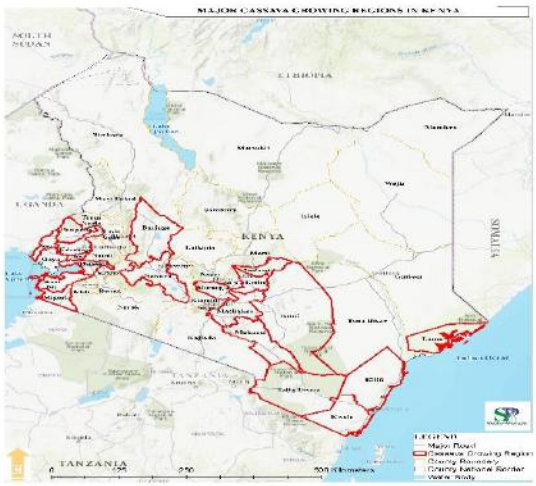
ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) STUDY REPORT FOR THE PROPOSED COMMERCIALIZATION OF GENETICALLY MODIFIED CASSAVA IN KENYA



ESIA STUDY REPORT

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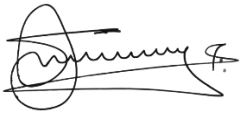
Signature:  **Date:** 4th September, 2025

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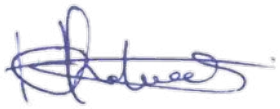
Mr. Humphrey Kitonyi	M.A in Urban & Regional Planning Bachelor of Environmental Planning and Management	Environmentalist. NEMA licensed Lead EIA/EA Expert Reg. No.7547	
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ABBREVIATIONS & ACRONYMS

ACMV	African cassava mosaic virus
AEZ	Agro-Ecological Zone
AFA	Agriculture and Food Authority
AO	Agricultural Officer
ATC	Agricultural Training Centre
BETA	Bottom-Up Transformational Agenda
CAIP	County Aggregation Industrial Parks
CBD	Convention on Biological Diversity
CBSD	Cassava Brown Streak Disease
CBSV	Cassava brown streak virus
CDA	County Director of Agriculture
CEC	County Environmental Committees
CECM	County Executive Committee Member
CL	Coastal Lowland
CMD	Cassava Mosaic Disease
CoK	Constitution of Kenya
CSE	Cassava Seed Entrepreneur
CSO	Civil Society Organization
DUS	Distinctiveness, Uniformity, and Stability
DVS	Directorate of Veterinary Services
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FAO	Food and Agriculture Organization
FDA	Food Drug Administration
GM	Genetically Modified
KALRO	Kenya Agricultural Livestock & Research Organization
KEBS	Kenya Bureau of Standards
KEPHIS	Kenya Plant Health Inspectorate Service
KII	Key Informants Interviews
LM	Lower Midland
MDGs	Millennium Development Goals
MEAs	Multilateral Environmental Agreements
MEDA	Mennonite Economic Development Associates
MoALD	Ministry of Agriculture and Livestock Development
MoH	Ministry of Health
NAVCDP	National Agricultural Value Chain Development Project
NBA	National Biosafety Authority
NECC	The National Environmental Complaints Committee
NEMA	National Environment Management Authority
NPTC	National Performance Trials Committee
NPTs	National Performance Trails
PCC	Public Complaints Committee
PPD	Post-harvest Physiological Deterioration

Q&A	Question and Answer
RELOs	Research Extension Liaison Officers
RFTs	Regulatory Field Trials
RNAi	Ribonucleic Acid Interference
ROI	Return on Investment
SCAO	Sub-County Agricultural Officer
SDG	Sustainable Development Goal
SMEs	Small and Medium-Sized Enterprises
SMEs	Small and Medium-sized Enterprises
SMS	Short Message Service
ToRs	Terms of References
UCBSD	East African cassava mosaic virus
UCBSV	Ugandan cassava brown streak virus
UM	Upper Midland
WAO	Ward Agricultural Officer
WHO	World Health Organization

EXECUTIVE SUMMARY

Project Background

Cassava is the second most important food crop after maize in Coastal and Western Kenya. Its utilization has been expanded in manufacturing of industrial products such as starch, flour and livestock feeds and other bio-based products including medicine, feed, cosmetics and biopolymers. However, cassava production is challenged by two devastating viral diseases, cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). Together they are estimated to cause losses worth US$1billion annually.

KALRO has successfully developed cassava varieties through modern biotechnology, with robust and durable resistance to CBSD and CMD. Event 4046 was developed for resistance against CBSD using RNAi strategy while the derivatives were developed through conventional breeding for dual resistance against CBSD and CMD in addition to other farmer preferred attributes. The Value for Cultivation and Use (VCU) of elite lines was completed in different agro-ecologies where cassava is widely grown. This was following an approval by National Biosafety Authority in pursuance to the Biosafety Release Regulations, 2011, under the Biosafety Act 2009. In compliance with the Environmental Management and Coordination Act (EMCA), National Environmental Management Authority (NEMA) granted the license for conducting National Performance Trial (NPT) in seven sites (Oyani, Alupe, Kakamega, Matuga, Mtwapa, Msabaha and Kiboko) ensuing Environmental and Social Impact Assessment (ESIA). Evaluation and release of new varieties in Kenya is governed by the Seeds and Plant Varieties Act (cap 326), 2012 and the accompanying Seeds and Plant Varieties (Variety Evaluation and Release) Regulations, 2016 of the laws of Kenya. In compliance to the prescribed release criteria, new cassava varieties were tested for two seasons under NPTs and one season Distinct, Uniformity and Stability (DUS) test. Environmental release and commercialization of new varieties developed through genetic modification require full Environmental and Social Impact Assessment studies in compliance with the Environment Management and Coordination Act EMCA 1999 (Amended, 2015). The Legal Notice 31 of 2019 lists major developments in biotechnology including commercialization of Genetically Modified Organisms (GMOs) as high-risk projects that require full Environmental & Social Impact Assessment (ESIA) study.

Project Coverage

Genetically improved cassava will be commercially released in the Republic of Kenya. However, this study is limited to 19 key cassava-growing counties including Lamu, Kilifi, Kwale, Taita Taveta, Makueni, Kitui, Machakos, Tharaka Nithi, Embu, Nakuru, Baringo, Kakamega, Bungoma, Busia, Vihiga, Kisumu, Migori, and Homabay. These counties, spread across Coastal, Eastern, Central, Rift Valley, Nyanza, and Western regions, where stakeholders' engagement were conducted and prioritized as key cassava growing regions.

ESIA Methodology

The consultant undertook environmental screening which categorized the proposed development as a high-risk project in accordance with Legal Notice 31 and 32 of 2019. Scoping was then conducted as part of the preliminary assessment, which identified the likelihood of significant environmental and social impacts as a result of the proposed commercialization of genetically improved cassava. In order to further investigate the identified issues, the study team employed various data collection methods. This encompassed both primary and secondary data collection methods that were keenly evaluated and analysed to assist in quality reporting of this document. Primary methods employed included field visits, stakeholders' engagement and consultation, and photography. Secondary sources of data included desktop studies and mapping. The process also employed impact prediction and analysis, impact mitigation, as well as public consultations with cassava farmers and interested groups across key cassava growing regions. Finally, the outputs of these processes led to the development of this ESIA study report in accordance with the format prescribed in the Environmental (Impact Assessment and Audit) Regulations (2003).

Baseline Information

The surveyed counties with regards to the proposed GM cassava commercialization span diverse biophysical and socio-economic settings, influencing production potential and market integration. They fall across multiple agro-ecological zones, from high-potential coconut–cassava belts in the coastal lowlands to semi-arid livestock–millet and ranching zones inland. Rainfall patterns are predominantly bimodal but vary widely (300–1,300 mm annually), with coastal and highland zones receiving more reliable precipitation than the arid interiors. Temperatures range from warm coastal and lowland conditions (23–34°C) to cooler highlands. Soils differ by geology, coastal sandy loams, fertile alluvials along river valleys, and clay-rich uplands, all supporting cassava,

especially in drought-prone areas due to its resilience. Water resources are a mix of permanent rivers, seasonal streams, aquifers, and rainwater harvesting, but are under pressure from salinity, overuse, and climate variability. Biodiversity includes forests, savannah, and marine ecosystems, though habitat loss, overexploitation, and land degradation are common threats.

Stakeholders' Consultation and Public Participation

The proposed commercialization of GM cassava in Kenya laid emphasis on undertaking stakeholders' consultation and public participation process, an integral component of this ESIA study, with an aim to ensure inclusivity, transparency, and integration of public views into decision-making. Stakeholders — categorized as primary (farmers, Cassava Seed Entrepreneurs, interested members of the public) and secondary (government agencies, civil society organizations) — were identified across 19 cassava-growing counties. Stakeholders' engagement methods included public forums, key informant interviews, and administration of questionnaires. Each county was allocated 10 questionnaires, divided equally among the farmers' representatives across all the sub-counties or wards present. A total of 190 questionnaires were completed. In order to ensure that the public engagement forums were as representative and effective as possible, KALRO, MEDA and CECMs coordinated with county directors of agriculture, and sub-county and ward agricultural officers to mobilize cassava farmers from all cassava-growing regions for public engagement forums. The process achieved 99.9% project acceptance, underscoring strong stakeholder support for the proposed GM cassava commercialization.

Policy, Legal, Regulatory and Institutional Frameworks

To ensure sustainable development, environmental issues normally take center stage in any development activities. The Constitution of Kenya, 2010 – Kenya's supreme law – safeguards the environment by guaranteeing every Kenyan a right to a clean and healthy environment. Further, with reference to the second schedule of the Environmental Management and Coordination Act 1999 (Amended 2015), projects that require undertaking of an ESIA are categorically listed. The proposed project is classified under high-risk impact project according to the Legal notice 31 and 32 of 2019. Overall, Kenya has over 77 statutes that relate to environmental concerns. Most of these statutes are sector specific, covering issues such as land uses, water quality, wildlife and forestry, public health; agricultural development, and biotechnology as well. This report has therefore analyzed all applicable policies and strategies, legislation (including pertinent regulations

and standards), institutional arrangements, and multilateral environmental agreements. Policies analyzed such as Kenya's Vision 2030; National Food and Nutrition Policy, 2011; Agriculture Sector Transformation and Growth Strategy 2019-2029; National Food Safety Policy 2013; and National Environmental Policy 2013. Key legislations examined include Environmental Management and Coordination Act (EMCA) of 1999, (Amended-2015); Biosafety Act, 2009 (Amended 2018); Agriculture, Fisheries, and Food Authority Act, 2013; The Crops Act, 2013; Seeds and Plant Varieties Act Cap 326; Environmental (Impact Assessment and Audit) Regulations, 2003; Seeds and Plant Varieties (Variety Evaluation and Release) Regulations, 2016; Biosafety (Environmental Release) Regulations, 2011; and Biosafety (Labelling) Regulations, 2012.

Evaluation of Alternatives

Several project alternatives were considered based on technical project information and professional judgement of the project team. In particular, four options namely: No project Alternative; Adoption of pesticide use alternative; Adoption of other roots and tuber crops; and the proposed alternative were considered. The evaluations elucidate why the 'proposed alternative' is the most viable option; environmentally, socially and economically.

Impact Identification and Management

This ESIA report assessed both the social and environmental impacts of the proposed commercialization of GM cassava varieties. Under the auspices of the NBA, the application for environmental release of GM cassava event 4046 was reviewed by experts on food safety, environmental safety assessment, and the relevant regulatory agencies, including NEMA, and was found to be as safe as the conventional cassava variety. Key positive impacts expected to arise from the proposed development include enhanced food security, resistance to diseases, improved productivity, source of income, and employment opportunities. Potential negative impacts include illegal release and inadequate access to planting materials, non-adherence to existing protocols, perceived food safety concerns, limited knowledge and public fear due to misconceptions. Social and environmental safeguard have been proposed to minimize the potential negative impacts and enhance the resultant positive impacts. These are presented in the Environmental and Social Management Plan (ESMP) in this report for implementation by responsible parties and stakeholders where applicable.

Conclusion and recommendations

The eight (8) approved GM cassava varieties have been recommended for commercial release by KEPHIS. These varieties have also met all the established crop safety development procedures and protocols under the mandate of NBA which ranges from application review to post-commercialization monitoring. The fundamental focus of NBA has been to ensure the GM cassava is fit for food, feed and environmental release in addition to other socioeconomic considerations. Consequently, stakeholders' engagement revealed that the CMD & CBSD have contributed to immense losses for cassava farmers over years with no sustainable solution. This has in turn led to most farmers shifting their focus to other fast-growing crops. Therefore, this leaves the future of cassava crop on the brink of becoming 'an orphan crop' in the regions that once engaged in large-scale production. Such prevailing challenges among many others discussed in this document creates the dire need for the approval of the proposed commercialization of GM cassava in order to inspire hope to farmers who have been discouraged and as a result abandoned the crop leaving the future of its existence at major risk. Ultimately, farmers across the major cassava growing regions unanimously expressed their desire and support for the commercialization of the eight (8) GM cassava varieties in order to avail clean planting materials to them. The access to clean planting materials will promote food security, resistance to diseases, better yields, and potential for higher income.

Thus, it is our recommendation that NEMA issues a license for the commercialization to proceed after approval by other key regulatory agencies. This is further based on the understanding that the proponent will adhere to the mitigation measures proposed herein and implement the proposed ESMP. In addition, the proponent ought to perform continuous monitoring and evaluation of the various environmental and social parameters to ensure close adherence to the ESMP

1.0 INTRODUCTION

1.1 Project Background

Cassava (*Manihot esculenta Crantz*) is the second most important food crop after maize in Coastal and Western Kenya. The crop immensely contributes to increased food supply in the country in line with food security pillar of the Government's Bottom-Up Economic Transformation Agenda (BETA). It is an excellent source of carbohydrates and calories. It is a hardy crop, growing relatively well in conditions of heat, drought and low soil fertility prevalent in many African countries. Cassava is also a potential industrial crop especially in production of livestock feed, starch, flour and ethanol, hence its contribution to the manufacturing pillar of the Big 4. However, cassava production in the recent past has been challenged by two devastating viral diseases, cassava mosaic disease (CMD) and cassava brown streak disease (CBSD). Together they are estimated to cause losses worth US$1billion annually.

KALRO, together with other partner institutions in Kenya, Rwanda, Nigeria, Uganda and the United States has successfully developed biotech cassava varieties, with robust and durable resistance to CBSD and CMD. The cassava has been validated over multiple cropping cycles in several locations in the country. An application for environmental release was submitted to the NBA in pursuance to the Biosafety Release Regulations, 2011, under the Biosafety Act 2009, and this application was subsequently approved on 18 June 2021. The release of new crop varieties in Kenya must comply with the Seed and Plant Varieties Act Cap 326. These varieties must also comply with the requirements of the Environmental Management and Coordination Act (EMCA) that require an ESIA to be conducted before environmental release and commercialization. Presently, eight (8) GM varieties have been recommended by the National Performance Trial Committee for approval by the National Variety Release Committee for release to farmers, paving the way for commercialization.

1.2 Rationale of the ESIA Study

The National Environmental Management Authority (NEMA) requires that new plant varieties (modified or transformed using biotechnology or imported) must comply with the requirement of Environmental Management and Coordination Act, 1999 (Amended 2015) that requires an Environmental and Social Impact Assessment (ESIA) to be conducted before and/or during the testing and introduction into the environment. Under Legal Notice 31 of 2019, Amendment to the

Second Schedule indicates that introduction of new crops falls under the high-risk projects. Section (8) on Agriculture specifies that major developments in biotechnology including testing and introduction including commercialization of genetically modified organisms require the undertaking of ESIA. Therefore, the main purpose of the ESIA is to ensure all negative project-related impacts are mitigated while enhancing the positive ones. In addition, the ESIA fundamentally assists NEMA and all other stakeholders in understanding the potential environmental consequences of a given project and thus provides a basis for making informed decisions regarding the project.

1.3 Terms of References (ToRs)

The consultant will seek to undertake the ESIA within the guidance of the following ToRs provided by the proponent;

1. To review baseline information (Physical, Biological and Social Cultural and Economic) and identify any information gaps.
2. To provide description and analysis of policy legal and institutional framework including but not limited to Kenyan policies, laws, regulation and guidelines; international guidelines, international conventions and treaties to which Kenya is party to, related to the commercial release and cultivation of genetically modified cassava, and will serve as benchmarks for monitoring and evaluation, and future environmental audits.
3. Carry out Consultation and Public Participation (CPP): Identify key cassava stakeholders and affected persons**.**
4. Verify compliance with national environmental regulations and policies and industry best practices and standards at local, national and international level
5. To adequately identify, predict and carry out in-depth analysis all actual potential and significant impacts on flora, fauna, soils, air, water, the social, cultural and community settings; the direct, indirect, cumulative, irreversible, short -term and long-term effects anticipated by the commercialization of genetically modified cassava, both positive and negative.
6. To recommend sufficient mitigation measures for all the potential negative impacts identified and analyzed in 5 above.

7. To identify gaps in knowledge and uncertainties which will be encountered in compiling the information.
8. To prepare a comprehensive ESIA project report in accordance with EMCA 1999 (Amended 2015) legislation for submission to NEMA for approval.
9. Seek the views of the affected persons in consultation with the Client, relevant stakeholders and the National Environmental Management Authority (NEMA).
10. Submit and present draft ESIA study report to KALRO management for review and comments.
11. Incorporate comments into the ESIA study report after review by the proponent into a final ESIA Study report.
12. Submit required number of hard copies and one soft copy of the ESIA study report to NEMA for the purposes of seeking a NEMA license that will approve commercial production of the released genetically modified cassava.
13. Submit to the proponent one copy of NEMA referenced ESIA project report one soft copy of the ESIA project report and acknowledgment letter from NEMA.
14. The ESIA consultant shall follow up processing and issuance of the ESIA License for the proposed commercial release of genetically modified cassava from NEMA and inform KALRO on the progress of issuance.

1.4 ESIA Methodology

1.4.1 Overview

The consultant employed a comprehensive approach in undertaking this ESIA for the commercialization of genetically modified cassava in Kenya. The ESIA study followed as systematic methodological process guided by the following elaborated steps;

1.4.2 Environmental Screening

Environmental screening was carried out to determine whether an EIA exercise is necessary for this type of project or not and if it is, then at what level of risk evaluation. The decision was informed by reference to the requirements of the Environmental Management and Coordination Act (EMCA), Cap 387 in conjunction with Legal Notice 31 of 2019 that amended the second schedule of the Act. This notice introduced the classification of projects into three categories namely; low, medium and high-risk projects. In the notice, under high risk projects segment, section 8(e) it

highlights that *"major developments in biotechnology including the introduction and testing of genetically modified organisms;"* require a high risk ESIA study. Therefore, this the section that was applied during screening to guide the proponent in undertaking this level of study.

1.4.3 Environmental Scoping

The scoping process was instrumental in assisting the consultant to narrow down onto the most critical issues requiring attention during the actual assessment. Key issues of concern were categorized into; environmental, social, economic and cultural aspects. The fundamental aspects were highlighted to inform further assessment and determine the extent and magnitude of their impact on the environment.

1.4.4 Baseline Assessment

This involved review of project documents from the proponent (KALRO), relevant policy, legal regulatory, and institutional frameworks both local and international. Other key documents were also referenced aimed at fetching critical information on climate, soils, agro-ecological zones, hydrological data for all the 19 counties regarded as cassava growing regions.

1.4.5 Stakeholders Engagement and Public Participation

Public and stakeholders' consultation was undertaken pursuant to Kenyan Constitution, 2010, Environmental Management and Coordination Act Cap 387 and County Government Act, 2012 (Amended 2020). Public participation is of essence in providing a platform for creating awareness about the proposed GM cassava commercialization project, enhancing project acceptance and also making a significant contribution to the successful project considerations and its subsequent implementation. Public participation was carried out through the following approaches;

- Public forums
- Administering of semi-structured questionnaires to the stakeholders
- Key informant interviews from select stakeholders

All these forms of data collection were employed, and the data received was synthesized and incorporated into the ESIA report.

1.4.6 Baseline Data Analysis, Reporting and Documentation

The significant data collected as part of project baseline information was fundamentally utilized to define the diverse characteristics of the receiver environment. Additionally, all the data collected during baseline survey from both primary and secondary sources was collated, analyzed, presented and integrated into various chapters of this ESIA study report. The reporting and subsequent documentation of this ESIA exercise also ensured that primarily all the key evidences of baseline information acquired from the lead government agencies, County governments as well as engagement with cassava farmers is annexed as an integral part of the document.

1.4.7 Evaluation of project Alternatives

This stage involved identification of the most preferred alternative, based upon environmental sustainability and accurately describing the relevant grounds for this choice. In addition, the do-nothing scenario (maintenance of the status quo) was also considered as a benchmark against which the other choices were compared. Comparisons of alternatives were presented in an understandable format in order to ease interpretation and analysis.

The evaluation of alternatives was assessed in form of the proposed alternative which advocates for the approval to commercialize the GM cassava. The section also evaluated the 'no project scenario" which advocates for status quo therefore, ignoring all the gains made by the research to make the GM varieties available to the public with its numerous benefits. The section also evaluated the option of considering the application of pesticide to deal with the prevailing challenge of CMD and CBSD against the genetically modified varieties. And lastly, the team evaluated the adoption of other root and tuber crops and forgo cassava production which is affected by the mentioned diseases. The comprehensive analysis of the various project alternatives was summed up by the picking of "proposed alternative" which was justified through evaluation of the anticipated project benefits.

1.4.8 Impact Assessment

The impact assessment stage involved the number of steps that collectively assessed the manner in which the approved 8 cassava varieties will interact with the elements of the physical, biological, cultural or socio-economic environment to produce impacts to receptors and resources. The primary objective of impact assessment was to identify and evaluate the likely significance of the potential impacts on identified receptors and resources according to defined assessment criteria in

order to develop and describe measures that will be taken to avoid, minimize, reduce or compensate for any potential adverse environmental effects.

At this stage, the potential and anticipated positive and negative impacts expected from the implementation of the project were identified, analyzed and presented in consideration of the type of impact and its effect on the receiving environment. The impacts were classified and discussed in two major project phases i.e., pre-release and post-release phases. In addition, the benefits that arise from the commercialization of the GM cassava were identified and summarized to form part of the justification on the significance of the project in terms of solving CMD & CBSD as well as other derived benefits.

1.4.9 Mitigation of Environmental and Social Impacts

Each predicted adverse impact was evaluated to determine whether it is significant enough to warrant any mitigation. This judgment of significance was based on one or more of the team of experts reference: to a) the existing relevant laws, regulations or accepted local and international standards, (b) consultation with the relevant stakeholders and key lead agencies, (c) reference to key documentation on the safety of the GM cassava on food, feed and environmental release (d) consistency with government policy objectives and (e) acceptability of the GM cassava project to the local community or the farmers across all cassava growing regions in the country. The mitigation of impacts covered the two phases: pre-release and post-release phases.

1.4.10 Environmental and Social Management Plan

The Environmental and Social Management Plan (ESMP) provides a practical tool for mitigating adverse negative impacts while enhancing the positive ones. This plan adopted the two phases presented in the impact assessment and mitigation sections. It also summarized the impacts together with their mitigation measures and cost of remedy. In addition, the section also attaches responsibility to various mitigation obligations in order to safeguard the environment from the adverse effects of the anticipated social and environmental impacts. This was undertaken for the best interest of the human population and the environment in which they live and relate to harmoniously.

2.0 PROJECT DESCRIPTION

2.1 Introduction

Cassava (*Manihot esculenta* Crantz is one of the most important staple food crops and sources of income in Africa, with an annual production of more than 178 million metric tons grown on 20 million hectares. Two devastating viral diseases of cassava mosaic disease (CMD) and cassava brown streak disease (CBSD) are the most important economic constraints to cassava production in Kenya. CMD is caused by related but distinct geminiviruses, the most important in sub-Saharan Africa being African cassava mosaic virus (ACMV) and the East African cassava mosaic virus (EACMV). CBSD is caused by two closely related RNA viruses, Cassava brown streak virus (CBSD) and Uganda cassava brown streak virus (UCBSV). Both CMD and CBSD are transmitted between cassava plants by the insect vector whitefly (*Bermisa tabaci* Gennadius), and via exchange of infected stem cuttings by farmers as planting materials.

2.2 CBSD Symptoms, Scoring and Detection

Characteristic symptoms for CBSD include; venial chlorosis, angular chlorotic blotches, and chlorotic spots on leaves, necrotic spots, lesions, streaks, withering, and dieback on stem; and yellow to dark-brown necrotic spots, and corky necrotic masses within the storage roots. Table 1 shows the severity rating scale, while Figures 1, 2 and 3 show diseased and malformed cassava roots, respectively.

Table 1: Severity rating scale for cassava brown streak disease in the field

Score Scale	Symptom description
Leaf	
1	No symptoms on leaves or stems
2	Mild vein yellowing; chlorotic blotches on leaves No brown streaks; lesions on green stem or leaves
3	Mild vein yellowing; chlorotic blotches on leaves Mild brown streaks; lesions on green stem portions
4	Sever; extensive vein yellowing; chlorotic blotches on leaves Severe brown streaks; dark lesions on green stem portions No defoliation; stem die-back and stunting
5	Severe/extensive vein yellowing; chlorotic blotches on leaves Severe brown streaks; dark lesions on green stem portions Defoliation, stem die-back and stunting
Storage Root	
1	No symptoms on storage roots
2	less than 5% of storage root tissue is necrotic

Score Scale	Symptom description
3	5-10% of storage root tissue is necrotic
4	10-50% of storage root tissue is necrotic
5	More than 50% of storage root tissue is necrotic

Figure 1: Image of CBSD severity scale
(Source: KALRO, 2025)

Figure 2: Diseased cassava roots
(Source: KALRO, 2025)

Figure 3: Malformed Cassava roots

(Source: KALRO, 2025)

2.3 Detection of cassava brown streak viruses

Table 2 below shows the reference genes, CBSD virus species and primer sequences used for reverse-transcription polymerase chain reaction (RT-PCR) and quantitative reverse-transcription polymerase chain reaction (RT-qPCR) employed to detect cassava brown streak viruses at the molecular level.

Table 2: Detection of Cassava Brown Streak Viruses

Gene description	Primer code	Primer sequence	Amplicon length (bp)	Reference
Cytochrome oxidase (COX)	COX F	Fwd 5'-CGTCGCATTCCAGATTATCCA-3'	79	Adams *et al.* 2013
	COX R	Rev 5'-CAACTACGGATATATAAGRRCCRRAACTG-3’		
Serine-threonine phosphatase (PP2A)	PP2AF	Fwd 5′-TGCAAGGCTCACACTTTCATC-3′	187	Moreno *et al.* 2011
	PP2AR	Rev 5′-CTGAGCGTAAAGCAGGGAAG-3′		

Gene description	Primer code	Primer sequence	Amplicon length (bp)	Reference
Uganda cassava brown streak virus (UCBSV)	UCBSVqF	Fwd 5'-AAGGCAAGGGTGGCTCTAAC-3'	112	This study
	UCBSVqR	Rev 5'-GCGTCCTTGTTGGCCCATTA-3'		
Cassava brown streak virus (CBSV)	CBSVqF	Fwd 5'-GCCAACTARAACTCGAAGTCCATT-3'	88	Adams *et al.* 2013
	CBSVqR	Rev 5'-TTCAGTTGTTTAAGCAGTTCGTTCA-3'		
3' untranslated (3'UTR) region of CBSV and UCBSV	CBSVDF2	Fwd 5'-GCTMGAAATGCYGGRTAYACAA-3'	437 (UCBSV)	Mbanzibwa *et al.* 2010
	CBSVDR	Rev 5'-GGATATGGAGAAAGRKCTCC-3'	343 (CBSV)	
Cassava brown streak viruses, CBSV and UCBSV	CBSVF2	Fwd 5'-GGRCCATACATYAARTGGTT-3'	1670 (UCBSV)	Mohammed *et al.* 2012
	CBSVDR	Rev 5'-GGATATGGAGAAAGRKCTCC-3'	1607 (CBSV)	

(Source: KALRO, 2025)

2.4 Detection of integrated trait

In order to provide unambiguous identification of new cassava varieties containing event 4046 as part of quality assurance during the production of planting material, an event-specific detection method has been developed. The method is based on PCR amplification of a unique DNA sequence spanning the junction of the 5' (LB) terminus of the inserted T-DNA and the flanking cassava genome. PCR amplification using primer pair 1 (Table 3) yields an amplified fragment of 1,618 bp that is diagnostic for the presence of event 4046.

Table 3: Primers used for event-specific detection of 4046 cassava and for amplification of the endogenous cassava phytoene desaturase gene

Primer Pair	Primer Name	Primer Sequence	Description	Amplicon Size (bp)
1	1470	5'GAAGATCTGAAGCTGGACTCTCTGGT-3'	T-DNA –left border event specific primer pair for 4046 cassava	1618
	1469	5'-TGATCTGGACGAAGAGCATCAGG-3'		
2	1088	5'-CAAGGGCAAAAATGACACGGAA-3'	Primer pair for amplification of a portion of the	528

Primer Pair	Primer Name	Primer Sequence	Description	Amplicon Size (bp)
	1089	5'CCTGAGAGTGAGAAATCCAG ATGAAGA-3'	endogenous cassava PDS encoding gene	

(Source: KALRO, 2025)

As a control to ensure the presence of template DNA, PCR amplifications are performed using primer pair 2 (Table 3) that results in the production of a 528-bp amplicon derived from the endogenous cassava phytoene desaturase *(PDS)* gene (accession number: Manes.05G193700).

2.5 GM cassava varieties approved by KEPHIS for Commercial Release

Table 4 shows the 8 cassava GM varieties recommended for commercial release by the national performance trials committee (NPTC). They are all resistant to CBSD and CMD as determined from multiyear, multilocation confined field trials across Western, Central and Coastal Kenya

Table 4: Cassava varieties recommended for release by KEPHIS

S/No	Line	Unique trait
1.	1807	CMD & CBSD resistant
2.	2087	CMD & CBSD resistant
3.	1812	CMD & CBSD resistant
4.	2113	CMD & CBSD resistant
5.	1720	CMD & CBSD resistant
6.	173	CMD & CBSD resistant
7.	1329	CMD & CBSD resistant
8.	1507	CMD & CBSD resistant

(Source: KALRO, 2025)

2.6 Road Map to the Development of CBSD resistant Cassava in Kenya

Cassava (*Manihot esculanta* Crantz) was genetically modified via *Agrobacterium*–mediated transformation of cassava cultivar TME 204 to create Event 4046 cassava that is highly resistant to CBSD. The resistance is mediated by ribonucleic acid interference (RNAi) via the expression of small interfering RNAs (siRNA) derived from the coat protein encoding sequences of CBSV and UCBSV, the causal agents of CBSD. Over 100 candidate events were obtained and challenged in greenhouse trials. More than 20 events were multiplied from initial plants by *in vitro*

micropropagation for 14-17 clonal cycles, they were further evaluated under contained confined field trials, across six locations in Kenya (Alupe, Kandara, Mtwapa) and Uganda (Namulonge, Serere Kasese) in 2015 and 2016 respectively, for initial agronomic evaluation. The events documented robust, durable resistance over multiple vegetative cropping cycles CBSV and UCBSV, the two causal agents of CBSD. Under high disease pressure, best performing events recorded up to 20 times increase in marketable storage root yields compared to non-modified controls.

The CBSD-resistant cassava lead event, Event 4046 was selected and advanced to regulatory field trials (RFTs) done at Kandara in Kenya and Kasese in Uganda over two cropping seasons (one year growing cycle), between 2016-2018. This was to generate material for compositional analysis (analysis of key nutrients and anti-nutrients) and molecular characterization (**Wagaba et al., 2021**). For new varieties, compositional assessment is part of the weight-of-evidence approach for evaluating any unintentional consequences of the genetic modification. Compositional components were assessed in 100 samples of cassava Event 4046. The parameters were those recommended in the OECD consensus document on new cassava varieties. There was no change in the nutritive value of storage roots or leaves which occurred as a consequence of the genetic modification resulting in cassava Event 4046. Multi season analysis of the data from the regulatory field trials demonstrated that the genetic modification did not have any unintended effects on plant growth, habit, morphology, reproductive biology, diseases and pest susceptibility. The Environmental safety assessment established that cassava Event 4046, there was no likelihood of weediness, pollen-mediated gene flow, impact on non-target organisms, biodiversity or cultivation practices.

An application for environmental release and placing on the market of cassava Event 4046 cassava and its progeny lines of cassava Event 4046 introgressed into farmer preferred varieties was submitted by KALRO to NBA in December 2019. The application sought approval for environmental release, for the cassava Event 4046 and its progeny lines to be entered into the variety release evaluation according to the Seeds and Variety Act of Kenya. This involved evaluation under NPTs for two cropping cycles, as well as a test for DUS for one season under the supervision of KEPHIS.

The NBA subjected the application to rigorous review, by local and international reviewers. A virtual National Dialogue was held on 10th June 2020 after placing a notification in the Kenya Gazette, and an advert in two widely read newspapers, as well as the KALRO and NBA websites. The virtual dialogue was attended by 1,197 people on Facebook live and zoom, the highest number NBA has ever had in a national dialogue. NBA received 3,342 comments about the cassava Event 4046. KALRO received an approval from NBA for Environmental release on 18th June 2021. It is a requirement of the Environmental Management and Coordination Act of 1999 cap 387, that before the environmental release and the NPTs are established, that the proponent obtains a license from the National Environment Management Authority (NEMA) after conducting an Environmental Impact Assessment. KALRO conducted the Environmental Impact Assessment across 7 seven sites proposed for the NPTs and DUS with a view of establishing the anticipated impacts on the environment and social effects for the environmental release of the genetically improved cassava. On the 14th February 2023, NEMA issued a license approving the undertaking of the NPTs which were executed and experimental results evaluated by KEPHIS. On 23rd July 2025, eight GM varieties were recommended by the National Performance Trial Committee for approval by the National Variety Release Committee for release to farmers for commercialization. Therefore, Cassava Event 4046 will benefit the Kenyan cassava farmers as they will have access to CBSD and CMV resistant germplasm, hence contribute to food security and provide economic opportunities for future generations in Kenya.

The Figure 4 shows the road map of the development of CBSD resistant cassava since commencement in 2008 to the current phase of application of ESIA license from NEMA for the commercialization of the GM cassava varieties.

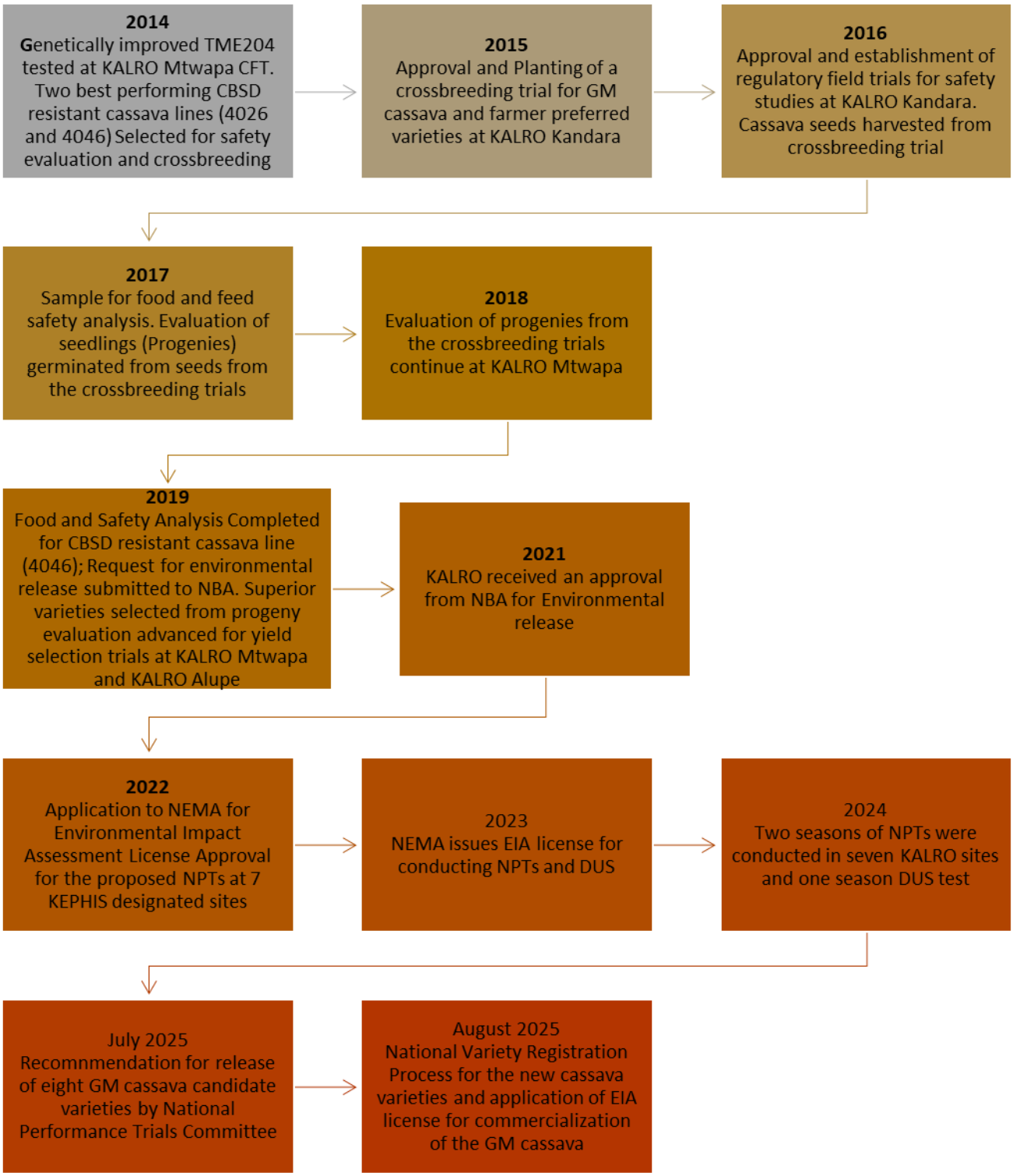


Figure 4: Road Map to the development of CBSD resistant Cassava in Kenya
(Source: KALRO, 2025)

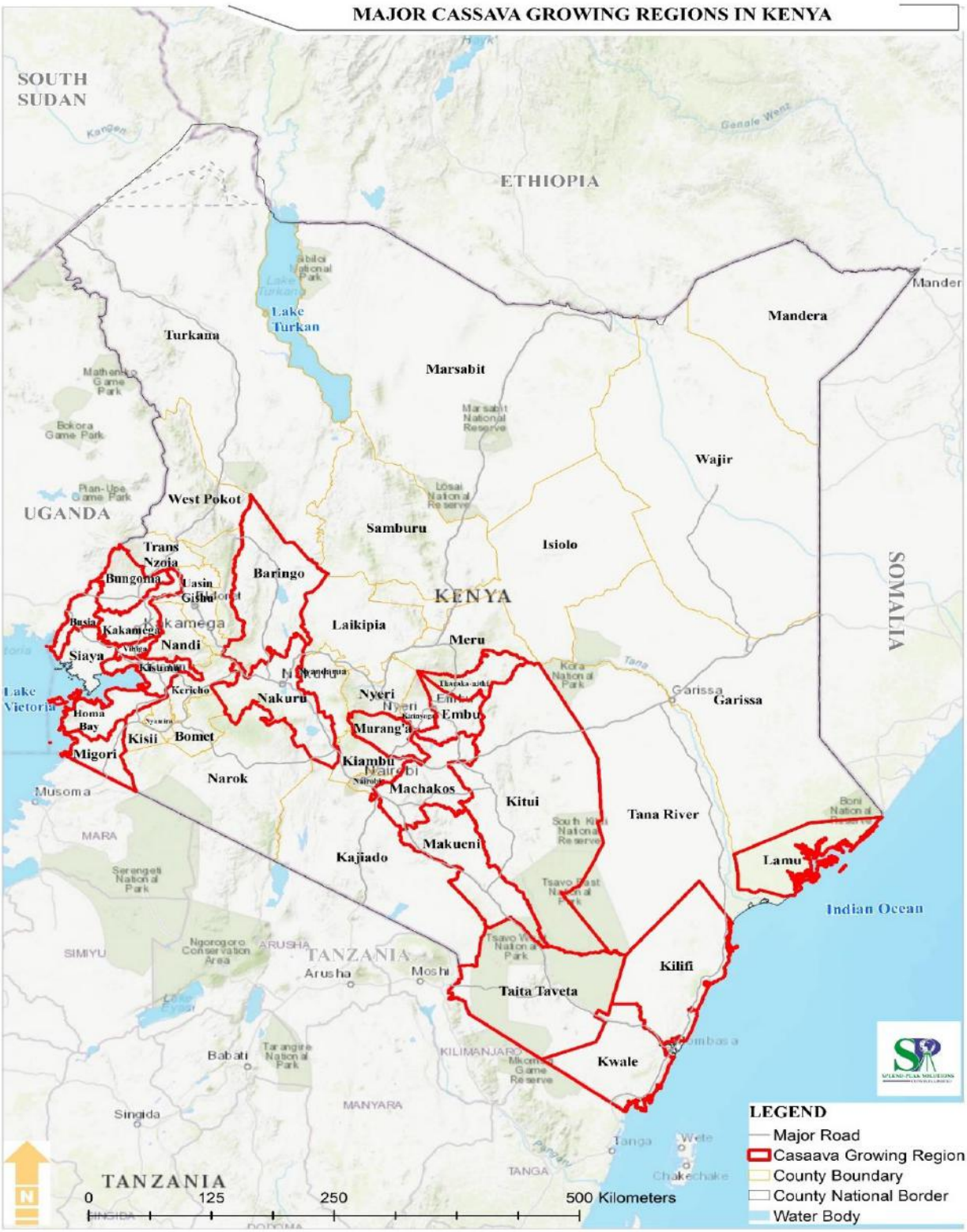
2.7 Project Cost

The total project cost for the commercialisation of the genetically modified cassava in Kenya is approximately; **Kenya Shillings Nine Million, Two hundred and Ninety-Seven Thousand, Two Hundred and Ninety-Six (KES 9,297,296.00)**

3.0 BASELINE INFORMATION

3.1 Introduction

Cassava is a vital food, cash, and industrial crop in Kenya, particularly in counties where agroecological conditions favour its cultivation. Noting that the genetically improved cassava will be commercially released in the Republic of Kenya, this study is limited to 19 key cassava-growing counties including Lamu, Kilifi, Kwale, Taita Taveta, Makueni, Kitui, Machakos, Tharaka Nithi, Embu, Nakuru, Baringo, Kakamega, Bungoma, Busia, Vihiga, Kisumu, Migori, and Homabay as illustrated in Map 1 below. These counties, spread across Coastal, Eastern, Central, Rift Valley, Nyanza, and Western regions, fall within seven diverse agroecological zones differentiated by factors such as rainfall, temperature, and soil type, which influence crop suitability and farming practices. Their varied environmental, socio-economic, and socio-cultural characteristics affect cassava production systems, market access, and climate resilience. Therefore, this chapter presents the biophysical and socio-economic setting of these counties, which were surveyed and assessed to establish a baseline for deducing potential environmental and social impacts of the proposed commercialization of the GM cassava.



Map 1: A Map showing major cassava growing areas in Kenya
(Source: GIS Data, 2025)

3.2 Lamu County

3.2.1 Geographical location

Lamu County is located on the North coast of Kenya and is one of the six counties in the coastal region of Kenya. It borders Tana River and Garissa counties to the southwest and north respectively. Republic of Somalia is bordered to the northeast and the Indian Ocean to the south. The County lies between latitudes 1^{o} 40' and 20^{o} 30' South and longitude 40^{o} 15' and 40^{o} 38' East. The County consists of a vast mainland and 65 Islands forming the Lamu archipelago. Of these Islands, the five major ones that are inhabited include Lamu, Manda, Pate, Kiwayu, and Ndau.

3.2.2 Topography and Physiography

Lamu County is generally flat and lies between altitude zero and 50m above sea level with the exception of the coastal sand dunes and the Mundane sand hills which hardly exceed 100 m above sea level. The main topographic features found in the County include: the coastal plains, island plains, Dodori River plain, the Indian Ocean and the sand dunes. The coastal plain, though not extending to the coastline, creates the best agricultural land in the County. The island plain is found in the coastal, northern and western parts of the County which have good potential for agricultural development. The inland plain is characterised seasonal water bodies being mostly large swampy areas and lake wetlands such as Lake Kenyatta, Lake Amu and Lake Moa.

3.2.3 Climatic Conditions

Based on the Köppen-Geiger climate classification, Lamu County can be said to be between the Tropical Monsoon and Arid Steppe Hot climate. The rainfall pattern in Lamu County is bimodal and is greatly influenced by the Monsoon winds with the long rains falling between late March and early June with May being the wettest month. Light showers fall in July and decreasing from August. The short rains come in November and December decreasing rapidly to a minimum in January and February. January to March are usually dry months.

The highest rainfall is recorded around Lake Kenyatta settlement scheme, Hindi, immediate area surrounding Witu, and the western side of Lamu Island. The rest of the County receives 600 mm - 700 mm with some recording less than 500 mm. Temperature is usually high ranging from 23^{0} C to 30^{0} C. The mean annual minimum and maximum temperatures range between 24^{0} C and 34^{0} C, respectively. The hottest months are December and April while the coolest months are May and July. The mean relative humidity in the County is 75%. The total amount of evapo-transpiration is

2,230m per annum, with the highest values occurring in March and September and the lowest in May.

