REPUBLIC OF KENYA

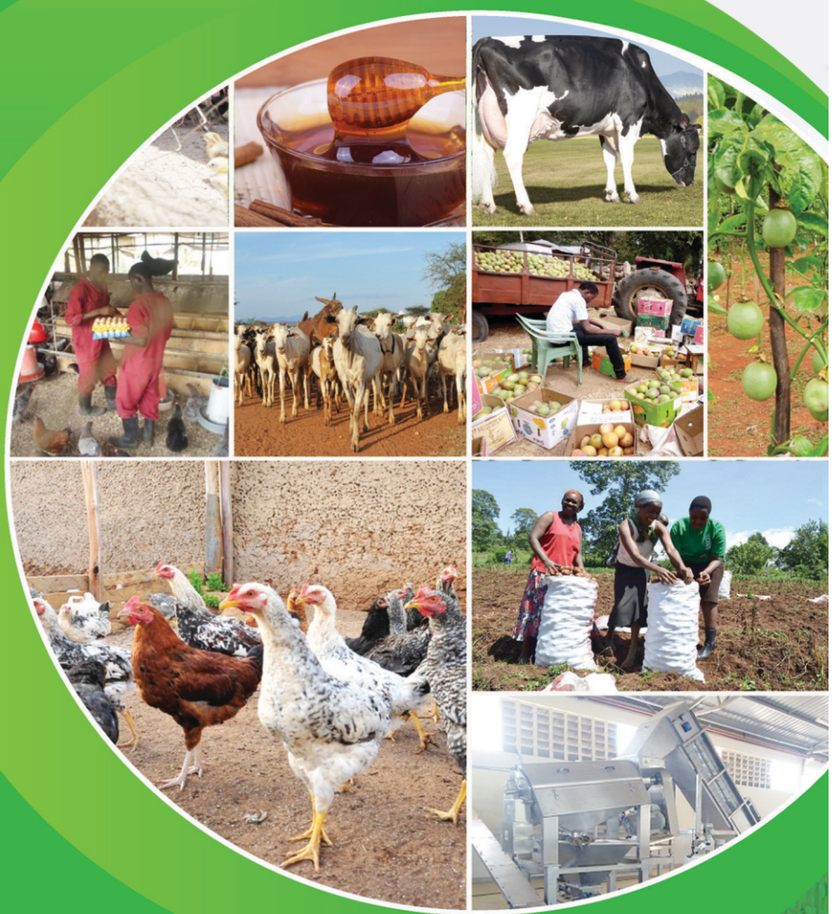
MINISTRY OF AGRICULTURE, LIVESTOCK, FISHERIES AND COOPERATIVES AND COUNTY GOVERNMENTS

ASDSP
AGRICULTURAL SECTOR DEVELOPMENT SUPPORT PROGRAMME

AGRICULTURAL SECTOR DEVELOPMENT SUPPORT PROGRAMME II (ASDSP II)

GARISSA COUNTY PRIORITY VALUE CHAIN SUITABILITY ATLAS

October 2020



"Transforming Kenya Agriculture Sector"

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Agricultural Sector Development Support Programme II (ASDSP II)

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ABBREVIATIONS

AHP	Analytical Hierarchial Process
ASDS	Agricultural Sector Development Strategy
AP	Agricultural Policy
APA	Apollo Pan Africa
ASALS	Arid and semi- Arid Lands
ASDSPII	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

FORWARD

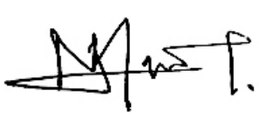
Agricultural sector growth and development is crucial to Kenya's overall economic and social development. In particular, agriculture significantly contributes to the county economy; ensures the county is food secure; generates incomes and provides employment both directly and indirectly for the population. 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 Agricultual 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 of subsidies and social protection. The county government of Marsabit 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 prirority value chains (camel milk, beef and tomato) 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 charectaristics) 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 contrainst 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.



Mohamed Shale
County Executive Committee Member (CECM) Department of Agriculture, livestock and Cooperatives
GARISSA COUNTY

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 is 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 County Agriculture, Livestock, Fisheries and Cooperatives Development department and the entire staff establishment.

Dr. Haret Hambe
Garissa County Programme Coordinator
Agricultural Sector Development Support Programme II (ASDSPII)

EXECUTIVE SUMMARY

Garissa County is principally a semi-arid area falling within ecological zone V-VI and receives an average rainfall of 275 mm per year. Three Priority Value Chains have been identified by the Agriculture Sector Development Support Programme II as being strategic for the county. These include; Tomatoes, Camel milk and beef Priority Value Chains- PVCs. A combination of the biophical, social, economic and policitcal parameter constituted suitability maps of the county. The biophysical parameters under review included temperature, rainfall, slope and soils.

The County biophysical parameters are marginally to moderately suitable for camel milk, tomato and beef priority value chain- PVCs. The economic parameters are moderately suitable wheras social parameters are highly suitable for the three PVCs. The county is moderately to highly suitable for camel value chain production with Dadaab sub county being the most suitable area while the southern part region of Ijara and Hulugho being moderately suitable.

The adaptation measures include refrigerated cooling systems, agroforesrty, upgrade roads and markets, strengthening public participation and implement policies and legislations. The county mostly is marginally and moderately suitable for beef value chain productivity could be enhanced through value addition, agroforestry, feed management and terrace. The tomato value chain is mostly conditionally suitable in Garissa County. The dark clays to alluvial soils along the Laghas, River Tana Basin and the Lorian swamp are highly suitable for tomato farming. The enhanced productivity of tomato value chain could be achieved through adaptation measures e.g greenhouse technology, irrigation as presented in table below. Overall, value addition should be promoted across the three PVCs, water points should be constructed for tomatoes across the county and feed management for beef.

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, To matoes	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	Irish potato, French Beans and Cow Milk
6	Embu	Cow Milk, Bananas 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	Ka jiado	Cow Milk, Tomatoes and Beef	34	Nyandarua	Irish Potato, Fish and Cow Milk
11	Kakamega	Cow Milk, Maize and Indigen ous Chicken	35	Nyamira	Irish potato, 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 Irish potato	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, Mango and Rice	39	Taita Taveta	Irish potato, Indigenous Chicken and Mango
16	Kisii	Cow Milk, Irish potato 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 Mango
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 F ruit	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 Mil k and Mango
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 Bomet County, the priority value chains are cow milk, maize, indigenous chicken and Irish potato (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).

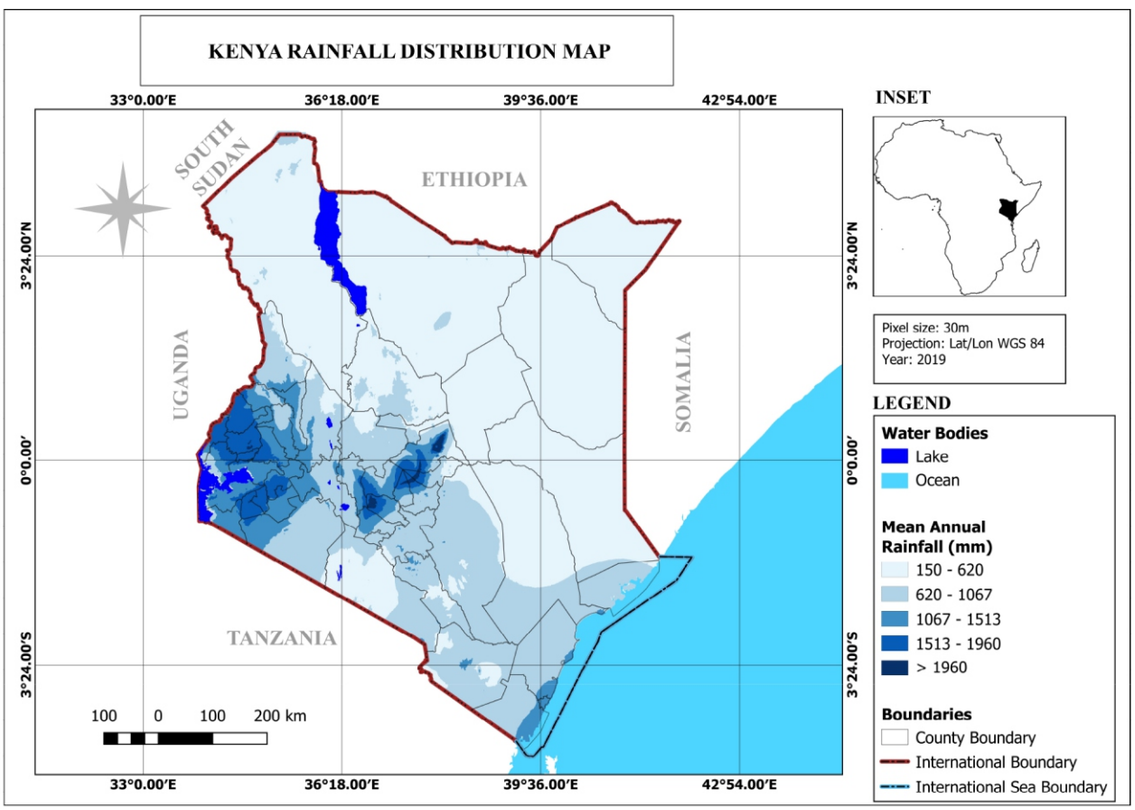


Figure 1: *Kenya Rainfall distribution*

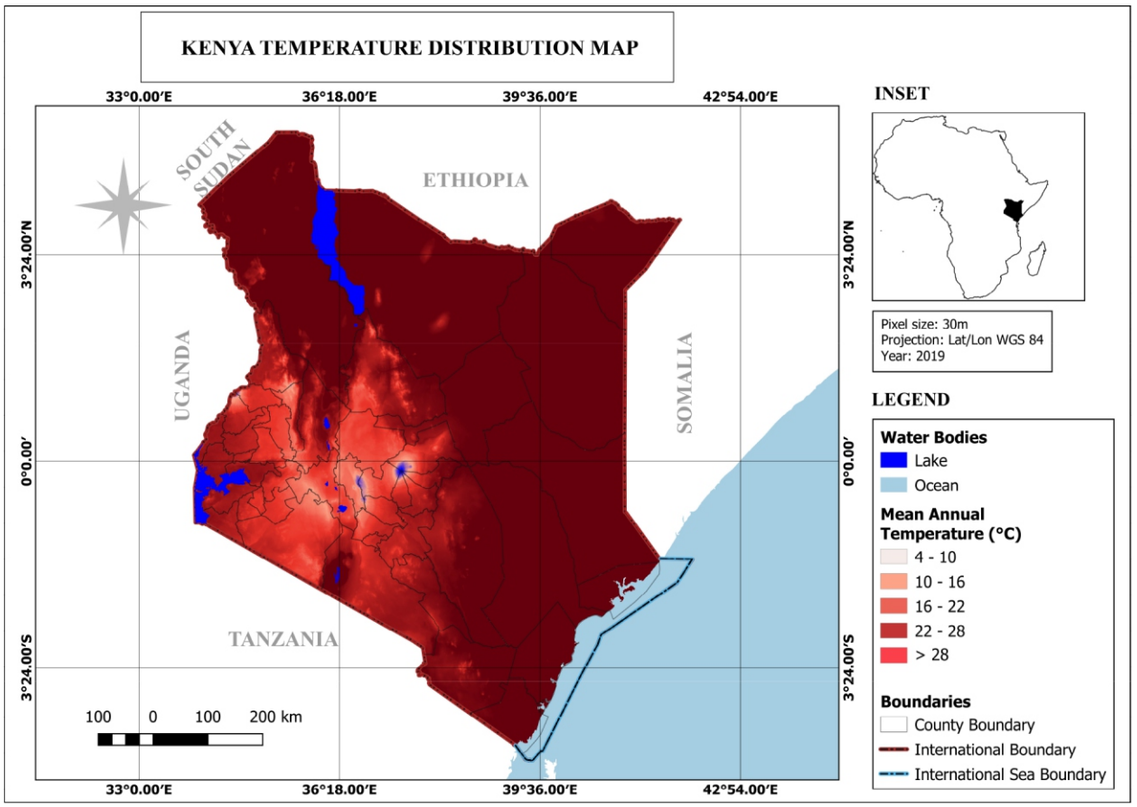


Figure 2: *Kenya Temperature*

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).

