is very important in physical planning, particularly in preparing spatial development plans, zoning of production areas and integrating agriculture in the urban form to improve economic competitiveness, food and nutrition security and sustainable development.

Key recommendations arising from this report are as follows:- Integrated and multi sector approach to improve on the beef suitability; Biophysical factors to improve on micro climatic conditions; Use of adaptation methods; Innovations and technologies to sustain or improve the value chain performance; and Agriculture related Policies, plans strategies and regulations to attract investment in the sector.

1. INTRODUCTION

1.1 National Agricultural development landscape

Agricultural development in Kenya was founded on large-scale production as advanced by white colonial settlers in the early 1900s. The development concentrated in the central and rift valley highlands which were found to be ***most suitable*** for the production of wheat, coffee, tea and dairy. During this period, structures were put in place by the colonial government and the settler farmers to support commercial production and marketing of agricultural commodities. These structures included input services and output market organizations such as the Veterinary Research Laboratories in 1910, the Kenya Farmers Association (KFA) in 1923 and the Kenya Co-operative Creameries (KCC) in 1925.

Between 1900 and 1950, the colonial administration established various Ordinances aimed at controlling ***land use*** in the country. The ordinances restricted Africans to ***rural areas*** and also from occupying land that belonged to ***other tribes***. The dual restrictive policy was marked by alienation and overcrowding of Africans in villages leading to agitation and struggle for better living conditions. In the late 1940s, due to escalation of the land use crisis and dwindling economic returns from native agricultural practices, a restructuring of African agriculture by the colonial government was made. This was aimed to support existing colonial production of food and raw materials for exports.

The most radical and comprehensive intervention during this period was the £5 million twenty year Swynnerton agricultural development plan that commenced in April 1954. The main thrust of this plan was to increase household incomes through radical changes in land tenure system mainly in central Kenya. Small parcels of land were consolidated into at least 10 acre units per family. These units were registered and developed to improve productivity and household earnings from agriculture that averaged £10 to £100 in cash sales per year. This action resulted in a dramatic rise in the value of recorded output from the small-holdings from £5.2 million in 1955 to £14 million in 1964 with coffee accounting for 55 percent of the increase. The impact of this policy action resulted in significant decrease in the proportion of small holders living below poverty from over 60% in 1953 to less than 18% in 1974 in Central Kenya. This reduction was significant when compared to near zero poverty reduction levels witnessed in other parts of the country that were not covered by the plan. The major failure of the Plan was the neglect and marginalization of other areas of the country which led to imbalances in development between different regions.

After Kenya attained her independence, the agricultural industry concentrated support on smallholder farming with the goal of attaining food self-sufficiency and rural development. The policy actions at this time saw the former large-scale farms in the highlands subdivided and sold to smallholder farmers. Subdivision of large scale farms into small scale systems compromised the commercial viability of most agricultural enterprises in the productive areas of Rift Valley and Central Kenya. Small scale agricultural production reduced productivity fourfold.

Another policy shift that had far reaching implications to agricultural development was the Sessional paper No. 10 of 1965 on African socialism and its application to planning in Kenya. This policy ensured that the country's wealth would remain in the productive areas, which included the former white highlands and those covered by early registration under the Swynnerton Plan. It stressed that to make the economy grow as fast as possible, development funds would be invested where it would yield the largest increase in net output. This approach clearly favoured the development of areas endowed with natural resources, good land and rainfall, transport and power facilities while areas without such facilities were neglected (Kenya, 1965).

The Sessional paper No. 1 of 1986 on Economic Management for Renewed Growth re-emphasized the place of agriculture as the leading sector in stimulating growth and job creation in the country. This sessional paper prompted the profound structural adjustment process ever initiated by the Kenya government. A key element of this policy development was the liberalization of the production and marketing of important agricultural commodities like maize.

Other efforts geared at improving agricultural production by national government aligned to land use planning before the advent of devolution included provision of targeted extension services including the Training and Visits Extension Program, The Catchment Approach to Soil Conservation and the focal area approach of the National Agriculture and Livestock Extension Program (2000). The Economic Stimulus Program (ESP) of 2009/2010 was another national government initiative that committed financial support aimed at jumpstarting the Kenyan economy towards long term growth and development. Priority areas in agriculture were skewed towards construction of horticultural markets and promotion of small holder inland aquaculture. Government interventions and programs in agricultural sector during the intervening period between 1963 to 2013 were not informed by any spatial plans that linked the resource base to agricultural development.

Following the promulgation of Kenya Constitution 2010, the country transited into a devolved government system in 2013 with agriculture becoming a devolved county function. The Kenya 2010 Constitution ushered a new planning system with the national and county governments tasked to develop national and county specific spatial maps to support zoning and designation of areas for production of scheduled agricultural commodities. The Kenya National Spatial Plan 2015-2045: An integrated Spatial Plan for Balanced and Sustainable National Development, was developed within this constitutional framework and has laid the foundation on which Article 66, on the regulation of land uses, Article 68, on maximum and minimum land holding sizes and Article 69 on environment management will be achieved. The Kenya Crops ACT 2013 designates the Cabinet Secretary in charge of Agriculture with the advice of the Agricultural and Food Authority with the responsibility of developing rules for identifying and zoning agricultural land suitable for the production of the scheduled crops. The Crops ACT 2013 however allows individual land owners to have a final say on the actual land use practice to implement.

The development of suitability maps to inform competitive land use practices aligned to promotion of priority value chains in the 47 counties of Kenya therefore builds on the demands for spatial planning and regulation of land uses by examining the suitability of the Kenyan land resource in supporting some 29 priority value chains (PVC). The maps offer an interim evaluation of and demonstrate to some extent the underlying reasons behind the decline in agricultural productivity based on the potentialities that exist to support commercialization of some 29 priority value chains. The value chain suitability maps provided here are aligned to each of the 29 value chain commodities promoted under the Agriculture Sector Development Support Program (ASDSPII), a five year program (2018-2022) of the Ministry of Agriculture, Livestock, Fisheries and Cooperatives with funding support from the national and county governments, The Swedish government and the European Union. For Embu County, these priority value chains are cow milk, banana and indigenous chicken.

1.2 Agricultural resources

The Kenyan agricultural development is mainly land and climate depended. The constitution of Kenya 2010 under Article 260 defines land broadly to mean the surface of the earth and the subsurface rock; any body of water on or under the surface; marine waters in the territorial sea and exclusive economic zone; natural resources completely contained on or under the surface; and the air space above the surface. The constitution under Article 60 calls for efficient, productive and sustainable use of land. Kenya is a diverse country with rainfall and temperature endowments that support a wide scope of crop, livestock and aquaculture systems. The country receives between 250mm to over 2000 mm of rainfall (**Error! Reference source not found.**) with temperature ranges as low as 4.6° C and highs of over 34° C (**Error! Reference source not found.**).

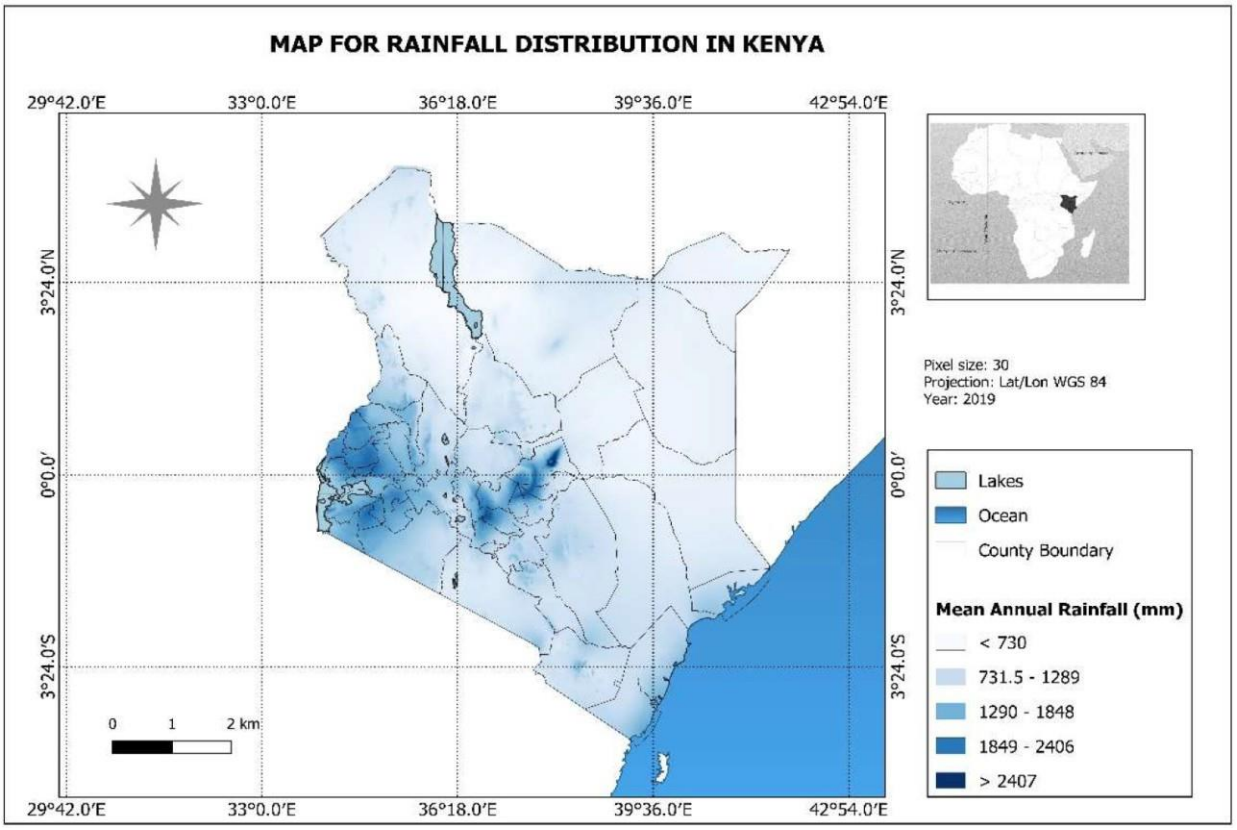

Figure 1: *Kenya Rainfall distribution*

The demand and distribution of agricultural produce within the country is affected by population density (**Error! Reference source not found.**) and infrastructure development (**Error! Reference source not found.**) since these attributes are key proxies to determining internal market access and size. The Kenyan population is not uniformly distributed while over the years the government has invested in the development and expansion of the road and railway networks actions that have contributed to improving market access for both the inputs and agricultural commodities.