3.2.4 Hydrology and Water Resources

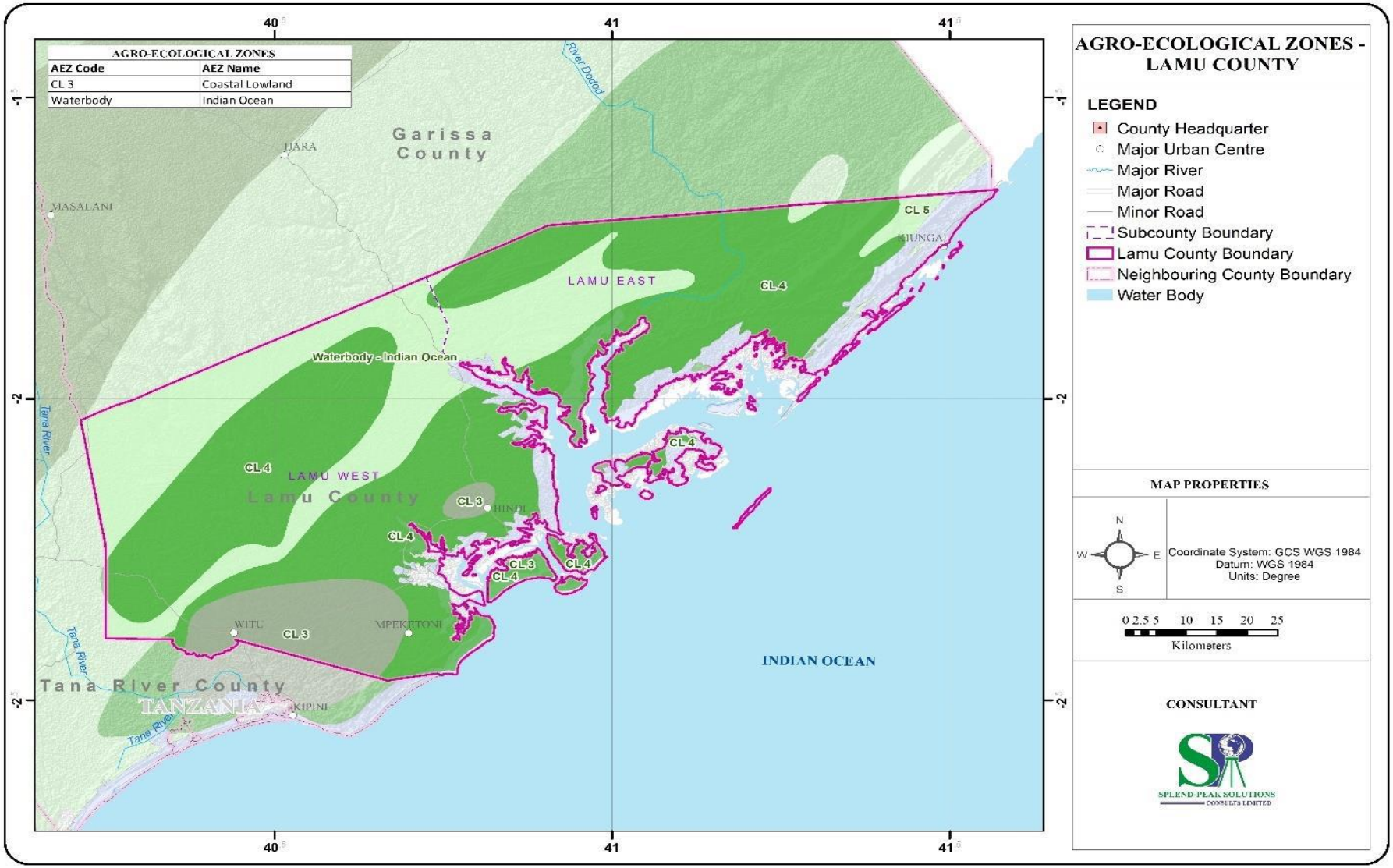
Lamu County's hydrology and water resources are influenced by its coastal location, low-lying topography, and seasonal rainfall patterns. Lamu County's water resources are primarily groundwater-based, with freshwater aquifers found in fossil coral reefs. These aquifers are recharged by rainwater and inflows from Lake Kenyatta. The County also relies on surface water from rivers such as the Tana and minor seasonal streams, and rainwater harvesting. Freshwater availability is limited due to saline intrusion from the Indian Ocean, especially in coastal aquifer.

3.2.5 Agroecological Zones

Lamu County is widely known as a major cassava growing area within the coastal region. The main sub counties supporting this extensive cassava production are Lamu East and West. There are three agro-ecological zones where cassava farming is widely practiced as captured in Table 5 and Map 2.

Table 5: Agro-ecological Zones supporting Cassava growth in Lamu County

AEZ-Code	AEZ-Name	Major-Crop	Sub-counties
CL 3	Coastal Lowland	Coconut - Cassava Zone	Lamu West
CL 4	Coastal Lowland	Cashewnut - Cassava Zone	Lamu East
CL 5	Coastal Lowland	Livestock – Millet-Cassava Zone	
Waterbody - Indian Ocean	Waterbody - Indian Ocean	Waterbody - Indian Ocean	



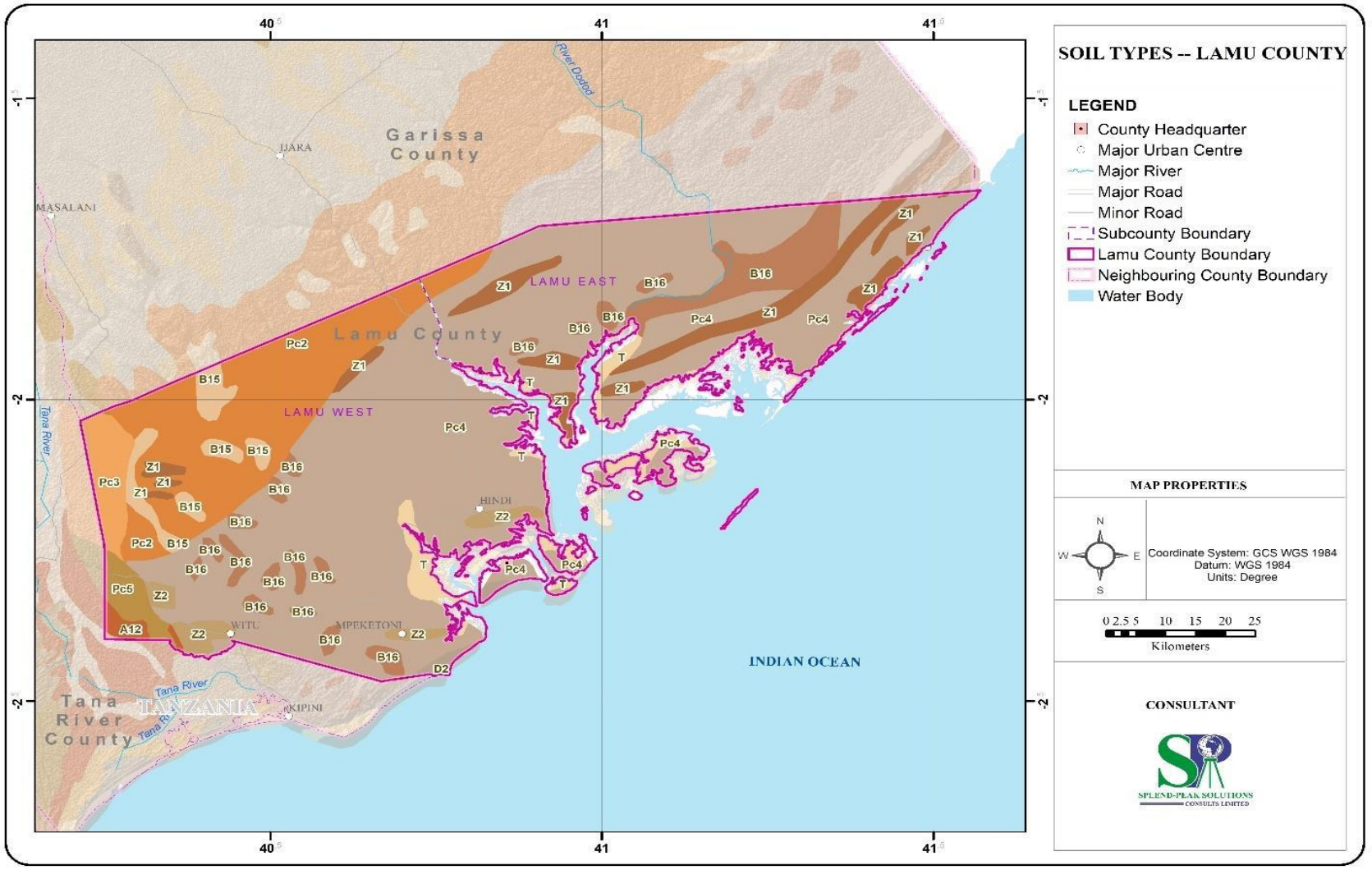
Map 2: A map showing agro-ecological zones in Lamu County
(Source: GIS Data, 2025)

3.2.6 Soils

The three-cassava growing agro-ecologies are supported by myriad types of soils that are suitable for the crop production. There is a total of 10 different soil types that promote the farming of cassava for subsistence and commercial farming as depicted in Table 6 and Map 3.

Table 6: Various soil types facilitating cassava farming in Lamu County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
B15	loamy	montmorillonitic	well		plain	flat
B16	loamy	montmorillonitic	well		plain	flat
D2	loamy	montmorillonitic	well		mountainous highland	gently undulating
Pc3	loamy	kaolinitic	well	deep	plain	flat
Pc4	sandy	montmorillonitic	well		plain	flat
Pc5	sandy	montmorillonitic	well		plain	flat
Ps23	loamy	montmorillonitic	well		plain	flat
Pt4	clayey	montmorillonitic	well		plain	flat
Z1	loamy	montmorillonitic	well		plain	flat
Z1	loamy	montmorillonitic	well		plain	flat



Map 3: Soil types within Lamu County
(Source: GIS Data, 2025)

3.3 Kilifi County

3.3.1 Geographical location

Kilifi County is one of the six counties in the Coastal region of Kenya. The County lies between latitude 3.5107° S and longitude 39.9093° E. It borders Kwale County to the South West, Taita Taveta County to the West, Tana River County to the North, Mombasa County to the South, and Indian Ocean to the East.

3.3.2Topography and Physiography

Kilifi County has four major topographic features. The first one is the narrow belt, which forms the coastal plain and varies in width from 3km to 20km. The coastal plain lies below 30m above sea level with a few prominent peaks on the western boundary such as the Mwembetungu hills. Across this plain are several creeks with excellent marine swamps that are richly endowed with mangrove forests and present great potential for marine culture. This zone is composed of marine sediments, including coral, limestone, marble, clay stones and alluvial deposits that support agriculture. The second topographical feature is the foot plateau that lies to the east of the coastal plain. It is characterized by a slightly undulating terrain that falls between 60m and 150m altitude and slopes towards the sea. A number of dry river courses transverse the surface with underlying Jurassic sediments consisting of shells, sandstones and clays. This zone is covered by grassland and stunted shrubs. The third feature is the coastal range, which falls beyond the foot plateau between 150m to 450m altitude and has distinct low-range sandstone hills. These hills include Simba, Kiwava, Daka, Wacha, Gaabo, Jibana, Mazeras and Mwangea. The fourth is the Nyika Plateau, which rises from 100m to 340m above sea level covering about two-thirds of the County area on its western side. This plateau is characterized by a low population density, thin vegetative cover, shallow depressions and gently undulating terrain. It constitutes the arid and semi-arid areas of the County, which are suitable for ranch.

3.3.3 Climatic Conditions

The County has a bimodal rainfall pattern with average annual precipitation ranging from 300mm in the hinterland to 1,300mm in the coastal belt. The coastal belt receives an average annual rainfall of about 900mm to 1,300mm, while the hinterland receives average annual rainfall of about 300mm to 900mm. The short rain season is experienced in the months of October, November and December, while the long rains are experienced in the months of March, April and May. The most

important season to the hinterland is the short rains for pasture regeneration and water recharge while the long rain season is the most important season for crop production. Areas receiving highest average annual mean evaporation ranges from 1800mm along the coastal strip to 2200mm in the Nyika plateau in the hinterland. The highest evaporation rates are experienced during the months of January to March in the County. The annual temperatures range between 21^0C and 30^0C in the coastal belt and between 30^0C and 34^0C in the hinterland.

3.3.4 Hydrology and Water Resources

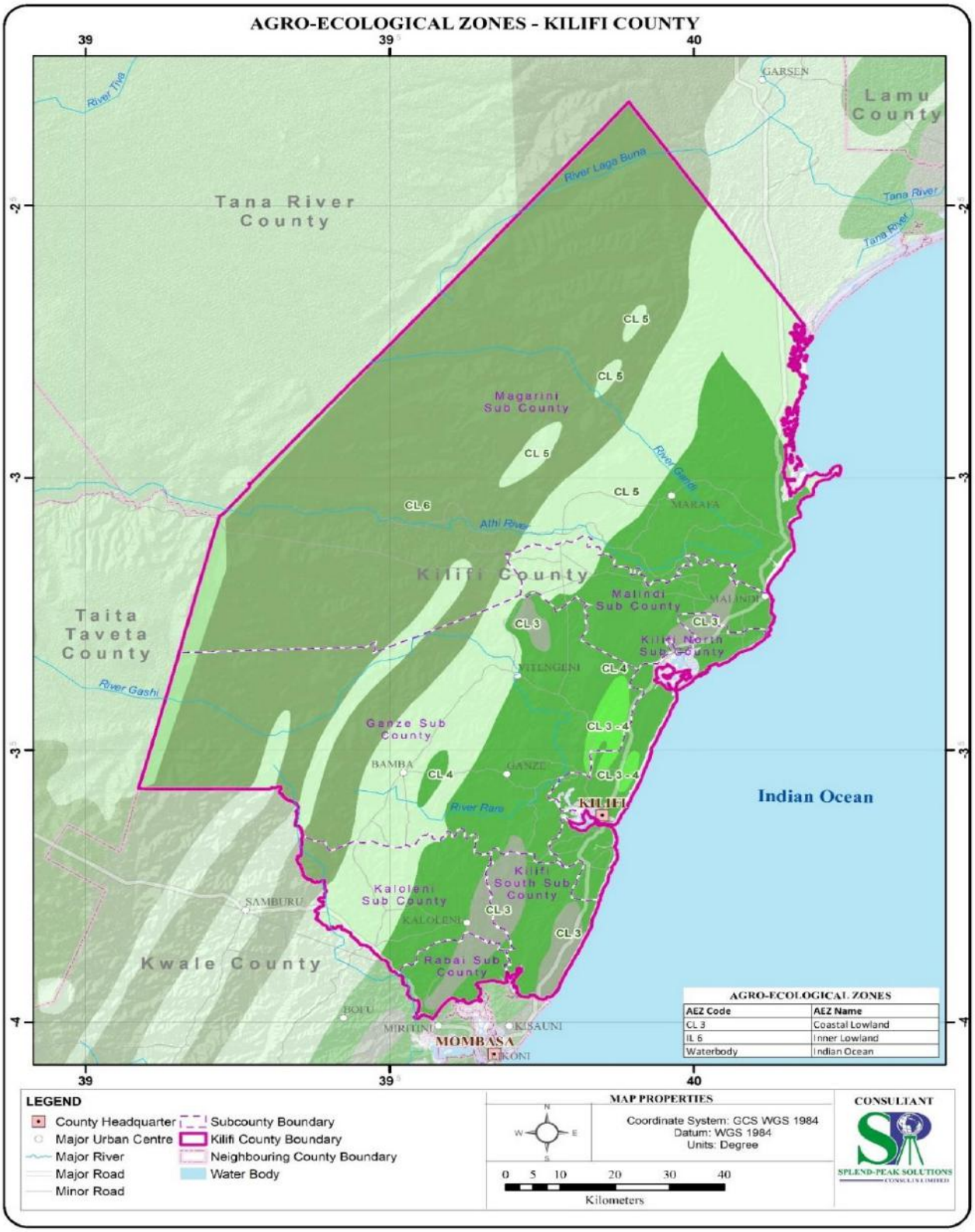
The drainage pattern of the County is formed by one permanent river, a number of ephemeral rivers and streams which drain into Indian Ocean. The permanent river is the Sabaki River while the seasonal rivers are Nzovuni, Rare, Goshi and Kombeni. The streams include Wimbi, Kanagoni, Masa, Muhomkulu and Mleji. Kilifi County relies heavily on groundwater, with aquifers in sedimentary formations providing nearly 50% of the water supply. These aquifers are found within fluvial and lacustrine deposits and are replenished by rainfall. The County's groundwater resources are primarily found in aquifers within sedimentary formations, including the Kilindini Formation. The Sabaki aquifer (near Baricho) and the Tiwi and Msambweni aquifers (south coast) are significant examples. Groundwater quality in Kilifi County varies, with concerns about saltwater intrusion near the coast and potential contamination from poor waste disposal and sanitation practices. Some areas experience high levels of iron, manganese, turbidity, nitrates, and chlorides.

3.3.5 Agro-ecological zones

Kilifi County is also a key cassava growing area in the coastal region of Kenya. The County possesses three (3) agro-ecological zones that support the growth of cassava for household and commercial purposes. These AEZs are spread across 5 sub-counties as shown in Table 7 and Map 4.

Table 7: Agro-ecological Zones of cassava production areas in Kilifi County

AEZ-Code	AEZ-Name	Major Crop	Sub-County
CL 3	Coastal Lowland	Coconut - Cassava Zone	Ganze,Rabai, Kilifi North, Kilifi South, Kaloleni
CL 3 - 4	Coastal Lowland	Coconut-Cassava/ Marg. Cottonand, Cashewnut-Cassava Zone	
CL 4	Coastal Lowland	Cashewnut - Cassava Zone	
Waterbody - Indian Ocean	Waterbody - Indian Ocean	Waterbody - Indian Ocean	



Map 4: A map showing agro-ecological zones in Kilifi County

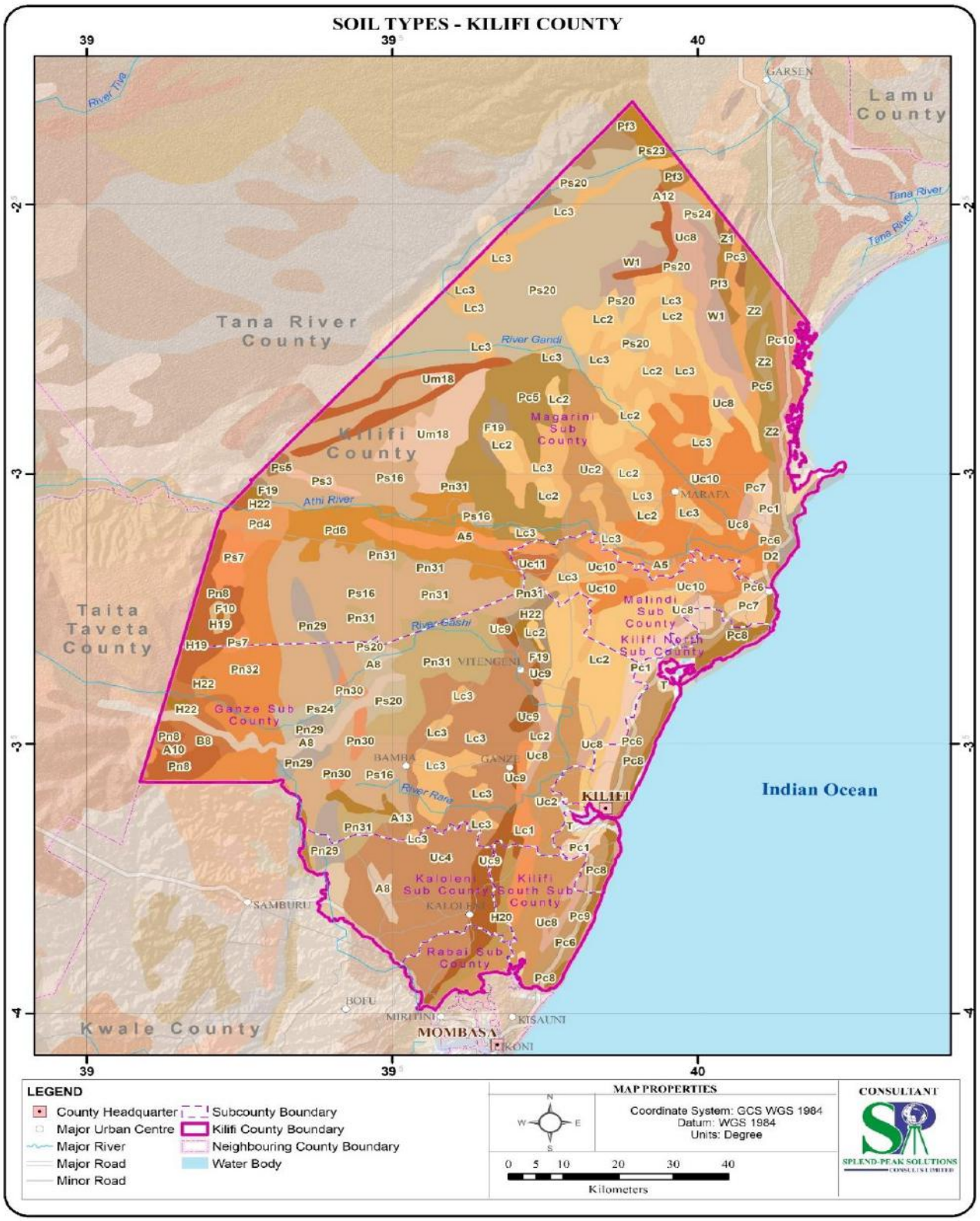
(Source: GIS Data, 2025)

3.3.6 Soils

Different agro-ecologies are characterized by various soil types suitable for the growth of diverse crops. In Kilifi County, the cassava production regions are covered by nine (9) different soil types. These soils have loamy, sandy and clayey textures and are largely well-drained. Table 8 summarizes the soils and their physical properties, while Map 5 illustrates their locations.

Table 8: Range of soil types supporting cassava growth in Kilifi County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
D2	loamy	montmorillonitic	well		mountanious highland	gently undulating
Lc3	sandy	kaolinitic	well	very deep	plateau	flat
Pc1	clayey	interstratified	well	very deep	plain	flat
Pc9	loamy	montmorillonitic	well		plain	flat
Ps20	clayey	montmorillonitic	well		plain	flat
Ps7	clayey	kaolinitic	well	very deep	plain	flat
Uc10	clayey	montmorillonitic	well		plain	flat
Uc4	loamy	kaolinitic	well	moderately deep	plain	flat
Uc8	loamy	kaolinitic	well	very deep	dissected plain	rolling



Map 5: Soil types within Kilfi County
(Source: GIS Data, 2025)

3.4 Kwale County

3.4.1 Geographical location

Kwale County is one of the six counties in the coastal region of Kenya. It borders Taita Taveta County to the North West, Kilifi County to the North and North East, Mombasa County and Indian Ocean to the East and South East, and the United Republic of Tanzania to the South West. The County is located in the Southern tip of Kenya, lying between Latitudes 30.05º to 40.75º South and Longitudes 38.52º to 39.51º East.

3.4.2 Topography and Physiography

The County comprises of the following main topographic features, which are closely related to the geological characteristics of the area:

a) **The coastal plain** - This strip of land consists of corals, sand, and alluvial deposits.
b) **The foot plateau** - This strip of land consists of corals, sand, and alluvial deposits.
c) **Coastal range/uplands** - Commonly known as Shimba Hills, the area rises steeply from the foot plateau to an altitude between 150 metres and 462 meters above sea level. This is an area of medium to high agricultural potential.
d) **The Nyika Plateau** - This zone stands at an altitude of about 180 to 300 meters above sea level on the western boundary of the region. The main activity in the area is livestock rearing.

3.4.3 Climatic Conditions

The County has a tropical type of climate influenced by the monsoon seasons. The average temperature is about 23ºC with maximum temperature of 25ºC being experienced in March during the inter-monsoon period and minimum temperature of 21ºC experienced in July a month after the start of the southwest monsoon (also known as *Kusi*). Rainfall is bi-modal with short rains *(Mvua ya Vuli*) being experienced from October to December, while the long rains (*Mvua ya Masika*) are experienced from March/April to July. There is a strong east to west gradient of decreasing precipitation with eastern (coastal) parts of the County receiving greater than 1000 mm of precipitation per year, while a majority of the County central to west receives around 500-750 mm. Some areas along the western side of the County receive less than 500 mm of precipitation per year. As such, heat stress, dry spells, and drought are hazards that strongly contribute to

agricultural risks in the County, especially in the central and western parts of the County. However, flooding due to intense rains has also occurred historically and as such is a risk to the County, especially in the central to eastern parts (including the coast) of the County.

3.4.4 Hydrology and Water Resources

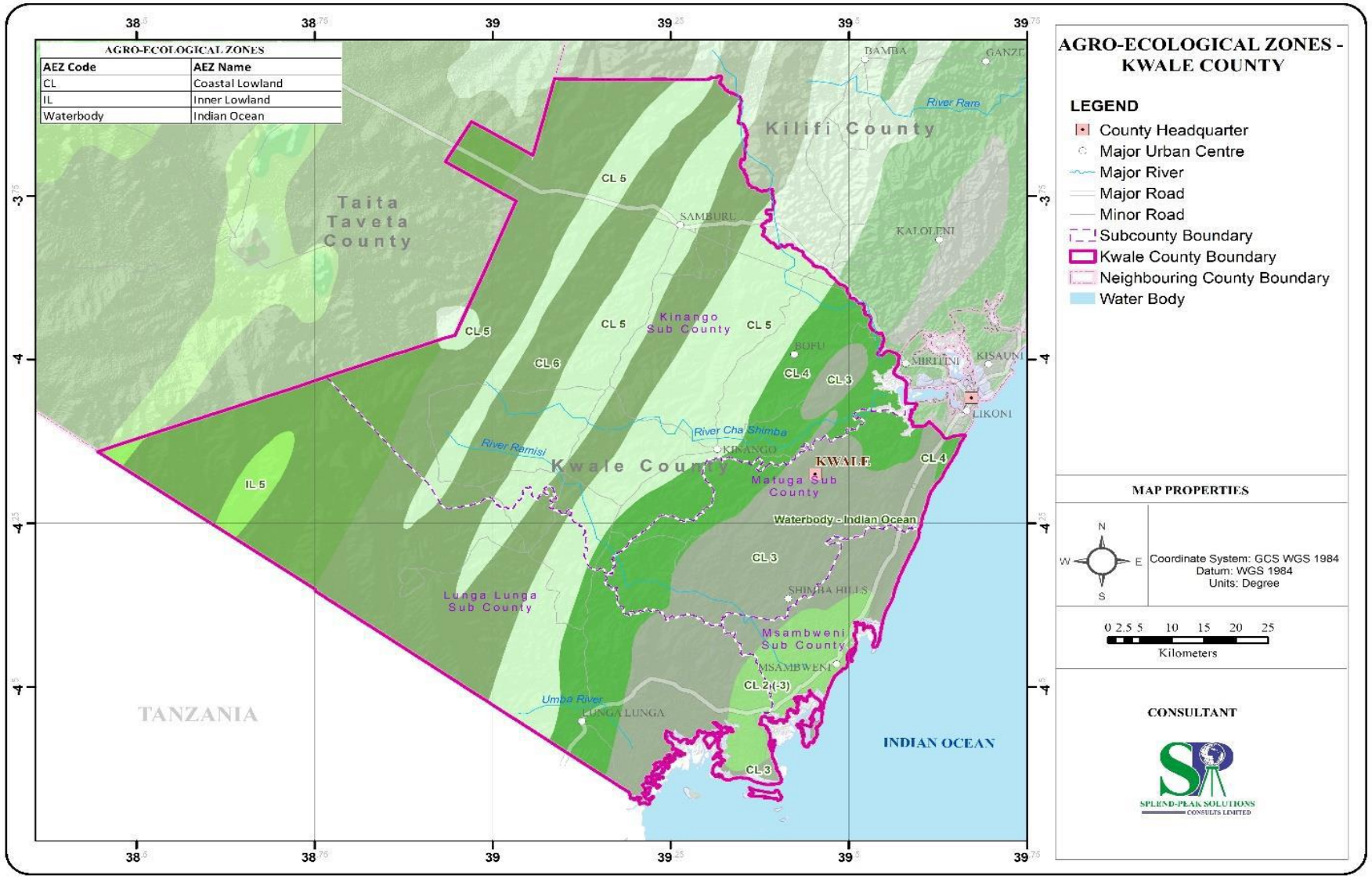
Kwale County is generally well-drained by a network of seven major rivers and numerous minor streams, forming a vital part of the County's hydrological system. The main rivers include; Ramisi, Marere, Pemba, Mkurumuji, Umba, Mwachema, and Mwache. Three of these, Marere, Mwaluganje, and the Ramisi River, are permanent which flow year-round and drain into the Indian Ocean, providing critical water resources for domestic use, irrigation, and supporting aquatic ecosystems. The remaining rivers are seasonal, flowing mainly during the rainy seasons and sustaining wetlands, riparian habitats, and groundwater recharge.

3.4.5 Agroecological Zones

Kwale County has five (5) sub counties which are actively engaged in the production of cassava as a subsistence and also a cash crop. The administrative areas cut across two major agro-ecologies namely; Coastal Lowland (CL3) and Coastal Lowland (CL4). Table 9 summarizes this information, while Map 6 gives a visual representation.

Table 9: Cassava farming Agro-ecological zone in Kwale County

AEZ-Code	AEZ-Name	Major Crop	Sub-County
CL 3	Coastal Lowland	Coconut - Cassava Zone	Matuga, Mswambweni, Linga lunga, Kinango
CL 4	Coastal Lowland	Cashewnut - Cassava Zone	
Waterbody - Indian Ocean	Waterbody - Indian Ocean	Waterbody - Indian Ocean	



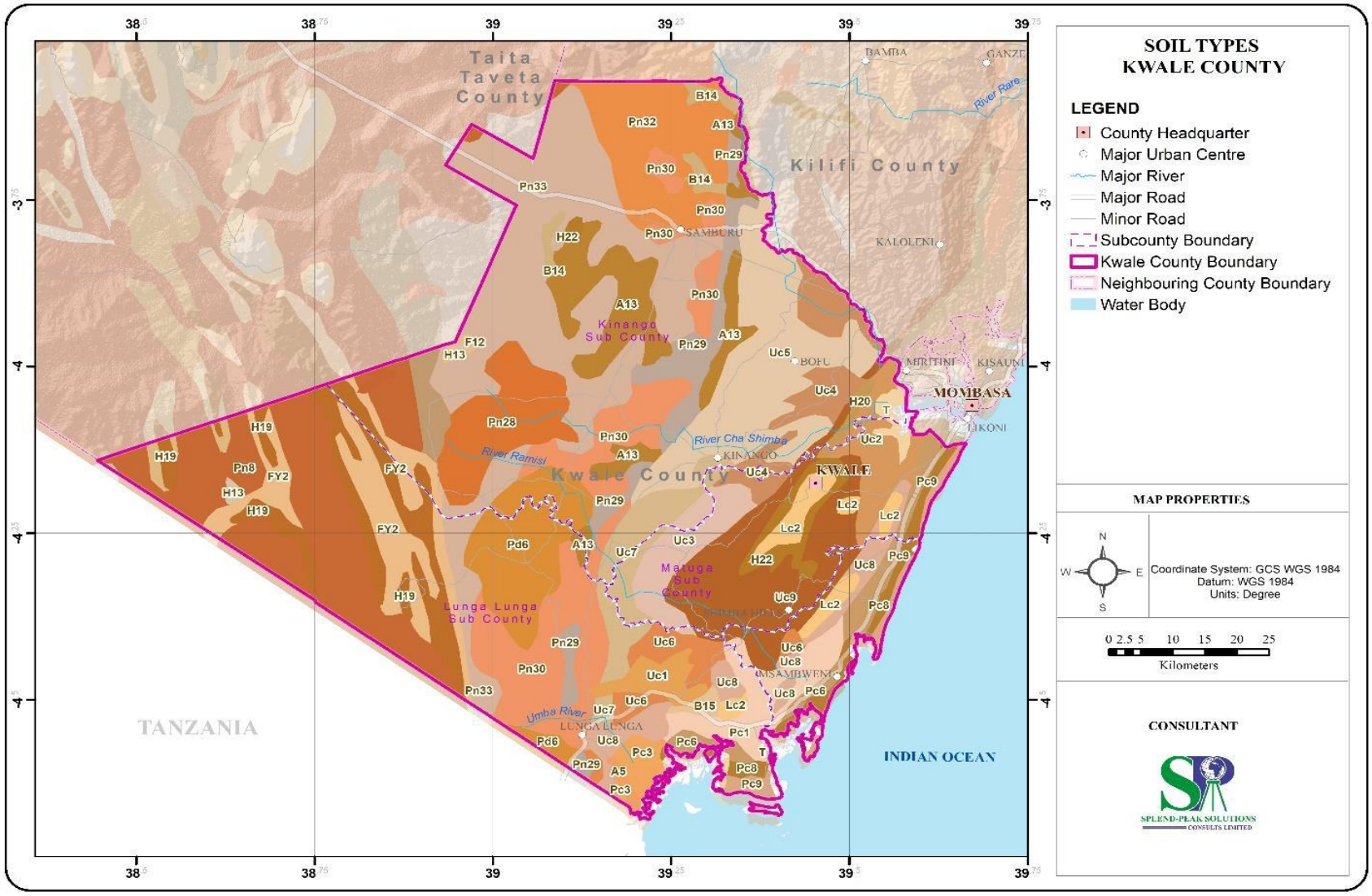
Map 6: A map showing agro-ecological zones in Kwale County
(Source: GIS Data, 2025)

3.4.6 Soils

Soils are regarded as a critical component of any farming venture. Different soils contain different moisture contents, drainage capabilities, textures, depth etc, which determine the range of crops that can be supported for optimal production. Kwale County has eight (8) soil types that are suitable for the cassava production as indicated in Table 10 and as illustrated Map 7.

Table 10: Diverse soil types in cassava growing areas of Kwale County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
H20	loamy	montmorillonitic	well		medium gradient hill	rolling
H22	clayey	montmorillonitic	well		medium gradient hill	rolling
Pc9	loamy	montmorillonitic	well		plain	flat
Pn29	loamy	kaolinitic	well	moderately deep	plain	gently undulating
Uc4	loamy	kaolinitic	well	moderately deep	plain	flat
Uc6	loamy	kaolinitic	well	deep	plain	gently undulating
Uc8	loamy	kaolinitic	well	very deep	dissected plain	rolling
Uc9	loamy	kaolinitic	well	very deep	plain	gently undulating



Map 7: Soil types within Kwale County
(Source: GIS Data, 2025)

3.5 Taita Taveta County

3.5.1 Geographical location

Taita Taveta County is also one of the six counties located in the coastal region and is approximately 200km North West of the coastal city of Mombasa, and 360km South East of Nairobi. The County covers an area of 17,084.1km^2 with 10,649.9 km^2 (62.3 per cent) being within Tsavo East and Tsavo West National Parks. The County borders Kitui, Makueni and Tana River Counties to the north; Kilifi and Kwale Counties to the east; Kajiado County to the north-west and the Republic of Tanzania to the South. The County lies between longitude 37^{0}36" east and 30^{0}14" east and latitude 2^{0}46" south and 4^{0}10" south.

3.5.2 Topography and Physiography

Taita Taveta County is classified into three major topographical zones, namely:

i) Upper zone – which comprises Mwambirwa, Taita and Sagalla hills regions with altitudes ranging from 304 meters to 2,208 meters above sea level. The zone is suitable for horticultural farming.
ii) Lower zone – which includes plains where the national parks, mines and ranches are found.
iii) Volcanic foothills zone – which covers the Taveta region with underground water and springs sourcing from Mt. Kilimanjaro.

3.5.3 Climatic Conditions

Taita Taveta County is mainly dry, with the exception of Taita Hills which are considerably wet. The south-easterly winds influence climate in the area, whereby hilly areas have ideal conditions for moisture condensation which then results in relief rainfall. Long rains are usually experienced between March and May – where on average, highlands record 265 mm as opposed to the 157 mm in lowlands. Short rains are anticipated between October and December, with annual rainfall being recorded at 1,200 mm (highlands) and 341 mm (lowlands). Rainfall distribution is usually uneven, with higher rainfall amounts being recorded in highland areas as compared to the lowlands. Annually, mean rainfall is 650mm. Average temperature in Taita Taveta County is 23^{0}C, with lows of 18^{0}C in hilly areas (Sagalla, Taita ad Mwambirwa) and rising to about 25^{0}C in lower zones.

3.5.4 Hydrology and Water Resources

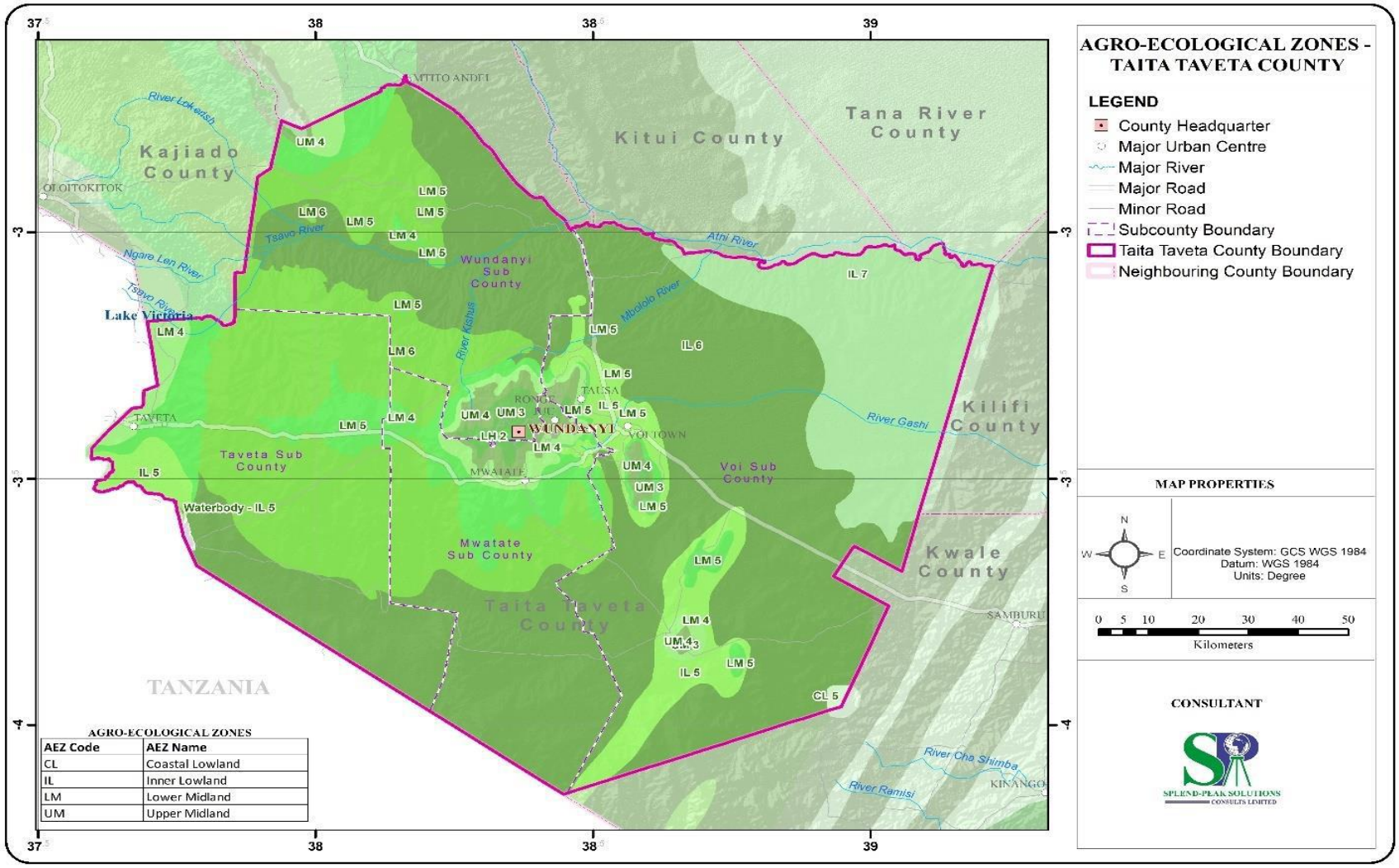
The hydrology and water resources are shaped by its varied topography, which includes the Taita Hills, expansive plains, and the Tsavo National Park ecosystems. The County has both surface and groundwater resources, with rivers originating mainly from the Taita Hills and draining into the Tsavo River system or Lake Jipe. Key rivers include Rivers Lumi, Voi, Tsavo, and Mbololo, which provide water for domestic use, irrigation, and wildlife. Springs such as Njoro Springs and Mwatate Springs are vital for local communities. The County also hosts Lake Chala (a transboundary Crater Lake shared with Tanzania) and Lake Jipe, both important for biodiversity and fishing.

3.5.5 Agro-ecological Zones

Taita Taveta County is usually considered to be within the coastal agro-ecology since majority of its terrestrial location is in the coastal region. However, the County also experiences characteristics of Arid and semi-arid lands (ASALs) majorly due to its location within Athi-river basin. The cassava growing zones cuts across three (3) sub-counties, which host the 3 agro-ecological zones that support the production of this crop as illustrated in Table 11 and Map 8.

Table 11: Taita-Taveta County Cassava Agroecologies

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
CL 5	Coastal Lowland	Livestock – Millet-Cassava Zone	Taveta, Mwatate, Voi
IL 5	Inner Lowland	Livestock – Millet-Cassava Zone	
LM 5	Lower Midland	Livestock – Millet- Cassava Zone	



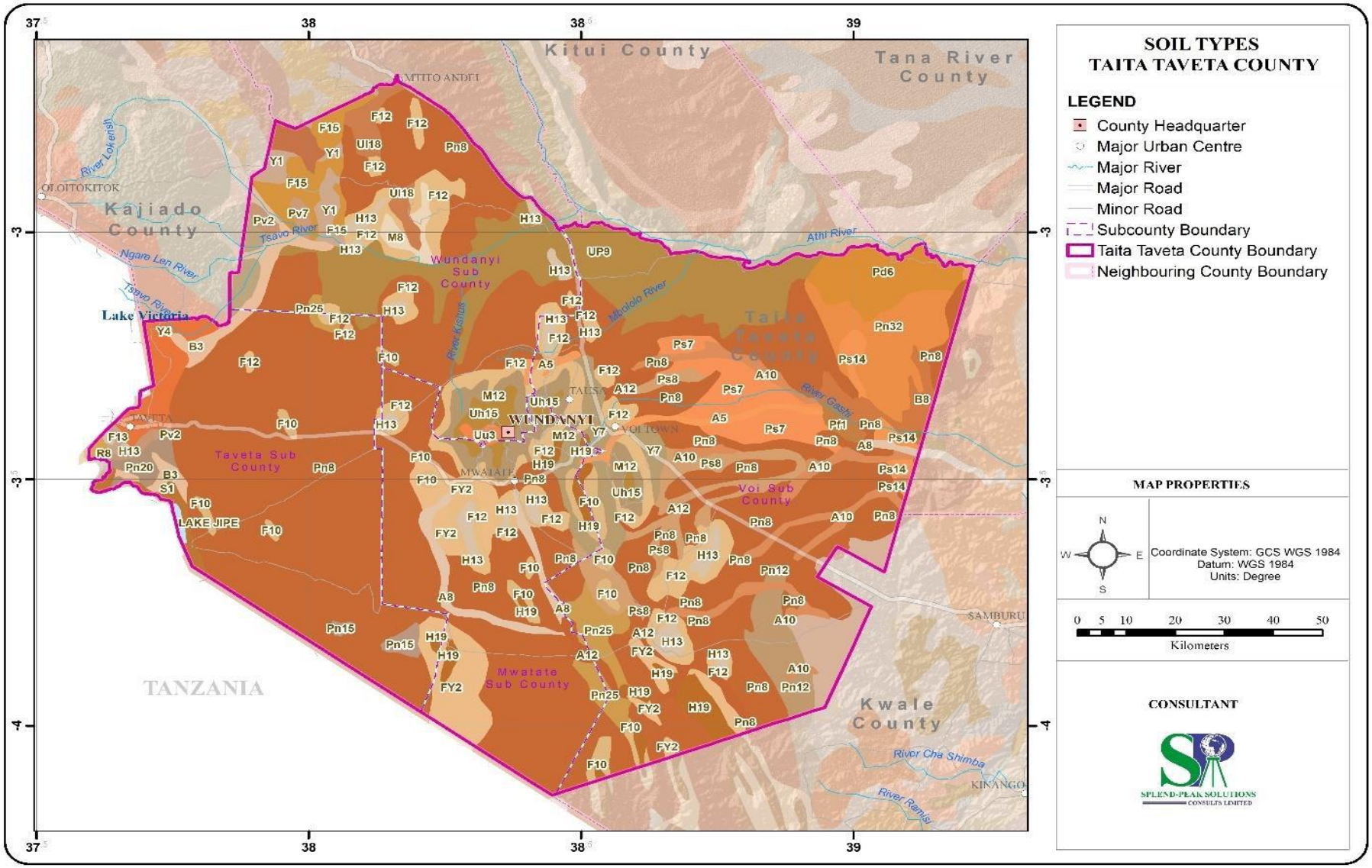
Map 8: Agro-ecological Zones for Taita-Taveta County
(Source: GIS Data, 2025)

3.5.6 Soils

In order to attain optimal cassava production, the nature of soils is a big consideration factor. Although cassava does well in majority of soils, a well-drained soil offers an advantage in enhancing yields, all other factors kept constant. There are two primary soil types within the three agro-ecological zones that are suitable for cassava farming in Taita Taveta County as expressed in Table 12 and demonstrated in Map 9.

Table 12: Soil characteristics supporting cassava growth in Taita-Taveta County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
F13	sandy	kaolinitic	well	deep	plain	undulating
Uh15	loamy	kaolinitic	well	moderately deep	medium-gradient escarpment	



Map 9: Soils types within Taita-Taveta County
(Source: GIS Data, 2025

3.6 Makueni County

3.6.1 Geographical location

Makueni County is situated in the South Eastern part of the country and borders the following counties: Machakos to the North, Kitui to the East, Taita Taveta to the South and Kajiado to the West. The County lies between Latitude 1º 35´ and 3° 00´ South and Longitude 37º10´ and 38º30´ East.

3.6.2 Topography and Physiography

Makueni County sits at an average altitude of 1,250M above Sea Level with the lowest point measuring 600M, while the highest point standing at 1,900M above Sea Level. The major physical features in the County include the volcanic Chyullu hills which lie along the South West border of the County in Kibwezi East and West sub-counties; Mbooni hills in Mbooni sub-County, which host Mbooni north and south forests and Kilungu and Iuani hills in Kaiti sub-County. Other features include Makongo forest and scenic view, Katende forest, Makuli forest and Nzaui hill.

3.6.3 Climatic Conditions

Makueni County is largely an Arid and Semi-Arid land; prone to frequent droughts due to unreliable and erratic rainfall. The County experiences two rain seasons in a year. The long rains are experienced during the March-May-April-June season with the volume of rainfall averaging at 140mm over the last five years. Short rains are experienced during the October – December season with higher volumes of precipitation being realized with a five-year average of 300mm. The mean annual temperatures in Makueni range from 22.7 Degrees Celsius to 24 Degrees Celsius over the last 5 year.

