ELGEYO MARAKWET COUNTY PRIORITIZED VALUE CHAINS SUITABILITY ATLAS

Cow Milk, Irish Potato and

OCTOBER 2020

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 its economic and social targets. The sector's Agricultural Sector Transformation and Growth Strategy (20190 2029) focuses on among others; increasing the income of 3.3 million small scale households through enhancement of land productivity and agro-processing and boosting household food resilience against environmental and fiscal shocks. The county government of Kakamega in collaboration with other development partners and specifically with initial support from the government of Sweden and the European Union has brought the realization of this goal a step closer through the Agricultural Sector Development Support Programme (ASDSP II). The programme 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 adaptation priorities 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 to address the constraints that affect productivity of the prioritized value chains. The adaptations,

innovations and technologies proposed to improve value chain performance are crafted as low lying fruits for action by all.

I wish to encourage all stakeholders to not only study Atlas but also to utilize the data and information to inform choices for implementation. As a department, we are committed to use the findings to improve value chain productivity and also to inform evidence based county domestication of policies and strategies and to guide current and future programming.

Sign…….

Anne Kibosia
County Executive Committee Member
Department of Agriculture and Irrigation

ACKNOWLEDGEMENT

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 county wide resource mapping was to provide information to inform intervention decisions to improve value chain productivity. The technical resource map development exercise at the county was undertaken by a county multi-disciplinary team in the period of June 2019 to January 2020.

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 to address any factor constrains.

I take this opportunity to extend special recognition and appreciation to those who contributed to the success of this exercise. In particular mention is made of members of the National Programme Secretariat, Value Chain Organisations, the County Programme Secretariat, the Service providers drawn from the University of Nairobi and representatives of value chain actors. I also acknowledge the valuable contribution made by the county executive with particular regard to staff drawn from the department of Crops, livestock and Cooperatives. To you all, I say thank you.

Jane Talam

Elgeyo Marakwet County Programme Coordinator

Agricultural Sector Development Support Programme II (ASDSPII)

Published by the
©The Agricultural Sector Development Support Programme
Offices Hill Plaza, Community Hill Nairobi and County headquarters Elgeyo Marakwet

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P.O. Box 30028-00100 Nairobi, Kenya
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March, 2020

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EXECUTIVE SUMMARY

ASDSP II is part of the implementation strategy of the Agricultural Policy (AP) for the National and County Governments. The overall goal of ASDSP II is to contribute to "transformation of crop, livestock and fishery production into commercially oriented enterprises that ensure sustainable food and nutrition security". The Programme Purpose is "to Develop Sustainable Priority Value Chains for improved income, food and nutrition security".

ASDSP II addresses four key problems that hinder commercialization of agriculture i.e. low productivity along the entire Prioritized Value Chains (PVC) inadequate entrepreneurial skills along the PVCs and among service providers, low access to markets by Value Chain Actors (VCAs) and weak and inadequate structures and capacities for consultation, cooperation and coordination within the Sector.

Value chain suitability mapping was done to address issues affecting agricultural sector PVCs. The three prioritized value chains in Elgeyo Marakwet County are cow milk, Irish Potatoes and indigenous Chicken. The County parameters that were considered in classifying suitability were biophysical, social, economic and political factors.

Economic parameters that include market access, roads and population have the highest influence on cow milk and indigenous chicken value chains while biophysical factors are the critical constraining conditions that affect commercialisation of the Irish potato value chain. The constraining biophysical elements are good soil drainage and sufficient rainfall during growth and flowering stages and soil moisture availability during stem and tuber formation. Favourable temperatures are required during growth and at maturity. The county has differentiated suitability based on whether it is the cool temperature aligned Irish Potato and cow milk value chain or the more hardy and warm temperature aligned indigenous chicken. The highlands are suitable for Irish potato and cow milk while the valley is suitable for indigenous chicken. Adaptations on temperature could foster dairy in the valley and indigenous chicken in the uplands.

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ABBREVIATIONS

AI	Artificial Insemination
AEZ	Agro Ecological Zones
ASDS	Agriculture Sector Development Strategy
ASTER	Advanced Space-borne Thermal Emission and Reflection Radiometer
ASDSP	Agricultural Sector Development Support
ASTGS	Agricultural Sector Transformation and Growth Strategy
CASSCOM	County Agricultural Sector Steering Committee
CIDP	County Integrated Development Plan
Cl	Consistency Index
CPS	County Programme Secretariat
ESP	Economic Stimulus Programme
GDEM V2	Global Digital Elevation Model Version 2
GDP	Gross Domestic Product
IDW	Inverse Distance Weighted
ILWIS	Integrated Land and Water Information System
KCC	Kenya Co-operative Creameries
KFA	Kenya Farmers Association
KNBS	Kenya National Bureau of Statistics
KHPC	Kenya Housing and Population Census
LH	Lower Highlands
LMI	Lower Midland I
LPG	Length of Plant Growth
MaS	Marginally Suitable
NS	Not Suitable
OC	Organic Content
PDP	Project Document Programme II
PO	Producer organization
PSP	Participatory Scenario Planning
PVC	Prioritized Value Chain
QGIS	Quantum Geographic Information System
SAGA	Systems for Automated Geo-Scientific Analysis
Scl	Silt- clay
Sil	Silt
SIVCAP	Strategic Integrated Value Chain Action Plan
THI	Temperature Humidity Index
TOC	Total Organic Carbon
VC	Value Chain
VCAs	Value Chain Actors

VCD	Value Chain Development
VCG	Value Chain Group
VCN	Value Chain Node
VCP	Value Chain Platform

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*** to produce 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 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 at supporting 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 per cent 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 while rural poverty increased from the low of 18% in 1974 to 25.6% by 2006 in some of these areas.

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 from 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 to produce the scheduled crops. The Crops ACT 2013 however allows individual landowners to have a final say on the actual land use practice to implement.

The suitability maps developed are meant to inform competitive land use practices to support promotion of priority value chains in the 47 counties of Kenya. The Atlas produced 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. They pick out the potentialities that exist in support of commercialisation of the 29 priority value chains (Table 1). The value chain suitability maps provided here are aligned to value chain commodities promoted under the Agriculture Sector Development Support Program (ASDSPII).

Table 1: Priority value chains

	County	Prioritized Value Chain			County	Prioritized Value Chain
1	**Baringo**	Meat Goat, Honey, Cow Milk		25	**Marsabit**	Meat Goat, Camel Milk, Kales
2	**Bomet**	Cow Milk, Maize, Irish Potato, Indigenous Chicken		26	**Meru**	Indigenous Chicken, Maize and Cow Milk
3	**Bungoma**	Cow Milk, Indigenous Chicken, Tomatoes		27	**Migori**	Cow Milk, Sweet Potato and Indigenous Chicken
4	**Busia**	Indigenous Chicken, Ground Nut, Fish		28	**Mombasa**	Fish, Local Vegetables and Cow Milk
5	**Elgeyo Marakwet**	Cow Milk, Irish Potato and Maize		29	**Muranga**	Banana, French Beans and Cow Milk
6	**Embu**	Cow Milk, Banana and Indigenous Chicken		30	**Nairobi**	Broilers, Kales and Cow Milk
7	**Garissa**	Tomatoes, Camel Milk and Beef		31	**Nakuru**	Pyrethrum, Fish and Cow Milk
8	**Homa Bay**	Indigenous Chicken, Fish and Sorghum		32	**Nandi**	Maize, Indigenous Chicken and Fish
9	**Isiolo**	Beef, Camel Milk, Tomatoes		33	**Narok**	Maize, Beef and Cow Milk
10	**Kajiado**	Cow Milk, Tomatoes and Beef		34	**Nyahururu**	Irish Potato, Fish and Cow Milk
11	**Kakamega**	Cow Milk, Maize and Indigenous Chicken		35	**Nyamira**	Banana, Local Vegetables and Cow Milk
12	**Kericho**	Cow Milk, Tomatoes and Indigenous Chicken		36	**Nyeri**	Irish Potato, Indigenous Chicken and Beef
13	**Kiambu**	Cow Milk, Indigenous Chicken and Banana		37	**Samburu**	Maize, Honey and Indigenous Chicken
14	**Kilifi**	Cassava, African Eye Bird Chilli and Indigenous Chicken		38	**Siaya**	Mango, Fish and Cow Milk
15	**Kirinyaga**	Cow Milk, Banana and Rice		39	**Taita Taveta**	Banana, Indigenous Chicken and Mango
16	**Kisii**	Cow Milk, Banana and Indigenous Chicken		40	**Tana River**	Beef, Fish and Mango
17	**Kisumu**	Indigenous Chicken, Fish and Cotton		41	**Tharaka Nithi**	Cow Milk, Indigenous Chicken and Banana
18	**Kitui**	Indigenous Chicken, Gadam Sorghum and Green Gram		42	**Trans Nzoia**	Maize, Indigenous Chicken, Fish
19	**Kwale**	Indigenous Chicken, African Eye Bird Chilli and Passion Fruit		43	**Turkana**	Sorghum, Meat Goat and Fish
20	**Laikipia**	Maize, Cow Milk and Sheep and Goats		44	**Uasin Gishu**	Passion Fruit, Indigenous Chicken and Cow Milk
21	**Lamu**	Indigenous Chicken, Fish and Cashew Nut		45	**Vihiga**	Indigenous Chicken, Cow Milk and Banana
22	**Machakos**	Cow Milk, Indigenous Chicken and Mango		46	**Wajir**	Water Melon, Indigenous Chicken and Camel Milk
23	**Makueni**	Indigenous Chicken, Mango and Green Gram		47	**West Pokot**	Honey, Indigenous Chicken and Meat Goat
24	**Mandera**	Tomatoes, Camel Milk and Meat Goat				

This is a five year program (2018-2022) of the Ministry of Agriculture, Livestock, Fisheries and Cooperatives. It is funded by the National and the County Governments of Kenya, The Swedish government and the European Union. In Elgeyo Marakwet County, the prioritized value chains are cow milk, Irish potato and improved indigenous chicken (Table 1).

1.2 Value chain development 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 (Figure 1) with temperature ranges as low as 4.6° C and highs of over 34° C (Figure 2).

