REPUBLIC OF KENYA

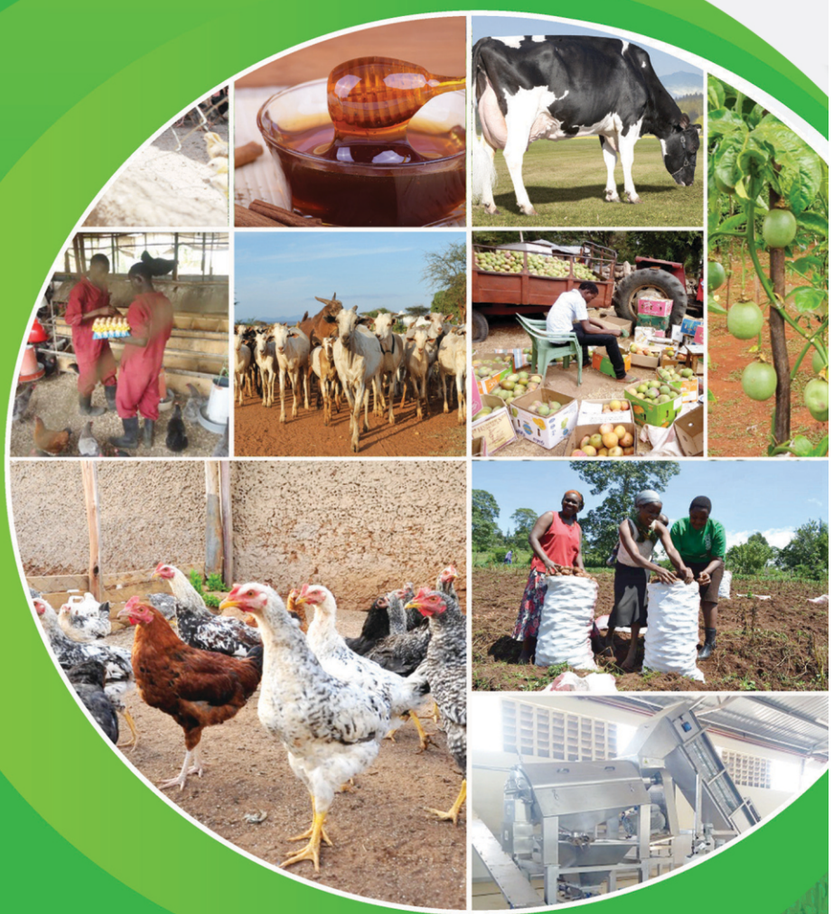
MINISTRY OF AGRICULTURE, LIVESTOCK, FISHERIES AND COOPERATIVES AND COUNTY GOVERNMENTS

ASDSP
AGRICULTURAL SECTOR DEVELOPMENT SUPPORT PROGRAMME

AGRICULTURAL SECTOR DEVELOPMENT SUPPORT PROGRAMME II (ASDSP II)

KAKAMEGA COUNTY PRIORITY VALUE CHAIN SUITABILITY ATLAS

January 2020



"Transforming Kenya Agriculture Sector"

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Agricultural Sector Development Support Programme II (ASDSP II)
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Disclaimer/Cautionary Note (SP)

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ABBREVIATIONS

AHP	Analytical Hierarchical Process
ASDS	Agricultural Sector Development Strategy
AP	Agricultural Policy
APA	Apollo Pan Africa
ASALS	Arid and semi- Arid Lands
ASDSP II	Agriculture Sector Development Support Programme II
ASTER	Advanced Space-borne Thermal Emission and Reflection Radiometer
ASTGS	Agriculture Sector Transformation and Growth Strategy
BDO	Business Development Officer
CA	Conservation Agriculture
CECM	County Executive Committee Member
CI	Consistency Index
CIC	Corporate Insurance Company
CIDP	County Integrated Development Plan
CO	Chief Officer
CPS	County Programme Secretariat
CR	Consistency Index
DEM	Digital Elevation Model
ESP	Economic Stimulus Program
FAO	Food and Agricultural Organization
GDEM	Global Digital Elevation Model
GDP	Gross Domestic Product
GIS	Geographical Information System
IWD	Inverse Distance Weighted interpolation
ILWIS	Integrated Land and Water Information System
ILRI	International Livestock Research Institute
KALRO	Kenya Agricultural and Livestock Research Organization
KEMFRI	Kenya Marine and Fisheries Research Institute
KCC	Kenya Cooperative Creameries
KCEP-CRAL	Kenya Cereal Enhancement Programme-Climate Resilience and Agricultural Livelihood
KDB	Kenya Dairy Board
KEPHIS	Kenya Plant Health Inspection Services
KFA	Kenya Farmers Association
KFS	Kenya Forest Services

KNBS	Kenya National Bureau of Statistics
KES	Kenya Shilling
MCE	Multi Criteria Evaluation
NARIGP	National Agriculture & Rural Inclusive Growth Project
NDMA	National Drought Management Authority
NEMA	National Environment Management Authority
NRM	Natural Resource Management
NPS	National Programme Secretariat
PWCM	Pairwise comparison matrix
PVC	Prioritized Value Chain
QGIS	Quantum Geographic Information System
RCI	Random Consistency Index
RCMRD	Regional Centre of Mapping of Resources for Development
SID	Society for International Development
Soil OC	Soil Organic Carbon
Soil CEC	Soil Cation Exchange Capacity
Soil AWC	Soil Available Water Content
Soil pH	Soil potential for hydrogen
USD	US Dollars
VC	Value Chain
VCA	Value Chain Actors
VCO	Value Chain Organization
VRL	Veterinary Research Laboratories
WB	World Bank
WETF	Women Enterprise Trust Fund
WGS	World Geodetic System

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 which 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 (20190 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 Kakamega 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 (cow milk, indigenous chicken and maize) 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 also guide current and future programs actions that will lead to realization of food and nutrition secure and wealthy households.

Mrs. Rachel Okumu OGW. CGJ.
CECM Agriculture, Livestock, Fisheries, Cooperatives and Irrigation.
COUNTY GOVERNMENT OF KAKAMEGA.

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 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 chair persons.

We are grateful to the National Programme Secretariat for the support during the exercise. We also take this opportunity to return our gratitude to the management of AL&F department and the entire staff establishment

Albert Atenya Ochenje MEP.
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 Kakamega 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 Kakamega county priority value chain being implemented by Agriculture Sector Development Support Programme (ASDSP) II different maps have been developed .

The base suitability condition for the production of cow milk value chain, after considering all the above parameters and variables, classify Kakamega county as moderately suitable for the growth and production of cow milk , improved indigenous chicken as moderately to highly suitable, and maize as marginally to highly suitable. Kakamega County offers a good opportunity for the improvement of value chain performance.

As regards 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 milk and chicken meat collection centers, improvement of cow and chicken shelter, improvement of meat and milk 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, irrigation, rain water harvesting, development of water infrastructure, planting cover crops and contour farming.

capacity building efforts on entrepreneurial skills 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, use of submersible solar powered hybrid water pumps, terracing , use of contour bands, use of cut off drains, supplementary feeding, paddocking, ranching, breed improvement, value addition, expansion of market segments, establishment of milk and chicken collection centers, contractual agreement, establishment of market info sharing platforms, use of greenhouse and shade nets, flood 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 chain.

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 replanting of degraded areas with indigenous and other improved tree 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, greenhouse, shed nets and mulching.

The suitability analysis reveals that the priority food value chains of meat goat, camel milk and kales vary from marginal to highly suitable in Kakamega 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 meat goat 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.**).

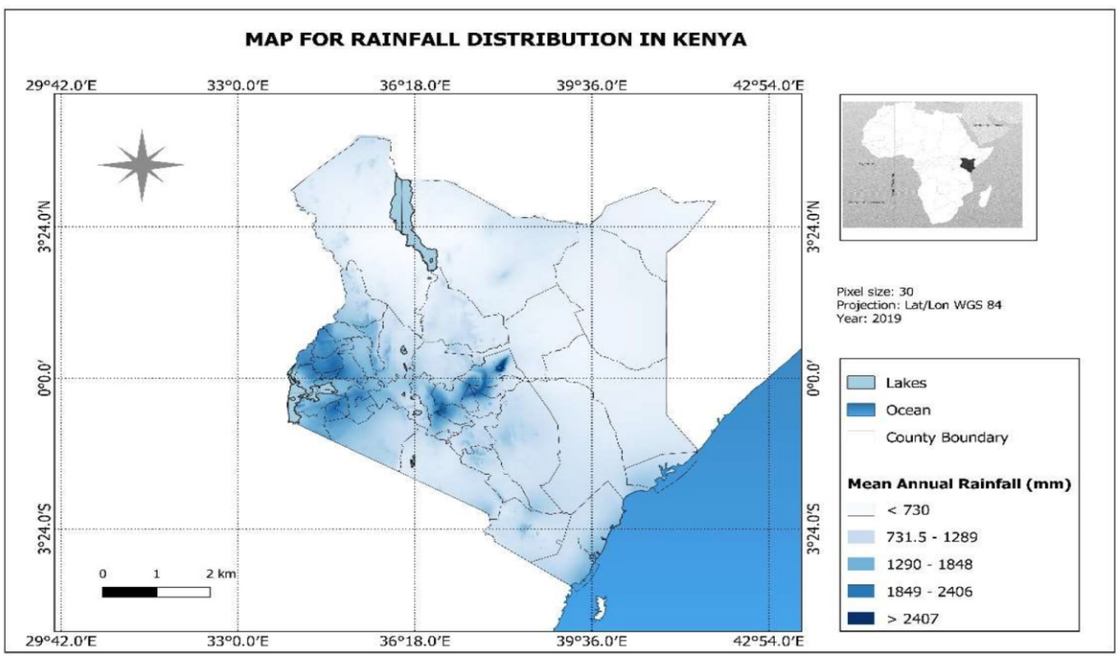


Figure 1: *Kenya Rainfall distribution*

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.