3.6.4 Hydrology and Water Resources

The County has a network of tributaries that flow downstream, successively merging into larger rivers namely; Thwake, Kaiti, Kikuu, Muooni, Kambu, Tsavo, Mtito Andei, and Kiboko. The latter eventually channel their waters into Athi River which forms the Eastern border with Kitui County and drains into Indian Ocean. Most of the rivers are seasonal. The Kibwezi River is a major distributary within the Kibwezi watershed, flowing approximately 25 kilometres. It's a key water source in the area and is known for its seasonal flow, particularly during the rainy seasons. The

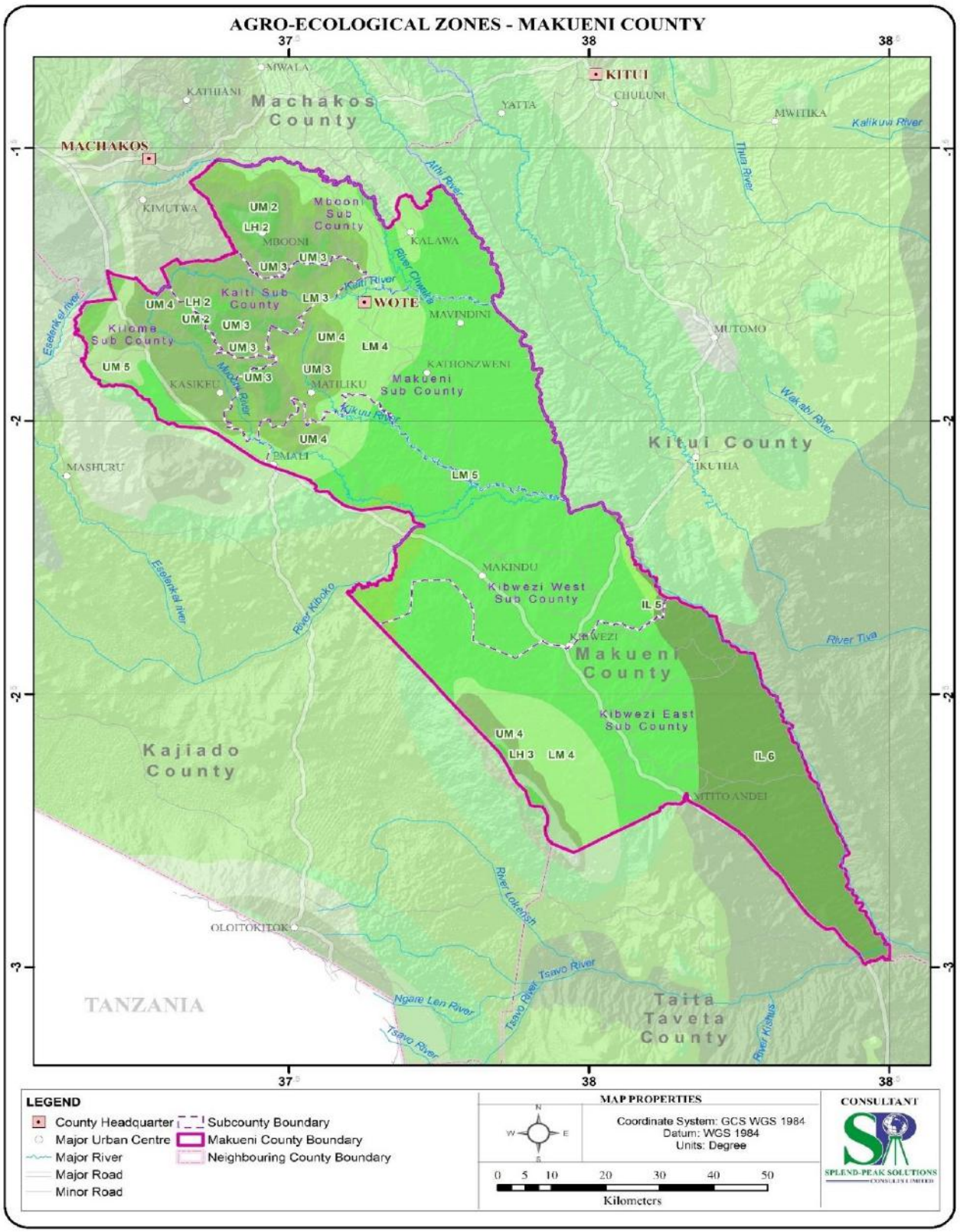
Kibwezi watershed is characterized by a semi-arid climate with varied and erratic rainfall. The river's water is utilized for various purposes including Kibwezi Irrigation Project.

3.6.5 Agro-ecological Zones

Makueni County undertakes cassava cultivation within the hotter and drier regions of the landscape. A total of four (4) agro-ecological zones are suitable for both small- and large-scale production of cassava. These AEZs cut across four sub-counties as shown in Table 13 and Map 10.

Table 13: Agro-ecological zones for cassava regions in Makueni County

AEZ-Code	AEZ-Name	Major Crop	Sub-counties
IL 5	Inner Lowland	Livestock – Millet-Cassava Zone	Kibwezi West Kibwezi East Makueni Kilome
LM 5	Lower Midland	Livestock – Millet-Cassava Zone	
UM 5	Upper Midland	Livestock – Sorghum-Cassava Zone	
UM 5 - 6	Upper Midland	Livestock – Sorghum-Cassava/Ranching Zone	



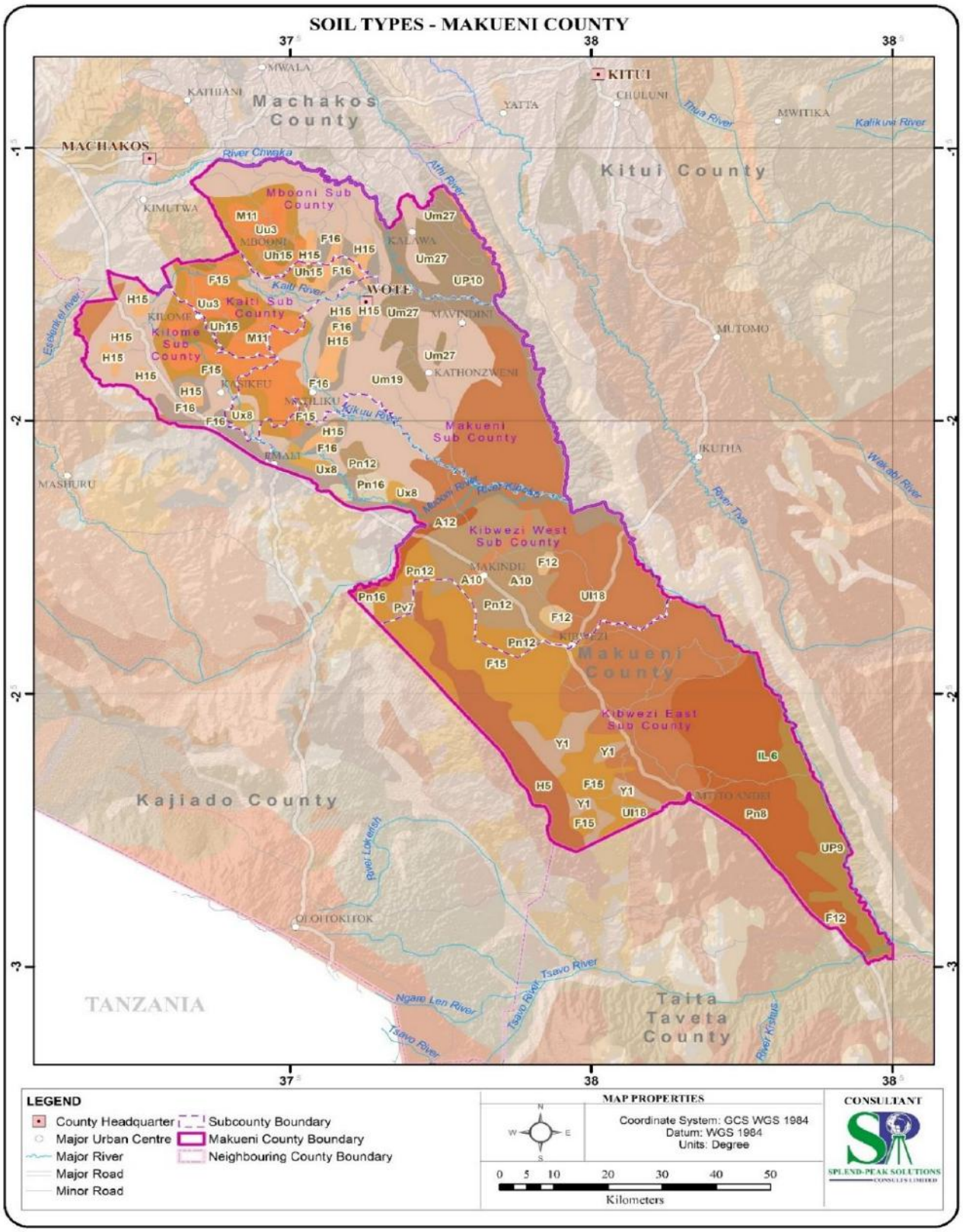
Map 10: A map showing agro-ecological zones in Makueni County
(Source: GIS Data, 2025)

3.6.6 Soils

Soils types and other suitability characteristics are an integral consideration prior to the undertaking of any farming activity. For Makueni County, there are seven different types of soils that support the production of cassava due to their well-drained characteristics which is generally, highly recommendable for cassava production. Table 14 and Map 11 recapitulate soil characteristics and their respective locations.

Table 14: Soil types in cassava growing regions in Makueni County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
F15	loamy	montmorillonitic	well		medium gradient hill	rolling
F16	clayey	interstratified	well	very deep	medium gradient hill	moderately steep
Uh15	loamy	kaolinitic	well	moderately deep	medium-gradient escarpment	moderately steep
Ul18	clayey	montmorillonitic	well		plain	gently undulating
Um19	clayey	kaolinitic	well	deep	plain	gently undulating
Um27	clayey	interstratified	well		medium gradient hill	moderately steep
Y1	clayey	montmorillonitic	rapid		plain	flat



Map 11: Soil types within Makueni County
(Source: GIS Data, 2025)

3.7 Kitui County

3.7.1 Geographical location

Kitui County is about 160 kilometres from Nairobi City on the eastern part of Kenya. The County is the sixth largest in Kenya covering an area of approximately 30,496.4 km^2. It shares its borders with seven other counties; namely, Machakos and Makueni counties to the west, Tana River County to the east and south-east, Taita Taveta County to the south, Embu to the north-west, and Tharaka-Nithi and Meru counties to the north. It is located between latitudes 0°10 South and 3°0 South and longitudes 37°50 East and 39°0 East.

3.7.2 Topography and Physiography

Kitui County, located in eastern Kenya, has a diverse range of physical and topographic features. The County's landscape is dominated by a semi-arid and arid environment, with rugged terrain, rocky hills, and vast plains. The County is located on the eastern side of the East African Rift Valley, with altitudes ranging from 200 meters to 2,100 meters above sea level. The County is bordered by Tana River County to the east, Machakos County to the west, Taita Taveta County to the south, and Embu and Tharaka Nithi Counties to the north. The County's topography is defined by the hills and mountains that are spread throughout the region. Some of the notable hills and mountains in the County include Ikoo Valley and Kanyonyoo Hills. The plains are characterized by a vast expanse of flat lands, with scattered shrubs and grasses. The plateau areas, such as the Yatta Plateau, are characterized by rugged terrain, rocky outcrops, and deep gorges. The plains and plateaus are suitable for rain-fed agriculture, with most of the County's agricultural activities taking place in these areas.

3.7.3 Climatic Conditions

The County is a region in Kenya that is predominantly characterized by arid and semi-arid climatic conditions. It is situated in the eastern part of the country and receives low and unreliable rainfall throughout the year. Most areas in the County receive an average of 200 to 600 mm of rainfall annually, which is insufficient to support agriculture and other human activities. The rainfall patterns in the County are characterized by two rainy seasons, the short rains from October to December and the long rains from March to May. However, the rainfall is highly unpredictable, and the County experiences frequent droughts and floods that affect the region's socio-economic activities. The high temperatures in Kitui County contribute to the arid conditions. It experiences

high temperatures throughout the year, with the average temperature ranging between 25 to 30 degrees Celsius with the lowest average of 14ºC and highest average of 32ºC. These hot and dry conditions make it difficult for crops and vegetation to thrive, thus contributing to limited agricultural productivity in the region.

3.7.4 Hydrology and Water Resources

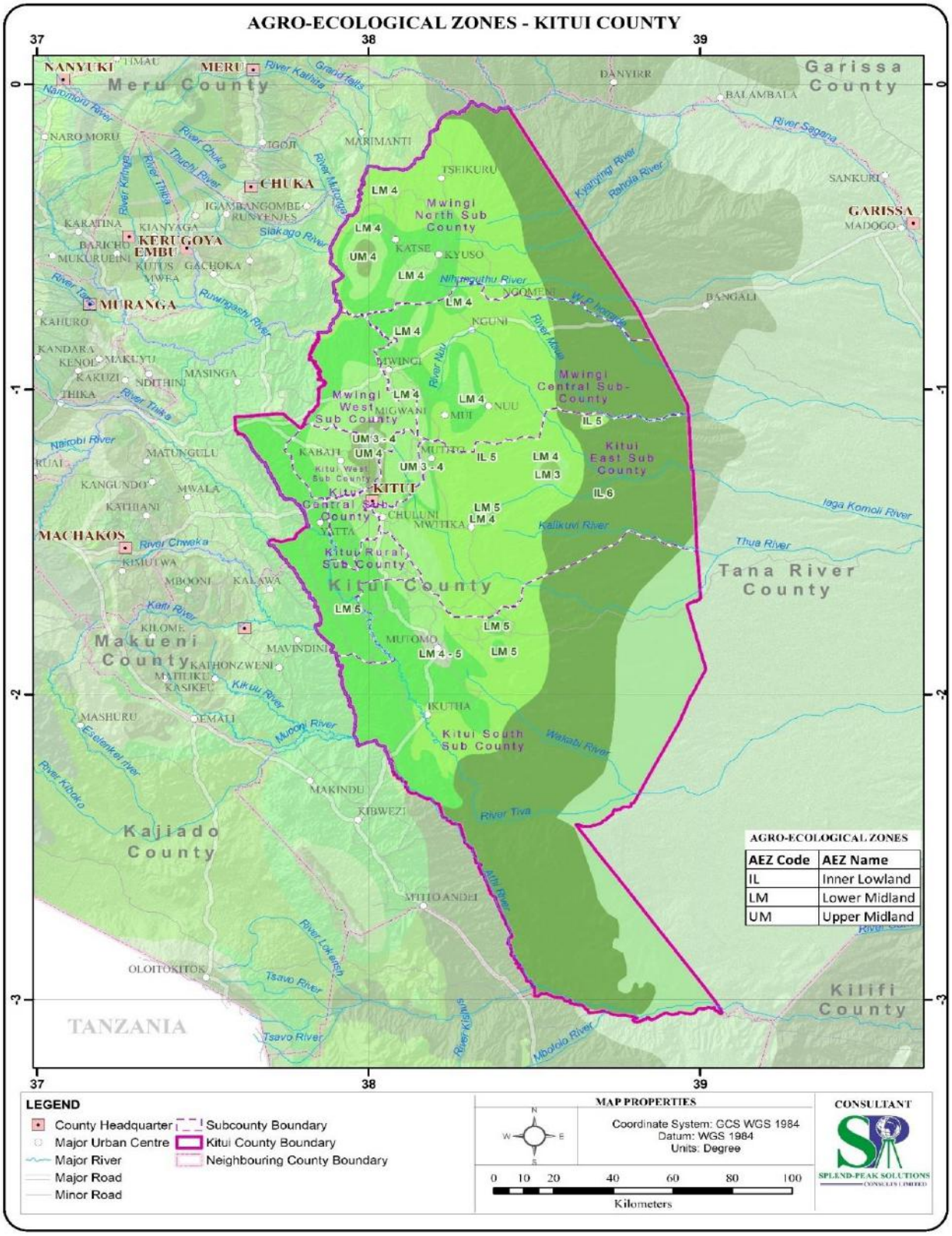
Kitui County's hydrology is largely characterized by seasonal rivers and streams, which flow mainly during the rainy seasons and dry up for much of the year due to the County's semi-arid climate. The main rivers include the Athi, Tiva, and Thika, which are critical for domestic water supply, small-scale irrigation, and livestock use. Water resources in the County also comprise sand dams, earth dams, pans, and shallow wells, which provide vital water storage and recharge points during dry periods. In some areas, boreholes tap into underground aquifers to supplement surface water.

3.7.5 Agro-ecological zone

Kitui County has cassava growing areas spread across five (5) sub-counties, which are covered by two agro-ecological zones namely; Inner Lowland (IL5) and Lower midland (LM5) as shown in the Table 15 and Map 12.

Table 15: Kitui Cassava Agro-ecological Zones

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
IL 5	Inner Lowland	Livestock – Millet-cassava Zone	Kitui East, Mwingi central, Kitui South, Kitui Rural, Kitui Central
LM 5	Lower Midland	Livestock – Millet-Cassava Zone	



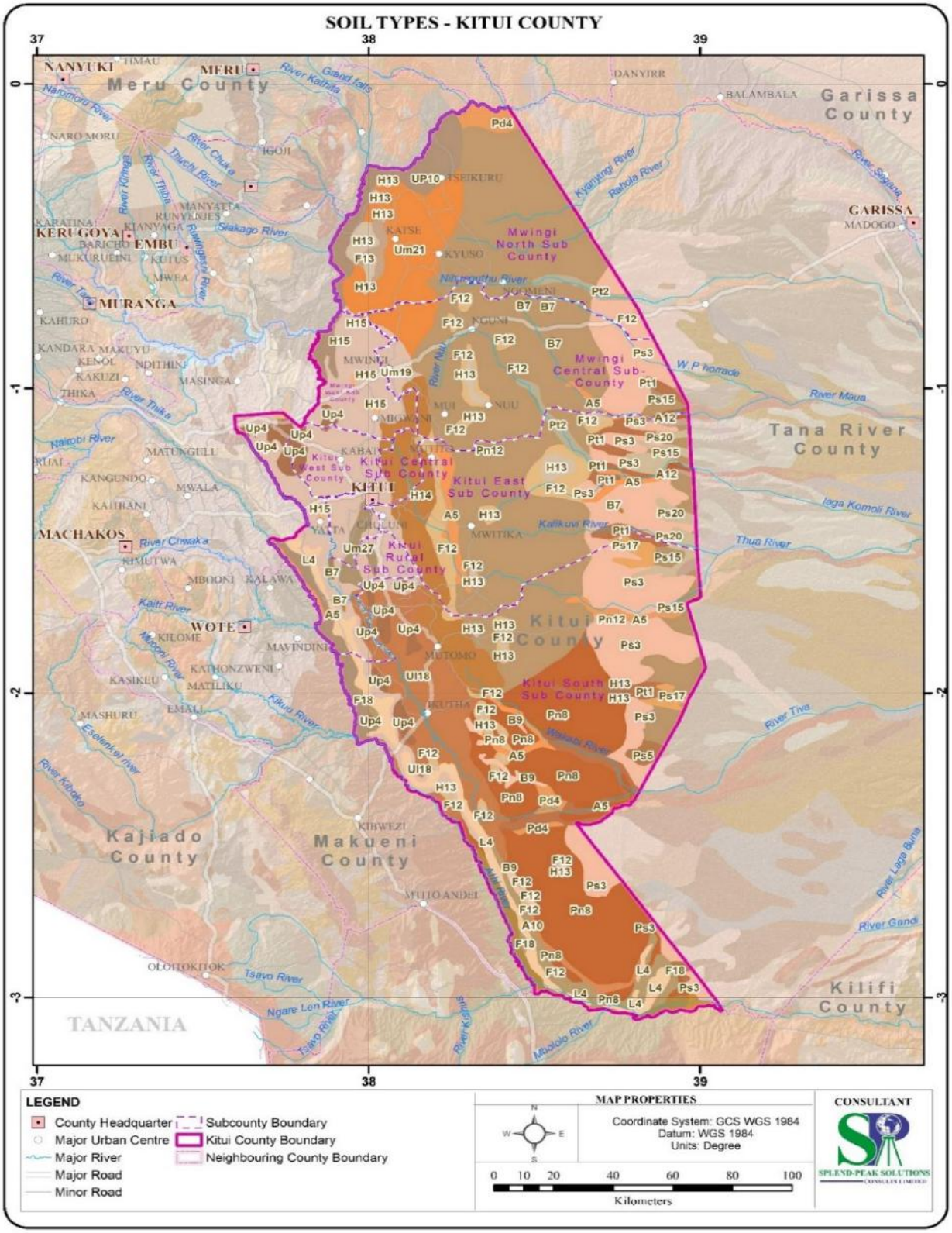
Map 12: A map showing agro-ecological zones in Kitui County
(Source: GIS Data, 2025)

3.7.6 Soils

Kitui County has four different types of soil that support the growth of cassava across the two main agro-ecological zones. These soils are characterized by different physical properties as illustrated in Table 16 and Map 13.

Table 16: Types of Soil supporting growth of cassava in Kitui County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
L4	loamy	kaolinitic	well	deep	plain	flat
Ps20	clayey	montmorillonitic	well		plain	flat
Pt1	loamy	kaolinitic	rapid	deep	plain	flat
Up4	loamy	montmorillonitic	well	deep	plain	undulating



Map 13: Soil types within Kitui County
(Source: GIS Data, 2025)

3.8 Machakos County

3.8.1 Geographical location

Machakos County borders Muranga and Kirinyaga counties to the North West, Embu to the North, Kitui to the East, Makueni to the South, Nairobi and Kiambu to the West, and Kajiado to the South. The County has a total land area of 6,037.3 Km^2 and is located between longitudes 36º45' East and 37º45' East and latitudes 0º45' South and 1º31' South.

3.8.2 Topography and Physiography

The County has distinctive topographical and physical characteristics. There are hills rising between 1800 – 2100m above sea level and the Yatta Plateau which is elevated to about 1700m above sea level and slopes to the South-East. There are other solitary hills in the North West. Some of the hills in the County include Ekalakala, Ithanga, Iveti, Lukenya, Kamuthamba, Kangonde, Komarock, Kiima Kimwe, Kyanzavi, Mavoloni, Mua, Nzii among others. The high-altitude regions, receive more rainfall and have dense vegetation while the plains are characterized by open grassland and sporadic trees.

3.8.3 Climatic Conditions

The County experiences bimodal rainfall pattern with short rains in October and December with mean rainfall of 500mm and long rains from March to May with a mean rainfall 1,250mm. The County's rainfall distribution is primarily influenced by altitude. The lowland areas get about 500mm of rain on average, compared to 1,000mm in the high areas like Mua, Iveti, and Kangundo. The temperatures range from 18 to 29 degrees Celsius throughout the year. Most of the dry spells take place between January and March and August and October.

3.8.4 Hydrology and Water Resources

The hydrology and water resources of Machakos County are characterized by a mix of seasonal and perennial rivers, with most waterways forming part of the Athi River basin. The Athi River, the largest in the County, flows along the eastern boundary, draining into the Indian Ocean and supporting irrigation, domestic use, and small-scale industrial activities. Other significant rivers include the Kalimanzuntu, Thwake, and Stony Athi, most of which are seasonal and prone to reduced flows during dry spells. Numerous streams and springs, such as Iveti and Nzii, provide critical water sources for communities, especially in the hilly regions. The County also relies on

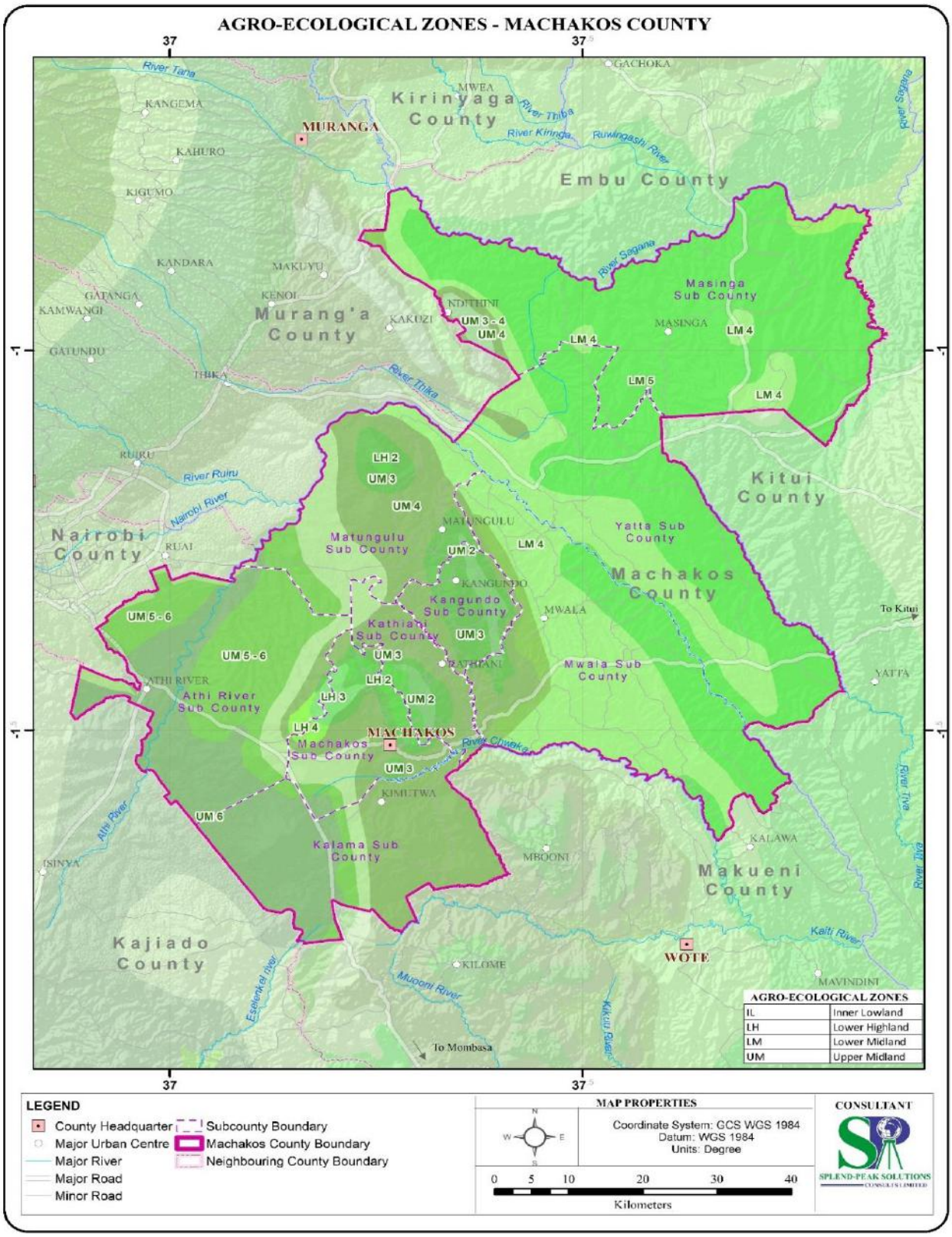
small dams, water pans, and boreholes for water storage and supply. Despite these resources, Machakos faces periodic water shortages due to erratic rainfall, high evaporation rates, and increasing demand from its growing population and agricultural sector.

3.8.5Agro-ecological Zones

In Machakos County, cassava is able to survive across several agro-ecological zones namely; Inner Lowlands (IL5), Lower Midland (LM5) and Upper Midland (UM5& 5-6) as highlighted Table 17 and Map 14.

Table 17: Agro-ecological Zones defining cassava growing regions in Machakos County

AEZ Code	AEZ Name	Major Crop	Sub-counties
IL 5	Inner Lowland	Livestock – Millet-Cassava Zone	Athi-River, Masinga, Yatta
LM 5	Lower Midland	Livestock – Millet-Cassava Zone	
UM 5	Upper Midland	Livestock – Sorghum-Cassava Zone	
UM 5 - 6	Upper Midland	Livestock – Sorghum-Cassava/Ranching Zone	



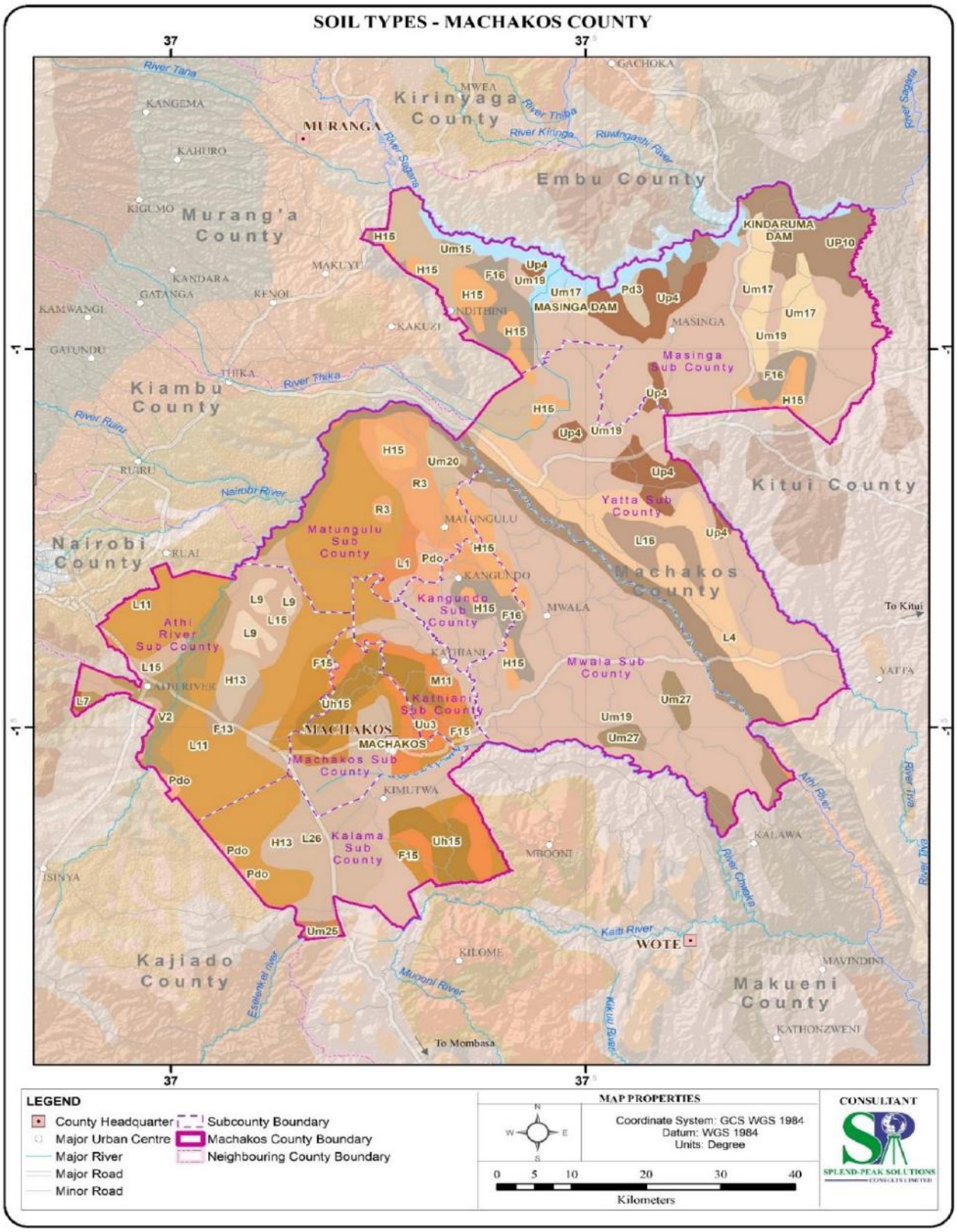
Map 14: Agro-ecological map for Machakos County
(Source: GIS Data, 2025)

3.8.6 Soils

There are two types of soils which cover the agro-ecological zones that support the growth of cassava. These soils types are L11 and Up4, which possess the characteristics presented Table 18 and Map 15.

Table 18: Types of soils suitable for cassava growing in Machakos County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
L11	very clayey	montmorillonitic	well	flat	plain	deep
Up4	loamy	montmorillonitic	well	undulating	plain	deep



Map 15: Soil types with Machakos County
(Source: GIS Data, 2025)

3.9 Embu County

3.9.1 Geographical location

Embu County is located approximately between latitude 0^0 10' and 0^0 55' South and longitude 37^0 15' and 37^0 55' East. It borders Kirinyaga County to the West, Kitui County to the East, Machakos County to the South, Murang'a County to the Southwest, Tharaka Nithi County to the North and Meru to the Northwest.

3.9.2 Topography and Physiography

Embu County is characterized by highlands, lowlands and slopes from North-West towards East and South-East, with a few isolated hills such as Kiambere and Kiang'ombe. It rises from about 515m above sea level at the River Tana Basin in the East to 5,199m at the top of Mt. Kenya in the Northwest. The southern part of the County is covered by Mwea plains which rise northwards, culminating in hills and valleys to the northern and eastern parts of the County. Towards the foot of Mt. Kenya, the County has presence of steep slopes.

3.9.3 Climatic Conditions

The rainfall pattern is bimodal with two distinct rain seasons. Long rains occur between March and June, while the short rains fall between October and December. Rainfall quantity received varies with altitude averaging to about 1,067.5 mm annually, but ranging from 640 mm in central and southern areas to as high as 1,495 mm per annum towards Mount Kenya. Extreme risk of floods is common during both rainy seasons. Temperatures range from a minimum of 12^0C in July to a maximum of 30^0C in March, with a mean average of 21^0C influenced by the extensive altitudinal range of the County. July is usually the coldest month, with an average monthly temperature of 15^0C, while September is the warmest month, with an average monthly temperature rising to 27.1^0C. There is, however, localized climate in some parts of the County especially the southern region due to their proximity to the Kiambere, Masinga, Kamburu and Kindaruma dams.

3.9.4 Hydrology and Water Resources

Embu County has a well-developed hydrological network, anchored by eight major rivers: Thuci, Tana, Kii, Rupingazi, Thiba, Kapingazi, Thura, and Ena. These rivers play a critical role in supporting domestic water supply, irrigation, and hydropower generation. The County also hosts notable waterfalls such as Ndunda Falls, Nthenge Njeru Falls, and Gitwa Falls, which are not only

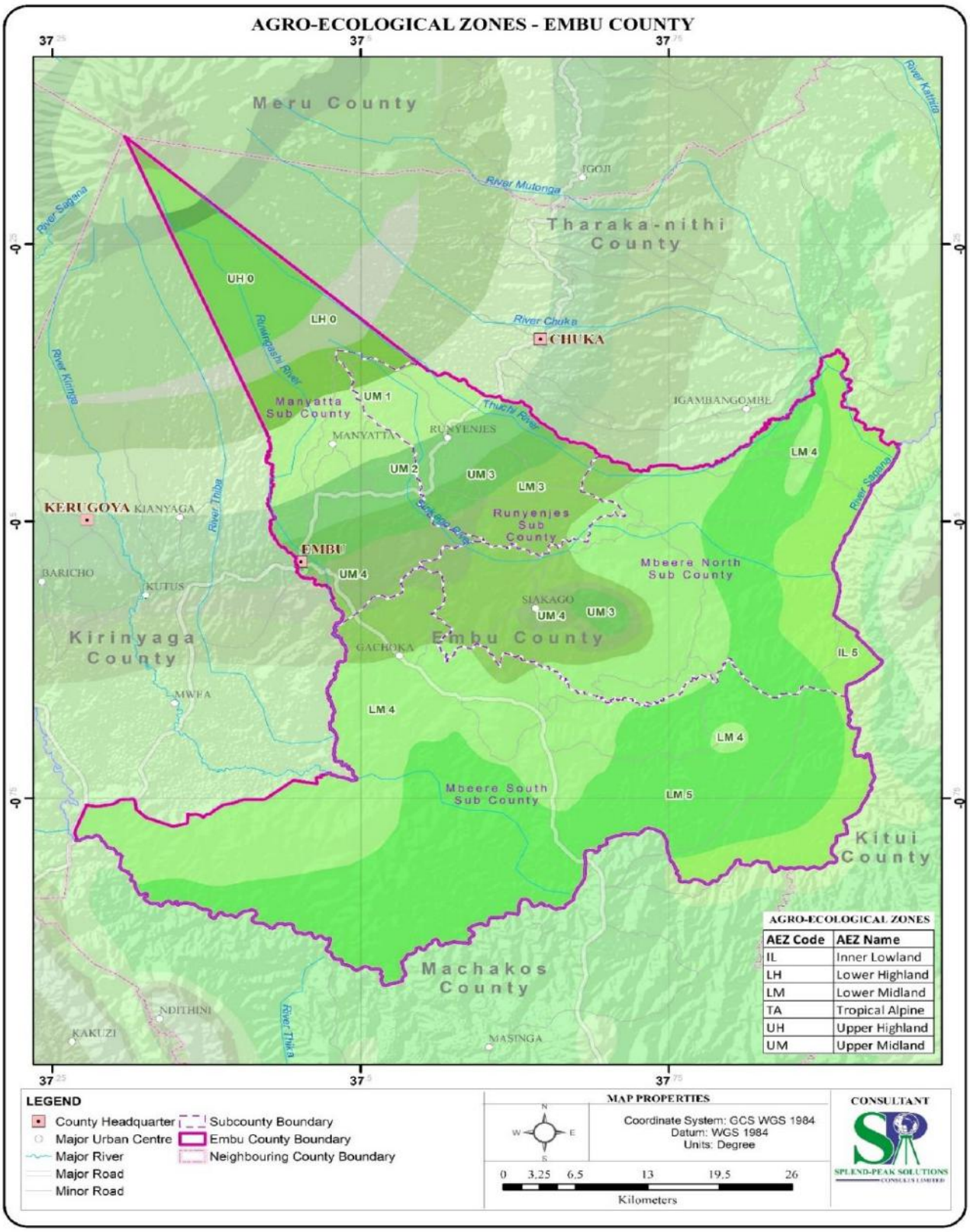
scenic attractions but also potential sources of small-scale hydropower and eco-tourism. Key reservoirs in the County include Masinga, Kamburu, Kindaruma, Kiambere, and Gitaru dams, which form part of the country's main hydroelectric power generation infrastructure.

3.9.5 Agroecological Zones

The County of Embu has two major acro-ecological zones suitable for the production of cassava which are; Inner Lowland (IL 5) and Lower Midland (LM 4) which are hosted within Mbere North and south Sub-counties. The climatic conditions in these zones are important for the good performance of cassava in the region. There are also other regions undertaking cassava production though at small-scale levels. Table 19 and Map 16 clearly depict this information.

Table 19: Suitable agro-ecologies for cassava production in Embu County

AEZ-Code	AEZ-Name	Major-Crop	Sub-counties
IL 5	Inner Lowland	Livestock – Millet-Cassava Zone	Mbeere North, Mbeere South
LM 4	Lower Midland	Marginal Cotton Zone	



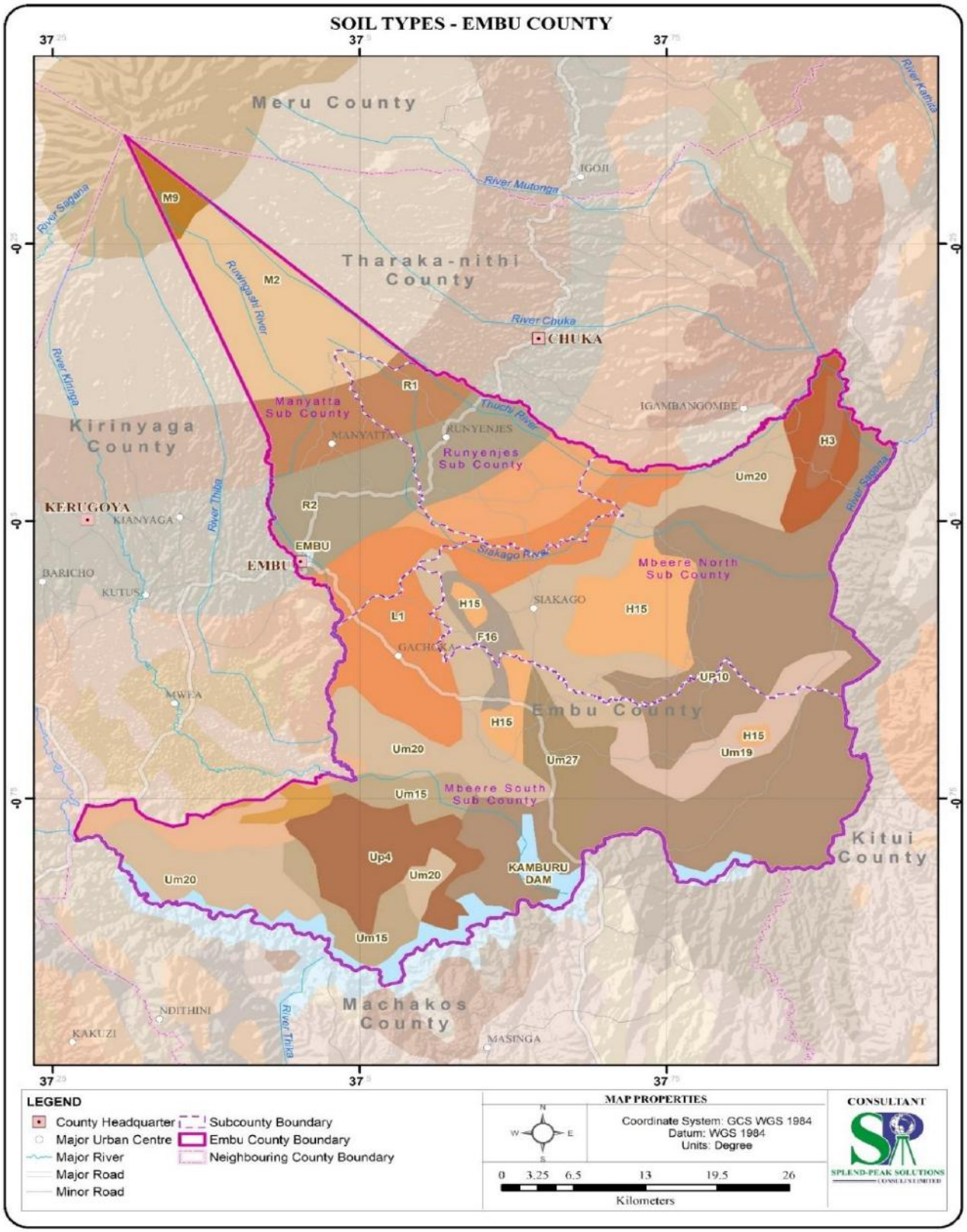
Map 16: Agro-ecological Zones for Embu County
(Source: GIS Data, 2025)

3.9.6 Soils

There are three types of soils that have the desired physical properties to support the growth of cassava. Majorly, the three soil types have a clayey characteristic with well-drained features and depth. The Table 20 gives a brief description of each soil type, while Map 17 illustrates it clearly.

Table 20: Existing soil types with cassava growing regions in Embu County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
H3	clayey	montmorillonitic	well		medium gradient hill	moderately steep
Um19	clayey	kaolinitic	well	deep	plain	gently undulating
Um20	clayey	kaolinitic	well	very deep	plain	gently undulating



Map 17: Soil types within Embu County
(Source: GIS Data, 2025)

3.10 Tharaka Nithi County

3.10.1 Geographical location

Tharaka Nithi County is in the eastern part of Kenya and borders the counties of Embu to the south and south-west, Meru to the north and north-east, Kirinyaga and Nyeri to the west, and Kitui to the east and southeast. The County lies between latitudes 00^0 07' and 00^0 26' South and between longitudes 37^0 19' and 37^0 46' East. The total area of the County is 2,564.4 km^2 including 360.1km^2 Mt. Kenya Forest.

3.10.2 Topography and Physiography

The highest altitude of the County is 5,200m in Chuka/Igambang'ombe and Maara, while the lowest is 600m Eastwards in Tharaka. The main physical feature of the County is the 360 Km^2 of Mt. Kenya Forest distributed between Maara and Chuka/Igambang'ombe constituencies. The forest serves as a tourist attraction, catchment area for Tana basin, a source of wood fuel, fodder and honey for the communities living around it. Major hills found in the County landscape include Kiera, Munuguni and Njuguni in Maara constituency, and Kijege, Gikingo and Ntugi in Tharaka constituency.

3.10.3 Climatic Conditions

Temperatures in the highland areas range between 14^{o}C to 30^{o}C, while those of the lowland area range between 22^{o}C to 36^{o}C. Some areas in the lower region experience temperatures of up to 40^{o}C especially during the dry season. The County has a bimodal rainfall pattern with the long rains falling during the months of April to June and the short rains in October to December. The short rains are more reliable than the long rains. The rainfall ranges from 2,200mm to 500mm with the high-altitude areas experiencing reliable rainfall, middle areas receiving moderate rainfall, while the lower areas receive low, unreliable, and poorly distributed rainfall. The climate is favourable for cultivation of tea, coffee, maize, cowpeas, pigeon peas, tobacco, and a variety of other food crops.

3.10.4 Hydrology and Water Resources

The hydrology and water resources of Tharaka Nithi County are shaped by its varied topography, which ranges from the high rainfall areas of Mount Kenya to the drier lowlands of Tharaka. The

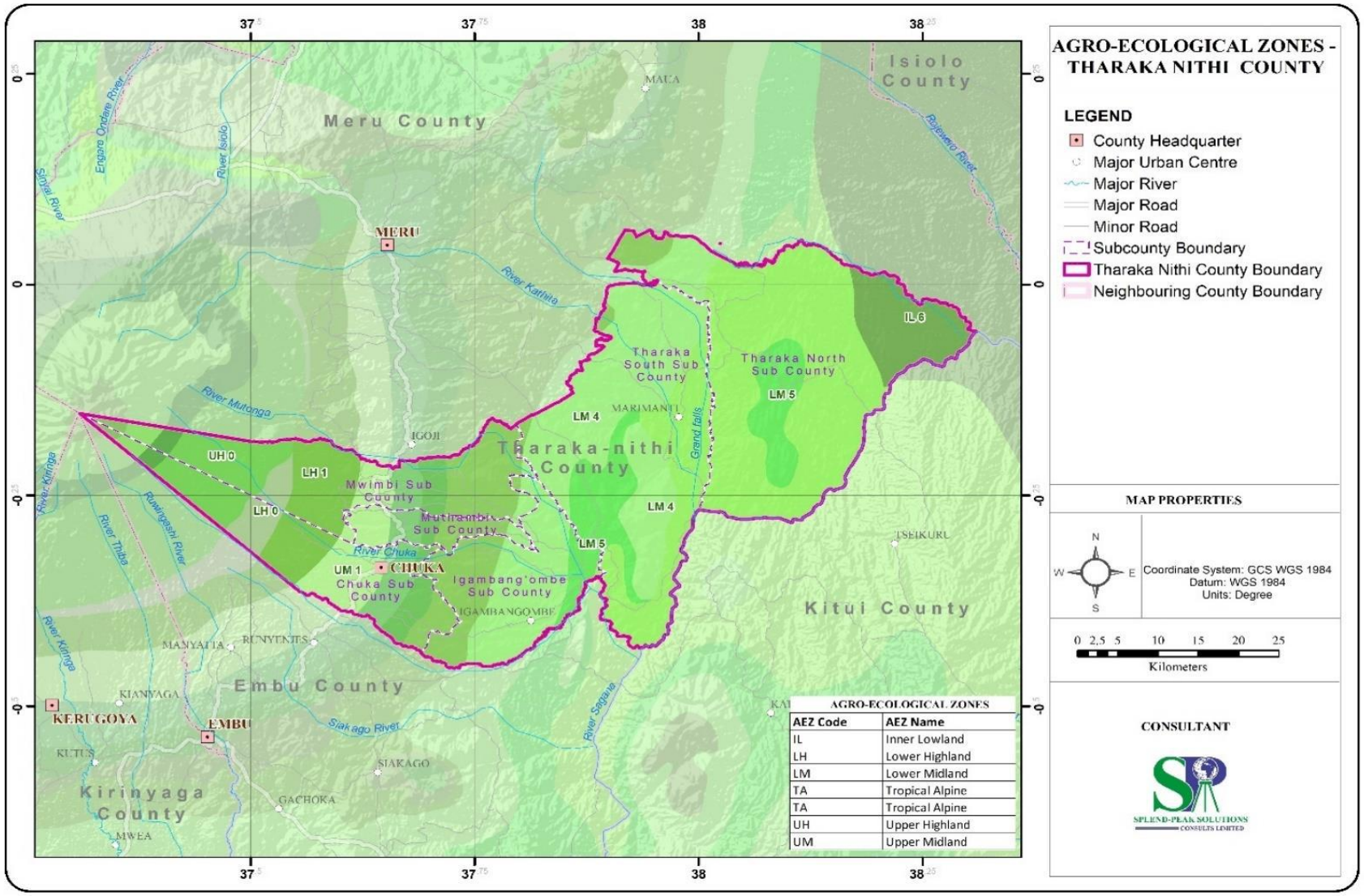
County is traversed by several rivers including; Thuci, Mara, Nithi, Mutonga, Naka, Ruguti, Kathita and Kithinu. Other rivers originate from Nyambene Hills, including Thingithu, Thanantu, Thangatha, and Ura rivers among others. These rivers provide water for domestic use and small holder irrigation schemes across the County. The Tana River, in particular, forms part of the County's boundary and supports hydroelectric power generation downstream. These water resources are essential for agriculture, which is the County's main economic activity, and for sustaining local biodiversity.