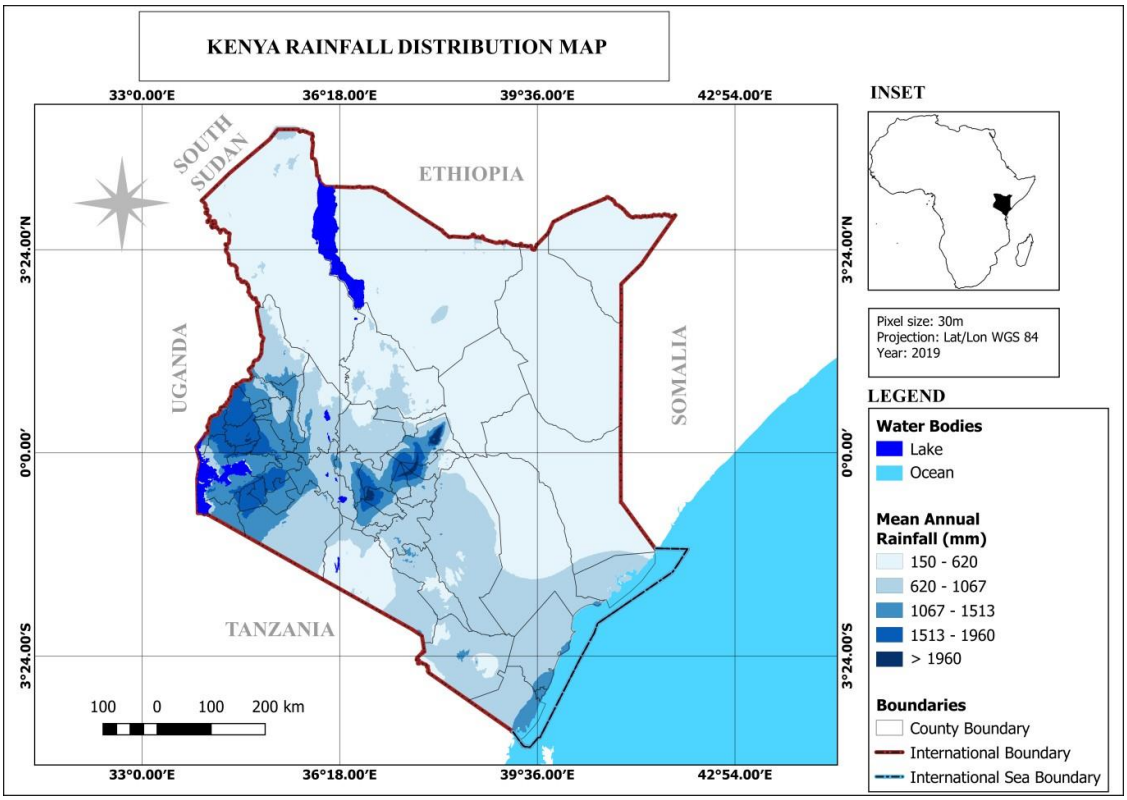

Figure 1: Kenya Rainfall distribution

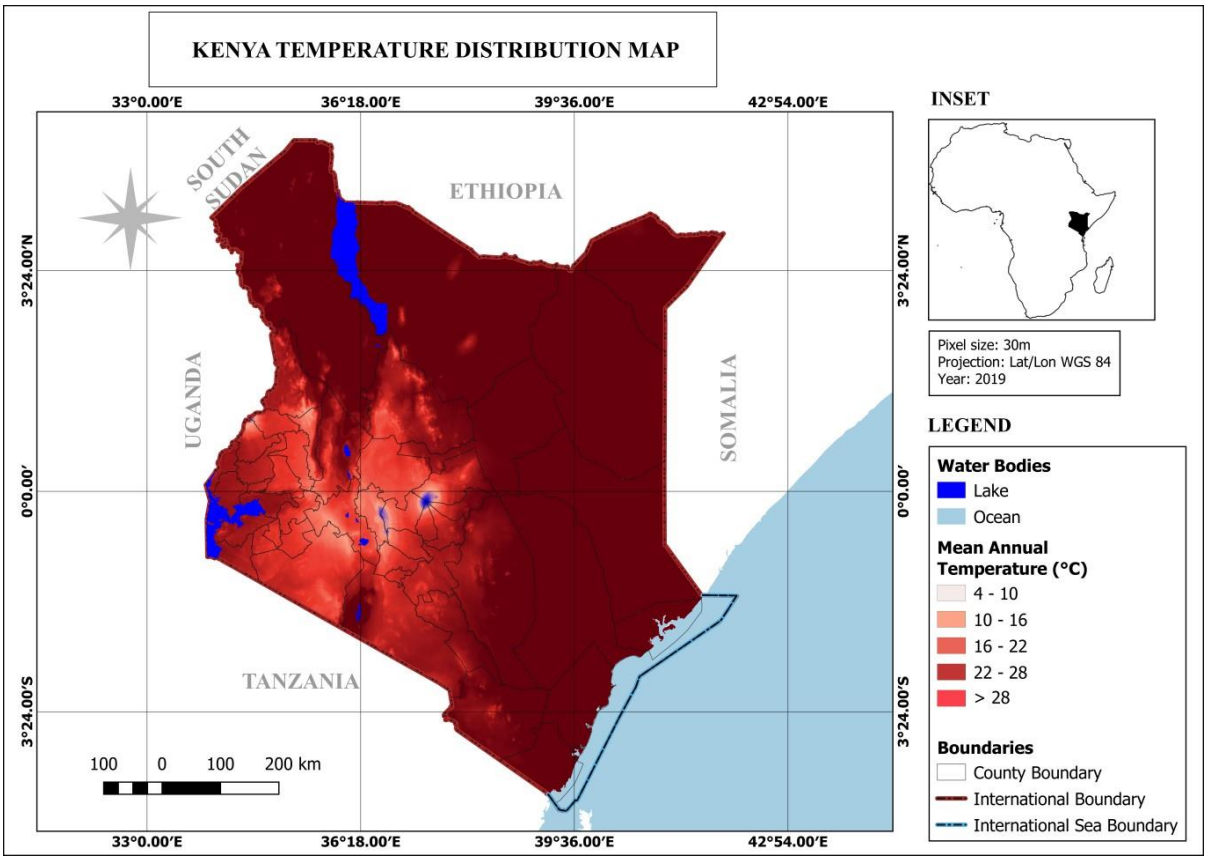

Figure 2: Kenya Temperature Map

The demand and distribution of agricultural produce within the country is affected by population density (Figure 3), purchasing power and infrastructure development (Figure 4). These attributes are key proxies to determining internal market access and size. The Kenyan population is not uniformly distributed across and within the counties meaning that demand for commodities is also not uniform. On the other hand, over the years the government has invested in the development and expansion of the road and railway networks. These actions have contributed to improving market access for both the inputs and agricultural commodities.

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 The Government of Kenya and The Government of Sweden. The first phase was implemented during a period of five years (2012-2017).

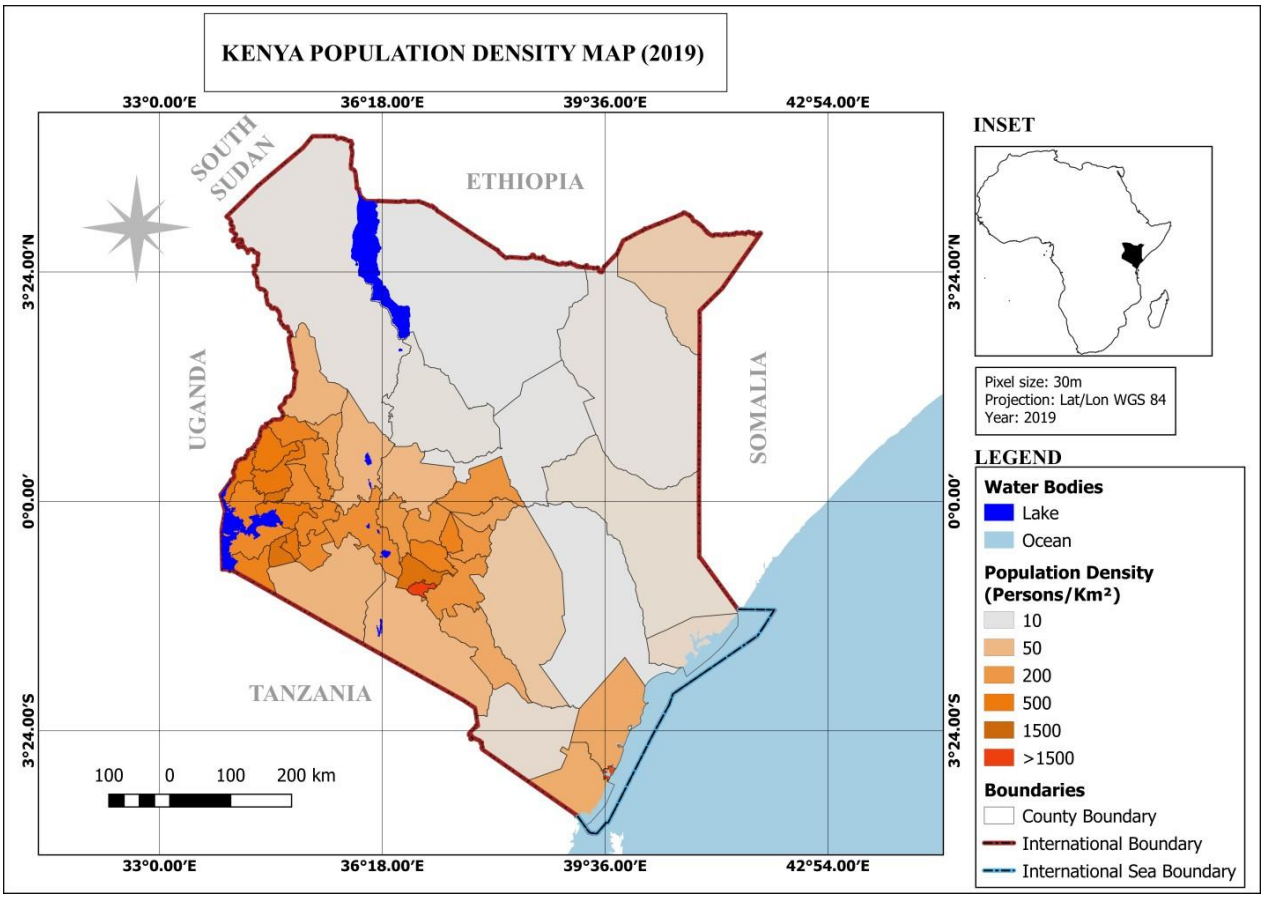

Figure 3: Kenya Population Density Map

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 (Table 1) were identified through a scooping and consultative study forum 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 (Table 1).

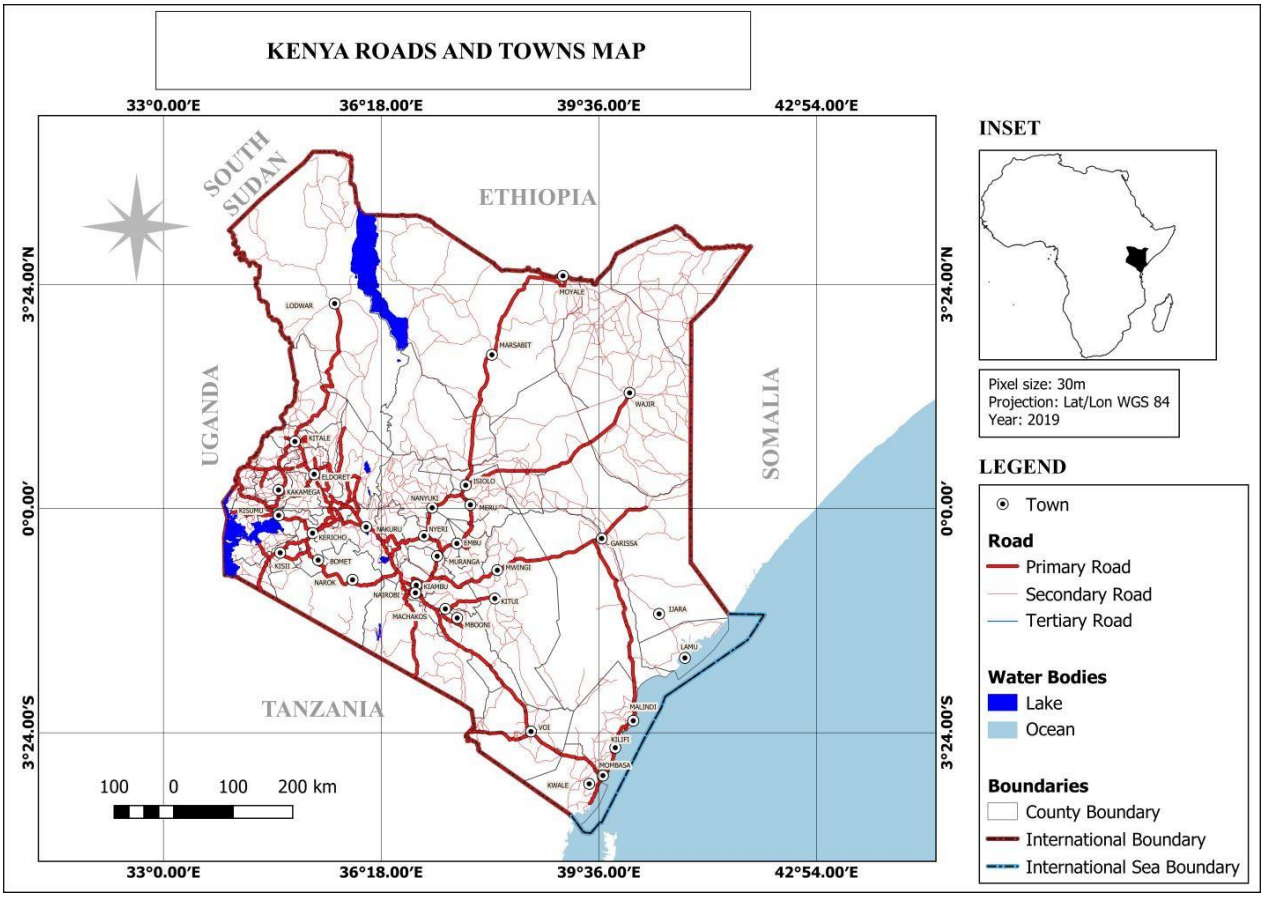

Figure 4: Kenya Roads and Major Towns Map

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 (Table 1) 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.

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 informs the Agriculture Sector Transformation and Growth Strategy (ASTGS: 2019-2029). Three flagship areas of the ASTGS of relevance are those that aim at;

i. Instituting measures to aid increasing household incomes beyond the poverty mark for some 3 million small scale producers,

ii. strengthening and launching priority digital and data use cases to drive decision making and performance management of the sector

iii. 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 are meant to inform development actions of priority value chains in the county. The suitability classes provide a spatial framework for designating areas and regions for the promotion of value chains based on their comparative advantage to improve their competitiveness. Correctly aligned value chains and focused resource allocation would contribute to the attainment of agricultural transformation and growth. Transformation and growth of the agricultural sector will only be achieved when the problems and challenges of rapid and unregulated urbanization is addressed. Unplanned urbanisation 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 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 therefore an important decision tool that can 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.

The priority value chains suitability maps considered biophysical, economic (population, towns, road access), social (agrarian orientation and entrepreneurial disposition) and political (existence or lack of framework conditions) attributes as they affect productivity and commercialisation of the value chains. This is a departure from the conventional agro ecological zoning procedures (Figure 5) that focused on the natural resources with particular interest on soils, rainfall, altitude and temperature. It is also a departure from the soil suitability and land capability mapping (Figure 6 and Figure 7) processes that focused on a few soil parameters

