



## GIS-BASED MULTI-CRITERIA LAND SUITABILITY ASSESSMENT FOR CASSAVA CULTIVATION IN KWARA STATE, NIGERIA

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### Abstract

Cassava is a vital staple crop with significant economic and food security importance in Nigeria, particularly in Kwara State, a state with vast untapped agricultural land. This study employs a Geographic Information System (GIS) integrated with the Analytical Hierarchy Process (AHP)-based Multi-Criteria Decision Analysis (MCDA) to assess land suitability for cassava cultivation in Kwara State. Multiple spatial datasets, including soil properties, climate factors, topography, land use/land cover, and infrastructure proximity, were analyzed and weighted according to expert judgments. The resulting suitability map classifies the land into five categories, highlighting that approximately 50.8% of the area is highly to moderately suitable for cassava production. Validation using the Receiver Operating Characteristics (ROC) curve yielded an Area Under the Curve (AUC) of 0.998, indicating excellent model accuracy in distinguishing suitable from unsuitable areas. The study provides a robust decision-support tool for policymakers and stakeholders to optimize land resource use and promote sustainable cassava production, thereby addressing local food security challenges. Recommendations emphasize targeted cultivation, soil fertility improvement, and the incorporation of spatial analysis in agricultural planning.

**Key words:** *land suitability analysis, food security, Analytical Hierarchy Process (AHP), Geographic Information System (GIS).*

### INTRODUCTION

The unprecedented growth of the global population, which surpassed 7.9 billion in the early twenty-first century and is projected to reach approximately 9.7 billion by 2050, has intensified pressure on food systems worldwide (UNDESA, 2017). Notably, two-thirds of this demographic expansion is expected to occur in Africa between 2020 and 2050, exacerbating challenges related to food security. Developing countries like Nigeria confront complex threats from climate change and resource limitations that hinder agricultural productivity, thereby amplifying the urgency for sustainable farming practices to maintain reliable food supplies (Ahmed et al., 2017; Ajala et al., 2020).

Cassava (*Manihot esculenta* Crantz) stands out as a resilient and sustainable staple crop critical to food security and poverty alleviation

across Africa and Asia (Borku, 2025; Fathima et al., 2023; FAO, 2013). Nigeria, the world's leading cassava producer, contributes approximately 21% of global output, producing around 60 million tonnes annually (FAO, 2018; FAOSTAT, 2019). Despite its significance, the country faces a persistent supply-demand gap for cassava products such as high-quality cassava flour and starch, indicating under-utilization of available agricultural potential (Okunlola, 2019). Kwara State in Nigeria presents a notable case where cassava production remains below its capacity despite vast untapped arable land. Historical practices of land use without regard to suitability have adversely affected agricultural productivity, necessitating a scientifically grounded approach to land allocation (Zhang et al., 2024; Abah and Petja, 2016; Merem et al., 2017).

Land suitability analysis, defined by the Food and Agriculture Organization (FAO) as the evaluation of land characteristics relative to specific crop requirements, is a vital tool in optimizing agricultural land use (FAO, 1976). This process involves integrating diverse datasets encompassing soil properties, climate, topography, land cover, and accessibility to identify and classify land based on its capacity to support particular crops (Pandey et al., 2021). The advent of Geographic Information Systems (GIS) coupled with Multi-Criteria Decision Analysis (MCDA) methods, such as the Analytical Hierarchy Process (AHP), has significantly enhanced the precision and effectiveness of land suitability assessments by enabling systematic weighting and integration of multiple environmental and socio-economic criteria (Saaty, 1980; Choudhary et al., 2023; Hussain et al., 2024).

Given the critical role of cassava in sustaining food security and the ongoing

scarcity of targeted land suitability studies in Kwara State, this research adopts a GIS-based MCDA framework anchored in the FAO land evaluation method to assess land suitability for cassava cultivation. The study incorporates high-resolution spatial datasets and multi-criteria weighting to delineate optimal cultivation zones, thereby supporting policymakers, land use planners, and local stakeholders in making informed decisions that maximize land productivity and contribute to sustainable agricultural development.

By addressing the complex interplay of climatic, edaphic, topographical, and infrastructural factors, this research contributes to bridging the gap between land potential and its practical utilization, promoting precision agriculture, and enhancing food security prospects for Kwara State amid rapidly changing environmental and demographic pressures.

## MATERIAL AND METHODS

### Study area

The study area is Kwara State, Nigeria. Kwara State, situated in the North-Central geopolitical zone of Nigeria, covers an approximate area of 36,835 km<sup>2</sup>. The state lies at an altitude ranging from 13 meters to 657 meters above mean sea level and had a population of approximately 2,365,353 according to the 2006 national census (NPC, 2006). Geographically, Kwara State features a diverse landscape characterized by a blend of tropical savannah vegetation and riparian forests along its riverbanks. The region experiences a typical tropical climate with two distinct seasons: the rainy season and the dry season. The rainy season extends from March to November, during which annual rainfall fluctuates between 800 mm and 1,200 mm,

peaking in August and September. Conversely, the dry season lasts from November to March.

Temperatures in Kwara State remain relatively high throughout the year, with average daily temperatures ranging from 22.5°C to 27.5 °C. These climatic and geographical factors collectively influence the state's agricultural potential and ecological characteristics (Babatunde et al., 2019). Diverse topography, climatic conditions, and soil types characterize the State, making it an ideal location for assessing land suitability for cassava (*Manihot esculenta* Crantz) cultivation. The State's agricultural landscape presents vast untapped land potential that can be optimized for enhanced cassava productivity. Figure 1 illustrates the location and spatial extent of the study area.