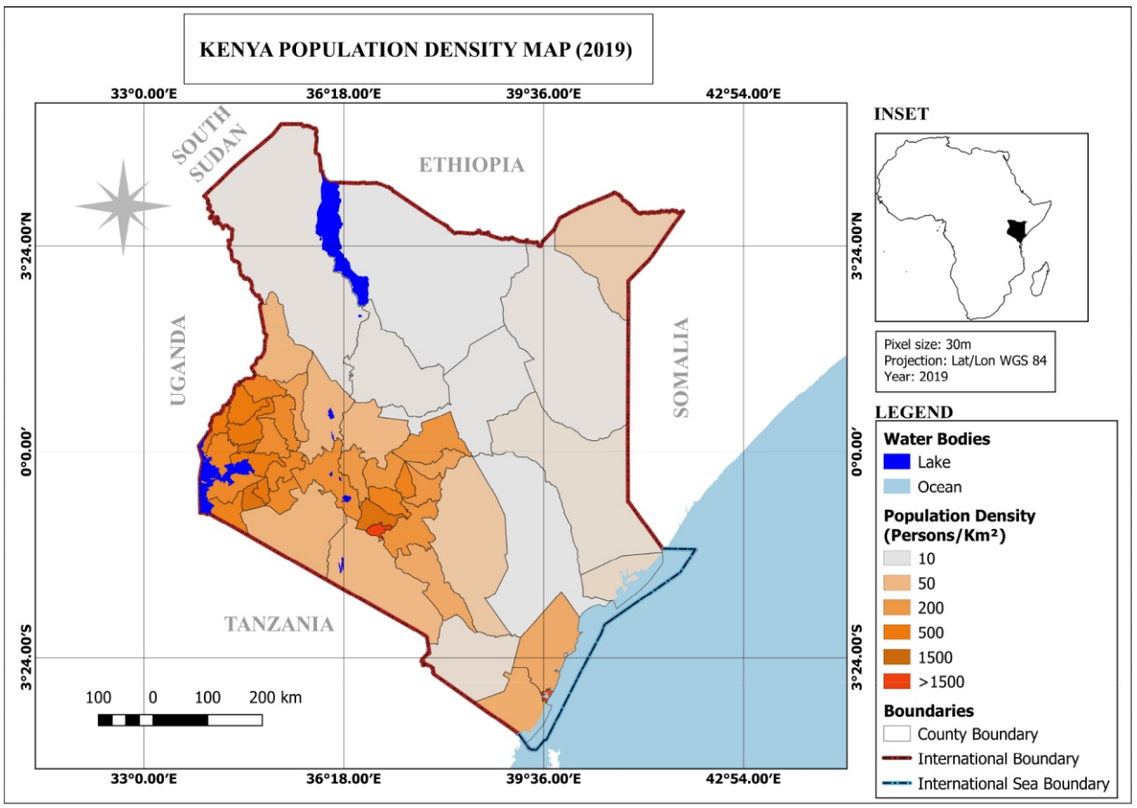


Figure 3: *Kenya Population Density Map*

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).

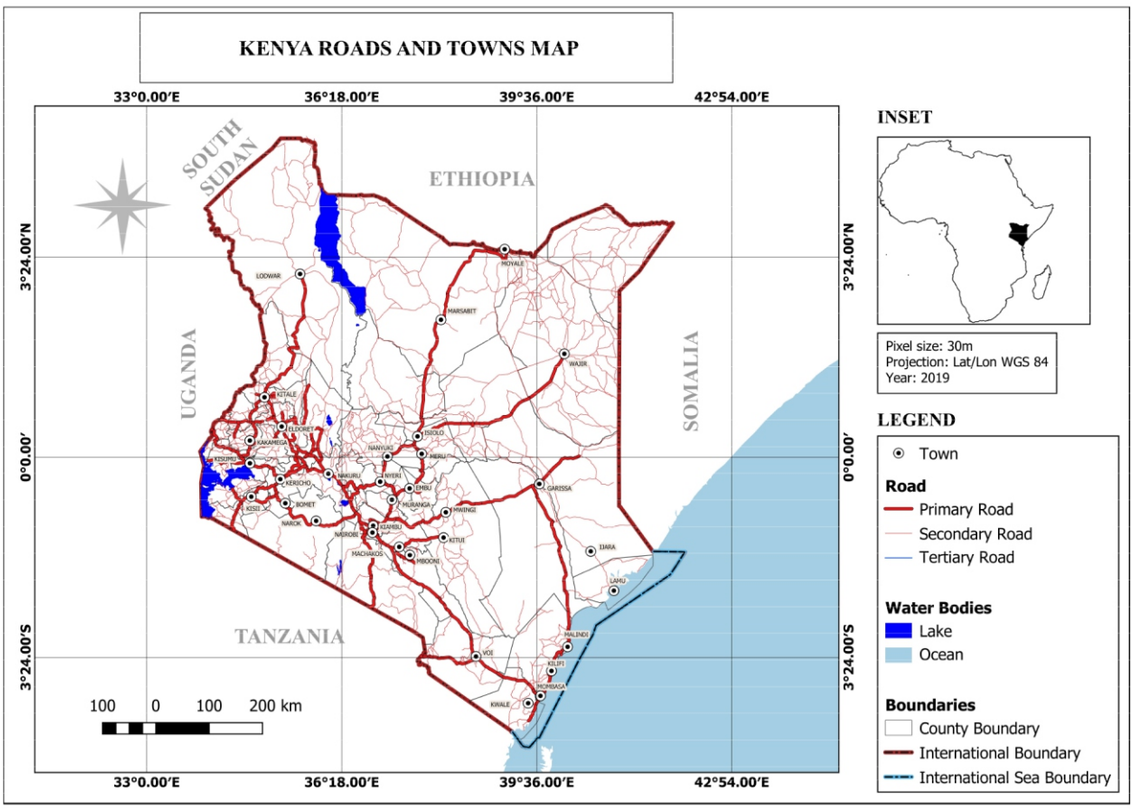


Figure 4: *Kenya Roads and Major Towns*

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; increasingproductivity 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.

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

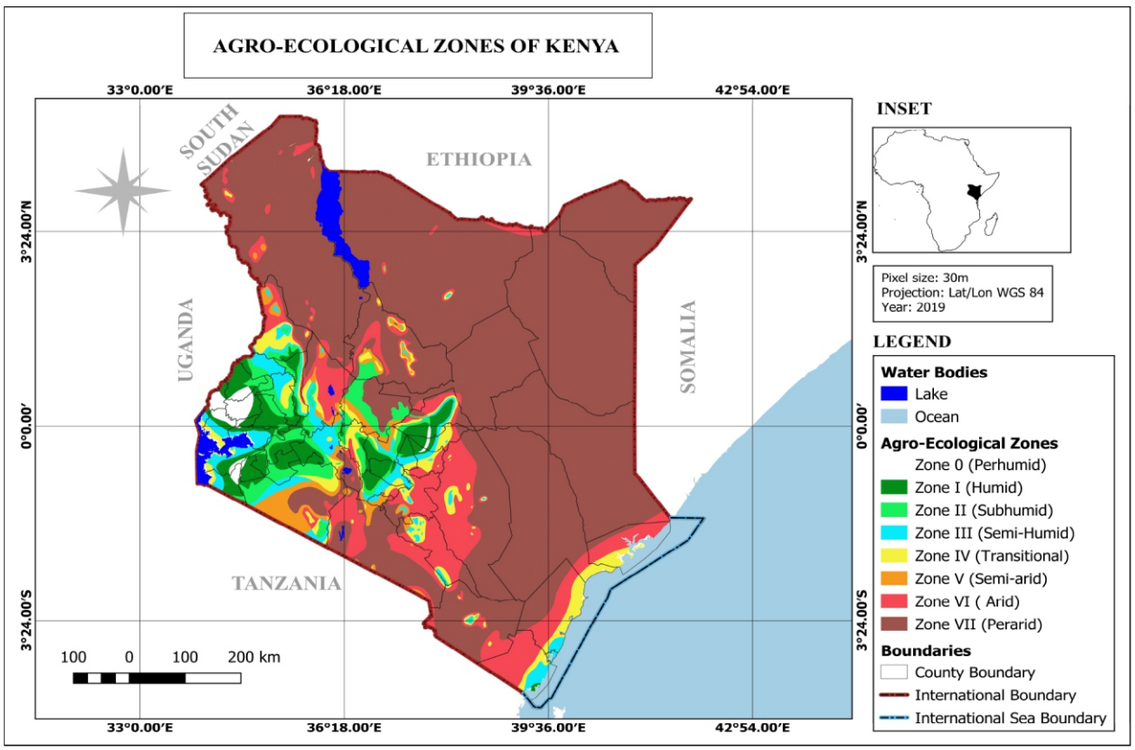


Figure 5: *Agro ecological zones*

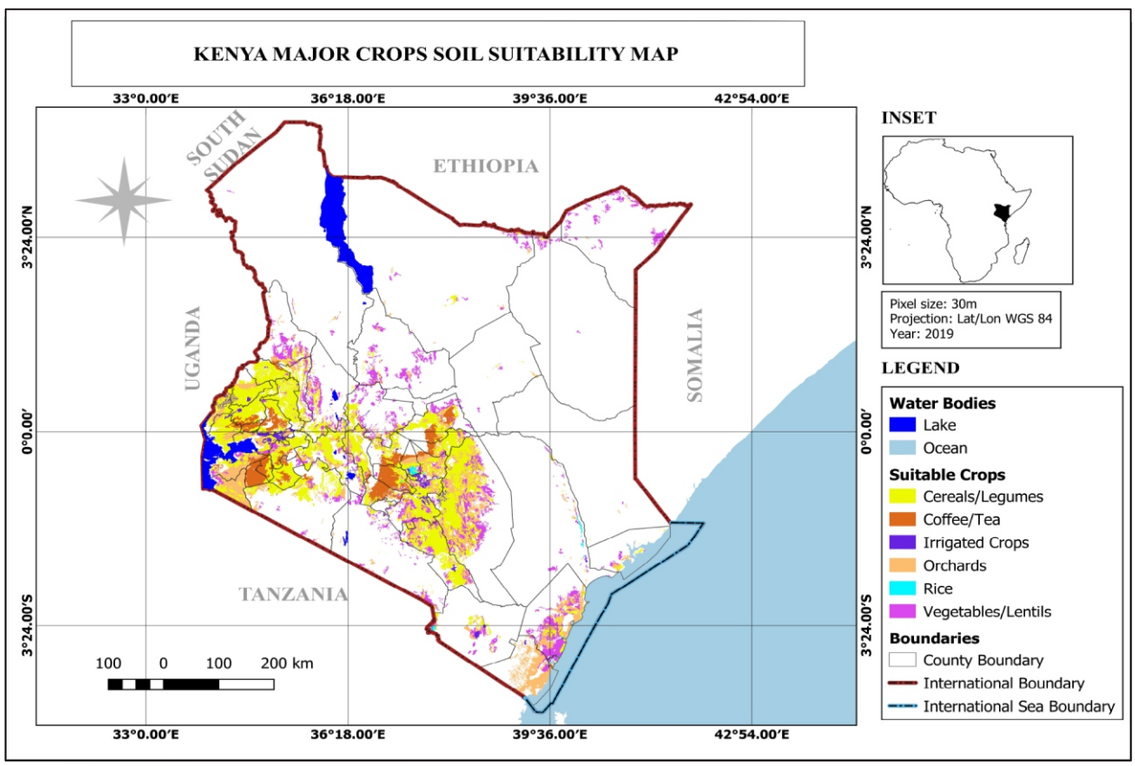


Figure 6: *Kenya Soil Suitability Map*

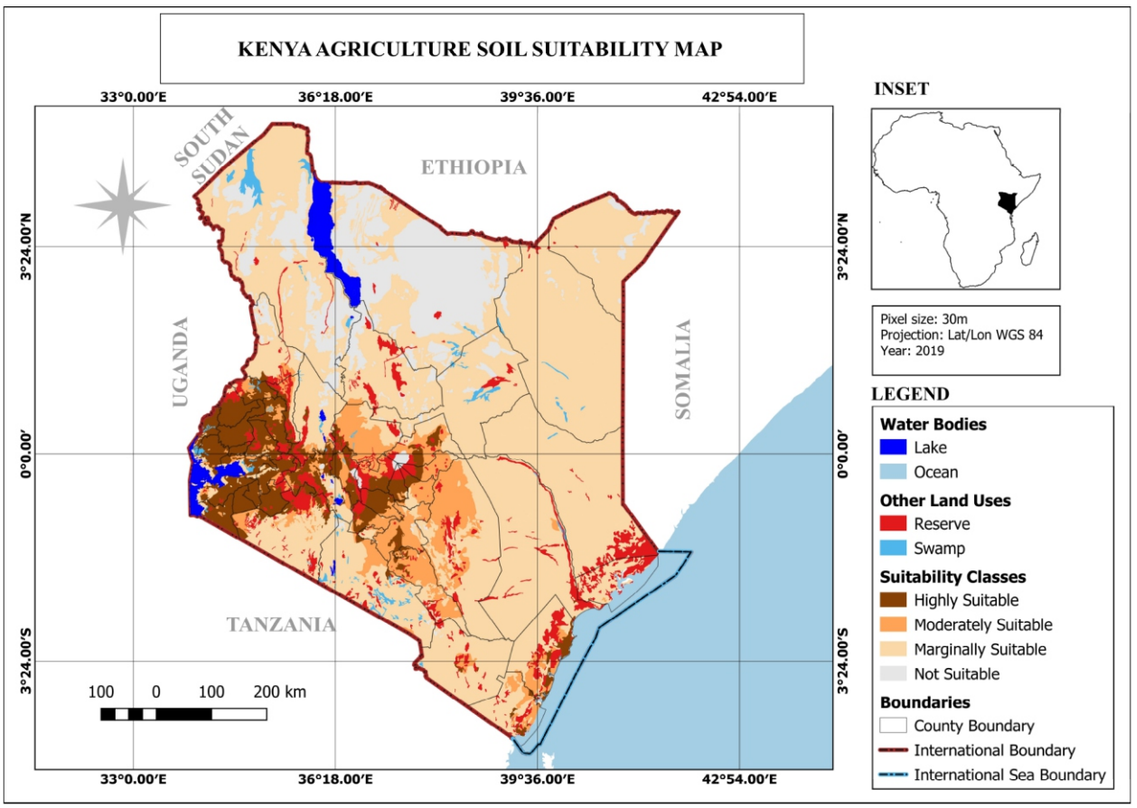


Figure 7: *Kenya soil suitability classification*

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.