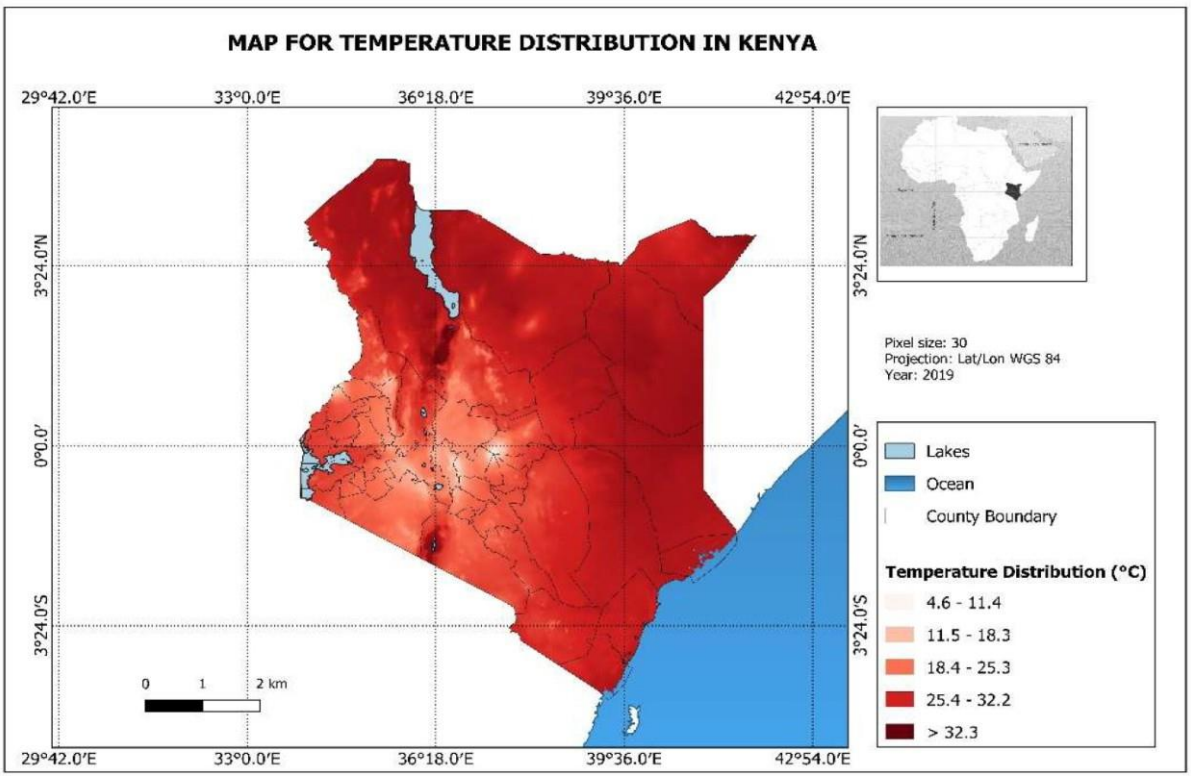

Figure 2: *Kenya Temperature*

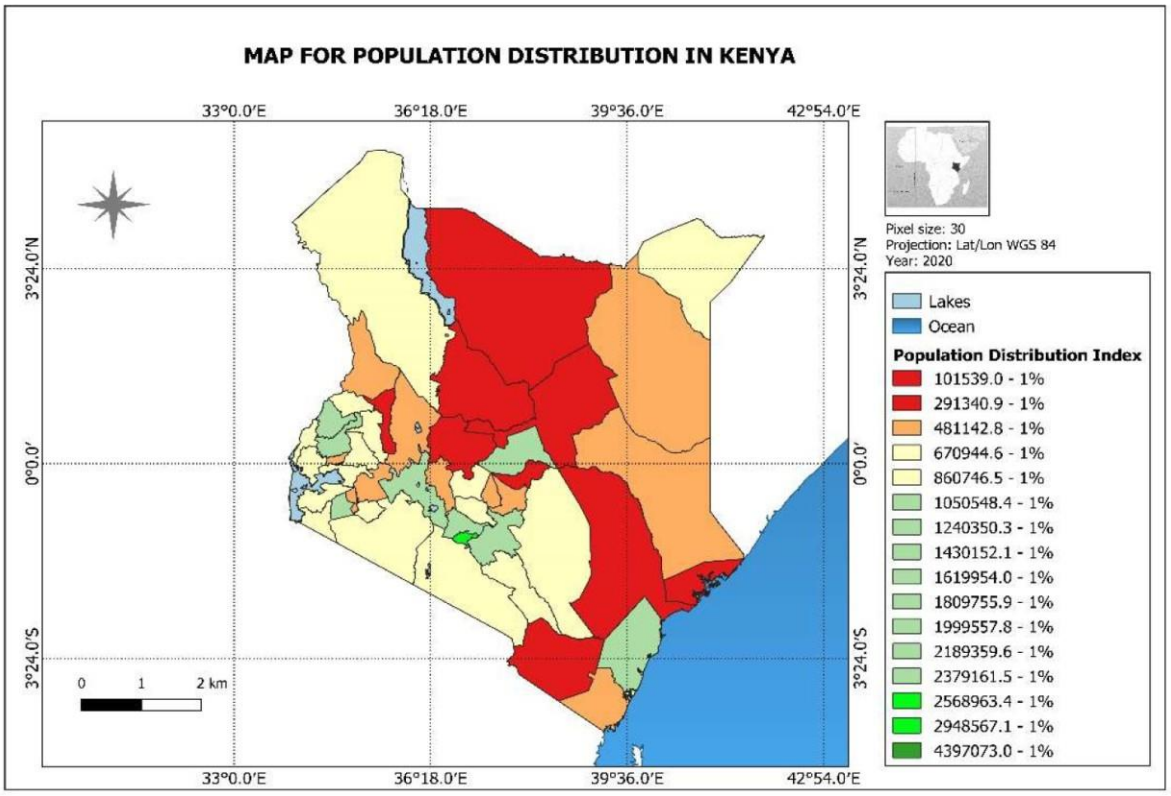

Figure 3: *Kenya Population Density*

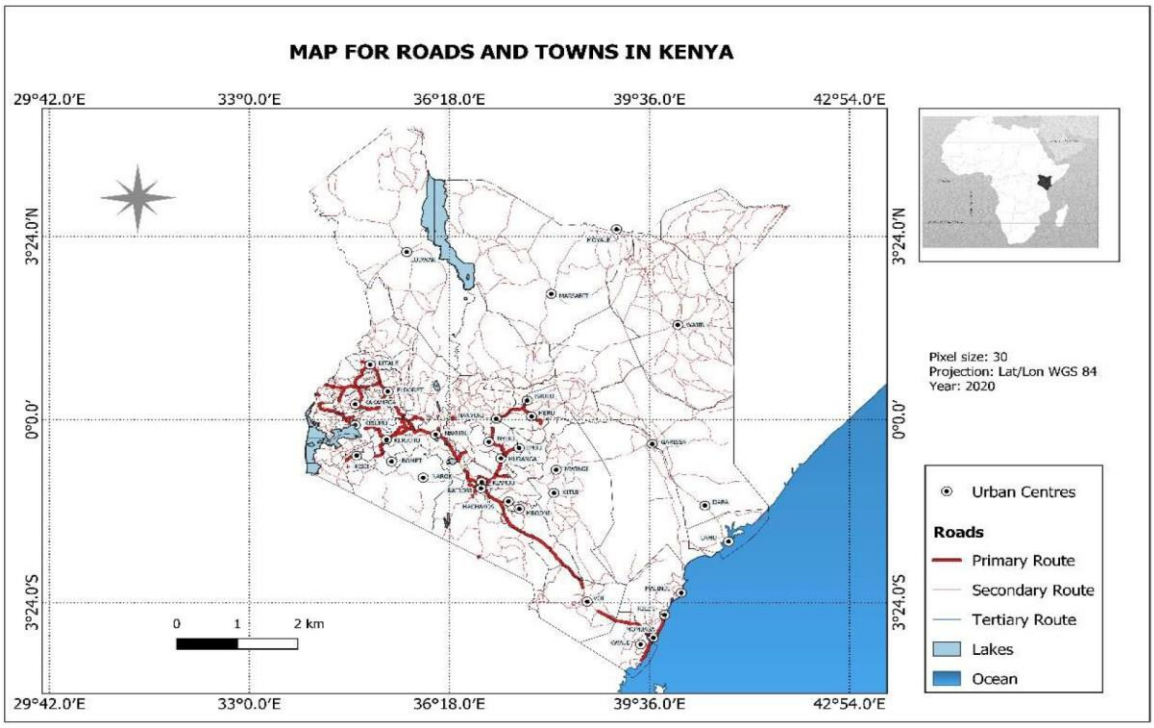

Figure 4: *Kenya Roads and Major Towns*

1.3 The Agricultural Sector Development Support Programme

1.3.1 ASDSP I

Agriculture Sector Development Support Programme (ASDSP I) was a national formulated and implemented programme financed by Government of Kenya and the Government of Sweden. The first phase was implemented during a period of five years (2012-2017). The developmental objective (purpose) of ASDSP I was *"increased and equitable incomes, employment and improved food security of the target groups as a result of improved production and productivity in the rural smallholder farm and off-farm sector"*. It was one of the major programmes implementing the sector strategy, Agriculture Sector Development Strategy (ASDS: 2010-2020) whose goal was to commercialize agriculture. During this programme phase, each county prioritized three agricultural value chains for promotion.

The priority value chains were identified through a scooping and consultative study forums facilitated by a team of experts in each of the seven regions of the country (the then Provinces except Nairobi, which was paired with Central). The 10 point criteria developed to guide the stakeholders in identifying and prioritizing the value chains examined among others; potential to increase in productivity; potential for private sector participation and crowding in; potential for contribution to sustainable land and natural resource management (NRM); competitiveness of the sector; unmet market demand; market size and growth prospects; profitability of enterprise; potential to contribute towards food security; potential to generate employment; potential for value addition; potential for women and youth involvement; potential for participation of vulnerable groups (i.e. low investments/quick returns enterprises) and Cultural Acceptability. Application of these criteria led to the selection of 29 priority value chains (PVCs) three in each of the 47 counties with the most preferred value chains being dairy, indigenous chicken, maize and fish (**Error! Reference source not found.**).

1.3.2 ASDSP II purpose

The overall goal of ASDSP II is aligned to the Agricultural Policy and is to contribute to "Transformation of crops, livestock and fisheries production into commercially oriented enterprises that ensures sustainable food and nutrition security". ASDSP II purpose is to commercialize priority VCs with expectations of increasing incomes among the VCAs and assure attainment of food and nutrition security to the VCAs households. The programme is devolved to all the 47 Counties. The identified outcome areas of the programme are; *increasing productivity of priority value chains, enhancing entrepreneurship of priority Value Chain Actors, improving access to market by VCAs* and support to strengthen structures and capacities for consultation, cooperation and coordination (3Cs) in the sector.

During the roll out of ASDSP II, a simpler and easy 5-point criteria (*Income, Food security, Employment creation, Environmental Sustainability and Opportunity to promote social inclusion*) was applied to validate the existing PVCs (**Error! Reference source not found.**) and in almost all the counties, the same PVCs promoted under ASDSP I were retained. Some counties however added an extra PVC and went ahead to invest additional resources on the programme.

Table 1: *Priority value chains*

	County	Prioritized Value Chain			County	Prioritized Value Chain
1	Baringo	Meat Goat		25	Marsabit	Meat Goat
		Honey				Camel Milk
		Cow Milk				Sukuma Wiki
2	Bomet	Cow Milk				ndigenous Chicken
		Maize		26	Meru	Maize
		ndigenous Chicken				Cow Milk
		Irish Potato				ndigenous Chicken
3	Buugoma	Cow Milk		27	Migori	Cow Milk
		ndigenous Chicken				Sweet Potato
		Tomatoes				ndigenous Chicken
4	Busia	ndigenous Chicken		28	Mombasa	Fish
		Fish				Local Vegetables
		Ground Nut				Cow Milk
5	Elgeyo Marakwet	Cow Milk		29	Muranga	Banana
		Irish Potato				French Beans and Snow Peas
		Maize				Cow Milk
6	Embu	Cow Milk		30	Nairobi	Broilers
		Banana				Sukuma Wiki
		ndigenous Chicken				Cow Milk
7	Garissa	Tomatoes		31	Nakuru	Pyrethrum
		Camel Milk				Fish
		Beef				Cow Milk
8	Homa Bay	ndigenous Chicken		32	Nandi	Maize
		Fish				ndigenous Chicken
		Sorghum				Fish
9	Isiolo	Beef				Maize
		Camel Milk		33	Narok	Beef

Table 1: *County Priority Value Chains cont'd.....*

	County	Prioritized Value Chain			County	Prioritized Value Chain
		Tomatoes			Cow Milk	
10	Kajiado	Cow Milk				Maize
		Tomatoes		34	Nyabururu	Irish Potato
		Beef				Fish
11	Kakamega	Cow Milk				Cow Milk
		Maize		37	Nyamira	Banana
		Indigenous Chicken				Local Yege tables
12	Kericho	Cow Milk				Cow Milk
		Tomatoes		36		Irish Potato
		Indigenous Chicken				Indigenous Chicken
13	Kiambu	Cow Milk				Beef
		Indigenous Chicken		37	Samburu	Maize
		Banana				Honey
14	Kilifi	Cassava				Indigenous Chicken
		African Eye Bird Chilli		38	Siaya	Mango
		Indigenous Chicken				Fish
15	Kirinyaga	Cow Milk				Cow Milk
		Banana		39	Taita Taveta	Banana
		Rice				Indigenous Chicken
16	Kisii	Cow Milk				Mango
		Banana		40	Tana River	Beef
		Indigenous Chicken				Fish
r	Kisumu	Indigenous Chicken				Banana
		Fish		41	Tharaka Nithi	Cow Milk
		Cotton				Indigenous Chicken
is	Kitui	Indigenous Chicken				Banana
		Gadam Sorghum		42	Tran-Nzoia	Maize
		Green Gram				Indigenous Chicken
19	Kwale	Indigenous Chicken				Fish
		African Eye Bird Chilli		43	Turkana	Sorghum
		Passion Fruit				Meat Goat
:o	Laikipia	Maize				Fish
		Cow Milk		44	Uasin Gishu	Passion Fruit
		Sheep and Goats				Indigenous Chicken
21	Lamu	Indigenous Chicken				Cow Milk
		Fish		4?	Vihiga	Indigenous Chicken
		Cashew Nut				Cow Milk
	Machakos	Cow Milk				Banana
		Indigenous Chicken		46	Wajir	Watermelon
		Mango				Indigenous Chicken
23	Makueni	Indigenous Chicken				Camel Milk
		Mango		47	West Pokot	Honey