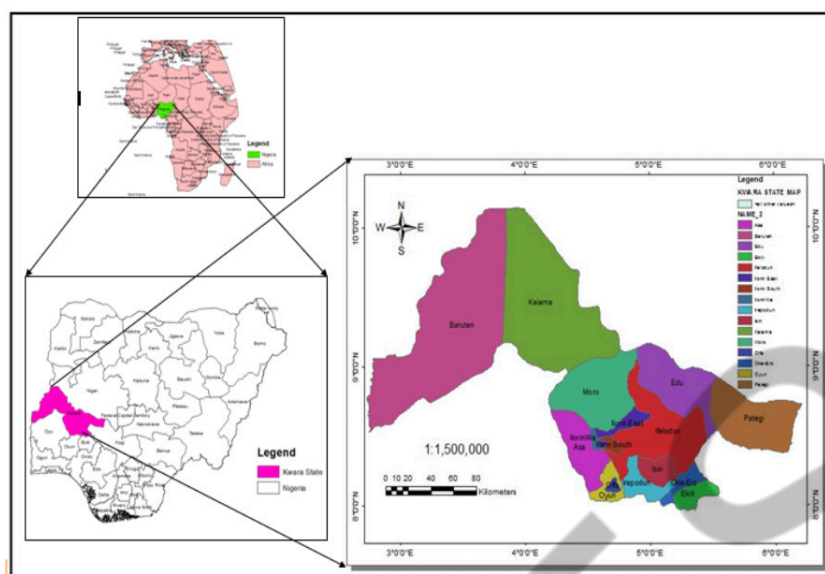


Figure 1. Map of Study Area (Kwara State, Nigeria).

## Methods

The methodological framework combined field reconnaissance, spatial analysis, and multi-criteria decision techniques to evaluate land suitability for cassava cultivation in Kwara State. Initial reconnaissance, supported by Google Earth imagery and GPS observations, guided the identification of relevant biophysical and environmental conditions. Spatial and aspatial datasets (primary and secondary) were then compiled to establish suitability criteria based on agronomic requirements for cassava.

Using GIS, thematic criteria maps were generated across four major factor groups: topographic factors (elevation, slope, aspect), soil factors (soil pH, soil organic carbon),

environmental factors (land use/land cover, rivers, roads), and climatic factors (temperature, precipitation, humidity). All variables were standardized through reclassification to ensure comparability across layers.

To integrate the diverse datasets, the Analytical Hierarchical Process (AHP) was applied to derive factor weights reflecting their relative importance for cassava production. The weighted layers were combined using a Weighted Sum Overlay in ArcGIS to produce a composite land-suitability map. Finally, results were validated and interpreted to support evidence-based land-use recommendations. Figure 2 presents the methodology flowchart.

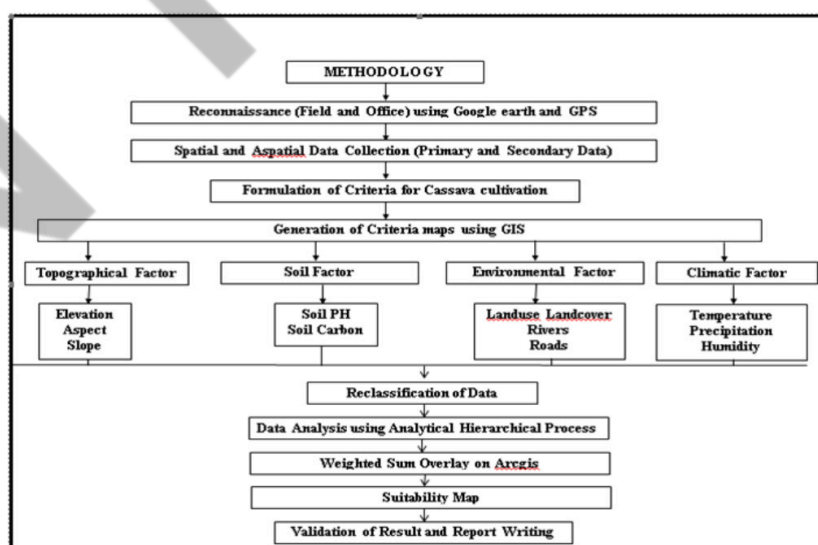


Figure 2. Methodology flowchart.

**Data Collection and Sources**

A suite of spatial and non-spatial datasets was compiled to characterize the environmental and infrastructural determinants of cassava cultivation suitability in Kwara State. Soil variables (pH, cation exchange capacity, and organic carbon) were obtained from the Harmonized World Soil Database and ISRIC (2020). Topographic parameters, such as elevation, slope, and aspect, were derived from the 30-m Shuttle Radar Topographic Mission

(SRTM) DEM. Climatic variables, including rainfall, temperature, and relative humidity, were sourced from WorldClim and WorldClimate.org (2022). Land use/land cover information was extracted from Landsat-8 imagery (2022) accessed via the USGS portal. Infrastructure layers, namely road networks and water bodies, were digitized from official geospatial datasets and local government maps, with distance rasters generated through standard GIS proximity analyses. All datasets and sources are summarized in Table 1.