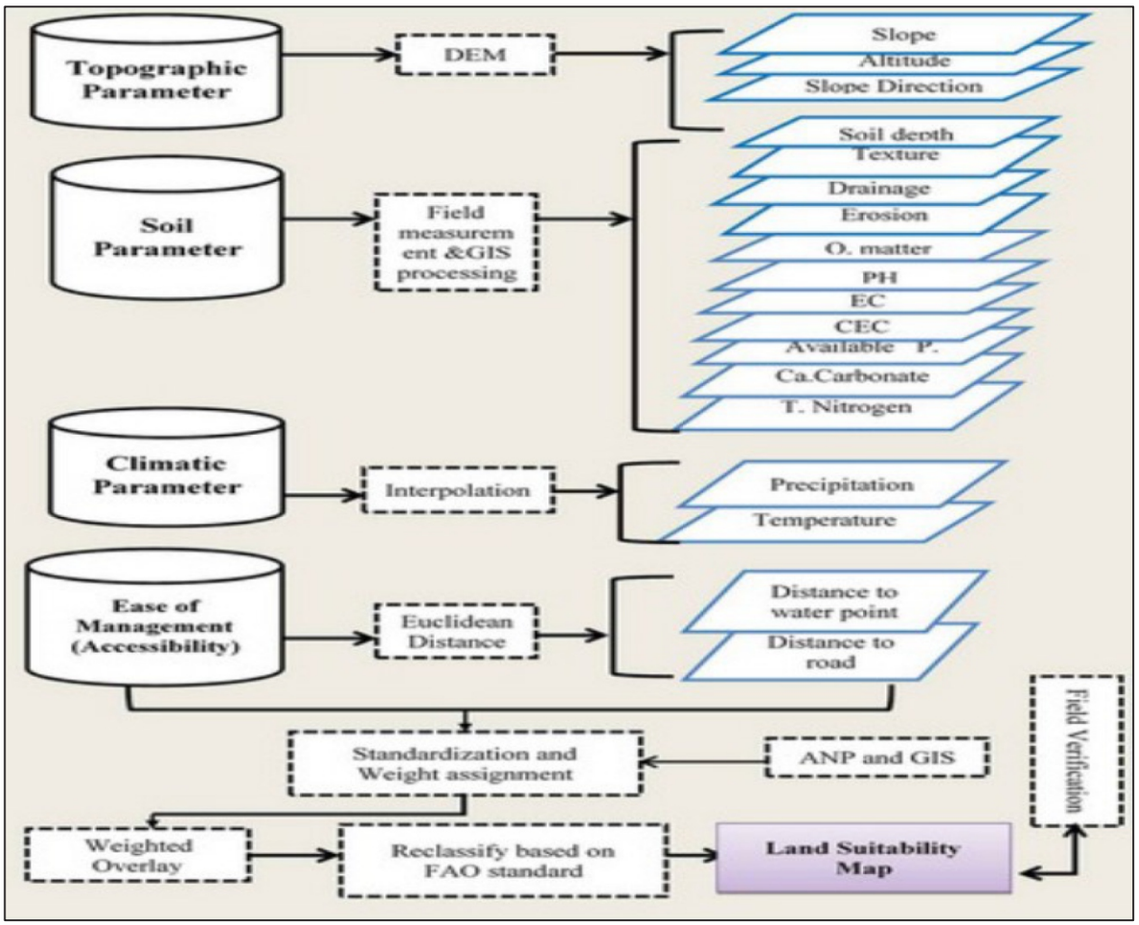


Figure 8: *Suitability mapping process*

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 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 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 for beef

Parameters	Soil	Climate	Topography (slope)
Soil (Biological)		3	
Climate (Physical)	1/3	1	
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	
Market proximity	1/4	1	
Total population	1/5	1/6	

Table 7: Sample pair wise comparison between the social and economic aspects

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

2.4 Overlaying the 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

Garissa County is one of the three counties in the North Eastern region of Kenya. It covers an area of 44,174.1Km^2 and lies between latitude 10 58'N and 20 1' S and longitude 380 34'E and 410 32'E. The county borders the Republic of Somalia to the East, Lamu County to the South, Tana River County to the West, Isiolo County to the North West and Wajir County to the North (Figure 9).

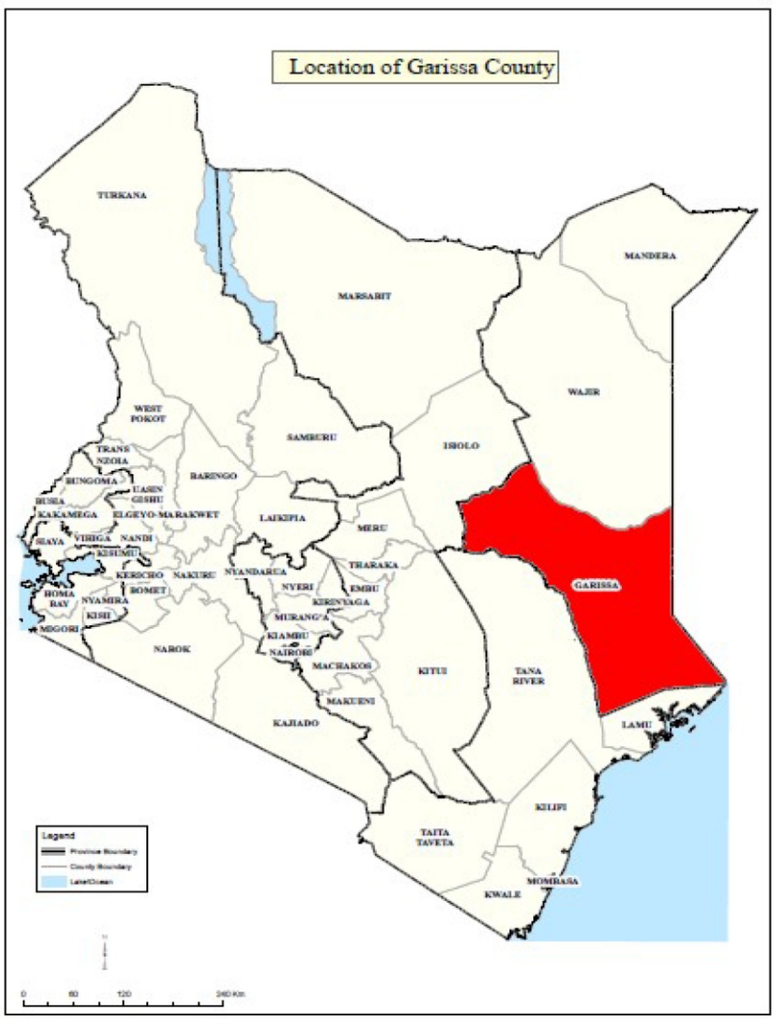


Figure 9: *Location of Garissa County in Kenya*

Garissa County has ten sub-counties which include: Garissa, Fafi, Ijara, Lagdera, Balambala, Dadaab, Bura East, Bothai and Liboi. These correspond to six constituencies in the County. There are 30 wards (administrative units) as shown in figure 10.

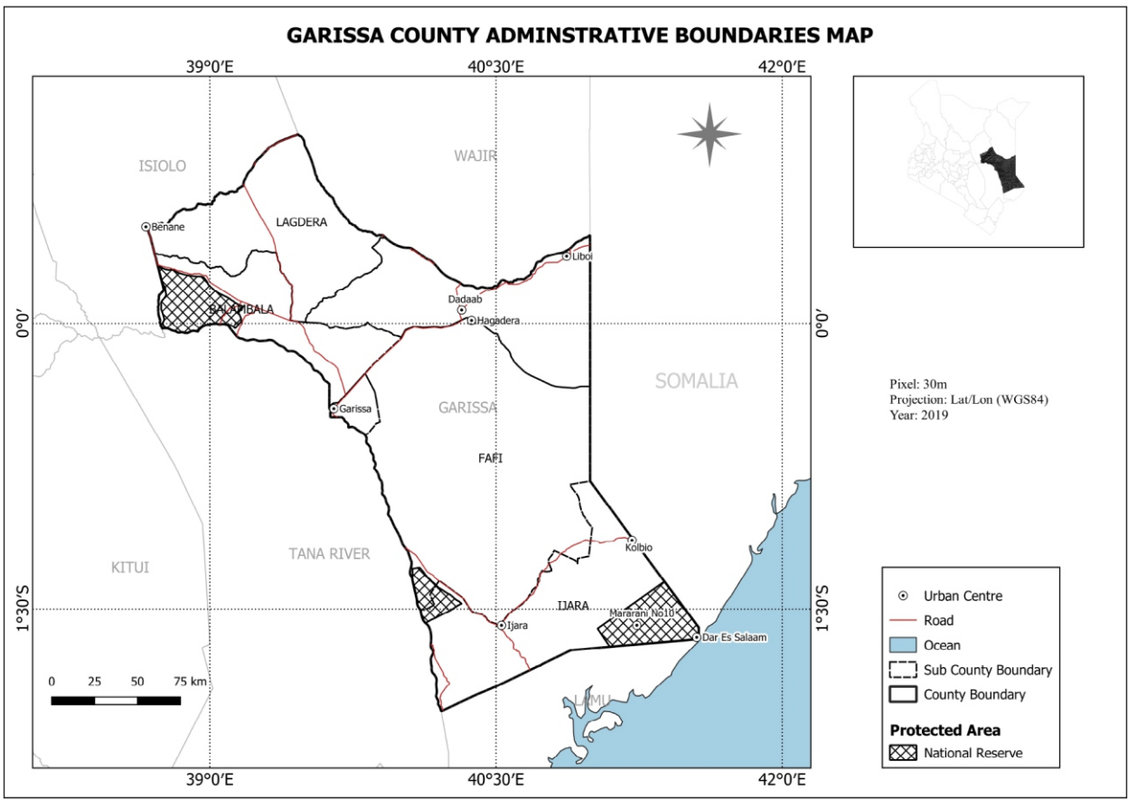


Figure 10: *Garissa County Administrative Map*

3.1 Agro-Ecological Zones

Garissa County is principally a semi-arid area falling within ecological zone V-VI and receives an average rainfall of 275 mm per year. There are two rain seasons, the short rains from October to December and the long rains from March to May. Mostly rainfalls are short torrential downpour and unreliable for vegetation growth. The southern parts of the County such as Hulugho, Masalani and Bura receive more rainfall than the northern parts. Dadaab, Lagdera, Balambala and Fafi Constituencies practice rain-fed agriculture on small scale. During the dry season, there is a general migration of livestock from the hinterland to areas near River Tana where water is readily available. However, some pastoralists move with their livestock to adjacent counties of Tana River and Lamu in search of pasture. Much of the County's livestock population are indigenous sheep, goats and cattle, found in the southern parts which receive more rain while camels occupy the drier north.

The humidity averages 60g/m3 in the morning and 55 g/m3 in the afternoon. An average of 9.5 hours of sunshine is received per day. Strong winds are also experienced between April and August with the rest of the months getting calm winds.

Occasioned by climate change the rainfall patterns and temperature have been changing. Thus, the county is prone to drought and flood emergencies leading to threat to livelihoods.

3.2 Physiacal and Topographical Features

Garissa County is basically flat and low lying without hills, valleys and mountains. It rises from a low altitude of 20m to 400m above sea level. The major physical features are seasonal Laghas and the Tana River Basin on the western side. The River Tana has tremendous effect on the climate, settlement patterns and economic activities within the county. Given the arid nature of the county, there is great potential for expansion of agriculture through harnessing of River Tana and Laghas.

3.3 Population

The county has a projected total population of 871,644 persons which consist of 468,489 males and 403,155 females as at 2017. The population is projected to increase to 948,880 and to 1,029,504 persons in 2020 and 2022 respectively (Garissa CIDP 2018-2022).

Garissa County has a child rich population, where 0-14 year olds was estimated to be 381,309 in 2017 which constitutes 43.7% of the total population. This is due to high fertility rates among women as shown by the percentage household size of 6 members at 35%. The proportion of 0-4 year olds is 14.6% of total population due to high infant and under five mortality rates. There is low population aged 65 years and above. This is due to low life expectancy rate at 56 years for males and 65 years for females. Dependency ratio of 1:0 i.e. for every 10 workers there are 10 people not of working age. This has a negative impact on development since more resources are required to take care of this population.

According to the current classification, the county has two townships namely Garissa and Masalani. There are six unclassified urban centers namely: Balambala, Bura East, Dadaab, Modogashe, Nanighi and Hulugho. Urban population constitutes about 16 per cent of the county's total population. Dadaab is a very unique urban center in the sense that it hosts a large population of refugees; mainly from Somalia. The refugees freely interact with the host community on issues such as trade and inter-marriages among others. The overall level of urbanization in the county is very high due to the influx of people from the hinterland, mainly due to loss of livelihood as a result of persistent drought. This causes strain on the social and physical infrastructure in these urban centers.

Garissa Township has the highest population at 163,734 with a density of 242 persons per km2. This is attributed to the fact that it is the entry point and the administrative centre for the North Eastern region in addition to having relatively well developed infrastructural facilities. Fafi has the lowest population density of nine persons per km2. The county is sparsely populated with majority of the population being concentrated in areas with infrastructural facilities such as Garissa Township. . The average population density is 20 persons per km2 in the county. Garissa Township Constituency has the highest population density of 242 persons per square kilometre. The town constituency attracts many people and is also the administrative centre for the North Eastern region and has relatively well developed infrastructural facilities. Fafi constituency has the lowest population density of nine persons per square kilometre. This is because of its expansive nature and relatively poor infrastructure.

3.4 County Resources

About 79% of the county's population use firewood as a source of energy for cooking purposes. Further, 18% of the population use charcoal while Garissa, Ijara, Dadaab, Bura East and Modogashe are connected to the national grid, with only 0.7% of the population having access to electricity.

Garissa County is water scarce with only 24% of the population having access to safe water. Access to piped water is limited to the sub-county headquarters where approximately 27,725 households have connection. The main source of water in the county is River Tana and seasonal ***Laghas and*** the average distance to nearest water point is 25km

The soils range from the sandstones, dark clays to alluvial soils along the Laghas, River Tana Basin and the Lorain swamp. These soils have potential for farming.