Table 1: *County Priority Value Chains cont'd.....*

	County	Prioritized Value Chain			County	Prioritized Value Chain
		Green Gram				Indigenous Chicken
24	Mandera	Tomatoes				Meat Goat
		Camel Milk				
		Meat Goat				

1.4 Rationale

The Kenya Vision 2030 aims at developing "an innovative, commercially-oriented and modern Agriculture". This Vision is embedded in the Agricultural Policy (2016) and in Agriculture Sector Transformation and Growth Strategy (ASTGS: 2019-2029). Two flagship areas of the ASTGS of relevance are those that aim at strengthening and launching priority digital and data use cases to drive decision making and performance management of the sector and establishment of systems for active monitoring of sustainable and climate-smart natural resource management of water basins, soil quality and land use. The preparation of priority value chain suitability maps was made in response to these policy directives. The maps will inform development actions ofpriority value chains in each leading to agricultural transformation and growth.

The ASDSPII outcome area one seeks to increase productivity of the priority value chains through enhanced application of climate smart agricultural interventions, practices and technologies. Suitability maps are important decision tools that shall be applied to demonstrate the feasible baseline productivity of geographical regions (county, ward, country etc.) and guide in generating adaptive actions to counter the excesses of climate change and unsuitable conditions. Identification and application of climate smart technologies to meet the production needs of value chain systems will facilitate commercialization.

Transformation and growth of the agricultural sector will only be achieved when the problems and challenges of rapid and unregulated urbanization is addressed. Unplanned urbanization leads to conversion of rich agricultural land to urban use; environmental degradation, unbalanced development of high potential areas at the expense of other areas, poor economic performance of agriculture and sub-optimal use of land and the rich natural resource endowment. The priority value chains suitability maps provide a framework for addressing challenges by providing strategies to address the challenges based on land capability classes.

The priority value chains suitability maps considered biophysical, economic, social and political attributes as they affect productivity and commercialization of the value chains. This is a departure from the conventionalagro ecological zoning procedures and the soil suitability mapping (Figure 6) processes.