3.10.5 Agro-ecological Zones

Tharaka Nithi County has two agro-ecological zones that are vibrant in cassava farming. These are within the inner Lowland (IL 5) and Lower Midland Zones. These cassava zones are distributed within Tharaka North and South as indicated Table 21 and Map 18.

Table 21: Suitable agro-ecologies for cassava production in Tharaka-Nithi County

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
IL 5	Inner Lowland	Livestock – Millet-Cassava Zone	Tharaka North
LM 5	Lower Midland	Livestock – Millet-Cassava Zone	Tharaka South



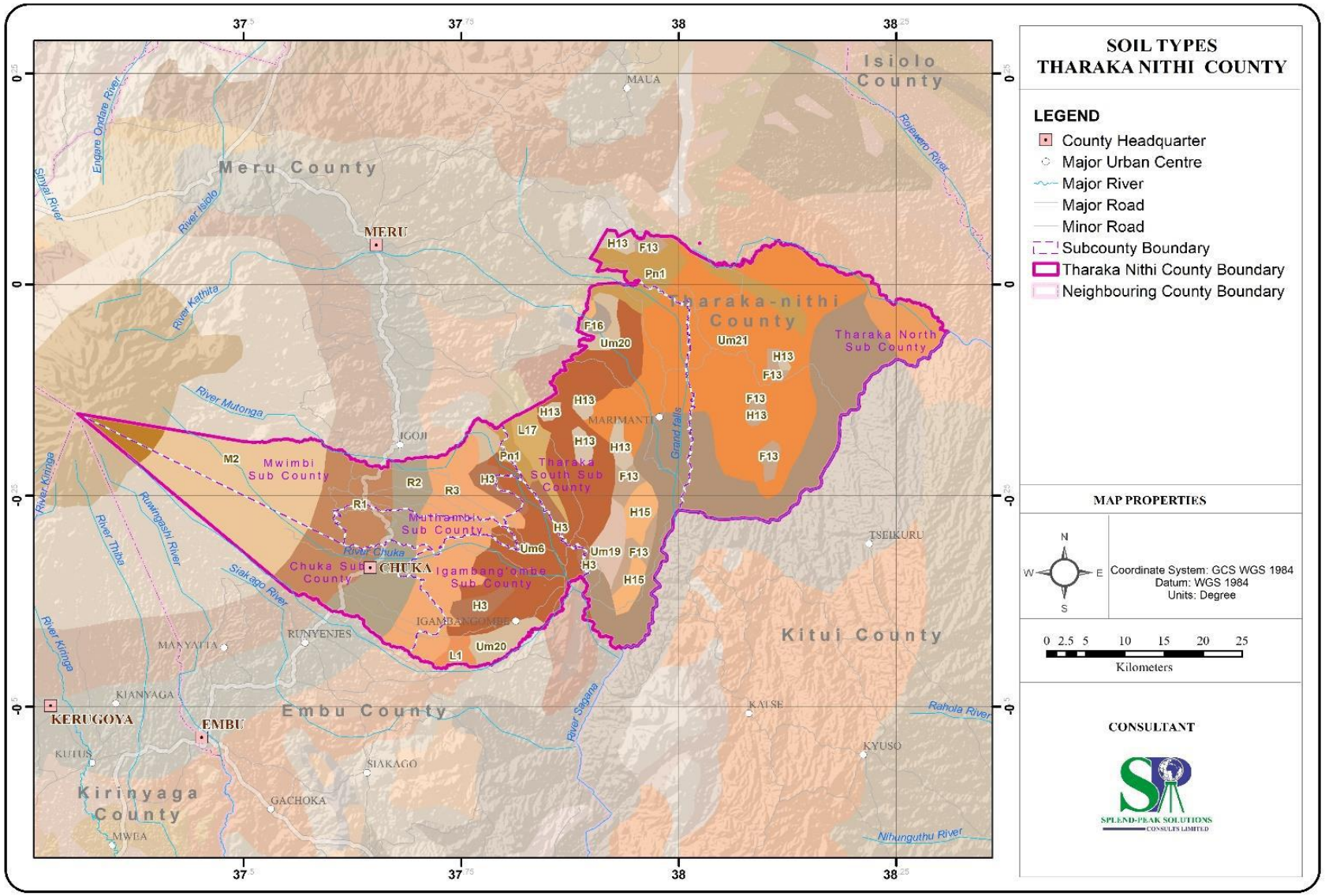
Map 18: A map showing the Agro-ecological Zones for Thara Nithi County
(Source: GIS Data, 2025)

3.10.6 Soils

The growth of cassava ideally requires well-drained soils because the crop is susceptible to root rot in poorly drained soils and water-logged conditions. Therefore, in Tharaka Nithi County, soils types F13 and H3 are the mostly favourable in supporting the growth of cassava as described in the Table 22 and as geographically distributed as illustrated Map 19.

Table 22: Favourable Soils for growth of Cassava in Tharaka Nithi

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
F13	sandy	kaolinitic	well	deep	plain	undulating
H3	clayey	montmorillonitic	well		medium gradient hill	moderately steep



Map 19: Soil types within Tharaka Nithi County
(Source: GIS Data, 2025)

3.11 Murang'a County

3.11.1 Geographical location

The County is located in the central region of the Republic of Kenya and lies between latitudes 0° 34';1°7' South and Longitudes 36°;37° 27' East. The County covers a total area of 2,558.8Km^2 and borders Nyeri to the North, Kiambu to the South, Nyandarua to the West and Kirinyaga, Embu and Machakos counties to the East.

3.11.2 Topography and Physiography

The County features a diverse topography and physiography characterized by significant variations in elevation and landscape features. The western part of the County, located along the slopes of the Aberdare Forest, rises to approximately 3,353 meters above sea level. This highland area is marked by deeply dissected terrain with steep slopes and valleys carved by numerous rivers that originate from the Aberdare ranges. These rivers flow south-eastward, eventually draining into the Tana River, Kenya's longest river, contributing significantly to the County's drainage system and water resources. In contrast, the eastern part of Murang'a lies at a much lower elevation of about 914 meters above sea level, featuring gentler slopes and more undulating landscapes. The physiography of Murang'a thus ranges from rugged highlands in the west to lower altitude plains and valleys in the east. This variation supports diverse ecosystems, agriculture, and settlement patterns, with the highlands generally cooler and wetter, suitable for tea and coffee farming, while the lower areas experience warmer conditions and support different crop types and livestock.

3.11.3 Climatic Conditions

The climatic conditions of the County consist of the western region with an equatorial climate, the central region with a sub-tropical climate and the eastern part with semiarid conditions. The Eastern region, covering the lower parts of Kigumo, Kandara, Kiharu and Maragua constituencies receive less rain and, as a result, crop production requires consistent irrigation. Long rains fall in the months of March, April and May. April reliably records the highest amount of rainfall averaging 213mm. The short rains are in October and November averaging about 135mm. The driest month is February with 21mm of rainfall. The Western region, covering Kangema, Gatanga, and higher parts of Kigumo and Kandara, is generally wet and humid due to its proximity to the Aberdare Ranges and Mt. Kenya. Rainfall in western and central regions is reliable, well

distributed throughout the year, and is adequate for cultivation. In the eastern areas, the annual temperature ranges from 26 to 30 degrees Celsius, while the mean minimum annual temperature ranges between 14 and 18 degrees Celsius. In the western wetter and colder areas, the mean minimum annual temperatures can be as low as 6 degrees Celsius or less. The temperatures in the central region fall between the minimum and maximum annual mean temperatures.

3.11.4 Hydrology and Water Resources

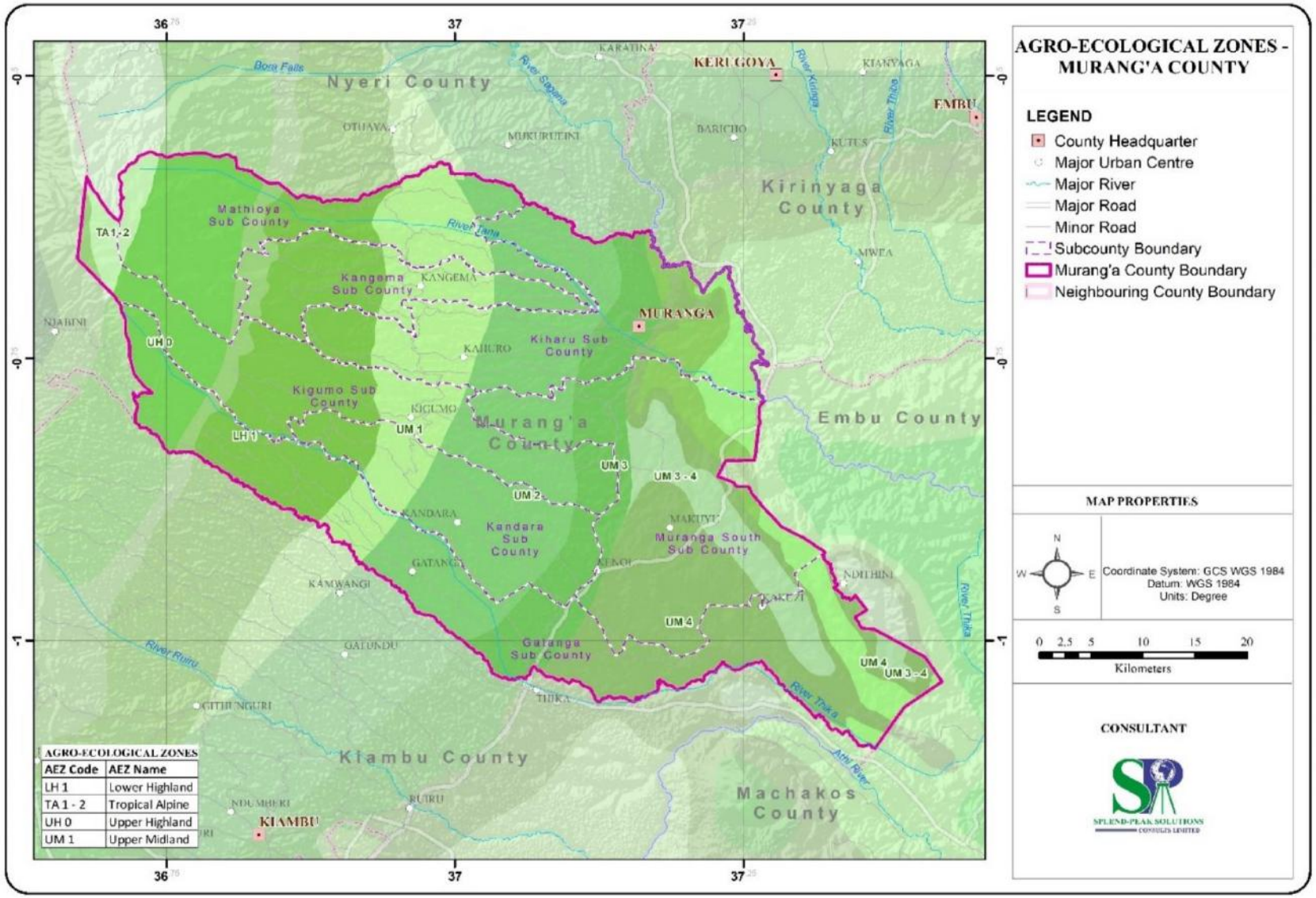
Murang'a County's hydrology and water resources are largely influenced by its highland topography and proximity to the Aberdare ranges, which serve as critical water catchment areas. The western highlands receive substantial rainfall that feeds numerous rivers and streams originating from the Aberdares, flowing southeastwards through the County. These rivers, including prominent ones like the Maragua, Thika, and Mathioya, are important tributaries to the larger Tana River basin, Kenya's longest and most significant river system. The County's dissected terrain enhances surface runoff and groundwater recharge in volcanic rock aquifers, particularly in the western regions where porous volcanic formations facilitate groundwater storage and movement. This groundwater is accessed through wells and boreholes and provides an essential water supply for domestic use, agriculture, and livestock.

3.11.5 Agro-ecological Zones

In Murang'a County, cassava production does well in coffee regions especially in those areas with suitable altitude and rainfall patterns. The major agroecological zones that support small-scale production of cassava in this County are; upper midlands (UM) 1, 2 and 3) as highlighted in the Table 23 and Map 20.

Table 23: Agro-ecological Zones supporting growth of cassava in Murang'a County

AEZ-Code	AEZ-Name	Major-Crop	Sub-counties
UM 1	Upper Midland	Coffee - Tea Zone	Kangema, Kiharu, Murang'a South, Gatanga
UM 2	Upper Midland	Main Coffee Zone	
UM 3	Upper Midland	Marginal Coffee Zone	



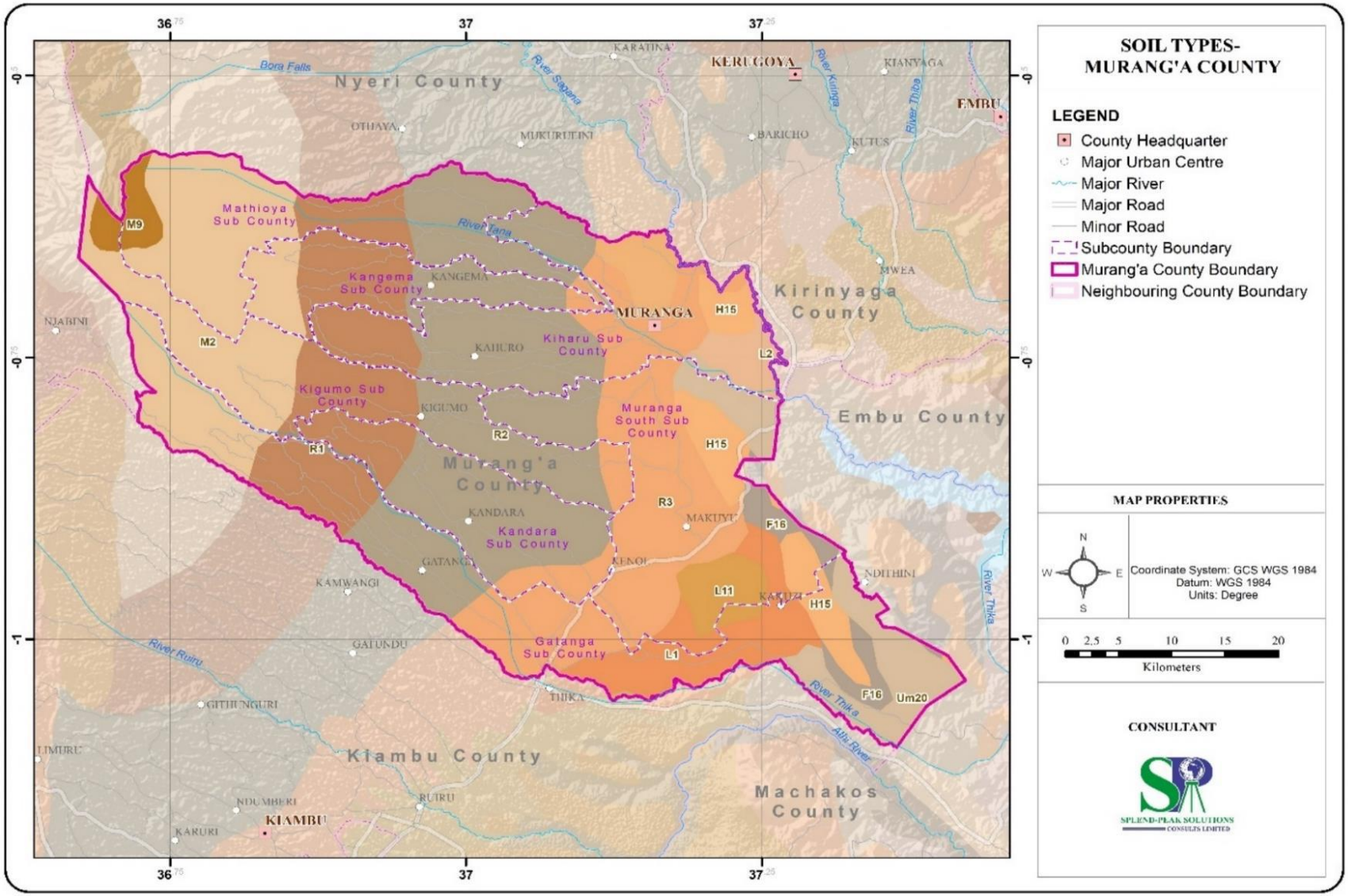
Map 20: A map showing the Agro-ecological Zones for Murang'a County
(Source: GIS Data, 2025)

3.11.6 Soils

There are two major soil types lined up within the agro-ecological regions supporting the growth of cassava in Murang'a County. Soil types R1 and R2 are well-drained and suitable for facilitating growth of diverse cassava varieties. Table 25 and Map 11 explain this narrative.

Table 24: Suitable soil types for cassava farming in Murang'a County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
R1	clayey	kaolinitic	well	very deep	ridges	moderately steep
R2	clayey	kaolinitic	well	very deep	ridges	undulating



Map 21: A map showing the soil types within Murang'a County
(Source: GIS Data, 2025)

3.12 Nakuru County

3.12.1 Geographical location

Nakuru County is strategically situated in the South Rift region of Kenya. It is located between Latitude 0°13′N and 0°10′N and Longitude 35°28′E and 35°36′E. This positioning places the County in the heart of Kenya's Rift Valley, known for its stunning landscapes and biodiversity. Nakuru County borders several other counties, each contributing to the region's agricultural and economic activities. To the north, Nakuru is bordered by Laikipia and Baringo, to the east by Nyandarua, to the south by Narok and Bomet, to the southeast Kiambu and Kajiado, to the west, it borders Kericho. The County capital, Nakuru City, lies approximately 160 kilometers northwest of Nairobi.

3.12.2 Topography and Physiography

Nakuru County is located within the great Rift Valley and lies approximately between 1,500-3,000 meters above mean sea level (amsl) with a mean elevation of 2,237 meters amsl. The western escarpment comprises of the Mau Hills lying 3,000 meters amsl. The valley floor comprises of the Ol-Doinyo Eburu volcano, Akira plains and Menengai crater. The eastern valley escarpments consist of Bahati and Marmanet lying approximately 2,500 meters amsl. Topographic features in the County include; Mt. Longonot, Hyrax hills, Hells Gate gorges, Menengai crater, honeymoon hill among others. These topographic features create an interesting niche that allow opportunities for research, biodiversity conservation, and tourism. The gazetted forests include; Mau Complex, Dundori, Eburu, Kiptunga, Bahati, Bararget, Logoman, Molo, Likia, Saino, Mariashoni, Menengai west and Subukia Shrine covering 73,462 hectares. These forests provide a natural habitat for a variety of flora and fauna and opportunities for biodiversity conservation.

3.12.3 Climatic Conditions

The rainfall pattern for Nakuru is bi-modal with the short rains falling between October and December and the long rains falling between March and May. The mean annual rainfall is highest on the Mau Forest, which receives over 1600mm and decreases to between 1200 mm and 1600 mm in Kuresoi region. The central parts of the County receive between 800mm to 1200mm. The areas around Lake Elementaita southwards receive moderate rainfall of between 600 and 800 mm. The drier parts of the County within Akira and parts of Naivasha receive low rainfall of between

400 mm and 600 mm annually. Notably, the drier parts lie within the sub-humid portion of the County and therefore do not receive bi-modal rainfall patterns. Average temperatures in the County range from a high of 29.3^{o}C between the months of December to early March, to low temperatures of up to 12^{o}C during the month of June and July. Molo, Kuresoi North and South Sub-Counties are relatively cold while Naivasha, Gilgil, and parts of Rongai Sub-Counties experience hot weather.

3.12.4 Hydrology and Water Resources

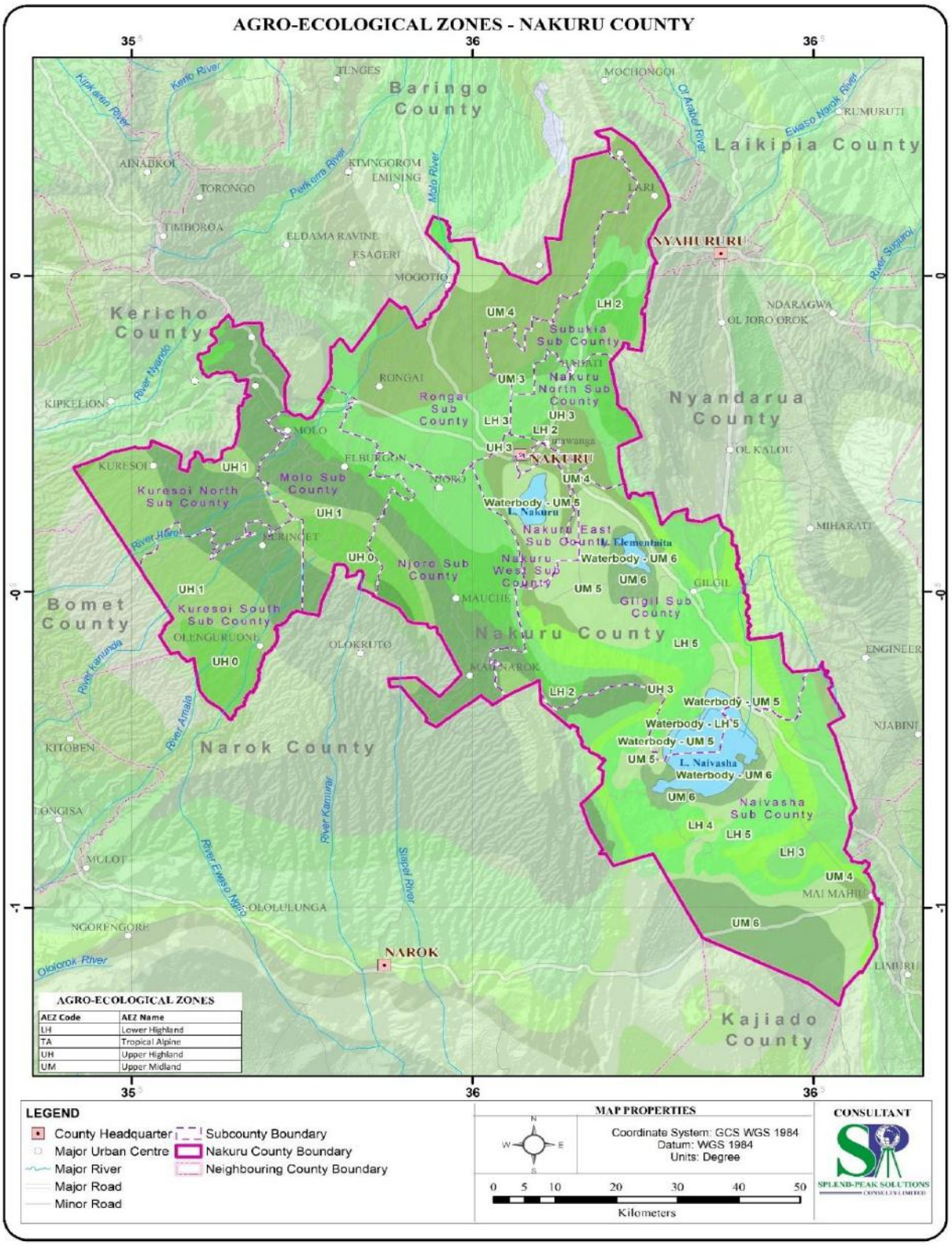
Nakuru County is well-endowed with abundant water resources, including several significant lakes, rivers, and wetlands that form the backbone of the County's hydrological systems. These water bodies are essential for supporting the region's agriculture, providing domestic water, and sustaining the biodiversity of the area. Some of the lakes include; Lake Naivasha, L.Nakuru and L. Elementaita. Some of the major rivers include; Malewa River, Njoro River, Molo River,and Igwamiti River.

3.12.5 Agro-ecological Zones

Nakuru County has two acro-ecological zones located within lower midland and upper midland zones. These zones and their corresponding codes are highlighted Table 25 and Map 22. Cassava crop is largely grown within four sub-counties.

Table 25: AEZ of Nakuru County active in Cassava growth

AEZ-Code	AEZ-Name	Major-Crop	Sub-counties
LM 5	Lower Midland	Livestock – Millet-Cassava Zone	Nakuru East, Nakuru West, Gilgil, Naivasha
UM 5	Upper Midland	Livestock – Sorghum-Cassava Zone	



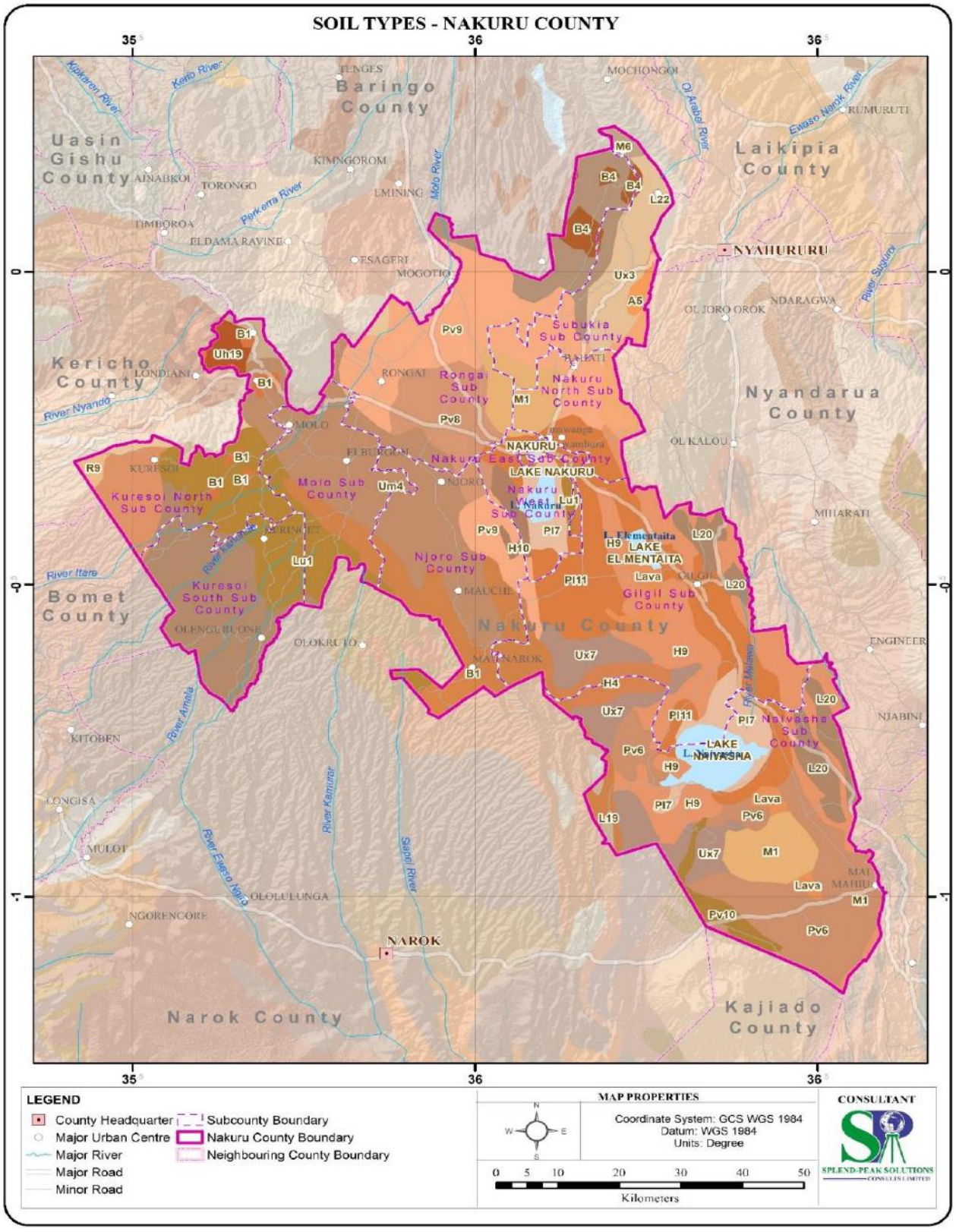
Map 22: A map showing the agro-ecological zones for Nakuru County
(Source: GIS Data, 2025)

3.12.6 Soils

Nakuru County's soil profile that supports the growth of cassava crop is mainly, H9 and Pv6 soil types. These soils possess very clayey and sandy textures respectively. They are well-drained and therefore perfect for the production of cassava. Other inherent characteristics are exhibited in Table 26 and Map 23.

Table 26: Soil types in Nakuru County's Cassava plantation areas

Soil - Code	Texture	Clay Description	Drainage	Land Form Description	Depth
H9	very clayey	montmorillonitic	well	high-gradient hill	steep
Pv6	sandy	montmorillonitic	very rapid	plain	gently undulating



Map 23: Soil types with Nakuru County
(Source: GIS Data, 2025)

3.13 Baringo County

3.13.1 Geographical location

Baringo County is situated in the Rift Valley Region of the Republic of Kenya and borders Turkana and Samburu Counties to the North, Laikipia to the East, Nakuru and Kericho to the South, Uasin Gishu to the South West and Elgeyo-Marakwet, and West Pokot to the West. It is located between longitudes 35^0 30' and 36^0 30' East and between latitudes 0^0 10' South and 1^0 40'. The Equator cuts across the County at the southern part. Baringo covers an area of 11,075 Km^2 of which approximately 221 Km^2 is covered by surface water from Lake Baringo, Lake Bogoria, 94 and Lake Kamnarok.

3.13.2 Topography and Physiography

One of the prominent features is the Kerio Valley, which is situated in the western part of the County. In the eastern part of the County near Lake Baringo and Bogoria is the Loboi Plain covered mainly by the latchstring salt-impregnated silts and deposits. The Tugen Hills form a conspicuous topographic feature in the County. The trend of the hills is north-south and mainly consists of volcanic rocks. The hills have steep slopes with prominent gullies. On the eastern and western parts of the hills are escarpments. Rivers on the hills flow in very deep gorges. The floor of the Rift Valley owes its origin to the tectonic and volcanic disturbances, which have dislocated surfaces, forming separate ridges. The troughs of the rift that have a northsouth alignment are occupied by Lake Baringo and Bogoria, which sit on 221 Km^2. Lake Bogoria is particularly spectacular because it is one of the few hot, salt water lakes in the world, with a number of hot springs and is the feeding ground for flamingoes.

3.13.3 Climatic Conditions

The rainfall varies from 1,000mm to 1,500mm in the highlands to 600mm per annum in the lowlands. Due to their varied altitudes, the Sub-Counties receive different levels of rainfall. Koibatek Sub-County receives the highest amount of rainfall. The lowland Sub-Counties of Mogotio, Tiaty East, Tiaty west and Baringo North receive relatively low amounts. The temperatures range from a minimum of 10°C to a maximum of 35°C in different parts of the County. Average wind speed is 2m/s and the humidity is low. The climate of Baringo varies from humid highlands to arid lowlands while some regions are between these extremes.

3.13.4 Hydrology and Water Resources

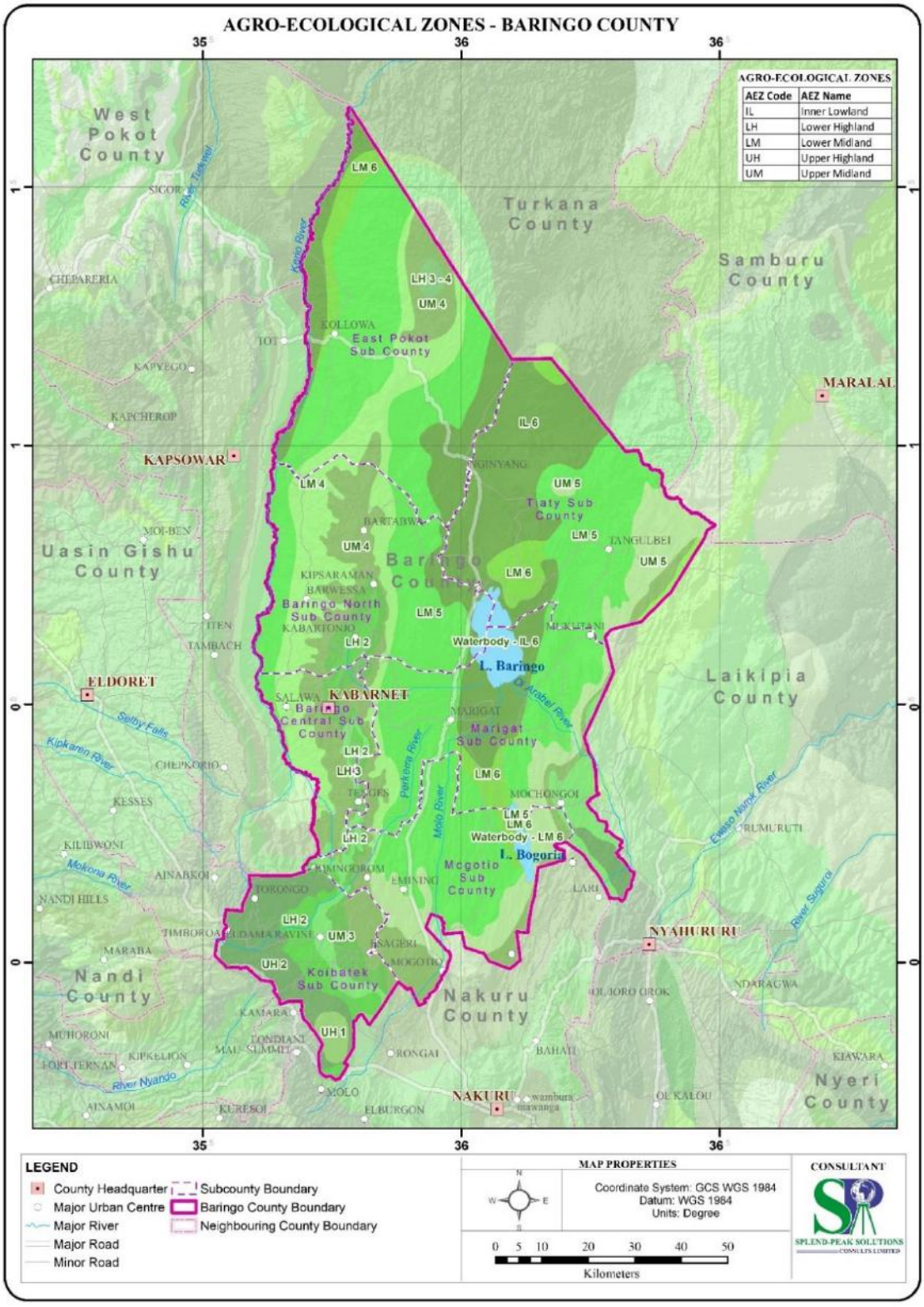
Baringo County's hydrology and water resources are shaped by its diverse topography and climatic conditions, which range from semi-arid lowlands to highland areas. The County is drained by several important rivers, including the Kerio, Perkerra, and Molo Rivers, which flow into Lake Baringo and Lake Bogoria, two of the major freshwater lakes in the region. These lakes are vital for local biodiversity, supporting a variety of aquatic species and attracting migratory birds, but they are also critical sources of water for domestic use, irrigation, and livestock. There's also Lake Kamnarok, an Ox Bow Lake located in the larger Rimoi Game Reserve which occupies Baringo and Elgeyo Marakwet counties, although it is at the verge of being silted due to climate change and excess environmental devastation (deforestation). Groundwater is another key water resource in Baringo, with aquifers found in various parts of the County, especially in the Rift Valley floor and upland areas, providing water through boreholes and wells. Despite these resources, Baringo faces issues of water scarcity, uneven distribution, and water pollution.

3.13.5 Agro-ecological Zones

Baringo County has six sub-counties supporting the growth of cassava. There are only two agro-ecological zones which favour the growth of cassava which are; lower midland(LM5) and Upper Midland(UM5) as demonstrated in the table 27 and map 24 below;

Table 27: Agro-ecological Zones supporting cassava production in Baringo County

AEZ-Code	AEZ-Name	Major-Crop	Sub-counties
LM 5	Lower Midland	Livestock – Millet-Cassava Zone	Baringo Central, Baringo North, Koibatek, Marigat, Mogotio, Tiaty
UM 5	Upper Midland	Livestock – Sorghum-Cassava ZoneZone	



Map 24: Map showing Agro-ecological zones for Baringo County

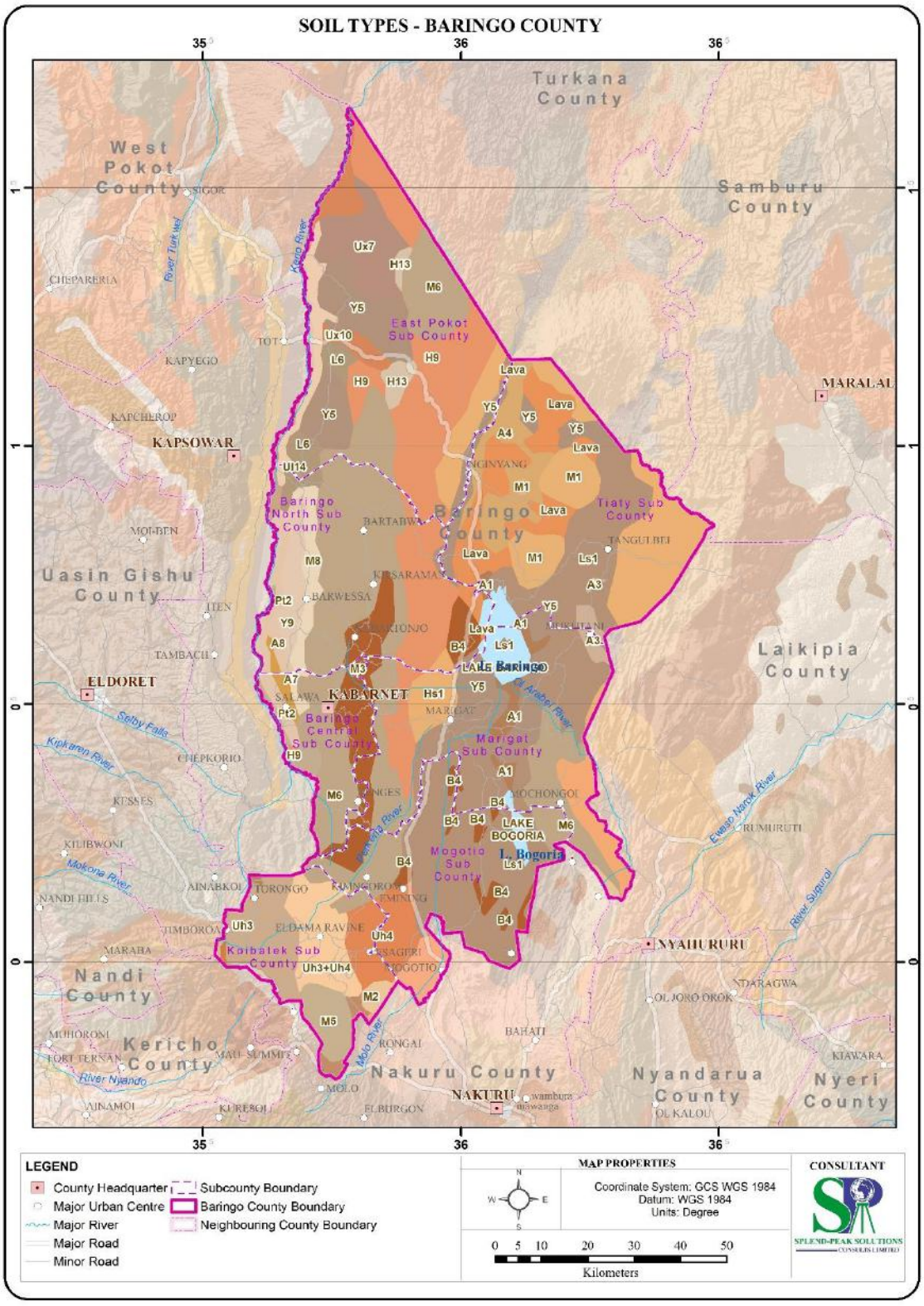
(Source: GIS Data, 2025)

3.13.6 Soils

The county of Baringo has four different soil types that are suitable for the growth of cassava across the identified agro-ecological zones. These soils are characterized by clayey texture and are well-drained, which is a prerequisite for soils that favour the growth of cassava. Table 28 and map 25 below clearly demonstrates the description and distribution within the county.

Table 28: Soil types in Baringo County's Cassava plantation areas

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
B4	clayey	kaolinitic	well	deep	plain	flat
Hs1	clayey	kaolinitic	well	shallow	plain	moderately steep
Ls1	clayey	interstratified	well	deep	plateau	gently undulating



Map 25: Soil types within Baringo County

(Source: GIS Data, 2025)

3.14 Kakamega County

3.14.1 Geographical location

Kakamega County is located in the Western part of Kenya and borders Vihiga County to the South, Siaya County to the West, Bungoma and Trans Nzoia Counties to the North and Nandi and Uasin Gishu Counties to the East. The County covers an area of 3,051.3 Km^2. The County lies between Latitude 0.2827° North and Longitude 34.7519° East.

3.14.2 Topography and Physiography

Kakamega County is located at an altitude of between 1240 meters and 2000 meters above sea level. The County is characterized by a rugged topography that varies from place to place with the Nandi escarpment forming a major feature on the eastern border. Its main escarpment rises from 1700 meters to 2000 meters. On the southern side, there are several hills with a general elevation that rises up to 2000 meters. The County is also comprised of several hills such as Misango, Imanga, Eregi, Butieri, Shikhokhochole, Mawe Tatu, Lirhanda, Kiming'ini hills among others.

3.14.3 Climatic Conditions

Kakamega's climate is classified as tropical and experiences rainfall throughout the year. This is mainly attributed to the existence of Kakamega rain forest which is the only remaining tropical forest in Kenya. The annual rainfall in the County ranges from 1280mm to 2214mm per year. The rainfall pattern is evenly distributed all year round with March and July receiving heavy rains while December and February receive light rains. The temperatures range from 18 degrees Celsius to 29 degrees Celsius. The months of January, February and March are the hottest with rest of the months having relatively warm temperatures except for July and August which have relatively cold spells. The County has an average humidity of 67 per cent.

3.14.4 Hydrology and Water Resources

Kakamega County's hydrology and water resources are defined by a network of rivers and streams that drain the County's undulating landscape, supporting both ecological functions and human livelihoods. The County lies within the Lake Victoria Basin and features several significant rivers, including the Nzoia, Yala, Lusumu, Isiukhu, Shiastala, Firatsi, Kipkaren, and Siville rivers. Smaller rivers such as the Lusumu, Isiukhu, Shiastala, Firatsi, Kipkaren, and Siville contribute to the County's extensive surface water system, feeding local water pans, wetlands, and underground

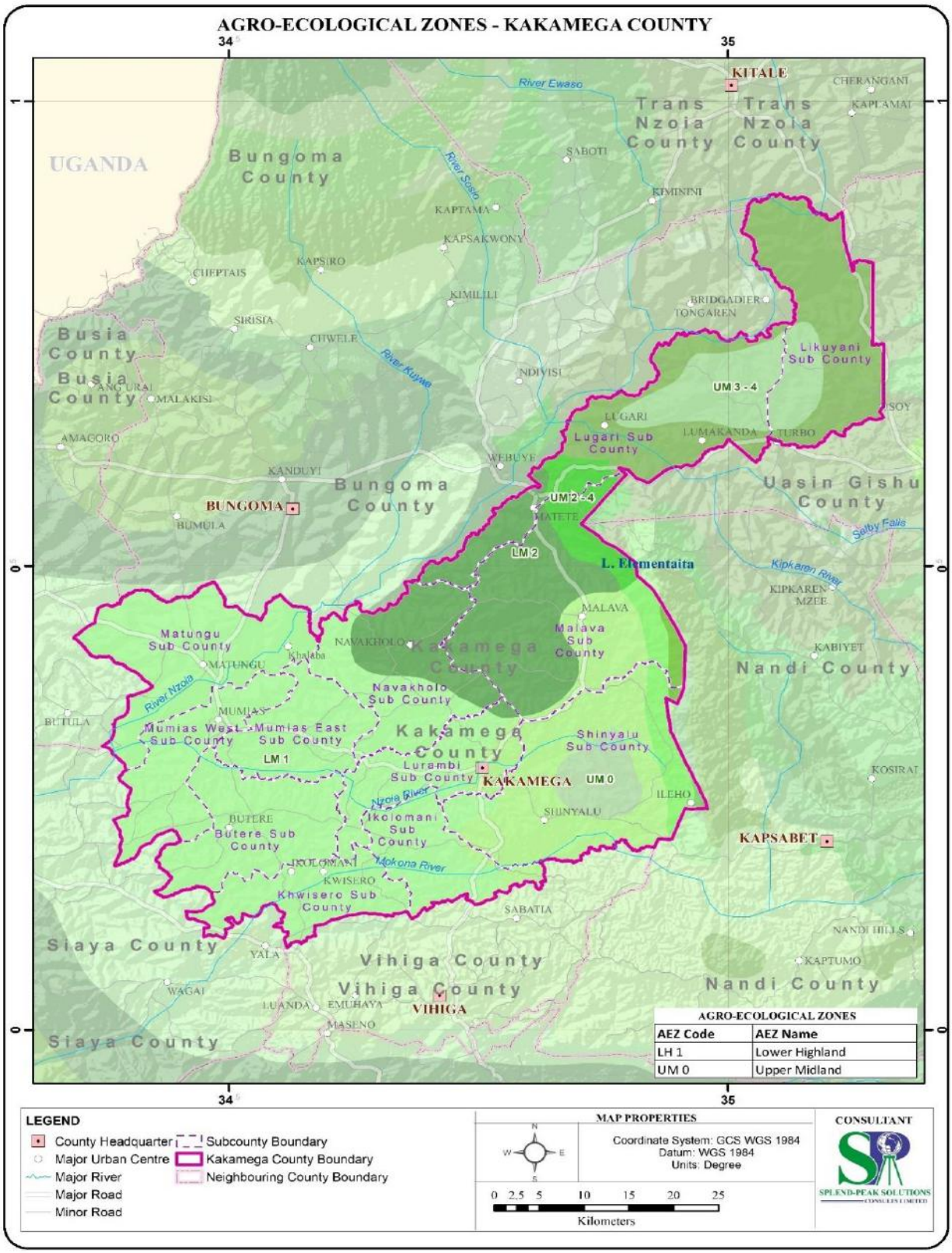
aquifers. These rivers originate from the County's higher altitude areas and flow through forested and agricultural landscapes, making them vital for maintaining water availability, especially during dry seasons. `

3.14.5 Agro-ecological Zones

Agro-ecological zones offer the most favourable conditions in regards to supporting particular crops to optimally thrive. In Kakamega County there are two AEZs that are highly utilized for cassava production which include LM 1 and LM 2. These zones are majorly found with Munias and Malava sub-counties as highlighted in Table 29 and Map 26.

