GIS-Based Multi-Criteria Land Suitability Mapping for Sorghum Production in South-Eastern parts of Niger State, Nigeria

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As global population growth continues to escalate, the imperative for sustainable agricultural practices intensifies. In this context, sorghum, as a vital cereal crop, holds considerable promise for ensuring food security and mitigating hunger. This study focuses on sorghum production in Niger State and highlights the crucial role of site suitability analysis in ensuring sustainable crop production amid global population growth. Employing geospatial techniques, the study maps suitable sites for sorghum production by integrating diverse criteria. The Analytical Hierarchical Process (AHP) for Multi-Criteria Evaluation (MCE) was employed to assign weighted values to soil, topography, land use, geology and water resources. Subsequently, the Weight Overlay (WO) method merges these criteria, yielding a nuanced suitability map. The findings revealed by the landscape distribution show that 36.46% (697,972 hectares) of the total area is highly suitable, 40.09% (766,055 hectares) is moderately suitable, 17.88% (342,026 hectares) is marginally suitable, 1.18% (22,857 hectares) has low suitability, and 4.36% (83,565 hectares) has very low suitability for sorghum production. Gbako, Bida, Mokwa, Katcha, and Wushishi LGA areas stand out as particularly favourable for sorghum production. The study recommends replicating this methodology for assessing other cereal crops, underscoring its adept handling of restriction factors hereby considering the employed criteria for future evaluations of a comprehensive approach to land suitability analysis to foster sustainable agriculture and large-scale farming in suitable areas employing modern technology.
Keywords: Analytical Hierarchy Process, GIS, Land Suitability Mapping, Multi-Criteria Evaluation, Sorghum, Weighted Overlay

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INTRODUCTION

The continuous population growth on a global scale is on a steady rise, and the need for sustainable agricultural practices to feed the growing population has become more urgent than ever before (Houshyar & Esmailpour, 2018). Within this broader context, sorghum stands out as a crucial cereal crop with substantial potential to tackle pressing issues concerning food security and the alleviation of hunger. In this regard, land suitability assessment plays a pivotal role by classifying land based on its compatibility with specific land uses, offering crucial insights into the viability of cultivating specific crops in given areas (Ruhollah *et al.*, 2020). The concept of sustainable agriculture hinges on the idea that land should be suitable for producing quality products in an environmentally friendly manner, socially acceptable, and economically efficient (Anushiya *et al.*, 2014). Suitability analysis is deemed essential for achieving the optimum utilization of available land resources in the context of sustainable agricultural production (Perveen *et al.*, 2007). The approach employed by the FAO in 1976 for land suitability analysis for agricultural crop production classifies land on a spectrum ranging from "highly suitable" to "not suitable" based on various criteria. Land classes that perfectly match desired land use are classified as highly suitable while land classes that fail to match the desired land use are classified as not suitable (Ahmed, 2015). Developing countries in Africa, including Nigeria, grapple with food insecurity, prompting studies like Ayehu and Besufekad's (2008) work in Ethiopia, which aimed to enhance rice productivity for hunger eradication and economic development.

Nigeria, with its escalating population, strives to boost food production, especially in cultivating cereal crops like rice, maize, and sorghum. Recognizing the economic importance of these crops, it becomes crucial to evaluate land suitability for optimal land use types, ensuring sustainable agricultural production which may suffer the limitations posed by traditional approach that relies on generalized soil maps that represent entire areas with a single soil profile hereby resulting to imprecise land suitability assessments, misclassification of sites, and the creation of artificial, sharply defined boundaries that do not accurately reflect the continuous nature of soil and landscape variation (Daigle *et al.*, 2005; Ruhollah *et al.*, 2020).