S/no	Name	Format Scale/ Resolution	Date	Relevance	Source
1	Map of Nigeria, Africa, Kwara State.	Digital	2019	For the Demarcation of the Study Area	Nigeria Shapefile
2	Soil Map for Kwara State	Digital	2020	For soil maps production.	Harmonized World Soil Database and International Soil Reference and Information Centre.
3	DEM data	Digital (30m)	2022	For Elevation, Slope, and Slope Aspect of the Area	Shuttle Radar Topographic Mission
4	Temperature, humidity, and Rainfall	Digital	2023	For Climate Factors maps	World Climate.Org
5	Landsat 8 images	Digital	2022	For the land use and land cover of the area.	USGS (United States Geological Surveys) explorer home
6	Cassava Farm locations in Kwara State	Digital	2025	For the validation of the research output.	Kwara State Agricultural Development Project (KWADP)

**Data processing and preparation**

The spatial datasets were pre-processed and standardized within the ArcGIS software environment. Elevation, slope, and aspect maps were generated from the DEM. Land use land cover was classified into thematic categories relevant for cropland assessment, such as forest, grassland, barren land, built-up area, and water bodies. All raster layers were reclassified

into suitability categories based on cassava's biophysical requirements using a rating scale adapted from FAO (1976) and relevant literature (Purnamasari et al., 2022; Nungula et al., 2024).

**Suitability criteria and weighting**

Land suitability factors were selected based on cassava cultivation requirements and prior studies. These included climatic variables

(temperature, rainfall, relative humidity), soil characteristics (pH, organic carbon, CEC), topography (elevation, slope, aspect), land use type, and accessibility (distance to roads and water). Each criterion was classified into four suitability classes: highly suitable, moderately suitable, marginally suitable, and not suitable.

To address the complex multi-criteria nature of land suitability assessment, the Analytical Hierarchy Process (AHP) was employed to assign weights to each criterion. The pairwise comparison matrices were developed based on expert knowledge, literature review, and a closed questionnaire distributed among agricultural specialists (Libório et al., 2024). The AHP weighting process was implemented using the Eigenvector method, ensuring consistency via the Consistency Ratio (CR), which was maintained below the acceptable threshold of 10%.

#### GIS-based Multi-Criteria Evaluation (MCE)

A GIS-based Multi-Criteria Evaluation framework was used to integrate spatial datasets with the criterion weights obtained from AHP. The

individual suitability layers were standardized and combined in the GIS environment through a weighted overlay analysis. This process produced a composite land suitability map classifying the entire study area into suitability classes for cassava cultivation according to the FAO classification system: S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), and N (not suitable).

In AHP, the input parameters are examined through the process of pairwise comparison in which the degree of importance of each pair of criteria is valued on a scale of 1 – 9, where 1 indicates “equal importance”, 3 represents “Moderate importance”, 5 denotes “Strong importance”, while 7 and 9 signify “Very strong- and Extremely importance” respectively (Ayo, 2021). The Analytical Hierarchy Process (AHP) offers a reliability check through the Consistency Ratio (CR) (Equation 1), ensuring that pairwise comparison ratings are not random (Saaty, 2013). A  $CR \leq 0.1$  (10%) indicates a reliable decision; while a  $CR > 10\%$  requires revision of the pairwise matrix.

$$CR = \frac{CI}{RI} \quad (1)$$

Where

$$CI = \frac{\lambda_{\max} - n}{(n-1)} \quad (2)$$

RI = Random Index, n = the number of criteria,  $\lambda$  = average of consistency vector, and  $\lambda_{\max}$  = priority vector multiplied by each column total.

Suitability levels for each input factor were categorized on a 1-5 scale with 5: Very high suitability, 4: High suitability, 3: Medium suitability, 2: Low suitability, and 1: Unsuitable (very low suitability). Using ArcGIS's Reclassification Tool, the suitability levels were reclassified, ensuring all input rasters were integer values. This process defined the relevance levels of each criterion.

#### Validation

The validation employed the Receiver

Operating Characteristics (ROC) method, leveraging its threshold-independent curve (Fawcett, 2006; Li, 2024). Areas like water bodies and urbanized/developed areas were excluded using restricted values in the land use/land cover map. The process objectively evaluated each layer's criteria and relevance, yielding a suitability decision for the entire area. The resulting map was validated using ROC's Area Under the Curve (AUC) measure, analyzing sampled points from Kwara State Ministry of Agriculture's cassava farms, field data collected using handheld GPS, and randomly selected negative points based on the author's knowledge.

## RESULTS AND DISCUSSIONS

### Land Use and Land Cover (LULC): Patterns, Pressures, and Implications

The land use and land cover (LULC) classification of Kwara State (Figure 3) reveals a landscape dominated by grassland (42.68%) and forest cover (34.41%), with smaller proportions of barren land (14.86%), built-up areas (7.57%), and water bodies (0.47%). The classification scheme was designed to reflect functional land-use categories relevant to agricultural suitability assessment, consistent with FAO land evaluation principles and previous GIS-based suitability studies in Nigeria and West Africa (Abah & Petja, 2016; Pandey et al., 2021). Built-up areas and water bodies were treated as restricted classes due to their incompatibility with crop production.

The dominance of grassland and forest suggests substantial potential for agricultural expansion; however, this potential is accompanied by important land degradation

and conservation trade-offs. Expansion into forested areas, particularly in the southeastern part of the state, could accelerate deforestation, biodiversity loss, and soil erosion if not managed sustainably. Conversely, barren lands, although currently degraded, may be rehabilitated through soil restoration and conservation agriculture practices. These findings highlight the need for land-use planning frameworks that balance cassava production goals with environmental protection, especially in ecologically sensitive zones.