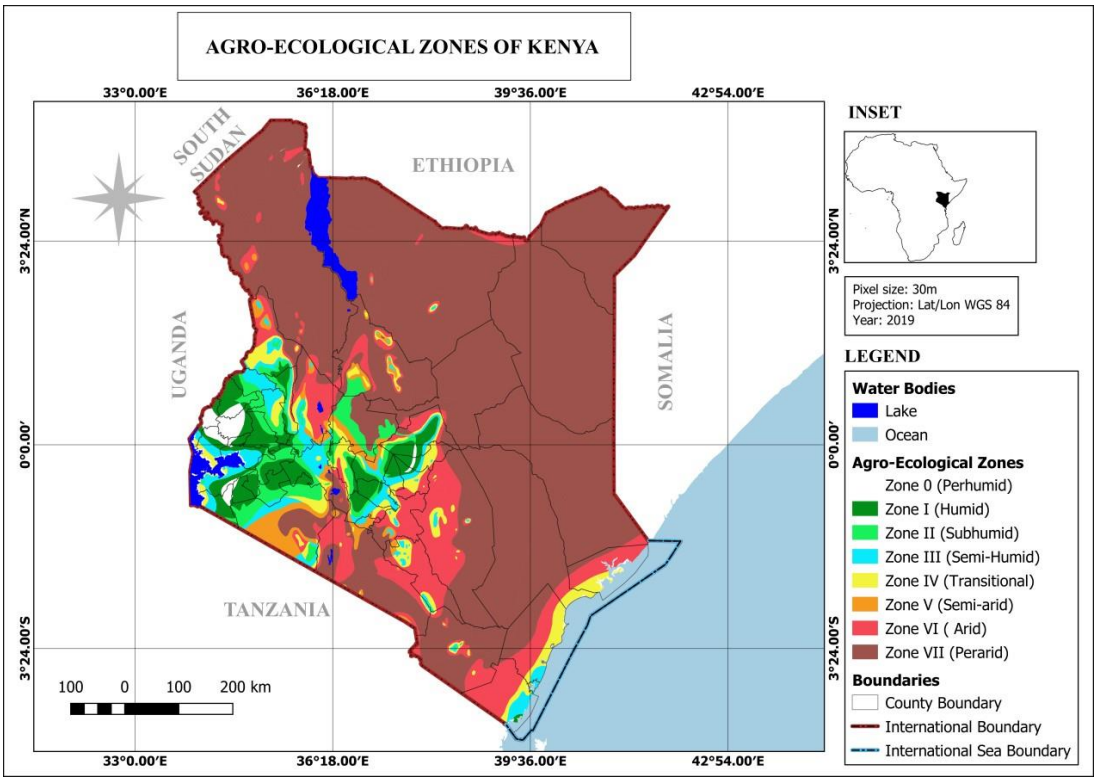

Figure 5: Kenya Agro-ecological Zones Map

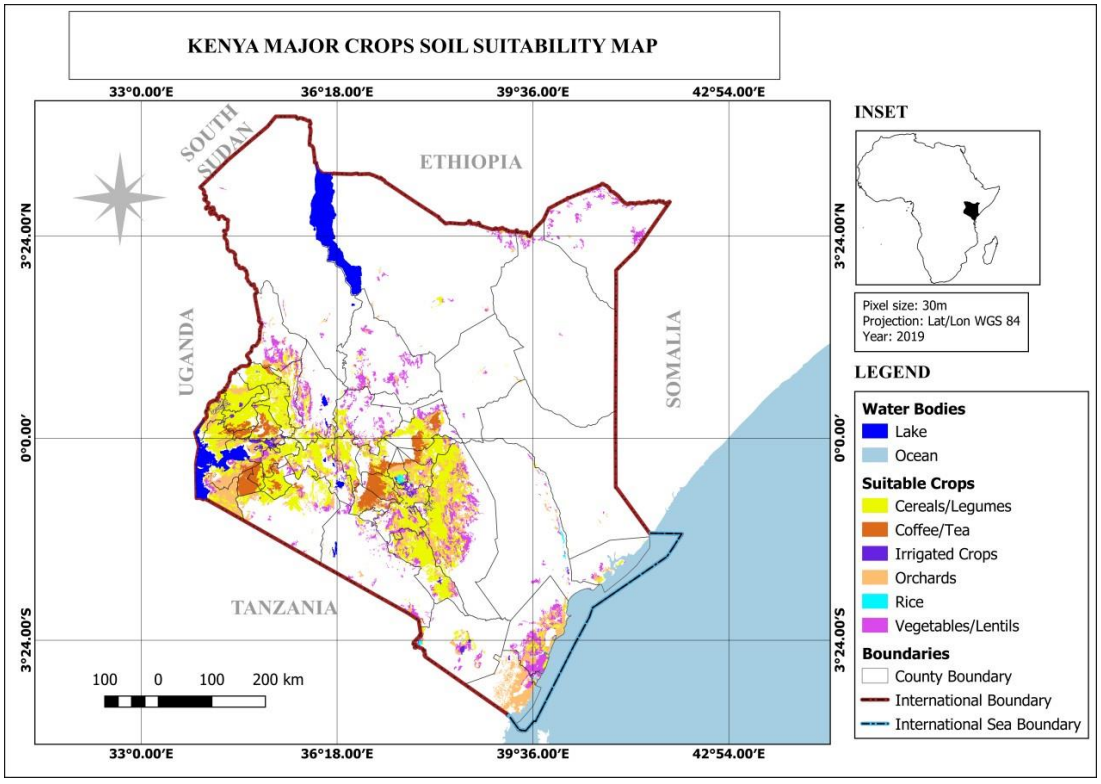

Figure 6: Kenya Major Crops Soil Suitability Map

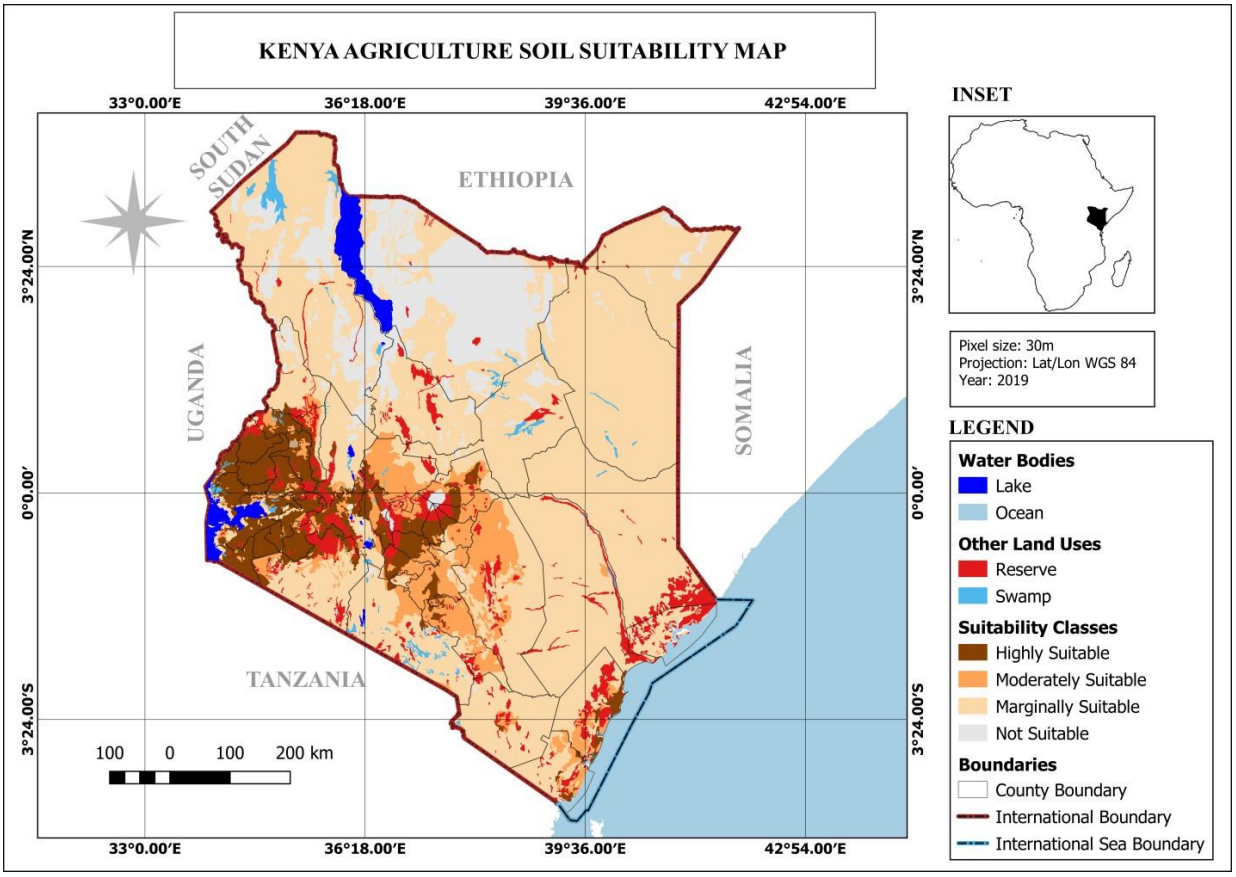

Figure 7: Kenya Soil Suitability Classification Map

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 and competitiveness;
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 commercialisation 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 prudently allocate resource to drive commercialisation 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 Organisation, 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 commercialising 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, analyse data, synthesize information for presentation and use by stakeholders.

v. *Climate smart agriculture and green growth:* The maps and the notes present measures that promote sustainable use of natural resources, increase resilience to climate change effects while leaving 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 as illustrated below (Figure 8).

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

2.2 Data gathering and preparation

Soil data was obtained from Kenya Soil Survey (KSS) Land Information Cradle (online) and 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 analyse the terrain.

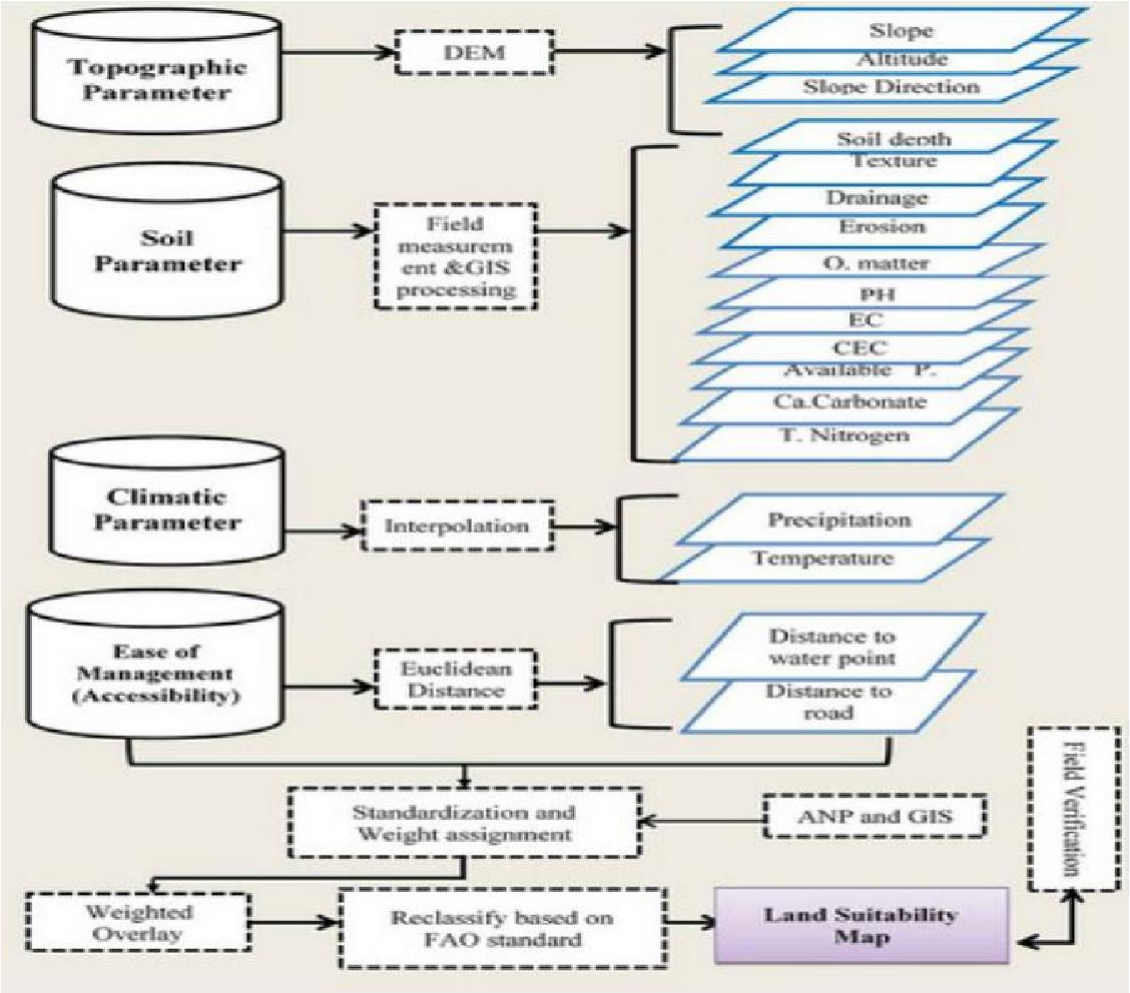

Figure 8: Suitability Mapping Process

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 S3 and Not Suitable N were assigned scores 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.

2.3 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 of 1 to 9 based on Saaty rating scale (Table 2). The experts provided direction on county specific interrelationships between the parameters as they affect productivity and commercialisation as illustrated in Tables 3 to Table 7. During the pairwise ranking, inconsistencies were checked by ensuring that the corresponding consistency ratio (CR) was less than 10% (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	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 for a crop

	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 climate sub-criteria with respect for beef

	Temperature	Rainfall
Temperature	1	1/3
Rainfall	3	1

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

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

2.4 Overlaying the maps 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

Elgeyo Marakwet County extends from latitude 0° 20′ to 1° 30′ to the North and longitude 35° 0′ to 35° 45′ to the East. It borders West Pokot County to the North, Baringo County to the East, Trans Nzoia County to the Northwest and Uasin Gishu County to the West. The county covers a total area of 3029.8 km^2 which constitutes 0.5% of Kenya's total area. The county is divided into four sub-counties, namely: Keiyo North, Keiyo South, Marakwet West and Marakwet East. These are further subdivided into 20 wards with 74 locations and 212 Sub-locations. County resources are described under biophysical features, socio characteristics, economic components and demography.

3.1 Biophysical

The county biophysical parameters explored for the mapping exercise are the temperature, rainfall, land slope and soils. The County has three distinct topographical zones: the Highlands, the Escarpment, and the Valley. The Highlands constitute 49% of the total land area and are suitable for dairy cows, Merino sheep kept for wool, Irish Potato potatoes, maize, wheat, and beans production. The escarpments cover about 11 % of the total land area and are good for maize, millet, sorghum and beans. The escarpments are predisposed to high risk of soil erosion, landslides and rock falls. The remaining 40% of the land area is covered by the Kerio Valley which is semi-arid area suitable for zebu cattle rearing, poultry, goats and sheep production; and crops like tropical fruits, millet, sorghum, groundnuts and green grams. The farm holdings are small scale averaging 1.36 ha with isolated cases of large-scale farmers who own an average of 17.3 ha. Climate hazards experienced in the county and that affect crop and livestock yields, increase costs of production as well as increase vulnerability of households include intense rainfall, increased temperatures and extended drought periods.

3.1.1 County Temperature Profile

The county temperature ranges from 7^0C to 25^0C (Figure 9). The coldest area is Marakwet East with a temperature range of 7˚C– 10.9˚C. This is followed by Kaptagat area which is less cold with a temperature range of 11˚C – 15.9˚C. Kaworor area follows with a moderate temperature range of 16˚C – 19.9˚C when compared to Kaptagat and Marakwet East. The warmer areas are found in Biretwo with a temperature range of 20˚C – 24.9˚ C while Tot is the hottest region with temperatures exceeding 25˚ C.

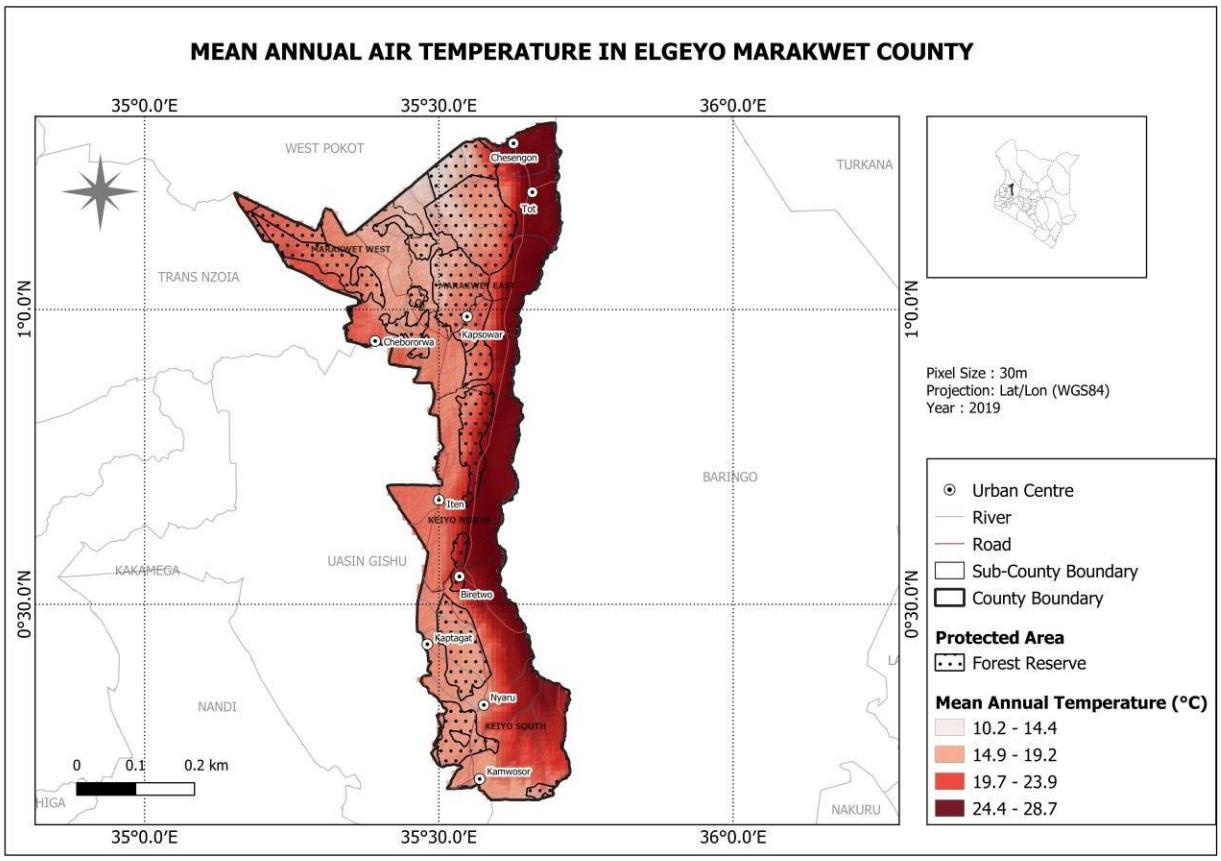

Figure 9: Elgeyo Marakwet County Mean Annual Temperature Map

The heat stress level follows the same pattern. Kerio valley experiences very high THI at about 84% while the cooler highland experiences lower THI of about 54% (Figure 10).