A study on site suitability by Giri *et al.* (2023) for industrial development in Odisha, India, highlights the crucial role of geospatial technology and Multi Criteria Decision Making (MCDM). While valuable for industrial planning, the study primarily addresses industrial suitability, leaving a gap in the broader understanding of land use. Studies globally, including Subbarayan *et al.,* (2022) and Halder (2013) in India, Mugo *et al.* (2016) in Kenya and Islam *et al.* (2017) in Bangladesh, have conducted land suitability assessments for various crops. However, the specific suitability assessment for sorghum production in Niger State, especially at this scale, is notably absent. While Abah *et al.* (2016) and Fanan *et al.* (2019) explored site suitability mapping for crop production in Benue state Nigeria, Merem *et al.* (2014) analyzed rice production in Niger state, there is a dearth of information regarding sorghum. Moreover, the utilization of Multi-Criteria Evaluation (MCE) and Analytical Hierarchy Process (AHP) methods, as demonstrated by Ahmed and Jeb (2014) and Nurcholis *et al.* (2023), have not been thoroughly explored for sorghum suitability farming in the study area. This study aims to conduct a comprehensive land suitability analysis for sorghum production while it acknowledges the importance of understanding the specific suitability of land for sorghum cultivation using MCE at an unprecedented scale given its potential impact on production output, a facet largely overlooked in previous studies in the region.

Study Area

The study area shown in Figure 1, is situated in the southeastern part of Niger State, Nigeria, with coordinates ranging from Latitude 9°02'0.79" to 9°02’39.80” N and Longitude 6°32'46.73" E to 6°34’15.20” E. The inhabitants of the area are Gwari, Nupe, Hausa and Kadara who are predominantly farmers. The region experiences distinct dry and wet seasons, featuring fertile soils such as fluvisols, leptosols, lixisols, luvisols and nitisols with fairly flat terrain and geological characteristics of Alluvium, Felspathic sandstone siltstone, older Granite, undifferentiated basement complex with pebble beds and undifferentiated meta-sediments enjoying the Southern Guinea Savannah vegetation. Notably, the Chanchaga River and other drainage channels enhance the area's agricultural potential and mineral wealth (Niger State Bureau of Statistics, 2012; Ibrahim *et al.,* 2023).