3.4.1 Biophysical Parameters Garissa County Mean Annual Temperature

The biophysical parameters include mean annual temperature, rainfall, slope and soils. Given the arid nature of the county, temperatures are generally high throughout the year and range from 20°C to 39°C. The average temperature is however 36°C. The hottest months are September and January to March, while the months of April to August are relatively cooler as shown in figure 11 below.

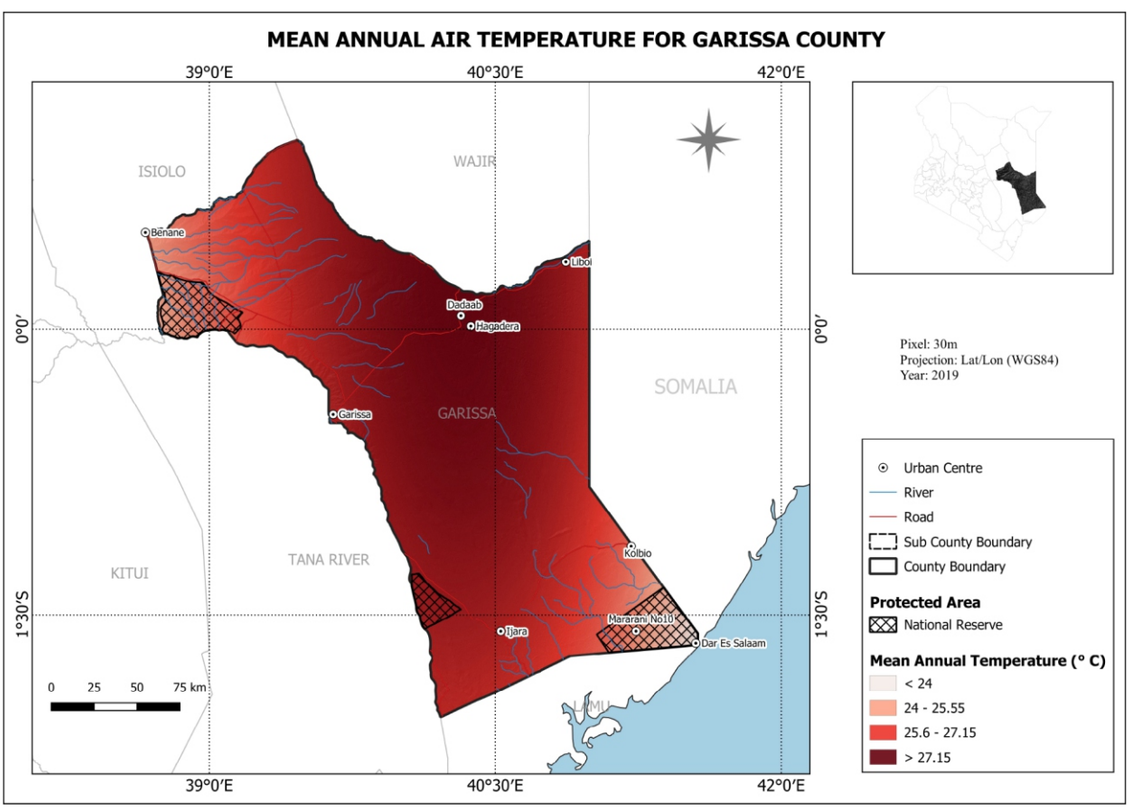


Figure 11: *Garissa County Mean Annual Temperature*

Rainfall Availability

Garissa County is principally a semi-arid area falling within ecological zone V-VI and receives an average rainfall of 275 mm per year. There are two rain seasons, the short rains from October to December and the long rains from March to May. Mostly rainfalls are short torrential downpour and unreliable for vegetation growth. The southern parts of the County such as Hulugho, Masalani and Bura receive more rainfall than the northern parts as shown in figure 10 below.

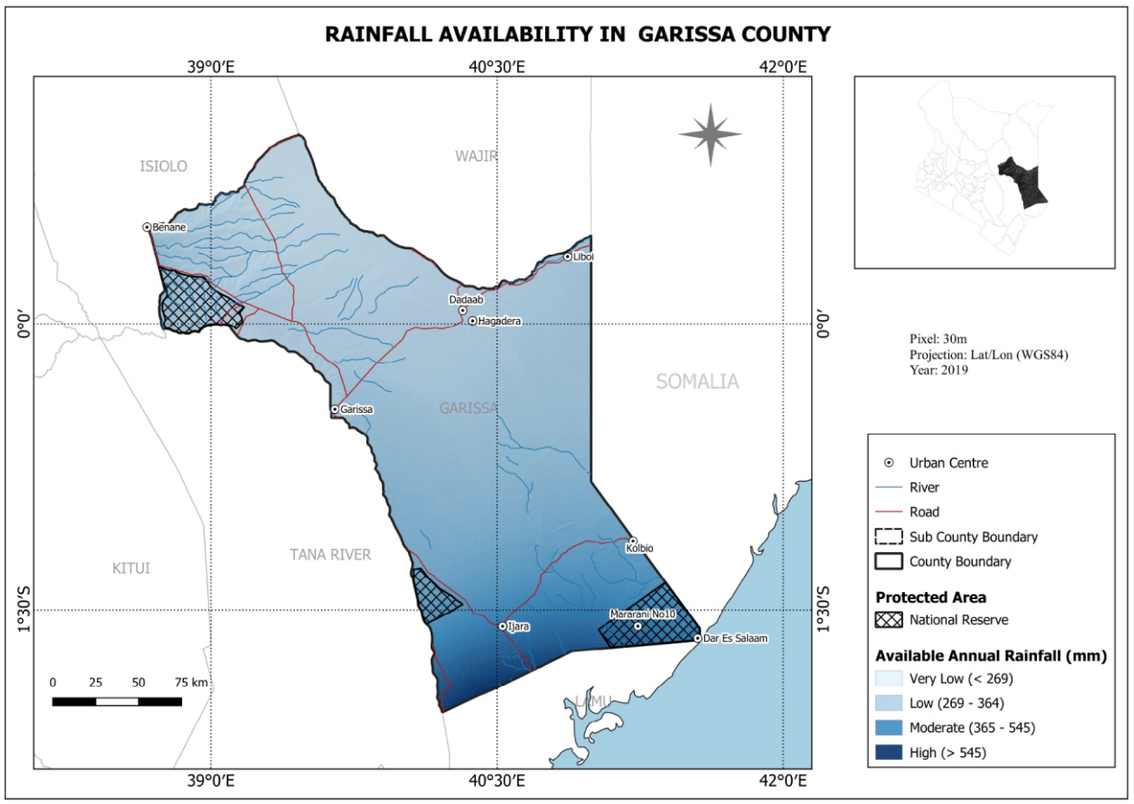


Figure 12: *Garissa County Rainfall availability*

Garissa County Topography

Garissa County is basically flat and low lying without hills, valleys and mountains. It rises from a low altitude of 20m to 400m above sea level.

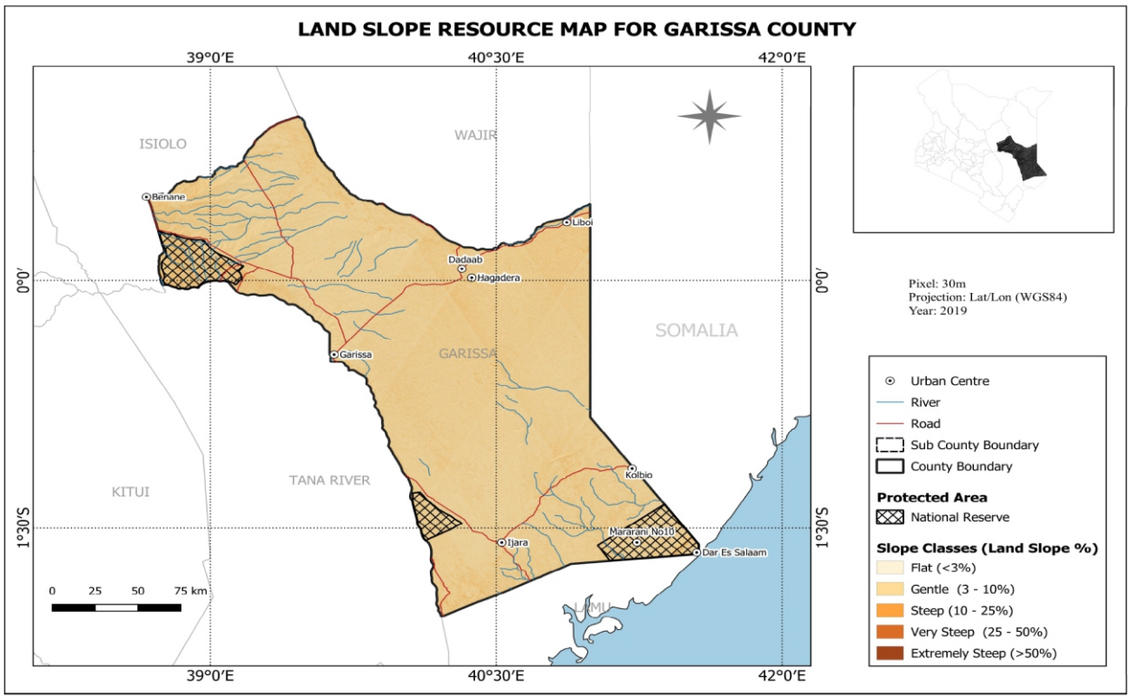


Figure 13: *Land Slope resource map for Garissa County*

Garisa County Heat Stress Levels

The county has areas an overall heat stress range of between 72.43 THI to 78.93 THI (Figure 14).

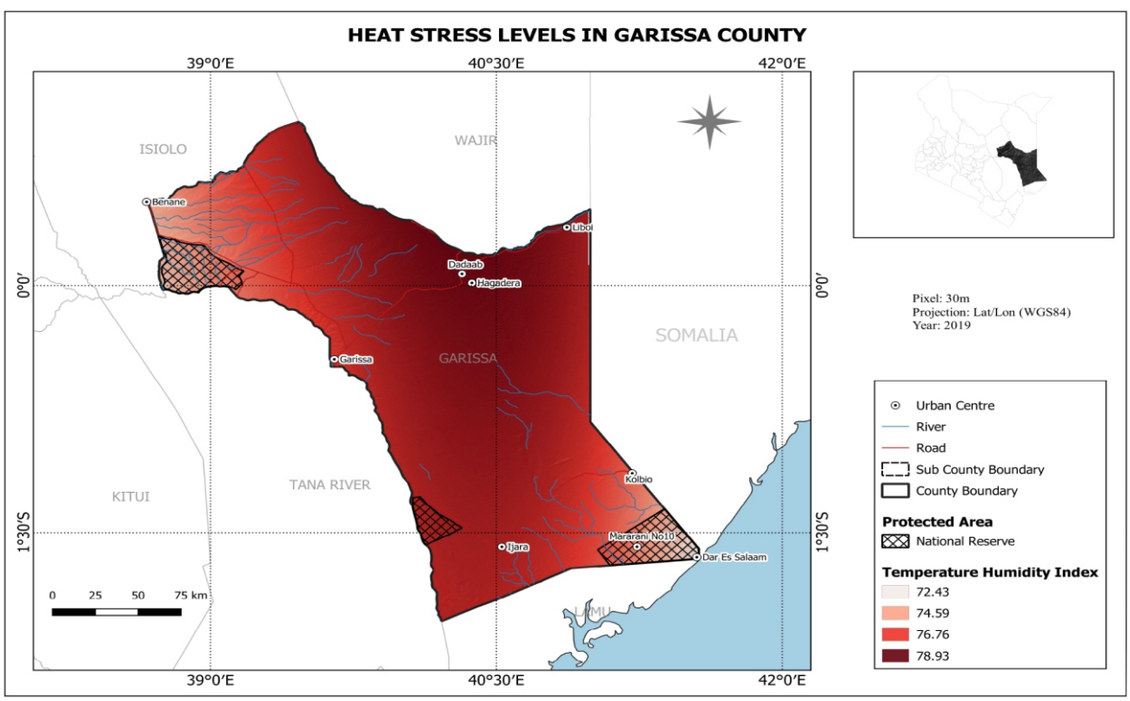


Figure 14: *Garissa county heat stress levels*

Garissa County soil resources

The soils range from the sandstones, dark clays to alluvial soils along the Laghas, River Tana Basin and the Lorian swamp. White and red soils are found in Balambala Constituency where the terrain is relatively uneven and well drained. The soils have low water retention capacity but support vegetation. These soils have potential for farming (Figure 15).

The rest of the county has sandy soils that support scattered shrubs and grasslands which are ideal for livestock production. The county's land is highly erodible. The exploitation of the soil resource thus must take into account conservation measures due to their fragile nature. The mineral potential of the soils is not exactly known as no geological mapping has been done. Reconnaissance surveys have however, indicated some occurrences of clay, good quality building sand along Laghas, lime and gypsum in places such as Benane in Lagdera Constituency and in Dadaab Constituency.