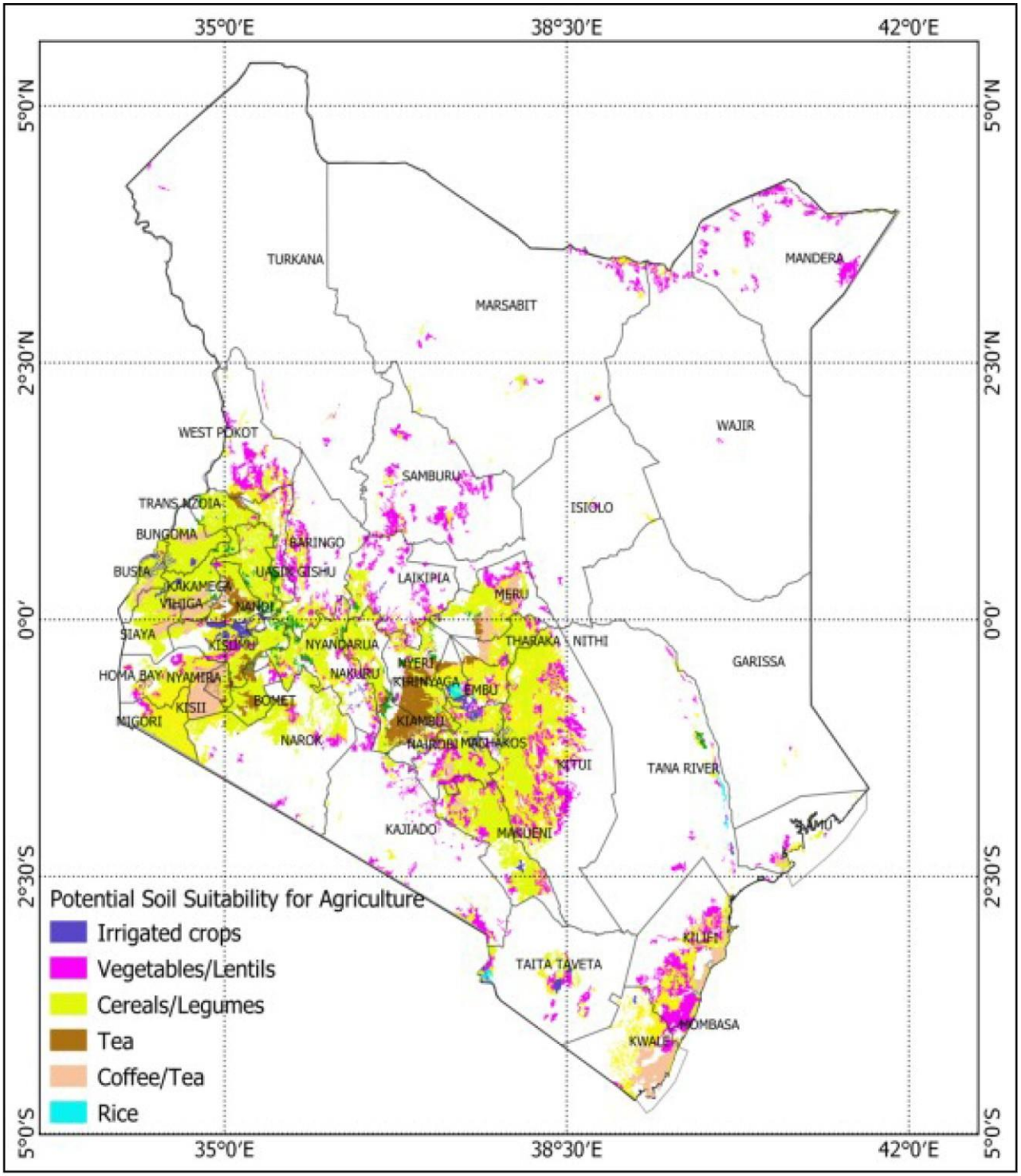

Figure 5: *Soil suitability classification*

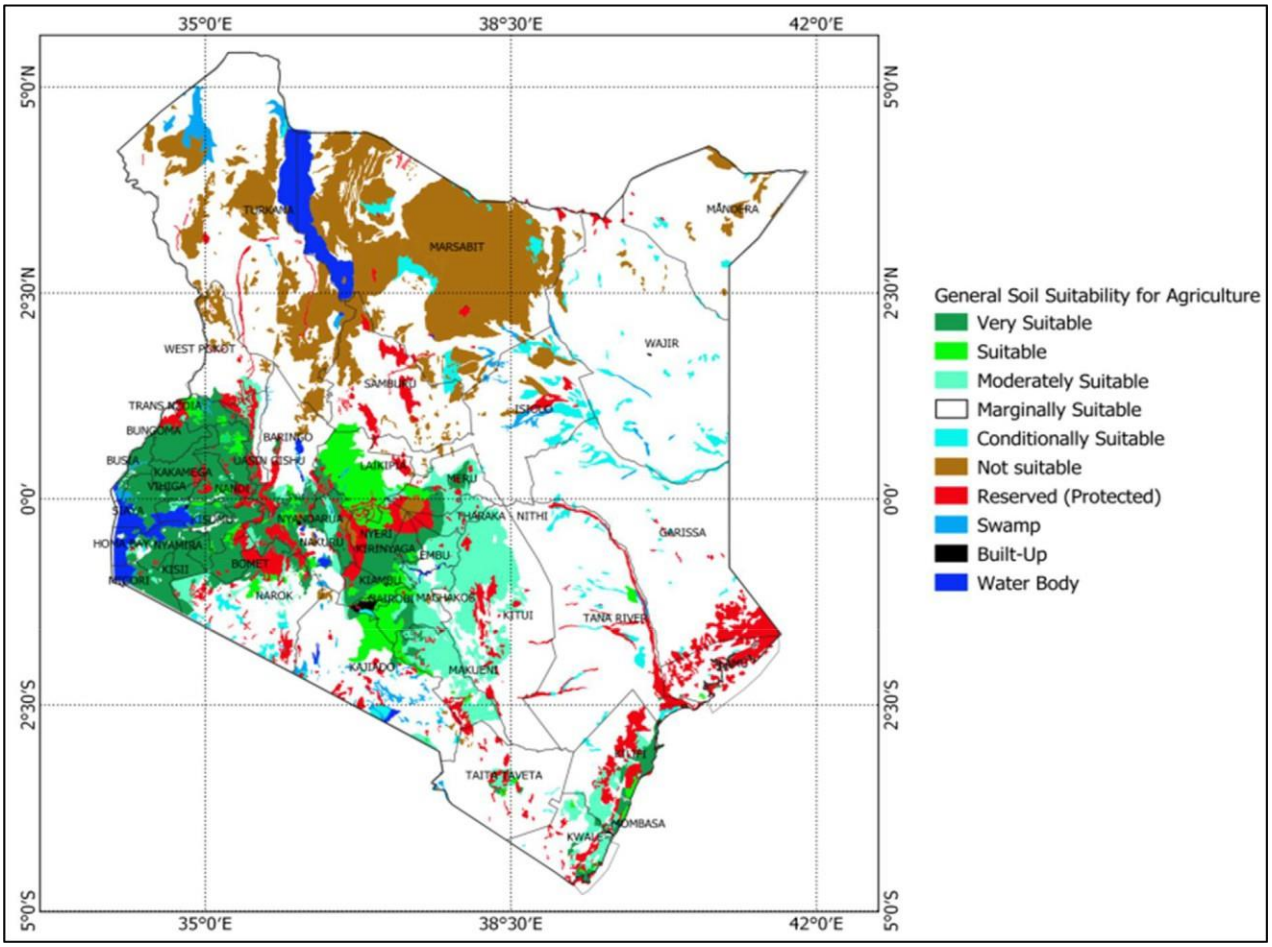

Figure 6: *Soil suitability classification*

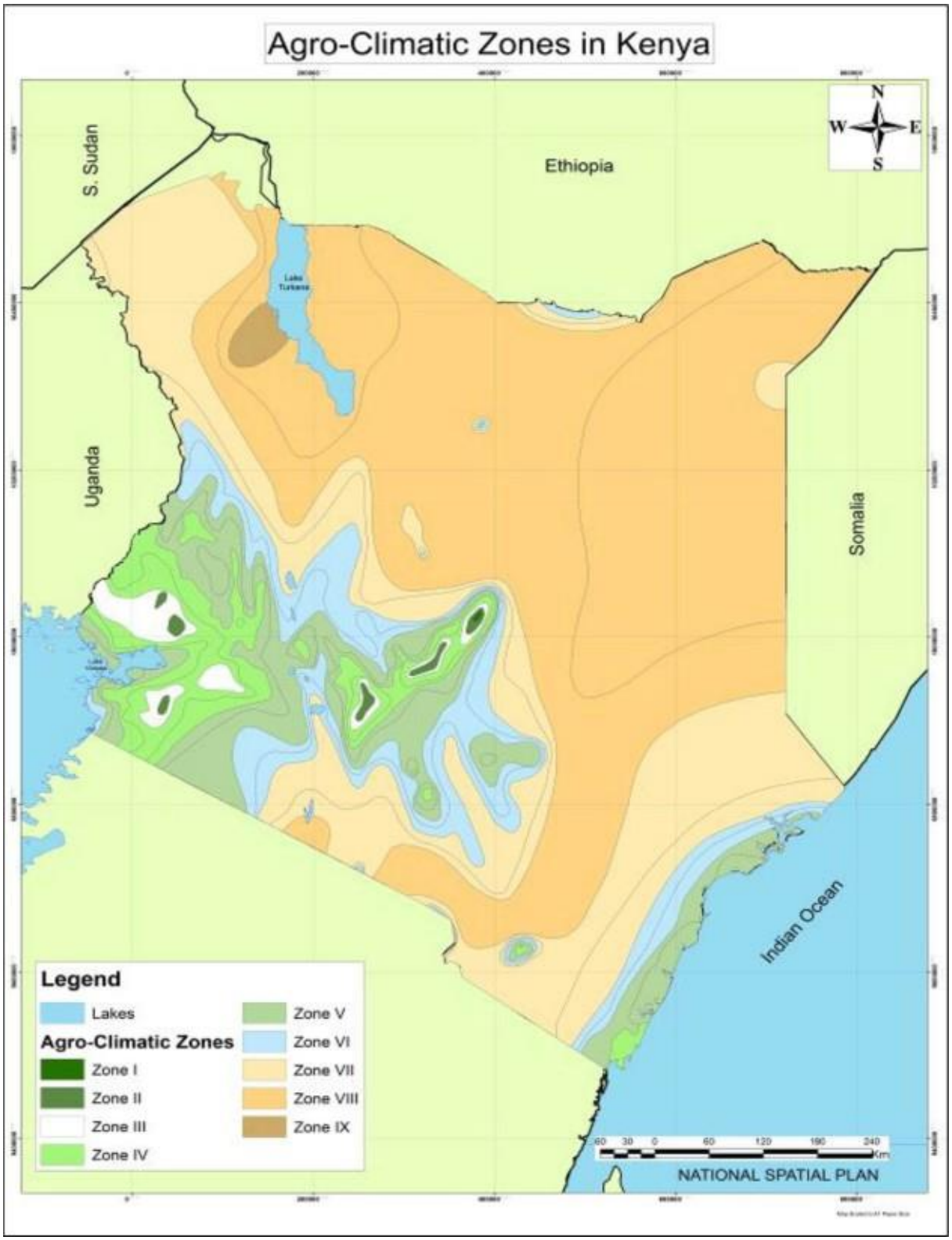

Figure 7: *Agro ecological zones*

1.5 Objectives

The objectives of the priority value chain suitability atlas are:

i. To create a spatial planning context to strengthen priority value chain competitiveness;

ii. To optimize allocation and utilization of land, natural human and capital resources to increase value chain productivity;

iii. To secure the natural environment for high quality of life;

1.6 Principles

The principles that guided the preparation of priority value chains suitability maps are;

i. Transformation and commercialization of agricultural value chains. That the value chain development must be anchored on scales that are commercially viable and technically feasible with direct benefits accruing to VCAs in incomes and food security terms. The maps were prepared to address the needs to plan resource allocation to drive commercialization and transformation of agriculture

ii. Consultation and effective public and cross sectoral participation and engagement: All the maps were prepared in a participatory and consultative manner with relevant stakeholders and sectoral actors. The process involved experts from Survey of Kenya, county physical planners, Kenya Agricultural Research Organization, Kenya Marine and Fisheries Research Institute, State and County agricultural personnel, value chain actors, universities and the private sector.

iii. Value chain approach to agricultural and rural development. Development of the maps considered factors that affect production, trade and marketing to derive parameters that most represent the ease of commercializing a value chain represented as suitability classes.

iv. Knowledge driven and evidence based planning and development. The process was driven by application of scientifically proven processes and tools to capture, query, analyze data, synthesize information for presentation and use by stakeholders.

v. Climate smart agriculture and green growth: The maps present measures that promote sustainable use of natural resources, increase resilience to climate change effects with low carbon footprints.

2. METHODOLOGY

The suitability maps were generated through integration of a set of parameters that were derived through expert opinion and literature review. The criteria considered were grouped into four main categories namely; biophysical (land, water, climate), economic (population density, proximity to roads and markets and poverty index), social (agrarian orientation) and political (policies and supportive framework conditions). The parameters were processed as thematic maps and consolidated by overlaying to produce suitability classes of land use practices on a GIS environment using QGIS, ILWIS, SAGA and R Studio. This approach was a progression from the traditional land suitability and land evaluation mapping process.

2.1 Selection of evaluation criteria

The biophysical parameters were assessed on the basis of climatic (rainfall, temperature, humidity and temperature humidity index) and soil (soil pH, soil CEC, soil organic carbon, soil texture, soil drainage, soil depth, available soil water and soil fertility, topography, length of growing period, stoniness and proximity to water resources) criteria. The economic criteria were based on total population, population density, proximity to roads/rail, and proximity to marketing points. The proxy indices were applied as representations for establishing market demand and access. The agrarian culture of the people was a proxy for examining the potential growth and adoption of a value chain. These parameters were used to determine suitable areas for promoting any crop, livestock or fish value chain through a methodological process illustrated below.

An Analytical Hierarchical Process (AHP) as a Multi Criteria Evaluation was used to determine relative importance of each criterion and the resulting weights were used to construct the attribute maps/layers on the GIS platform. It was preferred because of its capacity to integrate a large quantity of the heterogeneous data. A further processing of the attribute maps was done overlaying them to generate suitability composite maps. The composite maps were then subjected to a validation process from where the explanatory notes were made and incorporated in this atlas

2.1.1 Data gathering and preparation

Soil data was obtained from Kenya Soil Survey (KSS) Land Information Cradle (online) and also from the ILRI GIS (online). Climate data was obtained from Kenya Meteorological Services (KMS – online services). The socio-economic data was obtained from Kenya National Bureau of Statistics (KNBS). The huge climate data from the KMS were interpolated to get the climate information of all the 47 Counties. Satellite image and Digital Elevation Model (DEM) were obtained from Regional Centre for Mapping of Resources for Development (RCMRD) at 30-meter spatial resolution and re-projected to WGS84 coordinate system. The slope information was obtained from Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) Global Digital Elevation Model Version 2 (GDEMV2) and processed on ILWIS and SAGA to analyze the terrain.

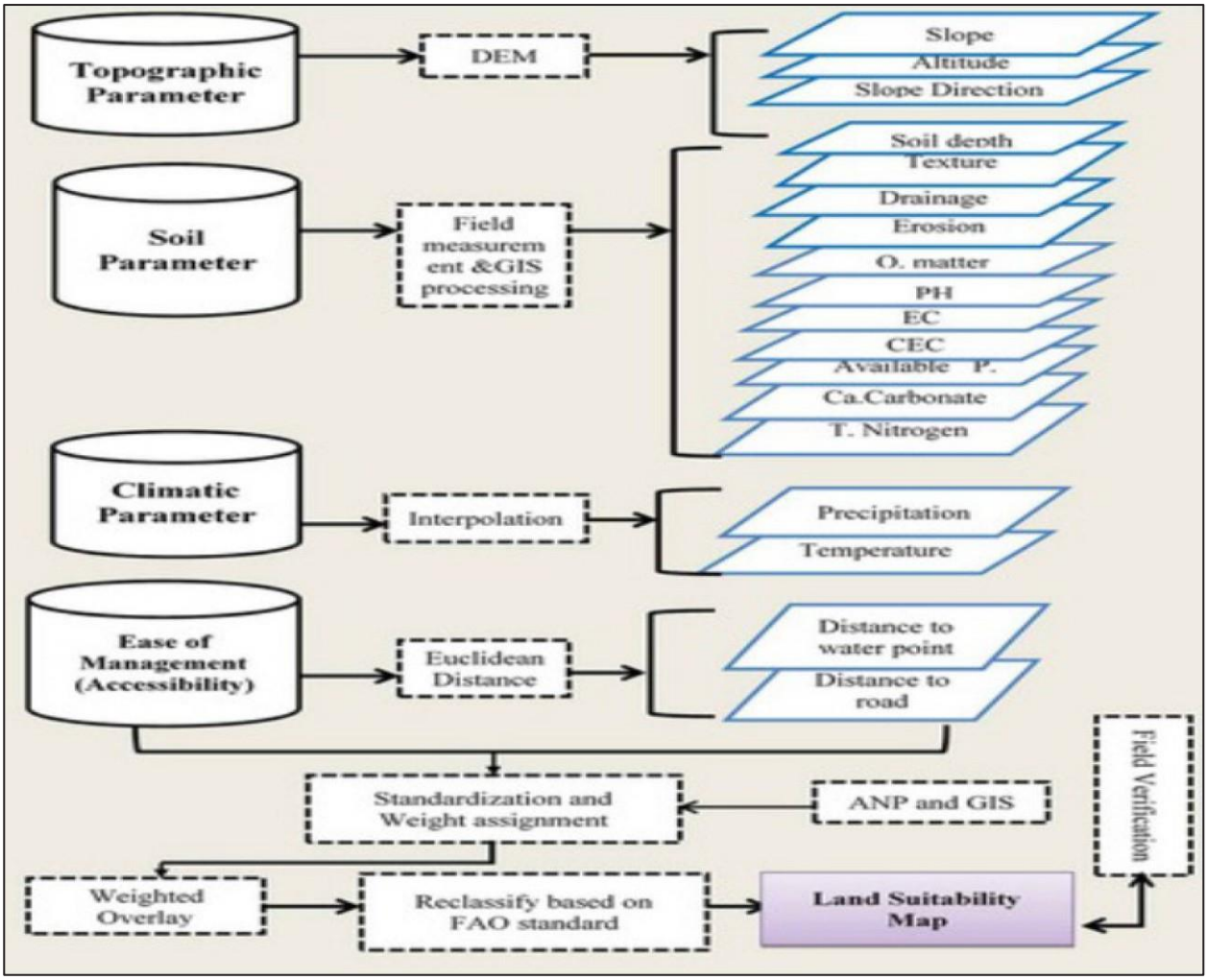

Figure 8: *Suitability mapping process*

Thematic maps for the slope and the soil parameters were developed using QGIS 3.4.2 software. Annual rainfall and mean annual temperature thematic maps were generated using Inverse Distance Weighted (IDW) interpolation. IDW interpolation determines cell values using a linearly weighted combination of a set of sample points. All the maps were geo-referenced to WGS84 coordinate system. Suitability levels Highly Suitable S1, Moderately Suitable S2, Marginally Suitable S3and Not Suitable N were assigned score 1, 2, 3, and 4 respectively. Pairwise ranking and weighting was done to the sub-criteria and classes with higher scores subjected to suitability evaluation. The thematic maps were resampled and reclassified before being run on the SAGA and ILWIS for the final output.

2.1.2 Applying MCE and Assigning weight of factors

To determine relative importance/weight of criteria and sub criteria, AHP method of MCE was used. In order to compute the weights for the four (4) criteria (biological, physical, social and economic aspects) and the sub-criteria (Soil pH, Soil Texture, Soil Depth, Soil Drainage, Soil Fertility, Soil OC, Soil CEC, Stoniness, Soil AWC, Slope, Rainfall, Temperature, Relative Humidity, Length of Growing Period, Market Proximity, Road Proximity, Temperature- Humidity Index, and Agrarian Culture), a pairwise comparison matrix (PWCM) was constructed

using information obtained from Agricultural Sector Development Support Programme (ASDSP) experts gathered at the Morendat Training Centre, Naivasha in June/July 2019 during an ASDSP sponsored validation workshop. During this exercise, each factor was compared with the other factors, relative to its importance, on a scale from 1/9 to 9 according to Saaty rating scale (**Error! Reference source not found.**). During the pairwise ranking, inconsistencies were checked by ensuring that the corresponding consistency ratio (CR) was less than 10% according to Triantaphyllou et al, 1995. The CR was obtained by working with the Consistency Index (CI) and the Random Consistency Index (RCI).