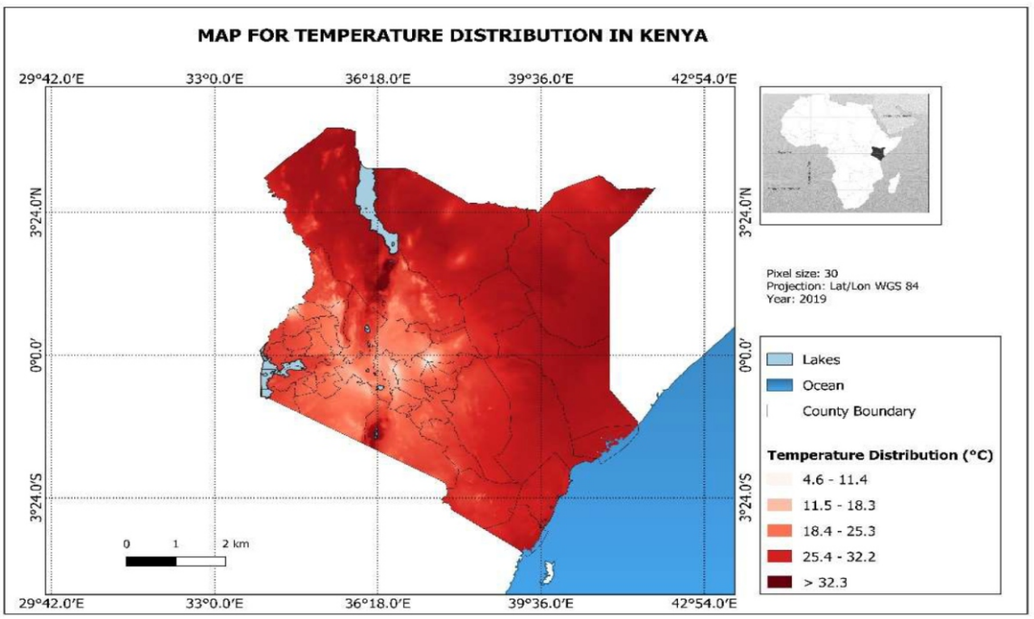


Figure 2: *Kenya Temperature*

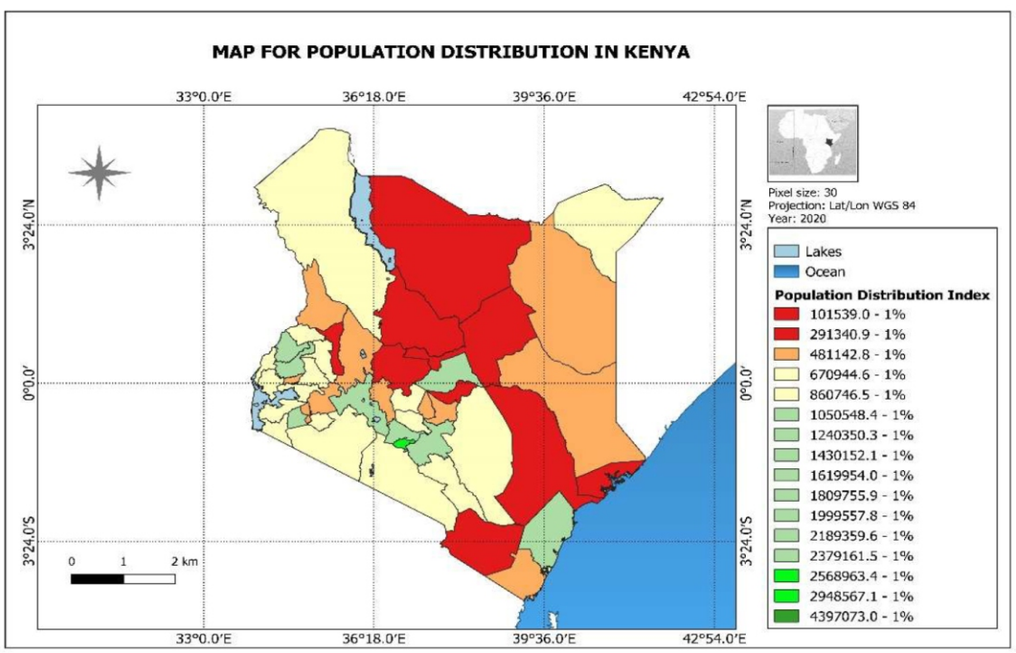


Figure 3: *Kenya Population Density*

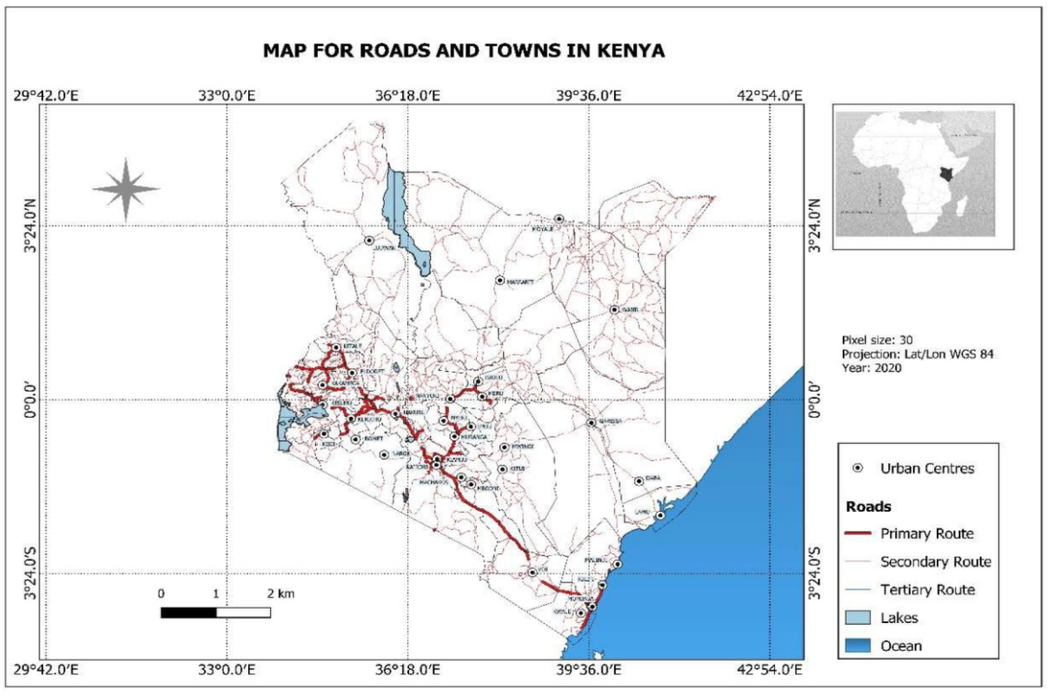


Figure 4: *Kenya Roads and Major Towns*

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				Indigenous Chicken
		Maize		26	Meru	Maize
		Indigenous Chicken				Cow Milk
		Irish Potato				Indigenous Chicken
3	Buugoma	Cow Milk		27	Migori	Cow Milk
		Indigenous Chicken				Sweet Potato
		Tomatoes				Indigenous Chicken
4	Busia	Indigenous 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
		Indigenous Chicken				Cow Milk
7	Garissa	Tomatoes		31	Nakuru	Pyrethrum
		Camel Milk				Fish
		Beef				Cow Milk
8	Homa Bay	Indigenous Chicken		32	Nandi	Maize
		Fish				Indigenous 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
		Ban				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 of priority 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 conventional agro ecological zoning procedures (Error! Reference source not found.4) and the soil suitability mapping (**Error! Reference source not found.5**) processes.