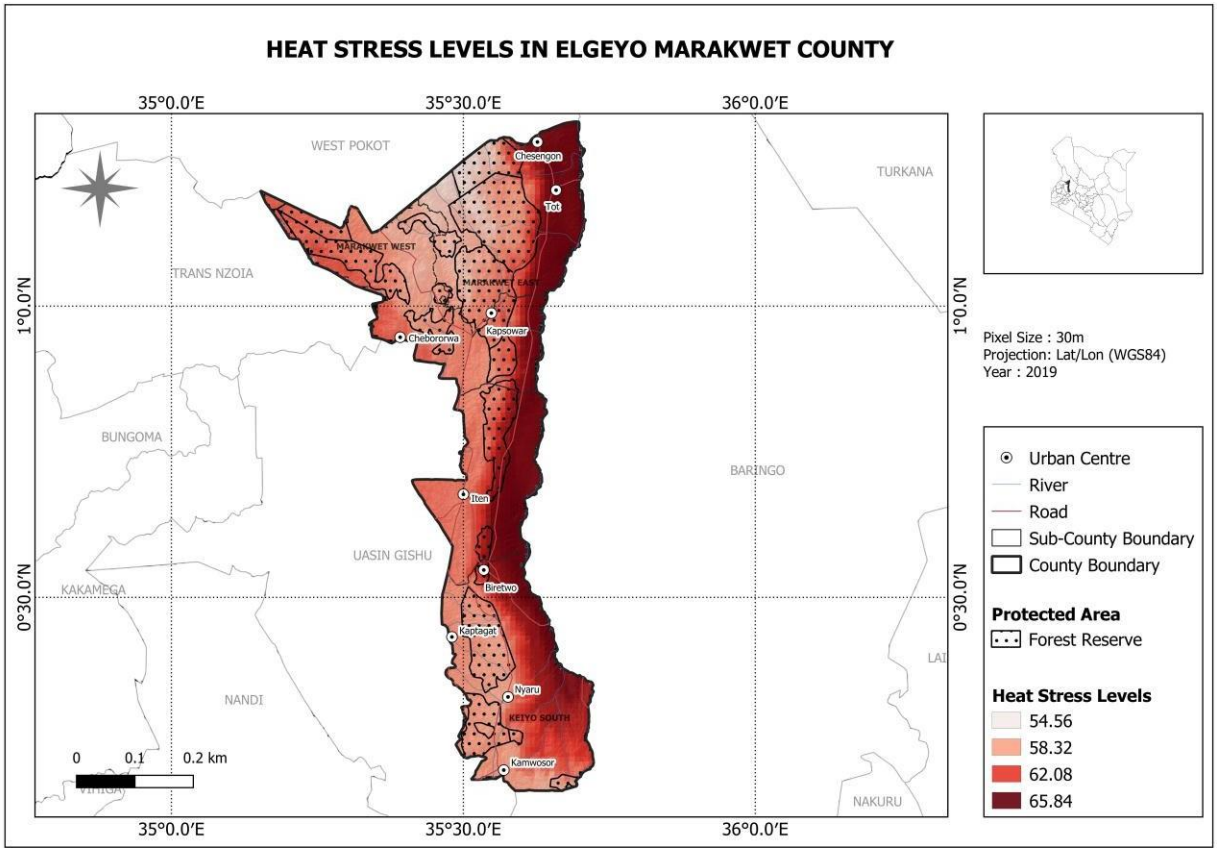

Figure 10: Elgeyo Marakwet County Heat Stress Map

3.1.2 County Rainfall Availability

The County rainfall is converse to the temperature regime. Hotter areas receive lesser rainfall while cooler areas receive higher rainfall. The county rainfall ranges from 700-1400mm (Figure 10). Tot receives the least rainfall (700mm) while Biretwo receives slightly higher rainfall of between 700-900mm annually. Similarly Kamworor, Iten, and Kapsowar receive moderate rainfall with mean annuals of between 901-1100mm. Kaptagat, Marakwet West, Marakwet East and Cheborорwa are county areas that receive rainfall above 1400mm.

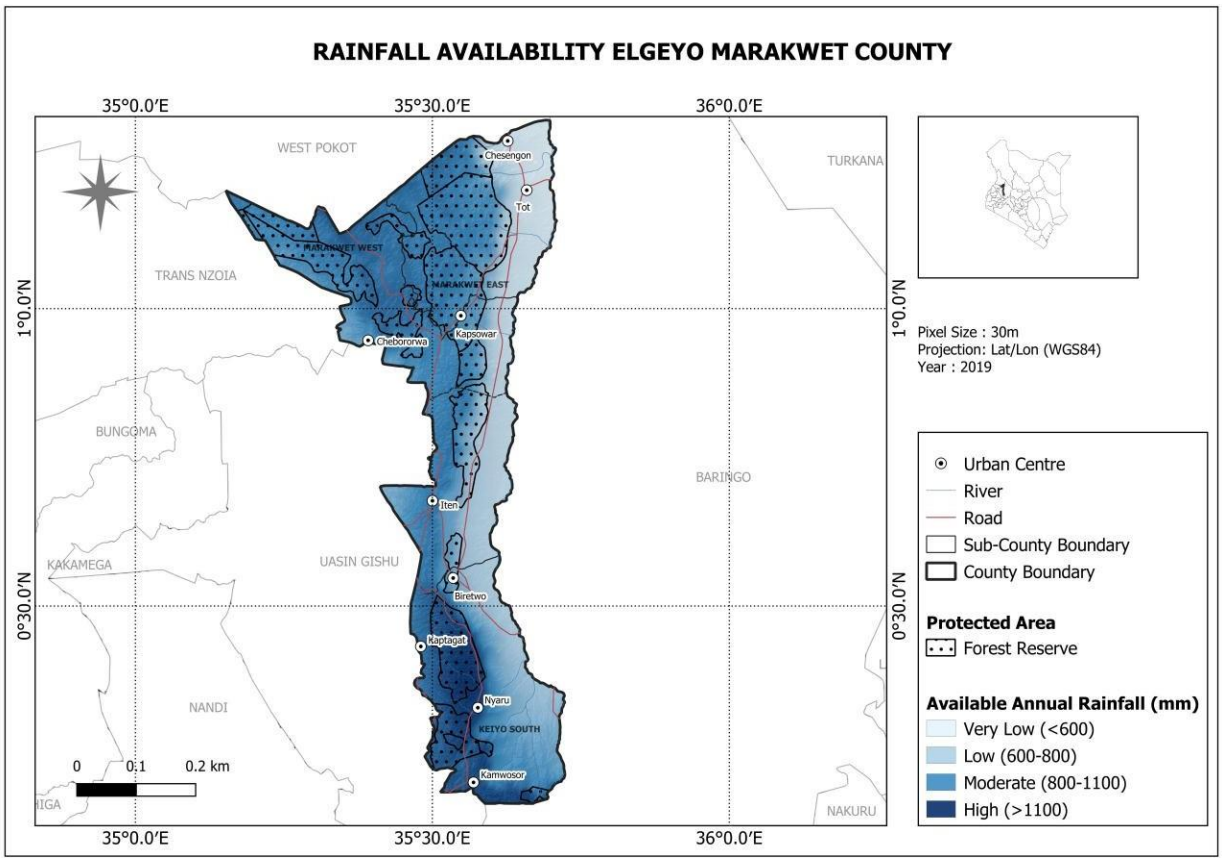

Figure 11: Elgeyo Marakwet County Rainfall Map

3.1.3 Soil Classification

Elgeyo Marakwet has an interspersed soil composition ranging from sandy to loamy and clay. The northern part has a greater percentage of clay soil with few pockets of loamy and sandy soils (Figure 11). The soils on the escarpments and Cherangani hills are shallow Lithosols and Regosols and patches of moderately deep to deep humic and/or chromic Cambisols. Kerio Valley has a mixture of cambic Arenosols, deep eutric Cambisols chromic Luvisols and calcaric Fluvisols. The highlands and the plateau have an interspersed composition consisting of deep humic Cambisols, humic Nitisols, humic Acrisols, humic Nitisols and Acrisols.

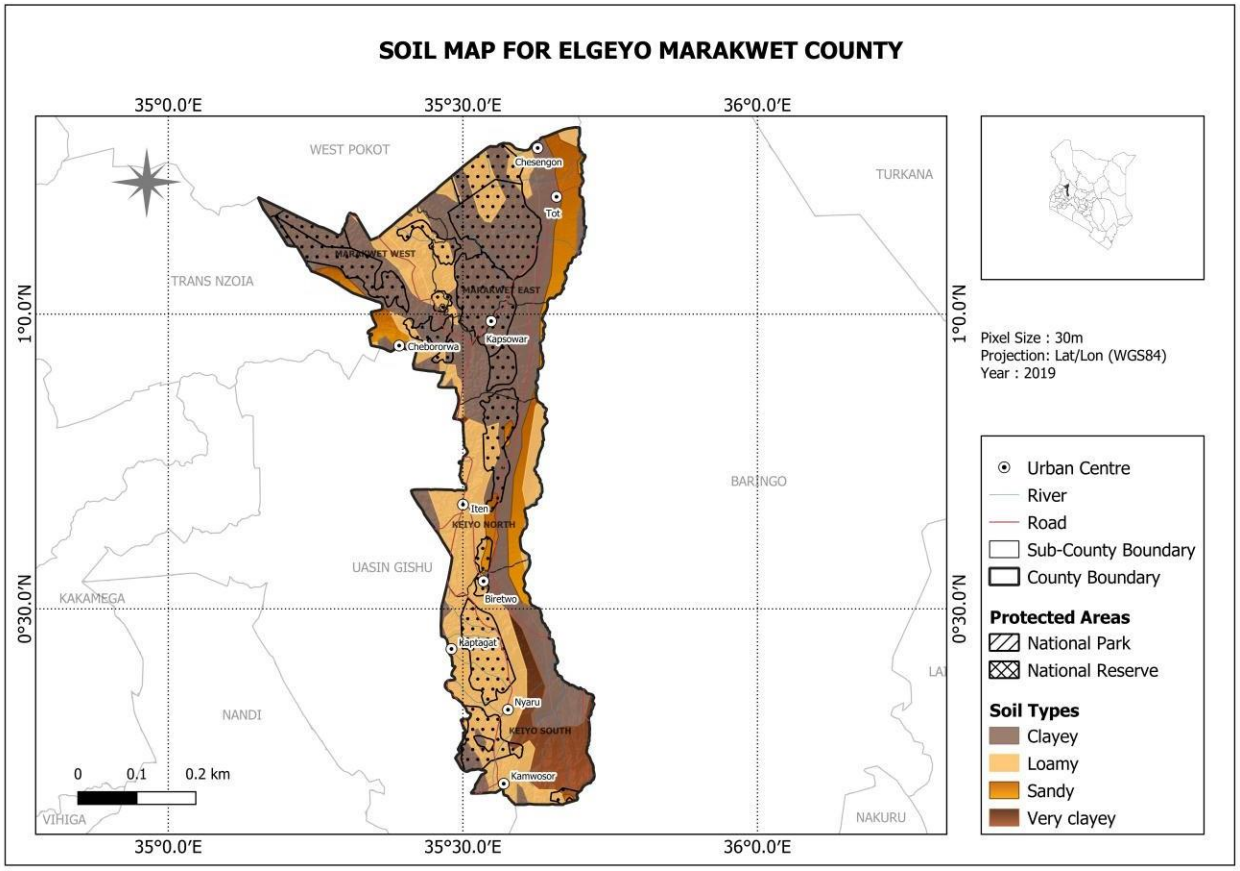

Figure 12: Elgeyo Marakwet County Soils Map

3.1.4 Land Slope Classification

Keiyo North is an area that is flat with a slope of < 3%, while Keiyo South has a gentle slope of 3-10%. This is followed by Marakwet East and Marakwet West which are very steep with a slope of 25-50% (Figure 12).