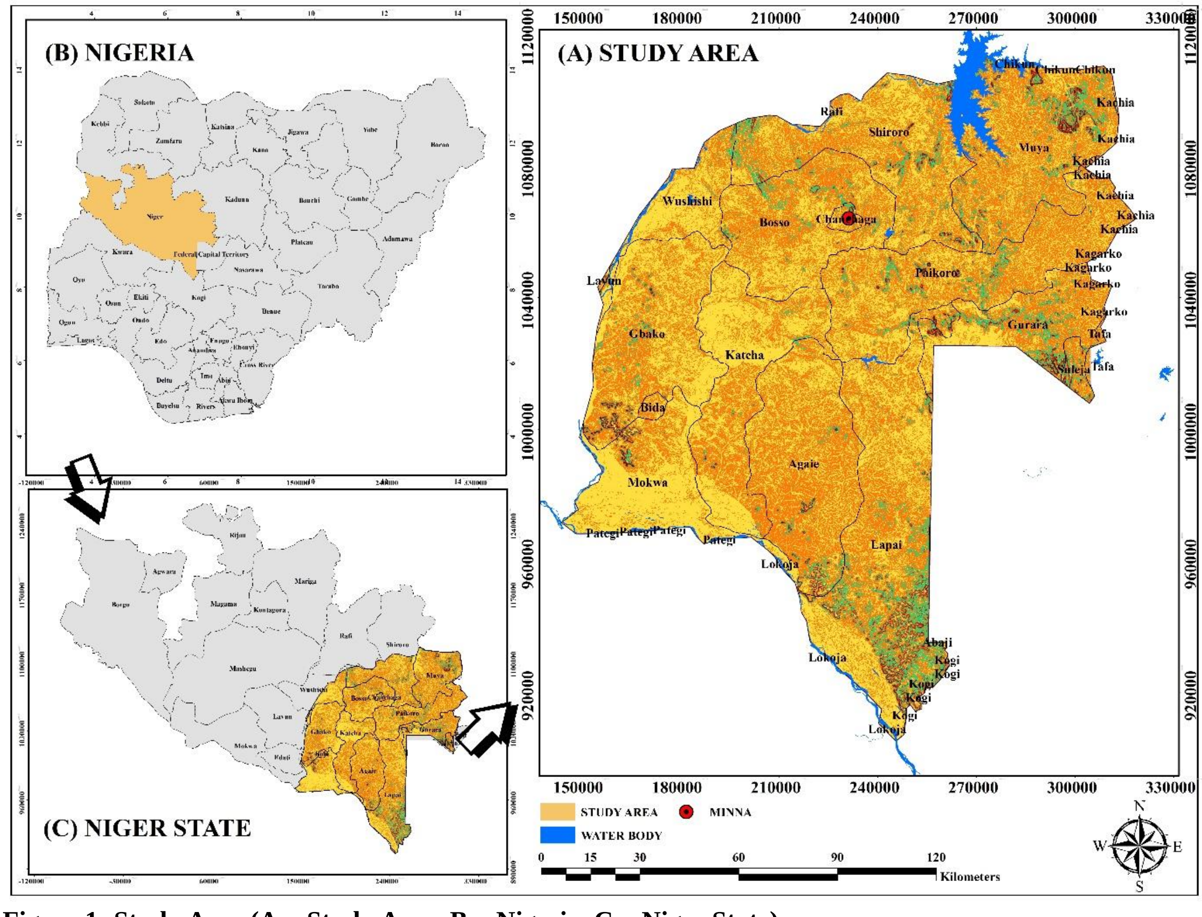

Figure 1: Study Area (A = Study Area, B = Nigeria, C = Niger State)

MATERIALS AND METHODS

The study used a multi-criteria site suitability model to identify suitable locations for sorghum production, considering various constraints and criteria. Criteria were selected based on their significant impacts on agricultural yield. Suitability map creation involves data collection, preparation, and geospatial analysis (Kahsay *et al.,* 2018; Khan & Ahmed, 2023). Key steps included sub-setting the study area, image processing, digitizing, and criteria selection. Diverse criteria, including soil characteristics, geology, land use, slope, elevation, stream order and distance to stream were used (Akinci *et al.* 2013; Islam, 2017; Mohammadi *et al.*, 2023). Table 1 shows a summary of the collected data from various sources, as depicted by the summarized workflow in Figure 2. The process involved the creation, standardization, weighting using the Analytical Hierarchy Process, ranking and merging of criteria maps using the Weighted Overlay method to produce the final suitability map of the study area (Pramanik, 2016).

Software used includes; ENVI for image processing and classification and accuracy assessment, Idrisi for AHP, assigning of weights and consistency ratio and ArcGIS for geospatial analysis, merging (WO), and suitability map creation.