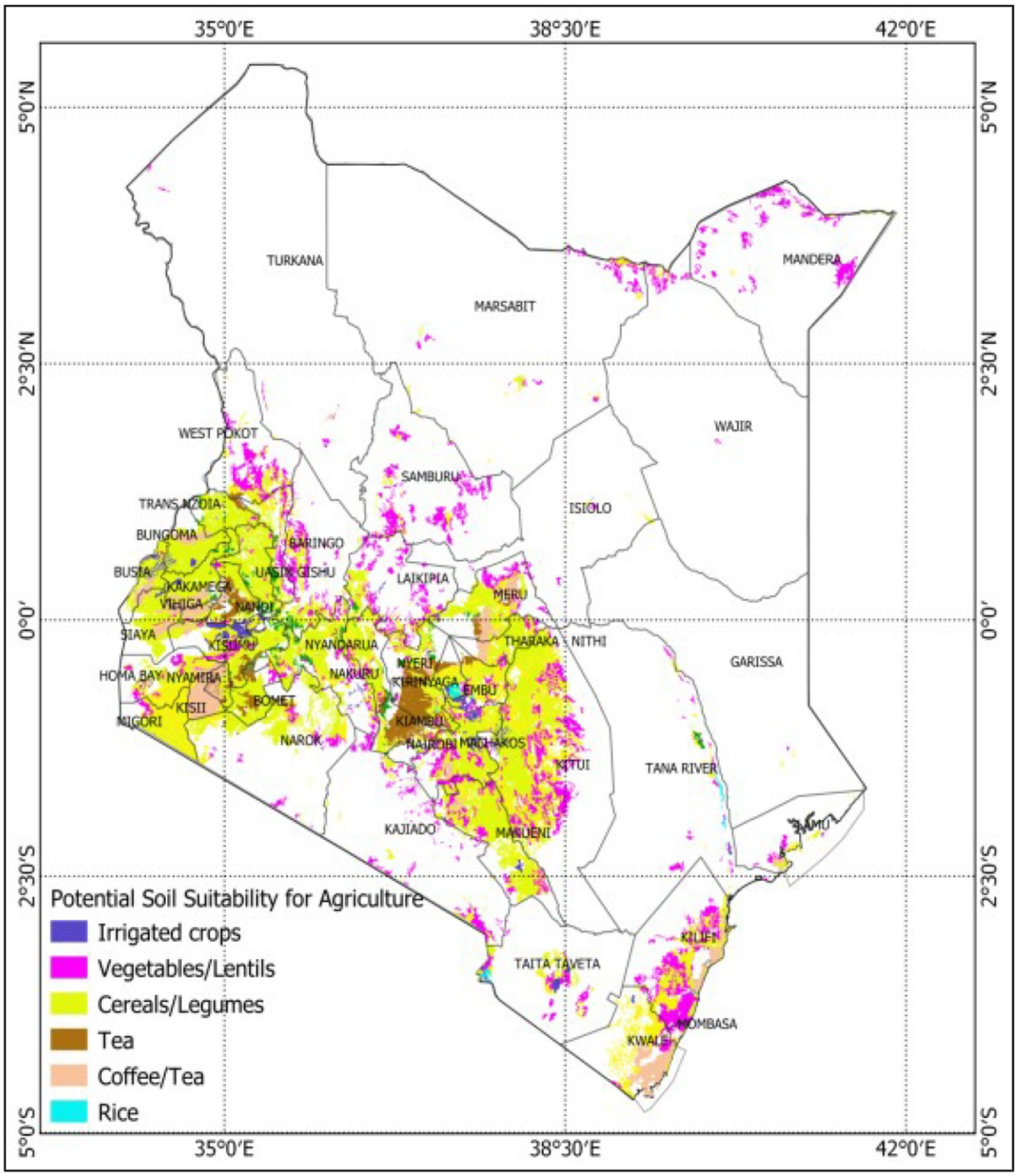


Figure 5: *Soil suitability classification*

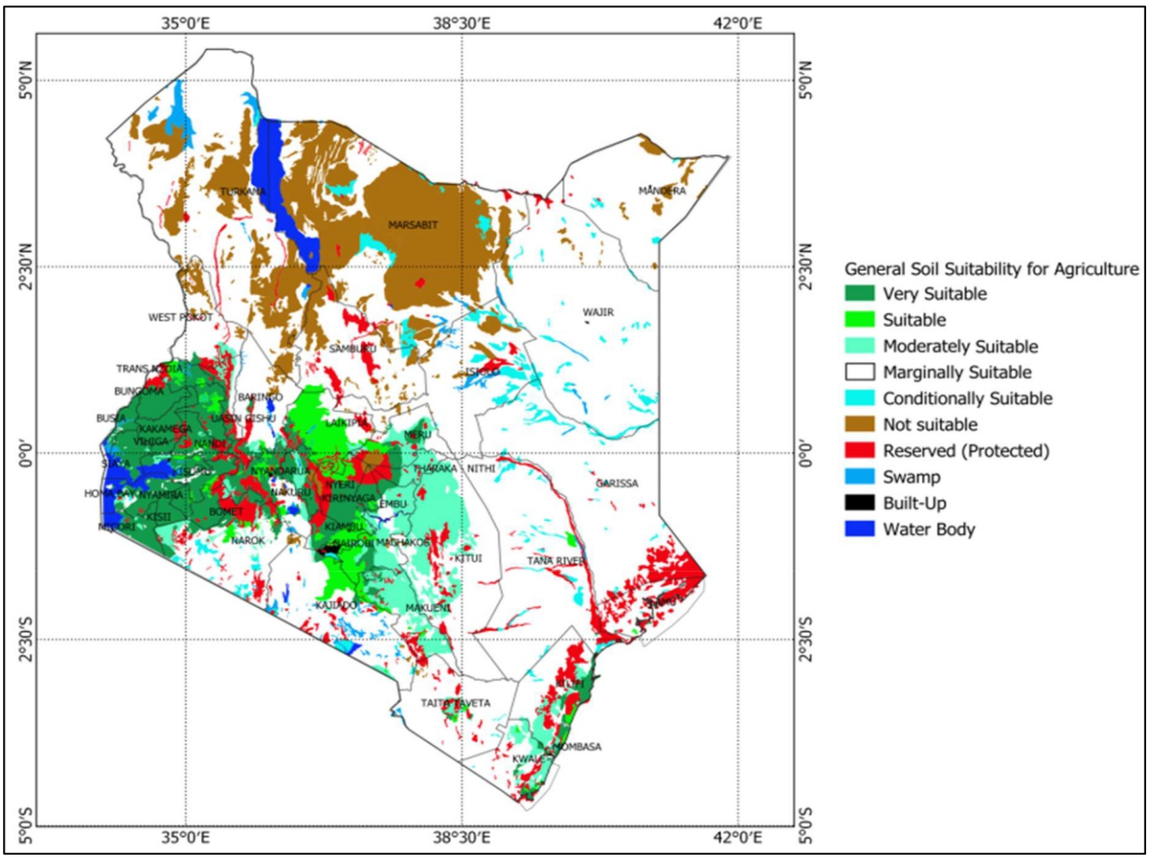


Figure 6: *Soil suitability classification*

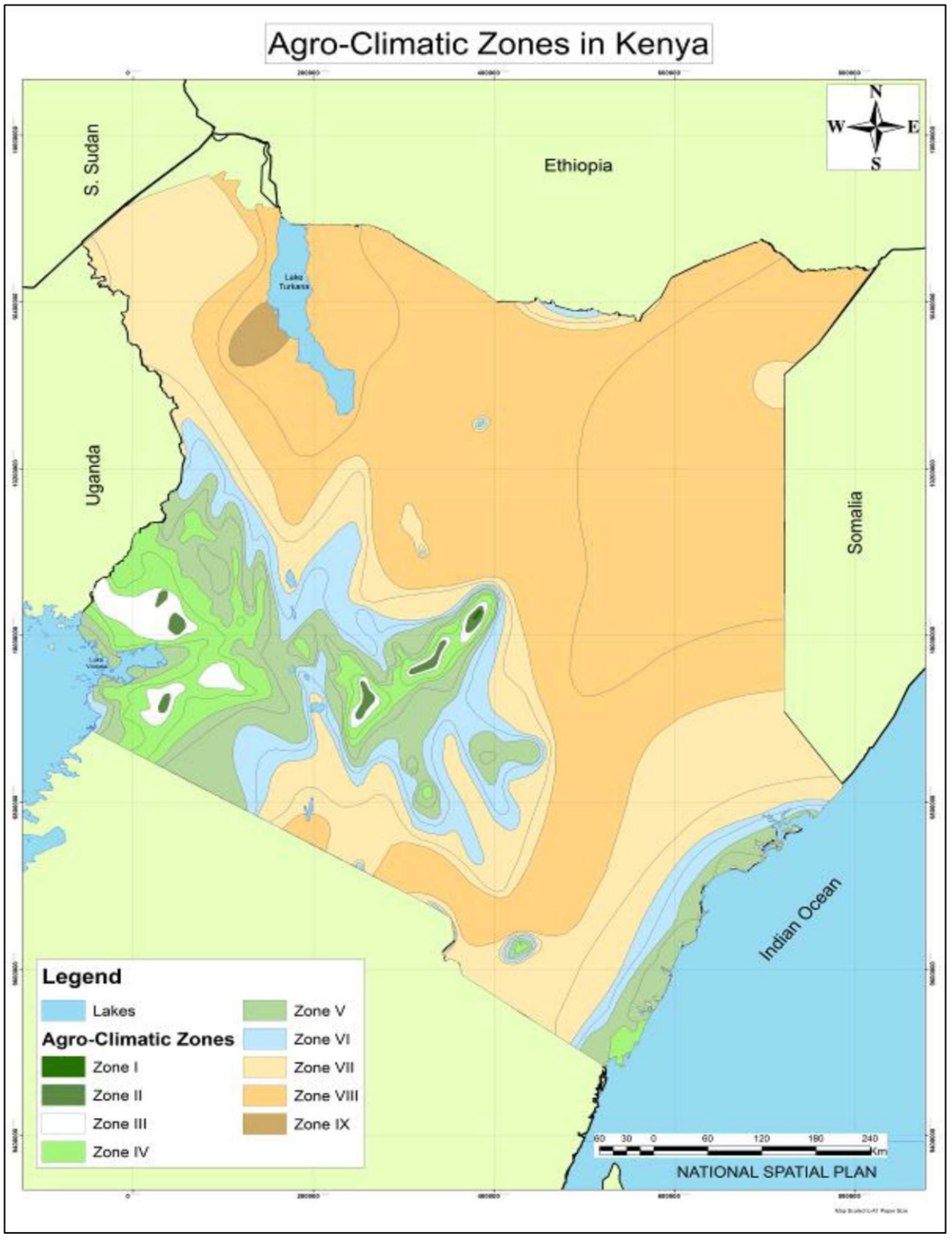


Figure 7: *Agro ecological zones*

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;

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 (GDEM V2) and processed on ILWIS and SAGA to analyze the terrain.

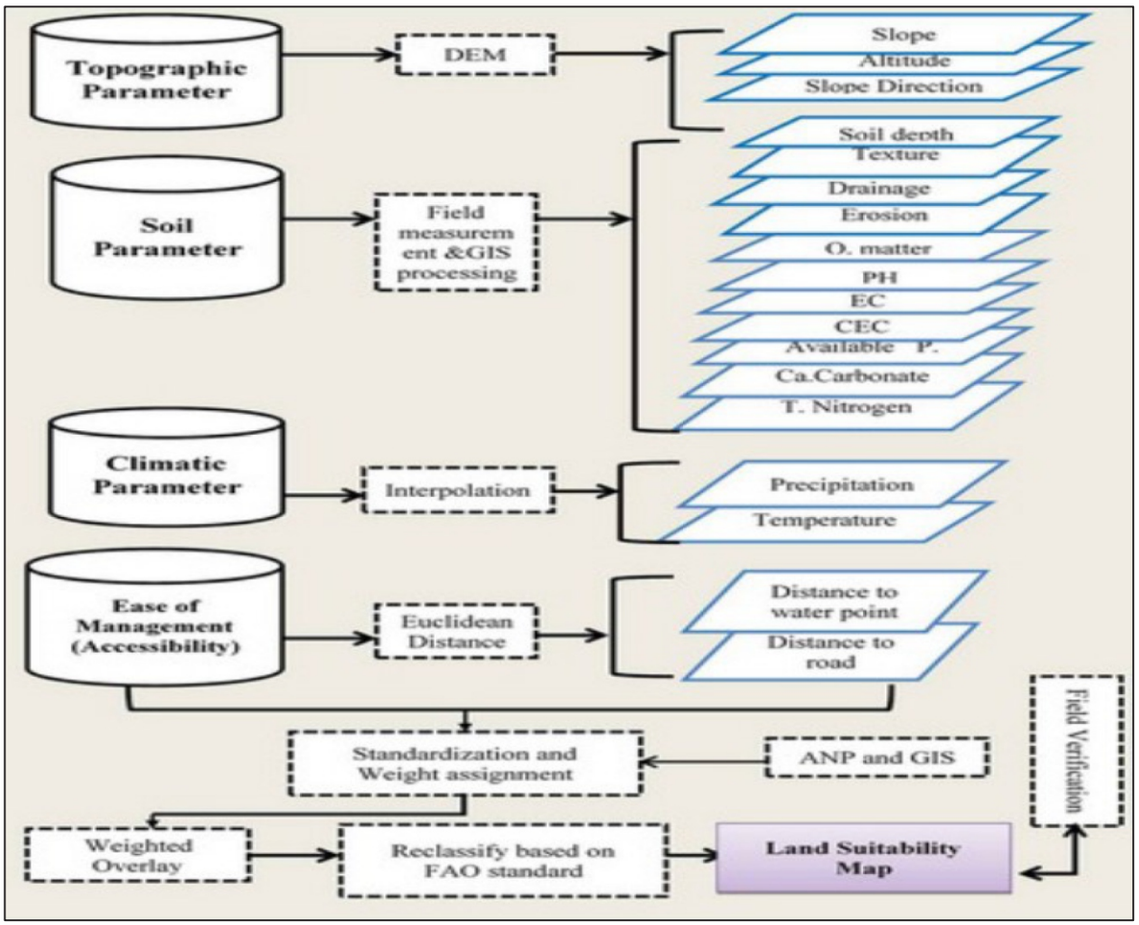


Figure 8: *Suitability mapping process*

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

The county resources that were considered for the purpose of suitability mapping were temperature rainfall, soils, road network, market access, population density and the social agrarian index

3.1 County background

Kakamega County has a population of 2.1 million persons (2009 National Housing & Population Census). It's the largest of the 4 Counties constituting former Western Province; Bungoma, Busia and Vihiga and covers an area of 3,050.3KM^2. The average land holding in the County is 1.5 acres per farm family (CIDP, 2018-2022). Administratively the County is divided into 12 constituencies and sub-counties (see figure 9).

The County has a bimodal rainfall pattern with an average of 1000-2000 mm per annum and mean temperatures range from 11 to 31°C. There are 2 Major Agro-Ecological zones upper midland (UM) and lower midland (LM) which supports a wide range of crops. Major food crops in the County include; Maize, beans, sweet-potatoes, bananas, sorghum, Irish potatoes, indigenous vegetables and cassava. Agriculture is the mainstay of Kakamega populace and contributes 65% of total income.