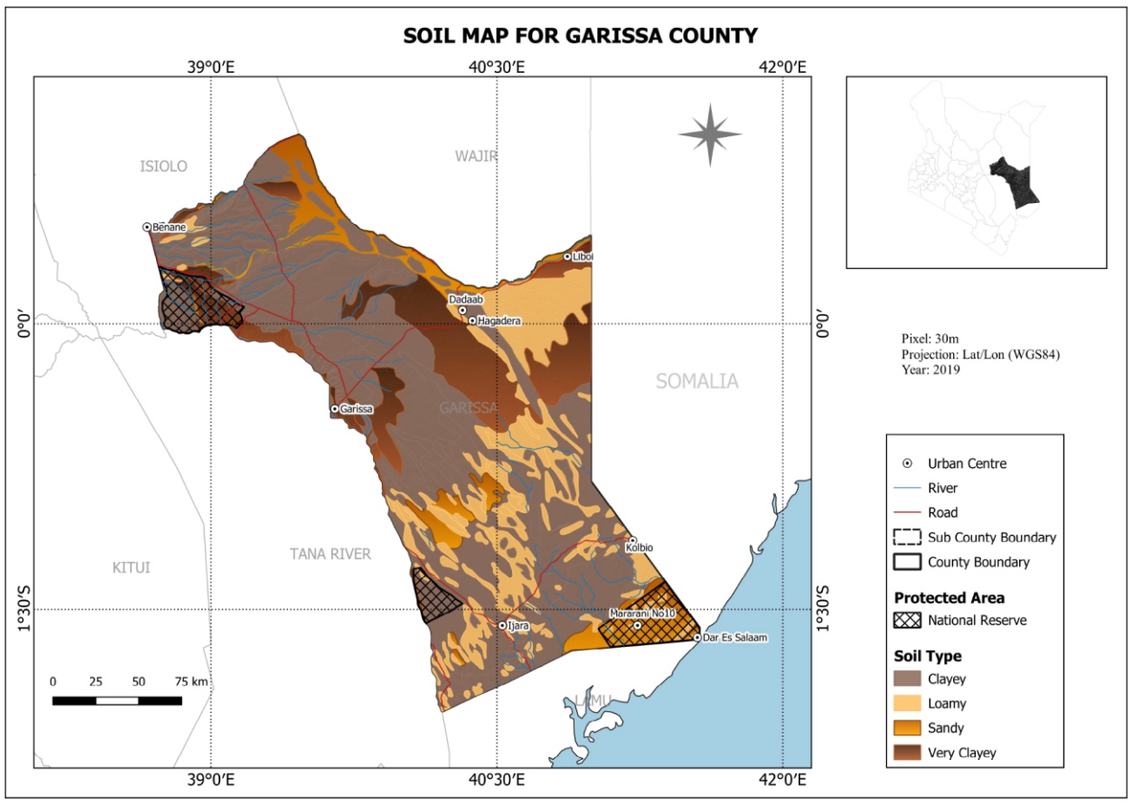


Figure 15: *Garissa County soil resource map*

3.4.2 Garissa County Agrarian Parameter

The population is mostly nomadic pastoralism which is practiced countywide while others are agro-pastoralists. However, it is spatially confined to along the riverine of Tana River. This is where the pastoralists have engaged in crop production. Thus there is a shift to sedentary life as migration is limited. The population is mostly Islamic religion.

The county has a total population of 841,353 persons which consist of 458,975 and 382,344 and male and females respectively (KNBS, 2019). The population is projected to increase to 948,880 and to 1,029,504persons in 2020 and 2022 respectively.

3.4.3 Garissa County Economic Parameters

The economic parameter include market and road access and population.

Markets Access

Markets are moderately suitable just within designated town centres and marginally suitable at the outskirts of the same centres. The markets are sparsely dispersed as shown in figure 12 below.

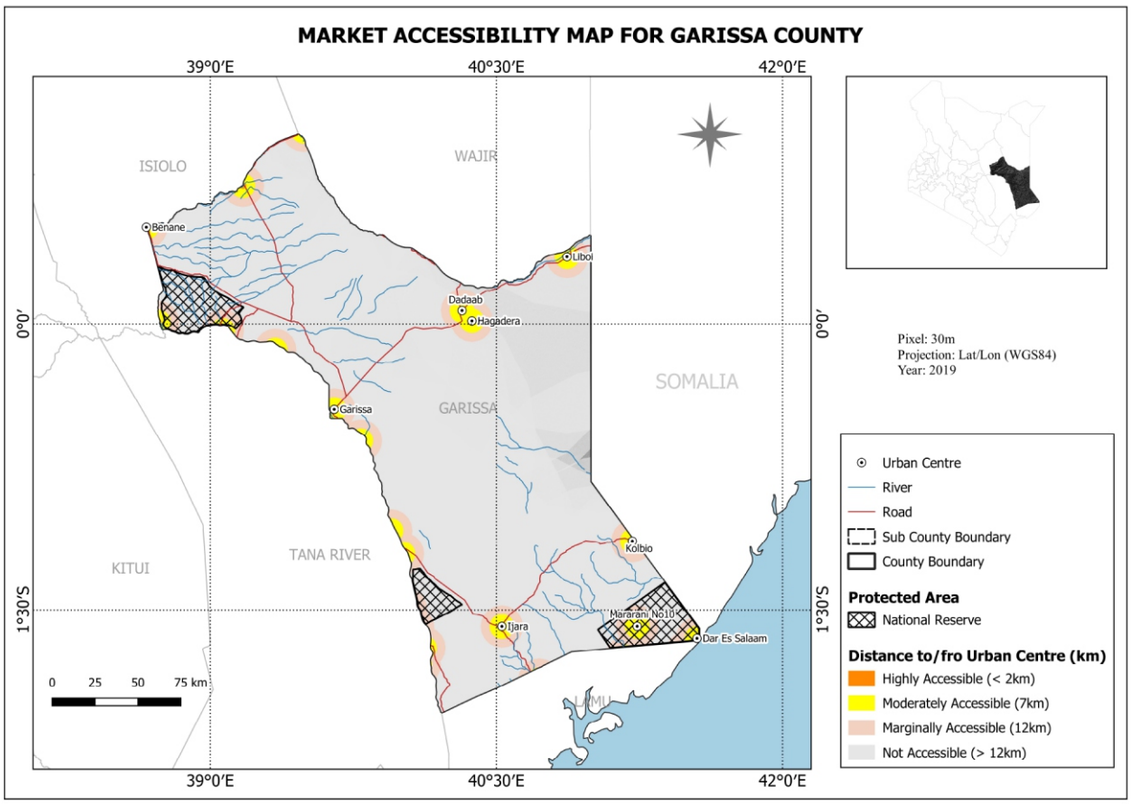


Figure 16: *Garissa County market accessibility*

Garissa County roads access

The County has a total road network of 1,804Km which comprise 60, 1,449 and 304 Km of bitumen, earth and gravel surface respectively. The County roads are in poor condition and most of them are rendered impassable during the rainy season. Most roads are marginally suitable as shown in figure 17 below.

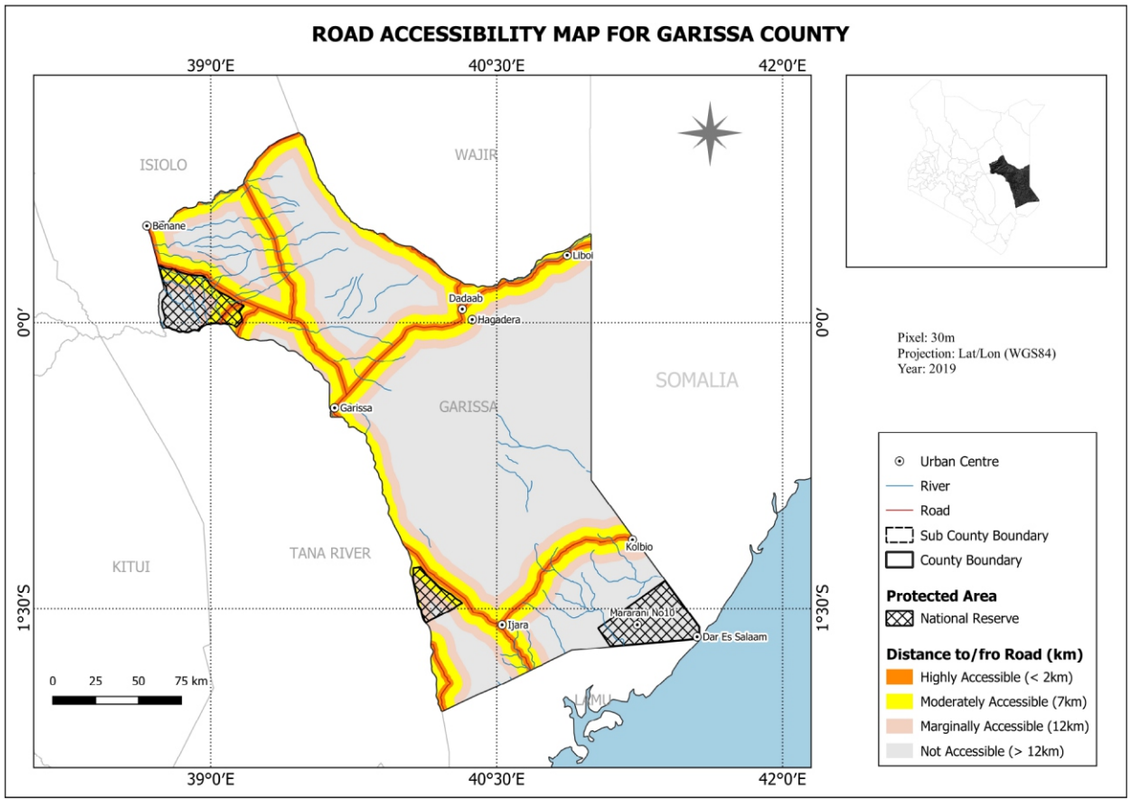


Figure 17: *Garissa County Rroads access*

3.4.4 Garissa County Political Landscape

The political landscape considered the extent to which the government intervened in the priority value chains in terms of providing supportive framework conditions and funding. The county has put in place policies and regulations that support agriculture. Livestock and the Agriculture fund bills are two major bills currently under debate in the assembly. Meanwhile, the Governor's manifesto is in place with key agricultural aspects being promotion of production and value addition of the priority value chains besides other crop and livestock enterprises.

4. PRIORITIZED VALUE CHAIN SUITABILITY MAPS

The analysis of biophysical, economic and social characteristics of Garissa show that the county is a highly suitable place for the commercialization of camel milk, moderately suitable for meat goat and most riverline areas do heavy tomatoes production.

4.1 Camel milk

The camel milk is an important livestock product in Garissa because its used directly as food and preserved for times of scarcity. Surplus camel milk is sold to earn household income. Over 80% of the households depend on camel milk directly or indirectly. Milk is sold to traders (brokers) who later sell to individual consumers

4.1.1 Parameter analysis of Camel Milk Value Chain

Table 8: *The parameters analysis of camel milk*

Parameter	County Specific	Value Required	Class
Temperature	20°-39°C	25.0°-27.9°C	Marginally Suitable
Rainfall	<400MM	<302MM	Highly Suitable
Slope	0-10%	0-10%	Highly Suitable
Soil Fertility	0.5-1	>1	Marginally suitable
Market Index	7.9	>10.8	Moderately suitable
Agrarian Index	5.27	>4	Highly Suitable

4.1.2 Suitability Classification of Camel Milk Value Chain

The results obtained from conducting a suitability test on camel milk production in Garissa County revealed that most of the parts in the county are moderately suitable for camel value chain production with Dadaab sub county being the most suitable area while the southern part region of Ijara and Hulugho being marginally suitable (see figure18 below). Suitability of the value chain was determined by evaluating 4 parameters of biophysical, economic, social and political factors.

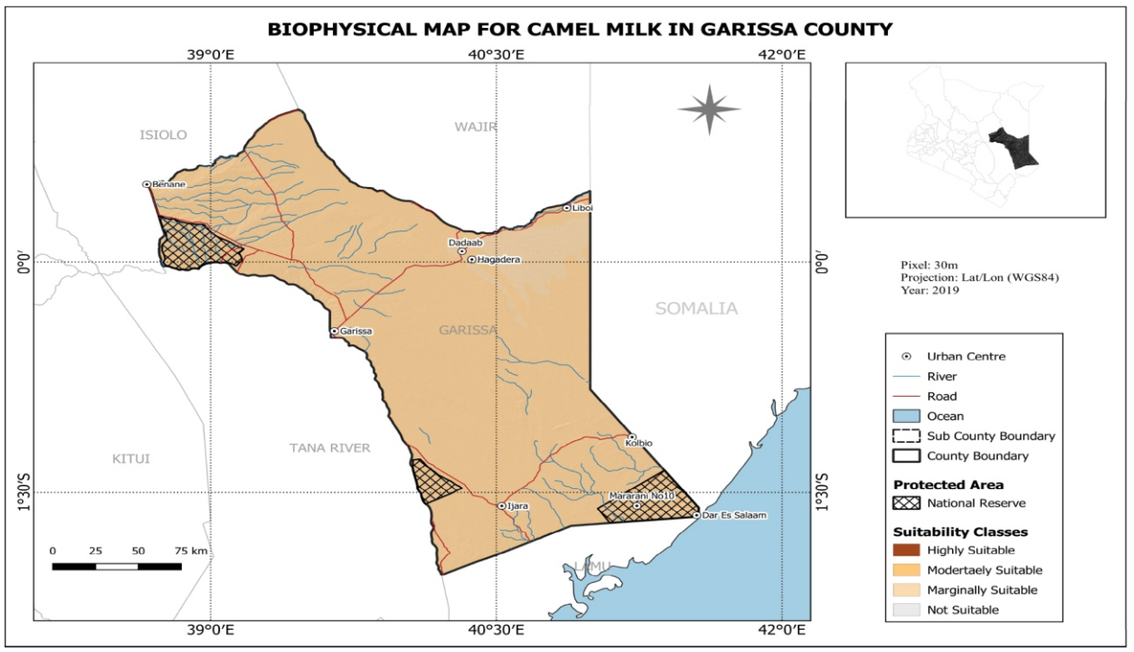


Figure 18: *Biophysical map for Camel Milk in Garissa County*

The soils were moderately suitable to highly suitable. Only about a third of the county has moderate soils while the rest are highly suitable soils for the growth of browse for the camels (Figure 19).