Table 2: *Saaty Rating Scale*

Intensity if importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgement slightly favour one over the other.
5	Much more important	Experience and judgement strongly favour one over the other.
7	Very much more important	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity
2,4,6,8	Intermediate values	When compromise is needed

Table 3: *Sample of Pair wise comparison matrix for the soil sub-criteria (Biological Aspects)*

	PH	Texture	Depth	Drainage	Fertility	OC	CEC	Stoniness
pH	1	1/3	1/3	1/3	5	7	1/4	3
Texture	3	1	3	3	1/7	1/3	1/3	3
Depth	3	1 3	1	1/2	3	5	6	1/3
Drainage	3	1 /3	2	1	5	9	7	5
Fertility	1/5	7	1/3	1/5	1	1/3	1/3	5
OC	1/7	3	1/5	1/9	3	1	4	5
CEC	4	3	1/6	1/7	3	1/4	1	6
Stoniness	1/3	1/3	3	1/5	1/5	1/5	1/6	1

Table 4: *Sample of Pair wise comparison matrix of Physical Aspects sub-criteria with respect to climate*

	Temperature	Rainfall
Temperature	1	1/3
Rainfall	3	1

Table 5: *Sample Pair wise comparison matrix of soil, climate and topography criteria*

Parameters	Soil	Climate	Topography (slope)
Soil (Biological)	1	3	7
Climate (Physical)	1/3	1	5
Topography (slope)	1/7	1/5	1

Table 6: *Sample Pair wise comparison between the economic aspects*

Parameter	Road proximity	Market proximity	Total population
Road proximity	1	4	5
Market proximity	1/4	1	6
Total population	1/5	1/6	1

Table 7: *Pair wise comparison between the social aspects*

	Population density	Agrarian culture
Population density	1	3
Agrarian culture	1/3	1

Table 8: *Pair wise comparison between the soil, climate, topography and socio-economic aspects*

	Soil	Climate	Topography	Socioeconomics
Soil	1	5	3	9
Climate	1/5	1	7	5
Topography	1/3	1/7	1	3
Socioeconomics	1/9	1/5	1/3	1

2.1.3 Overlaying map layers

The reclassified thematic maps/layers of each variable were weighted using the weights derived from the AHP process and the Boolean algebraic logic. The weighted maps/layers were combined by performing the weighted overlay using SAGA, Raster calculator and ILWIS to produce the final suitability map.

3. MAPPING COUNTY RESOURCES

3.1 County Background

Narok County lies between latitudes 0° 50´ and 1° 50´ South and longitude 35° 28´ and 36° 25´ East. It borders the Republic of Tanzania to the South, Kisii, Migori, Nyamira and Bomet counties to the West, Nakuru County to the North and Kajiado County to the East. The county headquarters is at Narok Town. It covers an area of 17,933.1 Km^2 representing 3.1 per cent of the total area in Kenya and therefore the eleventh largest in the country.

3.2 County Resources

Narok County is endowed with various natural resources including forests, agricultural land, minerals, energy, water towers, wildlife, livestock and an outstanding socio-culture practice making it a major tourist destination in the country.

3.3 Biophysical

3.3.1 Rainfall

The climatic condition of Narok County is strongly influenced by the altitude and physical features. The county has four agro-climatic zones namely: humid, sub-humid, semi-humid to arid and semi-arid. Two-thirds of the county is classified as semi-arid (Narok DEAP Page 22 2009-2013). Rainfall ranging between 500mm – 1800mm is highest in Kilgoris area which is the central western part of the county while the rest of the county experiences low and unreliable rains (Plate 3.1).

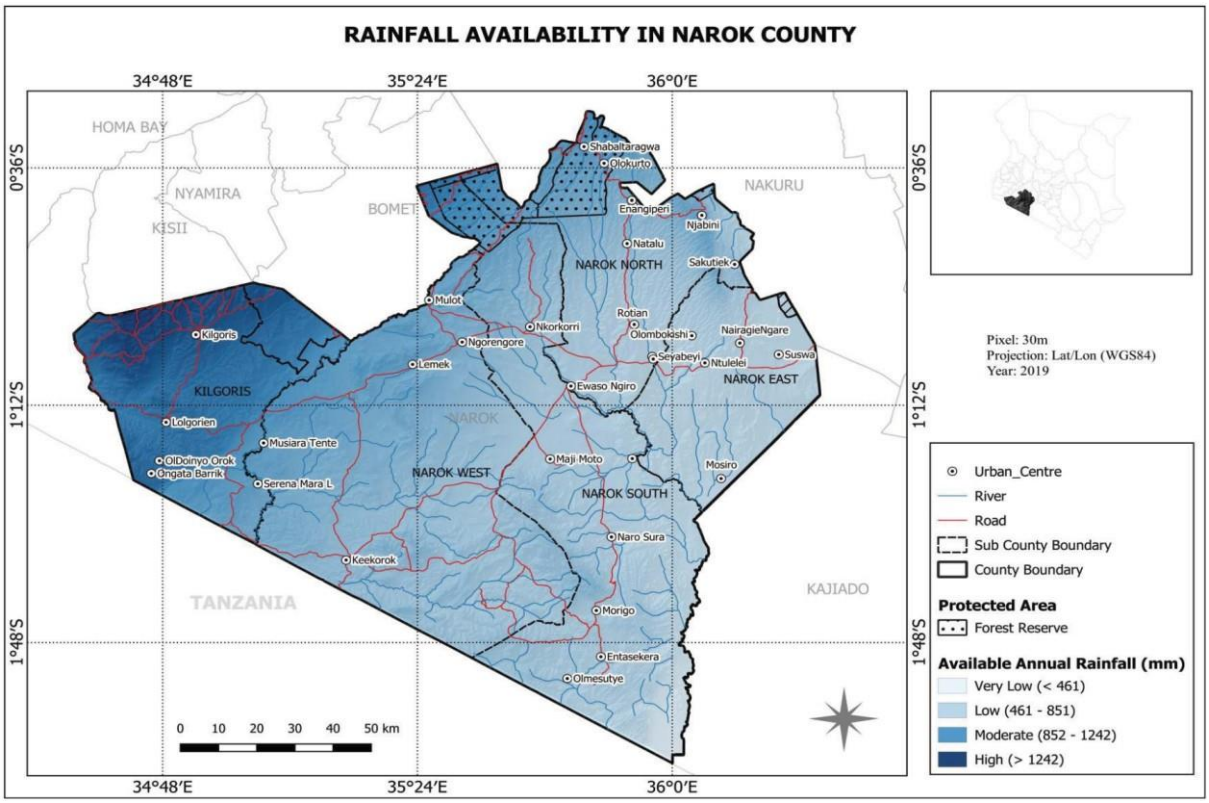

Plate 3.0: *Rainfall Availability in Narok County*

3.3.2 Temperature

Temperatures range from 20°C (January - March) to 10°C (June - September) with an average of 18°C. However, on average most parts of the county are experiencing temperatures of 18-22°C annually (Plate 3.1).

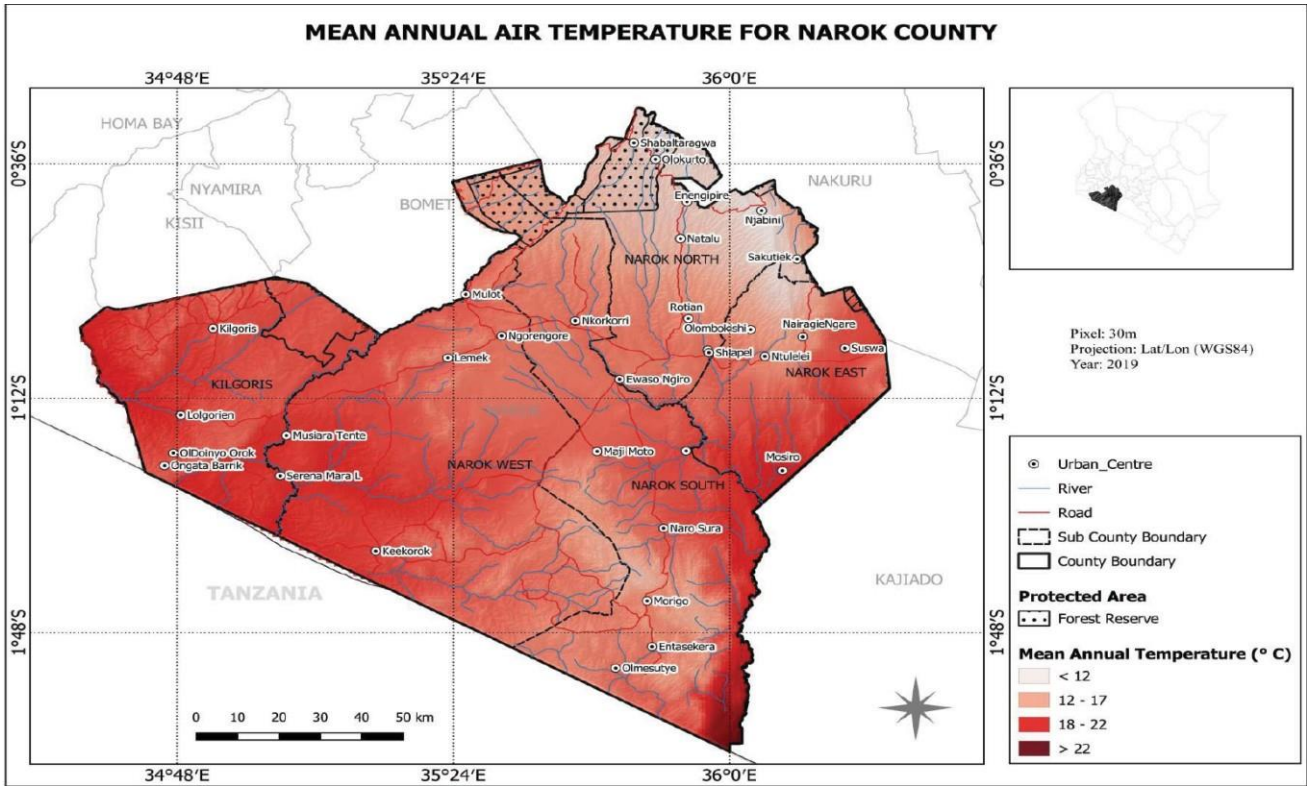

Plate 3.1: *Narok County Mean Annual Temperature*

3.3.3 County Soils

The county soils are quite stochastic ranging from clay to sandy and loamy (Plate 3.2). The predominant soils are sandy loam with black cotton soils being prevalent in Transmara East. Noteworthy, is the big acreage of arable land totaling 164,730 km^2 out of which only 69,000 Ha is under cultivation.