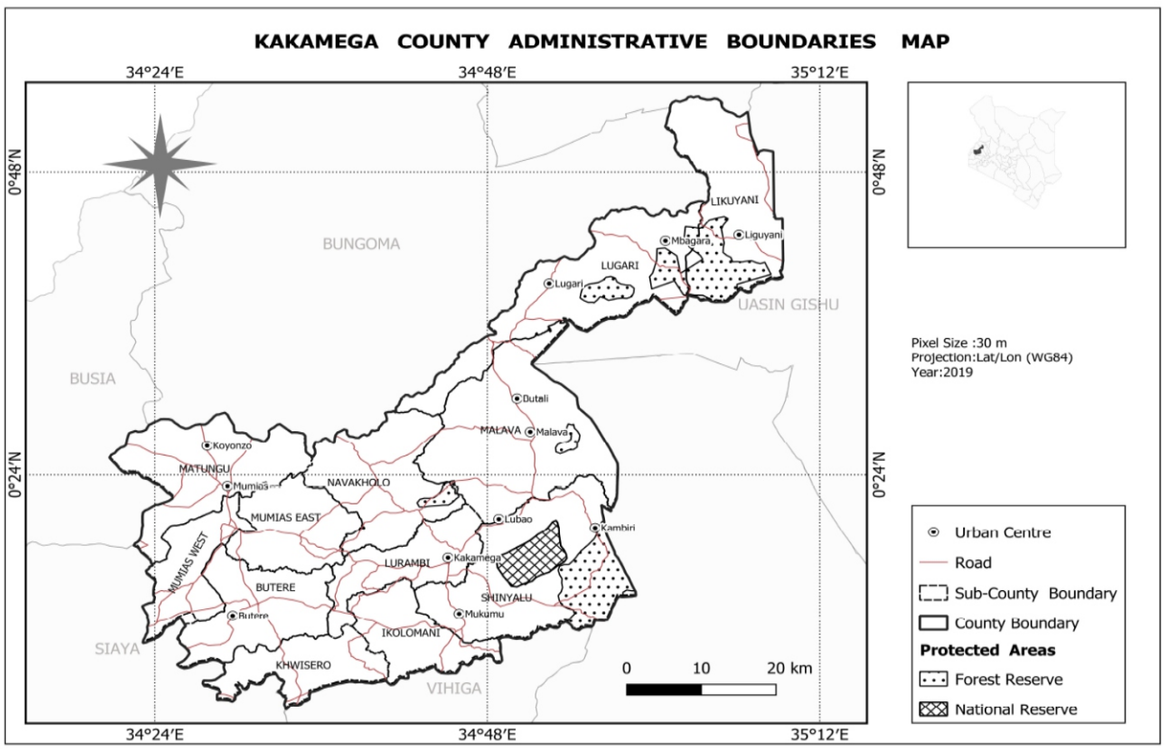


Figure 9: *Kakamega County administrative boundaries*

3.2 County Biophysical Resources

Kakamega biophysical resources that affect value chain development are temperature, rainfall, water, wind and soils. Those applied for mapping were temperature, rainfall, land slope and soils. The annual rainfall in the county ranges from 1280 - 2214 mm. The rainfall pattern is evenly distributed all year round with March and July

receiving heavy rains while December and February receive light rains. Recent trends show a marked increase in inter-annual variability and distribution of rains, with an increase in the number of consecutive dry days and shorter but more intense periods of rainfall resulting in an increase in frequency of floods. The temperatures range from 11°C to 30°C. Most parts of Kakamega County soils range from 5.0- 4.9 pH yet