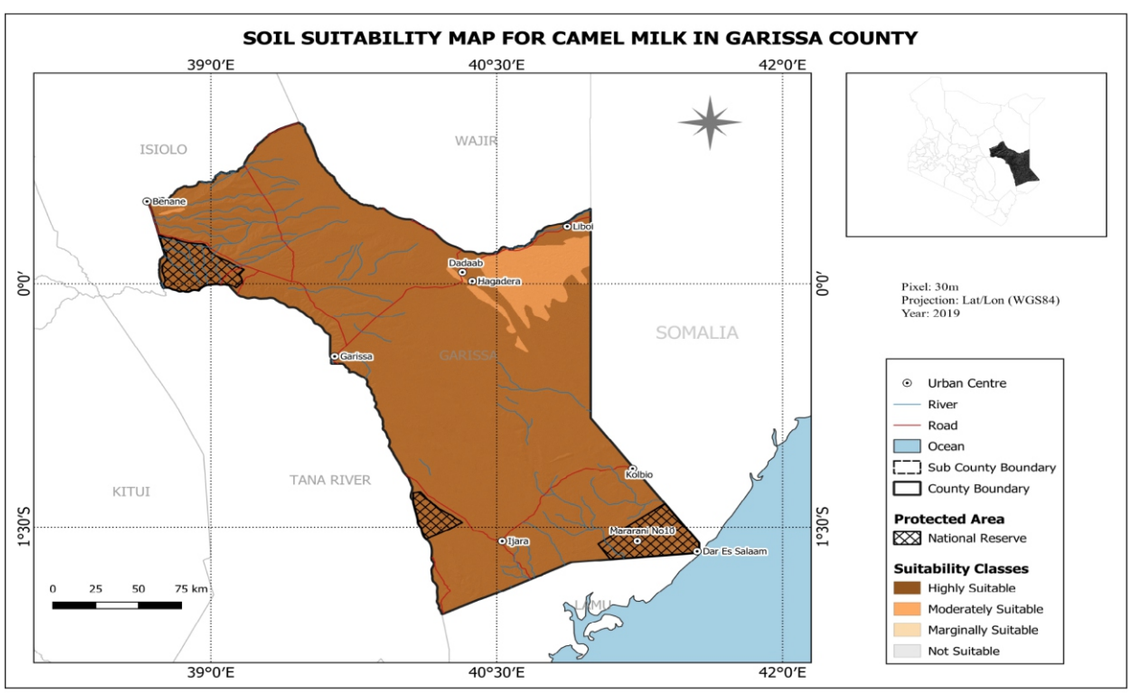


Figure 19: *Garissa County soil suitability for camel milk value chain*

4.2.2 Camel milk suitability maps

The Camel milk value chain is moderately suitable in most part of the Garissa county. Only the South East in areas of Ijara and Kolbio is highly suitable for the camel milk value chain as shown in the figure 20 below.

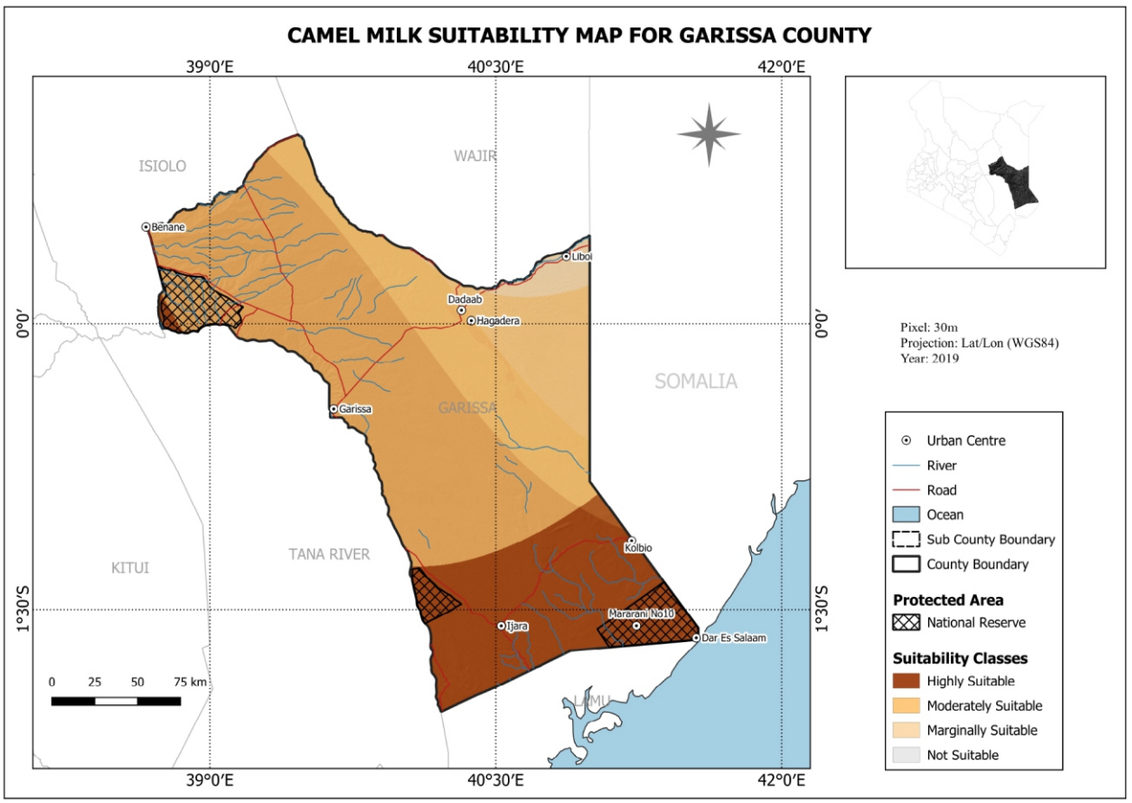


Figure 20: *Camel milk suitability maps*

4.2.3 Adaptation measures on Camel milk value chain

The adaptation measures are necessary to enhance the productivity of the camel milk value chain. The adaptation measures are shown in table 9 below.

Table 9: *Adaptation measures on Camel milk value chain, Garissa County*

Total	Adaptation
Temperature	Use of vehicles with refrigerated cooling systems, Modify temperature through agroforestry, improve Range management practices, Improved transport for milk, establishment of camel milk collection centres; feed management
Rainfall	Rain water harvesting e.g. water pans, irrigation
Slope	control run off waters
Population	Awareness creation on economic value of camel milk, explore other outside markets, promotions

Table 9: Adaptation measures on Camel milk value chain, Garissa County cont'd....

Total	Adaptation
Roads	Upgrade to all season weather roads
Markets	Strengthening market linkages among VCAs, Improved market structures
Social	Attitude change, trainings, sensitization
Political	sensitize on policies, regulations and strategies related to agriculture and livestock, increase budget allocation for the sector, strengthening public participation

4.2.4 Innovations and Technologies - Camel milk value chain

Table 10: Innovations and Technologies - Camel Milk Value chain, Garissa County

Parameter	Innovation	Technology
Temperature	Agroforestry-reseeding of the rangeland technology, establishment of solar powered coolers, Use of aluminum cans for transportation	Planting of indigenous trees and other improved varieties in degraded areas, Cold chain, Suitable packaging
Rainfall	Use of Information technology (IT) to support community decision making on resource Use. Use of feed lots Insitu water harvesting Flood/surface water harvesting	Trapezoidal bands, Negarims, Terracing, Contour bands
Slope	Terracing, bands, cut off, dykes	Strip Fodder and forage production
Population	Trade exhibitions on camel milk products	mass media advertisement
Roads	Public private partnerships for improvement of road infrastructure. Community mobilization and take action to open roads. Equip motor bikes fabricated containers	
Markets	Contractual arrangement, establishment of market information sharing platforms	Use of e apps and mass media
Social	Commercialization, value addition	processing, packaging and branding
Political	Introducing favorable policies	

4.3 Beef Value Chain

4.3.1 Parameter analysis- Beef Value Chain

Table 11: Parameter analysis- Beef Value Chain

Parameter	County Specific	Value Required	Class
Temperature	20°C-39°C	25°C-27.9°C	Marginally Suitable
Rainfall	<400MM	<302MM	Highly Suitable
Slope	0-10%	0-3%	Highly Suitable
Soil Fertility	0.5-1	>1	Marginally suitable
Market Index	7.9	>10.8	Moderately suitable
Agrarian Index	5.27	>4	Highly Suitable

4.3.2 Suitability classification of beef value chain

About 70% of the population are engaged in the value chain, almost entirely in the production nodes. There are few beef processors in the county. The main animals reared for beef are cattle, goats, and sheep. The men are mostly involved in cattle and camel herding while women are involved in goat and sheep rearing. In addition, men are denominated the main decision- makers with respect to issues of production and marketing of beef. The livestock are generally sold to butchers and other markets outside the county. The county is mostly highly to moderately suitable for beef value chain (Figure 21).

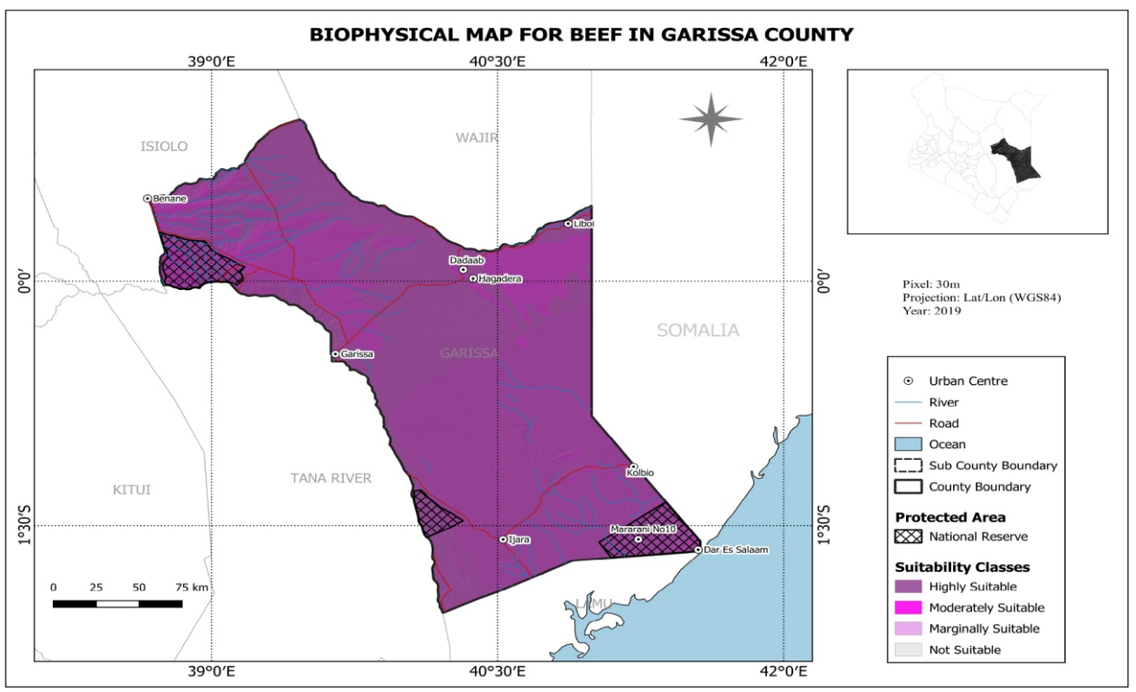


Figure 21: Biophysical for beef value chain , Garissa County

In terms of soil parameters analysis, the county is largely moderate to highly suitable in supporting pastures needed for the promotion of the beef value chain as shown below in figure 22 below.

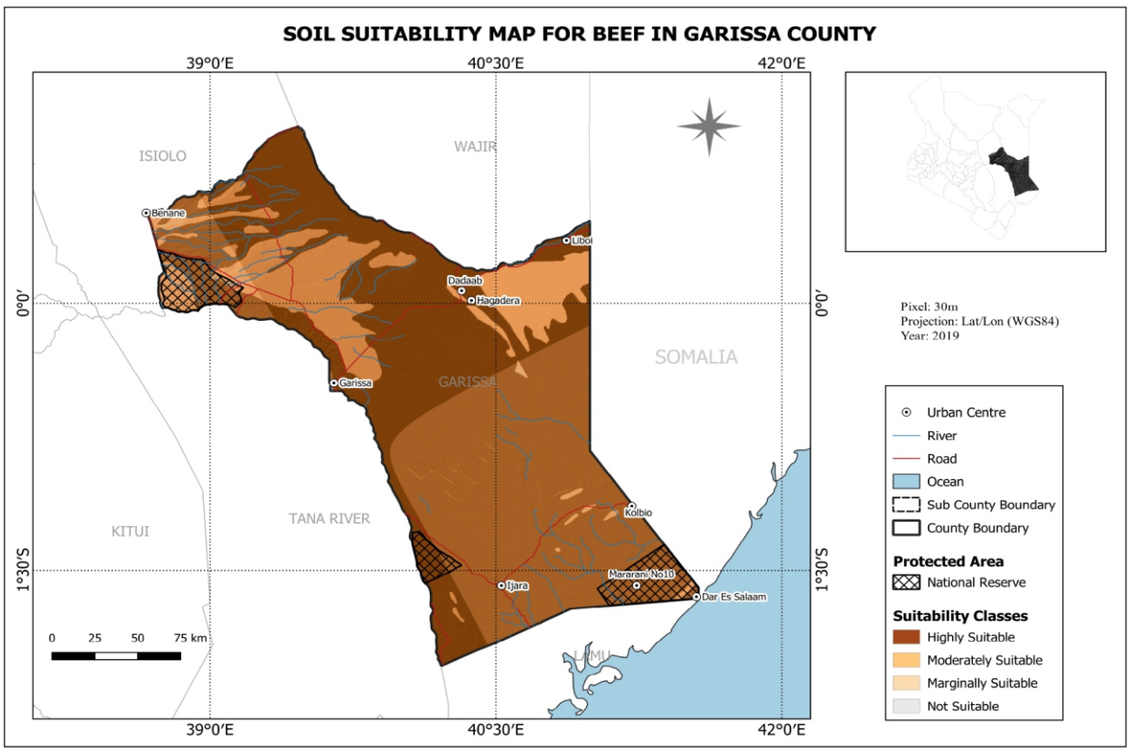


Figure 22: *Soil suitability map for beef value chain, Garissa County*

4.3.3 Adaptation measures- Beef Value chain

the adaptation measures meant to enhance the productivity of the beef value chain are as presented in the table 12 below.