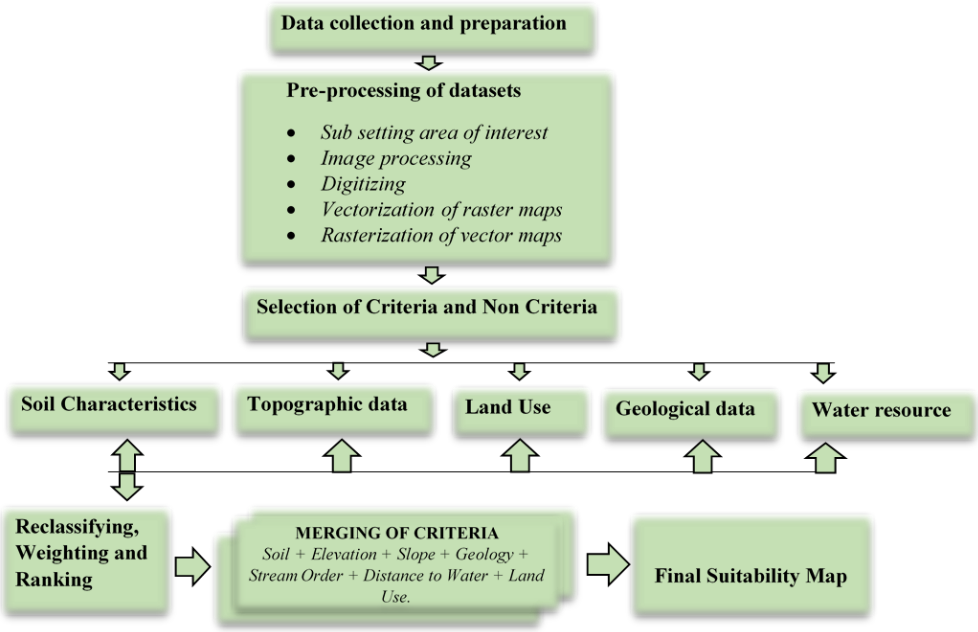

Figure 2: Workflow Diagram

Table 1: Data Sets

Data	Source	Format/Description	Purpose/Usage
Landsat 8 Satellite Imagery	http://earthexplorer.usgs.gov	Raster/30 Meters spatial resolution, 11 bands multispectral image, Scene Id = LC81890532017269LGN00. Cloud Cover = 0 – 10%. Part 190/Row 53.	Land Use/Land Cover Classification
SRTM	http://earthexplorer.usgs.gov	Raster/3 arc-seconds (approximately 30 meters) spatial resolution.	Terrain Modelling (DEM)
Soil	FAO Soil Data	Vector/ A Global Soil Data with Physical and Chemical Properties.	Suitability Mapping Criteria
	Laboratory Soil Data of Central Service Laboratory National Cereals Research Institute Badeggi	Hard Copy Document/Soil Properties of Wushishi, Minna and Doko	Data Validation
	World Soil Resources office in cooperation with O.R.S.T.O.M land and water development division/FAO	Soil Resources Map of Nigeria, Map of Present Productivity of Soils Based on Natural Fertility of Soil and On the Use of Traditional Agricultural Practices. Map Ref: NIGA 4.4 (A)	Data Validation
Administrative Map	http://www.gadm.org/	Vector/A map showing the political boundaries of Nigeria, its states, local governments and places	Boundary Demarcation
Geology	Nigerian Geological Survey Agency	Raster/The Nigeria geological map for Niger state	Suitability Mapping Criteria
Hydro	http://data.biogeo.ucdavis.edu/data/diva/wat/NGA wat.zip	Vector/Dataset containing rivers, streams, lakes, dams etc.	Suitability Mapping Criteria
Google Earth Imagery	https://www.google.com/earth	Raster/ Extracts of images covering the study area.	Classification Verification

Land Use/Land Cover Data

In this study, classification operations for identifying land use/land cover classes were conducted using Landsat 8 satellite data with spatial resolutions ranging from 15 to 30 meters. This data, covering specific geographic coordinates, enabled the distinction between various land use types, crucial for evaluating suitability for crop production (Lei *et al.*, 2017).

Topography Data Set

In this study, emphasis was placed on utilizing topographic data, particularly elevation and slope information. The calculated slope values were instrumental in identifying terrain characteristics crucial for agricultural suitability, with flatter terrains being particularly advantageous for facilitating uniform water distribution, essential for efficient agricultural practices (Fanan *et al*., 2019).

Soil Data

A good knowledge of the physical and chemical properties is useful for suitability mapping. The nutrient content of the soil determines the survival of plants in any particular area (Fanan *et al.*, 2019). Our agroecosystem relies significantly on soil as a vital component (Ayehu & Besufekad, 2015).

Geology Data

Typically, geological data is important to this study to pinpoint soils with low carbon and nitrogen, these types of soils tend to form hard crusts, especially after the first rain which will also serve as a pointer to areas that are suitable and unsuitable for cultivation of crops (Singh & Chandran, 2015). Areas with poor capacity for retaining nutrients, poor water penetration and shallow water tables can adversely affect cropping potential.