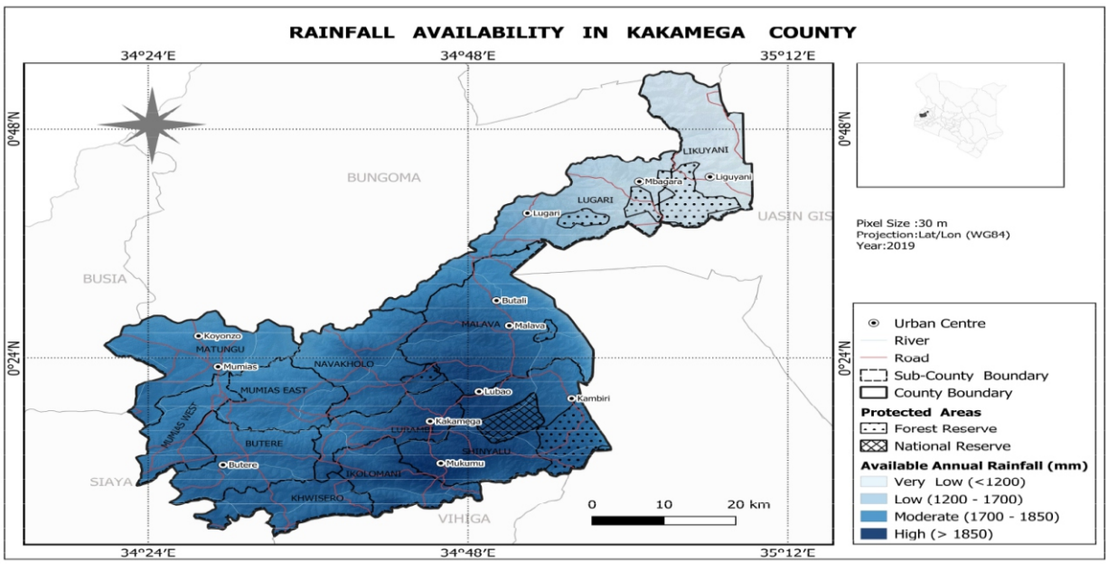


Figure 10: *Rainfall availability in Kakamega County*

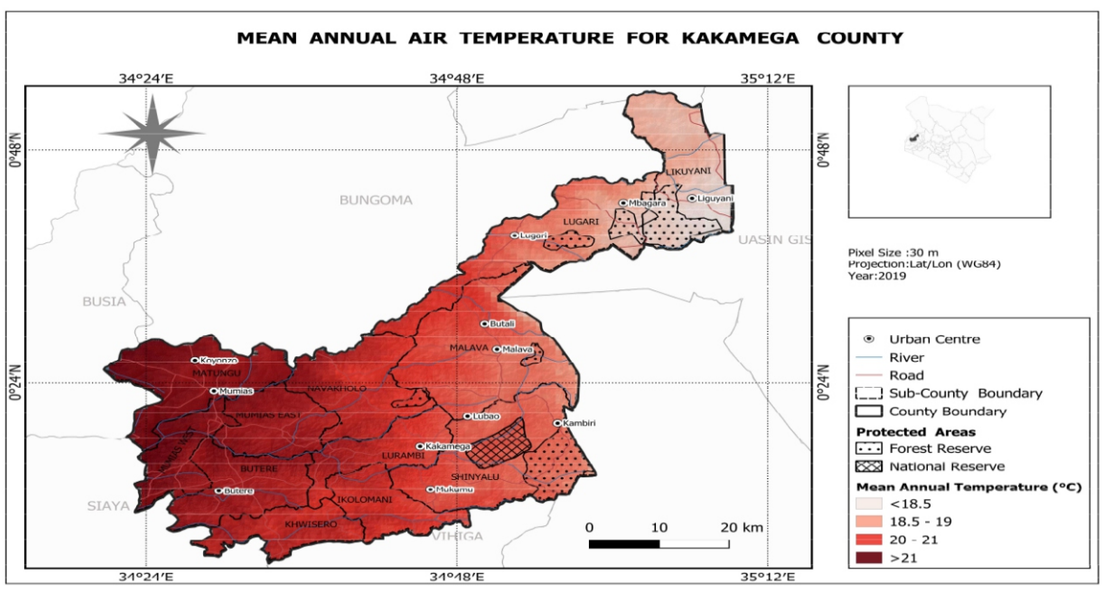


Figure 11: *Mean annual air temperature for Kakamega County*

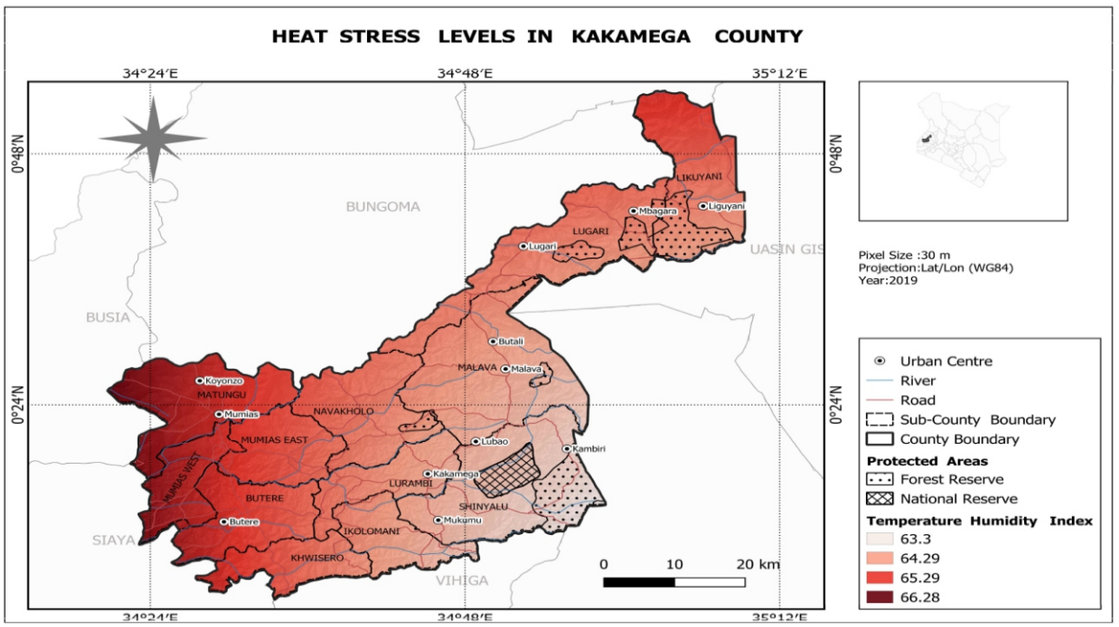


Figure 12: *Heat stress levels in Kakamega County*

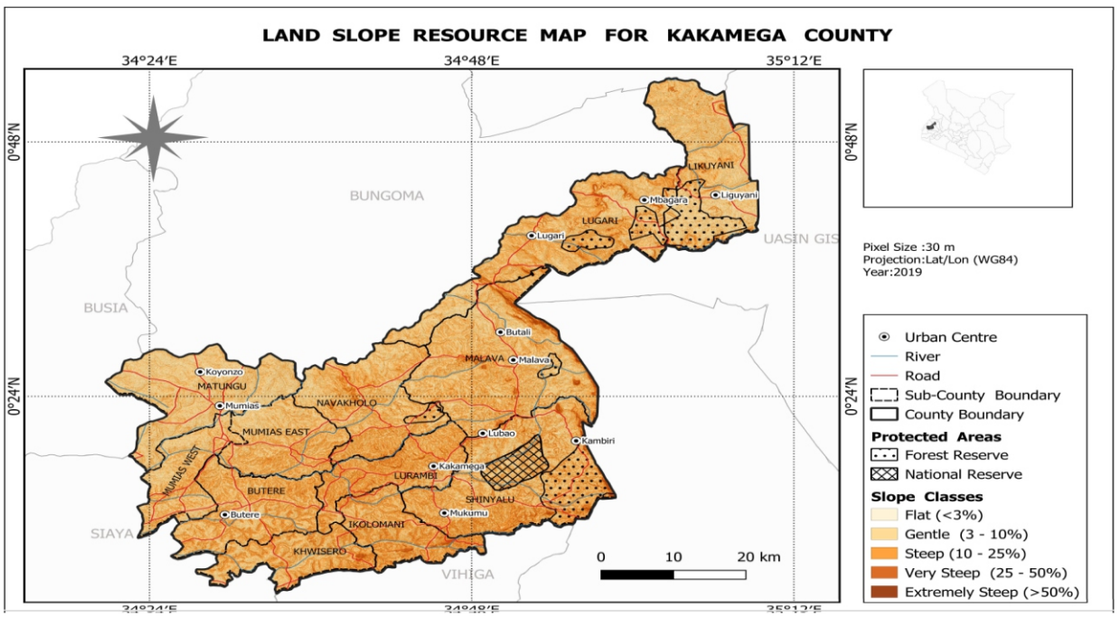


Figure 13: *Land slope resources for Kakamega County*

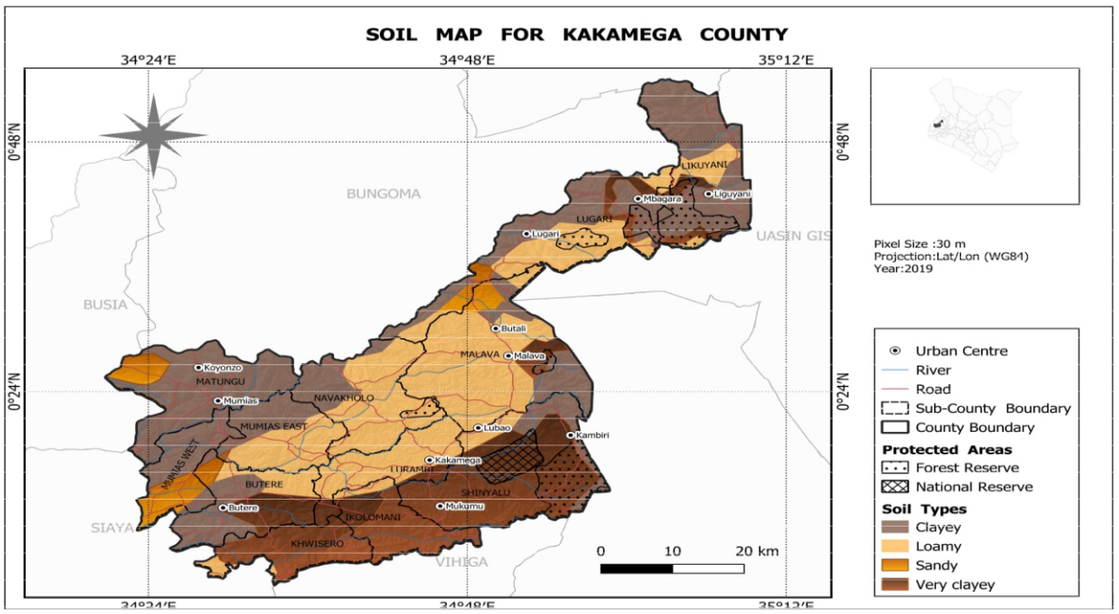


Figure 14: *Soil map for Kakamega County*

3.3 Economic parameters

The economic parameters analyzed included access to roads and markets including demographic characteristics.

Market access

Most markets in Kakamega County are moderately accessible (see figure 15). This is because of good road network constructed by the County Government.

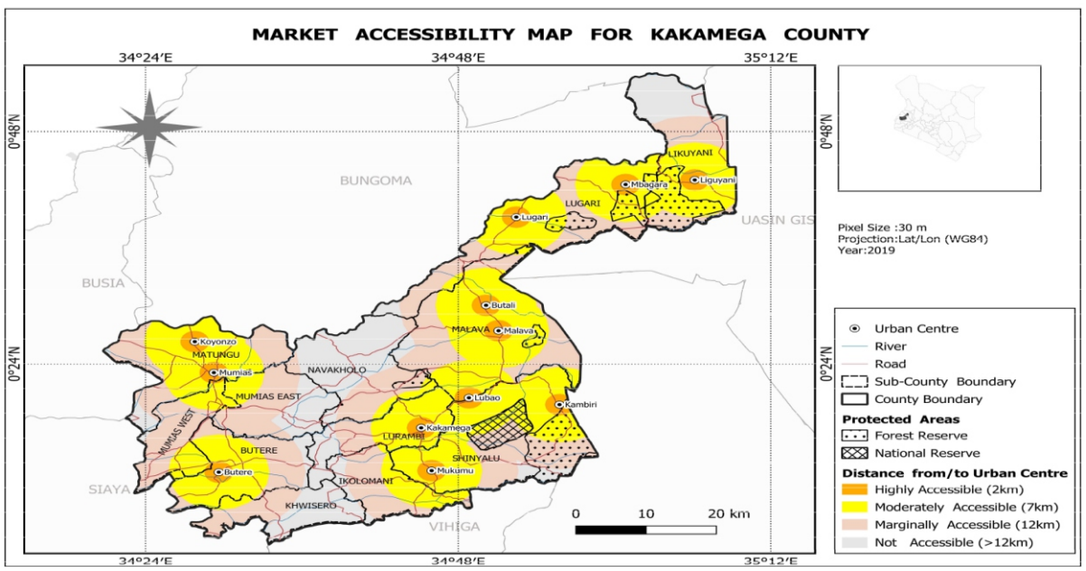


Figure 15: *Market accessibility map in Kakamega County*

Road access

The total inventory of roads in the County is at 4,451.3Km which comprises 2,236.17 Km for gravel, 1,308.90 Km for earth surface and 939.32 Km for narrow unpaved roads. The bitumen and gravel standard roads stand at 307.5 Kms and 2,792.25 Kms respectively. On routine maintenance a total of 589.5 Kms of graveled road has been maintained to ensure efficient road network. The County is served by the Kisumu-Kakamega-Kitale highway and the rehabilitated to Kisumu – Ebuyangu - Mumias - Bungoma road will improved accessibility of County.

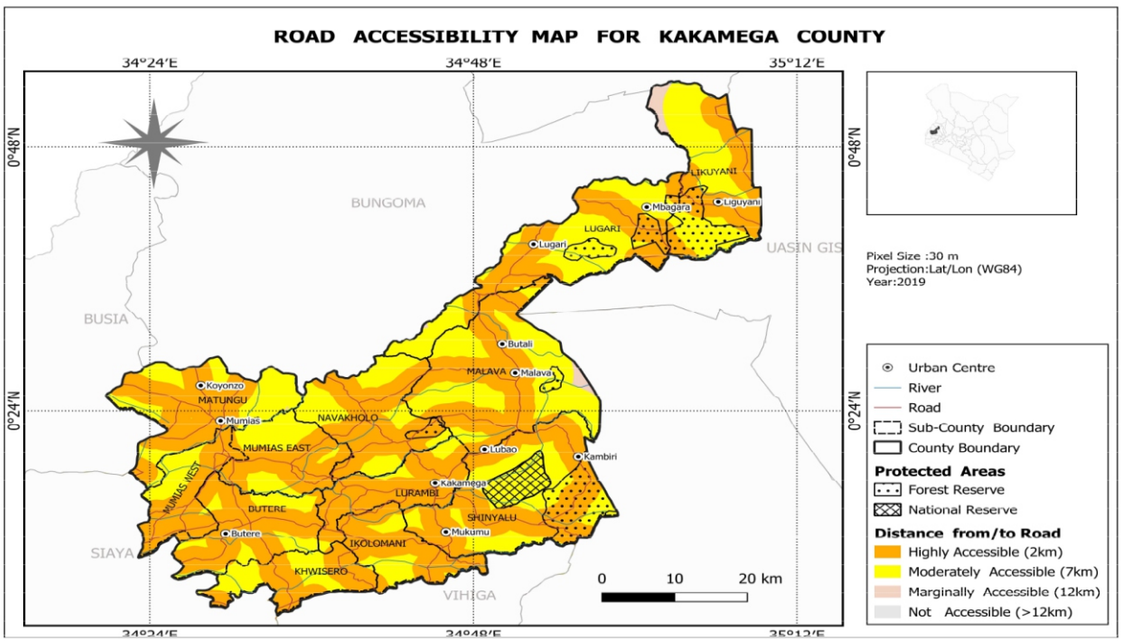


Figure 16: *Road accessibility map for Kakamega County*

3.4 The Agrarian characteristics of Kakamega people

The County had a population of 1,660,651 comprising of 800,896 males and 859,755 females. This population is projected to be growing at an annual growth rate of 2.5 %. The residents of Kakamega are predominantly mixed farmers keeping both livestock and crops. The livestock and crop enterprises are well received and supported socially by the agricultural communities.

4. PRIORITIZED VALUE CHAIN SUITABILITY MAPS

4.1 Background

The analysis of biophysical, economic and social characteristics of Kakamega show that the county is moderately to highly suitable place for the commercialization of cow milk, improved indigenous chicken and maize value chains.

4.2 Cow milk value chain

4.3 Biophysical parameters and thematic maps Cow milk value chain

the County receives between 1,280 to 2,214mm of rainfall annually which largely runs off untapped and can be harnessed. There are 35 dams and 50 water pans existing in the county which are not enough to harness and store much of the surface runoff that drains off into these water bodies. The temperatures range from 18 ^{0}C to 29 ^{0}C. January, February and March are the hottest months with other months having relatively similar temperatures except for July and August which have relatively cold spells. The county has an average humidity of 67 percent. The biophysical parameters are presented in Table 9.

Table 9: *Biophysical Parameter analysis for Kakamega County*

Parameters	**County specific parameters**	**Value chain Parameters**	**An evaluation between B&C**
Soil Fertility Index	0 - 50	>1	Highly suitable
Rainfall (mm)	<1200 - >1850	>1100	Moderately Suitable
Tsetse fly risk	None	<1	Moderately suitable
Temperature in ^{0} C	<18^{0} - >21^{0}C	15 - 20	Highly suitable
Slope (%)	0% - 40%	<8	Highly suitable
THI	<65	<68	Moderately Suitable
Agrarian culture		>4	
Market Index		<3	Highly Suitable

The cow milk value chain is moderately suitable in Kakamega County as shown in figure 17 below.