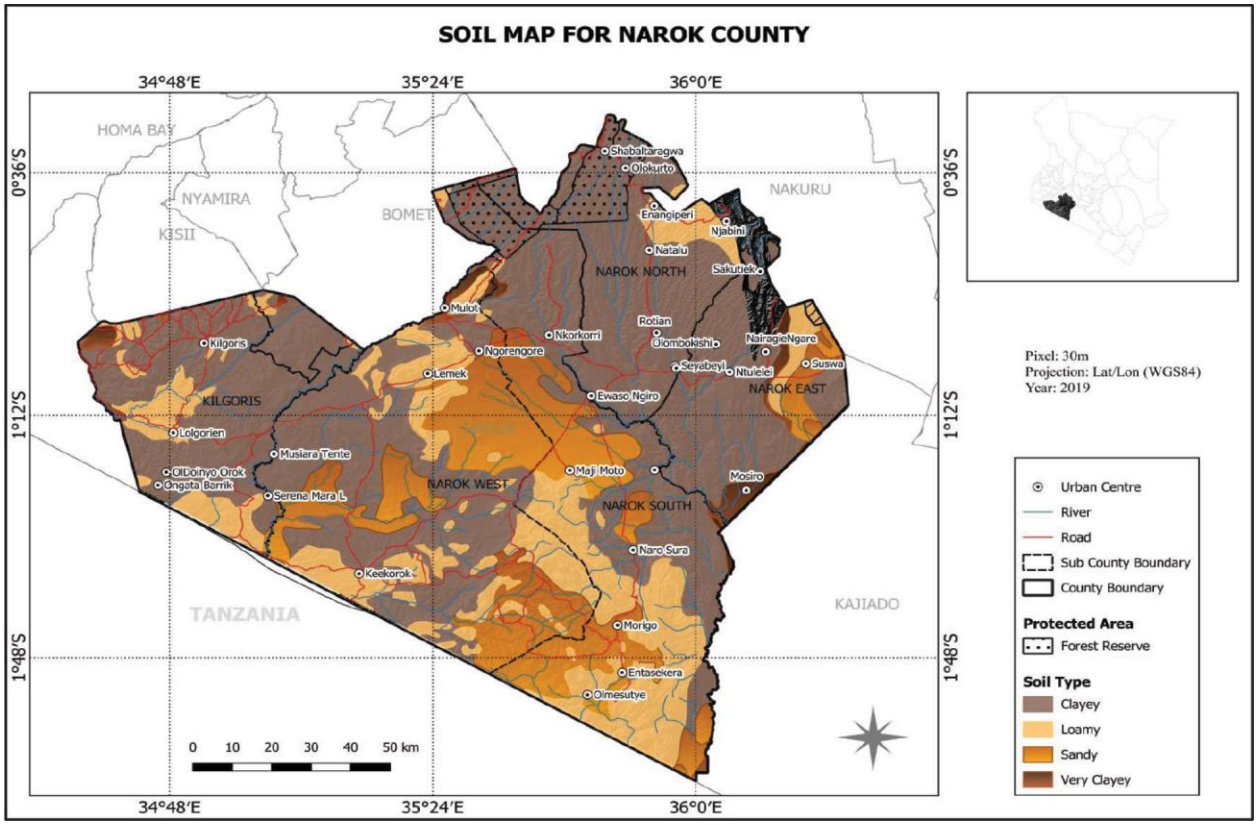

Plate 3.2: *Narok County Soil Map*

3.3.4 Social

The County annual population growth rate stands at 4.7 per cent as compared to 2.7 (NCPD, 2017) per cent at the national level. The 2018 projected population in the county stands at 1,130,703 consisting of 570,963 males and 559,740 female. Population density in the county is varies across the six sub-counties. The density for the county as at 2018 stands at 63 persons per square kilometer, an increase from 47 persons per square kilometer recorded during the 2009 housing and population census. Densities are influenced by among other things climatic condition, availability of social amenities and altitude (Narok CIDP, 2018-2023).

3.3.5 Economics

There are two urban centers in the county namely; Kilgoris town and Narok town. The two urban areas are highly cosmopolitan and are fairly developed in terms of socio-economic infrastructure. In partnership with other stakeholders the department achieved tremendous results towards improvement of the roads and transport network which includes tarmacking of 300km of roads up from 260km in 2013. Other achievements included renovation and maintenance of three airstrips at the Maasai Mara Game Reserve (Narok CIDP 2018-2023).

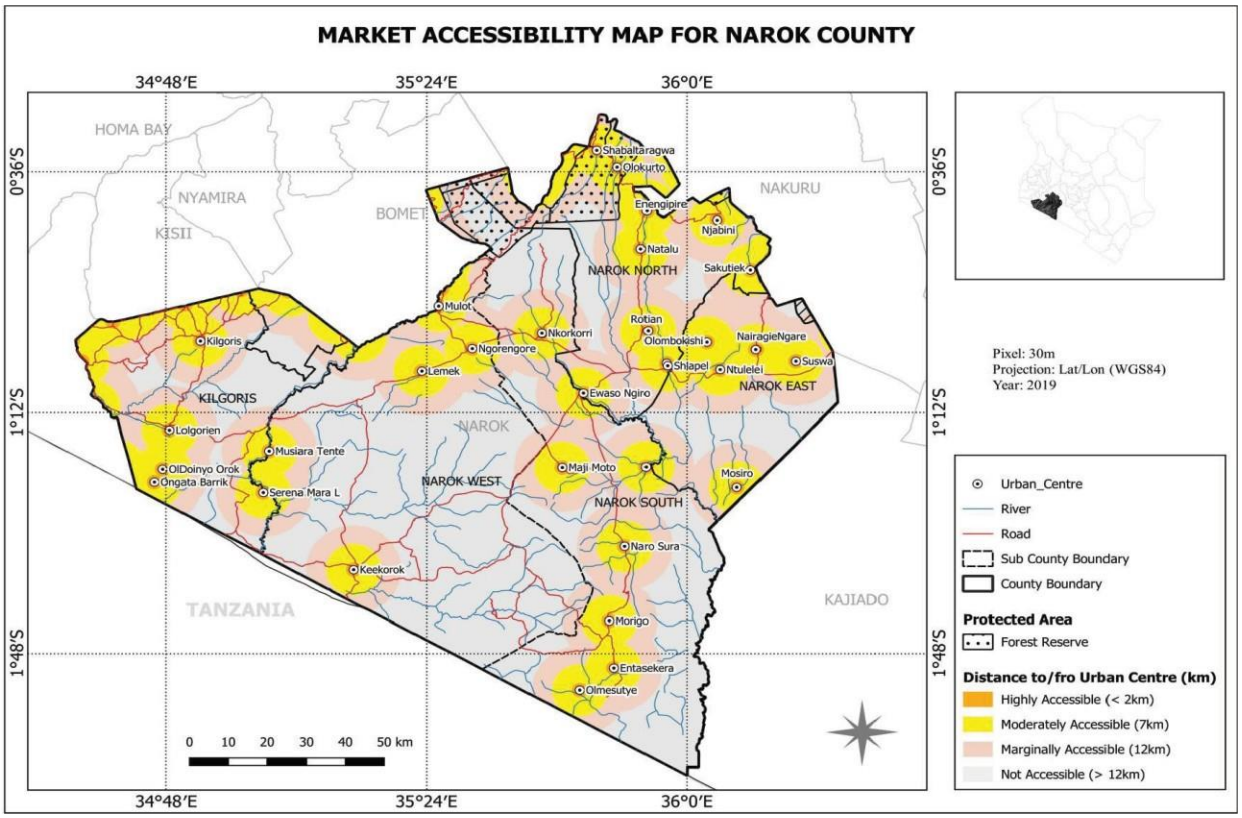

Plate 3.3: *Narok County Market Accessibility*

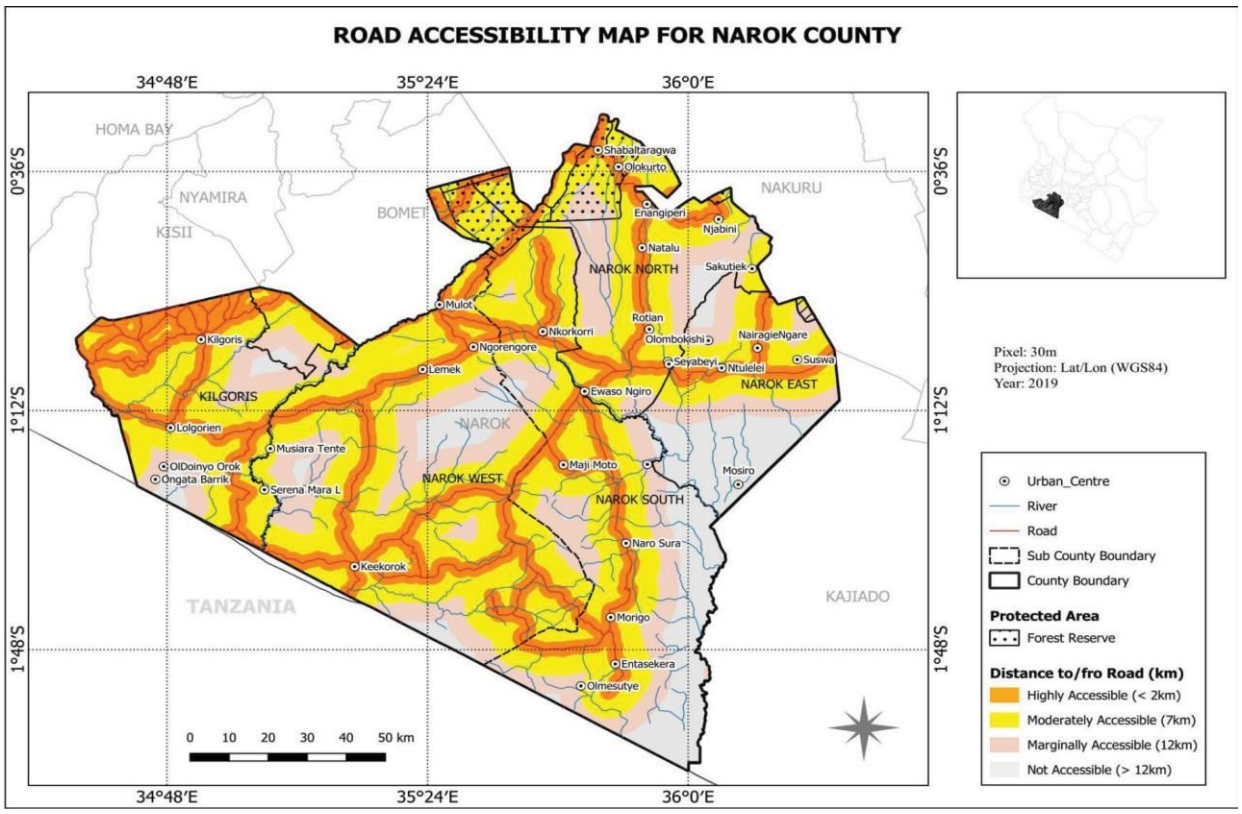

Plate 3.4: *Narok County Road Accessibility*

3.3.6 Political

Administratively, Narok County is divided into six sub- counties namely; Transmara West, Transmara East, Narok North, Narok South, Narok West and Narok East. Politically, the county has six political constituencies and 30 electoral wards. The constituencies are Narok North, Narok South, Narok East, Narok West, Kilgoris and Emurua Dikirr (Narok CIDP 2018-2023).

Table 9: *Narok County Demographics*

County/Sub County	Population				Number of households	Average Household Size	Land Area (Sq.m)	Pop. Density (No. per Sq. Km)
	Male	Female	Intersex	Total				
Narok County	**579,042**	**578,805**	**26**	**1,157,8 73**	**241,125**	**4.8**	**17950.3**	65
Narok East	58,699	56,617	7	115,323	25,078	4.6	2042.0	56
Narok North	128,024	123,829	9	251,862	59,996	4.2	2159.4	117
Narok South	118,441	120,029	2	238,472	46,723	5.1	4577.3	52
Narok West	97,085	98,198	4	195,287	38,658	4.9	5563.0	35
Trans Mara East	54,545	56,637	1	111,183	20,506	5.4	309.8	369
Trans Mara West	122,220	123,491	3	245,714	50,132	4.9	2545.9	97

Table 2: Population by sex; number of households; and average household size, at county and sub-county level in 2019 (source-KNBS, 2019 KENYA POPULATION AND HOUSING CENSUS, VOLUME I)

4.0 PRIORITIZED VALUE CHAIN SUITABILITY MAPS

4.1 MAIZE

The main crops grown in the county are wheat, barley, maize, beans, Irish potatoes and horticultural crops. Maize and wheat are the highest income earning cash crops in the county. On average, the county produces about 200,000MT of maize and 135,000 MT of wheat each year. However, production of these crops has been fluctuating because of erratic rains and emergence of the devastating diseases such as Maize Lethal Necrosis Disease (MLND). The area under maize also declined from 116,605 ha in 2012 to 110,079 ha in 2016. The total production fell from 462,981 tons, valued at 9.6 billion shillings, in 2013 to 271,158 tons, valued at 7.5 billion shillings, in 2015.

4.1.1 Parameter Analysis

Highly suitable

In these areas, the prevailing temperatures 15-25 degrees are within the optimal 18-25 degrees requirement for maize to attain maturity. Rainfall is within the optimal requirements for maize production with a high demand for maize consumption.

Moderately suitable

In such areas, the soil physical conditions and chemical properties lie close to the optimal requirements.