Hydro Data

In this study, distance to stream (Pramanik, 2016) and stream order, a hydrological measure indicating the size and hierarchy of streams, can serve as a criterion for sorghum site suitability mapping (Malczewski, 2004; Elshamly *et al.*, 2023). It offers insights into water availability for irrigation, drainage characteristics, and potential flooding risks, crucial considerations for sorghum cultivation. It is also a pointer to waterlogging which is not suitable for sorghum (Promkhambu *et al.*, 2010).

METHODS/ANALYSIS

Various Remote Sensing and GIS software exhibit strengths in specific analysis areas, leading to the selection of software renowned for their proficiency in this study. To address any performance deficiencies, a combination of these software was utilized for data processing and analysis. Additionally, raw datasets from diverse sources underwent preprocessing to enhance data comprehension and ensure adherence to accuracy standards. The shapefile of the study area was extracted from the administrative boundary vector data and with this, all other dataset sets were clipped to select the area of interest.

Image Classification

The satellite dataset was re-projected to Geographic Coordinates System (GCS_WGS 84) and subjected to haze reduction, Noise reduction, histogram equalization, and radiometric and atmospheric corrections after clipping out the area of interest. The maximum likelihood supervised classification method was adopted obtaining a Kappa coefficient of 0.8991 out of 1.0000 accuracy assessment.

Digitization of Soil and Geology Maps

The soil and geology data for the study area underwent georeferencing and digitizing in ArcGIS to separate individual geology and soil types, input their attribute data, and convert the data layer into a raster dataset for compatibility with criteria requirements.

Generation of Slope and Stream Order

The slope and stream order were generated from the DEM after clipping the area of interest using the slope spatial analyst tool in ArcGIS was then used to generate a percentage slope map to determine the maximum rate of change between the pixels and their neighboring pixels. Essentially, lower (or higher) slope values indicate a level (or steeper) terrain. flat terrains are particularly advantageous as they enable the even and equal distribution of water for agricultural practices (Fanan *et al.*, 2019). The DEM was to be classified to show the different elevations in the area. Whereas distances to streams were generated by computing Euclidean distance to depict the distance to water resources.

Reclassification

To implement the Weighted Overlay Method effectively, all selected criteria, originally in different units were brought to uniform units using standardization techniques following techniques outlined by Effat and Hassan (2013). In this study, reclassification played a vital role in ensuring compliance with the Weighted Overlay model in ArcGIS. This model shows an ability to handle criteria ranks of importance, weights, and constraints in a single interface while merging them as shown in Table 2. Criteria, including soil data and land use, were categorized into six classes, and reclassification involved assigning scale values, no data values, and restricted values (constraints). This process was essential for compatibility with the weighted overlay model, enabling effective merging. Soil and all other criteria maps, initially in vector format, were converted to raster before reclassification for optimal utilization of the reclassify tool. Reclassification in this study involved categorizing the soil data set on a scale of 1 to 6, representing the less to most favorable soil types. The same reclassification process was applied to other criteria.

Weighting

Weighting involves assigning importance to various criteria used in this study, recognizing that not all criteria had equal significance. Soil, land use, water, and elevation varied in impact on the suitability for sorghum cultivation. Drawing on Analytic Hierarchy Process methodologies (Saaty, 1980) and insights from Tzeng *et al.* (1998), Borcherding *et al.* (1991) and Xu (2004). Each reclassified criterion, with assigned values, received weights based on its importance to sorghum cultivation as shown in Figure 4, ensuring the total weights maintain a consistency ratio of 0.1 as in Figure 3 and were converted to 100% thereafter for WO as shown in Table 2.