Table 29: Agro-ecological Zones favouring cassava growth in Kakamega County

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
LM 1	Lower Midland	Sugar Cane-cassava Zone	Mumias Malava
LM 2	Lower Midland	Marginal Sugar Cane-cassava Zone	



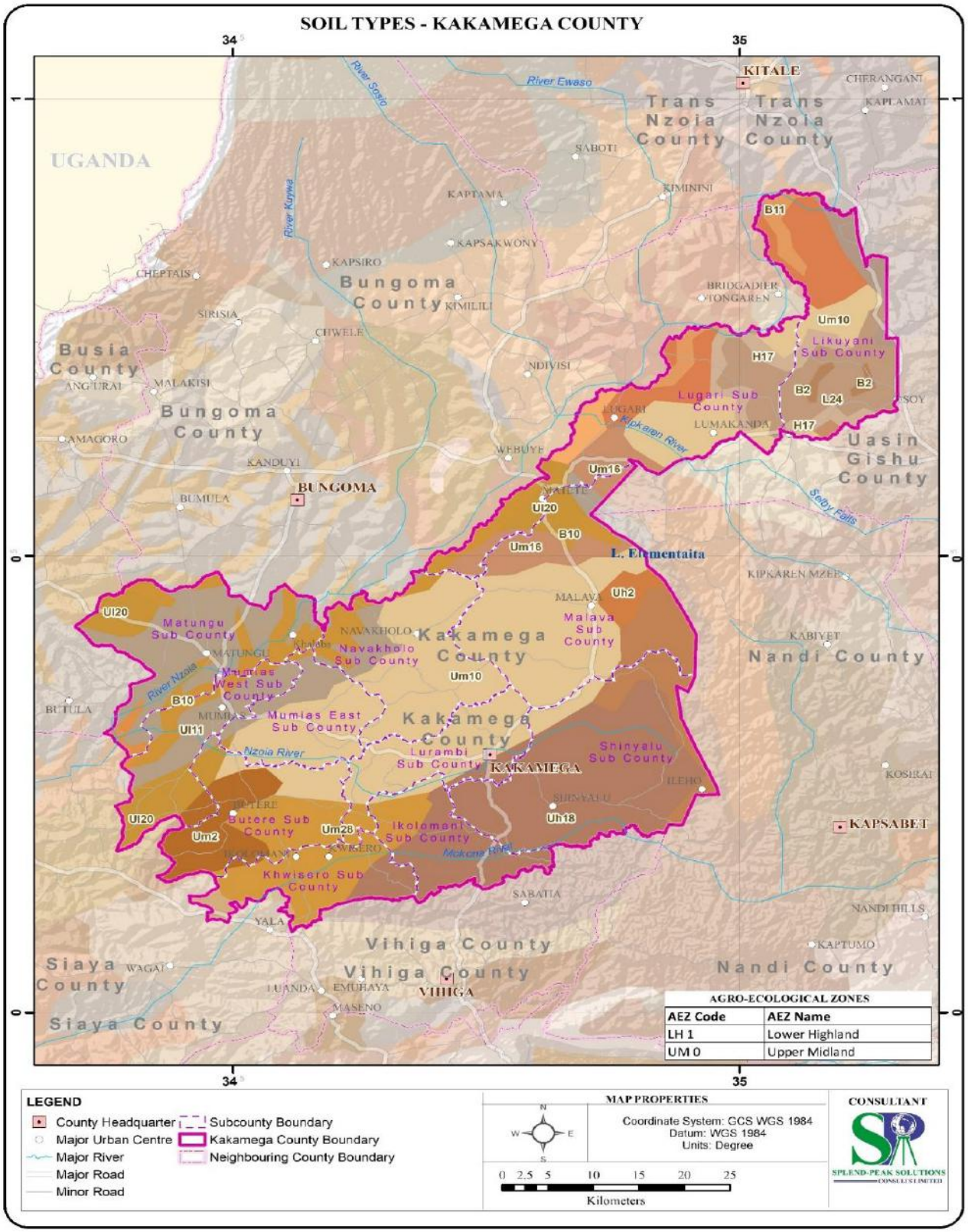
Map 26: A map showing the agro-ecological Zones for Kakamega County
(Source: GIS Data, 2025)

3.14.6 Soils

Specific agro-ecological zones are normally covered with various types of soils favouring the growth of particular types of crops. In Kakamega County, the identified cassava zones have two types of soils in place which are; UI11 and Um16, which possess the properties highlighted Table 30 and Map 27.

Table 30: Specific soil types facilitating cassava production in Kakamega County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
Ul11	clayey	interstratified	well	moderately deep	plain	gently undulating
Um16	loamy	montmorillonitic	well		plain	flat



Map 27: Soil types within Kakamega County
(Source: GIS Data, 2025)

3.15 Bungoma County

3.15.1 Geographical location

Bungoma County lies between latitude 0^0 28' and latitude 1^0 30' North of the Equator, and longitude 34^0 20' East and 35^0 15' East of the Greenwich Meridian. It borders the Republic of Uganda to the Northwest, Trans-Nzoia County to the North-East, Kakamega County to the East and South East, and Busia County to the West and South West.

3.15.2 Topography and Physiography

Bungoma County's topography and physiography are shaped by its location in the fertile western highlands of Kenya, resulting in a varied landscape that supports diverse land uses and ecosystems. The County's altitude ranges from about 1,200 meters above sea level in the lower western areas to 4,321 meters at the summit of Mount Elgon, which forms the County's most prominent physiographic feature along the Kenya–Uganda border. Mount Elgon, an extinct shield volcano, dominates the northern part of the County with its rugged terrain, steep slopes, and volcanic soils, serving as an important water catchment for several rivers. Beyond Mount Elgon, the County is characterized by notable hills such as Chisamba, Sang'alo, and Kabuchai, which add to the region's varied relief and scenic beauty. The central and southern parts feature rolling hills and gentle undulations interspersed with plateaus, offering expansive agricultural land.

3.15.3 Climatic Conditions

Bungoma County has had monthly temperatures of 15-29°C. The annual average temperature range for Bungoma is between 10-25°C, although elevation affects temperatures and most of the land area experiences an annual average temperature of more than 20°C while the highest point of Mt Elgon records less than 00C. The average wind speed is 6.1 km/hr. The total annual rainfall has remained stable since 1985 and is expected to decrease slightly until 2040. The long rains season, which runs between February and June, is wetter than the second rainy season, experienced between late July and December. A dry season (characterized by fewer than 80 mm rainfall) is experienced from December to February. April and May receive the highest rainfall (more than 200 mm per month). The annual average precipitation in the County is 1100-1700 mm. Most of the County receives an annual average precipitation of more than 1400 mm. The eastern part of the County, primarily Tongaren and Webuye sub-counties, is the driest, receiving less than 1000

mm of average rainfall every year. The northern part of the County, covering the Mt. Elgon region, is significantly cooler than the southern parts (Mainly covering Bumula and Kanduyi sub counties), with temperature differences on the order of 10°C or more.

3.15.4 Hydrology and Water Resources

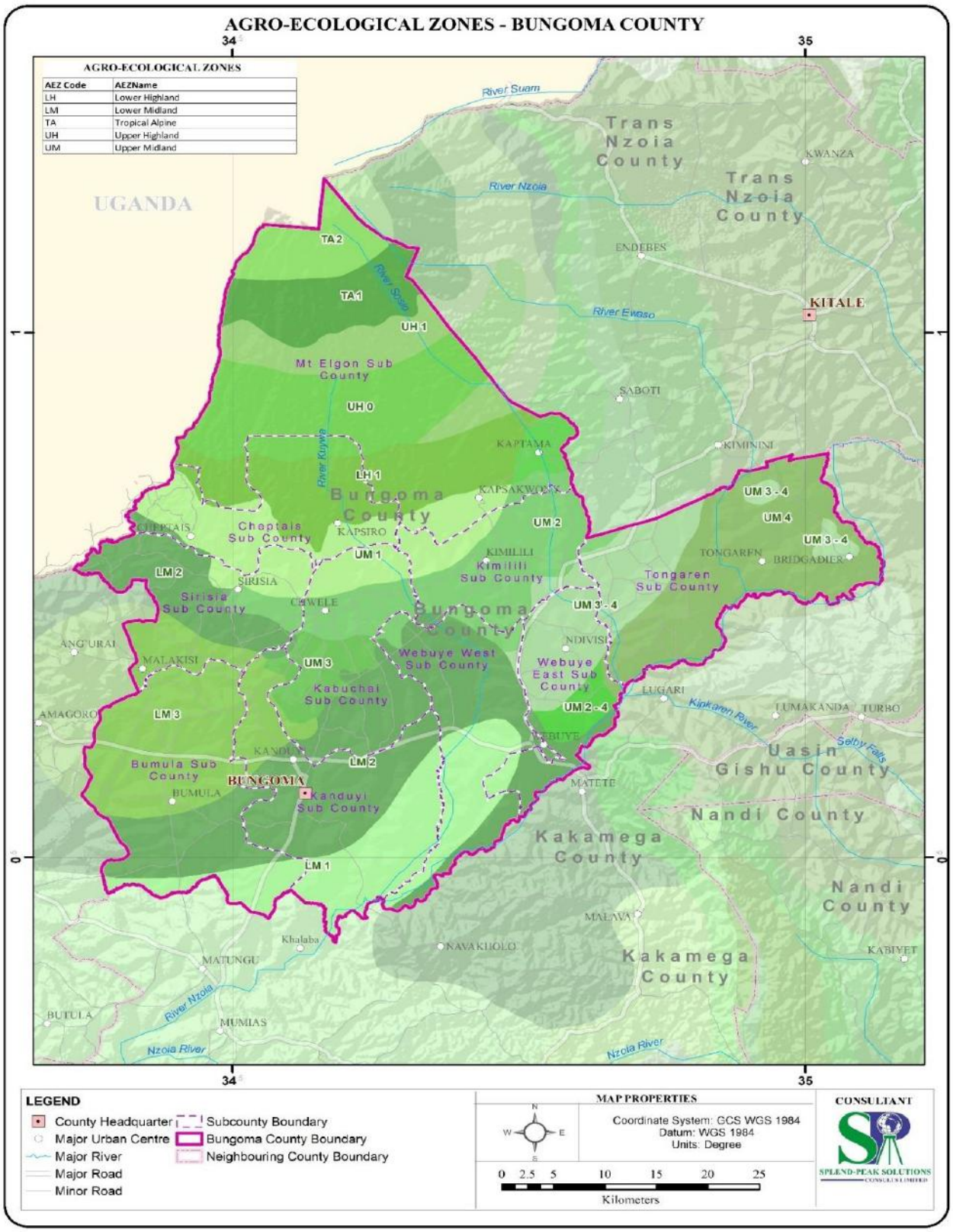
The County's hydrology and water resources are defined by its location within the Lake Victoria Basin and its role as a major catchment area fed by the slopes of Mount Elgon and surrounding highlands. The County's drainage system is dominated by the Nzoia River, one of Kenya's largest rivers, which originates from the Cherangany Hills and Mount Elgon before flowing through Bungoma into Lake Victoria. The Nzoia and its tributaries such as the Kuywa, Sosio, Kibisi, and Sio-Malaba/Malakisi rivers, form an extensive fluvial network that supports irrigation, domestic water supply, fisheries, and small-scale hydropower potential. Groundwater is another important resource in Bungoma County, stored in aquifers within the volcanic rock formations of Mount Elgon and in alluvial deposits in lowland areas. Shallow wells, boreholes, and protected springs are common sources of potable water for rural households, though access remains uneven due to infrastructure limitations.

3.15.5 Agro-ecological zones

The lower midland zones are the most productive agro-ecological zones for cassava production in Bungoma County. These zones are widely regarded in ensuring the continual survival of local varieties of cassava. They are primarily domiciled within five (5) sub-counties although most production is in small-scale and for subsistence farming. Table 31 and Map 28 showcase this clearly.

Table 31: Major agro-ecologies involved in cassava production within Bungoma County

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
LM 1	Lower Midland	Sugar Cane-Cassava Zone	Sirisia, Kanduyi, Kabuchai, Bumula, Webuye West
LM 2	Lower Midland	Marginal Sugar Cane-Cassava Zone	



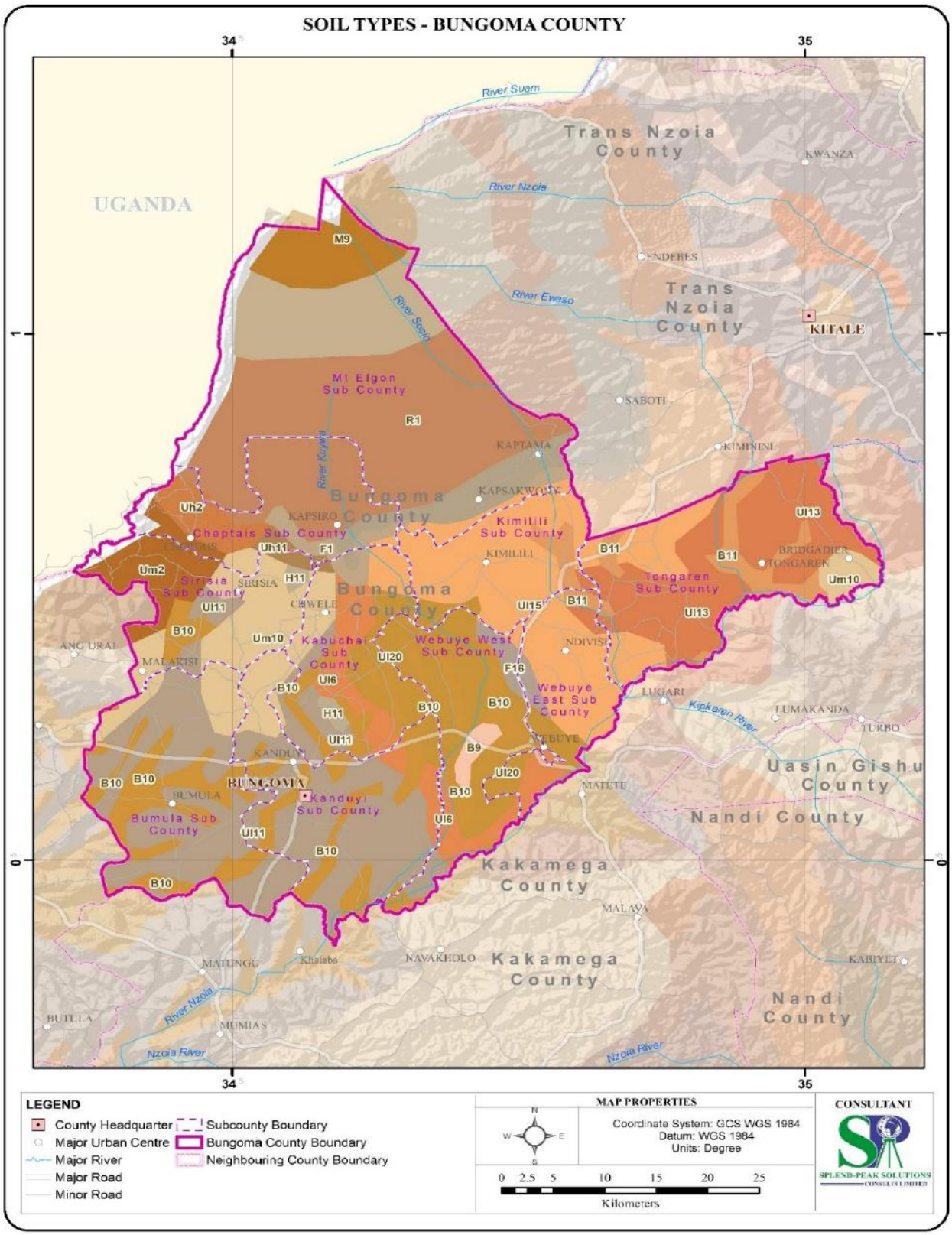
Map 28: A map showing Agro-ecological Zones for Bungoma County
(Source: GIS Data, 2025)

3.15.6 Soils

Soils types are fundamentally important in determining the performance of crops across different agro-ecologies. Therefore, the most suitable soil types covered in the identified AEZs in Bungoma County are; UI11, U16 and UI20 which possess the following attributes summarized in Table 32 Map 29.

Table 32: Suitable soils for Cassava production in Bungoma County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
Ul11	clayey	interstratified	well	moderately deep	plain	gently undulating
Ul6	clayey	kaolinitic	well	moderately deep	plain	undulating
Ul20	sandy	kaolinitic	well	moderately deep	plain	flat



Map 29: Soil types within Bungoma County
(Source: GIS Data, 2025)

3.16 Busia County

3.16.1 Geographical location

Busia County shares a border with Uganda to the west, Bungoma County to the North, Kakamega County to the East and Siaya County to the West. Moreover, it's bordered by Lake Victoria to the South West. Based on its strategic location, Busia County is the gateway to Kenya's regional neighbors in the East African Community – Uganda, Burundi, Rwanda, DRC Congo and Southern Sudan with Busia and Malaba towns serving as designated crossing points. The County covers 1,694.5 square kilometers (km2) at latitudes 0º and 0º 45 N and longitude 34º 25 east. The County can be accessed both by the Lake Victoria from the counties of Siaya and Kisumu. Also, it can be accessed through the road including Kisumu-Busia Road.

3.16.2 Topography and Physiography

The County's altitude varies from about 1,130 metres (m) above sea level at the shores of Lake Victoria to a maximum of about 1,500metres (m) in the Samia and North Teso Hills. The central part of the County, particularly Butula and Nambale Sub - Counties, is marked by low flat divides of approximately uniform height, often capped by lateritic and a shallowly incised swampy drainage system. The Northern part of the central region features hills and tors such as Amukura and Chelelemuk. The hills which run from the North East to the South West culminating at Port Victoria, forms a very conspicuous topographic feature. The Southern part of the County is partially covered by the Yala Swamp which is a down warped area associated with the formation of Lake Victoria.

3.16.3 Climatic Conditions

Busia County is fairly hot and moist. The mean temperature in the County is about 21-27° C whereas the annual rainfall is about 750-2000mm. There is a strong precipitation gradient with the northern areas receiving the most precipitation greater than 1750 mm, and the southern areas closer to Lake Victoria receiving between 760 and 1,250 mm of precipitation. The temperature is fairly consistently warm through the year. The Precipitation is consistent throughout the year, although the first half of the year known as first season (January-June) receives a slightly greater amount of precipitation than in the second season (July-December). 50% of the rainfall falls in the long rain season which is at its peak between late March and late May, while 25% falls during the short rains

between August and October. The dry season with scattered rains falls from December to February.

3.16.4 Hydrology and Water Resources

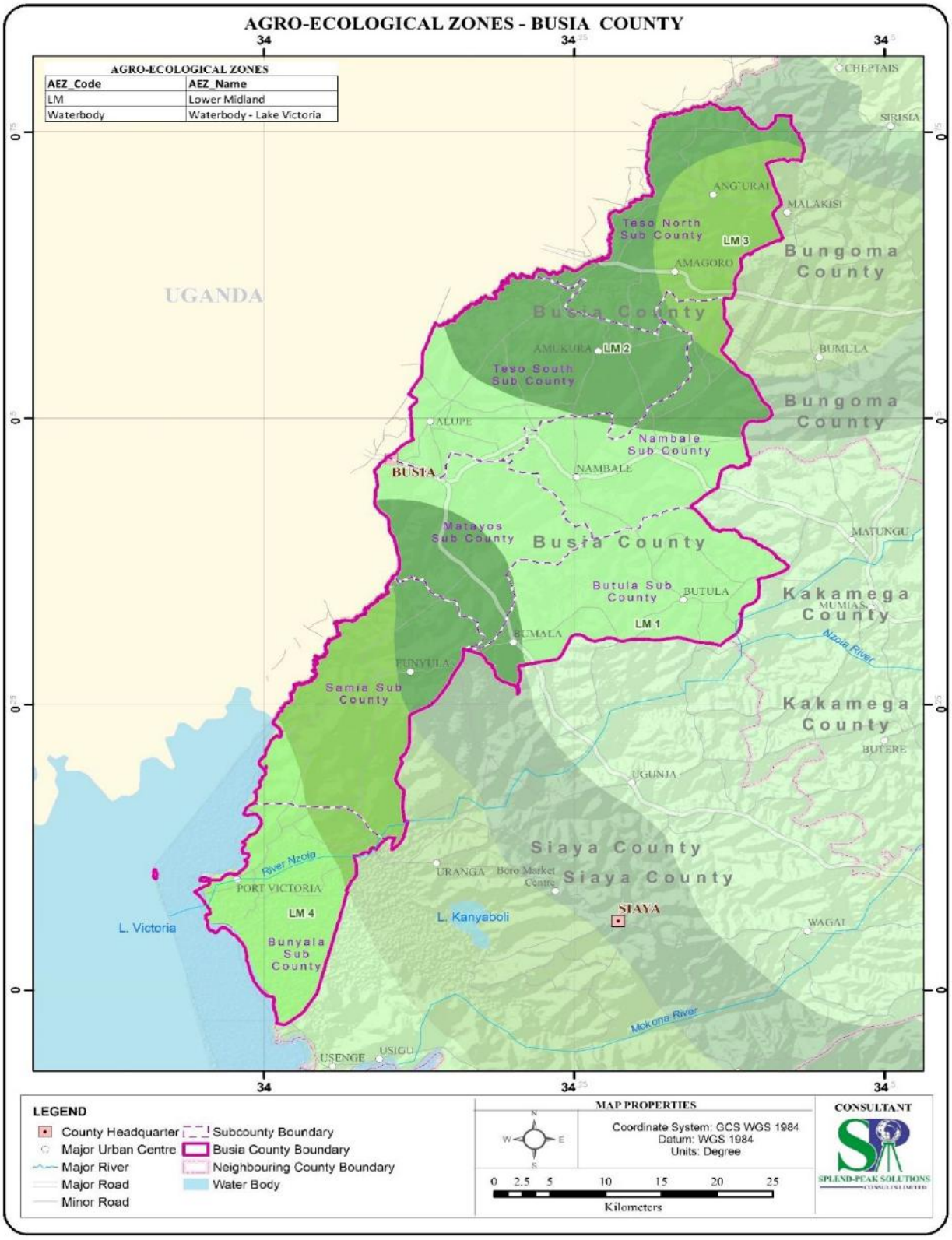
Busia County's hydrology is largely influenced by its location along the western border of Kenya and proximity to Lake Victoria. The County is served by four major Rivers namely; Malakisi to the extreme North, Malaba in the Northern entry of the Central Region, River Sio which sneaks through Nambale, Matayos and Funyula Sub – Counties and River Nzoia which drains into Lake Victoria through Budalang'i Sub-County. River Sio and River Nzoia are the most prominent rivers in the County. River Sio flows along the Kenya-Uganda border and drains into Lake Victoria, serving as a key water source for both domestic and agricultural use. Wetlands such as Yala Swamp, extending partially into Busia, plays a crucial role in water retention, flood control, and biodiversity conservation. Groundwater is accessed through boreholes and shallow wells, particularly in areas without reliable surface water sources.

3.16.5 Agro-ecological Zones

Busia County is a major cassava production area within the western region of Kenya. The County has two agro-ecological zones which squarely fall within the lower midland segments. These zones stretch across four administrative borders as highlighted in Table 33 and Map 30.

Table 33: Agroecological zones actively supporting cassava growth in Busia County

AEZ-Code	AEZ-Name	Major Crop	Sub-County
LM 1	Lower Midland	Sugar Cane-Cassava Zone	Teso South, Butula, Matayos, Nambale
LM 2	Lower Midland	Marginal Sugar Cane - Cassava Zone	



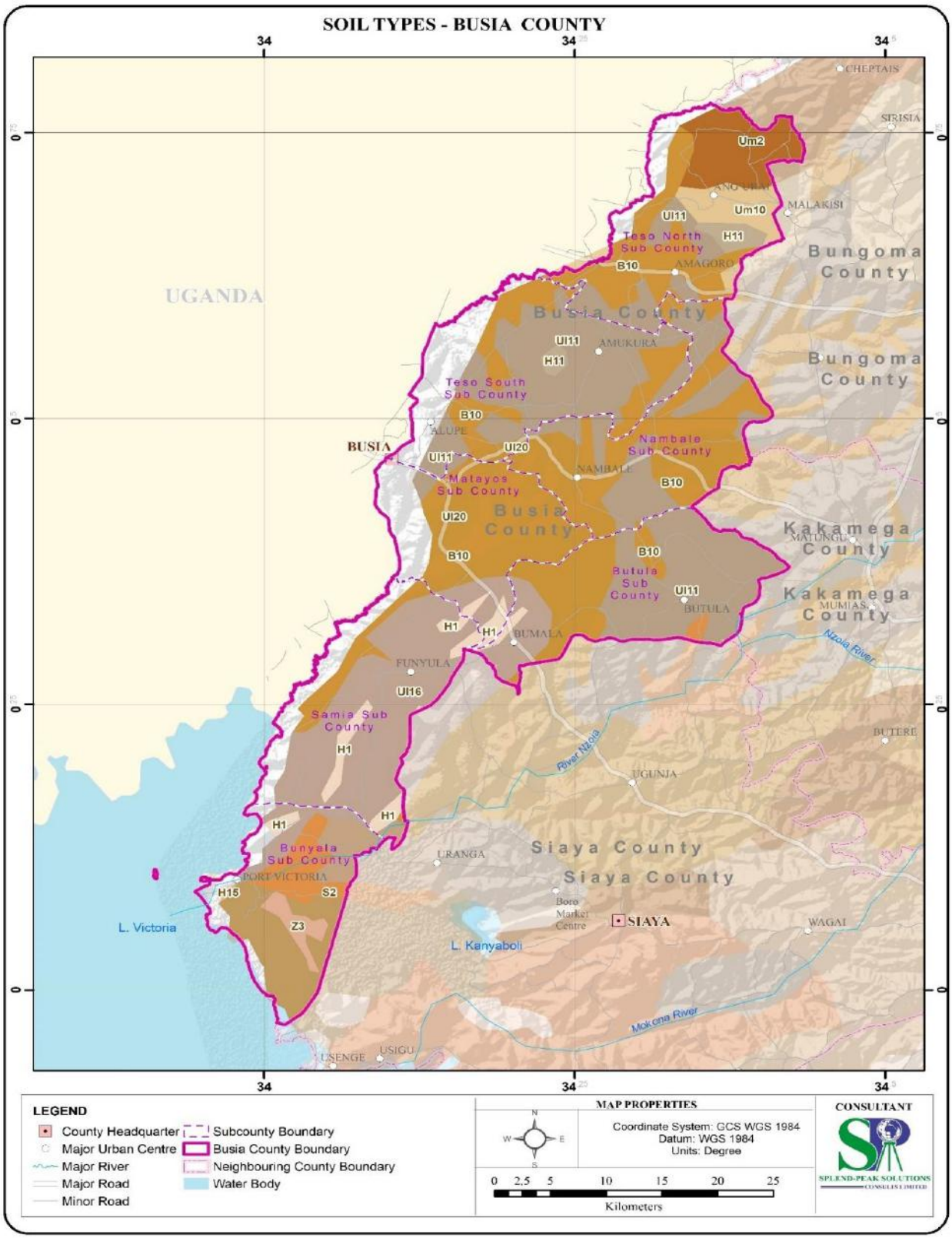
Map 30: A map showing the agro-ecological Zones for Busia County
(Source: GIS Data, 2025)

3.16.6 Soils

The County of Busia being one of the most cassava productive regions has major soil types that efficiently facilitate good production of cassava. These soils are mainly; UI11 and UI20 which possess clayey and sandy textures respectively. Other properties of the soils are highlighted Table 34 and Map 31.

Table 34: Soil types within cassava production areas of Busia County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
Ul11	clayey	interstratified	well	moderately deep	plain	gently undulating
Ul20	sandy	kaolinitic	well	moderately deep	plain	flat



Map 31: Soil types within Busia County
(Source: GIS Data, 2025)

3.17 Vihiga County

3.17.1 Geographical location

Vihiga County is located in the Lake Victoria Basin in Western Kenya region. It lies between longitudes 34°30' and 35°0' east and between latitudes 0° and 0°15' north. The County borders Nandi County to the east, Kisumu County to the south, Siaya County to the west and Kakamega County to the North.

3.17.2 Topography and Physiography

Vihiga County is characterized by a predominantly hilly and rugged terrain, with altitudes ranging from about 1,300 meters to 1,800 meters above sea level. The landscape is part of the Kavirondo highlands, marked by a series of undulating hills, dissected slopes, and narrow valleys. Some of the notable hills include Maragoli Hills, Mungoma Hills, and Emmabwi Hills, which not only define the County's scenic landscape but also influence its microclimates and drainage patterns. The County's terrain slopes gently towards the west and south, eventually draining into the Lake Victoria basin. Physiographically, the County can be divided into upland areas and valley bottoms. The uplands are the most densely settled and are used extensively for farming, while the valleys host streams and wetlands that act as important water catchments. Vihiga's river systems, mainly tributaries of the Yala and Isiukhu rivers, originate from the highland zones, where rainfall is heavier, and flow through steep gradients before reaching low-lying flood-prone area.

3.17.3 Climatic Conditions

Vihiga experiences tropical climate with fairly well distributed rainfall throughout the year with an average annual precipitation of 1900mm. Historical Temperatures range between 14^0C – 32^0C with a mean temperature of 23^0C. Rains are experienced in the months of March, April and May which be wettest while short rains are experienced in the months of September, October and November. The driest and hottest months are December, January and February with an average humidity of 41.75%.

3.17.4 Hydrology and Water Resources

Vihiga County's hydrology is defined by its position within the Lake Victoria Basin, with an extensive network of rivers, streams, and springs that originate from its highland areas. The County lies within the upper catchments of the Yala River and the Isiukhu River systems, both of which

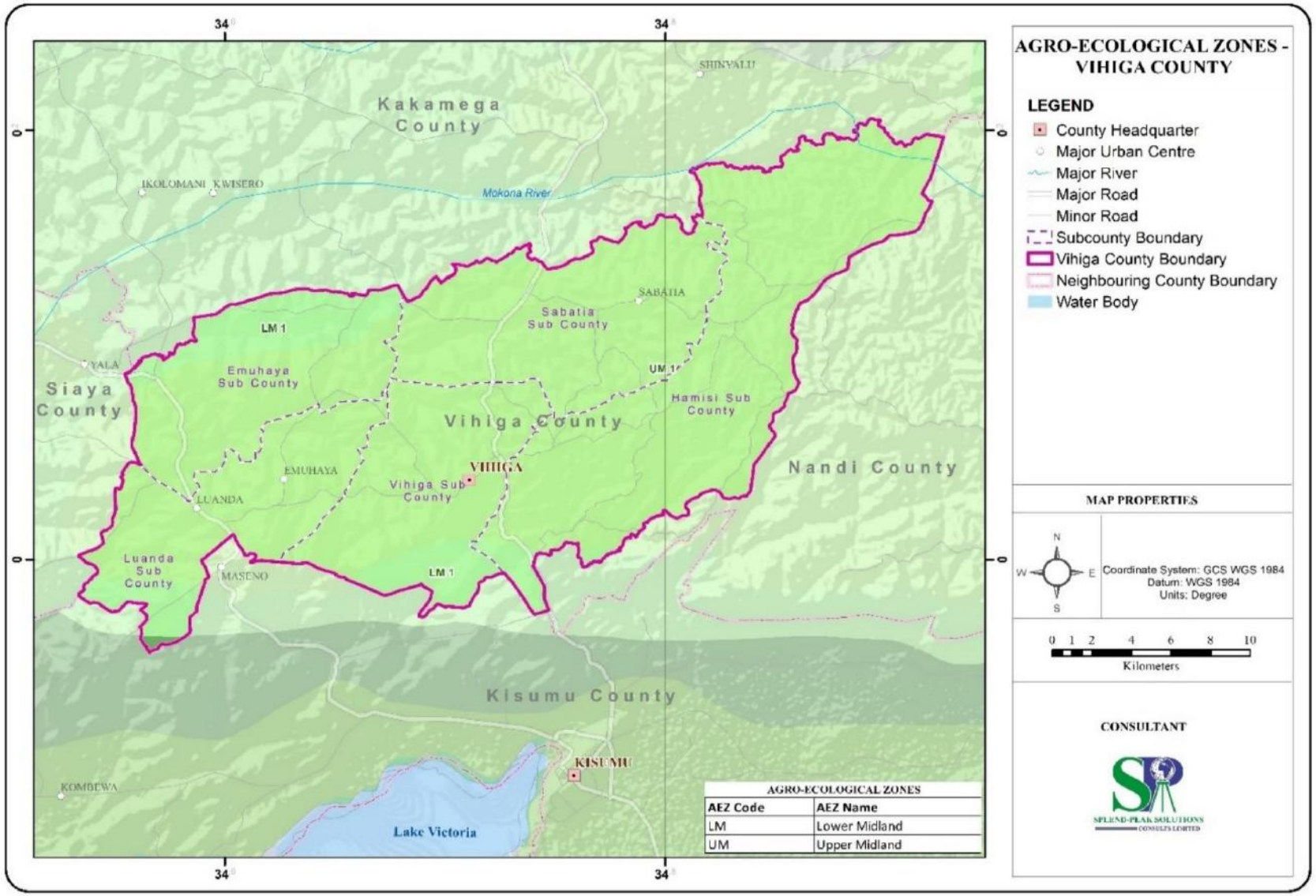
drain westwards into Lake Victoria. These rivers are fed by numerous perennial and seasonal streams, such as the Ebusiratsi, Edzava, and Kisimani, which are sustained by high rainfall in the uplands. The granitic and metamorphic rocks in much of Vihiga limit aquifer capacity, meaning boreholes are fewer and often produce low yields. Shallow wells are common but may dry up during prolonged dry periods, highlighting the County's vulnerability to water scarcity in dry seasons.

3.17.5 Agro-Ecological zones

The zoning of terrestrial land into various agro-ecologies is mainly influenced by an interplay of factors such as climatic variability, soil types, and land use practices among other factors. Therefore, for a zone to be termed to be agro-ecologically suitable for a particular crop, then its performance must be optimal keeping all factors constant. Vihiga County has two AEZs highly regarded for cassava farming of which they are all located within the lower midland zonation and majorly within Emuhaya Sub-County. This administrative location is the primary producer of cassava in the County. Table 35 and Map 32 illustrate the agro-ecological zones in Vihiga County.

Table 35: Cassava production in Vihiga County's Agro-ecological Zones

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
LM 1	Lower Midland	Sugar Cane-Cassava Zone	Emuhaya
LM 2	Lower Midland	Marginal Sugar Cane -Cassava Zone	



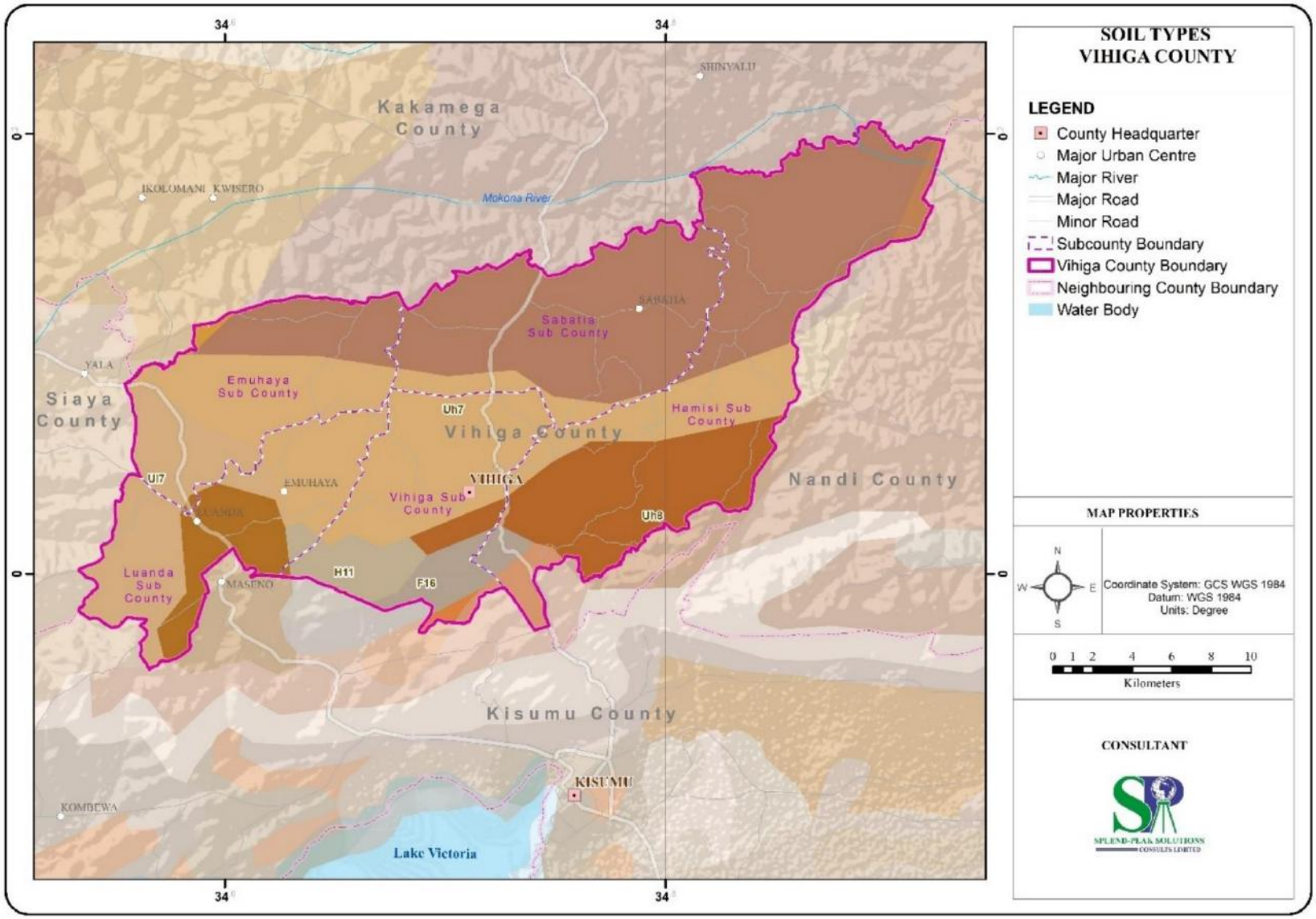
Map 32: A map showing agro-ecological zones for Vihiga County
(Source: GIS Data, 2025

3.17.6 Soils

There is one particularly soil type that is predominant across Emuhaya Sub-County which is the primary producer of cassava in Vihiga County though in small-scale. The specific soil type within the region is UI17 possessing a loamy texture and with the following properties as described both Table 36 and Map 33.

Table 36: The dominant soil type in cassava growing region of Vihiga County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
Ul7	loamy	interstratified	extremely slow	very deep	plain	gently undulating



Map 33: Soil types within Vihiga County
(Source: GIS Data, 2025)

3.18 Kisumu County

3.18.1 Geographical location

Kisumu County lies between longitudes 33^0 20'E and 35^0 20'E and latitude 0^0 20' South and 0^0 50' South. The County is bordered by Homa Bay County to the South, Nandi County to the North East, Kericho County to the East, Vihiga County to the North West, Siaya County to the West and surrounded by the second largest freshwater lake in the World; Lake Victoria.

3.18.2 Topography and Physiography

Kisumu County's topography and physiography are defined by its location along the northeastern shores of Lake Victoria, giving it a combination of low-lying plains, rolling hills, and highland zones. The County's altitude ranges from about 1,131 meters above sea level at the lakeshore to over 1,500 meters in the highland areas of Maseno and parts of Kisumu West and Kisumu East sub-counties. The lakeshore lowlands dominate the western and southern parts of the County, characterized by flat to gently undulating terrain that forms part of the Kano Plain. The Nyando Escarpment and the ridges around Kajulu and Kisian form prominent physiographic features, while the Maseno highlands on the County's northwestern edge provide cooler conditions and scenic views.

3.18.3 Climatic Conditions

The climatic conditions in Kisumu County are generally warm and humid. The County has a tropical climate, with temperatures ranging from an average high of 33 degrees Celsius to an average low of 23 degrees Celsius. The County experiences two rainy seasons, the long rains from March to June and the short rains from October to December. The dry seasons are from July to September and January to February. The County also experiences high humidity levels throughout the year, with an average humidity of around 80%.

3.18.4 Hydrology and Water Resources

Kisumu County's hydrology is largely influenced by its location along the northeastern shores of Lake Victoria, the largest freshwater lake in Africa and second largest freshwater lake in the world. The County's terrain gently slopes towards the lake, facilitating surface runoff and drainage into the lake basin. Numerous rivers and seasonal streams traverse the County, including major ones such as River Nyando, River Kibos, and River Sondu-Miriu, which drain the highlands of the

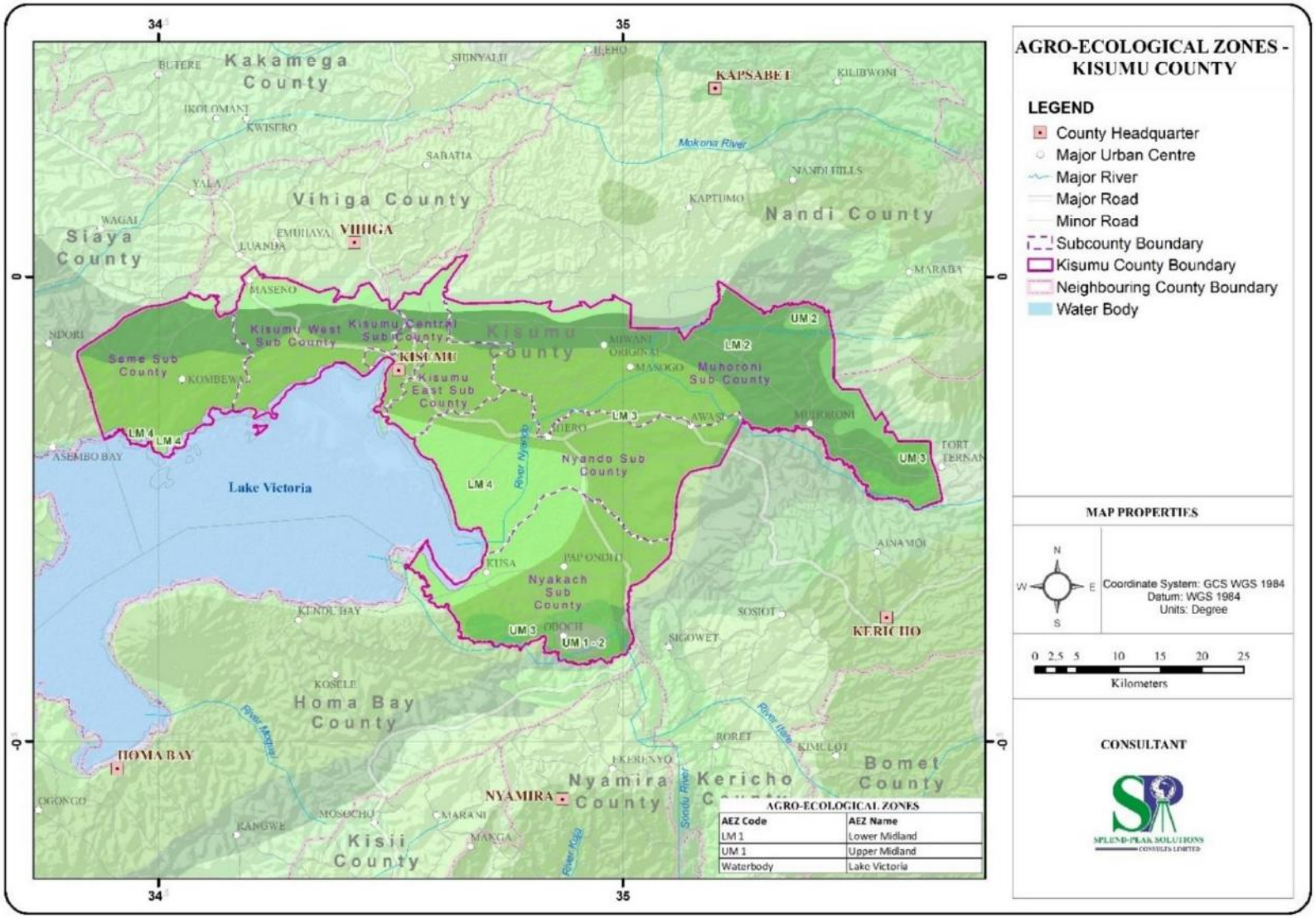
surrounding counties before emptying into Lake Victoria. The County has expansive floodplains, papyrus wetlands, and swamps such as the Nyando and Dunga wetlands, which serve as important water retention and filtration zones while also supporting biodiversity. Generally, Kisumu's hydrology is a dynamic system centered on the lake and its tributaries.