The LULC classification accuracy was assessed using reference data from Landsat imagery and ancillary datasets, ensuring thematic reliability for subsequent suitability modeling. Accurate LULC representation is critical because misclassification of urban or water areas could significantly inflate suitability estimates. Table 2 illustrates the land use/land cover pattern of the state.

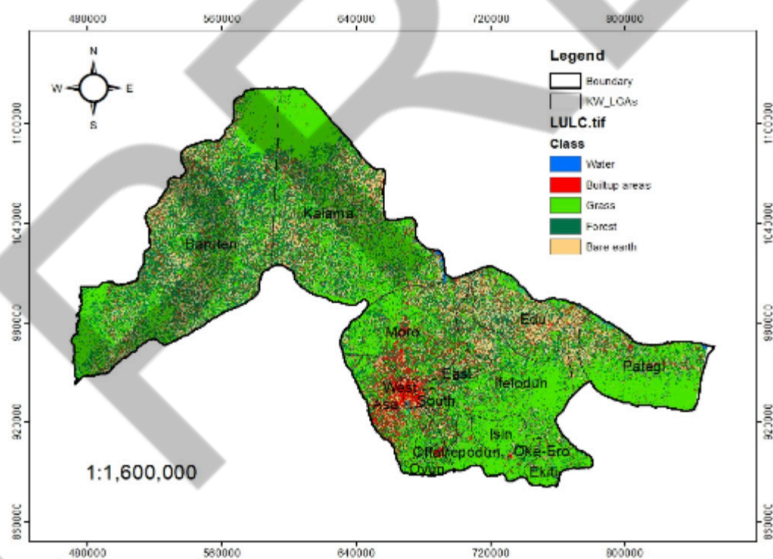


Figure 3. Land Use/Land Cover map.

Table 2. Land Use/Land Cover

Land Use Class	Area (ha)	Percentage (%)
Grassland	1,511,755.17	42.68
Forest	1,218,904.34	34.41
Barren Land	526,481.40	14.86
Built-up Area	268,128.29	7.57
Water Bodies	16,762.69	0.47
<b>Total</b>	<b>3,542,031.89</b>	<b>100.00</b>

**Topographic suitability: elevation, slope, and aspect**

*Elevation*

Elevation in Kwara State ranges from approximately 13 m to 657 m above mean sea level. Areas below 200 m were classified as highly suitable, reflecting cassava’s preference for low to moderate altitudes where temperature regimes and soil moisture conditions are optimal. Elevations above 400 m were classified as marginally suitable to unsuitable due to potential reductions in temperature and increased erosion risks. These thresholds are consistent with cassava agroecological requirements reported in tropical Africa (FAO, 2013; Nungula et al., 2024). The elevation map is presented in Figure 3b.

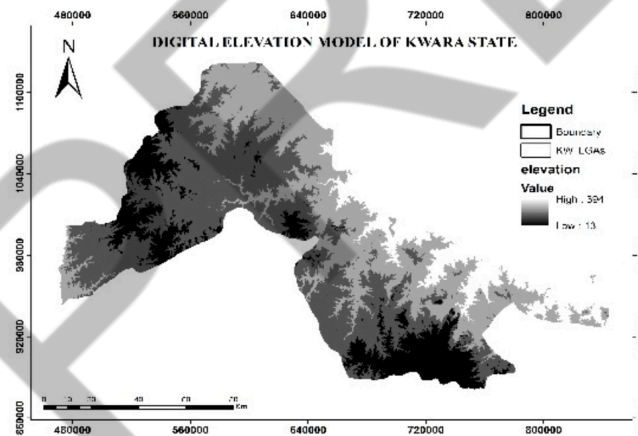
*Slope*

Slope is a critical determinant of mechanization feasibility, erosion risk, and soil moisture retention. Slopes between 0–15% were classified as highly suitable because they minimize erosion and facilitate farm operations,

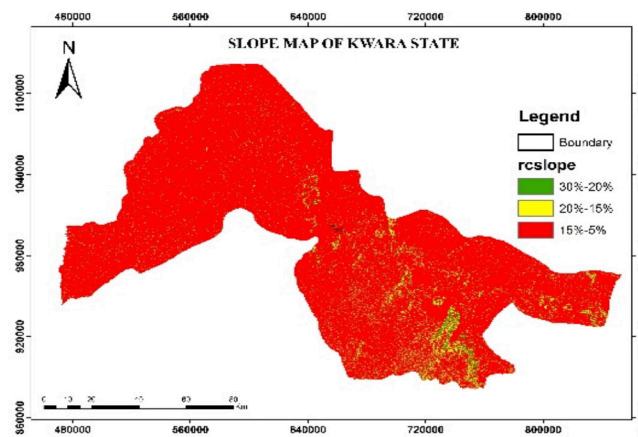
while slopes above 30% were classified as not suitable due to severe erosion risks and cultivation constraints. These thresholds align with FAO land evaluation guidelines and similar studies in Nigeria and East Africa (Ajala et al., 2020; Purnamasari et al., 2022). The slope map is presented in Figure 5.

*Aspect*

Aspect influences microclimatic conditions such as solar radiation, evapotranspiration, and soil moisture. North-facing and flat areas were classified as highly suitable due to reduced heat stress and improved moisture retention, which are favorable for cassava root bulking. South- and west-facing slopes were considered less suitable because they receive higher solar radiation, increasing evapotranspiration and moisture stress during dry periods. This classification is supported by agroecological studies linking slope orientation to crop water balance in tropical environments (Huang & Hong, 2024). The aspect map is presented in Figure 6.