- pHs 4.7-8.5 as compared to the optimal; 5.5-7.3
- CEC is also optimal at 3-140 meq/100g soil
- Soil depth ranges 15-50 cm while
- Slope is fairly gentle or steep at 3-8%.
- Most feeder roads are in fair state during dry season but these roads become impassible during heavy rains.
- Distance to market is >7 km Market is diverse/sufficient because of high internal and external demand
- These areas have fairly developed market infrastructure
- The big population demands more maize, either for trade or for consumption.
- Most maize is sold at individual level. There are no organized cooperatives to take advantage of the associated benefits

Marginally Suitable

- Pockets are prone to water logging
- Some maize zones have steep slopes > 8% not suitable for mechanization
- Feeder roads are in poor state hence inhibiting efficient transportation of inputs and produce
- Distance to market is >7 km making it less economical to deliver to market

4.1.2 Adaptation Measures

- Plant AEZ specific maize varieties for specific temperatures and rainfall
- Have many outlets for maize closer to the consumer

- Use appropriate fertilizers as prescribed
- Use organic manure products
- Technologies that increase soil depth and water retention
- Soil fertility improvement practices
- Implement water drainage technologies
- Land Drainage
- Improve all feeder roads, with murram and proper drainage

4.1.3 Suitability Maps

Narok county is predominantly moderately to highly suitable for maize value chain with an exception of the eastern strip which covers most of Narok East and parts of Narok South Constituencies (Plate 4.0).

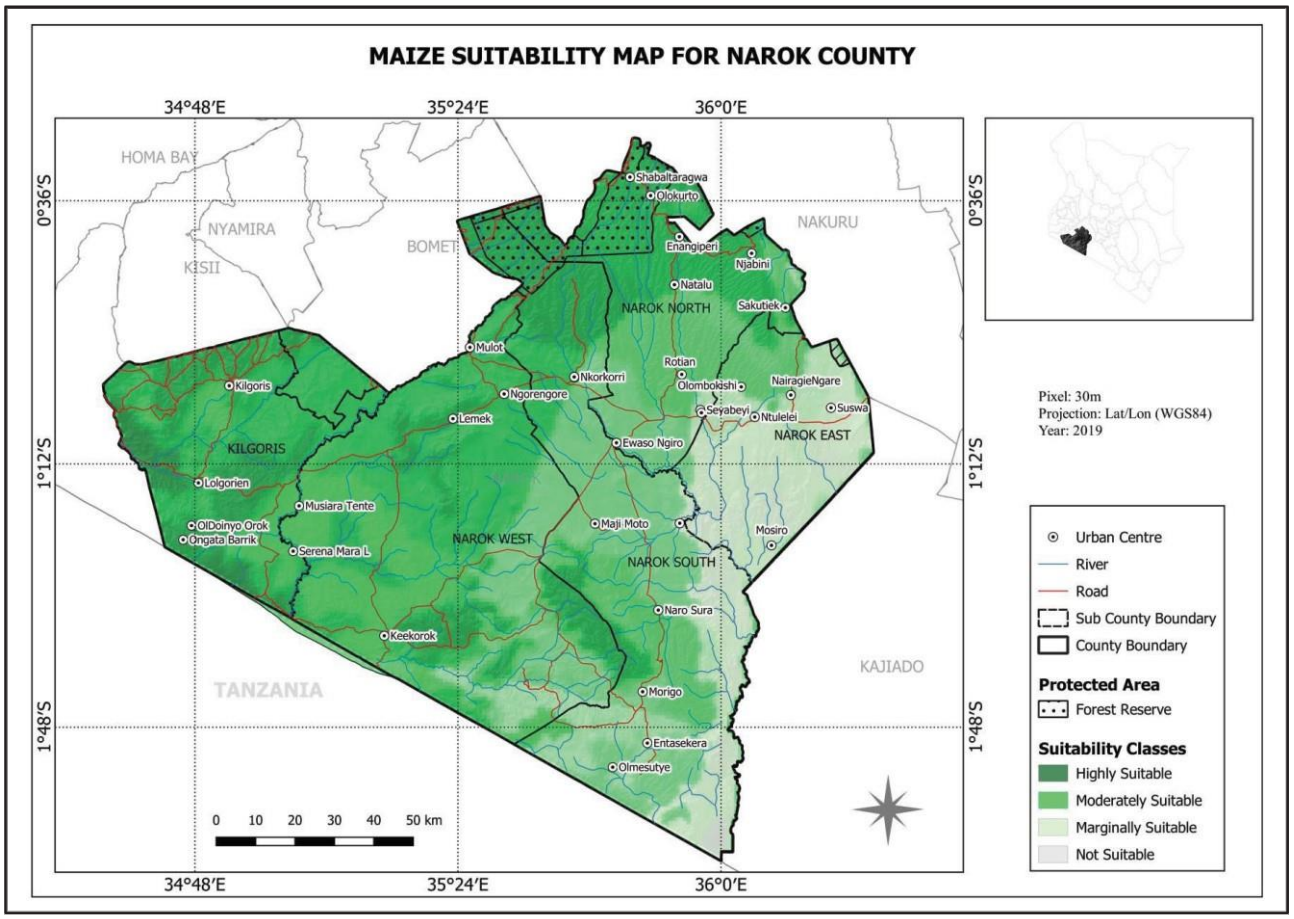

Plate 4.0: *Narok County Maize Suitability*

4.1.4 Adaptation technologies and innovations

Adaptation

- Use appropriate fertilizers as prescribed
- Use organic manure products
- Technologies that increase soil depth and water retention
- Soil fertility improvement practices
- Implement water drainage technologies

Innovation:

- Plant temperature and rainfall specific maize varieties
- Lobby for construction of maize infrastructure at consumer level

4.2 BEEF

To improve livestock breeds there has been adoption of the A.I or improved bulls to upgrade local breeds. To enhance the initiative, farmers are organized into beef cooperatives and linked to affordable credit and insurance service providers.

4.2.1 Parameter Analysis

Highly suitable

- Population is high which creates demand for the purchase and consumption of beef
- Agrarian – there is high acceptability of beef products within the county
- There is support from the county government for beef production

Moderately Suitable

- The Temperature within the county falls within the optimal requirement for beef farming
- Rainfall in the county falls within the optimal requirements for beef VC
- Soils in the county are varied with respect to OC, OM, CEC, fertility and drainage
- There are areas with slopes over 8%
- There are areas with THI within the requirement for beef production
- There is moderate access to markets as road networks is fairly good
- Distance to market is more than two kilometers away

Not Suitable

- Some pockets of the county (riparian areas, bush land) are tsetse infested

Implications of value chain in relation to commercialization

- Beef farming is commercially viable within Narok County based on the parameters analyzed (including but not limited to rainfall, temperatures, market etc).
- Tsetse fly infestation should be eradicated in areas where it is prevalent to minimize on diseases,

- Road network should be improved to enhance market access
- Rain water harvesting should be prioritized in areas that have insufficient rainfall

4.2.2 Suitability maps

Narok County has most parts of the county highly suitable for beef value chain with an exception of the southern tip Narok West and East, which is moderately suitable (Plate 4.1).

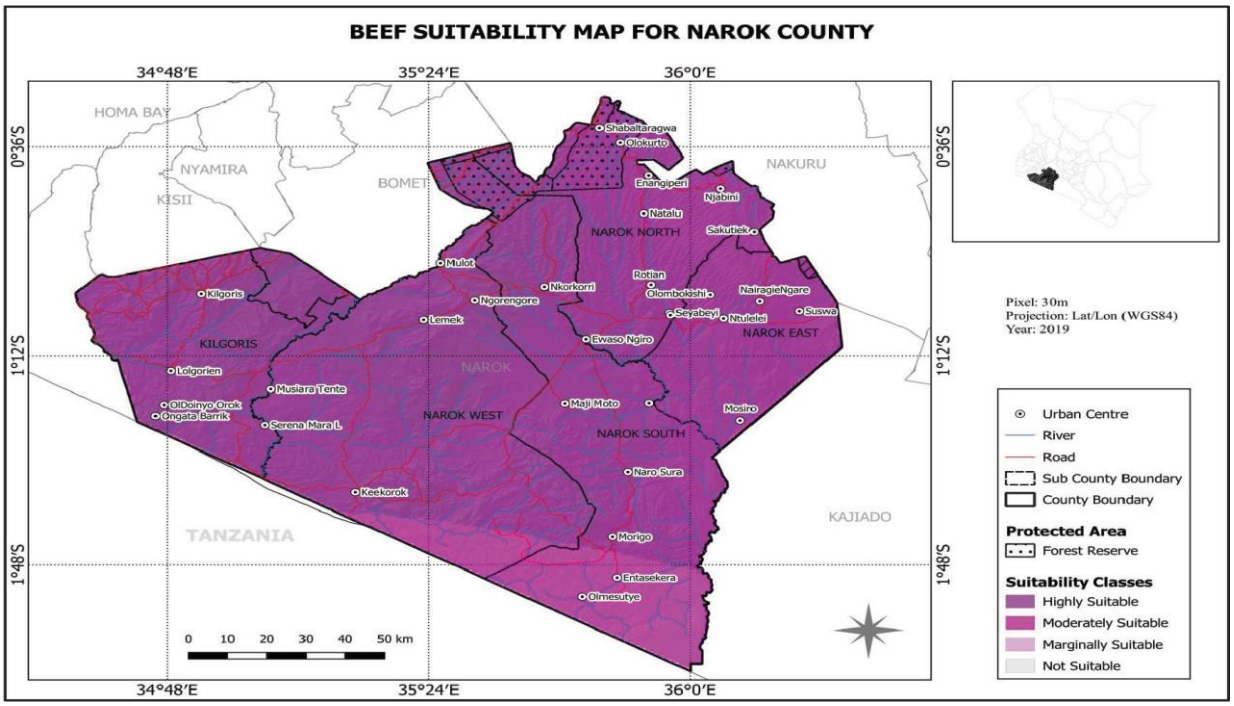

Plate 4.1: *Narok County Beef Suitability*

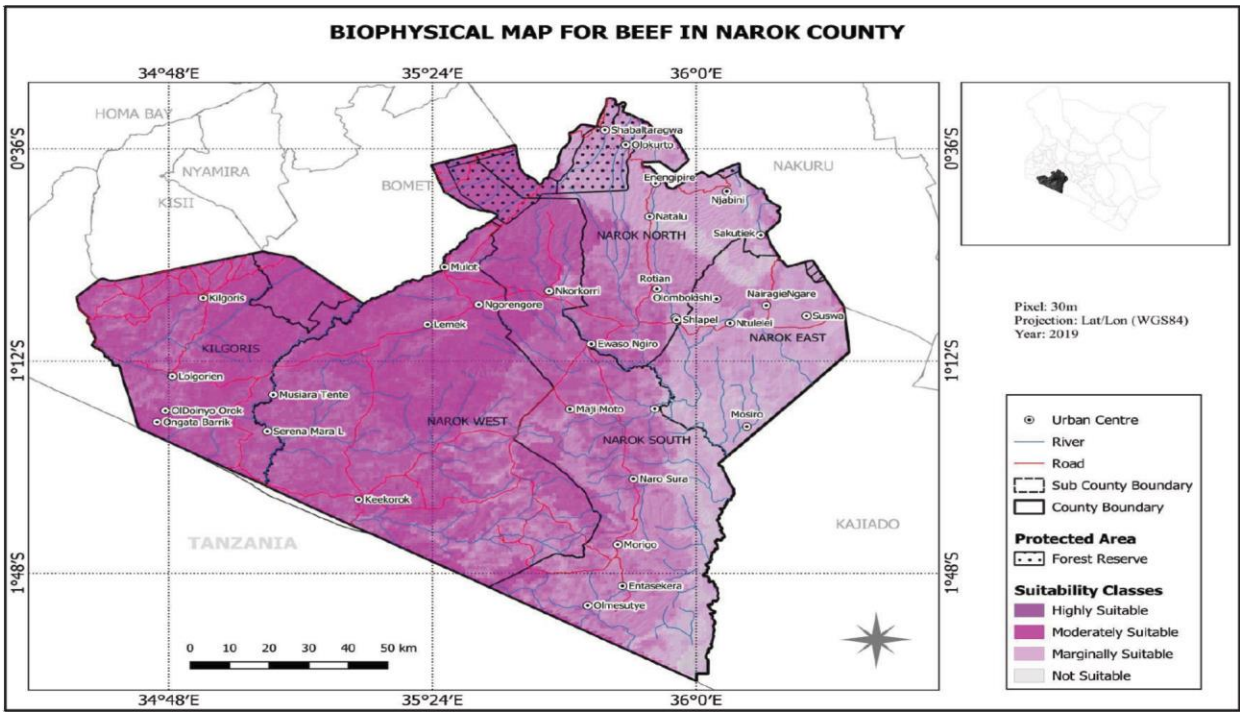

Plate 4.2: *Narok County Beef Biophysical Map*

4.2.3 Adaptation Technologies and Innovations

Adaptation measures

Item	Adaptation Measure
Temperature	Adopt breeds and pasture/fodder species suitable for each AEZ
Rainfall	Rainwater harvesting-pans, in-situ harvesting
Soil fertility	Improve soil physical and chemical conditions
Slope	Soil and water conservation
Tsetse fly	Tsetse eradication actions
THI	Micro-climate modification
Roads	Improve feeder roads to motor standards
Agrarian	Value addition of beef for segmented market
Market	Enhance access to local markets