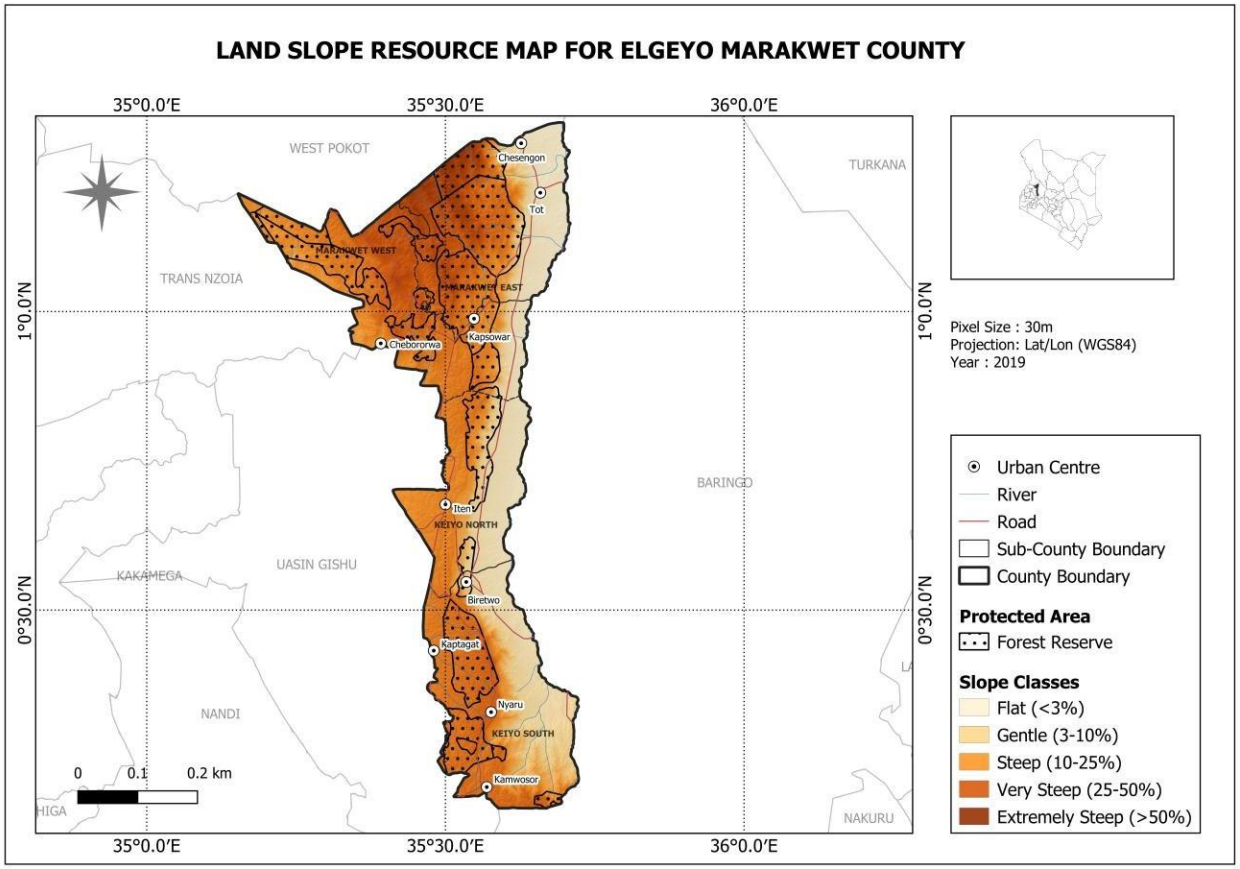

Figure 13: Elgeyo Marakwet County Land Slope Map

3.2 Social

The county is dominated by the Keiyos located in Keiyo Sub-county and Marakwets in Marakwet Sub-county. The three Priority Value Chains being promoted provide a livelihood to both communities. The Keiyos are an enterprising agro-pastoral community residing to the southern part of the county while the Marakwets are a resilient pastoral community with ventures in crop production.

3.3 Economics

The factors that affect demand, price and availability of the products across the value chain nodes are accessibility of the road network and road linkages to towns and market centres. The population in terms of numbers and income levels determine local uptake of the products.

3.3.1 Road network and access

The County is well served with roads with most places being within 2-7 kms to the nearest road. Most of the county is highly suitable with only a small part being classified as moderately suitable (Figure 14). The county is connected to Eldoret, Kitale and Kabarnet through a series of well developed bitumen carpeted roads.

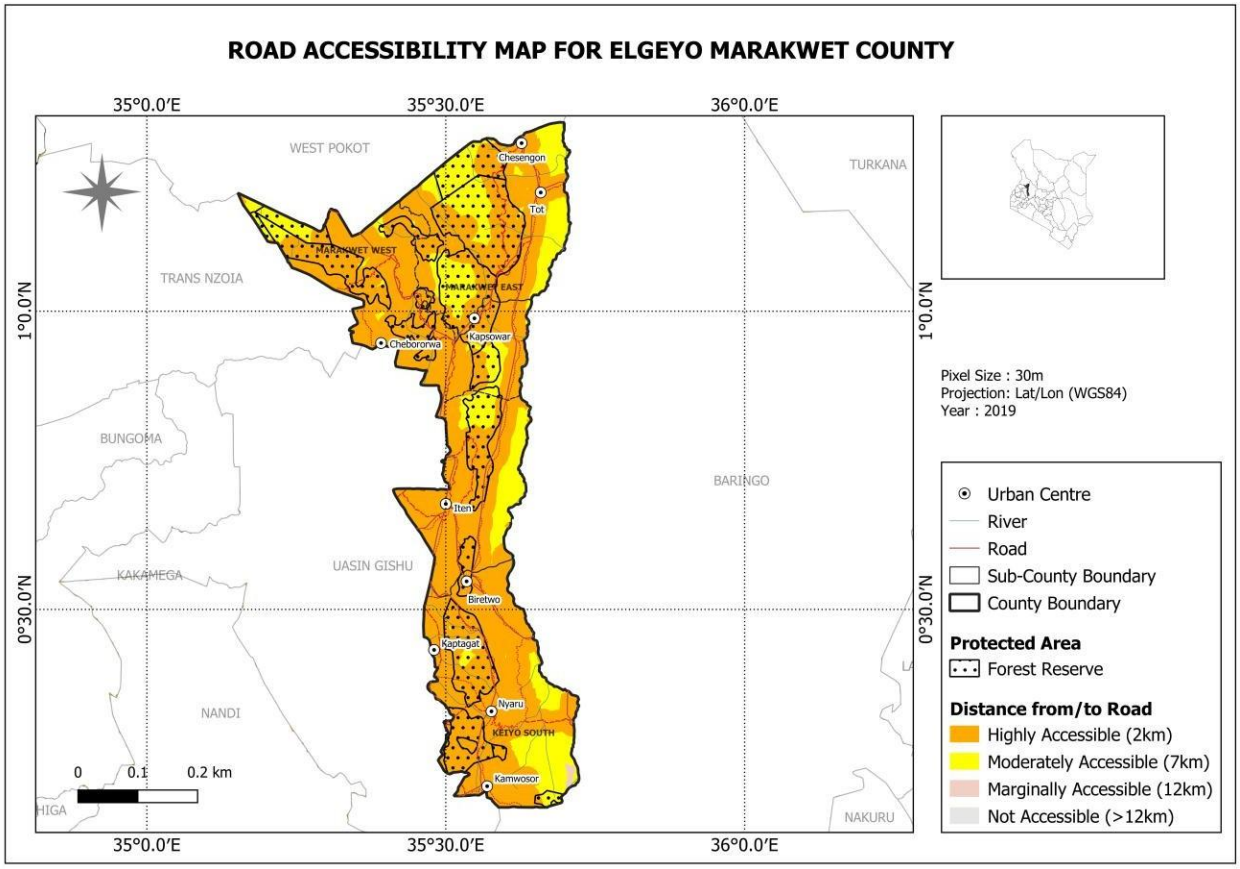

Figure 14: Elgeyo Marakwet County Roads Access

3.3.2 Market access

The county has several market centres and one that includes; Tot, Kapsowar, Chebiemit, Cheptongei, Iten, Kaptagat, and Bugar. It is also linked to Kitale, Eldoret and Kabarnet through a good road network system. The accessibility to these markets grants some parts of the county a classification rating of moderate suitability with a few pockets of the county rated as highly suitable. However close to a third of the County is classified as not suitable due to very low urbanisation and lack of developed market centres (Figure 15)

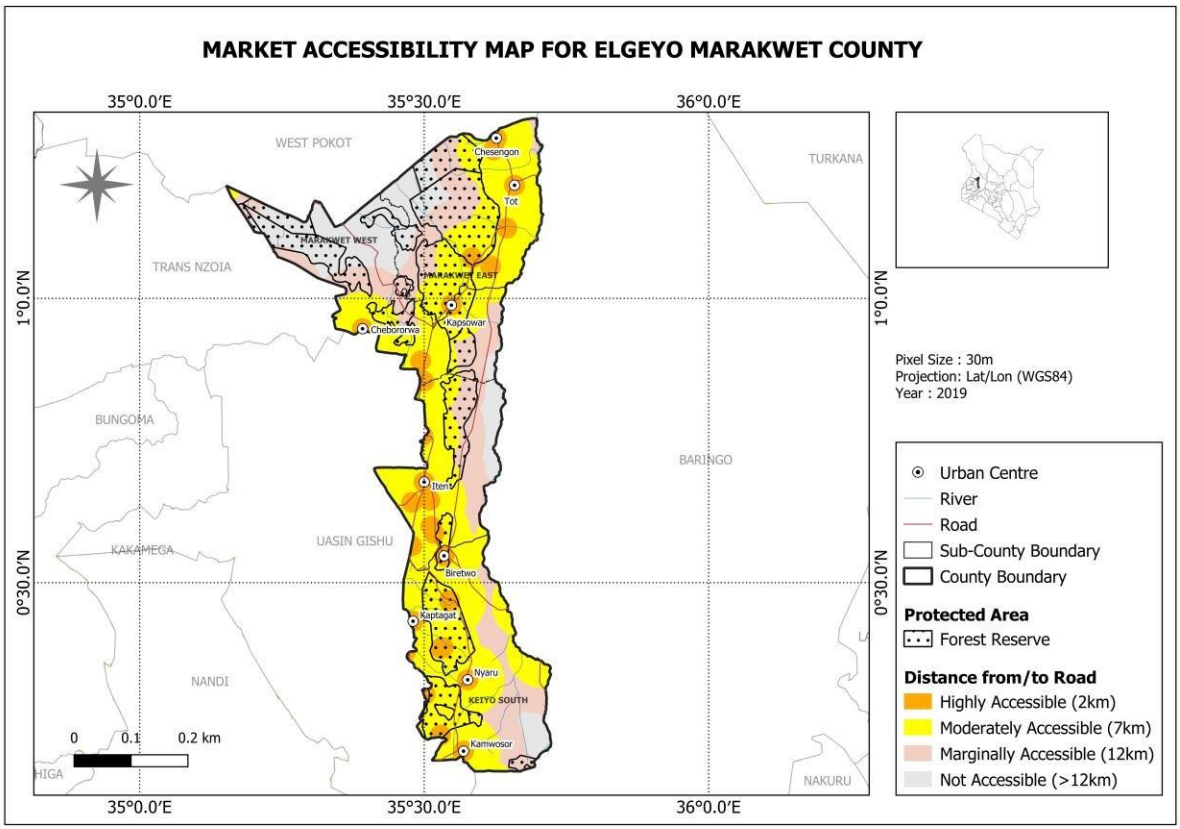

Figure 15: Elgeyo Marakwet County Market Accessibility Map

3.3.3 Population

The population of Elgeyo Marakwet is 454,480 persons of which 50% are male and the other 50% female (KNBS, 2019). The county population stood at 166 /km^2 in 2019 with the highland and escarpment areas recording higher densities than those of the valley. The average poverty index for the county in 2009 census was 52.7%. This improved to 43.6% according to Kenya Integrated Household Budget Survey (KIHBS) of 2019.

4 PRIORITIZED VALUE CHAINS SUITABILITY MAPS

Elgeyo Marakwet County is implementing three value chains namely dairy cow milk, indigenous chicken and Irish potatoes. These were identified by stakeholders who considered the value chain's contribution to food security, income generation, environmental resilience and gender responsiveness.

4.1 Irish Potato Value Chain

4.1.1 Parameter Analysis

The biophysical parameters considered for classification are temperature, rainfall amount and distribution, land slope and the soil conditions. The soil conditions are suitable as the pH and rooting are within the range required; however temperature requirements are only suitable in the western areas and not the eastern zones (Table 8, Figure 20)

Table 8**:** Elgeyo Marakwet Irish Potatoes Biophysical Parameters Analysis

Parameter	**County Parameter**	**VC parameter**	**VC Suitability Classes**	**Adaptation**	**Technology**
Rainfall (mm)	700-1400	600-800	HS	Water harvesting	In situ water harvesting structures
Temperature	7->25˚C	16-25	HS	Cooling system	Plant suitable trees
Soil rooting conditions (cm)	3-50%	25-50	MS to HS	Conservation agriculture	Use implements that can break the hand pan
pH	4.43-6.8	5.5-6.5	HS	Conservation agriculture	Manure application

4.1.2 Suitability maps

Soil suitability

The county soils have the right pH for Irish potato. It is moderately to highly suitable as represented in the map in Figure 16. A small tip at the northern end is not suitable due to poor depths and high ph.

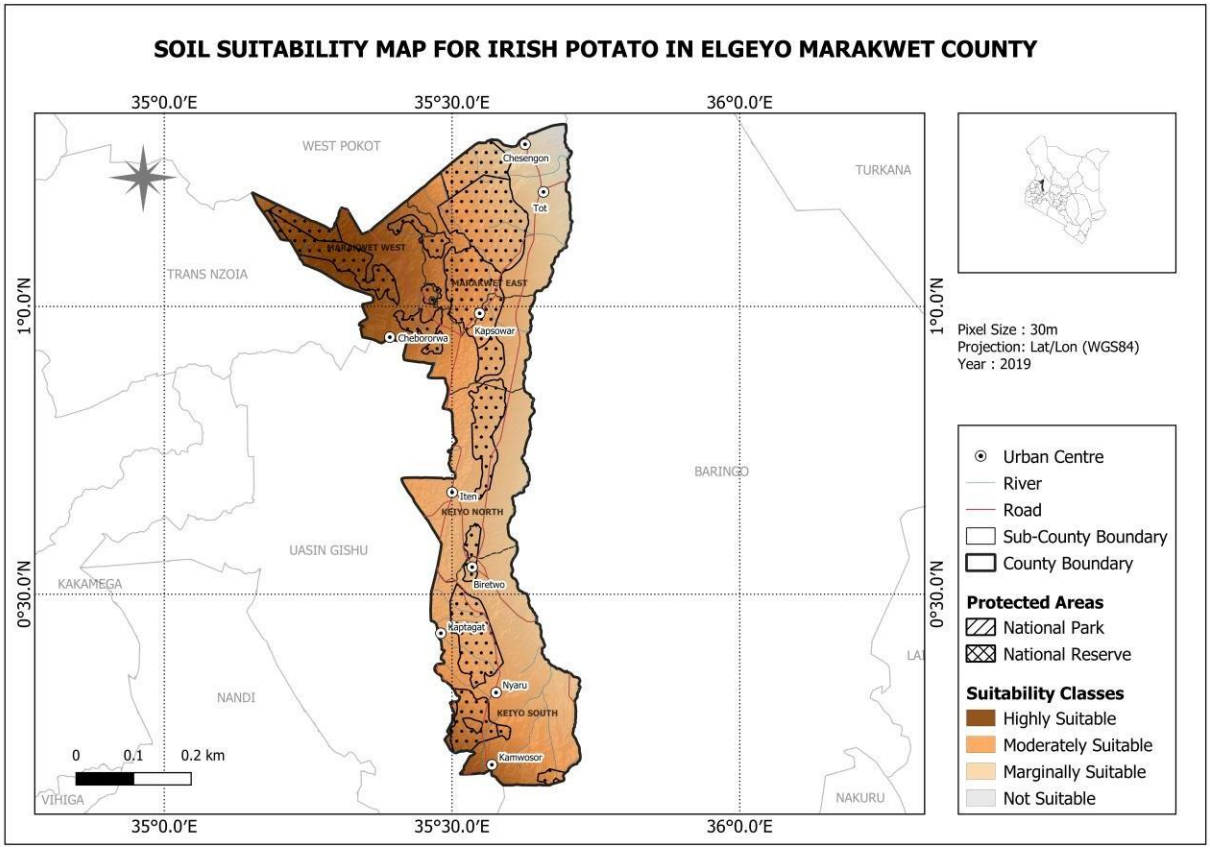

Figure 16: Soil Suitability for Irish Potato

Biophysical suitability

The biophysical parameter classification shows areas of high suitability to regions that are not suitable due mainly to temperature constraints (Figure 17).