**Figure 4.** Elevation map.



**Figure 5.** Slope map.

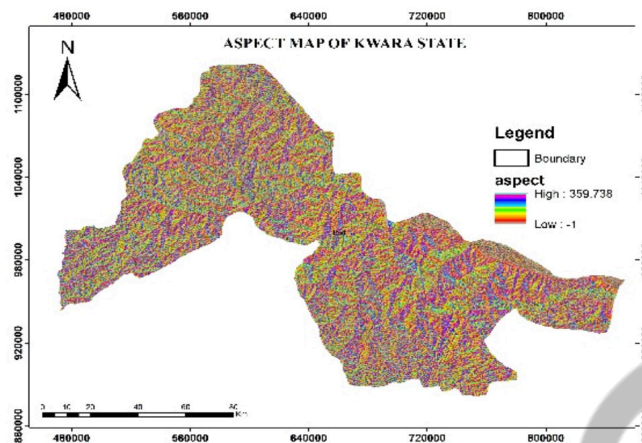


Figure 6. Aspect map

### Soil Fertility Constraints and Long-Term Productivity Implications

Soil analysis reveals that while soil pH conditions across most of Kwara State are within cassava’s tolerance range (5.3–6.8), soil fertility constraints pose a significant challenge. The predominance of **low cation exchange capacity (CEC)** and **low organic carbon content** indicates limited nutrient retention and poor soil structure.

Although cassava is known for its tolerance to marginal soils, sustained cultivation under

such conditions can lead to progressive yield decline, increased fertilizer dependency, and land degradation. Low organic carbon reduces soil water-holding capacity and biological activity, undermining long-term yield stability. These findings emphasize the necessity of integrated soil fertility management strategies, including organic amendments, crop residue retention, and legume integration, to sustain cassava productivity over time (Chaudhry et al., 2024).

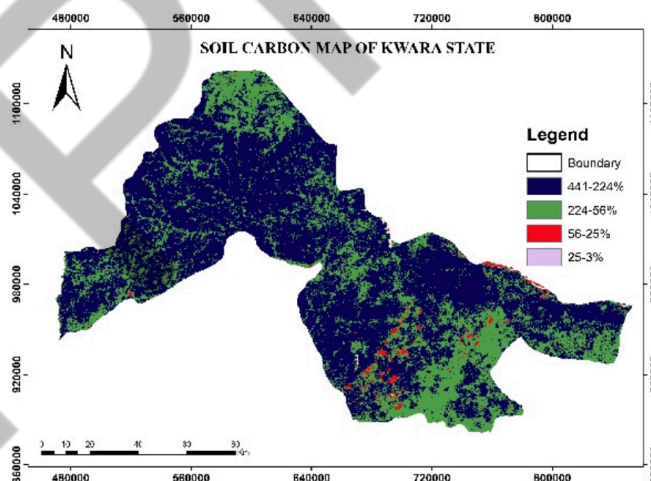


Figure 7. Soil carbon map

### Climatic Suitability in Relation to Cassava Physiological Tolerances

Climatic variables emerged as the most favorable factors for cassava cultivation in Kwara State. Mean annual temperatures (22.5–27.5 °C) fall within the optimal physiological range for cassava photosynthesis, root initiation,

and starch accumulation, typically reported as 25–29 °C (FAO, 2013; Okoma et al., 2025). Similarly, annual rainfall between 900 and 1500 mm satisfies cassava’s water requirements for rain-fed production while avoiding prolonged waterlogging.

Relative humidity levels (40–65%) further support cassava growth by limiting excessive evapotranspiration and reducing disease pressure. The strong alignment between

observed climatic conditions and cassava’s tolerance thresholds explains the high weighting assigned to climatic variables in the suitability model.