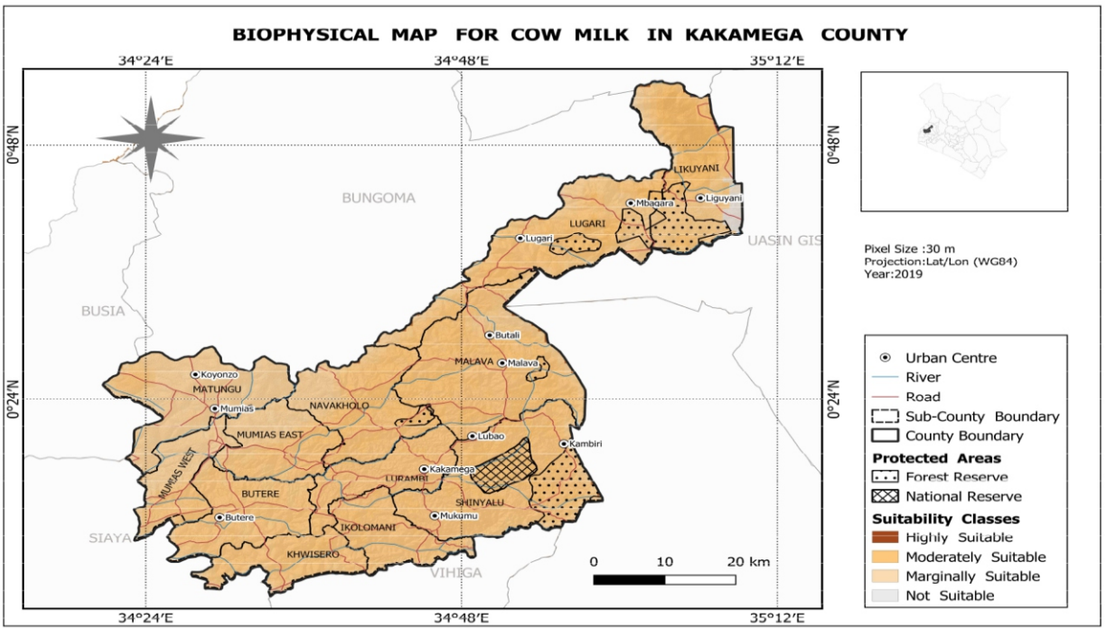


Figure 17: *Biophysical map for cow milk value chain in Kakamega County*

4.2.2 Kakamega County cow milk suitability classes

The cow milk value chain is moderately suitable in most part of Kakamega county (figure 18) though the soils are not suitable in a few parts of the county (figure 19).

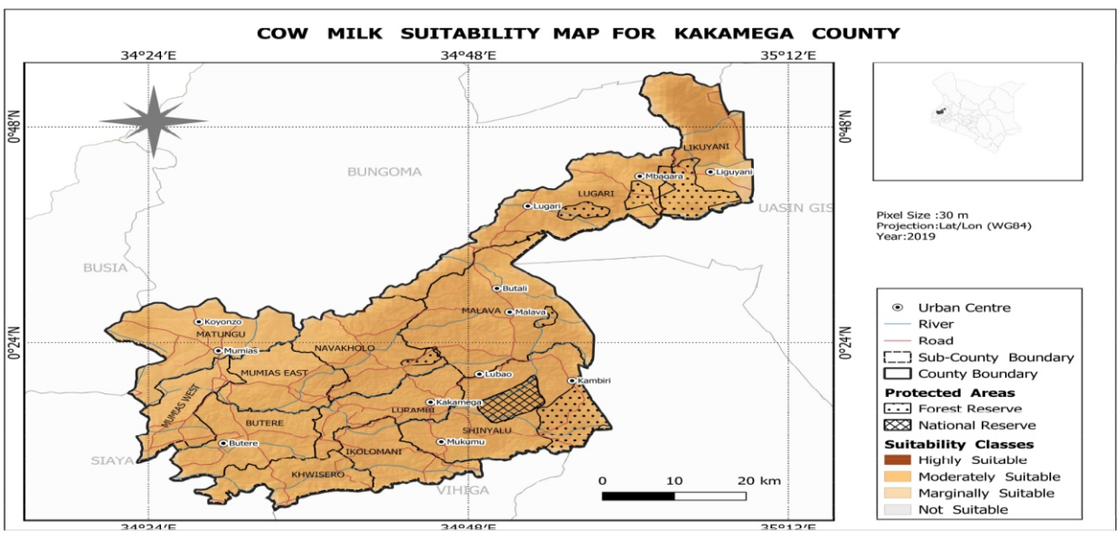


Figure 18: *Cow milk suitability map for Kakamega County*

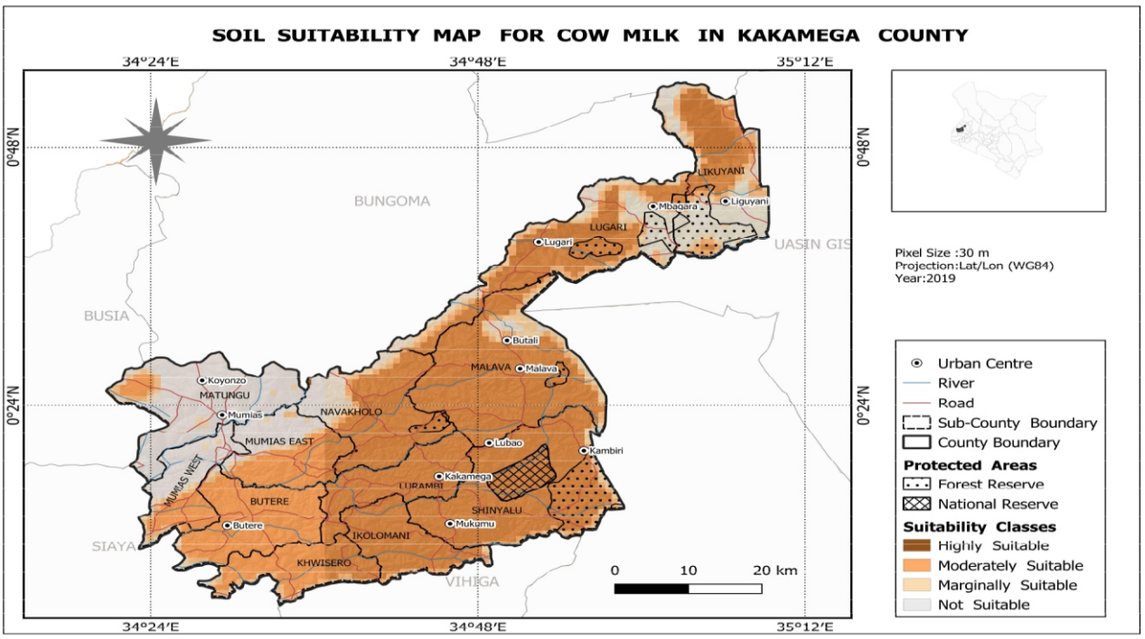


Figure 19: *Soil suitability map for cow milk in Kakamega County*

4.2.2 Adaptation measures

Various modifications need to be adopted to enhance productivity of dairy cow milk value chain. These include rainwater management for improved fodder and pasture productivity, in-situ and supplemental irrigation water harvesting, irrigation and industrial water harvesting as depicted in figure 20 below.

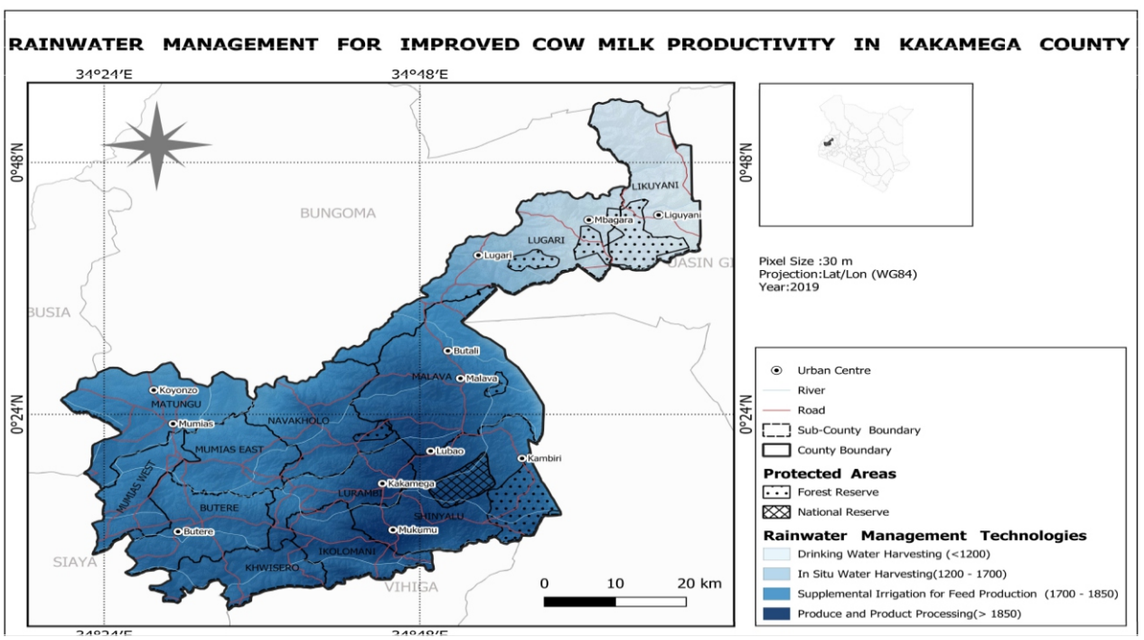


Figure 20: *Rainwater management for improved cow milk productivity in Kakamega County*

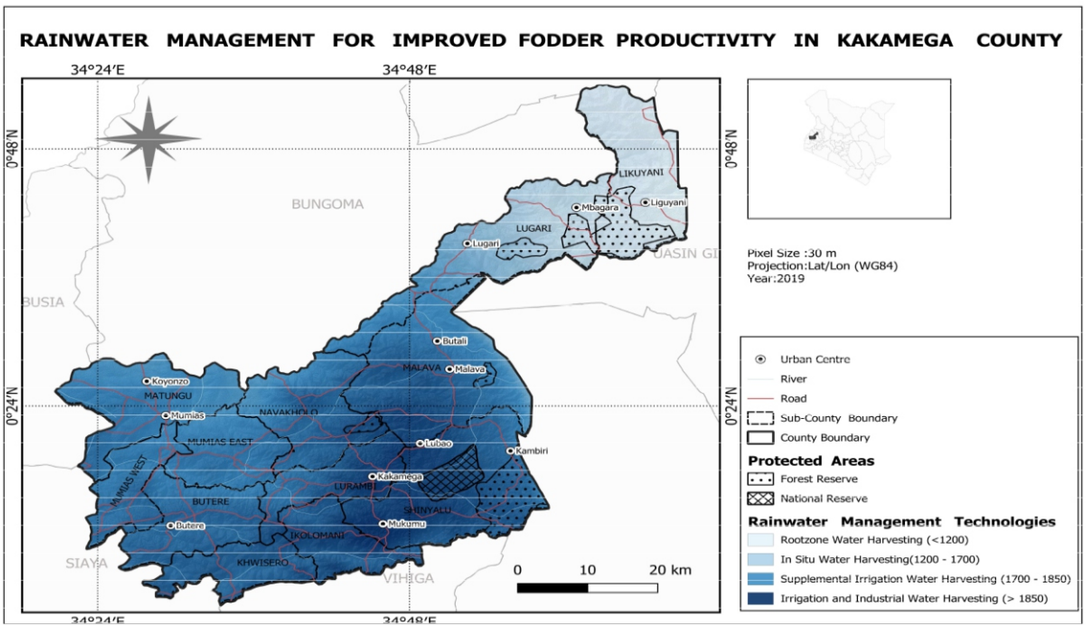
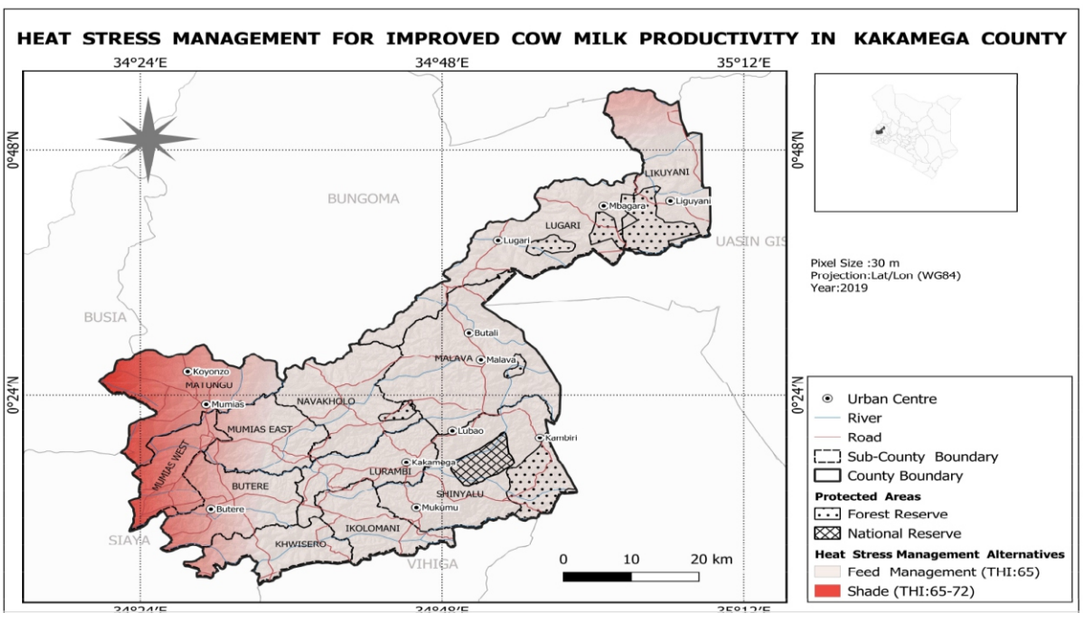