Technology

- Construct shed and ventilation for hot areas
- Adopt water harvesting technologies such as: Retention ditches, Tumbukiza technology and construction of Negarims
- Use farm Yard Manure and inorganic fertilizers to improve soil fertility
- Construct terraces and stabilize them with grass and fodder trees
- Track tsetse fly using Pheromone traps
- Adopt Housing designs to manage heat levels.
- Practice Agroforestry
- Adopt modern technology for road construction to enhance life span of the road network.
- Beef parts for various market segments
- Strengthen institutions and structures for effective lobbying and marketing

Innovations

- Adoption of Micro climate moderation techniques eg agroforestry
- Rainwater harvesting
- Routine soil sampling, testing/analysis
- Construction of terraces and benches
- Surveillance and spraying
- Improve all feeder roads, with murram and ensure proper drainage to protect road network from destruction
- Improve beef infrastructure including road network to enhance access to market
- Widen market through sourcing for contract markets

4.3 Dairy/ Cow Milk

Indigenous breed are the main livestock breed being reared in the county although in the recent times, farmers farmers have embraced exotic breeds which are better performing in growth rates and production. In the highlands, there is high concentration of dairy cattle compared to the low lands. Thus, Boran, Sahiwal, exotic dairy breeds and their crosses are progressively becoming popular. Dairy value chain is growing faster under intensive and semi-intensive production systems (Narok CIDP 2018-2023).

4.3.1 Parameter Analysis

a) Highly suitable Baseline conditions

- Temperature, 15-25 degrees Celsius falls within the optimal/recommended range 18-27 degrees
- Rainfall 700-1100mm is within the optimal/recommended range 600-1100 mm
- Slopes are appropriate 1-5%, appropriate for animal housing and pasture production
- The total heat index (THI) for the areas is optimal<65, meaning only feed management is what is required to effectively rear the dairy cow.
- There is NIL tsetse infestation; implying incidences of Tripanosomiasis disease are not a threat to the dairy cow.
- The community considers milk as basic food hence their support to value chain and high acceptability of milk makes these areas highly suitable.
- Distance to the market is <2km, making it convenient to buy inputs for dairy production as well as deliver the milk to points of sale.
- There is a huge population of consumers who can afford to buy the milk, hence guaranteeing market for the farmer.
- There is adequate political support through being factored in the CIDP and support with the basic infrastructure and subsidies for milk coolers, breeds, pasture seed and vaccines.

b) Moderately suitable

Rainfall in some areas is slightly below the optimal range hence in-situ rainwater harvesting is required for pasture development

- Soils are moderately suitable in terms of physical and chemical parameters. Land slope is 3-10% making it convenient to house the dairy cow as well as develop pasture. Some pockets (riparian areas and bush land) are infested by tsetse; however, KENTTEC and Department of Livestock Veterinary Services have intervened to manage the pest.
- THI is 65-72, making it mandatory to manage heat stress through adaptation mechanisms such as housing and agroforestry practice.
- Road network is poor while existing roads are not passable during the rainy seasons, thereby delaying delivery of milk to the milk collection points. This also makes it costly to buy inputs from the agro vet shops in urban centres
- Distances to the basic milk aggregation points and cooling plants and associated infrastructure are >7 km

c) Marginally suitable

Rainfall received falls below the lower limit of 800mm, making it difficult to grow pasture and fodder trees. Occasionally, during dry spells, feed has to be imported and stored to sustain the dairy animals; this action eats into the profits from milk enterprise. Milk yield also declines due to insufficient feed and water quantity / quality for the dairy animals.

Temperatures exceed the higher limit of 30 degrees, while the total heat index (THI) range is 72- 75, making it mandatory to modify the microclimate through agroforestry.

The land slope is 25-50 %, classified as very steep, making it mandatory to modify the environment for housing the dairy cow.

The feeder roads network is poor and their conditions are bad, especially during rainy season.

4.3.2 Adaptation measures

- Upscale pasture production and conservation
- Improvement of milk infrastructure
- Adopt milk processing and value addition
- Improve microclimate to manage high heat stress
- Roads and infrastructure improvement under PPP engagement
- Make the unsuitable area free of tsetse flies

4.3.3 Suitability maps

Narok County is moderate to marginally suitable for cow milk value chain with pockets of highly suitable areas in central to the northeastern parts of the county (Plate 4.3).

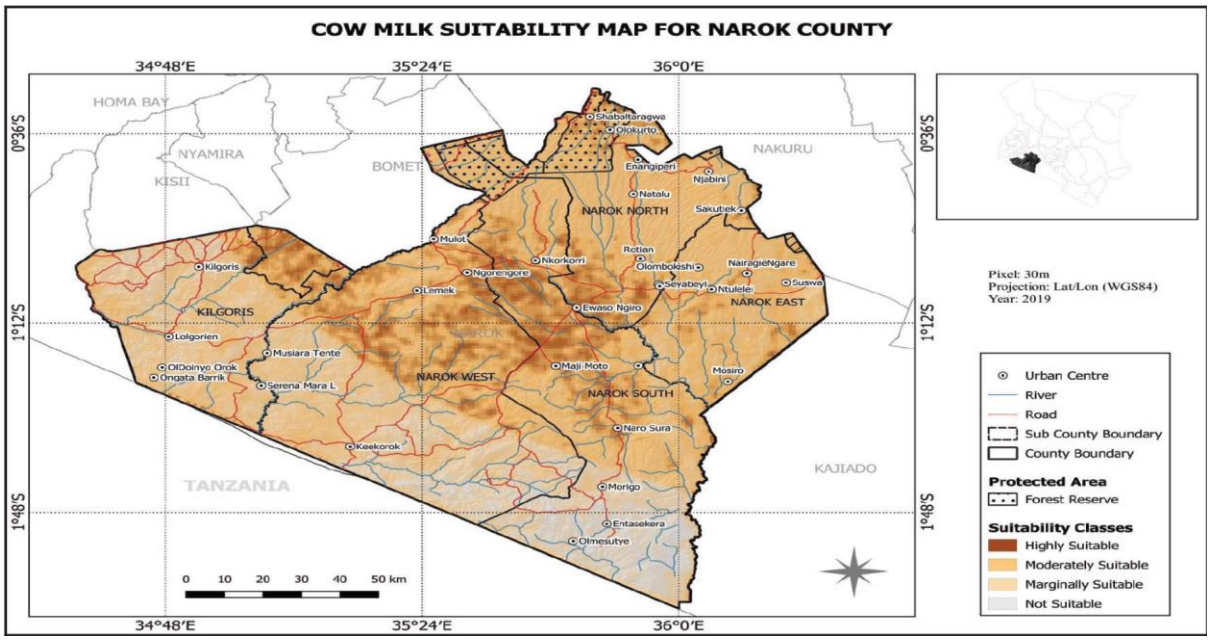

Plate 4.3: Narok County Cow Milk Suitability

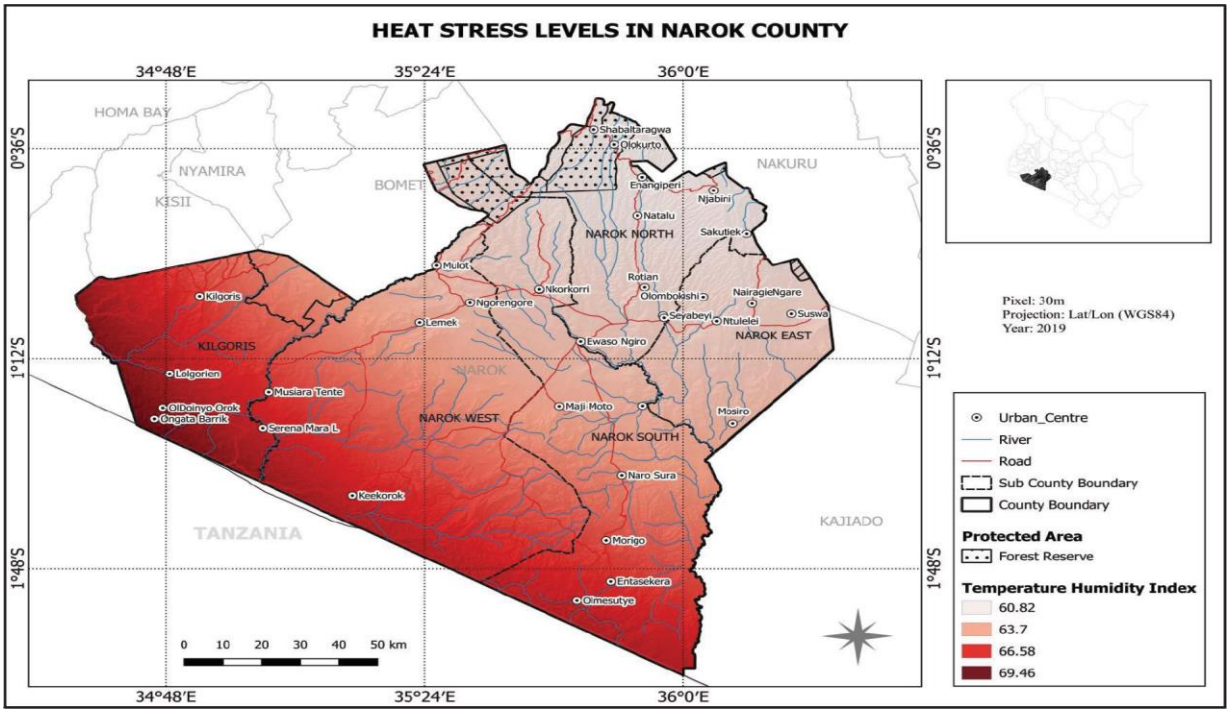

Plate 4.4 Hest Stress levels

4.3.4 Adaptation technologies and innovations

Adaptation

- Upscale pasture production and conservation
- Improvement of milk infrastructure
- Adopt milk processing and value addition

Technologies

- In-situ water harvesting
- Feed production and conservation/storage
- Making milk products: Yoghurt, Mala, Cheese

Innovations

- Adopt: Retention ditches, Tumbukiza technology, Negarims
- Feed formulation in the form of hay, silage, TMR, feed pellets, feed blocks
- Open Milk outlets-milk bar/kiosks
- Milk ATM

Adaptation

- Improve microclimate to manage high heat stress
- Roads and infrastructure improvement under PPP engagement

Innovation

- Improve housing and agroforestry
- Value addition of milk for various market segments
- Lobby for county to avail the machinery for roads improvement

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

The suitability analysis reveals that the priority food value chains of maize, beef and cow milk vary from marginal to highly suitable for Narok County. The maps and the statistical analysis of ranking and weighting provided factual understanding for decision-making. This model is very important in physical planning, especially when preparing spatial development plans, zoning of production areas and integrating agriculture in the urban areas to improve economic competitiveness, food security and sustainable development.

5.2 Recommendations

- Integrated and multi sector approach is required to improve on the suitability of the three value chains
- Unsuitable biophysical factors can be managed to improve micro climatic conditions
- Use of adaptation methods, innovations and technologies is highly recommended
- Agriculture related policies, plans, strategies and regulations are required to attract investment in thesector
- There is need for partnership and collaboration with other programs and projects implementing similar value chains for synergy.

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For more information, contact
ASDSP Secretariat, 6th Floor, Hill Plaza Building,
Community along Ngong Road
P. O. Box 30028 - 00100, Nairobi, Kenya
Tel: +254 721 148 821
Website: www.asdsp.kilimo.go.ke | www.nafis.go.ke

SWEDEN

COUNTY GOVERNMENTS