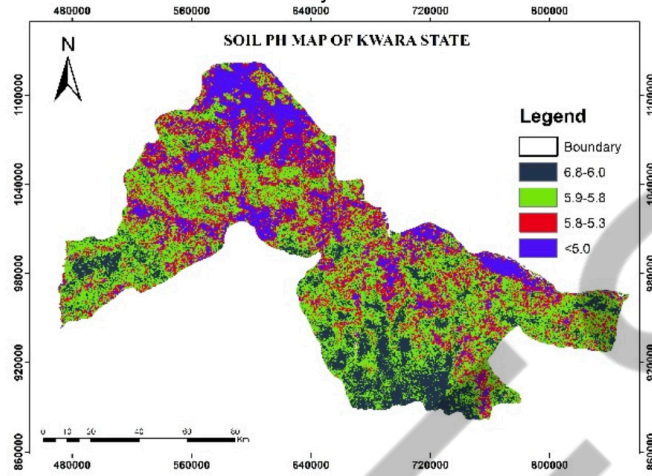


Figure 8. Soil carbon map

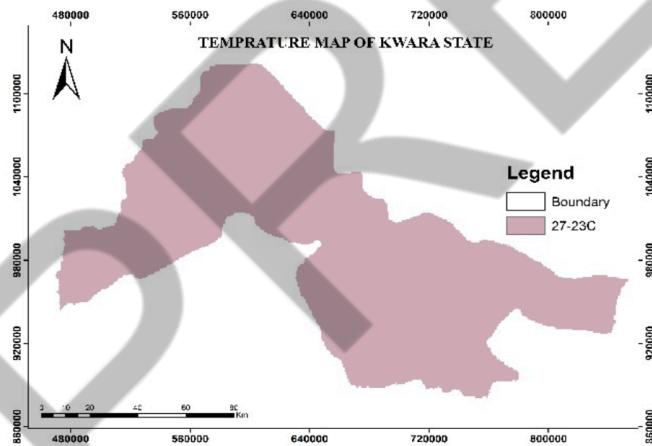


Figure 9. Soil carbon map

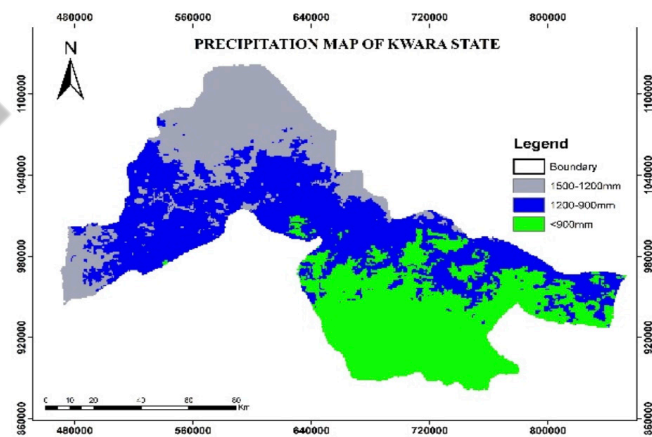


Figure 10. Soil carbon map

### Accessibility Analysis

Accessibility was assessed using buffer thresholds around roads and water bodies to capture logistical feasibility rather than biophysical suitability. Distance classes were defined based on common thresholds used in agricultural land evaluation studies, where proximity within 5–10 km to roads significantly reduces transport costs and post-harvest losses (Choudhary et al., 2023).

The finding that over 94% of the state lies within 22 km of road networks suggests strong market integration potential. Improved accessibility enhances farmers’ access to inputs, extension services, and markets, thereby increasing profitability and reducing vulnerability to price shocks. Proximity to water bodies also supports supplemental irrigation and climate-resilient farming practices, particularly under increasing rainfall variability.

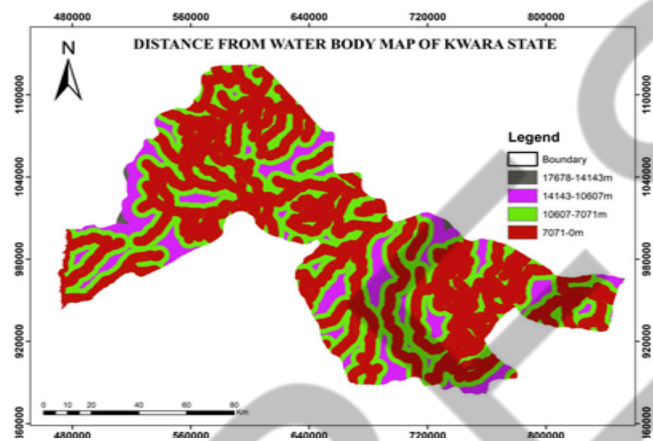


Figure 11. Distance from Water Body map.

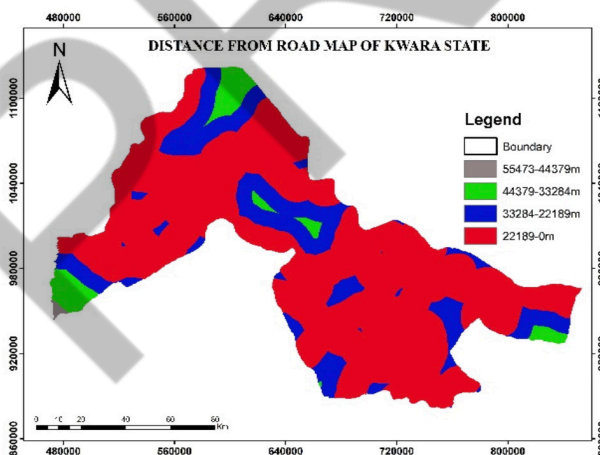


Figure 12. Distance from Road Map.

### AHP Weighting

The AHP results indicate that precipitation and temperature received the highest weights, reflecting their direct control over cassava growth, yield stability, and climatic risk exposure. This weighting structure is consistent with agronomic literature identifying climate as the primary limiting factor for cassava production in sub-Saharan Africa (FAO, 2013; Huang & Hong, 2024).

Soil properties were assigned moderate weights because, although cassava tolerates low

fertility, soil conditions ultimately regulate yield potential. Topographic and accessibility variables received lower weights as they function mainly as modifying or enabling factors rather than direct physiological constraints. The Consistency Ratio (CR) of 8.7% falls below the accepted 10% threshold, indicating that expert judgments were logically consistent and not random (Saaty, 2013). This confirms the robustness of the weighting scheme used in the suitability analysis.