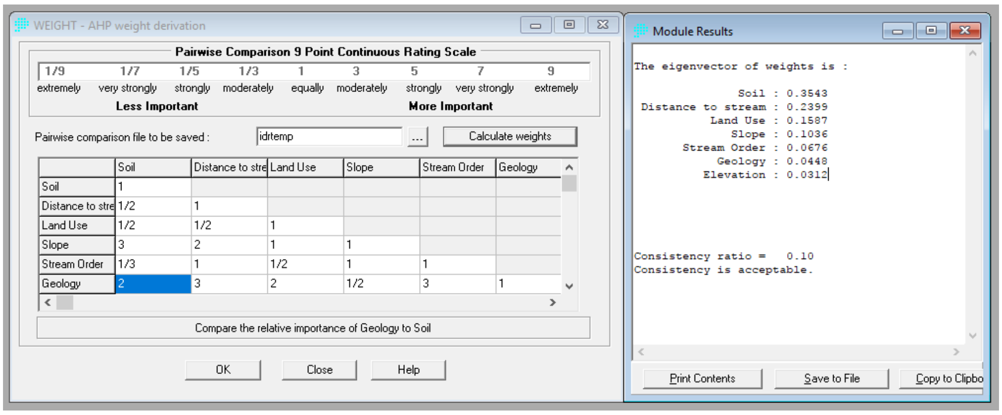

Figure 3: Weight derivation using AHP.

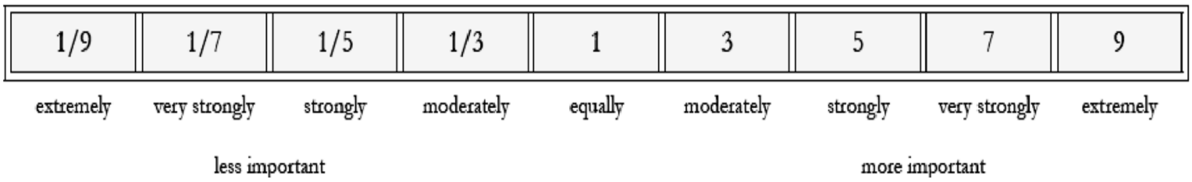

Figure 4: Nine-point weighting scale for pair-wise comparison (Saaty, 1980)

To enhance the accuracy of such assessments, the readings of pairwise comparisons elicited from the 1–9 scale (Saaty 1980; Malczewski 1999; Feizizadeh *et al.* 2014) as in Figure 4. The computation involved the criteria of reciprocity expressed as n (n - 1)/2 for n components in the pairwise comparison matrix (Saaty 1980; Akinci *et al.* 2013; Khan & Ahmed, 2023). Saaty's method has been used to compute relative weights/eigenvectors since, assessing the decision-makers inconsistency via their Consistency Index (CI) and Random Index (RI) (Cengiz & Akbulak, 2009).

$$CR = \frac{CI}{RI} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textit{Equation. (1)}$$

CR of 0.10 was computed using equation 1, implying consistency is within acceptable limits since it is less than or equal to 0.10 (Park *et.*, 2011).

Table 2: Results of weights and ranks used for WO

SN	Criteria	Class	Rank	Weight (%)	FAO Standard
1	Slope	0% - 2.5%	5	10.36	S1
		2.51% - 6.78%	4		S2
		6.79% - 14.98%	3		S3
		14.99% - 27.46%	2		N1
		27.47% - 90.95%	Restricted		N2
2	Geology	Alluvium	5	4.48	S3
		Felspathic sandstone and siltstone	4		S3
		Older Granite	3		S3
		Undifferentiated basement complex with pebble beds	2		S3
		Undifferentiated meta-sediments	1		S3
3	Land use	Built up Area	Restricted	15.07	N2
		Cultivated Land	6		S2
		Grassland	4		S1
		Light Forest	5		S2
		Open land Rock	2		S3

		Water Body	Restricted		N2
4	Elevation	34 – 118	5	3.12	S1
		119 – 204	4		S2
		205 – 316	3		S3
		317 – 434	2		N1
5	Stream order	0 - 1st	1	6.76	S1
		1st - 2nd	2		S2
		2nd - 4th	3		S3
		4th - 6th	4		N1
		6th - 9th	5		N2
6	Soil	Fluvisols	1	36.41	S3
		Leptosols	2		S2
		Lixisols	3		S2
		Luvisols	4		S2
		Nitisols	5		S1
7	Distance to stream	0 – 1600m	5	23.99	S1
		1600 – 3200m	4		S2
		3200 – 4800m	3		S3
		4800 – 6300m	2		S3
		6300 – 7900m	1		S3
				Total = 100	