3.18.5 Agro-ecological zones

Kisumu is also an active cassava producer. The major production zones are cutting across two agro-ecological zones all in the lower midland coverage. Additionally, the zones are spread within four sub-counties as indicated in Table 37 and AEZ Map 34.

Table 37: Favorable agro-ecological zones for cassava production in Kisumu County

AEZ-Code	AEZ-Name	Major-Crop	Sub-counties
LM 1	Lower Midland	Sugar Cane-Cassava Zone	Muhoroni, Kisumu East, Kisumu West, Seme
LM 2	Lower Midland	Marginal Sugar Cane-Cassava Zone	



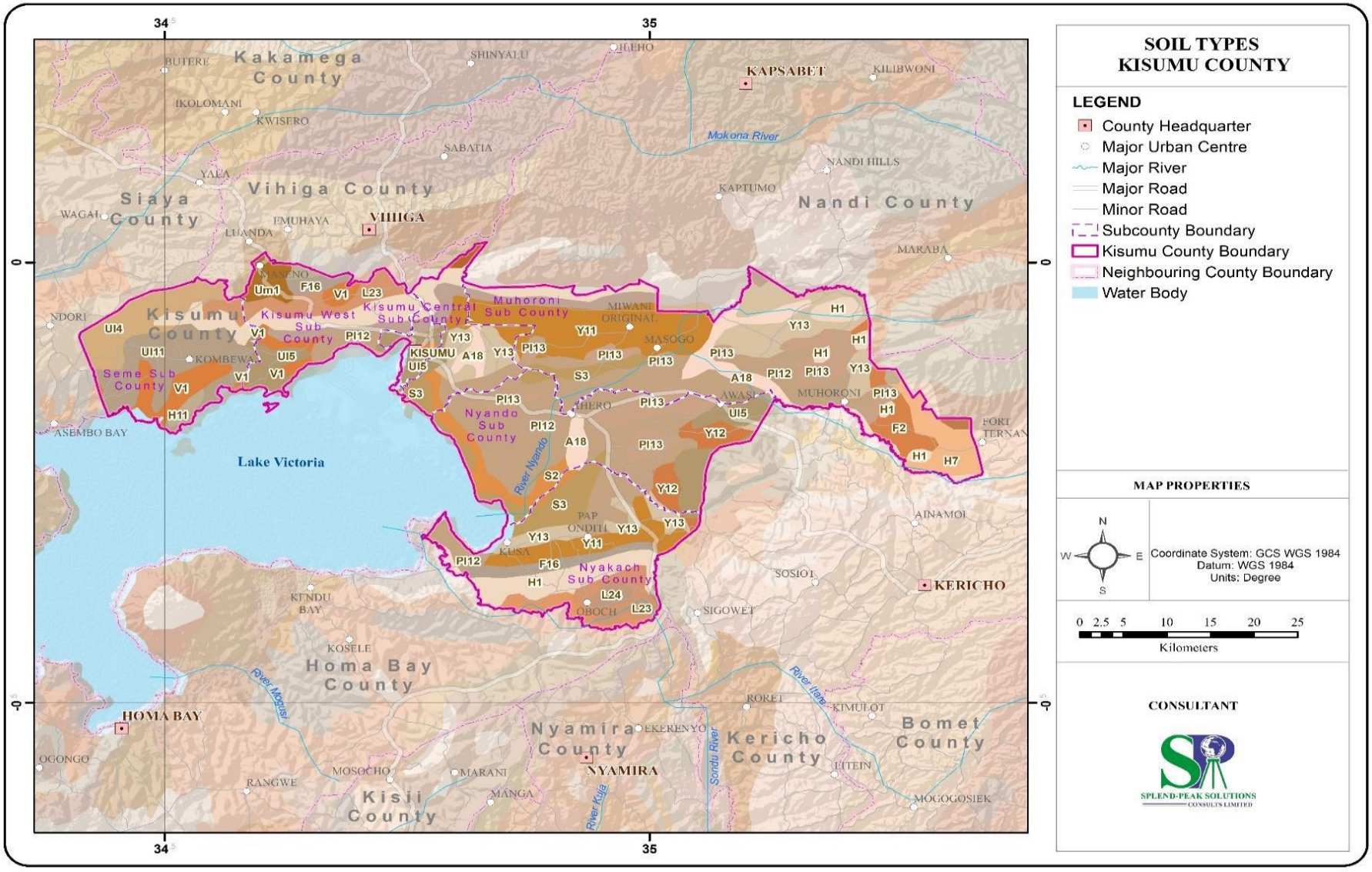
Map 34: A map showing the agro-ecological Zones for Kisumu County
(Source: GIS Data, 2025)

3.18.6 Soils

The importance of soil types in support of crop production is well-known. In order to achieve the desired optimum productivity from a given crop, besides other environmental factors, soils play an integral role. Therefore, specific soils are playing the critical role of boosting the production of cassava in Kisumu County and are summarized in the Table 38 together with their specific attributes. The Map 35 outlines its visual representation.

Table 38: Soil types and characteristics within cassava planting regions of Kisumu County

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
Pl12	clayey	interstratified	well	deep	plain	flat
Ul11	clayey	interstratified	well	moderately deep	plain	gently undulating
Ul4	very clayey	kaolinitic	well	moderately deep	plain	gently undulating
Y11	clayey	kaolinitic	well	very deep	plain	gently undulating



Map 35: Soil types within Kisumu County
(Source: GIS Data, 2025)

3.19 Homa Bay County

3.19.1 Geographical location

Homa Bay County is one of the Lake Region in Kenya and lies between latitudes 0°15' South and 0°52' South and between longitudes 34° East and 35°o East. The County is located in South Western Kenya along Lake Victoria, where it borders Kisumu and Siaya counties to the North, Kisii and Nyamira counties to the East, Migori County to the South, and Lake Victoria and the Republic of Uganda to the West.

3.19.2 Topography and Physiography

Homa Bay County's topography and physiography are shaped by its location along the southern shores of Lake Victoria and its diverse inland terrain. The County lies at an altitude ranging from approximately 1,140 metres above sea level along the lakeshore to higher elevations of over 1,800 metres in hilly and upland areas such as Gwassi Hills, Homa Hills, Gembe Hills, and the Kuria Hills. The landscape is a mix of low-lying plains, rolling hills, escarpments, and river valleys, creating varied micro-climates and land-use patterns. The lakefront plains are relatively flat and prone to seasonal flooding, especially in areas such as Asego, Kendu Bay, and Mbita, while the uplands and highland slopes to the south and east feature well-drained soils and cooler temperatures. The Gwassi Hills form a prominent physiographic feature in Suba South, acting as a water catchment and influencing local weather patterns.

3.19.3 Climatic Conditions

Homa Bay County has an inland equatorial type of climate. The climate is, however, modified by the effects of altitude and nearness to the lake, which makes temperatures lower than in equatorial climates. There are two rainy seasons: the long rainy season from March to June and the short rainy season from August to November. The rainfall received in the long rainy season is 60 percent reliable and ranges from 250 – 1000 mm, while 500 –700 mm is received in the short rainy season. The County receives an average annual rainfall ranging from 700 to 800mm. Temperatures in the County range from 18.6°C to 17.1°C, with hot months being between December and March. February is usually the hottest month of the year. The temperatures are, however, lower in areas bordering Kisii and Nyamira highlands and higher in areas bordering the lake.

3.19.4 Hydrology and Water Resources

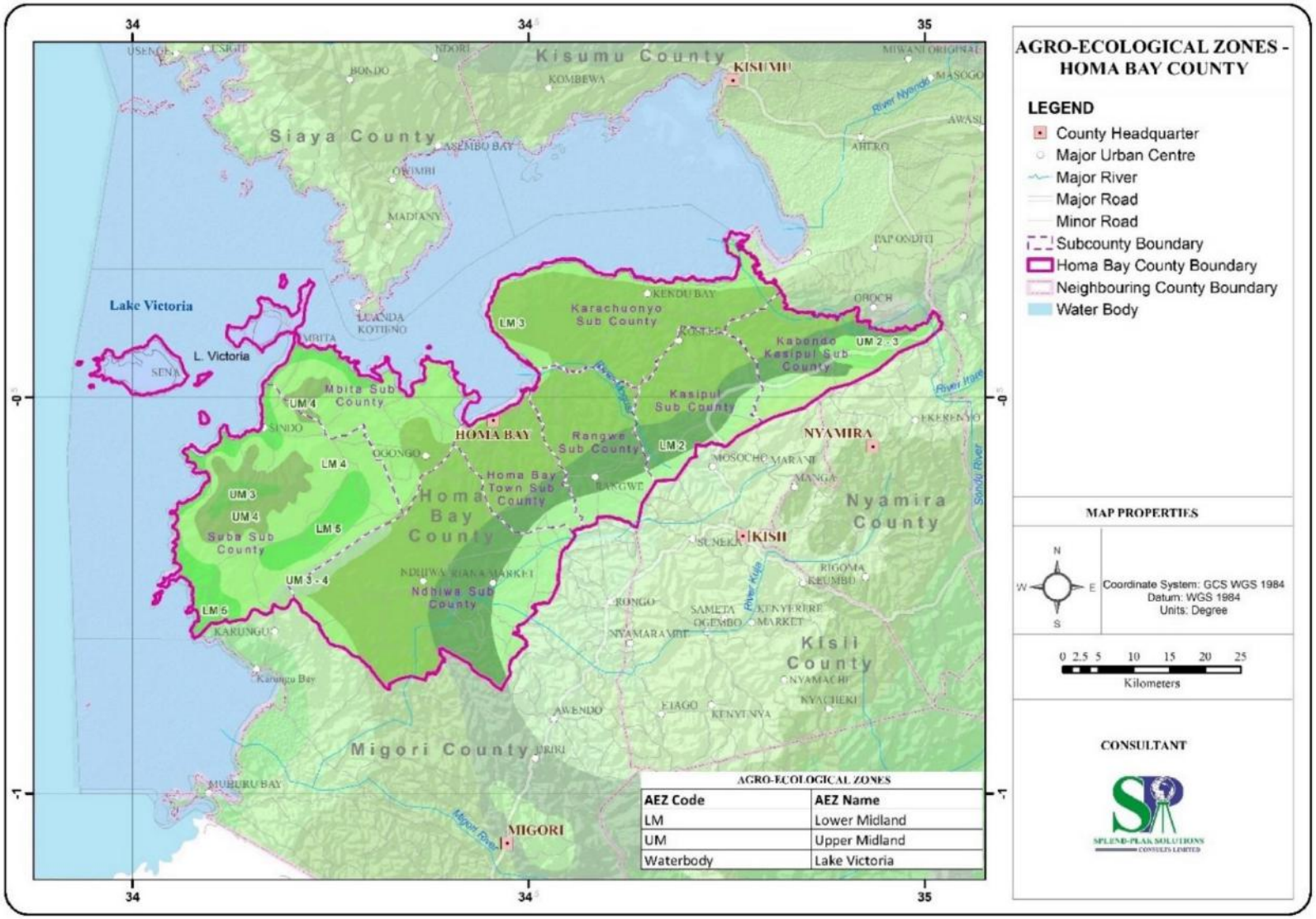
Hydrology and water resources of Homabay County are dominated by its strategic position along the southern shores of Lake Victoria, which is the primary water body and a key driver of the County's economy, ecology, and livelihoods. Lake Victoria provides abundant freshwater resources that support fishing, transport, domestic use, and irrigation, with major fish landing sites including Mbita, Kendu Bay, Homa Bay Town, and Sindo. The lake also moderates local climate and serves as the receiving body for numerous rivers and streams originating from the County's uplands. The County has several perennial and seasonal rivers, including the Kuja (Gucha), Awach Tende, Awach Kibuon, Riana, Miriu, and Oluch, which drain into Lake Victoria. These rivers are fed by rainfall in the highland catchment areas such as Gwassi Hills, Homa Hills, and the Kuria Highlands, and they play critical roles in irrigation, domestic water supply, and small-scale hydropower generation.

3.19.5 Agro-ecological Zones

The lower midland zones (LM 1, LM 2 &LM 5) of Homa bay County are known for their active role in cassava production. These zones are distributed in three sub counties as illustrated in Table 39 and Map 36.

Table 39: Agro-ecological zones vibrant in cassava production in Homa Bay County

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
LM 1	Lower Midland	Sugar Cane-Cassava Zone	Rangwe, Homabay, Ndhiwa
LM 2	Lower Midland	Marginal Sugar Cane-Cassava Zone	
LM 5	Lower Midland	Livestock – Millet-Cassava Zone	



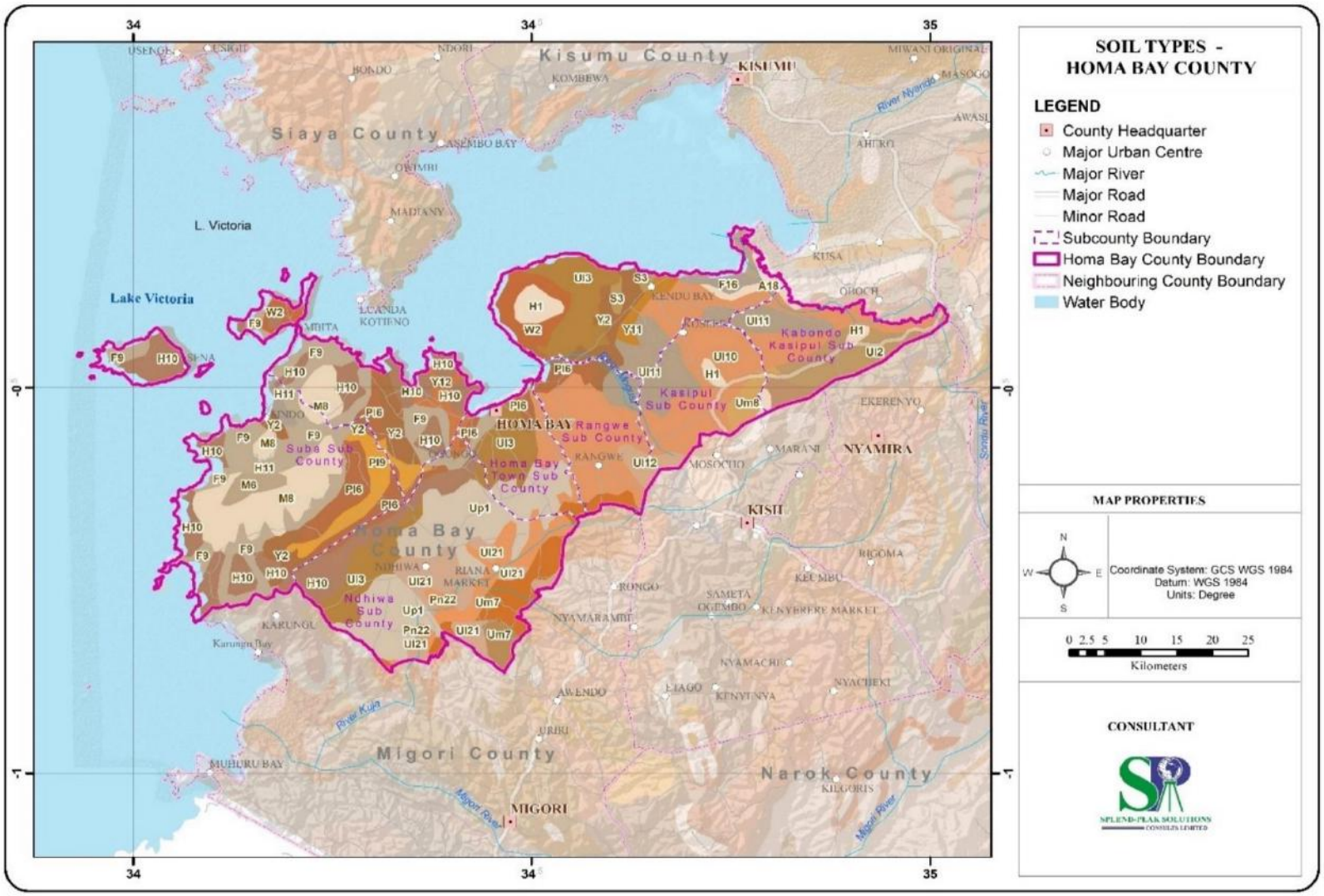
Map 36: A map showing agro-ecological Zones for Homa Bay County
(Source: GIS Data, 2025)

3.19.6 Soils

There is only one dominant soil type that favours the growth of cassava within Homabay County which is highlighted in the both Table 40 and Map 37.

Table 40: Soil types in Homabay County supporting cassava production

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
Ul21	very clayey	montmorillonitic	well	deep	plain	gently undulating



Map 37: Soil types within Homa Bay County
(Source: GIS Data, 2025)

3.20 Migori County

3.20.1 Geographical location

The County is situated in the South-Western part of Kenya. It borders Homa Bay County to the North, Kisii and Narok Counties to the East and the Republic of Tanzania to the South. It also borders Lake Victoria to the West. It is located between latitude 1º 24" South and longitude 34º 50" East.

3.20.2 Topography and Physiography

Migori County's topography and physiography reflects diversity and is influenced by its location in southwestern Kenya between the Lake Victoria basin and the Kenya–Tanzania border. The County lies at altitudes ranging from approximately 1,140 metres above sea level along the Lake Victoria shoreline in Nyatike Sub-County to about 1,800 metres in the highland areas of Kuria and Uriri. The western part of the County, bordering Lake Victoria, is characterised by low-lying plains that gradually slope towards the lake. These plains include the flood-prone lower Nyatike area, which is part of the Lake Victoria drainage basin. The shoreline is marked by sandy beaches, wetlands, and fishing bays such as Sori Bay and Muhuru Bay. Moving inland, the landscape becomes undulating with rolling hills and ridges. The central zone of the County, covering parts of Rongo, Awendo, and Uriri, is dominated by agricultural highlands with well-drained soils, supporting both subsistence and cash crop farming. The eastern and southern parts, particularly in Kuria East and Kuria West, are more rugged, with a series of hills and rocky outcrops, including Macalder Hills and Migori Hills.

3.20.3 Climatic Conditions

Annual temperatures vary between a mean minimum of 240C and maximum of 310C, with high humidity and a potential evaporation of 1800mm to 2000 mm per year. Migori County has two main rainy seasons. The long rains fall between March and May while the short rains occur between September and November. Dry seasons are experienced in two annual phases: December-February and June-September. The total annual rainfall trends showed a slight decrease since 1985 and is expected to continue until 2040 for the long rainy season. In the opposite, the short rainy season will see a sharp increase in the precipitation.

3.20.4 Hydrology and Water Resources

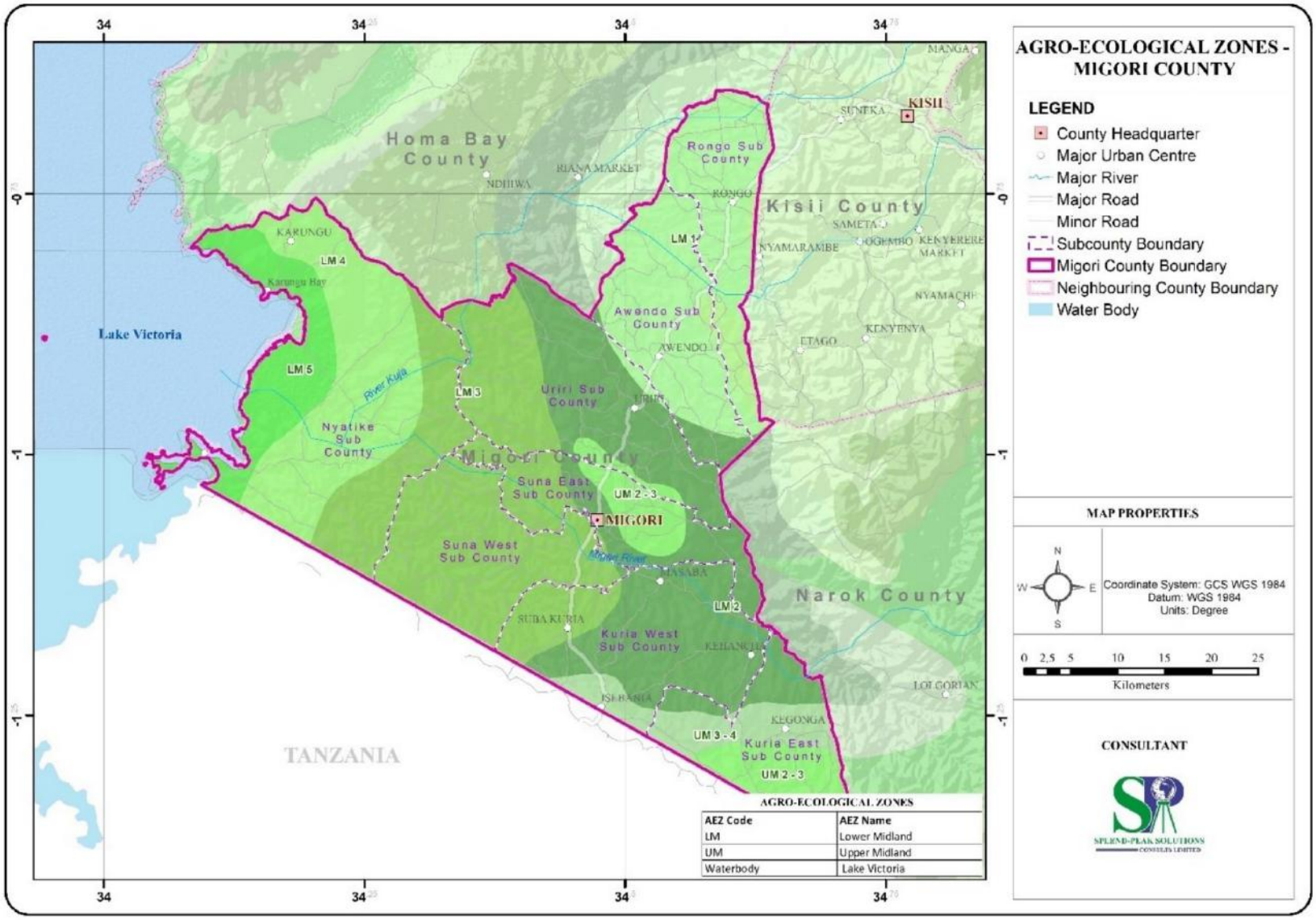
The County's location within the Lake Victoria Basin and its network of perennial and seasonal rivers influences its hydrology and water resources. The County's main rivers are Kuja (Gucha), Migori, and Riana, all originating from the highland regions of the neighbouring Kisii and Narok Counties. These rivers flow westward, supporting agriculture, domestic use, and small-scale irrigation before eventually draining into Lake Victoria, which forms the County's western boundary. River Kuja is the largest and most significant, receiving inflows from several tributaries within Migori County. Smaller but important rivers such as Ongoche, Oyani, Sare, Tebesi, and Nyangoto also contribute to the County's drainage system. Rivers Migori, Ongoche, Oyani, and Sare merge into River Kuja at different points, while Nyangoto and Tebesi feed into River Migori, which later joins River Kuja before it empties into Lake Victoria. The County's surface water resources are supplemented by wetlands, swamps, and seasonal streams, particularly in low-lying areas like Nyatike.

3.20.5 Agro-ecological Zone

There are three (3) agro-ecological zones actively engaging in the production of cassava within Migori County. These zones are all within the lower midland zones and are distributed across five sub-counties as shown in Table 41 and Map 38.

Table 41: Cassava Supporting AEZs in Migori County

AEZ-Code	AEZ-Name	Major-Crop	Sub-County
LM 1	Lower Midland	Sugar Cane-Cassava Zone	Kuria West, Rongo, Nyatike, Awendo, Kuria East
LM 2	Lower Midland	Marginal Sugar Cane-Cassava Zone	
LM 5	Lower Midland	Livestock - Millet Zone	



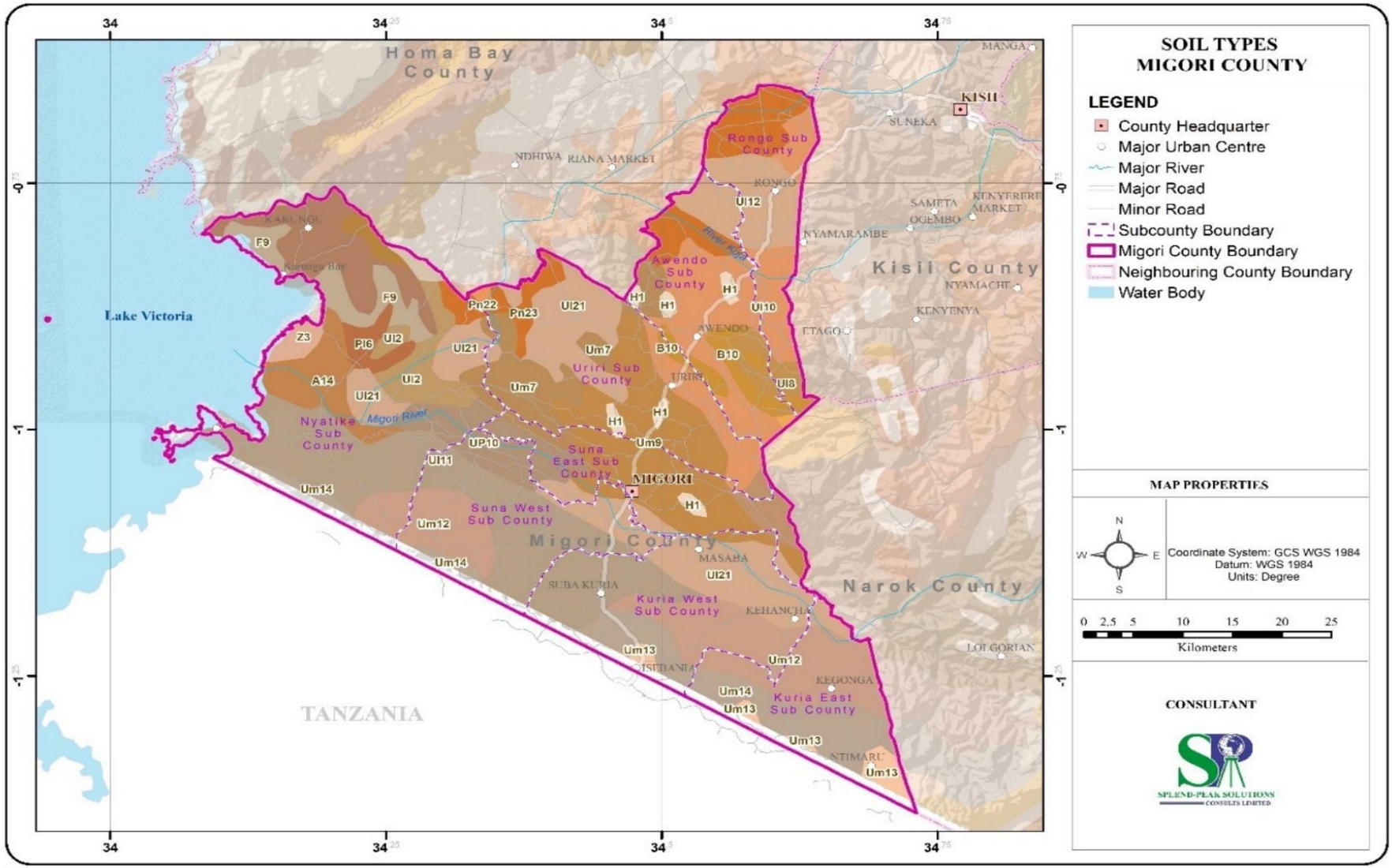
Map 38: A map showing agroecological zones for Migori County
(Source: GIS Data, 2025

3.20.6 Soils

Migori County has diverse soil profiles which support the growth of different crops. However, cassava is performing exemplary well within loamy and clayey soils of the region which are characterized by good drainage properties. Table 42 has broken down the different soil types and their characteristics and Map 39 gives a visual representation of the same.

Table 42: Types of Soils in Migori County's cassava growing regions

Soil - Code	Texture	Clay Description	Drainage	Slope	Land Form Description	Depth
H1	loamy	montmorillonitic	rapid		dissected plain	moderately steep
Ul2	loamy	montmorillonitic	well		plain	gently undulating
Ul21	very clayey	montmorillonitic	well	deep	plain	gently undulating



Map 39: Soil types within Migori County
(Source: GIS Data, 2025)

4.0 POLICY, LEGAL, REGULATORY AND INSTITUTIONAL FRAMEWORKS

4.1 Introduction

This chapter presents the policy, legal, and regulatory provisions relevant to the proposed commercialization of GM cassava in Kenya, particularly with regard to the development of disease-resistant GM crops and the agriculture and food security sectors, as well as the anticipated environmental and social impacts. This aligns with EIA/EA regulations, which require an in-depth analysis of all applicable policies and strategies, legislation (including pertinent regulations and standards), institutional arrangements, and multilateral environmental agreements during an ESIA study. The analysis focuses on frameworks governing environmental management, GMO regulation, and sustainable agricultural development, including resilient food systems that are appropriate for the commercialization process.

4.2 Policy Frameworks

4.2.1 Sustainable Development Goals (2015-2030)

The SDGs provide a framework for the entire international community to work together towards a common end making sure that human development reaches everyone, everywhere. If these goals are achieved, world poverty will be cut by half, tens of millions of lives will be saved, and billions more people will have the opportunity to benefit from the global economy.

Up to 2015, the development agenda was centered on the Millennium Development Goals (MDGs), which were officially established following the Millennium Summit of the United Nations in 2000. The MDGs were supposed to be achieved by 2015, so a further process was needed to agree and develop development goals from 2015-2030. Discussion on the post- 2015 framework for international development began well in advance. On 19 July 2014, the UN General Assembly's Open Working Group on SDGs forwarded a proposal for the SDGs to the Assembly. The proposal contained 17 goals with 169 targets covering a broad range of sustainable development aspects.

The proposed commercialization of GM cassava in Kenya aligns with the following SDGs:

- ✓ **SDG 2: Zero Hunger**

  This goal aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture. It emphasizes increasing agricultural productivity and incomes of

small-scale food producers, particularly women, indigenous peoples, family farmers, and pastoralists.

Relevance

The commercialization of GM cassava contributes directly to food security by improving resistance to CBSD and CMD, hence improved production. By ensuring reliable and higher yields, GM cassava strengthens food availability and enhances the livelihoods of smallholder farmers, key actors in Kenya's cassava value chain.

- ✓ **SDG 3: Good Health and Well-being**

It promotes healthy lives and well-being for all at all ages. It includes targets to reduce illness from foodborne diseases and improve access to nutritious food.

Relevance

GM cassava is developed to meet food safety standards, including permissible cyanogenic levels, ensuring it is safe for consumption.

- ✓ **SDG 13: Climate Action**

This goal urges urgent action to combat climate change and its impacts. It includes strengthening resilience and adaptive capacity to climate-related hazards.

Relevance

Cassava is known for its climate resilience, and the developed GM varieties improve this trait further by ensuring yield stability even under disease pressure and drought stress. The crop's ability to sequester carbon in soils and support intercropping systems enhances climate-smart agriculture practices in Kenya's vulnerable regions.

4.2.2 Kenya's Vision 2030

Kenya's Vision 2030 aspires to transform the nation into a newly industrialized, globally competitive, and prosperous middle-income country by the year 2030. The Vision identifies agriculture as one of the six priority sectors under the Economic Pillar, recognizing its central role in ensuring food security, employment creation, and poverty reduction. It aims to achieve a

sustainable average economic growth rate of 10 percent per annum, reduce poverty levels to 25 percent, and improve food security by 30 percent by 2030. The policy envisions a modern, commercially-oriented, and technology-driven agricultural sector that transitions from subsistence to innovation-led farming systems, with an emphasis on value addition, agribusiness, and market integration.

Relevance

In line with this Vision, the proposed commercialization of GM cassava directly supports the socio-economic goals of Vision 2030. The GM cassava varieties offering enhanced resistance to CBSD and CMD will improve cassava yield stability and lower production losses thereby guaranteeing increased productivity, higher farmer incomes, and reduced input costs. Furthermore, through improved market linkages, cassava value chain will offer significant opportunities for value addition and employment. The emphasis on technological innovation, public-private partnerships, and value chain development is in alignment with the vision. In addition, it promotes climate-resilient agriculture and diversification of food systems, critical components of Kenya's food and nutrition security strategy. Therefore, the commercialization of GM cassava is not only a culmination of scientific breakthrough but also a strategic intervention that resonates with Kenya's long-term national development blueprint.

4.2.3 Bottom-Up Economic Transformation Agenda (BETA) 2022-2027

The Kenyan government's Bottom-Up Economic Transformation Agenda (BETA) is a development plan adopted in 2022 and aims to create jobs and reduce poverty by focusing on the informal sector and small and medium-sized enterprises (SMEs). BETA is poised for integration of the blueprint into the Kenya Vision 2030 flagship programmes and projects implemented through the Fourth Medium Term Plan 2023-2027. BETA focuses on inclusive growth by transforming key sectors through five pillars: Agricultural Transformation, the MSME Economy, Healthcare, Housing and Settlement, and the Digital Superhighway & Creative Economy. Key objectives include reducing the cost of living, eradicating hunger, creating jobs, expanding the tax base, improving foreign exchange reserves, and ensuring inclusive economic growth for all Kenyans.

Relevance

In the context of agricultural transformation pillar of BETA and with particular regards to food security and resilience, the proposed commercialization of GM cassava resistant to CBSD will ensure ensures stable yields, reduces crop losses, and enhances household food security. This ultimately supports BETA's goal of eradicating hunger and reducing the cost of living by ensuring consistent supply of a staple crop. For MSME Economy particularly value addition & agribusiness, the proposed commercialization stimulates establishment of cassava-based MSMEs in processing (flour, starch, bioethanol, animal feed). It will also strengthen farmer cooperative societies, cassava seed entrepreneurs, and SMEs engaged in cassava value chains, creating employment opportunities.

4.2.4 National Food and Nutrition Policy, 2011

The policy aims to ensure that all Kenyans have access to sufficient, safe, and nutritious food at all times. This policy is a framework that addresses various aspects of food security and nutrition, aiming to improve the overall well-being of the population. It aligns with the country's long-term development goals, including Vision 2030, and contributes to global efforts like the Sustainable Development Goals, specifically Goal 2: Zero Hunger. The policy highlights three key aspects in respect of the proposed commercialization of GM cassava in Kenya: food availability and access; food safety, standards and quality; and nutrition improvement to achieve food and nutritional security for optimum health of Kenyans.

Relevance

The policy supports the commercialization of GM cassava through the aforementioned three key aspects. First, food availability and access are enhanced as GM cassava offers higher yields and resistance to CBSD and CMD, improving food supply and household access, especially in vulnerable regions. Second, food safety, standards, and quality are upheld through rigorous regulatory approvals by NBA, KEPHIS, and NEMA, ensuring the GM cassava meets both national and international safety standards, including Codex Alimentarius. Third, nutrition improvement is promoted as cassava contributes significantly to caloric intake and through biofortification with micronutrients.

4.2.5 Agriculture Sector Transformation and Growth Strategy 2019-2029

This strategy is based on the belief that food security requires a vibrant, commercial and modern agricultural sector that supports Kenya's economic development sustainably and its commitments to regional and global growth. The strategy outlines nine "flagship" projects prioritized for implementation in the first five years, with a review to be conducted before developing the next set of projects. The strategy has three anchors to drive the 10-year transformation: Increase small-scale farmer, pastoralist, and fisherfolk incomes; Increase agricultural output and value addition; and Boost household food resilience. Therefore, the strategy aims to significantly raise the incomes of small-scale farmers and enable achievement of 100% food and nutrition security, ensuring availability and affordability of food, especially for those in need. It also focuses on increasing value addition to agricultural products, creating more opportunities for farmers and businesses, and alleviate poverty in rural areas.

Relevance

By introducing high-yielding, disease-resistant cassava varieties, the initiative will increase productivity and reduce losses, thereby raising incomes for small-scale farmers. The proposed commercialization process will promote value addition through processing, enhancing the economic potential of cassava beyond subsistence use. Further, by ensuring a stable and affordable food supply, especially in cassava-growing regions, the strategy supports the enhancement of household food resilience. Therefore, the proposed commercialization aligns with Kenya's goal of achieving long-term food and nutrition security while contributing to rural poverty reduction and inclusive economic growth.

4.2.6 National Food Safety Policy 2013

The National Food Safety Policy aims to ensure consumer health, facilitate food trade, and align with international standards. It focuses on a "farm-to-fork" approach, integrating various sectors and agencies to manage food safety risks effectively. The policy emphasizes the importance of harmonizing efforts, minimizing conflicts between agencies, and ensuring compliance with international regulations. The policy establishes a rational and integrated food safety system, covering all stages from production to consumption. It also promotes risk-based approaches to food safety, focusing on identifying and managing potential hazards at different stages of the food chain. Moreover, it prioritizes the protection of public health and safety in relation to food

consumption and emphasizes the importance of traceability in the food chain and the need for effective enforcement of food safety standards.

Relevance

The development of the GM cassava has undergone rigorous regulatory approvals by NBA, KEPHIS, and NEMA, ensuring the GM cassava meets both national and international food safety standards, including Codex Alimentarius. To satisfy these food safety standards, the developed cassava varieties underwent food compositional analysis in an internationally accredited laboratory. Further, KEPHIS has certified that the developed cassava varieties have cyanogenic levels within the permissible limits, in line with the Codex Alimentarius, therefore classifying them as sweet varieties.

4.2.7 National Biotechnology Development Policy, 2006

The policy aims to guide the safe development and application of biotechnology for socio-economic development. It prioritizes research, sustainable industrial development, and capacity building in biotechnology. The policy also addresses ethical, environmental, and biosafety concerns, ensuring that biotechnology benefits key sectors while safeguarding citizens and the environment.

Relevance

This policy provided the basis for the establishment of the National Biosafety Authority and enactment of Biosafety Act of 2009, both of which have provided legal framework for the development of GM cassava. They have ensured the safety of the improved cassava varieties as food, feed, and in relation to the environment, as well as enabling regulatory compliance.

4.2.8 National Environmental Policy, 2013

National Environmental Policy provides a framework for integrated environmental management and sustainable resource use. It aims to strengthen governance, coordination, and management of the environment and natural resources, ensuring sustainable development for economic growth and improved livelihoods. It proposes policy measures to mainstream sound environmental management practices in all sectors. It also recommends strong institutional and governance measures to support achievement of the desired objectives and goals. The policy further

emphasizes principles such as environmental rights, polluters pay principle, sustainable resource use, and equity, guiding the nation towards a clean and healthy environment. It recognizes ESIA as a crucial tool for ensuring sustainable development by identifying, assessing, and mitigating potential negative impacts of projects on the environment.

Relevance

The policy underscores the importance of ESIA in identifying and mitigating potential adverse environmental and social effects, which aligns with the regulatory steps taken before introducing the improved cassava varieties. In line with the policy, the proponent has ensured that the proposed commercialization process is environmentally responsible, socially inclusive, and contributes to sustainable agricultural development and moreover, resilient food systems.

4.2.9 National Gender and Development Policy, 2011

The National Gender and Development Policy provides a framework for advancement of gender equity and an approach that would lead to greater efficiency in resource allocation and utilization to ensure empowerment of women. The National Policy on Gender and Development is consistent with the Government's efforts of spurring economic growth and thereby reducing poverty and unemployment, by considering the needs and aspirations of all Kenyan men, women, boys and girls across economic, social and cultural lines. The policy is also consistent with the Government's commitment to implementing the National Plan of Action based on the Beijing Platform for Action (PFA). The overall objective of the Gender and Development Policy is to facilitate the mainstreaming of the needs and concerns of men and women in all areas in the development process in the country.

Relevance

The proponent employed a gender-responsive participatory varietal selection technique, incorporating gender integration in the final varietal selection and will execute the same approach in the naming of the eight improved cassava lines, in line with the policy.

4.3 Legal Frameworks

4.3.1 Constitution of Kenya (CoK), 2010

Article 42 states that every person has the right to a clean and healthy environment. The constitution provides guidance on steps that may be taken in case any of any infringement on these rights. In addition, the constitution provides for the establishment of systems for carrying out environmental impact assessment, environmental audit and monitoring of the environment.

CoK 2010 also recognizes the right to food and adequate nutrition as fundamental human rights. Specifically, Article 43(1) (c) states that every person has the right to be free from hunger and to have adequate food of acceptable quality.

Further, Article 69 outlines the state's responsibility to ensure a sustainable environment and equitable access to natural resources. It mandates the state to manage and conserve the environment and natural resources, ensuring their sustainable exploitation, utilization, and equitable benefit sharing. Article 69 is also crucial for ensuring a healthy and sustainable environment for all Kenyans and is closely linked to other provisions in the Constitution, including Article 42 (the right to a clean and healthy environment), Article 21 (implementation of rights and fundamental freedoms), and Article 70 (enforcement of environmental rights).

Relevance

The aforementioned provisions provide a robust legal grounding for this ESIA process, as a necessary tool to assess, mitigate, and monitor environmental and social impacts of the proposed commercialization, ensuring the project upholds environmental rights and principles of sustainable development. Furthermore, the developed cassava varieties will boost food security having been approved safe for food in accordance with Codex Alimentarius.

4.3.2 Environmental Management and Coordination Act (EMCA) of 1999, (Amended-2015).

EMCA serves as the principal law for environmental management in Kenya. It establishes NEMA and other institutions to implement environmental policies. It mandates to oversee environmental protection through mechanisms such as Environmental Impact Assessment, Environmental Audit, and restoration orders. Part II of the Act states that every person in Kenya is entitled to a clean and healthy environment and has the duty to safeguard and enhance the environment.

According to section 58 of the Act, an environmental impact assessment needs to be carried out on all projects specified in the second schedule of the act which are likely to have a significant impact on the environment. It further states that an environmental impact assessment study report shall be prepared by individual experts or a firm of experts authorised in that behalf by the Authority.

Relevance

Environmental release and commercialization of new varieties developed through genetic modification require full ESIA Studies in compliance with this Act. An ammendment to the Second Schedule of this Act through Legal Notice 31 of 2019 lists major developments in biotechnology including the introduction and testing of Genetically Modified Organisms (GMOs) as high-risk projects, hence necessasitating the preparation of this ESIA Study Report by NEMA-authorized Firm of Experts, Splend-Peak solutions Consults Ltd, contracted by the proponent.

4.3.3 Biosafety Act, 2009 (Amended 2018)

This law is an Act of Parliament to regulate activities in genetically modified organisms, to establish the National Biosafety Authority (NBA), and for connected purposes. This Act may be cited as the Biosafety Act, 2009. It came into operation 1 July 2011 and revised in 2018. Part III Section 18 (1) states that a person shall not conduct any contained use activity involving genetically modified organisms without the written approval of NBA. Section 19 (1) of the Act states that no person shall introduce into the environment a genetically modified organism without the written approval of the Authority. Section 21 (1) emphasizes that no person is allowed to place on the market a genetically modified organism without written approval of the Authority. The fourth schedule provides information required in application for approval for placing on the market of GMOs. Of significance to note is that the act also mandates a thorough risk assessment process, including ESIA, to evaluate the potential risks associated with GM crops before they are approved for commercialization. NBA is further required to conduct public participation on applications for environmental release and commercialization of GM crops, ensuring transparency and incorporating public views.

Relevance

An application was made to NBA to approve environmental release and the subsequent commercialization of the GM cassava. For commercialization to be done an ESIA need to be

conducted and approved by NEMA. Previously for the purposes of NPTs rigorous public participation and stakeholder engagement was undertaken during the time of application for environmental release. This included the risk assessment process, which featured a Kenya Gazette notice, publications in two newspapers, and a National Dialogue held on 10th June 2020 that attracted 1,197 participants and generated 3,342 comments. The ESIA study for the National Performance Trials (NPT) involved public barazas with a total of 223 participants across seven KEPHIS-designated NPT sites in six counties, consultations with 35 key stakeholders representing County and national governments, as well as the mandatory Kenya Gazette notice, newspaper publications for two consecutive weeks with nationwide circulation, and radio announcements. At this current stage of the ESIA study for commercialization, public barazas and stakeholder consultations have so far attracted 783 participants across 19 key cassava-growing counties, with the mandatory Kenya Gazette notice, publications in two newspapers for two consecutive weeks with nation-wide circulation, and radio announcements is pending.

4.3.4 Agriculture, Fisheries, and Food Authority Act, 2013

This Act establishes the Agriculture, Food and Fisheries Authority, whose key mandate, among others, is to administer the Crops Act, 2013. Section 22(3B), with regard to rules on the preservation, utilization, and development of agricultural land, states that the occupier of agricultural land shall be deemed to fulfil his or her responsibilities to farm it in accordance with the rules of good husbandry if the occupier maintains a reasonable standard of efficient production, both in terms of the kind of produce and its quality and quantity, while keeping the land in a condition that enables such a standard to be maintained in the future. Section 40 recognizes the importance of ensuring effective participation of farmers in the governance of the agricultural sector in Kenya through their registered farmers' organizations in the development of policies or regulations, and before making any major decision that affects the sector.

Relevance

The rules of good husbandry ensure that farmers adopting the improved varieties maintain high productivity without compromising long-term soil health or environmental quality. Further, the focus of Section 40 on farmer participation, through their representatives or registered organizations, ensures that cassava farmers are actively involved in varietal selection, and decision-making processes related to commercialization of the developed cassava varieties. This

inclusive governance framework aligns with the ESIA's participatory approach and fosters acceptance, responsible adoption, and sustainability of the GM cassava initiative.

4.3.5 The Crops Act, 2013

The Crops Act provides a framework for regulating the entire crop value chain, from production to marketing with an aim of promoting agricultural growth, enhance farmer incomes, and improve the overall efficiency of agribusiness. The Act emphasizes the importance of biotechnology in crop improvement, particularly for addressing challenges like diseases and pests. It mandates collaboration between the Crops Directorate of Agriculture and Food Authority and the NBA to advise the government on the introduction and safe use of GMOs. It further provides for registration, promotion and regulation of scheduled crops listed under the first schedule of the Act.

Relevance

The Act supports initiatives to develop a sustainable cassava seed system, including the production and distribution of KEPHIS-certified clean planting materials of improved varieties. It also encourages private sector participation and investment in the cassava value chain to increase production and meet market demands. The act recognizes the potential of biotechnology to transform root and tuber crops like cassava into a commercially viable enterprise. In light of this, the proposed commercialization of GM cassava resistant to CBSD and CMD will address issues such as yield stability, food security and farmer livelihoods.

4.3.6 Seeds and Plant Varieties Act Cap 326

The act regulates the production and sale of seeds, including requirements for certification, testing, and registration. It aims to ensure farmers have access to quality seeds, prevent the spread of plant diseases, and protect plant breeders' rights. Specifically, the Act prohibits the sale of seeds that are not certified, tested, or of approved varieties, and it regulates the descriptions under which seeds are sold. The act provides for variety release after NPTs, highlighting that varieties demonstrating superior performance and meeting the required standards are officially released. It requires that seeds of officially released varieties be certified before they can be placed on the market. It further designates KEPHIS as the regulatory body responsible for seed certification and variety release.