Table 12: *Adaptation measures for Beef Value chain, Garissa County*

Total	Adaptation
Temperature	Use of vehicles with refrigerated cooling systems, Modify temperature through agroforestry, improve Range management practices, Improved shelters. Improved meat storage
Rainfall	Rain water harvesting e.g. water pans; irrigation, fodder production (mega scale)
Slope	control run off, healing gullies
Population	Awareness creation on economic value of beef production, explore other outside markets, promotions

Table 12: Adaptation measures for Beef Value chain, Garissa County cont'd....

Total	Adaptation
Roads	Upgrade to all season weather roads
Markets	Strengthening market linkages among VCAs, Ensure Improved market structures, establishment of market collection centres
Social	Attitude change, trainings, sensitization slaughter and exposure, establishment of slabs
Political	Sensitize on policies, regulations and strategies related to agriculture and livestock, increase budget allocation for the sector, strengthening public participation

4.3.4 Adaptation technologies and innovations – Beef value chain

The beef value chain technologies and innovation that could be considered to enhance productivity are as shown in table 13 below.

Table 13: Adaptation technologies and innovations for beef value chain in Garissa County

Parameter	Technologies	Innovations
Temperature	Agroforestry-reseeding of the rangeland technology, establishment of solar powered coolers for meat. Refrigerated tracks for meat transportation; feed management	Planting of indigenous trees and other improved varieties in degraded areas. Cold chain. Suitable packaging
Rainfall	Use of Information technology (IT) to support community decision making on resource Use. Use of feed lots, Insitu water harvesting. Flood/surface water harvesting. Use of solar powered hybrid pumps	Trapezoidal bands, Negarims, Terracing, Contour bands, water pans, wells
Slope	Terracing, contour bands, cut off drains, dykes	Strip Fodder and forage production, gabions, dams
Population	Trade exhibitions on beef products, expansion of market segments	mass media advertisement
Roads	Public private partnerships for improvement of road infrastructure. Community mobilization and take action to open roads. Equip motor bikes fabricated containers	PPPs for improvement of roads

Table 13: Adaptation technologies and innovations for beef value chain in Garissa County cont'd...

Parameter	Technologies	Innovations
Markets	Contractual arrangement, establishment of market information sharing platforms; upgrade market stalls	Use of e apps and mass media
Social	Commercialization of Beef production, value addition, Breed improvement	processing and branding
Political	Introducing favorable policies	County website sharing platforms

Rainwater Management

Drinking water harvesting and in-situ water harvesting predominate rain water management technologies in the County. Other interventions include utilization of the rainwater for supplemental irrigation of pastures and fodder as well for produce and product processing (Figure 23).

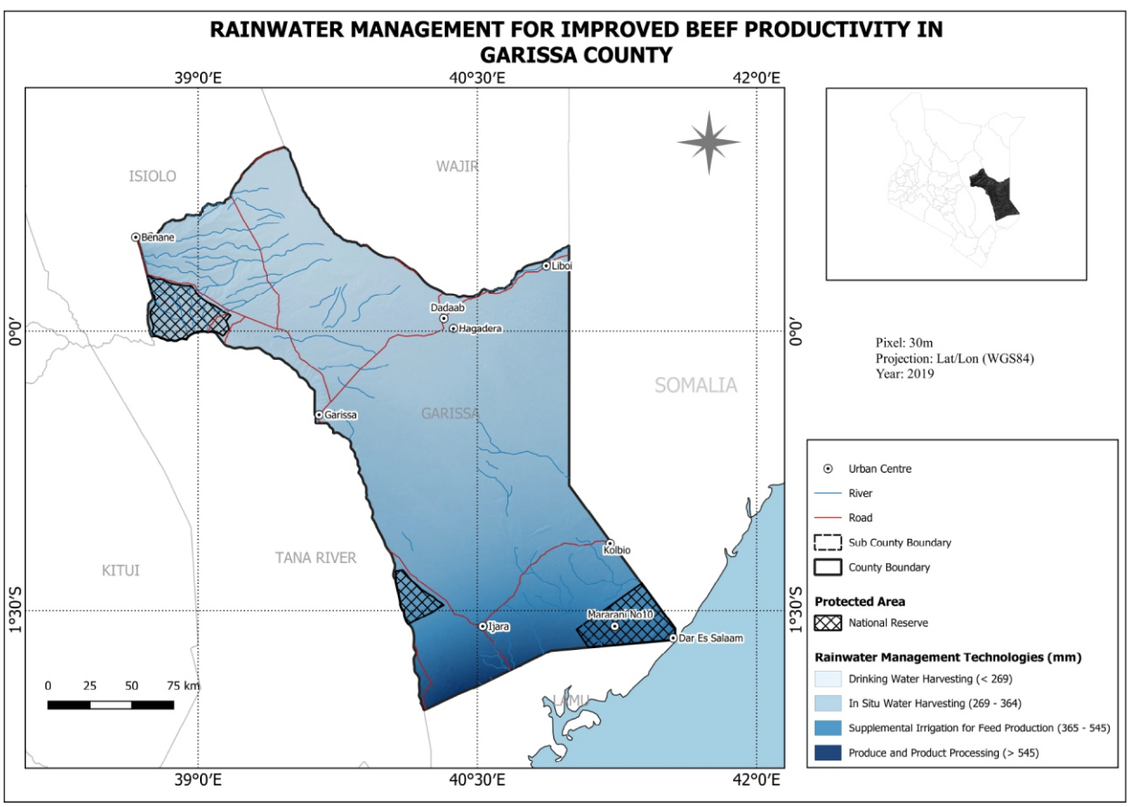


Figure 23: Garissa County Rainwater management for pasture and beef production

4.4 Tomato value chain

Tomatoes are mainly grown along the riverine areas of Tana River. About 10% of the county population is engaged in horticulture. The farmland average 1.3 ha and use small-scale irrigation. The tomato farmers mostly sell to brokers. Sales of produce are carried out individually and/or through cooperatives. Value addition by the farmers is largely driven by transportation (a youth-dominated activity) and bulking at collection centres but processing is minimal.

4.4.1 Parameter analysis for Tomato Value Chain

Table 14: Tomato value chain parameters

Parameter	County Specific	Value required	Class
Temperature	20°C-39°C	26.0°C-26.9°C	Highly Suitable
Rainfall	<400MM	<302MM	Conditionally Suitable
Slope	0-10%	0-3%	Highly Suitable
Soil Fertility	0.5-1	>1	Marginally suitable
Biophysical			Moderately Suitable
Market Index	7.9	>10.8	Moderately Suitable
Agrarian Index	5.27	>4	Highly Suitable

4.4.2 Suitability Classification for Tomato Value Chain

Based of the analysis of the biophysical parameters, the county is moderately to marginally suitable for tomato value chain as shown in the figure 24 below.

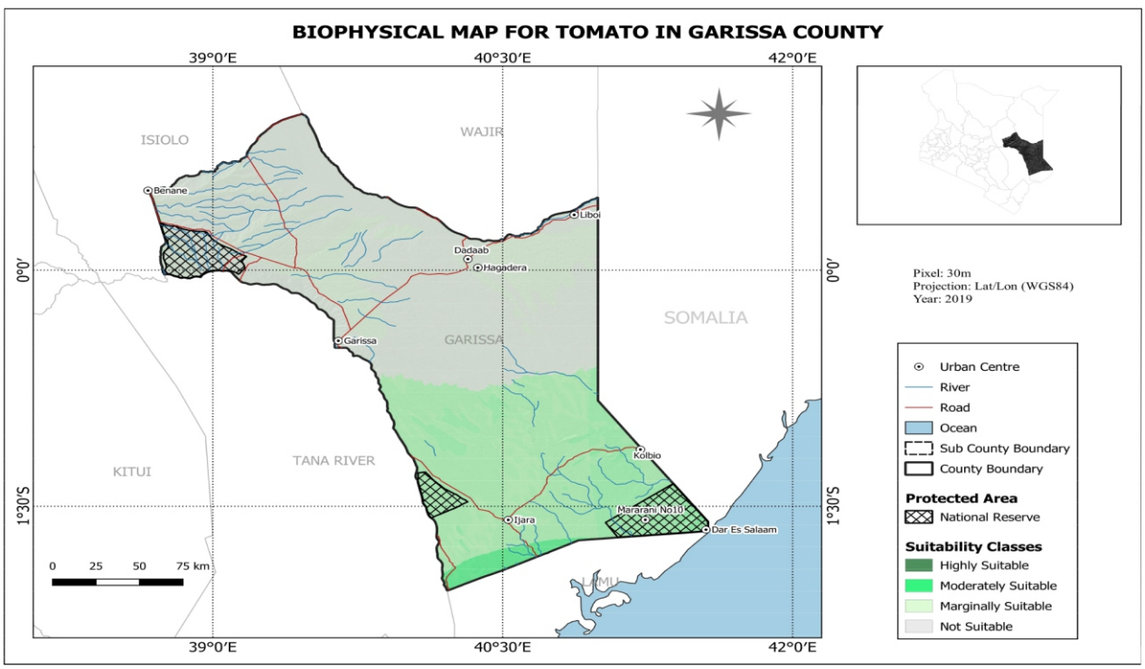


***Figure 24:** Biophysical map for tomato value chain in Garissa County*

Soil parameters analysis indicate that Garissa County is largely moderate to highly suitable for establishing tomato crop as shown in figure 25 below.

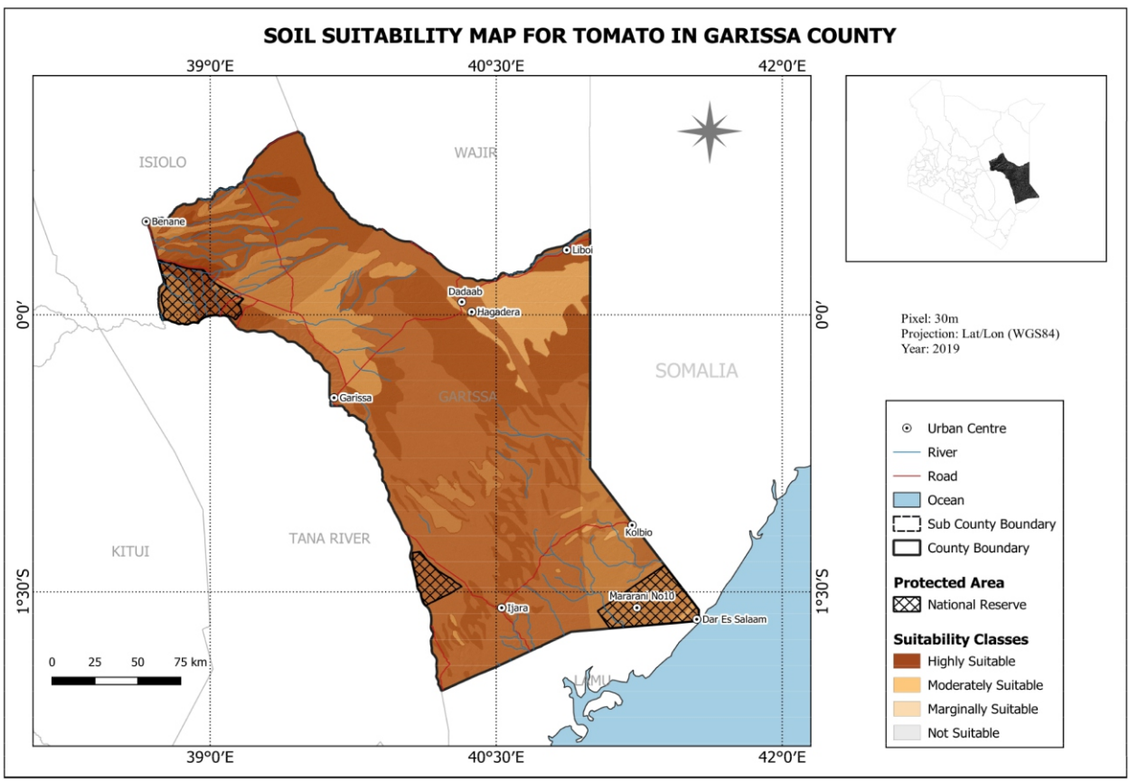


Figure 25: *Garissa County soil suitability map*

Garissa County Tomato Suitability Classification

Composite factors analysis indicate that the tomato value chain is mostly moderately suitable in Garissa County as indicated in figure 26 below.