**Table 3. AHP Results**

S/n	Variable	Priority	Rank	Consistency check
1	Temperature	22.6%	2	12.1%
2	Precipitation	24.3%	1	16.2%
3	Soil PH	10.9%	4	4.4%
4	Soil carbon	10.5%	5	4.9%
5	Soil Cation Exchange	12.4%	3	7.6%
6	Slope	3.9%	7	2.2%
7	Aspect	4.1%	6	2.3%
8	Elevation	3.7%	8	2.1%
9	Relative Humidity	2.6%	9	1.1%
10	Dist. to the river	1.8%	10	0.6%
11	Dist. to road	1.5%	12	0.9%
12	LULC	1.7%	11	0.6%

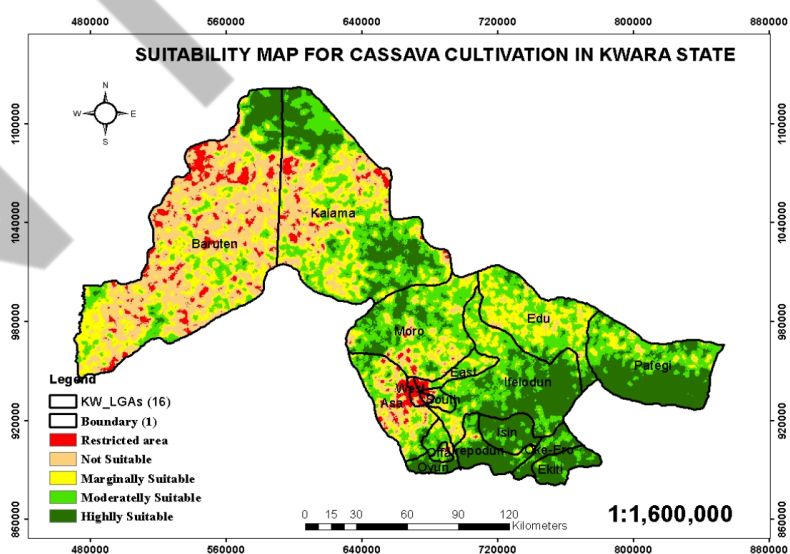
**Consistency Ratio CR = 8.7%; Principal eigenvalue = 13.467 and Eigenvector solution: 8 iterations**

Number of comparisons = 66, Principal Eigen-value = 13.467, Eigenvector solution: 8 iterations, delta = 4.1e-9, Consistency Ratio CR = 8.7%.

### Spatial Patterns of Suitability and Regional Clustering

The final suitability map reveals clear spatial clustering. Highly suitable areas are concentrated in the southern and southeastern regions (such as Pategi, Isin, Irepodun, and Ifelodun LGAs), where favorable climate, gentle slopes, and relatively better soil conditions converge. Moderately suitable zones dominate central areas, while

northern and upland regions exhibit marginal to unsuitable conditions due to soil fertility limitations and topographic constraints. Such spatial heterogeneity underscores the need for location-specific land management strategies rather than uniform agricultural expansion. Table 4 presents the suitability classification results, and Figure 11 presents the final cassava cultivation suitability map for the study area.



**Figure 13.** Suitability map for cassava cultivation in Kwara State.

**Table 4.** Suitability Classification result.

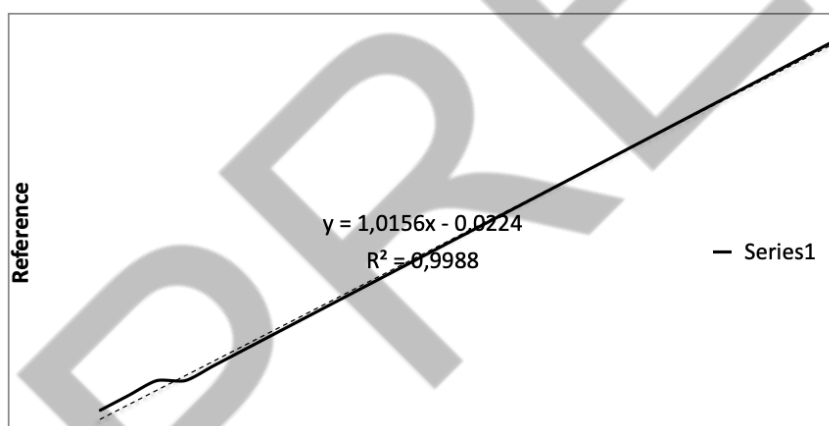
Suitability Class	Percentage (%)	Area (ha)
Highly Suitable (S1)	23.0	815,573
Moderately Suitable(S2)	27.8	984,504
Marginally Suitable(S3)	22.6	801,693
Not Suitable (N)	21.9	775,244
Restricted	4.7	165,017
<b>Total</b>	100.0	3,542,032

### Model Validation, ROC Performance, and Limitations

The Receiver Operating Characteristics (ROC) value of 0.998 indicates excellent discriminatory power; however, such high performance warrants careful interpretation. The validation dataset consisted of known cassava farm locations and randomly generated non-cassava points. While this approach is widely used, the possibility

of over-fitting cannot be entirely excluded, particularly if training and testing datasets are not fully independent.

Future studies should strengthen robustness through k-fold cross-validation, sensitivity analysis of AHP weights, and the inclusion of independent field datasets. Incorporating uncertainty analysis would further enhance confidence in the suitability outcomes.

**Figure 14.** ROC curve result of the validation.

### Discussion and Implications of Findings

The land suitability assessment demonstrates considerable potential for expanding cassava production in Kwara State, with just over half of the land classified as highly to moderately suitable. Climatic conditions across the state align closely with cassava's physiological requirements, as mean temperatures (22.5–27.5 °C), annual rainfall (800–1200 mm), and moderate humidity fall within established tolerance ranges for optimal growth and yield (Huang & Hong, 2024; Okoma et al., 2025). This confirms climate as the primary driver of suitability, consistent with previous studies in tropical Africa (Nungula et al., 2024).

Soil properties generally support cassava cultivation, particularly mildly acidic pH conditions (5.3–6.8). However, the widespread occurrence of

low organic carbon and cation exchange capacity highlights a critical constraint to long-term yield sustainability. While cassava is tolerant of low-fertility soils, continued cultivation without soil restoration measures could accelerate nutrient depletion and land degradation, underscoring the need for integrated soil fertility management (Chaudhry et al., 2024).