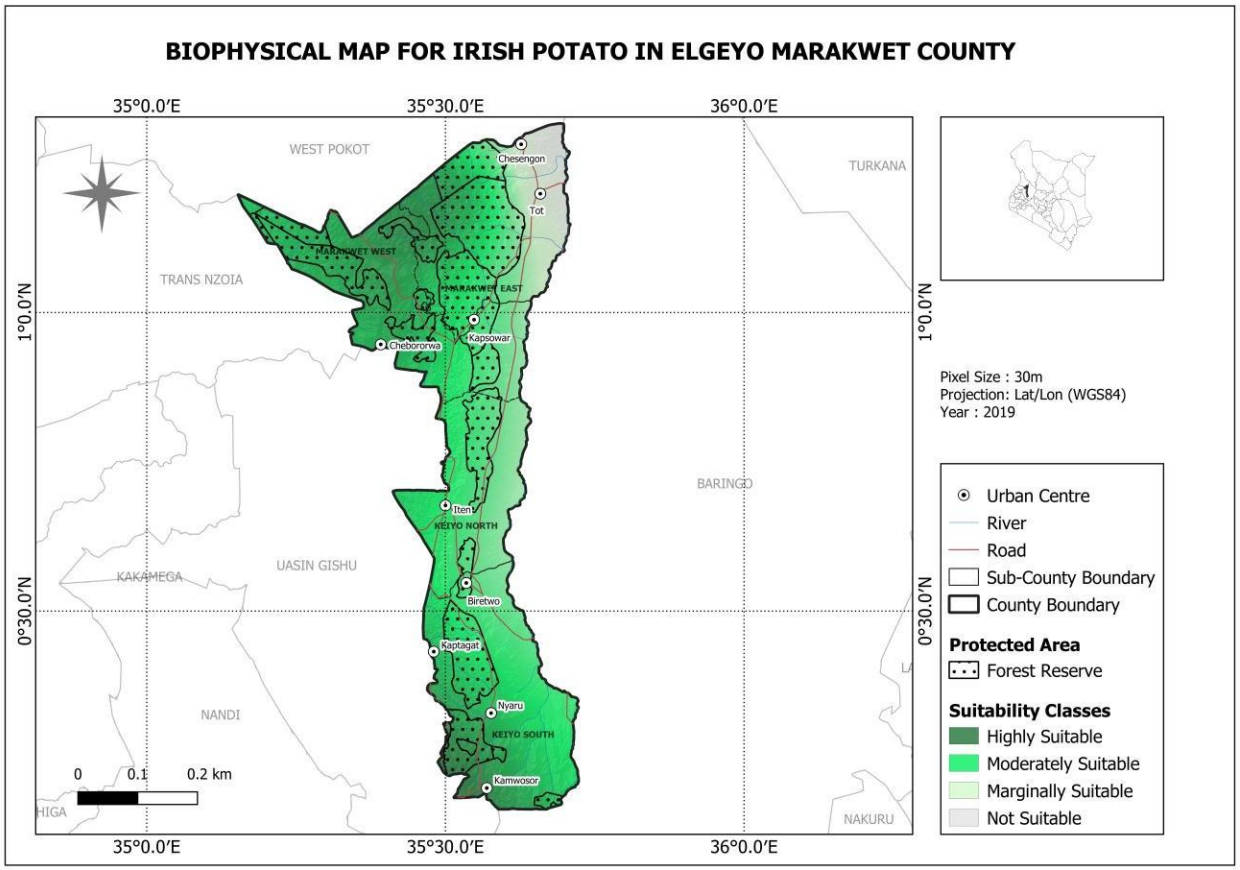

Figure 17: Elgeyo Marakwet Irish Potato Biophysical Suitability Map

Suitability classification

The eastern region is not suitable due to temperature and rainfall constraints while the western region has areas that are highly suitable for Irish Potato (Figure 18).

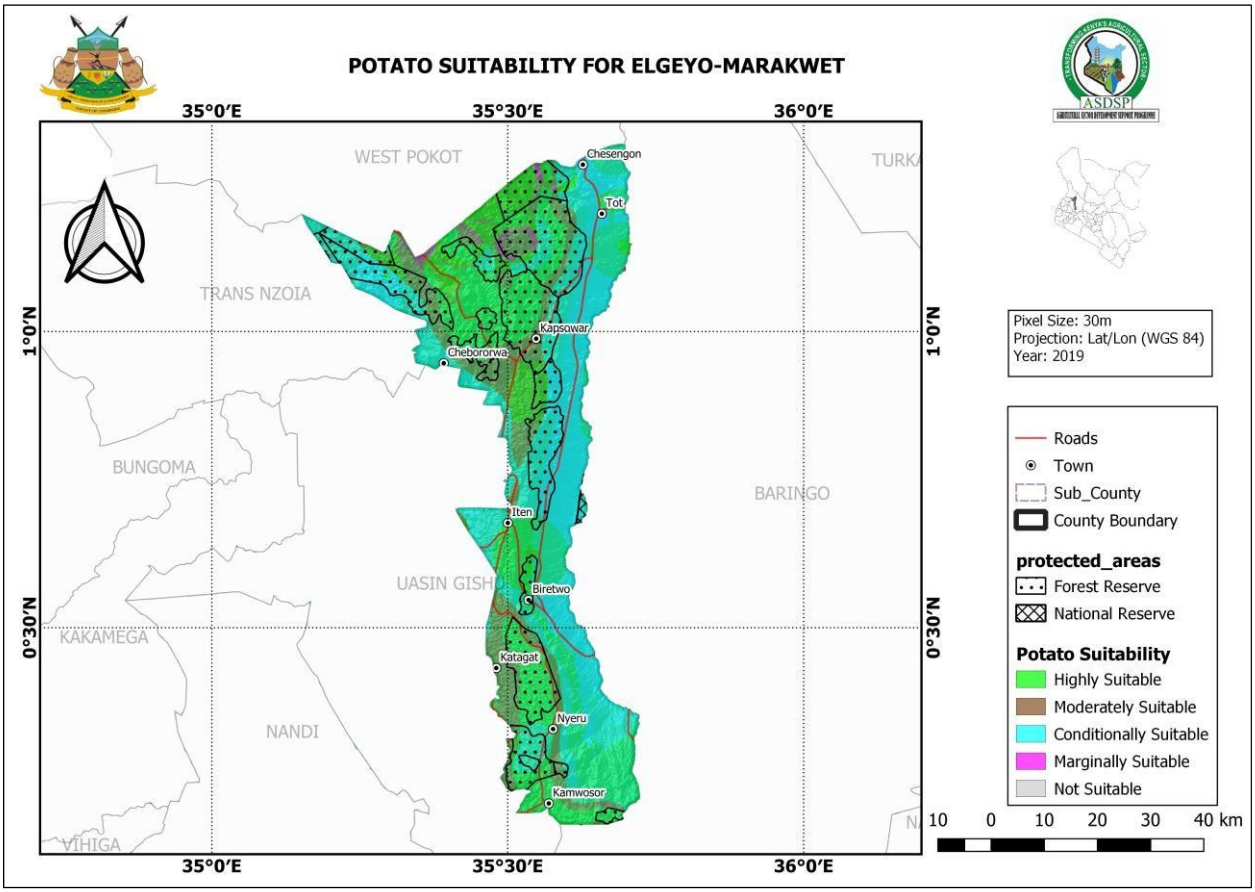

Figure 18: Elgeyo Marakwet Irish Potato Suitability Map

4.1.3 Adaptation technologies and innovations

The adaptation measures proposed include, use of early maturing varieties (like Unica Sherekia, Kenya mpya varieties which take 75-105 days) to manage shorter lengths of plant growth (LPG) period; soil and water management technologies (Figure 19) to address steep slopes and planting of high yielding varieties to increase productivity. Other measures considered are establishment of digital marketing platforms and promotion of rainwater harvesting to improve soil water availability (Figure 19). The rainfall availability differs with regions and this calls for differentiated rain harvesting methods. The regions that receive less than 600mm would apply root water harvesting systems while regions with rainfall of 600-800mm could apply in-situ

water harvesting systems. The other regions with higher rainfall could harvest water and use it for supplementary irrigation.

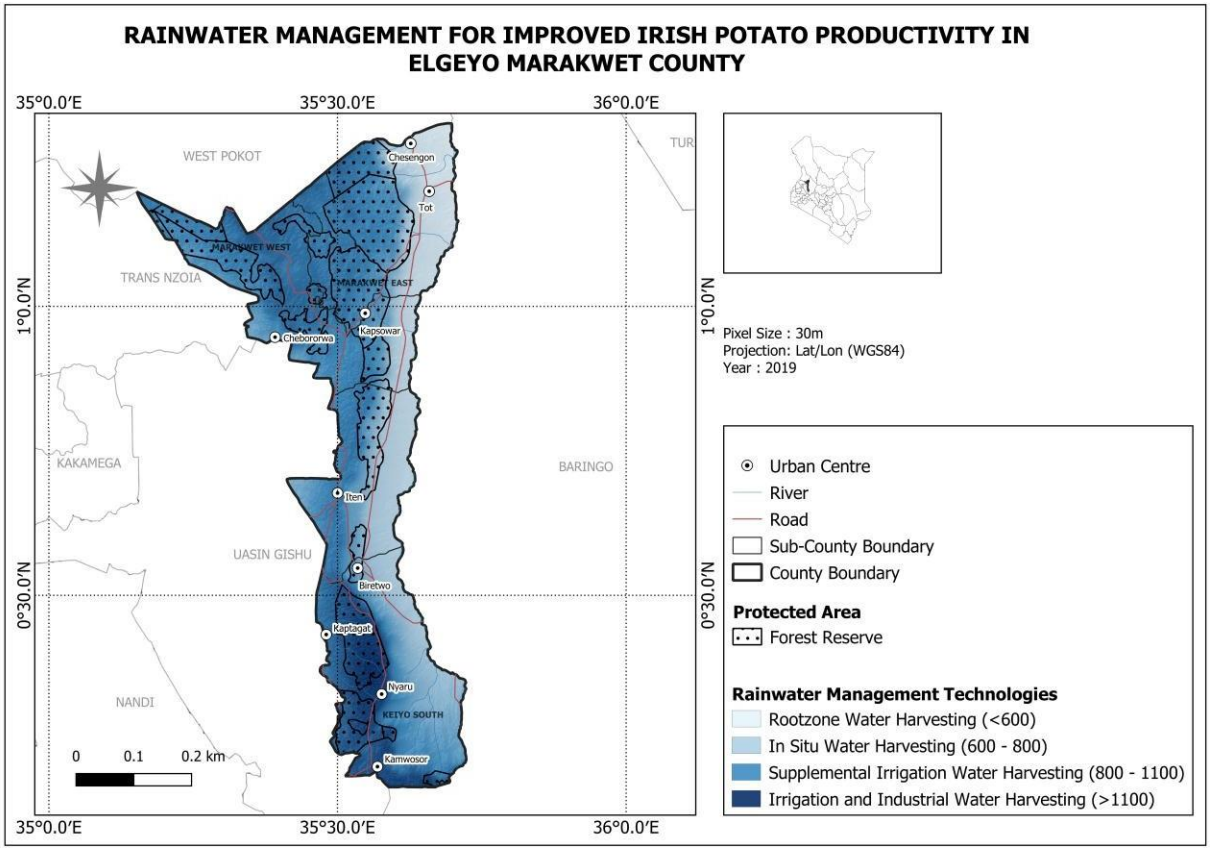

Figure 19: Elgeyo Marakwet Irish Potato Rainwater Management Map

Slope modification and mechanisation profile

The recommended slope modification and slope appropriate mechanisation systems are presented in Figure 20 and Figure 21 respectively.