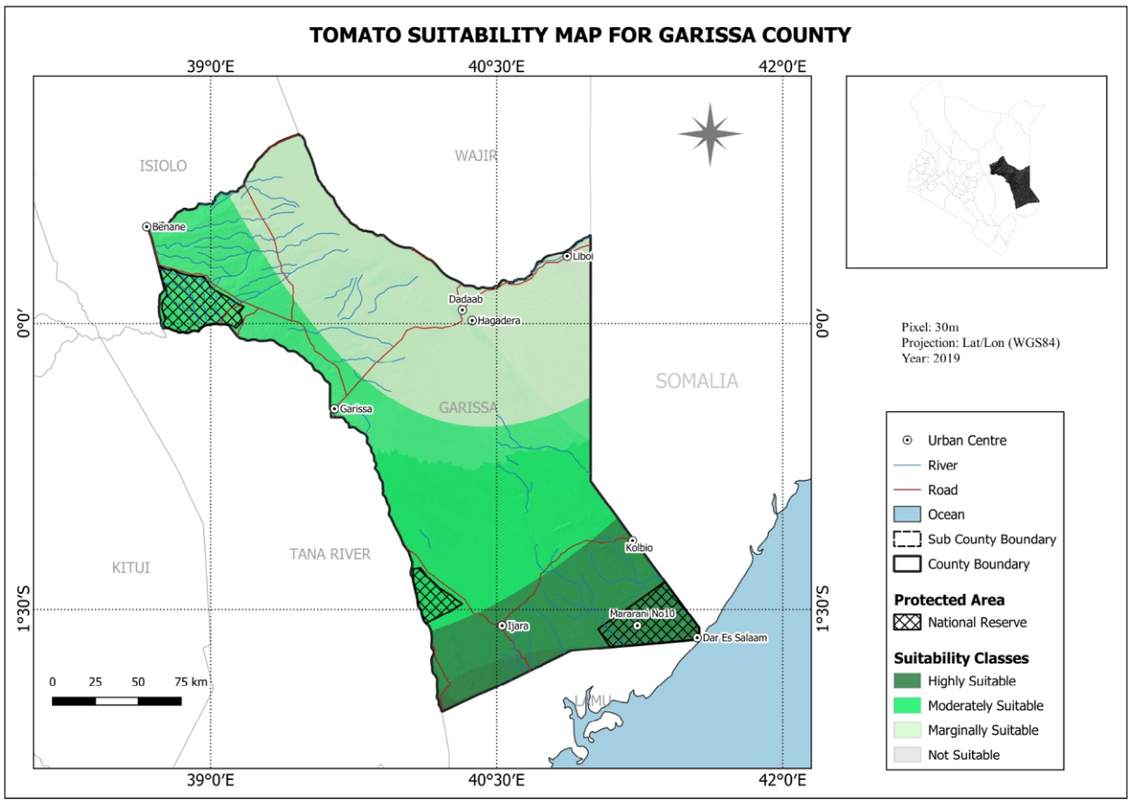


Figure 26: *Tomato value chain suitability map for Garissa County*

4.4.3 Adaptation measures – Tomato VC

Enhanced productivity of tomato value chain could be achieved through adaptation measures e.g greenhouse technology, irrigation as presented in table 15 below.

Table 15: *Adaptation measures for tomato value chain*

Parameter	**Adaptation**
Temperature	Modification of temperatures through agroforestry
Rainfall	Rain Water Harvesting; Develop of water infrastructure
Slope	planting cover crops, Contour farming
Population	create awareness on health and commercial benefits, expand on outside markets, involve more youth in VC operations
Roads	Upgrade farm feeder roads to all season weather roads

Table 15: Adaptation measures for tomato value chain cont'd....

Parameter	Adaptation
markets	Strengthening market linkages among VCAs, Ensure Improved market structures, establishment of market collection centres
Social	Attitude change, trainings, sensitization and exposure
Political	Sensitize on policies, regulations and strategies related to agriculture and livestock. Increase budget allocation for the sector, strengthening public participation

Other adaptation measures

The adaptation measures necessary include land slope modification through terracing, promotion of rainwater water harvesting and conservation agriculture practices (figure 27), promoting mechanization to improve potato production efficiency (Figure 28).

Other measures include promoting need to do water harvesting and have efficient water utilization where irrigation water is available to support tomato production in the drier areas of the county (Figure 29)

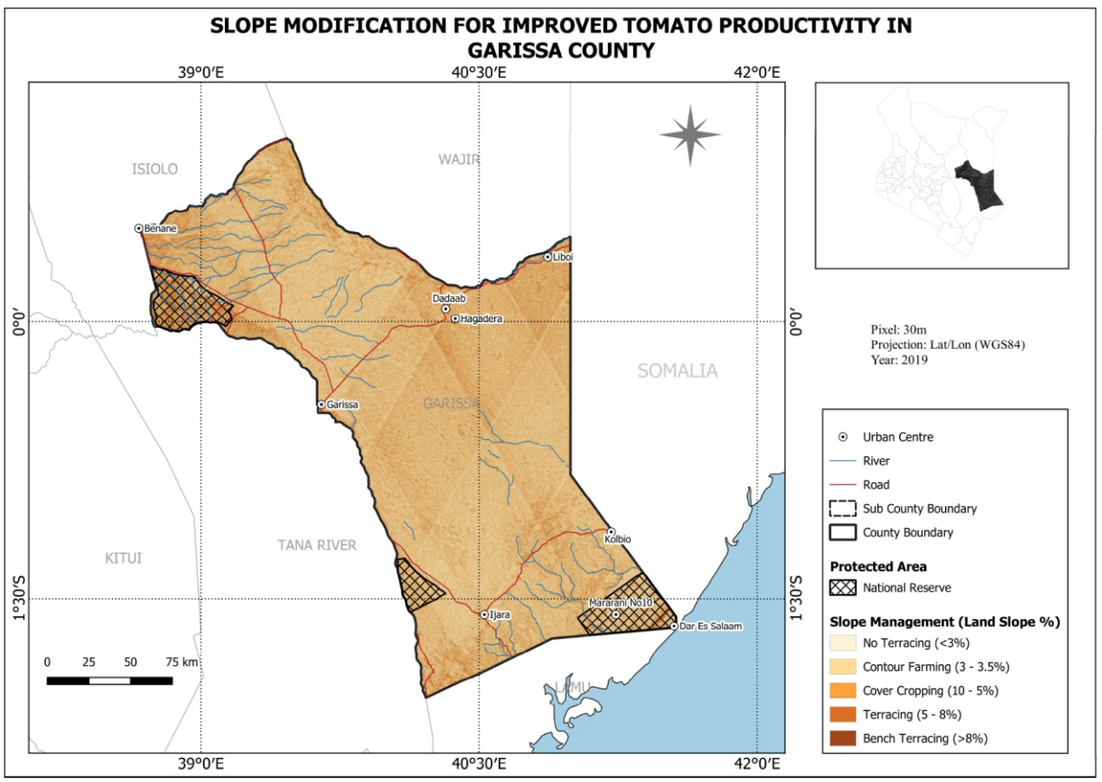


Figure 27: Soil modification for improved tomato productivity

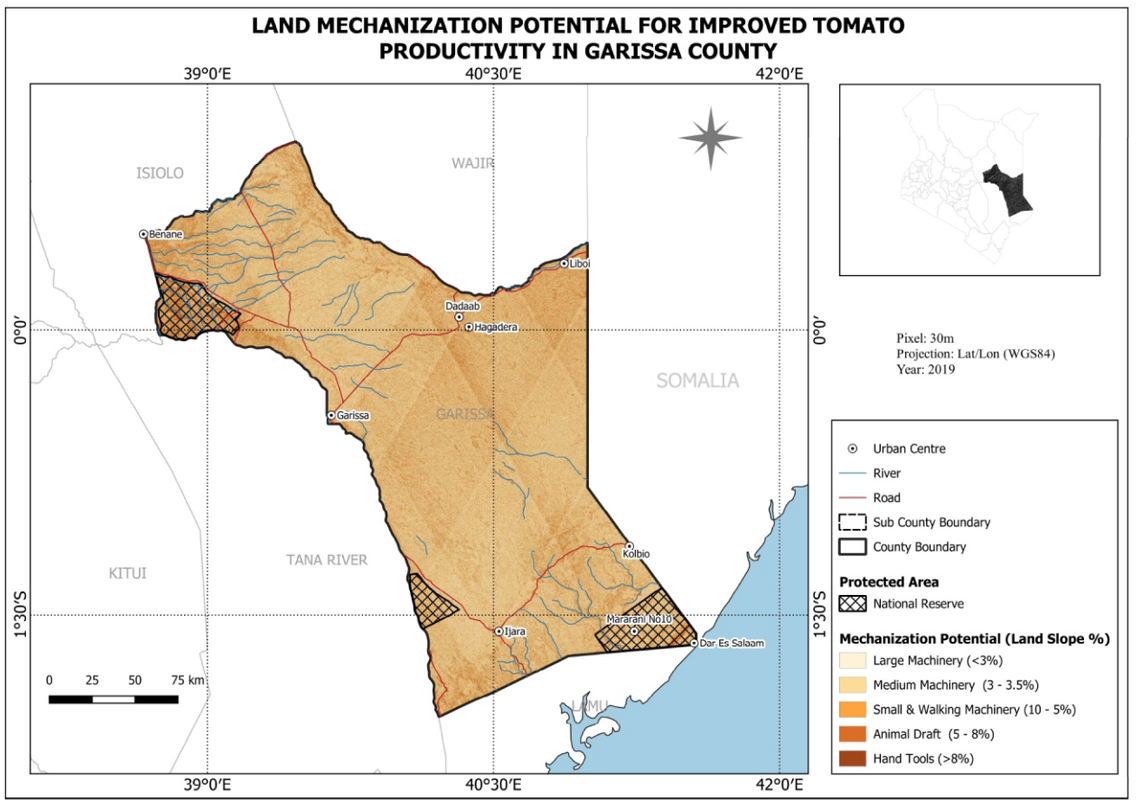


Figure 28: *Land mechanization potential for improved tomato productivity*

The slope modification approaches proposed include contour farming for the gentle slope (3-3.5%), cover cropping for 3.5-5% slope, terracing for 5-8 % slope and bench terracing for over 50% slope. The spatial extent for land modification to improve productivity of potato is presented in (Figure 27).

The water management technologies proposed should address soil moisture availability. In-situ rainwater harvesting and appropriate conservation agriculture approaches are recommended (Figure 29).

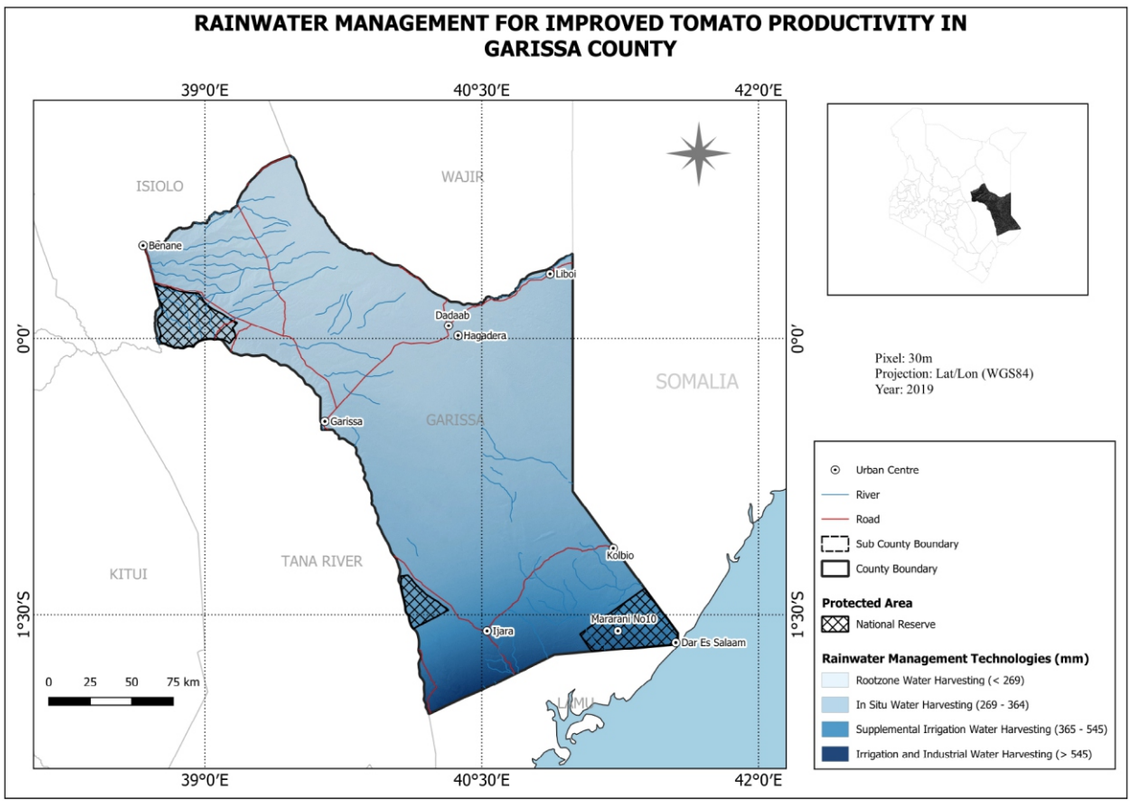


Figure 29: *Rain water management for improved tomato productivity*

4.4.3 Innovations and Technologies – Tomato VC

Table 16: *Adaptation technologies and innovations for tomato value chain, Garissa County*

Parameter	Innovation	Technology
Temperature	Green house technology and shade nets	Green house farming, Irrigation, mulching
Rainfall	Roof catchment, Flood water harvesting	water pans, Negarims, trapezoidal bands, Contours, boreholes
Slope	Terracing, contour bunds	Cut off drains, Strip/ relay farming, conservation agriculture
Population	Trade exhibitions, farm demonstrations on production and utilization	Mass media advertisement

Parameter	Innovation	Technology
Roads	Public private partnerships for improvement of road infrastructure. Community mobilization and take action to open roads. Use of recommended transport materials. Strengthen linkages between producers and transporters. Contractual agreements	PPPs for road improvements
Markets	Contractual arrangement, establishment of market information sharing platforms	Use of e apps and mass media
Roads	Kitchen gardens, value addition, use of improved varieties	Processing, packaging and branding
Political	Introducing favorable policies	County website sharing platforms

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COUNTY GOVERNMENTS