Figure 21: *Water management for improved fodder productivity in Kakamega County*

Heat stress management



4.2.3 Adaptation technologies and innovations

To enhance the productivity of the cow milk value chain the technologies and innovations to promote include: Artificial insemination; milk collection centers; milk coolants and agroforestry for shed and feed; digital software to that map all the dairy cows and their production level in the county.

4.3 Improved Indigenous Chicken

4.3.1 Biophysical parameters for improved indigenous chicken

Improved indigenous chicken is a superior crossbreed which produces more eggs, and matures faster compared to the typical indigenous chicken. The improved IC is marginally to highly suitable for Kakamega County. The parameters presented in table 10 below.

Table 10: *Biophysical Parameter analysis for indigenous chicken in Kakamega County*

Parameters	[B] County specific parameters	[C] Value chain Parameters	An evaluation between B&C
Temperature	<18^0 - >21^{0}C	<25^{0}C	Highly suitable
THI (%)	<65	<65	Highly Suitable
Average Humidity	<65	<70%	Moderately suitable
Agrarian culture	1 - 4	>4.2	Moderately Suitable
Market Index	1.5 - >8	>8	Highly suitable
Land slope °C/%	0% - 40%	<1 (0.3%)	Moderately Suitable

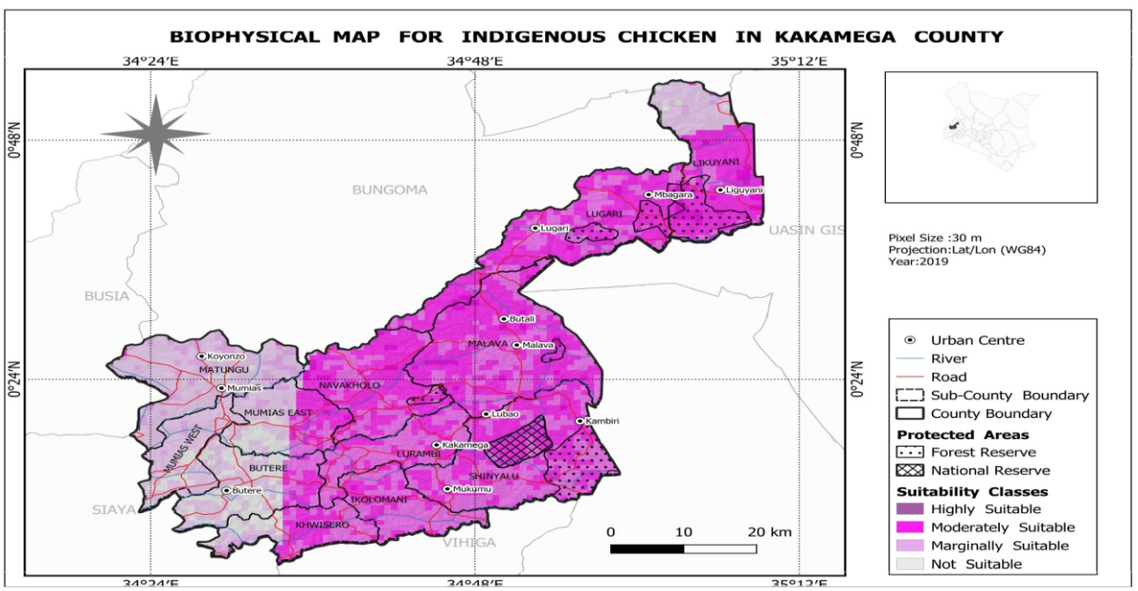


Figure 22 : *Biophisical map for indegenous chicken, Kakmenga County*

4.3.2 Suitability classes of improved indigenous chicken in Kakamega County

The analysis of the suitability classes revealed that improved indigenous chicken is moderately suitable for Kakamega county as shown in figure 23 below.

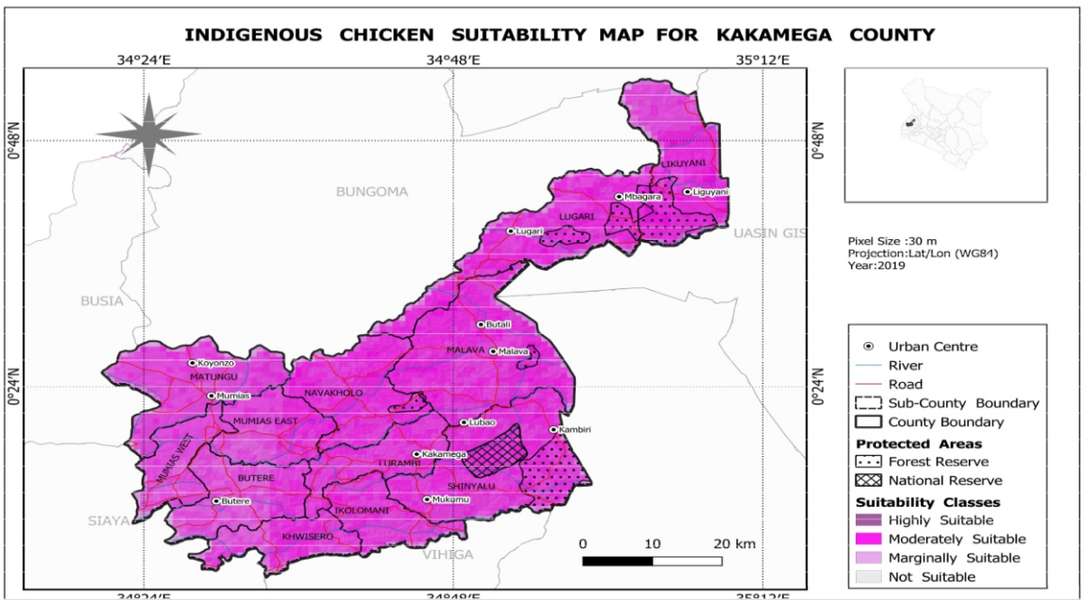


Figure 23: *Indigenous chicken suitability map for Kakamega County*

4.3.3 Adaptation measures

The IC adaptation measures include; use of non- charcoal brooders, vaccination calendar, farm feeds formulation, sensitization on breeding management, good poultry practices; use of auto metered feeds & drinkers, enhanced use of pelleted feed and Promote use of Naivasha feeder.

4.3.4 Adaptation technologies and innovations

Adaptation technologies include construction of suitable house with a run to enable birds both housed and scavenge; use of air conditioners in poultry houses; develop county policies on poultry and use of thermo-stable vaccines. Innovations include; develop poultry vaccination campaigns programmes for poultry diseases on quarterly basis; e-marketing, inculcate farmers with entrepreneurial skills, farmer group marketing; meat and egg collection centers and agroforestry for feed and shade.

4.4 Maize

The mean maize acreage is 1.5 acres with a yield of 14 bags (90kg) per acre which is very low as compared to the county's potential of 25 bags per acre.

4.4.1 Parameter Analysis for Maize Value Chain

The maize value chain is marginally to highly suitable in Kakamega County. The parameter specific ranges and their implication on the maize VC development is as summarized in the table 11.

Table 11: *Parameter analysis for maize value chain Kakamega County*

Parameters	**[B] County specific parameters**	**[C] Value chain Parameters**	**An evaluation between B&C**
Temperature	20^0C - 21^0C	21^0C - 32^0C	Highly suitable
Total Rainfall	1280.1mm 2214.1mm	900 – 1000mm	Highly Suitable
Moisture Availability	60 - 120	<100.	Highly suitable
Texture	l, cl, scl, sil	l, cl, scl, sil	Highly suitable
Drainage	Poorly to well drained	Well drained soils	Highly suitable
PH	4.2 - 6.48	5.5 - 7.0	Highly Suitable
CEC	15 - 20	> 20	Highly suitable
Organic carbon	Low to high	High	Highly suitable
Effective soil depth	< 25 - 80	> 75	Moderately suitable
Stoniness	> 50 – non gravelly	Non gravelly	Moderately suitable
Salinity (EC saturation extract)	10 – non saline	Non saline	Highly suitable
Sodicity (ESP)	>15	Non sodic	Moderately Suitable

4.4.2 Biophysical Parameter analysis

Analysis of biophysical parameters revealed that maize value chain is marginally to highly suitable in Kakamega county as shown in figure 24.