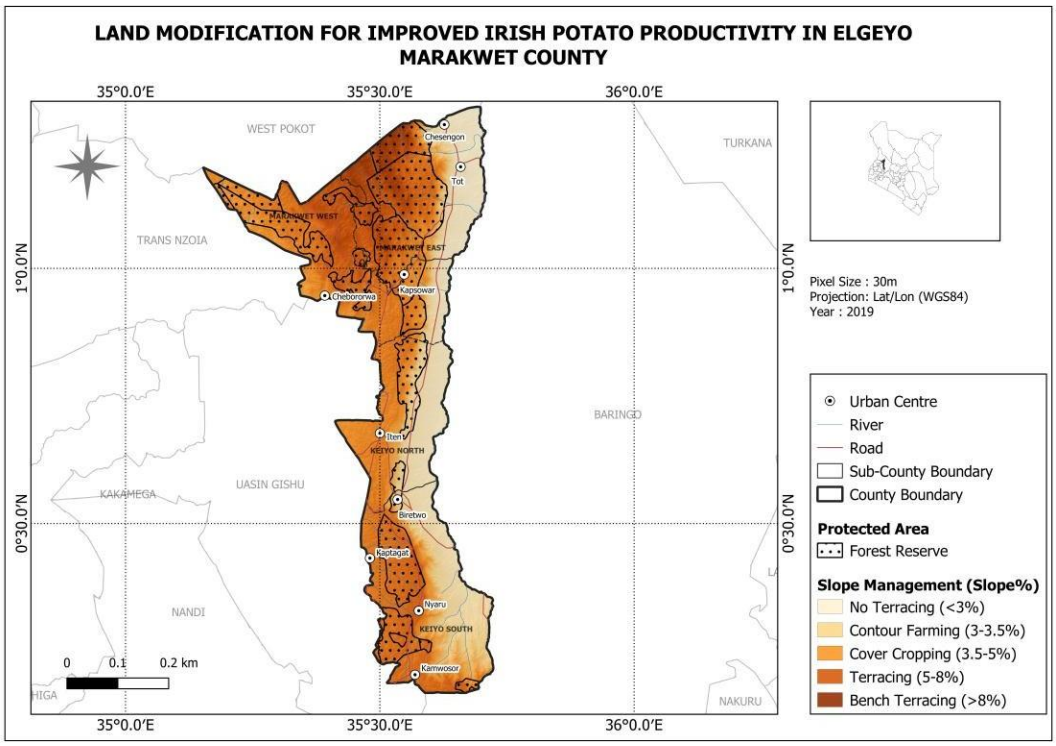

Figure 20: Elgeyo Marakwet Land Modification Map

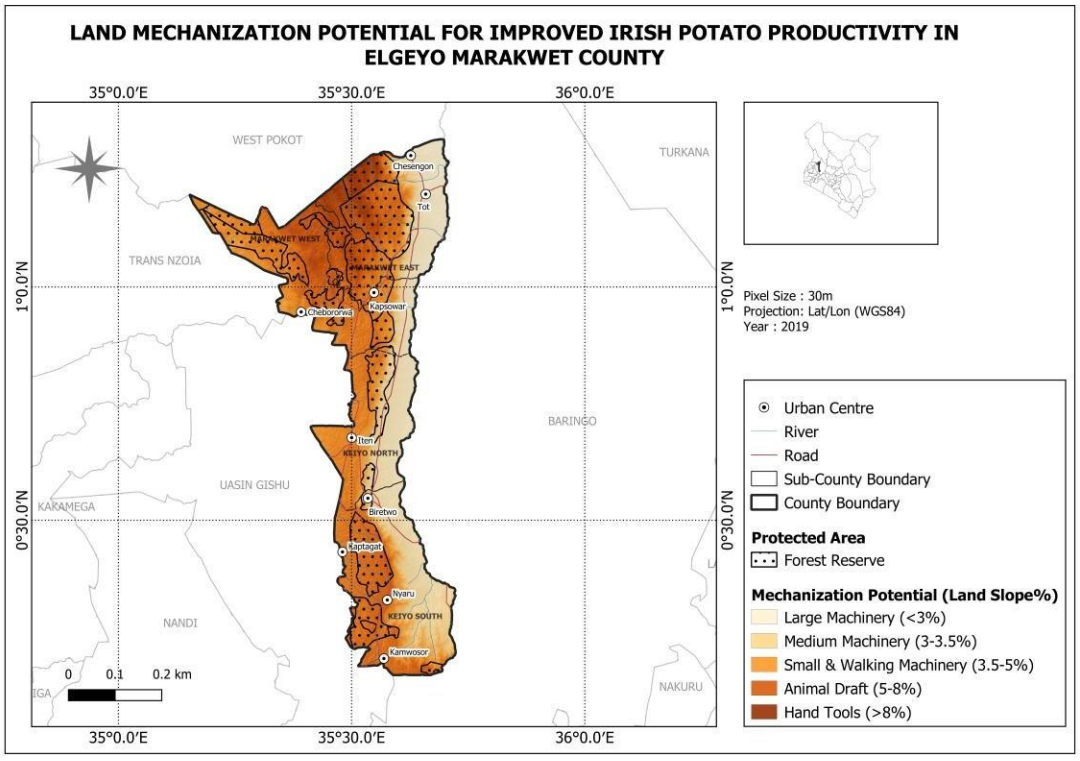

Figure 21: Elgeyo Marakwet Land Mechanization Systems Map

4.2 Cow Milk Value Chain

4.2.1 Parameter Analysis

The critical biophysical parameters that were considered included temperature, rainfall, Thermal Humidity Index that affect primary milk production and land slope and the soil conditions which affect secondary pasture and fodder production. In Elgeyo Marakwet the (THI) ranging from 54-84 indicates that some areas are suitable for local breeds which are a bit tolerant to heat stress while others are suitable for exotic dairy cows that do well in cooler environments. Gently sloped terrain is the best for cattle rearing especially the dairy cattle with areas having 8% or below slope being ideal. The gentle slopes also allow mechanize operations for pasture and fodder. The biophysical parameter analysis is presented in Table 9. The spatial soil and overall classification of the county are presented in Figure16 and Figure 17 respectively. It classifies the county as disaggregated into marginal (valley), moderate (escarpment) and highly suitable (upland and plateau) for the cow milk value chain.

Table 9: Elgeyo Marakwet Biophysical Parameter Analysis

Parameter	**County Parameter**	**VC parameter**	**VC Suitability Classes**	**Adaptation**	**Technology**
Rainfall (mm)	700-1400	500-1000	MS-HS	Rainwater harvesting	Water conservation structures
Temperature	7->25˚C	6°C-21°C	NS-HS	Animal shade	Appropriate houses Suitable breeds
THI	54-84	<65	NS-HS	Cooling system	Solar fans
Slope (%)	3-50%	<8	NS-HS	Reduce slope Reduce erosion	Build terraces, plant shrubs and grasses

4.2.2 Suitability classes

Dairy farming requires highly suitable areas, while areas that are moderately suitable will experience heat stress with major effects on in-calf and milk production. THI profile in the county shows a rise from comfort zone of 54% in the highlands on the western side of the county to stress zones of 84% on the eastern regions. It is known that regions that experience high spikes in heat stress experience milk yield decreases of up to 30-40% and this loss in milk production is irreversible. Areas that are not suitable to those that are marginally suitable will have low milk production to significant milk loss. Heat management actions should therefore be put in place before introduction of the herd.

The soils are considered for pasture and fodder production while the compounded biophysical parameters consider both primary milk production and secondary fodder production systems.. The county soils are generally moderate to highly suitable to support fodder production as a secondary input into cow milk production (Figure 22).

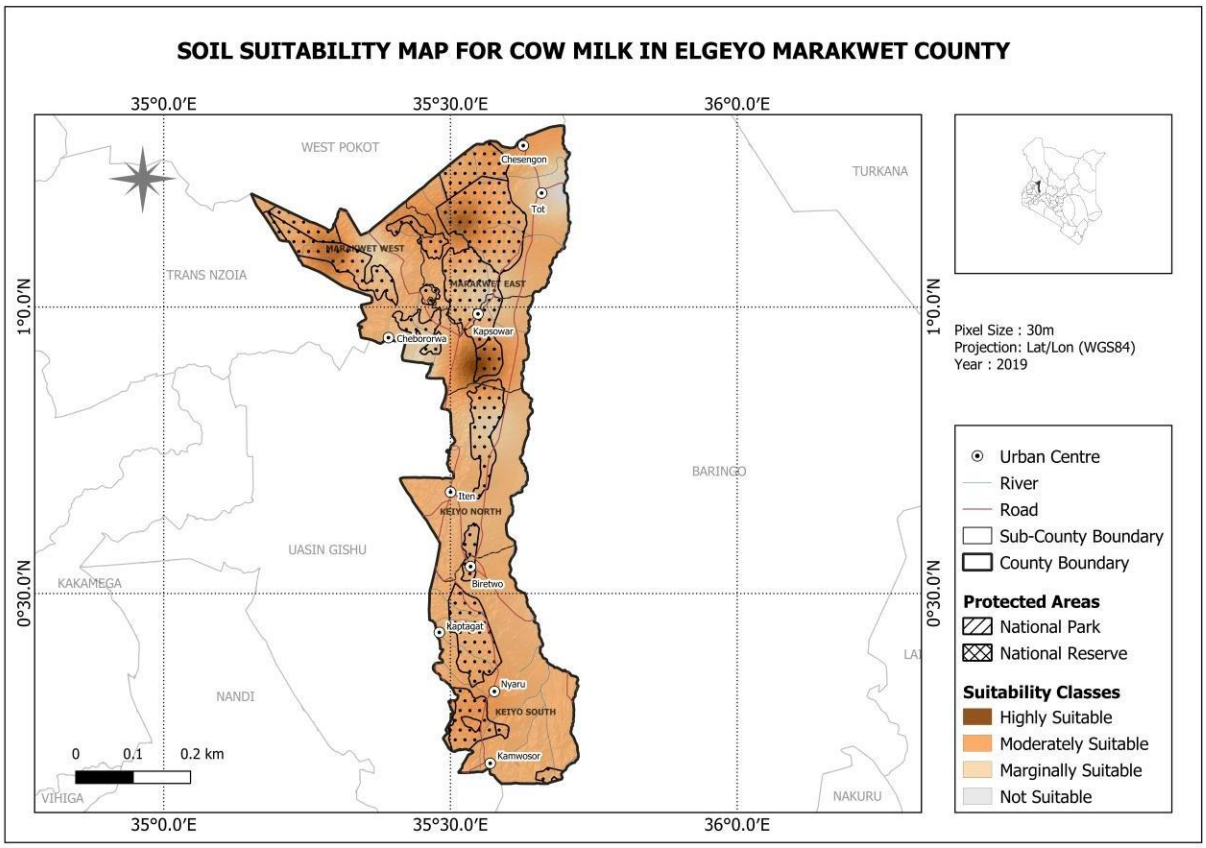

Figure 22: Elgeyo Marakwet Cow Milk Soil Suitability Map

The overall classification of biophysical, economic, social and political parameters indicate that the county has regions that are highly suitable, moderately suitable, marginally suitable and those that are not suitable for the commercialisation of the cow milk value chain (Figure 23). Most parts of eastern Elgeyo Marakwet County is not suitable for rearing dairy cows. The entire western strip of the County highlands is highly suitable (Figure 23).

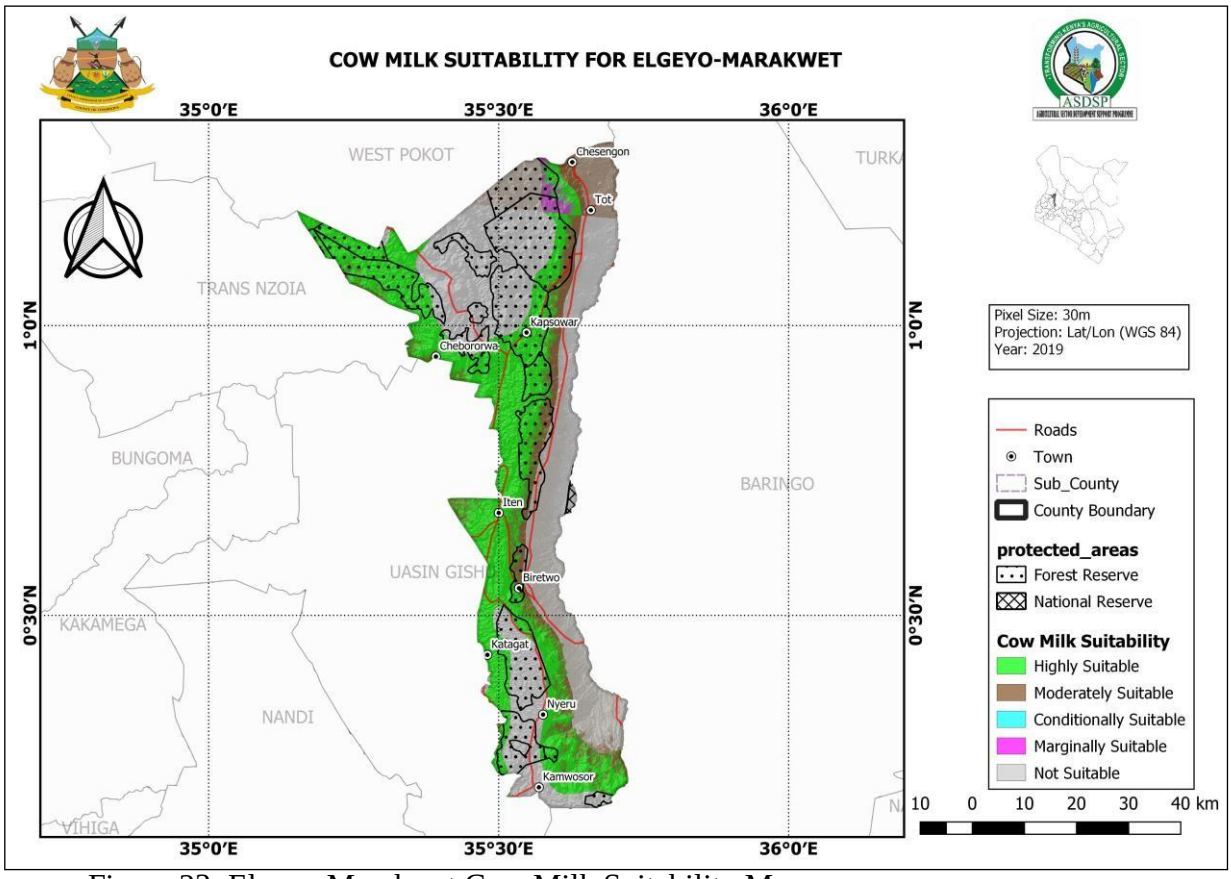

Figure 23: Elgeyo Marakwet Cow Milk Suitability Map

4.2.3 Adaptation Measures

The heat alternatives management will be required for areas with a THI range of 65- 80. The county has more than two-thirds of the region experience THI of less than 65. A THI of less than 68 is highly suitable for animal feeding and milk production. A third of the county has a THI of 65-80. Regions that have THI of 65-72 are moderately suitable calling for installation of animal shades. The escarpment and other regions with THI 72-75 are marginally suitable and requiring installation of ventilation and spray cooling systems and establishment of tree shades. Lastly the regions with THI of 75-80 are not suitable and such areas require heavy investment on feed management and modification of the microclimate or breed substitution (Figure 24).