Relevance

The National Performance Trial Committee has reviewed data from two seasons of NPT and recommends that the National Variety Release Committee registers and releases all eight as varieties in Kenya. Data from two seasons of NPT was reviewed by the National Performance Trial Committee which recommended the 8 varieties for approval by the National Variety Release Committee for release to farmers for commercialization, pending approval of the ESIA process by NEMA. Given that cassava is listed as a scheduled crop under Part 2 of the First Schedule of the Crops Act, the eight lines will undergo national varietal registration in accordance with the Act, after which they will be gazetted and officially released for commercialisation.

4.3.7 Climate Change Act, 2016 (Amended 2023)

This act established a regulatory framework for enhanced response to climate change and mechanisms for achieving low-carbon development. Its primary goal is to ensure the sustainable development of the country by addressing climate change impacts. The Act focuses on building Kenya's capacity to withstand the effects of climate change and also promote strategies that reduce greenhouse gas emissions and transition towards a low-carbon economy. It established the Climate Change Council and the Climate Change Directorate. It also provides legal basis for development of national climate change action plans. The act further highlights the significance of public engagement in matters relating to climate change policy, strategy, programme, plan or action.

Relevance

The newly developed disease-resistant cassava greatly supports climate-smart agriculture by stabilizing yields under increasingly variable climatic conditions and strengthening food security in vulnerable regions. Additionally, it does not need pesticides or fertilizer application hence contributing to lower greenhouse gas emissions and promoting sustainable, low-carbon agricultural practices. Public engagement provisions in the Act also align with the participatory processes in the ESIA, ensuring local communities are involved in decision-making.

4.3.8 Food, Drugs and Chemical Substances Act (Cap 254)

This Act (which has been invoked for the consumption of genetically modified food), requires that food, drugs, cosmetics, devices and chemical substances should not be sold if they are unwholesome, poisonous, or adulterated. It further prohibits deceptive labelling, which is closely

linked to the Biosafety (Labelling) Regulations, 2012, requiring clear labelling of food substances, including those derived from GMOs. The statute also gives powers to authorized officers to inspect and examine any premises for evidence of contravention of the provisions of the law.

Relevance

This act applies to the developed cassava varieties with regards to their safety and quality as food for human consumption. It prevents the sale of food that is not of the nature, substance, or quality demanded by the consumer. The act also restricts misrepresentation or mislabeling of improved cassava varieties or their derived products. Further, the developed cassava varieties have undergone food compositional analysis and have been found to be low-cyanogenic varieties.

4.3.9 County Government Act, 2012 (Amended 2020)

This act was enacted to give effect to Chapter Eleven of the Constitution, which establishes the system of devolved government in Kenya. It outlines the powers, functions, and responsibilities of County governments to ensure they effectively carry out their constitutional roles. The act outlines the framework for devolved functions, including agriculture, in Kenya's County governments. It specifies that County governments are responsible for functions assigned to them by the Constitution or Acts of Parliament, with the Fourth Schedule detailing specific areas of responsibility including agriculture, which means counties are tasked with managing and developing agricultural services within their jurisdictions.The Act therefore facilitates the transfer of powers and functions related to agriculture from the national government to the County governments. This transfer aims to bring decision-making and service delivery closer to the people and tailor them to local needs. Moreover, the act mandates public participation in County governance by outlining principles, establishing mechanisms, and defining roles for various stakeholders. It emphasizes the right of citizens to be consulted and involved in decision-making processes, ensuring their contributions are considered, and providing access to relevant information.

Relevance

Agriculture being a devolved function, County Departments of Agriculture (CDAs) who have interacted with the project in the past have been identified as key actors in the implementation of the proposed commercialization, particularly with regards to distribution of KEPHIS-certified,

clean planting materials, farmers field training and extension services, post-harvest management, and value addition & market linkage interventions. Public participation, as provided for in this Act and conducted in the selected counties, formed the lifeline of this ESIA process and will play a key role in the decision-making process.

4.4 Regulatory Frameworks

4.4.1 Environmental (Impact Assessment and Audit) Regulations, 2003

The Environmental (Impact Assessment and Audit) Regulations of 2003 provide guidelines on conduct, report preparation, submission, and other relevant information on EIA/EA studies. It outlines the methodology of carrying out EIA and contents of an EIA study report.

The EIA and Audit Regulations state in Regulation 3 that "the regulations should apply to all policies, plans, programmes, projects and activities specified in Part IV, Part V and the Second Schedule of the Act. Part II of the Regulations indicates the procedures to be taken during preparation, submission and approval of this project report. The Regulation also stipulate when Environmental Audits in a bid to promote environmental soundness.

Relevance

The proposed commercialization of GM cassava in Kenya, classified as a high-risk project under the second schedule, must undergo an ESIA study and a full study report written following the outline recommended in this regulation. It also recommends the period under which the initial environmental audit will be conducted.

4.4.2 Seeds and Plant Varieties (Variety Evaluation and Release) Regulations, 2016

These regulations give effect to the Seeds and Plant Varieties Act (Cap 326) by providing a set of legal guidelines that govern the evaluation and release of new plant varieties in the country, with the ultimate aim of ensuring that only varieties that have been thoroughly tested and proven suitable for Kenyan agro-ecological conditions are released for commercial use. They outline the procedures for evaluating new plant varieties, including trials for yield, other attributes, and DUS testing, before they can be officially released. They also protect the intellectual property rights of plant breeders and allow them to recover their investments in developing new varieties. These regulations further establish the National Variety Release Committee charged with approving the

release of varieties that have successfully completed the required trials. Lastly, it recognizes the crucial role of KEPHIS in implementing this regulation, NPTs and DUS testing, overseeing seed certification, and the registration of new varieties.

Relevance

KEPHIS regulated the NPTs across seven sites representing different agroecological zones, as well as one DUS test, over two planting seasons. Data from two seasons of NPT was reviewed by the National Performance Trial Committee which recommended the 8 varieties for approval by the National Variety Release Committee for release to farmers for commercialization." Clean planting materials will be sourced from KALRO Centres within reach or from trained cassava seed entrepreneurs (CSEs), who are seed merchants licensed by KALRO to sell seed materials of cultivars that been certified by KEPHIS.

4.4.3 Biosafety (Environmental Release) Regulations, 2011

Regulations 5(1) states that no person shall place on the market a genetically modified organism without the written approval of the Authority. 5(2) states that an application to place on the market a genetically modified organism shall be made to NBA in a form set out in Part B of the First Schedule of the Regulations and shall be accompanied by an application fee of 850,000 Kenyan shillings and where necessary, a risk assessment report.

Relevance

Data from two seasons of NPT was reviewed by the National Performance Trial Committee which recommended the 8 varieties for approval by the National Variety Release Committee for release to farmers for commercialization.

4.4.4 Biosafety (Labelling) Regulations, 2012

Regulation 9 states that an operator shall at all stages of placing on the market a product consisting of or containing GMOs, including bulk quantities, ensure that the written information transmitted to the subsequent operator and all other operators along the supply chain specifies the product consists of or contains GMOs, and has a unique identifier assigned to those GMOs. This regulation further mandates NBA to establish a mechanism for development and assignment of unique identifiers where they are particularly useful in traceability of the GMOs.

Relevance

The eight cassava varieties earmarked for commercialization have been given unique identifiers and duly registered with the NBA and KEPHIS.

4.5 Relevant Multilateral Environmental Agreements (MEAs)

4.5.1 Introduction

A multilateral environmental agreement (MEA) is a legally binding agreement between three or more states relating to the environment. They are predominantly produced by the United Nations. It is called a bilateral environmental agreement if the agreement is between two nation states.

4.5.2 Cartagena Protocol on Biosafety

The **Cartagena Protocol on Biosafety** is an international agreement on biosafety, as a supplement to the Convention on Biological Diversity. The Biosafety Protocol seeks to protect biological diversity from the potential risks posed by genetically modified organisms resulting from modern biotechnology.

The Biosafety Protocol makes clear that products from new technologies must be based on the precautionary approach and allow developing nations to balance public health against economic benefits. The Protocol for example, lets countries exercise stricter regulatory oversight for genetically modified organisms if they feel there is not enough scientific evidence that the modified product is safe or let countries proceed with use of such products where there is considerable experience in use of the product.

The principle implies that there is a social responsibility to protect the public from exposure to harm, when scientific investigation has found a plausible risk. These protections can be relaxed only if further scientific findings emerge that provide sound evidence that no harm will result**.**

Relevance

It provides a framework for ensuring the safe development, handling, and use of genetically modified organisms. In line with the Protocol's precautionary principle, Kenya has subjected the GM cassava to rigorous regulatory processes, including risk assessments and public consultations, before commercialization. The Protocol empowers the country to prioritize biosafety and public health while considering socio-economic and ecological contexts. It ensures

that decisions regarding the GM cassava are evidence-based yet mindful of potential uncertainties, promoting sustainable agricultural development while safeguarding biodiversity and consumer safety.

4.5.3 Convention on Biological Diversity (CBD-1992)

Article 14 of the CBD (Impact Assessment and Minimizing Adverse Impacts) calls on member states to take measures to prevent the degradation of systems that support biodiversity across land, inland water systems, and marine life. Specifically, the Convention calls upon contracting Parties to act as follows:

i) Introduce appropriate procedures requiring Environmental Impact Assessment and audits of its proposed or on-going projects that are likely to have significant adverse effects on biological diversity with a view to avoiding or minimizing such effects and, where appropriate, allow for public participation in such procedures;

ii) Introduce appropriate arrangements to ensure that the environmental consequences of its programmes and policies that are likely to have significant adverse impacts on biological diversity are duly taken into account;

iii) Promote, on the basis of reciprocity, notification, exchange of information and consultation on activities under their jurisdiction or control which are likely to significantly affect adversely the biological diversity of other States or areas beyond the limits of national jurisdiction, by encouraging the conclusion of bilateral, regional or multilateral arrangements, as appropriate;

iv) In the case of imminent or grave danger or damage, originating under its jurisdiction or control, to biological diversity within the area under jurisdiction of other States or in areas beyond the limits of national jurisdiction, notify immediately the potentially affected States of such danger or damage, as well as initiate action to prevent or minimize such danger or damage; and

v) Promote national arrangements for emergency responses to activities or events, whether caused naturally or otherwise, which present a grave and imminent danger to biological diversity and encourage international cooperation to supplement such national efforts and, where appropriate and agreed by the States or regional economic integration organizations concerned, to establish joint contingency plans.

Relevance

In line with Article 14, the ESIA process for GM cassava ensures that biodiversity considerations are integrated into project planning, public participation is upheld, and measures are in place to maintain ecological integrity. This aligns Kenya's actions with global commitments to safeguard ecosystems while advancing sustainable agricultural innovations.

4.5.4 The International Union for the Protection of New Varieties of Plants (UPOV)

The International Union for the Protection of New Varieties of Plants (UPOV) is an intergovernmental organization based in Geneva, Switzerland. UPOV was established in 1961. The mission of UPOV is to provide and promote an effective system of plant variety protection, with the aim of encouraging the development of new varieties of plants, for the benefit of society. The UPOV Convention provides the basis for members to encourage plant breeding by granting breeders of new plant varieties an intellectual property right: the breeder's right.

Relevance

The Convention is domesticated in Kenya in the Seeds and Plant Varieties Act Cap 326, guiding commercialization process including protection of plant breeder's rights, national variety registration process, and seed certification.

4.5.5 Codex Alimentarius-International Food Safety Standards

The Codex Alimentarius, or "Food Code" is a collection of standards, guidelines and codes of practice adopted by the Codex Alimentarius Commission. The Commission, also known as CAC, is the central part of the Joint FAO/WHO Food Standards Programme and was established by FAO and WHO to protect consumer health and promote fair practices in food trade. Codex Alimentarius includes standards for all the principal foods, whether processed, semi-processed or raw, for distribution to the consumer. Materials for further processing into foods should be included to the extent necessary to achieve the purposes of the Codex Alimentarius as defined. The Codex Alimentarius includes provisions in respect of food hygiene, food additives, residues of pesticides and veterinary drugs, contaminants, labelling and presentation, methods of analysis and sampling, and import and export inspection and certification. The Codex Alimentarius Commission has over

170 member countries including Kenya, representing a wide range of nations involved in global food production and trade. KEBS serves as the National Codex Contact Point.

Relevance

The developed cassava was subjected to food compositional analysis to ascertain its safety for human consumption, in accordance with the Codex Alimentarius.

4.6 Institutional frameworks

4.6.1 Introduction

Environmental management is highly interdisciplinary and transcends legal and institutional differentiation. Therefore, the legal and regulatory framework outlined in the preceding section and the specific institutional roles refers to relevant institutions with regards to this project. NEMA works in tandem with other government Ministries, Departments and Agencies (MDAs) in dealing with environmental issues in the country. The Ministry of Environment, Climate change, and Forestry is the parent ministry for the NEMA and the authority works closely with other directorates and departments of the ministry.

Under EMCA, several institutions have been established, but there are two key ones i.e., the National Environment Council (NEC) and the National Environmental Management Authority (NEMA). In addition, matters of modern biotechnology are dealt with under the lead agency called the National Biosafety Authority. In the Biosafety Act, there are 8 regulatory agencies listed in the First Schedule that should work in harmony to regulate and monitor genetic engineering.

4.6.2 National Environment Council

NEC is chaired by the Minister for Environment and Natural Resources with membership from all relevant ministries as well as a broad range of other interests. It functions to formulate national policies, goals, and objectives and the determination of policies and priorities for environmental protection. The Council also promotes co-operation among all the players engaged in environmental protection programmes.

4.6.3 National Environment Complaints Committee

The National Environmental Complaints Committee (NECC) was established under Section 31 of the Environmental Management and Co-ordination Act, 1999. It was formerly known as the Public Complaints Committee (PCC) but its name changed in the EMCA (Amendment) No. 5 of 2015).

It is an important institution in the assessment of the condition of the environment in Kenya. It plays an important role in the facilitation of alternative dispute resolution mechanisms relating to environmental matters. The NECC makes recommendations to the Cabinet Secretary and thus contributes significantly to the formulation and development of environmental policy. The membership of NECC is drawn from key stakeholders in environmental management.

The Committee consists of seven members headed by a chairperson, who is appointed by the Cabinet Secretary and qualifies to be a judge of the Environment and Land Court of Kenya. Other members are; a representative of the Attorney General, a representative of the Law Society of Kenya, one person who has demonstrated competence in environmental matters to be nominated by the Council of Governors and who is the Secretary to the Committee, a representative of the business community and two members, appointed by the Cabinet Secretary for their active role in environmental management.

4.6.4 County Environmental Committees (CEC)

The County Environmental Committees (CEC) are responsible for the proper management of the environment within the County for which it is appointed. The Committees also develop the County Strategic Environmental Action Plan every five years.

The overall climate change roles of the County governments are in section 15 and 19 of the CCA: Section 15 (1) empowers the Council to impose climate change duties on public entities, including the national and County government and agencies under them), and once these duties have been imposed, the public entities must act in a manner best suited to achieve successful implementation of the CCA and the NCCAP and to mainstream the implementation of the NCCAP, taking into account national and County priorities.

4.6.5 National Environment Management Authority

NEMA is a corporate body responsible for the administration of the EMCA 1999 (Amended, 2015). The Authority is headed by Director General appointed by the President on recommendation of the board. The authority functions include the coordination of various environmental management activities, initiation of legislative proposals and submission of such proposals to the Attorney General, research, investigations and surveys in the field of environment. NEMA also undertake to enhance environmental education and awareness on the need of sound environmental management. In addition, NEMA advises the Government on regional and

international agreements to which Kenya should be a party and issue of an annual report on the state of environment in Kenya. NEMA is charged with the responsibility of the execution of Environmental Impact Assessment (EIA) and Environmental Audit (EA) as well as provisions of other Legal Notices emanating from EMCA, 1999 (Amended, 2015). NEMA has initiated various Regulations so as to fully operationalize the EMCA 1999 (Amended, 2015).

4.6.6 Kenya Agricultural and Livestock Research Organization

KALRO is a corporate body created under the Kenya Agricultural and Livestock Research Act of 2013 to establish suitable legal and institutional framework for coordination of agricultural research in Kenya with the following goals:

- Promote, streamline, co-ordinate and regulate research in crops, livestock, genetic resources and biotechnology in Kenya.
- Expedite equitable access to research information, resources and technology and promote the application of research findings and technology in the field of agriculture.

4.6.7 Kenya Plant Health Inspectorate Service

KEPHIS is a State Corporation under the Ministry of Agriculture, Livestock and Fisheries that is mandated to regulate and facilitate all plant materials coming into the country or produced locally. They are responsible for implementing phytosanitary and quarantine measures. They are also mandated to implement the national policy on the introduction and use of GM plant species in liaison with the National Biosafety Authority. KEPHIS is also responsible for regulating imports of GM seeds. KEPHIS is mandated with overseeing NPTs, national variety registration process, and seed certification in compliance with the UPOV convention and the Seeds and Plant Varieties Act. In the specific context of this project, KEPHIS has a plant variety protection department for coordination purposes.

4.6.8 National Biosafety Authority

The National Biosafety Authority (NBA) was established by the Biosafety Act No. 2 of 2009 to exercise general supervision and control over the transfer, handling and use of genetically modified organisms (GMOs). The objective and purpose for which the Authority was established is to regulate research and commercial activities involving GMOs with a view to ensuring safety of human and animal health and provision of an adequate level of protection of the environment. To

achieve this objective, the Authority has established a transparent science-based process to guide decision making on applications for approval of research and commercial activities involving GMOs.

The National Biosafety Authority implements the Cartagena Protocol on Biosafety, a protocol under the Convention on Biological Diversity, which Kenya has also signed and ratified, in order to address safety for the environment and human health in relation to modern biotechnology. The National Biosafety Authority is under the Ministry of Agriculture and Livestock Development and has the following duties & responsibilities:

- Creating a National Biosafety Clearing House (BCH) where information on all approvals is posted.
- Data sharing with the International Biosafety Clearing House located in Montreal Canada.
- NBA is Kenya's Focal Point for Cartagena Protocol on Biosafety which Kenya has signed and ratified.
- Coordinating Biotechnology & Biosafety issues in the country to all the relevant stakeholders.
- Collaborating with relevant Government Departments and University faculties, to develop strategies in the fields of Biotechnology & Biochemistry.
- Conducting Environmental Risk Assessment for all GMO and products of modern biotechnology.

To do this, the NBA board is comprised of representatives of the following government ministries.

1. State Department for Science, Research and Innovation – Ministry of Education
2. State Department for Public Health – Ministry of Health
3. Ministry of Agriculture and Livestock Development
4. Ministry of Finance and National Treasury

4.6.9 Agriculture and Food Authority (AFA)

AFA is a state corporation under Section 3 of the Agriculture and Food Authority Act of 2013. The role of the Authority is to regulate, develop and promote Scheduled Crops value chains, for

increased economic growth. Roots and tuber crops are based in the food crops directorate. Cassava is listed as a scheduled crop under Part 2 of the First Schedule of the Crops Act.

4.6.10 Ministry of Agriculture and Livestock Development (MoALD)

The Ministry is charged with the creation of an enabling environment for the sustainable development and management of crops and livestock to ensure the country's food and nutrition security. It plays a key role in the economic and social development of the country by enhancing food and nutrition security, creating employment and wealth, and generating foreign exchange earnings. The MoALD is the parent ministry of KALRO and provides policy direction on agricultural research, including improving crop varieties to promote disease and pest resistance, enhance drought tolerance, increase crop yields, and improve nutrition through biotechnology.

4.6.11 Ministry of Health (MoH)

A government ministry whose key mandate is to build a progressive, responsive and sustainable healthcare system for accelerated attainment of the highest standard of health to all Kenyans as enshrined in the CoK 2010. In 2013, Kenya transitioned into a devolved system of governance comprising two levels: the national government and 47 County governments. Under the new system, the health service delivery function was assigned to County governments while the national government was responsible for health policy and regulatory functions, technical assistance to counties, and management of national referral health facilities. MoH provided expert review with regards to human health safety during the risk assessment process for the developed GM cassava varieties.

4.6.12 Kenya Bureau of Standards

KEBS develops standards for food products, including those related to food safety, specifications, and codes of practice. The bureau conducts food safety assessments and evaluates data to ensure food products, including those derived from GM crops, are safe for consumption. It is also involved in inspecting and monitoring such food products to ensure they meet the established standards. KEBS provided expert review with regards to food safety during the risk assessment process for the developed GM cassava varieties. KEBS serves as the National Codex Contact Point, which means it is responsible for facilitating communication and coordination related to Codex activities within the country.

4.6.13 Directorate of Veterinary Services (DVS)

Domiciled in the Ministry of Agriculture and Livestock Development, it is responsible for implementing strategies, policies, and legal frameworks related to animal health, including disease management and laboratory diagnostic services, and also the regulation of veterinary practices. Among its roles include regulation, inspection, and ensuring the quality of veterinary inputs, live animals, animal feed, and animal products as well. DVS provided expert review with regards to feed safety during the risk assessment process for the developed GM cassava varieties.

4.6.14 County Departments of Agriculture

Agriculture being a devolved function, County Departments of Agriculture are tasked with developing and managing agricultural services and programmes within their jurisdictions. These departments will be key actors in the implementation of the proposed commercialization, particularly with regards to distribution of KEPHIS-certified, clean planting materials, farmers field training and extension services, post-harvest management, and value addition & market linkage interventions.

5.0 STAKEHOLDERS CONSULTATION AND PUBLIC PARTICIPATION

5.1 Introduction

Stakeholders' consultation and public participation are integral to the ESIA process. They ensure the opinions, concerns, and suggestions of primary and secondary stakeholders are heard, considered and shape the decision-making process regarding the project. Effective public participation ensures that these concerns are adequately addressed while fostering transparency and accountability creating a sense of responsibility, commitment and local ownership for smooth implementation. Additionally, this process helps to identify potential environmental and social impacts ensuring that mitigation measures are developed in line with the concerns raised.

The need for stakeholders' consultation and public participation when carrying out ESIA studies is underscored by the Kenyan Constitution, 2010; County Government Act, 2012 (Amended 2020); and EMCA, 1999 (Amended 2015), particularly Section 58. Regulation 17 of the Environmental (Impact Assessment and Audit) Regulations, 2003 requires project proponents to seek the views of the public pertaining to the ESIA study being conducted for projects listed under EMCA's second schedule. It is a critical process through which stakeholders, including project beneficiaries, members of the public, and other interested parties, are given the opportunity to contribute to the project by making recommendations and raising concerns before its implementation. Therefore, the role of public consultation and involvement in ESIA process is to assure the quality, comprehensiveness and effectiveness of the assessment and ensure that the public views are adequately integrated in decision making process.

This chapter describes the process of the public consultation and participation that was followed in order to identify the key issues and impacts of the Proposed Commercialization of Genetically Modified Cassava in Kenya.

5.2 Objectives of Consultation and Public Participation (CPP)

By incorporating public input, the ESIA process ensures that the proposed placing in the market of the GM cassava is not only environmentally and socially sustainable but also economically beneficial to targeted beneficiary farmers and local communities, and aligned with both national and international development goals. Therefore, the ESIA team conducted the public consultation and participation, with respect to the proposed development, to fulfil the following objectives:

- To adhere to the legal requirement in accordance with Section 58 of the Environmental Management and Coordination Act, 1999 (Amended 2015), and Regulation 17 of the Environmental (Impact Assessment and Audit) Regulations, 2003;
- To disseminate and inform the stakeholders about the proposed GM cassava commercialisation project with special reference to its development and importance to cassava farmers;
- To enhance ownership of the project through the devolved agricultural governance structures, the local cassava farmers and the larger community by extension.
- To understand stakeholders 'concerns and expectations about the newly developed and approved GM cassava and its commercialization process;
- To understand and characterize potential environmental and socio-economic impacts of the proposed GM cassava commercialization project, as well as proposing possible mitigation measures; and
- To integrate all the views, concerns and suggestions collected in the ESIA study.

In addition, the process enabled the establishment of a communication channel and fostering of synergy among the general public, consultant, project proponent, and both County and national governments. The views collected were very crucial in helping decision makers to fully understand the concerns of the stakeholders and the anticipated impacts of the project at an early phase of project planning.

5.3 Methodology for conducting CPP

Stakeholder's engagement started from an early stage of the scoping and continued throughout the assessment to ensure legislative requirements and standards were met. Just as the degree of stakeholder relevance may vary throughout the project lifecycle, the most appropriate communication and consultation method also vary between stakeholders. Consultation with stakeholders was initiated by undertaking stakeholder analysis and identification. The stakeholder identification and analysis were undertaken by the consultant in close collaboration with the client.

The stakeholders were categorized into two major groups;

a. Primary Stakeholders – Those directly affected by the project such as cassava farmers representatives in 19 cassava growing counties, Cassava Seed Entrepreneurs (CSEs), community opinion shapers, and interested members of the public.

b. Secondary Stakeholders – Those indirectly affected by the project but who influence development as part of its project implementation. They included the responsible agencies of both the County and National Government, and agricultural civil society organizations.

To ensure adequate representation of cassava farmers, their representatives were drawn from wards within selected sub-counties located in the 19 cassava-growing counties where public participation forums were undertaken, as indicated in the Table 43. This inclusive approach was aimed at capturing diverse views, promoting transparency, and facilitating equitable input across all key cassava-producing regions. Involving representatives from the grassroots level ensured that the unique needs, concerns, and recommendations of farmers from different agroecological zones in Coastal, Western, Eastern, Central, Rift Valley, and Lake Regions were documented and considered in decision-making processes in regard to the proposed commercialization of GM cassava.

Table 43: Farmers Representation from wards and sub-counties in the respective cassava-growing counties

County	Sub-County	Ward
Lamu	Lamu West	Shella/Manda
		Mkomani
		Hindi
		Mkunumbi
		Hongwe
		Witu,
		Bahari
Kilifi	Kilifi South	Junju
		Mwarakaya
		Shimo la Tewa
		Mtepeni
		Chasimba
	Kilifi North	Tezo
		Sokoni
		Kibarani

County	Sub-County	Ward
		Dabaso
		Matsangoni
		Watamu
		Mnarani
Kwale	Matuga	Tiwi
		Kubo South
		Tsimba-Golini
		Mkongani
		Waa
	Msambweni	Gombato/Bongwe
		Ukunda
		Kinondo
		Ramisi
Taita-Taveta	Taveta	Mahoo
		Bomeni
		Mboghoni
Makueni	Kibwezi West	Kikumbulyu North
		Kikumbulyu South
		Makindu
		Nguu/Masumba
		Kwakakulu
	Kibwezi East	Masongaleni
		Mtito Andei
		Thange
		Ivingoni/Nzambani
Kitui	Kitui Central	Mulango
		Kyangwithya East
		Kyangwithya West
		Miambani
		Township
	Kitui Rural	Kisasi
		Mbitini
		Kwa Vonza\Wote
		Kanyangi
	Kitui West	Mutonguni
		Kauwi
		Matinyani
		Kwa Mutonga/Kithumula

County	Sub-County	Ward
Machakos	Machakos Town	Muvuti/Kiima-Kimwe
		Mutituni
		Mumbuni North
		Mua
		Machakos Central
		Kalama
		Kola
Embu	Runyenjes	Kyeni North
		Kyeni South
		Kagaari North
		Kagaari South
		Gaturi North
	Mbeere North	Evurore
		Nthawa
		Muminji
	Mbeere South	Kiambere
		Mavuria
		Mbeti
Tharaka Nithi	Maara	Mitheru
		Muthambi
		Chogoria
		Ganga
	Chuka/Igambang'ombe	Magumoni
		Igambang'ombe
		Mugwe
		Mariani
		Karingani
	Tharaka North & South	Marimanti
		Gatunga
		Chiakariga
Muranga	Maragua	Makuyu
		Ichagaki,
		Kambiti
		Kamahuha
	Kandara	Muruka
		Kagundu
		Gaichanjiru

County	Sub-County	Ward
		Ithiru
	Kiharu	Mbiri
		Township
		Gaturi
		Mugoiri
	Gatanga	Gatanga
		Kihumbu-ini
		Kakuzi/Mitubiri
		Ithanga
		Mugumoini
Nakuru	Njoro	Lare
		Njoro
		Kihingo
	Subukia	Subukia
		Kabazi
	Rongai	Soin
		Menengai West
		Solai
	Gilgil	Gilgil
		Elementaita
		Mbaruk/Ebburu
Baringo	Tiaty West	Ribkwo
		Kollowa
	Tiaty East	Tangulbei
		Loiyamorok
		Churo/Amaya
	Mogotio	Mogotio
		Emining
		Kisanana
	Baringo Central	Kabarnet
		Kapropita
		Sacho
	Baringo North	Kabartonjo
		Barwessa
		Saimo Soi
		Saimo Kipsaraman
		Bartabwa
	Baringo South	Marigat

County	Sub-County	Ward
		Ilchamus
	Eldama Ravine	Lembus
		Ravine
		Lembus Kwen
		Lembus Perkerra
		Mumberes/Majimazuri
Kakamega	Kakamega South	Idakho East
		Idakho Central
		Idakho North
		Idakho South
Bungoma	Kanduyi	Tuuti/Marakaru
		Khalaba
		Township
		Musikoma
		Bukembe West
		Bukembe East
	Sirisia	Malakisi/South Kulisiru
		Lwandanyi
		Namwela
	Tongaren	Milima
		Soysambu/Mitu
		Naitiri/Kabuyefwee
		Mbakalo
		Tongaren/Kiminin
		Ndalu/Tabani
	Bumula	South Bukusu
		Bumula
		Khasoko
		Kabula
	Webuye West	Bokoli
		Matulo
		Sitikho
		Misikhu
Busia	Teso South	Amukura Central
		Amukura East
		Amukura West
		Chakol North
		Chakol South

County	Sub-County	Ward
		Angorom
	Matayos	Bukhayo West
		Burumba
		Busibwabo
		Matayos South
		Mayenje
	Teso North	Angurai East
		Angurai North
		Angurai South
	Samia	Agengá Nanguba
		Bwiri.
		Namboboto Nambuku
		Nangina.
	Nambale	Bukhayo Central.
		Bukhayo East
		Bukhayo North/Walatsi.
		Nambale Township
Vihiga	Emuhaya	West Bunyore
		Central Bunyore
		North East Bunyore
Migori	Rongo	North Kamagambo
		East Kamagambo
		Central Kamagambo
		South Kamagambo
	Awendo	Central Sakwa
		North Sakwa
		West Sakwa
		South Sakwa
	Suna East	God Jope
		Suna Central
		Kakrao
		Kwa
	Suna West	Wiga
		Wasweta II
		Ragana-Oruba
		Wasimbete
	Uriri	Central Kanyamkago
		East Kanyamkago

County	Sub-County	Ward
		West Kanyamkago
		North Kanyamkago
		South Kanyamkago
	Nyatike	North Kadem
		Kanyasa
		Kaler
		Macalder Kanyaruanda
		Got Kachola
		Muhuru
		Kachieng
	Kuria East	Gokeharaka / Getambwega
		Nyabasi West
		Nyabasi East
		Ntimaru West
		Ntimaru East
	Kuria West	Nyamosense / Komosoko
		Tagare
		Masaba
		Isebania
		Makerero
		Bukira Central / Ikerege
		Bukira East
Kisumu	Seme	Central Seme
		West Seme
		East Seme
		North Seme
Homa Bay	Rangwe	Kagan
		Kochia
		Gem East
		Gem West

(*Source: Field Survey, 2025*)

NB: It is important to note that further public involvement will include inviting members of the public, including farmers who were not reached during the physical public participation meetings, to submit written comments to NEMA following the Kenya Gazette notice, publications in two newspapers for two consecutive weeks with nationwide circulation, and radio announcements.

Both participatory methods and analytical tools were applied to ensure the inclusion of the opinions of all stakeholders. Data collection involved consultative meetings held with cassava farmer representatives, as well as discussions and interviews with key stakeholders representing various government institutions and interested groups including agricultural civil society organizations. In addition, structured questionnaires were administered to supplement qualitative findings and generate quantitative insights. This combination of methods ensured that the ESIA process was grounded on comprehensive, inclusive, and representative stakeholder engagement, aligning the project outcomes with community expectations and regulatory requirements.

5.3.1 Questionnaire administration

The consultant prepared open-ended questionnaires tailored for each group of stakeholders including cassava farmer representatives and key informants to elicit detailed and thoughtful responses from the participants (Plate 1). The approach employed to ensure that the views of the farmers' representatives were as diverse and representative as possible. It entailed giving each sub-County or ward with representatives an opportunity to discuss and complete the presented questionnaire. Each County was allocated 10 questionnaires, divided equally among the farmers' representatives across all the sub-counties or wards present. A total of 190 questionnaires were completed.

This method of stakeholder engagement not only facilitated information gathering but also promoted active stakeholders' involvement and ownership of the project's assessment process. All the views from the stakeholders were summarized and incorporated in the relevant sections of this report. In the ESIA report, the consultant has annexed a repository of the filled questionnaires, ensuring transparency and accessibility to the stakeholders' input.

Plate 1: Farmer's representatives in Machakos and Migori counties engaging in discussions during questionnaire administration

5.3.2 Public Forums

Public forums were held across 19 key cassava-growing counties in the former provinces of Coast, Eastern, Central, Rift Valley, Western, and Nyanza between 25th June 2025 and 29th July 2025. In order to ensure that the public engagement forums were as representative and effective as possible, the consultant with the support of KALRO and MEDA in some areas reached out to the County Executive Committee Members (CECMs) in charge of Agriculture across all the 19 counties. The CECMs were officially briefed about the proposed commercialisation of GM cassava and the public participation exercise for undertaking the ESIA. Thereafter, they were requested to assist in the invitation of farmer representatives from all cassava-growing regions within their jurisdiction.

The CECM then engaged County Directors of Agriculture (CDA) to cascade the information to the cassava farmers within the relevant sub-counties and wards. The CDAs then directed the Sub-County Agricultural Officers (SCAOs) and Ward Agricultural Officers (WAOs) to undertake the mobilisation of farmers to attend the public engagement forums at the respective venues booked for the exercise. The invitation to attend the meeting managed to cut across a wide spectrum of attendees including but not limited to; crops development officers, agricultural officers, sub-County and ward administrators, Agricultural Civil Society Organisation (CSO) groups, Chiefs among others. Public meeting notices were communicated via Short Message Service (SMS) texts and phone calls, and disseminated through the mobilizers. Notices were sent at least one week prior to the meetings.

The public meetings aimed to engage a wider audience in information sharing and discussion. They helped raise awareness of the proposed commercialization of GM cassava and provided participants with the opportunity to voice their concerns, opinions, and suggestions. The meetings were instrumental in securing a social license for the project by fostering community acceptance. Most importantly, the sessions facilitated deliberations on the potential positive and negative impacts of the project, as well as identifying appropriate mitigation measures and capturing other pertinent issues raised by affected stakeholders. Minutes of the public barazas and signed attendance sheets have been annexed to this report.

Table 44 and Plates 2 to 5 depict the venues and their respective counties, the dates on which the meetings were held, and the number of participants.

Table 44: A List of Public Forums held across cassava growing regions

S/No	Venue/County	Nature of Meeting	Date	No. of Participants
	Total No. of Participants-783			
1.	Baroness Hotel, Piketon, Lamu County	Public Forum	25th June 2025	51
2.	KALRO Mtwapa Conference Hall, Kilifi County	Public Forum	27th June 2025	50
3.	KALRO Matuga, Kwale County	Public Forum	30th June 2025	48
4.	Ngaringashe Chief's Office, Taveta, Taita Taveta County	Public Forum	1st July 2025	44
5.	Kitui Agricultural Training Centre, Kitui County	Public Forum	3rd July 2025	51
6.	KALRO Embu Library Hall, Embu County	Public Forum	9th July 2025	30
7.	EAPC Chuka Town Church, Tharaka Nithi County	Public Forum	9th July 2025	61
8.	ACK Machakos Town Church, Machakos County	Public Forum	10th July 2025	49
9.	Kambua Resort, Kibwezi, Makueni County	Public Forum	11th July 2025	49

S/No	Venue/County	Nature of Meeting	Date	No. of Participants
10.	Mulwanda PAG Assembly, Idakho North, Kakamega County	Public Forum	14th July 2025	31
11.	Mukhwana's Homestead, Tuuti/Marakaru, Bungoma County	Public Forum	15th July 2025	40
12.	KALRO Alupe Conference Hall, Busia County	Public Forum	16th July 2025	33
13.	Essunza Church of GOD, Emuhaya, Vihiga County	Public Forum	17th July 2025	39
14.	ACK St. John's Dudi Church, Seme, Kisumu County	Public Forum	18th July 2025	36
15.	Sunaton Hotel, Suna East, Migori County	Public Forum	21st July 2025	32
16.	Sinogo Catholic Church, Rangwe, Homabay County	Public Forum	22nd July 2025	41
17.	Baringo Central NG-CDF Conference Hall, Baringo County	Public Forum	24th July 2025	38
18.	Agricultural Technology Development Centre-Soilo, Nakuru County	Public Forum	25th July 2025	33
19.	ACK St. Mary's Church, Kenol, Muranga County	Public Forum	29th July 2025	27

(*Source: Field Survey, 2025*)

Plate 2: Public baraza with cassava farmers in Mpeketoni, Lamu County

Plate 3: Public baraza with cassava farmers and County department of agriculture officers in Chuka, Tharaka Nithi County

Plate 4: Stakeholder engagement through public baraza and questionnaire administration at Kitui Agricultural Training Centre, Kitui County

Plate 5: Stakeholder engagement with cassava farmer representatives and CSEs at KALRO Alupe, Busia County

5.3.3 Key Informants Interview (KII)

The consultant engaged various key informants including project proponent, opinion leaders in their respective local communities, National Government Administration Officers (NGAOs), interested groups including Civil Society Organizations (CSOs), as well as representatives from various government ministries and County departments. These groups are highlighted in the table below 45 below were engaged through face-to face interviews, and in some cases, questionnaire administration. This particular stakeholders' engagement approach served as a means to obtain in-depth information and opinions regarding the proposed commercialization of GM Cassava's potential impacts and its implications on the concerned parties. KII facilitated the exchange of information, fostering understanding, and ensuring that the project's potential impacts are thoroughly assessed and considered. These interviews played a key role in addressing concerns and ultimately contributing to more informed decision-making and development of effective mitigation strategies.

Government officials and representatives from ministries, departments and agencies offered insights into the project's alignment with existing policies, laws, and regulations. Engagement with community opinion shapers and CSOs offered help in understanding the community's sentiment towards the project, hence providing an opportunity to address community concerns and build support or consensus where possible.

Table 45: Key Informants Consulted

S/No.	Key Informants
1.	County Executive Committee Members (CECM), Department of Agriculture and Livestock, and Cooperatives as well
2.	County Directors of Agriculture
3.	Sub-County and Ward Agricultural Officers
4.	Crop Development Officers in respective Wards, Sub-Counties, and Counties
5.	NGAOs, particularly Assistant Chiefs and Chiefs
6.	Sub-County Administrators
7.	KALRO Research Scientists in Alupe, Mtwapa, Matuga, Embu, and Kakamega
8.	Technical Officer, Build Resilience for Food and Nutrition in the Horn of Africa Project (BREFONS), Baringo County
9.	Community-Driven Development Committee (CDDC) Members in National Agricultural Value Chain Development Project (NAVCDP) in various counties
10.	Agricultural CSOs – Gilgil Seed Savers Network, Nakuru County
11.	Area Manager in charge of Homabay, Migori, Kisumu, Bungoma, Busia, and Kakamega Counties, Mennonite Economic Development Agency-Kenya (MEDA-K)
12.	CSEs commissioned by MEDA-K
13.	Cooperative Officers at Sub-County and County Levels
14.	VIRCA Plus Technical Assistants and Field Personnel
15.	Cassava Farmers' Cooperative Societies
16.	Gacharu Irrigation Scheme Representatives, Muranga County

(*Source: Field Survey, 2025*)

Plate 6: Consultant and KALRO scientist engaging with Baringo CECM for Agriculture and other staff from the department
(Source: Field Survey, 2025)

Plate 7: Consultant team engaging with KALRO Matuga Centre Director

(Source: Field Survey, 2025)

5.4 Analysis of views of stakeholders and public with regards to the proposed commercialization of GM cassava in Kenya

Based on consultations and public participation forums held, various opinions and views were collected. All relevant stakeholders and interested groups expressed the anticipated benefits likely to arise from the proposed commercialization of GM cassava in Kenya. Some of the perceived benefits associated with improved cassava varieties and their proposed commercialization include:

- Cassava as a source of food and feed: Both the roots and leaves are edible for humans and animals, and cassava peelings can also be fed to livestock.
- GM cassava is poised to offer farmers a better return on investment, thereby improving their household incomes and enhancing overall livelihoods.
- Genetically modified cassava will contribute significantly to food security by ensuring stable and increased yield.
- The broad leaves of cassava provide shade to the soil, reducing moisture loss, improved soil structure and fertility, and also suppressing weed growth.
- Dried cassava stems can be repurposed as firewood, providing an additional source of household energy and reducing deforestation.
- The disease-resistant GM cassava will lower the overall cost of production.
- Cassava can act as a natural cover crop, helping to protect the soil from erosion, preserve soil health, and enhancing sustainability in intercropping systems.
- The crop promotes zero-waste utilization, as all parts of the plant can be used in various productive ways, aligning with circular economy principles.
- The GM cassava offers great potential for value addition through the processing of its roots into various products, thereby contributing to agro-industrial development and job creation.
- Cassava is naturally drought-resistant, making it a highly reliable crop in arid and semi-arid regions.
- The commercialization of GM cassava will catalyse job creation across the agricultural value chain
- The development of the GM cassava has created a significant platform for advancing agricultural biotechnology research and scientific innovation in Kenya.
- Farmers and CSEs will benefit from income opportunities through certified seed multiplication and value chain integration, supported by actors such as MEDA and County Governments.
- Reduced Pesticide Use and Environmental Safety as in-built resistance of the developed GM cassava to CBSD and CMD will significantly reduce or eliminate the need for chemical pesticides.

The table 46 below highlights concerns that were raised by stakeholders and suggested mitigation measures:

Table 46: Issue and Comment Matrix Table

S/No.	Environmental or Social Concerns	Responses in terms of mitigation measures
1.	Concerns over the levels of cyanide in the newly developed varieties, and whether they were safe	• KEPHIS has certified that the developed cassava varieties have cyanogenic levels within the permissible limits • Proper pre-consumption processing methods such as drying, boiling, fermenting, or thorough washing, particularly for leaves, are recommended to significantly reduce cyanogenic contents.
2.	Public fear and misconceptions regarding adverse effects of genetically modified crops including the developed cassava on human and animal health and environment	• Public awareness and sensitization to simplify the science behind GM cassava, clearly explaining safety assessments, regulatory approvals, and nutritional and economic benefits. • Establishment of demonstration farms and farmer field days in KALRO centres where farmers can engage with the developed GM cassava in real conditions. • Clear and inclusive communication channels showing the multiple trials and rigorous testing GM cassava has undergone covering food safety, animal feed, and environmental impact.
3.	Challenge of losing the tuber crop to rodents such as moles (as reported in the counties of Busia, Vihiga) and porcupines (as reported in Baringo)	• Biological control strategies such as intercropping sesame in cassava plantations, which acts as a natural repellent to moles; chemical control, using products like *FukoKill*; and traditional methods such as mixing dried manure with pepper and burning it inside underground holes where the moles inhabit can wade off moles. • Farmers should minimize vegetative debris on their farms and to undertake frequent weeding, as such practices help reduce habitats that may harbor rodents.

S/No.	Environmental or Social Concerns	Responses in terms of mitigation measures
4.	Societal attitude (considered as a "poor man's crop") attributed to low cassava consumption	• Need for awareness creation and sensitization on the nutritional and financial benefits of cassava, including its potential for value addition.
5.	Challenges of poor market prices and market accessibility associated with cassava	• Value addition can improve market prices and accessibility • Farmers to form cassava cooperative societies or revive those that are already registered but dormant to enhance market linkages to potential value addition processors • Collaboration between County Departments of Agriculture (CDAs) and farmers' groups to enhance market accessibility, improve existing market prices, and integrate the cassava value chain into ongoing relevant projects as a way of strengthening the sector.
6.	Challenge of storage of the developed cassava considering its highly perishable	• Dry the cassava for longer storage, and keep it in a dry place as well • Use hermetic storage bags can store cassava for close to a year • Encourage small-scale processing of cassava into flour, chips, or starch at household or cooperative level to extend shelf life and reduce losses. • Build farmers' capacity on proper harvest planning and staggered planting to avoid glut. Coupling this with training on post-harvest handling techniques will ensure minimal spoilage and a more sustained supply to the market or processors. • County governments should fast track completion of County Aggregation Industrial Parks to provide decentralized, climate-smart storage and processing facilities such as cool storage rooms & mobile graters/dryers.
7.	Accessibility challenges to KEPHIS-certified cuttings of the newly developed cassava	• Collaboration between farmers' groups, KALRO, MEDA (where they have presence), and CDAs should be fostered to facilitate access to clean planting materials.

S/No.	Environmental or Social Concerns	Responses in terms of mitigation measures
		• Establish demonstration farms in counties where KALRO centres are involved in multiplying and bulking the cultivars, to promote farmer field training on good agricultural practices for the improved cassava varieties. • Build the capacity of County extension officers and train lead farmers or CSEs to act as localized trainers and knowledge brokers. • Engage Research Extension Liaison Officers (RELOs) enacted by the MoALD through KALRO to strengthen scientific extension services.
8.	Challenges of pests and diseases after varietal release	• Strengthen seed system and use of certified planting materials to ensure farmers consistently access clean planting materials, and maintain varietal integrity across production cycle. • Train farmers on Integrated Pest and Disease Management to sustainably manage emerging pests and diseases.
9.	Farmers might consider planting other cash crops due to the long growing period of the developed cassava, societal attitude, market access challenges, and poor market prices	• Encourage phased planting and compatible intercropping to reduce the economic burden of cassava's long maturity period while diversifying income streams and enhancing food security. • Collaborate with private sector players and government agencies to establish structured markets, promote contract farming, and incentivize processors to prioritize cassava.
10.	Lack of farmer knowledge on different varieties and their characteristics, as well as their involvement in final selection of varieties and naming	• Conduct gender-responsive participatory varietal selection technique to ensures that farmers' preferences on traits such as yield, taste, maturity period, and drought resistance are considered before release. This will also allow farmers to propose or vote on local names for the varieties selected for commercialization • Establish demo plots across agroecological zones to showcase the performance of the developed varieties.