Topographic conditions, notably gentle slopes (0–15%) and low elevations, further enhance suitability by reducing erosion risk and improving soil moisture retention. Accessibility analysis indicates that most suitable areas benefit from proximity to road networks and water bodies, improving market access, reducing transport costs, and supporting irrigation potential, key socio-economic factors influencing adoption and profitability of cassava farming.

Despite these favorable conditions, substantial portions of the state remain unsuitable or restricted due to topographic limitations, soil degradation, or competing land uses. Highly suitable zones in the southeastern region largely coincide with forested landscapes, presenting trade-offs between agricultural expansion and environmental conservation. In contrast, northern and central areas face growing pressures from nutrient depletion and urbanization, reinforcing the need for spatially targeted land management strategies.

The spatial clustering of suitability highlights priority areas for intervention, particularly in Pategi, Isin, Irepodun, and Ifelodun LGAs,

while moderately suitable zones may benefit from phased development supported by soil improvement programs. The GIS–AHP framework proved effective in integrating diverse datasets into a robust decision-support tool, consistent with similar studies in Nigeria and West Africa (Ajala et al., 2020; Nungula et al., 2024).

The findings have implications beyond cassava, informing land-use policy, climate-resilient agricultural planning, and rural development strategies. Targeted investments in soil management, infrastructure, and extension services can enhance productivity while balancing food security objectives with environmental sustainability across Kwara State.

## CONCLUSION

This study presents a comprehensive land suitability assessment for cassava cultivation in Kwara State using an integrated Geographic Information System (GIS) and Analytical Hierarchy Process (AHP)-based Multi-Criteria Decision Analysis (MCDA). The findings indicate that a substantial proportion of the state's land is suitable for cassava production, highlighting strong potential for agricultural expansion and improved food security.

Climatic factors, particularly temperature, rainfall, and relative humidity, emerge as the dominant drivers of suitability, reflecting cassava's strong dependence on favorable hydrothermal conditions. Topographic characteristics, including gentle slopes and moderate elevations, further enhance suitability by reducing erosion risk and improving soil moisture retention. In contrast, soil fertility constraints, notably low organic carbon content and limited cation exchange capacity, pose potential risks to long-term productivity if not addressed through appropriate soil management practices.

Access to road networks and water bodies enhances the economic feasibility of cassava farming by facilitating market access, input delivery, and irrigation opportunities. However, marked spatial variability in suitability

underscores the need for targeted, site-specific land management strategies that balance agricultural development with ecological conservation, particularly in forested and environmentally sensitive areas.

From a policy perspective, the suitability framework provides a robust decision-support tool for guiding land-use planning, prioritizing agricultural investments, and promoting sustainable intensification rather than indiscriminate land conversion. The GIS–AHP approach demonstrated here is adaptable and transferable to other crops and regions, supporting climate-resilient agricultural planning.

Notwithstanding these contributions, limitations include the coarse spatial resolution of soil datasets, the absence of explicit socio-economic indicators, and the inherent subjectivity of expert-based weighting. Future research should integrate higher-resolution soil data, socio-economic variables, participatory validation, and uncertainty analysis, as well as climate change projections, to enhance model robustness and support sustainable land management and food security planning in Kwara State and beyond.

## DISCLOSURE

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## ГИС-БАЗИРАНА ПОВЕЌЕКРИТЕРИУМСКА ПРОЦЕНКА НА ПОГОДНОСТА НА ЗЕМЈИШТЕТО ЗА ОДГЛЕДУВАЊЕ НА МАНИОКА ВО ДРЖАВАТА КВАРА, НИГЕРИЈА

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### Резиме

Маниоката е важна основна земјоделска култура со значително економско значење и клучна улога во обезбедувањето на прехранбена сигурност во Нигерија, особено во државата Квара, која располага со големи неискористени земјоделски површини. Ова истражување вклучува применет Географски информациски систем (GIS) интегриран со Аналитички хиерархиски процес (АHP) и повеќекритериумска анализа на одлучување (MCDA) за проценка на погодноста на земјиштето за одгледување маниока во државата Квара. Повеќе просторни бази на податоци, вклучувајќи својства на почвата, климатски фактори, топографија, користење/покривка на земјиштето, како и близина до инфраструктурата, беа анализирани и оценувани врз основа на експертски проценки. Добиената карта на погодност го класифицира земјиштето во пет категории и покажува дека приближно 50,8 % од површината е високо до умерено погодна за производство на маниока. Валидацијата на моделот со помош на ROC (Receiver Operating Characteristics) кривата даде вредност на површината под кривата AUC (Area Under the Curve) од 0,998, што укажува на исклучително висока точност на моделот во разликувањето на погодните од непогодните површини. Истражувањето обезбедува цврста алатка за поддршка при донесување одлуки за креаторите на политики и засегнатите страни со цел оптимално користење на земјишните ресурси и унапредување на одржливото производство на маниока, придонесувајќи кон решавање на локалните предизвици поврзани со прехранбената сигурност. Препораките вклучуваат насочено одгледување на маниока на најпогодните површини, подобрување на плодноста на почвата и поширока примена на просторни анализи во земјоделското планирање.

**Клучни зборови:** анализа на погодност, прехранбена сигурност, Аналитички хиерархиски процес (АHP), Географски информациски систем (GIS).