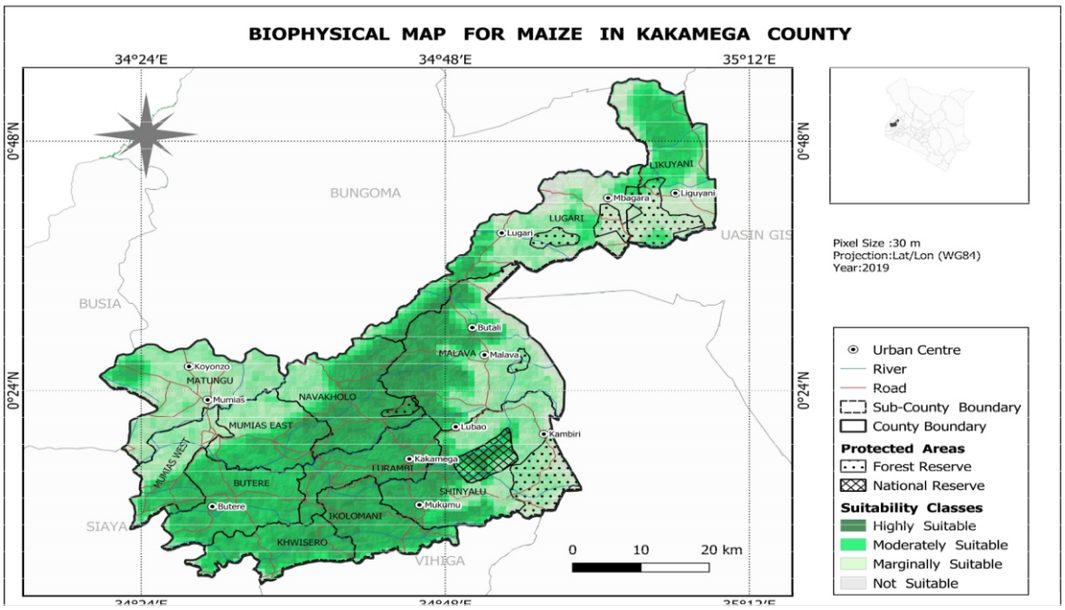


Figure 24: *Biophysical map for maize in Kakamega County*

4.4.3 Suitability classification of maize value chain, Kakamega County

Maize value chain is marginally to highly suitable in Kakamega County as shown in figure 25.

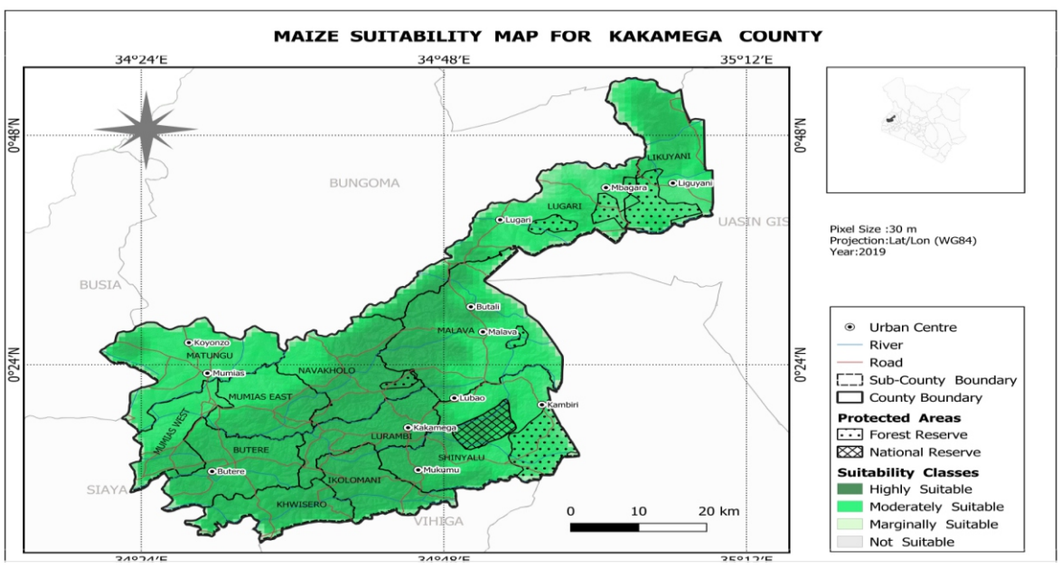


Figure 25: *Maize suitability map for Kakamega County*

4.4.4 Adaptation measures

The adaptation measure to improve the productivity of maize value chain include; use of organic manures, composting, rotation or intercropping cereals with legumes and leguminous cover crops and increased biomass productivity through the combined use of mineral fertilizers and organic materials. Soil testing, rain water management as shown in figure 26; land mechanization (fig 27) and slope modification fig 28 below.

Rainwater management

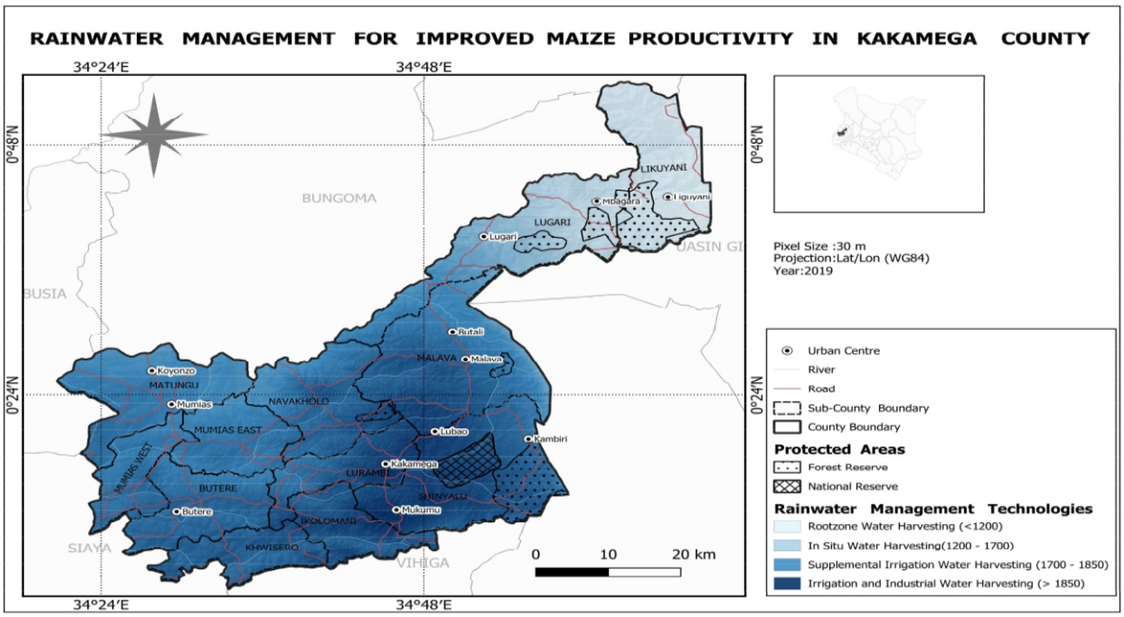


Figure 26: *Rainwater management for improved maize productivity in Kakamega County*

Land mechanization

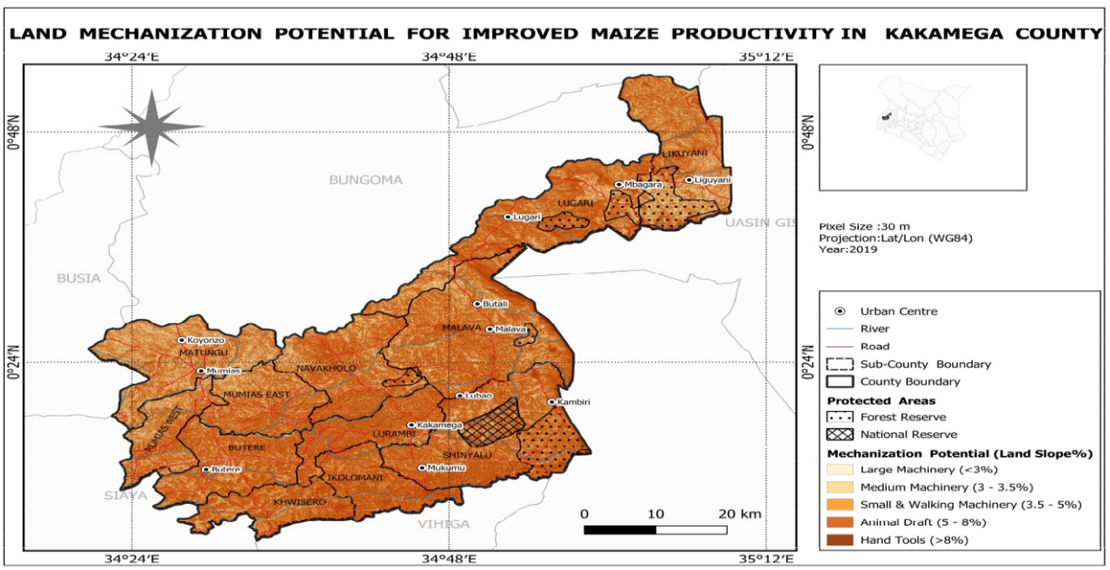


Figure 27: *Land mechanization potential for improved maize productivity in Kakamega County*

Slope modification

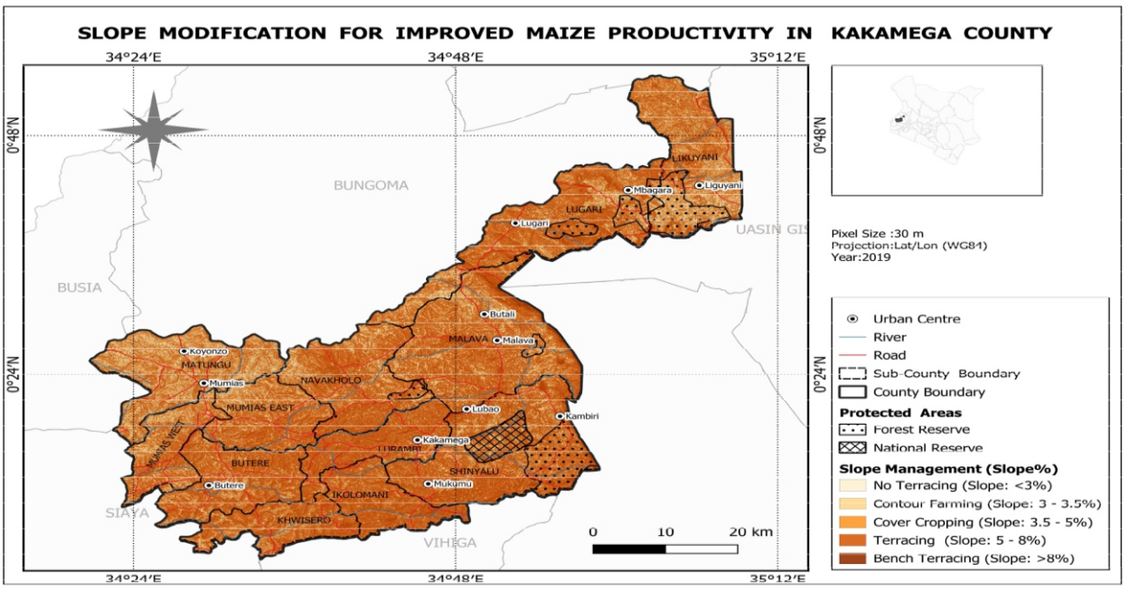


Figure 28: *Slope modification for improved maize productivity in Kakamega County*

4.4.5 Adaptation technologies and innovations

In the areas where the soil pH is less than 5.1 it should be raised with application of organic fertilizers and or/and liming; maize drying and use of hematic bags for storage; value addition; group marketing and e-marketing and inculcate entrepreneurial skills on chain actors.

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The suitability analysis reveals that the priority food value chains of cow milk, improved indigenous chicken and maize marginal to highly suitable for Kakamega 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 cow milk, improved indigenous chicken and maize suitability
- 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 the sector
- There is need to partner with other programs and projects implementing similar value chains for synergy.

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COUNTY GOVERNMENTS