S/No.	Environmental or Social Concerns	Responses in terms of mitigation measures
11.	Crop losses to wildlife, particularly elephants and warthogs from Tsavo East National Park and Chyulu Hills National Park in Makueni and Taita Taveta Counties, and Shimba Hills National reserve in Kwale County, have been reported, while in Kisumu County, parts of Seme sub-County, crops are damaged by monkeys	• Promote buffer planting with less palatable crops. • Support community-led wildlife barriers such as eco-friendly deterrents such as solar-powered electric fences, beehive fences (effective against elephants), and trenching where feasible • Institute prompt assessment and compensation or losses, especially where GM cassava is being promoted as a key livelihood crop.
12.	Concerns over theft of the newly developed cassava varieties from farms	• Lobby for increased uptake of the newly developed varieties and production by farmers to reduce the novelty and scarcity that often triggers theft and can plant the cassava with guard rows as well. • Large-scale farmers should also consider securing their cassava plantations adequately, including the use of fencing and regular surveillance. • Encourage farmer groups or cooperatives to work with local administration
13.	Concerns over disappearance of existing cassava varieties such as *Kibanda Meno*, *Selina*, *Karembo*, and *Tajirika* after adoption of the improved cassava, and whether the new cassava varieties will affect diversity of existing varieties	• Promote on-farm conservation by encouraging farmers to continue growing traditional varieties alongside GM cassava • Ensure germplasm of the existing varieties is preserved at KALRO's gene bank, considering their unique breeding abilities, for future breeding or reintroduction. • Conduct gender-responsive participatory varietal selection technique and promote a co-existence model where traditional and GM varieties are cultivated together, maintaining biodiversity and farmer choice. • Ensure documentation of agronomic traits, cultural significance, and uses of local varieties.

Additional suggestions and recommendations provided by stakeholders in regard to the proposed commercialization of GM cassava in Kenya:

- Need to establish national roots and tuber crops policy through fostering synergies between government agencies and institutions such as KALRO, MoALD, County Governments, and Agriculture and Food Authority.
- Consider issuing farmers with certified cuttings of the newly developed cassava varieties before the onset of the planting season to ensure timely planting.
- Organize farmer field days at demonstration farms within KALRO stations once the developed varieties are commercially released.
- MEDA-K has provided trainings on enterprise development, record keeping and financial management that will go a long way in ensuring the sustainability of the seed development/production system.
- Educate farmers on proper agronomic practices as well as post-harvest handling and processing techniques specific to the newly developed cassava varieties.
- MEDA has put plans in place to link farmers to markets and value addition industries, with an emphasis on the use of clean planting materials propagated by CSEs and certified by KEPHIS to facilitate market access.
- In the context of training and capacity building, there is a need to enlighten farmers, beyond the CSEs, to serve as ambassadors for the adoption and uptake of the developed cassava varieties, while also coordinating efforts to continually manage CBSD and CMD
- Impart knowledge and create awareness on the safety of the tuber as a biotechnologically improved cassava variety, aimed at addressing challenges of accessibility caused by misconceptions about GM crops.
- Leverage the upcoming County industrial parks to enhance skills development and provide infrastructure necessary for cassava value addition.
- Ensure timely dissemination of information regarding access to the released cassava varieties through available channels, including communication updates by County agricultural officers and CSEs.
- Farmers should follow the due procedure when seeking compensation for crop losses to wild animals, which includes reporting the incident to Kenya Wildlife Service (KWS), filling out the required form, and undergoing an assessment initiated by the KWS in liaison

with the CDAs. Farmers were cautioned against falsifying information during the reporting process, as this could jeopardize their eligibility for compensation.

- Emphasis placed on the urgent need to ensure that all research outputs developed through participatory approaches involving local communities directly benefit those same communities at the grassroots level.
- Explore and promote modern storage techniques to reduce post-harvest losses.

5.5 Project Acceptance

The public engagement was entirely successful with 99.9% acceptance rate within all cassava growing regions. In particular, there was an open segment in the questionnaire where farmers' representatives and other stakeholders were to tick to either support or reject the project. Fortunately, 99.9% ticked 'YES' as an expression of their unwavering support for the commercialization of the GM cassava.

Note: Copies of minutes, attendance lists and the questionnaires used to collect views of stakeholders on the project have been annexed in this report.

6.0 EVALUATION OF PROJECT ALTERNATIVES

6.1 Introduction

This chapter evaluates several project alternatives based on technical and professional judgement of the project team. In addition, the section has considered four options namely; "No project Alternative", Adoption pesticide use; Adoption of other roots & tuber crops and the 'proposed alternative". The evaluations elucidate why the 'proposed alternative' is the most viable option; environmentally, socially and economically.

6.2 No project alternative

The 'No project alternative' is where the GM cassava varieties commercialization project fails to materialize. It is also referred to as maintaining the 'status-quo option'. By adopting this approach, it will have dire ramifications to the survival and existence of cassava as a crop in the near future. From the evidence gathered from the farmers across cassava growing regions CMD and CBSD have continuously discouraged farmers who after a long period of waiting to harvest cassava, continuously end up in total economic losses. In addition, the conventional varieties have been accused of containing high cyanogenic levels that has occasioned the harvesting of the existing bitter varieties that are constantly associated with cassava-related deaths. Therefore, with such varieties engulfing the farmers' environment, deaths will be imminent and cause more famers to shun away from growing cassava. The looming effects of this has started taking a toll on farmers since majority of cassava farmers currently, have switched to other fast-growing crops that are termed to be reliable and profitable.

The notable implication owing to the change in farmer practice -to switch to other crops- has been linked to the witnessed closure of the existing cassava processing industries. The primary reason has been blamed on the low supply of raw materials to support the value-addition process. Consequently, a lot of people have lost their source of livelihoods. Another consequence of this option is the current witnessing of infiltration of cassava into the country from our neighboring countries. Evidently, the lack of clean planting material will completely kill the local production of cassava making Kenya to entirely rely on imports from Uganda to meet the population's cassava needs.

6.3 Adoption of pesticides use alternative

This is an alternative option at the disposal of the proponent and cassava farmers. It well known that cassava mosaic and cassava brown diseases are transmitted by whiteflies. However, pesticides are considered ineffective overtime since whiteflies easily develop resistance to insecticides. Also, pesticides can be expensive especially to small-scale farmers and may offer little in terms of return on investment (ROI). Another challenge of using pesticide is their potential to be harmful to other beneficial insects as well as their likelihood to pollute the environment. Additionally, these insecticides also pose a major risk to the human health. The use of pesticides may lead to the risk of harmful residues in the harvested crop hence unsafe for human consumption. Finally, the act of eliminating natural predators with pesticides can result to unprecedented cycle of increased pest populations hence the need for more pesticide application. Despite the application of pesticides to eliminate the existing whiteflies, an already infected plant will remain infected and since cassava is vegetatively propagated, if a farmer replants an already infected stem cutting then the disease will keep on spreading with no control.

6.4 Adoption of other roots and tuber crops

This is an option however; pest and diseases are also affecting other complimentary root and tuber crops such as potatoes. For example, potato late blight is a major fungal disease that can devastate potato crops, especially in cool, humid conditions. In addition, bacterial wilt and viral infections technically reduces yields and tuber quality when using farm-saved or uncertified seeds in potato production. Also, sweet potato virus disease is considered as a viral disease affecting yield quantities and often leads to poor quality sweet potatoes. Therefore, the complementary options for cassava are also contending with a range of pest diseases including but not limited to; aphids, weevils and other insects. Hence, the adoption of this option would mean that farmers forgo the production of cassava owing to the persistent losses occasioned by the prevailing CMD &CBSD. Such a decision would curtail the economic growth of some cassava growing regions in the country where it is a major cash crop. Consequently, this would further lead to stifling of cassava related Small and Medium-sized Enterprises (SME's) and existing cassava processing industries such as the one in Busia County. Generally, there is no safer route than resolving the persistent cassava mosaic and brown streak diseases through the introduction of the approved genetically modified varieties.

6.5 Proposed project Alterative

The proposed alternative supports the commercialization process of the approved GM cassava varieties owing to numerous benefits attached to it. For a long time, farmers across the country have grappled with the discouraging virus infection transmitted by white flies (*Bemisia tabaci*) and spread through the use of infected stem cuttings since the crop is vegetatively propagated. The resultant diseases caused by the virus are mainly; cassava brown streak and cassava mosaic diseases. These diseases have caused tremendous losses to farmers who have largely decided to switch to other fast-growing crops. Their actions have been occasioned by the prolonged maturity period for conventional varieties coupled with the prevailing diseases that has not only affected yield levels but also the edibility of the harvested cassava due to high cyanogenic levels. With the approved GM varieties, the issue of diseases will be a thing of the past owing to introduction of clean planting materials which are disease-free and containing desired genetic purity. This is expected to create an enormous relief to farmers because the approved varieties are characterized by better yield content, lower cyanogenic levels, less maturity period, multi-purpose usage (household and industrial uses) and are all sweet varieties.

Further, the research for the approved GM varieties began in 2008 and has undergone rigorous tests and experiments seeking for a lasting sustainable solution. In addition, a lot of man hours and resources have been utilized across the numerous years of scientific research up to the undertaking of the national performance trials (NPTs) in 2023 and 2024. KEPHIS [through National Performance Trials Committee (NPTC)] having recommended release of the 8 varieties, the proposed alternative is regarded as a game changer in the cassava production. It will spur a renewed interest from farmers to engage in planting a once abandoned crop that will impact livelihoods through revitalization of dormant and/or closed cassava processing industries as well as motivate the establishment of the new ones across cassava growing regions. This will be linked to abundance in supply of the cassava crop. Therefore, this option has a lot of environmental, social and economic benefits which cassava farmers will enjoy upon commercialization of the approved varieties.

7.0 ANTICPATED PROJECT IMPACTS AND MITIGATION MEASURES

7.1 Introduction

This section has discussed comprehensively all the project anticipated impacts. This segment has addressed all project associated benefits likely to be derived from the proposed commercialization of the GM cassava in Kenya. Further, all anticipated adverse environmental and social impacts likely to result from the proposed commercialization activities have been methodically discussed and their corresponding mitigation measures enumerated. All this was undertaken with the aim of safeguarding both human population and their surrounding environment.

7.2 Positive Impacts

7.2.1 Enhanced food security

The newly developed and approved GM varieties will act as a source of food and feed for livestock just as the conventional ones. The roots can be consumed in multiple form which includes; raw state, through boiling or after processing it into flour which can further be utilized for making porridge, baking or blending with other cereals. Majority of the farmers also recorded that leaves forms part of their delicacies mainly as nutritious vegetables thus a source of vitamins, proteins, minerals and fibre. Therefore, the GM varieties will continue to contribute to both food and feed to households and the Kenyan community at large.

7.2.2 Resistance to diseases

The developed and approved cassava GM varieties have been improved using biotechnology to be resistant to both cassava mosaic and cassava brown streak diseases. These diseases have been a menace for all cassava growing regions in the country significantly affecting yield and making farmers to abandon the growth of this once treasured crop within Kenyan homesteads. The prolonged maturity period coupled with prevalent diseases has discouraged farmers from engaging in its cultivation thus switching to other short-term crops that are likely to meet their hunger needs without fear of great losses. However, with the new varieties, the challenge of diseases has been resolved and farmer confidence restored on the crop cultivation with guaranteed improved yield without worrying about CBD & CBSD. As a result, with this assurance of disease resistant varieties, most of the farmers will now revert to cassava production.

7.2.3 Drought-Resistant varieties

KALRO has ensured that the newly developed and approved cassava GM varieties possess similar characteristics to the conventional ones. The eight (8) varieties are adaptable in different agro-ecologies as evidenced during national performance trails (NPTs). The varieties have proved to be drought resistant due to their ability to tolerate very harsh dry conditions through a combination of both physiological and morphological adaptations. The GM varieties similarly adopts the normal plant behavior of rapid stomatal closure aimed at reducing water loss, the shedding of the leaves to reduce surface area to volume ratio exposed for transpiration and the use of its extensive root system to access water from deeper layers of soil.

7.2. Soil fertility improvement

The GM cassava plantation just like conventional ones are usually designed to shed their leaves as one way adapting to the harsh dry conditions. These leaves contribute in boosting soil fertility by decomposing and releasing nutrients that enrich the soil with organic matter hence improving its structure. Therefore, this recycling of nutrients particularly when leaves decompose ends up reducing significantly the dire need for synthetic fertilizers.

7.2.5 Important as a cover crop

The GM cassava varieties will be suited for use as a natural cover crop especially in environment possessing poor soils and harsh climatic conditions. The dense foliage in cassava plantations effectively suppress the growth of weed hence reducing the need for use of herbicides and manual weeding. In addition, the extensive root system of the cassava plants is fundamental in stabilizing the soil thus preventing soil erosion particularly in sloppy terrains. Finally, the intercropping of cassava with other crops is integral in creating diverse and resilient farming ecosystem

7.2.6 Source of biofuel

Cassava stems are usually regarded as a source of energy for rural communities. After harvesting, the harvested stems once dry are used as firewood hence helping homesteads light fire for various purposes such as lighting, cooking etc. The use of the stem as biofuel is important in reducing over-reliance on fossil fuels thereby promoting the adoption of more sustainable energy systems.

7.2.7 Easily propagated

The GM varieties of cassava will be propagated in an identical manner to the conventional varieties. This is done through stem cutting (stakes) rather than by seed. The stem cuttings are

highly preferable because the seeds are not reliable and often results in high degree of the genetic variability. The farmers will be able to use their harvested GM stems in order to expand on cassava acreage, thus further relieving farmers on the cost of purchasing fresh planting materials.

7.2.8 Improved productivity

The new GM varieties will offer better yield content owing to its resistance to CMD and CBSD. The breeding process ensured that the selected varieties are high in productivity as compared to the conventional varieties in the market. Improved productivity translates to more food and income for the cassava farmers.

7.2.9 Employment opportunities

The commercialization of new varieties will create more jobs for farmers during across the value chain which includes during farming, processing, transportation and marketing. Since the new varieties are engineered to have immense yield production, it will result to numerous job opportunities.

7.2.10 Source of income

All persons along the value chain will derive income from the interaction with the newly developed and approved eight (8) varieties. The income generated will boost their living standards.

7.3 Anticipated Negative Impacts (Pre-release Phase)

7.3.1 Illegal release and inadequate access to planting material

The proponent should continuously engage in replanting the eight (8) approved varieties earmarked for commercial release to ensure availability of clean planting materials upon NEMA approval. This will aid in ensuring that planting materials are multiplied, adequate and ready for distribution to farmers across all cassava growing regions in the country during the commercialization process. Care should also be taken to prevent any illegal release of the planting material before commercialization is sanctioned by the relevant government authorities.

Mitigation Measures

- The cassava plantations should be within confined fields to prevent any illegal release of stem cuttings for the GM varieties until all approvals are acquired.

- Engage in seed production of the approved GM varieties across various KALRO stations to ensure the clean planting materials are available and adequate for distribution to farmers upon commercialization.
- Segregate the best performing GM varieties for each cassava growing region based on their adaptability in different agro-ecologies to ensure they are available for commercialization
- Institute prior mechanisms using existing protocols for the naming of the various GM varieties with the aid of farmers and all relevant stakeholders for easier identification upon acquisition of all relevant approvals.

7.3.2 Non-adherence to existing protocols

There are diverse relevant legal, policy and regulatory frameworks both locally and internationally which establishes guidelines on development and environmental and commercial release of GM crops as discussed in previous chapters. Just as the prior phases of development of the GM cassava have been guided by the existing guidelines, it is also expected that the commercialization phase will follow suit to avoid legal repercussions and impediments.

Mitigation Measures

- The proponent to comply with the relevant sections of all applicable local & international policies, legal and regulatory frameworks prior to commercialization of the GM cassava varieties.
- The proponent to ensure prior acquisition of all other regulatory approvals from NBA, KEPHIS & NEMA before commercial release of the approved cassava GM varieties.
- Ensure adequate public engagements is undertaken to foster public awareness and approval of the GM cassava during the undertaking of the ESIA.

7.3.3 Perceived Food Safety Concerns

Food safety is a major concern for every farmer and consumer of any crop production. Therefore, to address the allayed fears especially to do with genetically modified crops, the National Biosafety Authority (NBA) was established. This is a state corporation mandated to foster safety of both human and animal health as well provide the necessary protection of the environment from harmful effects that are likely to emanate from genetically modified organisms. Consequently, to eradicate all the crop safety doubts due to misconceptions perpetrated by limited knowledge in the public

domain, the proponent has adhered to all the relevant provisions stipulated in the National Biosafety Act, 2009 through adoption of the following measures;

Mitigation measures

- Acquisition of NBA approval declaring the GM cassava varieties earmarked for commercialization as safe for food, feed, and environment.
- Possessing approval for commercial release of genetically modified (GM) cassava resistant to both cassava mosaic disease (CMD) & cassava brown streak disease (CBSD) from NBA is an indicator that all safety protocols have been scrutinized and ascertained.
- Undertaking public sensitization on the safety of the targeted eight (8) GM cassava varieties earmarked for commercialization in Kenya during the undertaking of the Environmental & Social impact Assessment across all cassava growing regions.

7.4 Anticipated Negative Impacts (Post-release phase)

7.4.1 Poor Access & availability of planting material

The farmers expressed concerns about a possible challenge of accessing clean and high-quality cassava planting materials for the GM varieties upon commercialization. This can be frustrating and confusing to farmers especially with limited knowledge on the appropriate locations where they can purchase the certified planting materials. Therefore, precise knowledge on the appropriate locations to access clean planting material will ensure that farmers are not bewildered by the available option which can significantly impacts on the yields contrary to their expectation.

Mitigation Measures

- KALRO to foster collaborative engagements with the County governments to ensure that information cascades through the available County agricultural structures (from CDA, SCAOs &WAOs) to reach cassava farmers within their jurisdiction.
- The proponent will continually offer training to cassava seed entrepreneurs (CSEs) across cassava growing regions to promote seed multiplication immediately after commercialization process is approved.

- Establish demonstration farms in KALRO satellite stations across various cassava growing regions where the multiplication and bulking of cultivars is undertaken in order to promote farmer field training & foster good agricultural practices for the improved cassava varieties.

7.4.2 Inadequate Knowledge

A knowledge gap and variance in information levels within the public domain is anticipated regarding the available GM cassava varieties especially on their suitability across the diverse agro-ecologies within the cassava growing regions. KALRO in conjunction with KEPHIS are privy to this information after carrying out the National Performance Trials (NPTs) successfully. Therefore, since this knowledge is in their domain, farmers also need to understand the best performing varieties suitable for their areas based on the varying soil types, climatic conditions and other considered environmental factors. In addition, farmers as one of the key stakeholders also require information on the suitable uses for the various varieties in order to inform their planting experience. In general, there is need to provide that fundamental link between the research and farmers in order to offer them practical advice as well as support to improve their agricultural practices and productivity. Therefore, to bridge the gap farmers require adequate information on dissemination on the new technologies, farming techniques and best agricultural practices in the growth of the GM cassava varieties.

Mitigation Measures

- The proponent may utilize the already existing KALRO centers involved in multiplication and bulking of cultivars to offer practical sessions (seeing is believing tours) to various stakeholders such as County Agricultural staff, CSEs, farmers, processors and consumers on the best performing varieties in their regions, yield potential, suitable uses and applicable farming techniques needed to achieve optimal results
- KALRO to work in conjunction with County Agricultural Extension Officers to disseminate information to farmers on the appropriate varieties suitable for the regions, their subsequent uses as well as the best farming techniques to achieve the ideal yields.
- The proponent can organize training and sensitization workshops to educate and create awareness on the best adoptable practices in cultivation of the GM varieties for the best production levels.

7.4.3 Poor storage techniques

The stakeholders raised poor cassava storage as a common phenomenon leading to significant post-harvest losses for farmers hence negatively impacting on their income and the desired achievement of food security. This has been occurring with the conventional varieties and therefore expected to be a bigger challenge if proper mechanisms are not put in place. It is expected that the genetically modified cassava will have a better yield as compared to the conventional varieties hence a dire need for devising solutions to the anticipated challenge. Normally, fresh cassava roots have a very short shelf-life therefore deteriorating within 48 hours of harvesting. This rapid deterioration is linked to post-harvest physiological deterioration (PPD) that usually make the roots unpalatable and subsequently unmarketable. Fresh cassava roots are regarded to be highly perishable due to high moisture contents (around 70%) and also the microbial infestation leads to biochemical changes and microbial activities that largely contribute to spoilage thus making the roots unfit for human and livestock consumption. Notably, poor storage practices which include inadequate handling and lack of proper storage facilities may exacerbate the losses.

Mitigation Measures

- Small-scale farmers can adopt traditional storage mechanisms to extend the shelf-life of the harvested cassavas such as sun drying, re-burying of the roots in trenches covered with soils, heaping & watering among others
- Adopt the use of hermetic bags that offers chemical-free method of storing cassava by effectively preserving its quality and preventing any form of pest infestations.
- Train and encouraging farmers on small-scale processing of cassava into basic products such flour, chips or starch at both household and/or cooperative levels to extend shelf-life and reduce post-harvest losses.
- Counties in cassava growing regions to adopt cassava as a high-value crop and fast track the completion of County Aggregation Industrial Parks (CAIP) to provide decentralized, climate-smart storage and processing facilities such as cool storage rooms and mobile graters/dryers.
- Farmers should adopt staggered planting seasons to avoid oversupply during harvesting periods which highly contributes to post-harvest losses owing to inadequate market availability

7.4.4 Climate change variability

The climate change variability phenomenon is widely and extensively impacting negatively on the growth of cassava across many regions in Kenya leading to reduced crop yield and increased disease susceptibility. In addition, reduced rainfall levels and increased evapotranspiration mainly leads to water stress in cassava plantation thus slowing their growth and development. Further, extreme weather events like floods and heavy rainfall may lead to extensive soil erosion, nutrient loss thus impacting cassava's ability to naturally thrive. Different agro-ecologies in the country are endowed with varying climatic conditions which support the growth of diverse varieties of cassava. Therefore, for optimal crop production within these agro-ecological zones, farmers need to implement various mitigation and adaptation strategies aimed at minimizing the negative effects in order to enhance the production of cassava.

Mitigation Measures

- Encourage farmers to adapt climate-smart farming practices such as mulching, crop diversification & rotation, organic manuring, mixed farming adoption of drought-resistant GM cassava varieties.
- Farmers to adopt climate-smart cassava GM varieties through selecting approved varieties considered to be tolerant to drought and heat as well as resistant to prevailing common diseases of CMD &CBSD.
- Farmers to adopt water management measures by implementing water harvesting techniques such as building of bunds or terraces to help conserve water and mitigate against the devastating effects of drought.
- Availing climate information to farmers such as weather forecasts and agricultural extension services to enable them make informed decision regarding their preferred farming practices.
- Farmers to be sensitized on employing integrated pest and disease management strategies that encompasses biological control and adoption of GM cassava varieties resistant to the prevailing CMD & CBSD.

7.4.5 Pest &Diseases

The prevalence of the persistent CMD &CBSD have been a daunting challenge for cassava farmers across all growing regions. Both diseases are caused by virus where CMD primarily affects the above-ground growth while the CBSD launches severe root necrosis. These two diseases are majorly transmitted by whiteflies and have significantly impacted negatively on cassava farming thereby reducing the crop yields, affecting the root quality and to a large extent threatening food security. The prevailing diseases have led to some farmers abandoning the cultivation of some local cassava varieties thus leading to potential loss of valuable genetic resources hence affecting crop diversity. In addition, the root necrosis caused by CBSD usually leads to the affected roots being unmarketable and consequently leading to huge losses to the farmers. These diseases have also reduced the availability of planting materials since the existing ones are poor quality cuttings hence making it extremely difficult for cassava farmers to replant and sustain their crops.

Mitigation Measures

- KALRO to commercially release genetically modified cassava varieties that are resistant to both CBD & CBSD to resolve this pest and disease challenge.
- Ensure availability and access to disease-free planting material from nearby KALRO stations involved in seed multiplication and bulking to reduce the spread of diseases by maintaining varietal purity and quality throughout the across production period.
- Discourage farmers from acquiring planting materials from uncertified sources to help curb the spread of pest and diseases.
- Encourage recruitment of farmers with adequate land for training as Cassava Seed Entrepreneurs (CSEs) to avail clean planting materials within the community reach so as to avoid acquisition of infected stem cuttings from unverified and uncertified sources

7.4.6 Soil contamination

One anticipated negative impact associated with cassava farming is soil contamination which can arise from myriad of sources such as monoculture practices. This phenomenon is accentuated by the continual cultivation of cassava within the same land and has overtime being associated with serious soil degradation. Also, to a large extent, susceptible conventional varieties have less foliage which predispose sloppy areas to soil erosion thus resulting to a decline in the organic matter and essential nutrients available in the soil. Another source of concern is the use of herbicides that are

well-known to cause soil and water contamination owing to the presence of chemicals like glyphosate.

Mitigation Measures

- Encourage farmers to practice crop rotation and diversification in order to maintain soil health thus integrating GM cassava into broader sustainable farming systems.
- Promote the adoption of genetically modified cassava varieties resistant to diseases and employ cultural practices that reduce pest and diseases pressure.
- Farmers can implement sustainable farming practices such as contour cultivation, closer plant spacing, adoption of intercropping with cover crops and minimal land tillage to reduce soil loss to the agents of erosion.
- The commercial release of the genetically modified varieties will eradicate the need for the application of chemical insecticides thereby lowering pesticide residues in soil, water and food.

7.4.7 Water loss

Generally, the cultivation of cassava can lead to water loss through two key mechanisms namely; transpiration by the plant and soil erosion both during and after harvesting. Cassava plantation just like other plants tend to lose water through their leaves through a process known as transpiration. This process can be intense especially in hotter and drier climatic regions. Furthermore, wide spacing of cassava combined by the slow initial growth exposes the soil hence leading to increased soil erosion and surface run off especially during rainy spells. This exacerbates water loss which can be substantial.

Mitigation Measures

- The availability of drought-tolerant GM cassava will contribute to sustainable water management by thriving with less water, particularly in hotter and drier regions facing water scarcity. These water-efficient GM cassavas will play a crucial role in enhancing agricultural sustainability and conserving soil moisture.
- The cassava GM varieties just like the conventional ones will self-regulate through natural processes like stomatal closure thus aid in reduction of water loss.
- The canopy formation during the growth of the GM cassava will reduce evaporation from soil surface occasioned by limited exposure of the soil to direct sunlight.

- The application of mulch (organic materials like straw or leaves) around the base of young cassava plants helps retain soil moisture by reducing evaporation from the soil surface, thereby reducing the plant's water requirements.
- Farmers to periodically engage in weed control to minimize competition for water and nutrients that depletes soil moisture content in the soil especially in hotter and drier cassava growing regions.

7.4.8 Public fear due to Misconceptions

There are numerous perpetrated misconceptions surrounding the genetically modified crops. These misconceptions are primarily fueled by misinformation as well as lack of proper understanding about the application of technology. These misconstrued notions range from safety concerns to environmental impacts where some may believe that GMSs are inherently dangerous and to a large extent very ineffective. In regards to safety, a significant section of the public is always drawn to think that GM crops are unsafe for human consumption with unfounded believes that such crops cause allergies, cancer or other unsubstantiated health problems. Others believe that GMO plants are incapable of being replanted thus making the farming expensive due to the need of buying new seeds every planting season. However, numerous scientific research and regulatory bodies such as US Food Drug and Administration (FDA) have extensively declared GM crops to be equally safe for human consumption just as the conventional ones.

Mitigation Measures

- Engage in continuous targeted public sensitization and awareness campaigns involving key actors such as NBA, KEPHIS & KALRO to debunk these misconceptions through simplifying the science behind the development of the GM crops more so cassava as well as all food safety protocols observed before the final commercial release of the tuber crop to the public.
- The proponent will establish demonstration farms and organize physical field visits in nearby KALRO satellite stations to provide farmers and other key stakeholders with first hand interaction with cassava research specialists. These field visits can serve as platforms for practical learning, Q&A sessions, and testimonies from trained attendees thus helping to demystify misconceptions and build trust through first-hand experience.

- National Biosafety Authority to consider spearhead a nationwide campaign to sensitize the public on the importance of GM food crops developed using biotechnology. The campaign should focus on creating public awareness on GM food safety hence demystify the negative public perceptions associated with GM crops.

7.4.9. Inadequate market and poor prices

The cassava farmers across the country are experiencing the challenge of inadequate market access for the produce. The eight (8) GM varieties earmarked for commercialization are expected to have better yield as compared to conventional varieties. Therefore, with the current market inadequacy, it means that if proper and prior mechanisms are not instituted then cassava farmers may grapple with a lot of post-harvest losses. From public engagements, it was evident that majority of farmers are struggling to sell their produce due to lack of formal consistent buyers which can be attributed to unstructured nature of the market that offers no guarantee to consistent quality and quantity. Further, cassava farmers in most regions operate as individual marketers to their produce and thus lack unified groups to help bridge the gap between them and potential buyers who may include processors, exporters or any other value chain stakeholder. Low prices also in the prevailing markets affects farmer income and subsequently discourages further investment in its production due to discouragement.

Mitigation Measures

- Enhancing link between cassava farmers and potential buyers by encouraging formation or activation of farmer groups, cooperatives or engaging in contract farming engagements. Such mechanisms once in place will improve access to market and stability of prices.
- Encourage farmers and processors to explore value addition of cassava through processing into products such as flour, starch etc. This will be integral in increasing market value and in the creation of new opportunities.
- Establish synergies between County governments and farmers' groups to develop programs that enhance market accessibility, improve existing market prices, and integrate the cassava value chain into ongoing high-value crops projects as a way of strengthening the agricultural sector.

7.4.10 Perceived cyanide toxicity

Cassava is regarded as an important crop by farmers who understand its full benefits. Despite them knowing its vitality as a source of food, there are chilling fears on some existing varieties which are considered to contain high levels of cyanide. Normally, cassava contains cyanogenic glycosides that is associated with the release of cyanide once consumed especially without proper processing. Majority of the farmers also expressed their high dependence on leaves as source of vitamins since they consume them as vegetables. That notwithstanding, it is well known that cassava leaves contain a higher level of cyanide as compared to the roots. On the other hand, roots contain varying levels of cyanide with higher concentrations associated with the outer layer (cortex) as opposed to the inner part (parenchyma). Therefore, since cyanide is a common factor is majority of the existing conventional cassava varieties, farmers were keen to enquire if the GM varieties have resolved this challenge or it will continue to persist and be a source of fear and impediment to the growing of cassava. They expressed that the persistent high level of cyanide in cassava has overtime discouraged the continuous growth of the crop for fear of death.

Mitigation Measures

- The developed and approved GM cassava varieties have cyanogenic levels within the permissible limits, in line with the Codex Alimentarius (the international food safety standards established by the FAO and WHO) standards.
- Low cyanogenic levels on all the approved cassava GM varieties makes them sweet varieties and therefore bitter varieties have been eradicated.
- The approved GM cassava varieties with low cyanogenic levels will ensure farmers consuming leaves as vegetables continue to eat them comfortably however, proper pre-consumption processing methods such as drying, boiling, fermenting, or thorough washing are recommended to guarantee safety.

7.4.11 Cultural barriers

Cassava is regarded as a staple crop for most regions undertaking its cultivation and consumption. There is an unfounded cultural belief that cassava is a subsistence crop for poor farmers hence the tag “a poor man’s crop”. This is a common misconception since cassava is consumed by both the rich and poorer households.

Mitigation measure

- Promote awareness and sensitization of the public on cassava production to change the skewed perception and consider the crop's importance based on both nutritional value and financial benefits

7.4.12 Prolonged maturity period

Cassava farmers across all growing regions ascertained that they have diverse varieties that range between 8-24 months to attain maturity and thus be ready for harvesting. The maturity period is fundamentally affected by the choice of the variety and the intended use. Some varieties are usually bred for early maturity while others are for late maturity. In terms of intended use, majority of the farmers start harvesting early (i.e. 8-12 months) for consumption purposes. This helps them get a mealy texture however, for industrial processing i.e. for flour or starch, farmers are usually forced to wait longer for periods ranging between 18-24 months in order to get a higher content of starch from the harvest. The prolonged maturity period coupled with the widespread cassava mosaic &cassava brown streak diseases has over a long time discouraged and caused numerous farmers to switch to fast growing crops like maize, beans etc. Therefore, there is need for farmers to regain confidence and satisfaction in growing cassava for both subsistence and commercial purposes.

Mitigation Measures

- The varieties earmarked for commercialization all have an early maturity period of between 8-12 months meaning no more extended maturity period extending to 24 months. This will act as an inspiration to cassava farmers who have shifted to other fast-growing crops owing to prolonged maturity period.

8.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

8.1 Introduction

The fundamental purpose of an Environmental and Social Management Plan (ESMP) is basically to ensure that all likely risks and liabilities (anticipated negative impacts) identified during the ESIA process are effectively managed across all project phases. Therefore, this ESMP was developed with specific mitigation and management measures to which the proponent and other responsible key actors are required to collaborate to ensure that the anticipated adverse impacts are minimized, avoided or compensated for. The ESMP also allocates management and monitoring costs for effective implementation of the project across all phases while safeguarding human population and their environment as shown in the table 47 below;

Table 47: Environmental and Social Management Plan for the Proposed Commercialization of GM Cassava

S/No	Anticipated Environmental/Social Impact	Mitigation Measures	Responsibility	Cost
Pre-release Phase				
1.	**Illegal release and inadequate access to planting material**	• Prevent illegal release of stem cuttings by ensuring cassava plantations for the newly developed and approved GM varieties are in confined fields until all approvals are acquired. • Engage in seed multiplication of the approved varieties within KALRO stations for availability of clean planting materials upon commercialization. • Segregate the best performing GM varieties based on their suitable agro-ecological zones for availability during commercialization. • Institute prior mechanism using existing protocols for an all-inclusive varietal naming exercise to promote easier identification of the varieties upon acquisition of all approvals.	KALRO	500,000/-
2.	**Non-adherence to existing protocols**	• Adherence to all relevant local and international policies, legal and regulatory frameworks. • Ensure prior acquisition of all regulatory approvals from NBA, KEPHIS& NEMA before commercial release of the approved cassava GM varieties. • Ensure adequate public participation is undertaken during the ESIA exercise to foster public awareness and approval of the cassava GM varieties.	KALRO	200,000/-

S/No	Anticipated Environmental/Social Impact	Mitigation Measures	Responsibility	Cost
3.	**Perceived food Safety concerns**	• Availability of NBA approval declaring the GM cassava varieties as safe for food, feed and environment. • Possession of the approval for commercial release is an indicator that all safety protocols have been met and ascertained.	✓ KALRO ✓ NBA	No direct cost
Post-release Phase				
5.	**Poor Access & availability of planting material**	• Foster collaborative engagements with County governments to facilitate smooth flow of information to the target population i.e. cassava farmers. • Collaborate with existing cassava partners such as KALRO to offer training to cassava seed entrepreneurs across cassava growing regions to enhance seed multiplication. • Establish demonstration farms in KALRO satellite stations undertaking multiplication and bulking of cultivars to promote farmer training and inculcate good agricultural practices.	✓ KALRO ✓ MEDA ✓ CSEs ✓ County Governments	500,000/-
6.	**Limited Knowledge**	• Utilize the existing KALRO stations undertaking multiplication and bulking of cultivars to offer practical sessions to all relevant stakeholders such as farmers, County agricultural staff, CSEs etc. to promote best farming techniques for optimal cassava production. • Partnership with County agricultural extension officers to disseminate information to farmers on suitable GM cassava varieties for various agro-ecologies with the aim of achieving optimum yields.	✓ KALRO ✓ County governments	

S/No	Anticipated Environmental/Social Impact	Mitigation Measures	Responsibility	Cost
		• Conduct trainings and sensitization workshops to create awareness on the best practices in the cultivation of the GM cassava varieties for best production levels.		
7.	**Poor storage techniques**	• Adopt traditional storage mechanisms to extend shelf-life of harvested GM cassava such as sun drying, reburying, heaping etc. • Embrace the use of hermetic bags for cassava storage which is a chemical free method that effectively preserves quality and inhibits pest infestations. • Train farmers on small-scale processing of cassava into basic products such as flour, chips or starch at both household and cooperative levels to minimize postharvest losses. • Adopt the GM cassava as a high value crop and fast truck completion of CAIP to provide decentralized, climate-smart storage and processing facilities such as cool storage rooms &mobile graters/driers. • Encourage staggered planting seasons to minimize oversupply during harvesting periods and minimize post-harvest loses as well as prevailing market challenges.	✓ County Governments ✓ Cassava farmers	400,000/-
8.	**Climate change variability**	• Farmers to adopt climate-smart farming practices such as mulching, crop diversification& rotation, organic manuring, mixed farming, adoption of drought-resistant GM cassava varieties. • Encourage adoption of climate-smart GM cassava varieties through selection of approved varieties considered tolerant to drought &heat and also resistant to common diseases of CMD&CBSD.	✓ KALRO ✓ Cassava farmers	

S/No	Anticipated Environmental/Social Impact	Mitigation Measures	Responsibility	Cost
		• Farmers to embrace water management measures by adopting water harvesting techniques such as building of bunds or terraces in order to conserve water and mitigate against drought effects. • Sensitize farmers to employ integrated pest and disease management strategies that include biological control and adoption the GM cassava varieties resistant to CMD&CBSD.		
9.	**Pest &Diseases**	• Commercially release the GM cassava varieties resistant to CMD & CBSD. • Ensure farmers can access clean planting materials in KALRO stations engaging in seed multiplication and bulking to reduce spread of diseases and also to maintain varietal purity and quality. • Discourage farmers from acquisition of planting materials from uncertified sources to minimize the spread of the diseases. • Encourage farmers with adequate land to be trained as cassava seed entrepreneur (CSE) to avail clean planting materials within the reach of the community and avoid acquisition from unverified and uncertified sources.	✓ KALRO ✓ Cassava farmers	
10.	**Soil contamination**	• Farmers to practice crop rotation & diversification to maintain healthy soils and further integrate GM cassava into broader sustainable farming systems. • Promote the adoption of genetically modified cassava varieties resistant to diseases and employ cultural practices that reduce pest& disease pressure.	✓ Cassava farmers	No direct cost

S/No	Anticipated Environmental/Social Impact	Mitigation Measures	Responsibility	Cost
		• Farmers to adopt sustainable farming practices such as contour cultivation, closer plant spacing, intercropping with cover crops and minimal land tillage to reduce soil loss to the agents of erosion. • Environmental release of the GM cassava varieties will eradicate the application of chemical insecticides thus lowering pesticide residues in soil, water and food.		
11.	**Water loss**	• The drought-tolerant GM cassava will ensure sustainable management by thriving in less water particularly in hot and dry regions experiencing water-scarcity. • In a similar way to the convention varieties, the approved GM cassava will self-regulate through natural processes like stomatal closure thus aid in reduction of water loss. • Canopy formation in the GM varieties during its growth period will reduce evaporation in the soil surface through limiting the ground from direct sunlight. • Encourage farmers to apply mulch (e.g. organic straws or leaves) around the base of young cassava plants to minimize evaporation thus retain soil moisture. • Encourage farmers to periodically undertake weed control to minimize competition for water and nutrients that deplete soil moisture content.	✓ Cassava Farmers	No direct cost
12.	**Public fear due to Misconceptions**	• Engage in continuous targeted public sensitization & awareness campaigns involving key actors to debunk all myths surrounding genetically modified crops and their safety prior to the final environmental release of the cassava varieties.	✓ NBA ✓ KEPHIS	1,000,000/-

S/No	Anticipated Environmental/Social Impact	Mitigation Measures	Responsibility	Cost
		• The proponent to set up demonstration farms within KALRO satellite stations to promote practical learning and observation for farmers and other stakeholders regarding the approved GM cassava varieties. The interaction with cassava specialists will help demystify prevailing misconceptions and build public trust. *NBA can consider spearheading a nationwide campaign to sensitize the public on the importance of GM crops developed using biotechnology, with main focus on food safety in order to demystify negative public perceptions.*	✓ KALRO	
13.	**Inadequate market and poor prices**	• Enhancing links between cassava farmers and potential buyers through formation or activation of farmer groups, cooperative societies or involvement in contract farming aimed at improving market access and stabilize prices. • Encourage farmer and processors to explore value addition of cassava through processing into various products such as flour, starch etc. with the aim of increasing market value and creating new opportunities. • Establish collaborations between County governments and farmer groups to create programmes that boost market accessibility, market prices as well as integrate cassava value chain into the ongoing high-value crops projects.	✓ Cassava farmers' Cooperative societies ✓ County Government	No direct Cost
14.	**Perceived cyanide toxicity fears**	• The developed and approved GM cassava varieties have cyanogenic levels within permissible limit as documented by international food safety standards for cassava. • The low cyanogenic levels make all the approved 8 varieties to be sweet thus eradicating the bitter varieties.	✓ KALRO ✓ NBA	No direct cost

S/No	Anticipated Environmental/Social Impact	Mitigation Measures	Responsibility	Cost
		• The approved GM cassava varieties will guarantee more safety to famers who consume cassava leaves as vegetables due to the low cyanogenic levels however, pre-consumption processing is highly encouraged such as drying, boiling or washing, etc.		
15.	**Cultural perceptions e.g. poor man's crop**	• Promote public awareness and sensitization on cassava production to adopt and consider the crop's importance based on nutritional value and financial benefit.	✓ KALRO ✓ NBA	300,000/-
16.	**Prolonged maturity period**	• All approved varieties have an early maturity period of between 8-12 months therefore inspiring the farmers its adoption by farmers who had shifted to other fast-growing crops.	✓ KALRO ✓ NBA	No direct cost

9.0 CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

Cassava is regarded as a major staple food crop for millions of people both in the tropical and sub-tropical countries. In the Sub-Saharan Africa, this crop forms a primary source of dietary calories for a huge population. Also, this tuberous storage cassava roots are rich in carbohydrates and can be utilized in various forms such as cooking or processing for human food, animal feed as well as for industrial purposes.

The eight (8) approved GM cassava varieties have been recommended for environmental release by KEPHIS. These varieties have also met all the established crop safety development procedures and protocols under the mandate of NBA which ranges from application review to post-commercialization monitoring.

The fundamental focus of NBA has been to ensure the GM cassava is fit for food, feed and environmental release in addition to other socioeconomic considerations. Consequently, stakeholders' engagement revealed that the CMD & CBSD have contributed to immense losses for cassava farmers over years with no sustainable solution. This has in turn led to most farmers shifting their focus to other fast-growing crops. Therefore, this leaves the future of cassava crop on the brink of becoming an 'orphaned crop' in the regions that once engaged in large-scale production. In addition, the periodic deaths caused by the existing bitter varieties containing high cyanogenic levels have continued to negatively impact on the farming of cassava. Such prevailing challenges among many others discussed in this document creates the dire need for the approval of the proposed commercialization of GM cassava in order to inspire hope to farmers who have been discouraged and as a result abandoned the crop leaving the future of its existence at major risk. Ultimately, farmers across the major cassava growing regions unanimously expressed their desire and support for the commercialization of the eight (8) GM cassava varieties in order to avail clean planting materials to them. The access to clean planting materials will promote food security, resistance to diseases, better yield and reduced cyanogenic levels.

9.2 Recommendations

The ESIA study recommends the following action areas during and post commercialization of the proposed GM cassava varieties;

1. KALRO to set up demonstration farms and offer trainings to cassava seed entrepreneurs (CSE) on the procedures of the new GM cassava varieties. This will enable transfer of knowledge to the local cassava farmers who will pass the same to their surrounding communities.
2. KALRO to continue provide trainings on cassava enterprise development, record keeping and financial management that will go a long way in ensuring the sustainability of the seed development/production system.
3. The proponent to ensure the ongoing bulking and multiplication of breeder seed is aligned to farmer planting seasons to avoid conflict or poor uptake upon environmental release.
4. The proponent to ensure prompt and timely dissemination of information regarding access of the released GM cassava varieties through available channels such as County agricultural officers and CSEs. This will enable the farmers to commence farm preparations in anticipation of the planting materials.
5. The proponent to engage Research Extension Liaison Officers (RELOs) across all cassava growing regions who are enacted by the MoALD through KALRO aimed at strengthening scientific extension services.
6. KALRO to partner with County governments to offer farmer trainings on proper agronomic practices and post-harvesting handling and processing of cassava to safeguard the high yield expected from the newly developed cassava varieties.
7. NBA should consider a national public awareness and sensitization campaigns regarding GMO crops in Kenya. This will go a long way in debunking the negative uninformed negative perceptions within the public domain hence align the country to embrace genetically improved crops in order to promote food security.
8. County governments within major cassava growing regions can earmark cassava as a high-value crop and utilize the upcoming County Aggregation and Industrial Parks (CAIPs) to inculcate skills and provide infrastructure necessary for cassava value addition.
9. Upon training, all CSEs must be register with KEPHIS before engaging in multiplication or bulking of the cassava seed for sale to other farmers.
10. With compliance with existing laws, the proponent, NBA and KEPHIS to periodically undertake monitoring and evaluation measures to assess the performance of the proposed GM cassava varieties.

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APPENDICES

Appendix 1: Photo catalogue

Appendix 2: NEMA Approved TORs Letter

Appendix 3: Stakeholders' Questionnaires

Appendix 4: Minutes for Public Fora held and List of Attendances

Appendix 5: KEPHIS (National Performance Trials Committee Report) Approval Letter

Appendix 6: KEPHIS National Performance Trials Committee Report

Appendix 7: Project Cost Summary

Appendix 8: Firm of Expert License

Appendix 9: Lead Expert License

Appendix 1: Photo catalogue

Public participation forum held at Baroness Hotel, Mpeketoni, Lamu County

Public participation forum held at KALRO Mtwapa, Kilifi County


Public participation forum held at KALRO Matuga, Kwale County


Public participation forum held at KALRO Embu, Embu County


Public participation forum held at EAPC Chuka Town Church, Tharaka Nithi County


Public participation forum held at Kitui ATC, Kitui County


Public participation forum held at Ngaringashe Chief's Office, Taveta, Taita Taveta County


Public participation forum held at Mulwanda PAG Assembly, Idakho North, Kakamega County


Public participation forum held at Kambua Resort, Kibwezi, Makueni County


Public participation forum held at ACK Machakos Town Church, Machakos County


Public participation forum at KALRO Alupe, Busia County


Public participation forum at Mukhwana's Homestead, Tuuti/Marakaru, Bungoma County


Public participation held at Sinogo Catholic Church, Rangwe, Homabay County


Public participation forum at Sunaton Hotel, Suna East, Migori County

Public participation forum held at ACK St. John's Dudi Church, Seme, Kisumu County

Public participation forum held at Essunza Church of GOD, Emuhaya, Vihiga County

Public participation forum held at ACK St. Mary's Church, Kenol, Muranga County


Public participation forum held at ATDC-Soilo, Nakuru County


Public participation forum held at Baringo Central NG-CDF Conference Hall, Baringo County

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Appendix 8: Current Firm of Expert Practicing License

Appendix 9: Current Lead Expert Practicing License