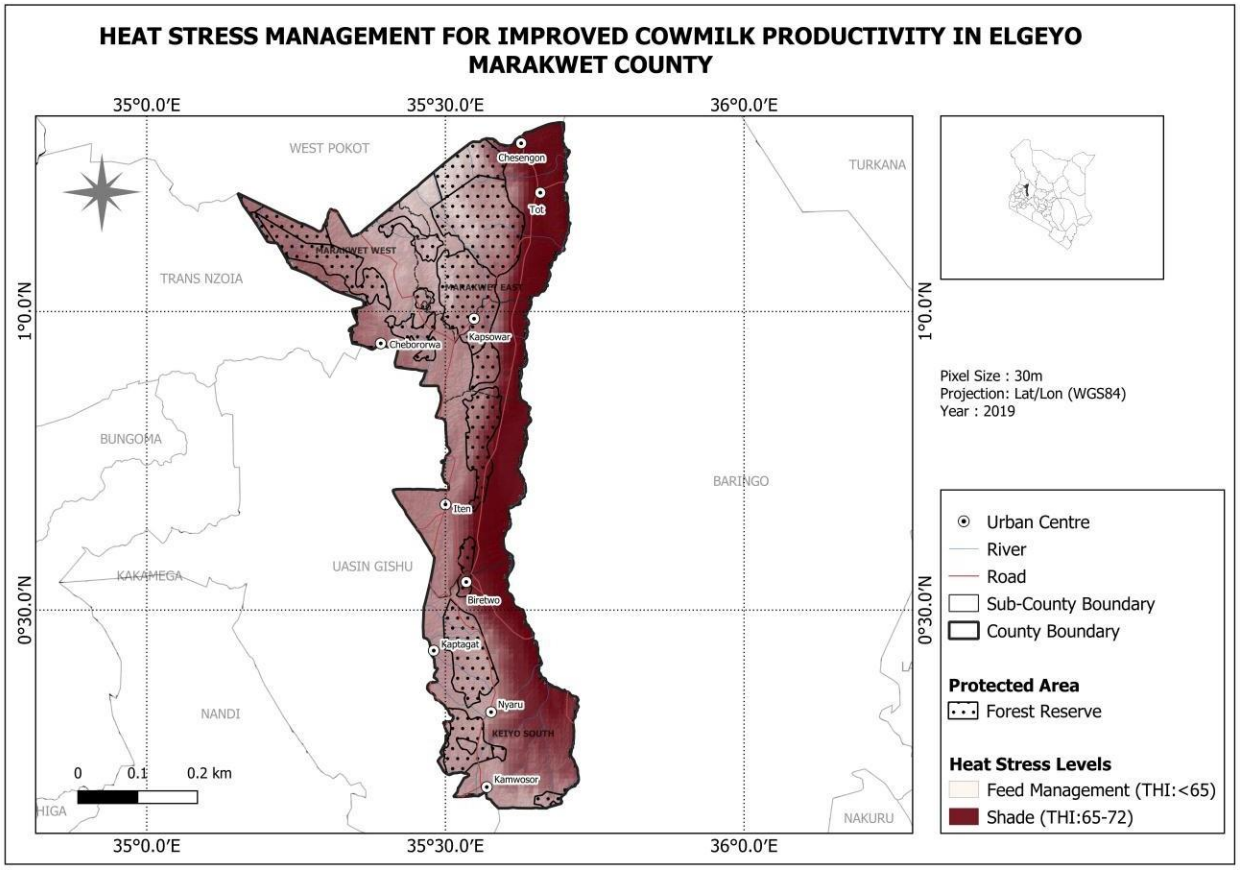

Figure 24: Elgeyo Marakwet Heat Stress Management Map

Other adaptation measures include promotion of conservation agriculture and rainwater harvesting to support fodder and pasture production and avail drinking water for the herd. Others include, feed conservation techniques such as silage making, planting drought-resistant and faster-maturing pasture varieties; keeping improved livestock breeds, use of water harvesting technologies to conserve water (Figure 25), soil and water conservation to adapt to steep slopes feed conservation like silage making, diversification through integration of crops with livestock adjustment of planting dates and use of improved pasture varieties that are early maturing and drought resistant.

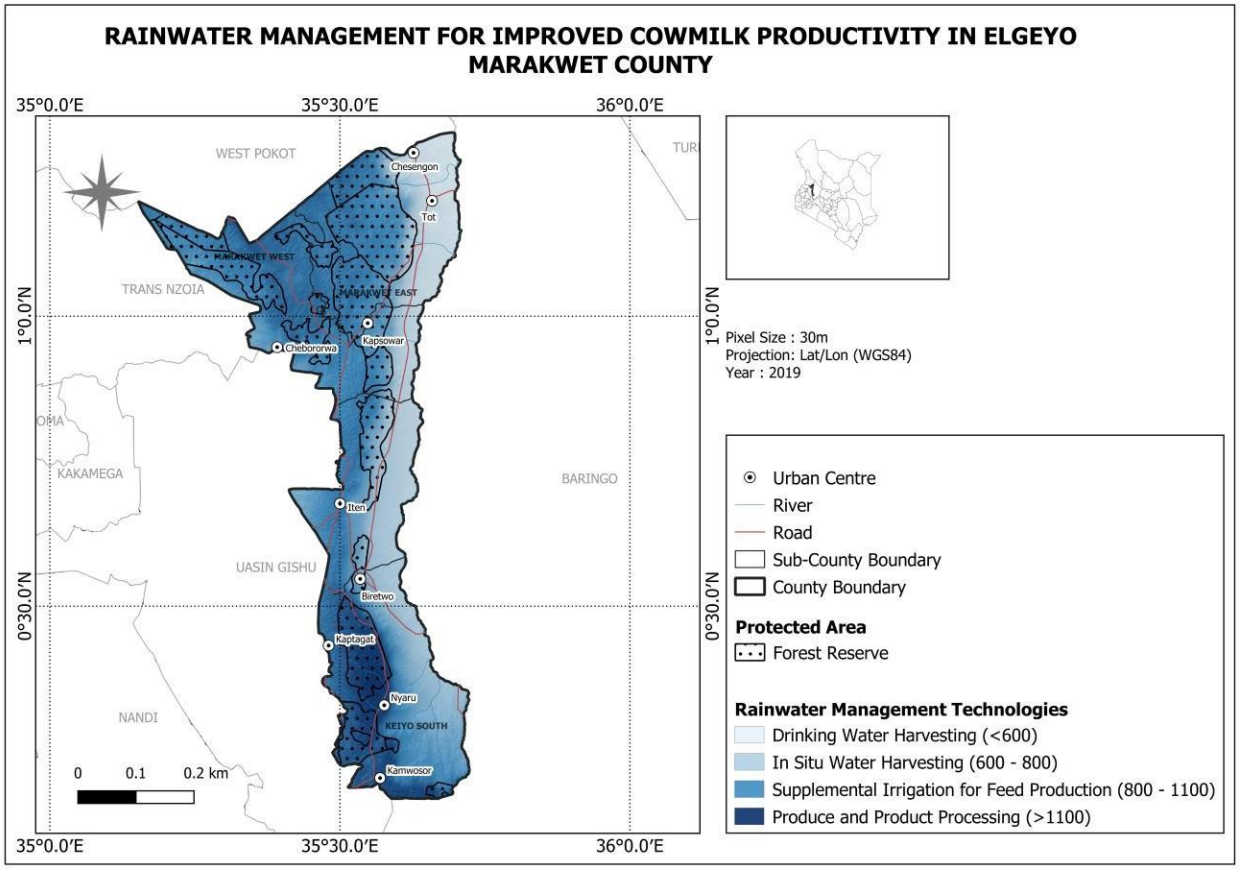

Figure 25: Elgeyo Marakwet Cow Milk Rainwater Management Map

4.2.4 Adaptation Technology and Innovations

The technologies and innovations to support management of constraints include: zero grazing, semi zero grazing which will enable value chain actors to modify the environment. To improve on the slope, pastures should be planted on terraces. Due to inadequate rainfall in-situ water harvesting for pasture production, maize and grass silage should be done. Further breeds relevant to specific areas in the county should be acquired, Friesians for low temperature highlands, Ayrshire for medium temperatures and Jerseys for the hotter valley and escarpment areas, also consider fodder trees growing to improve protein gap at farm level and provide biogas to provide fuel energy needed along the value chain.

4.3 Indigenous Chicken

4.3.1 Parameter analysis Biophysical

The county biophysical parameters considered against the requirements of the indigenous chicken is presented in Table 10 and mapped in Figure 26. The critical constraining parameter is the temperature. Very low temperature is not suitable since the birds use the feed to warm their bodies instead of applying it to meat and egg production. When the temperatures are too high as happens within the valley, then the birds are stressed and reduce feed uptake to adapt to the higher heat in the environment.

Table 10: Indigenous Chicken adaptation technologies and innovations

Parameter	**County Parameter**	**VC parameter**	**VC Suitability Classes**	**Adaptation**	**Technology**
Rainfall (mm)	700-1400	800-1000	HS	Rain water harvesting	In situ water harvesting especially for chicken feeds
Temperature	7->25°C	27°C- 30°C	MS-HS	Improve air circulation	Construct appropriate chicken house
THI	65-80	68-72	S	Modify the environment within the homesteads	Plant appropriate trees

4.3.2 Suitability Maps

The biophysical indicate that the county has regions that are highly suitable, moderately suitable and marginally suitable (Figure 26). Indigenous chicken production is good for areas that are highly suitable, while in areas that are moderately suitable the constraining factor is heat stress that compromises production. Overall when the factors of markets and policy frameworks are considered, the weight of biophysical parameters is overshadowed by the strong social and political interests of those in the western region making the valley to gain high suitability classification (Figure 27).

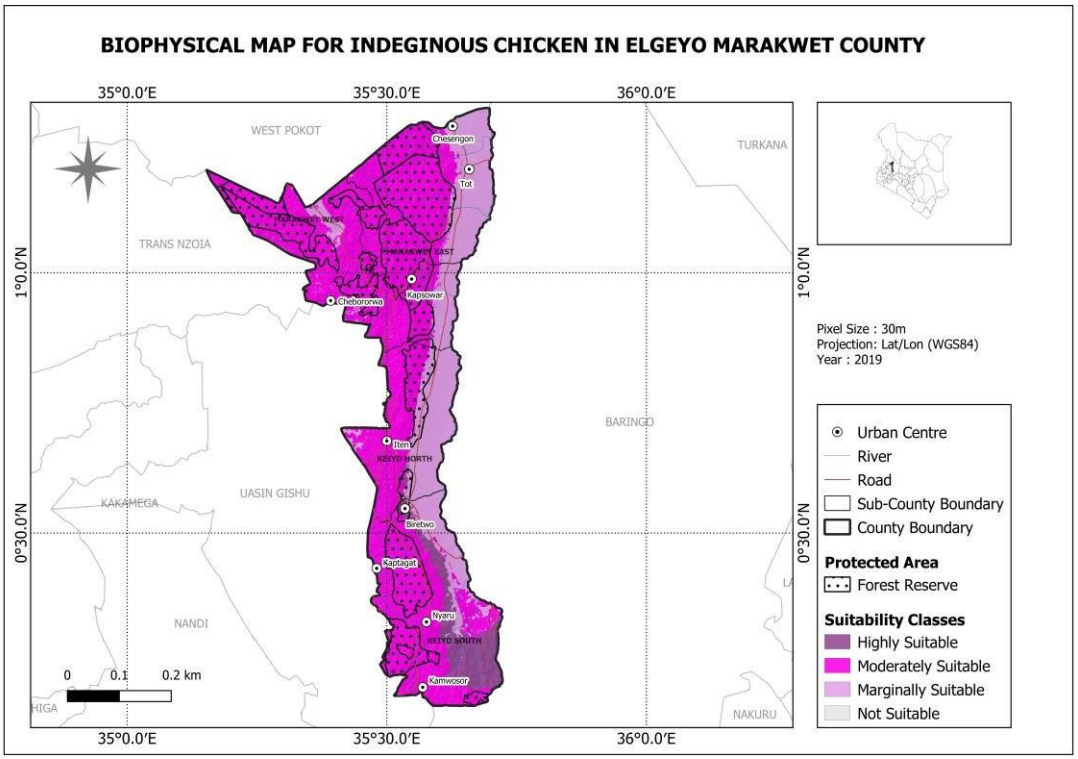

Figure 26: Elgeyo Marakwet Indigenous Chicken Biophysical Suitability Map

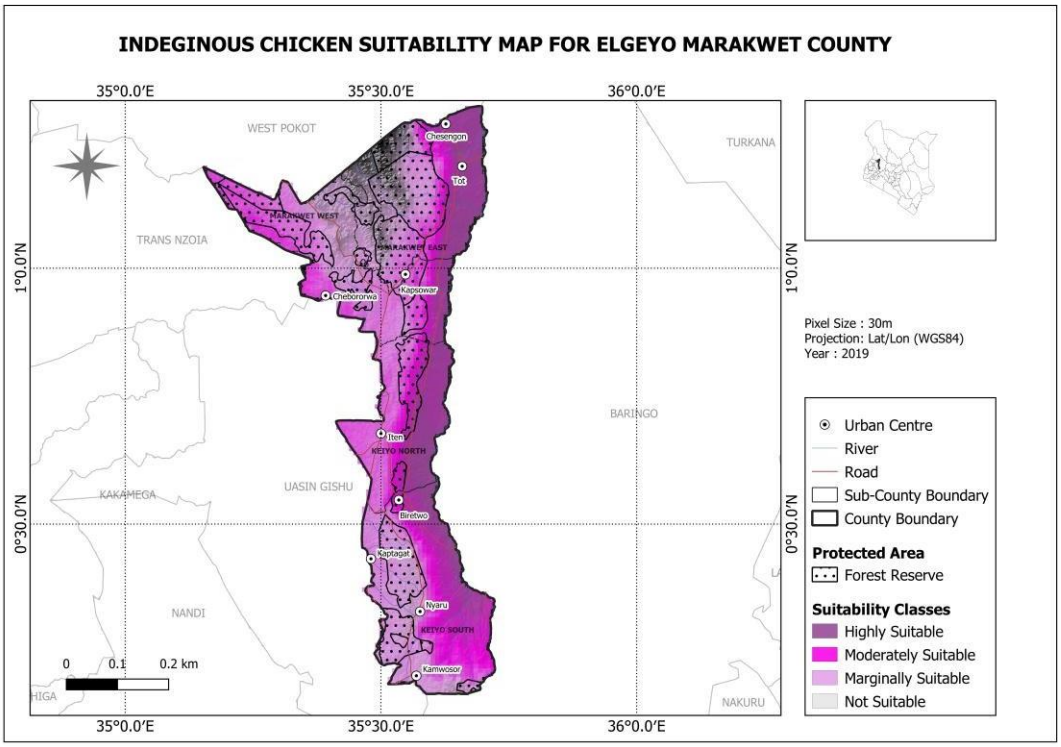

Figure 27: Elgeyo Marakwet Indigenous Chicken Suitability Map

4.3.3 Adaptation Technologies and Innovations

Solar powered air conditioning is recommended to improve air temperature and regulate humidity. Good appropriate houses with good aeration should be constructed augmented by targeted agro forestry measures. Awareness on business and income opportunities presented by this value chain should be done to increase production and scale. To address feed production, rainwater management for feed production and production of drought resistant crops like sorghum is recommended.

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