Suitability Map Creation

The final suitability map was generated employing the Weighted Overlay (WO) spatial analyst tool in ArcGIS. This method was preferred due to its capability to incorporate restrictions, ranks, and weights within a single input, as demonstrated in Table 2. This approach surpasses other methods such as weighted sum (Ahmed, 2015), weighted linear combination (Akomolafe, 2015), Boolean intersection, and similar models, which may lack the integrated functionality offered by the Weighted Overlay technique.

$LS = \sum_{i=1}^{n} WiOi$ ………………… *Equ. (2)*

Where *LS* indicates the total land suitability, *Wi* indicates weight for selected land suitability criteria, *Oi* indicates the assigned sub-criteria score of *i* land suitability criteria, and n indicates the total number of land capability criteria (Pramanik, 2016).

In addition, the Weighted Overlay process was used to combine criteria based on their assigned weights, with higher weights indicating greater influence. Constraints were ranked as restricted (see Table 2).

RESULTS AND DISCUSSION

The land use and cover analysis revealed distinct classes despite some similarities. Built-up areas comprised 1.0% of the study area, while cultivated land, mainly yam and cereal crops, covered 5%. Grasslands accounted for 35%, and light forests dominated 46%, indicating ample available land for farming. Bare land/rock outcrops occupied 12%, and water bodies constituted only 1.0% of the classified land use (See Table 3). Results show a Kappa coefficient of 89.91% and an overall accuracy of 95.45% for the image classification. This suggests an 89.91% statistical agreement between ground truth pixels and the classified image, with less than 5% total error, reflecting high accuracy in pixel classification on the map.

Table 3: Land Use Classification Result

Land Use Classes	Area (km^2)	Percentage (%)
Light Forest	8716.614	46
Bare land/Rock Outcrop	2241.091	12
Water Body	242.8338	1
Built up Areas	157.8594	1
Cultivated Land	994.0264	5
Grass Land	6784.934	35
Total	**19137.358**	**100**

Geology result also shows that Felspathic sandstone and siltstone constituted 31.13% of the study area, formed by the deposition and compaction of sand-size grains with a cementing material. Undifferentiated basement complex with pebble beds covered 43.29%, comprising metamorphic or igneous rocks beneath sedimentary layers. Other geological features included undifferentiated meta-sediments (8.38%), older granite (7.05%), and alluvium (10.15%), the latter known for its fertile soil composition and mineral deposits.

Results generated from DEM also display elevations ranging from 34 to 750 meters above mean sea level, the DEM highlights a uniform descent from the northeast to the south. Additionally, the generated slope map reveals predominantly gentle slopes with the lowest ranging from 0-2.5% and the highest ranging from 27%-90%. The stream order map identifies five distinct classes of streams across the study area, enriching the analysis with valuable hydrological insights.

The soil map of the study area delineates five distinct soil classes, each with varying physical and chemical characteristics. Ferric Luvisols, covering 37.6% of the area, exhibit moderate resilience and fertility but are susceptible to erosion. Fluvisols, forming highly prized soil for agriculture, cover an unspecified portion, while Lithosols, Dystric Nitosols, and alluvium occupy 15.8%, 20.5%, and 10.15% respectively. Soil analyses, validated using field data and laboratory results, reveal normal Cation Exchange Capacities (CEC) dominated by calcium, indicating overall fertility. Additionally, distribution analyses highlight pH values conducive to crop growth, while total Nitrogen and Organic Carbon concentrations suggest moderate fertility across the area. Uniform CEC distribution indicates high soil fertility (Table 5). A five (5) level classification of land suitability for agriculture i.e. high, moderately, marginally, currently not suitable and permanently not suitable was adopted by WO for land suitability for sorghum production.

Table 4: Land Suitability Distribution Result

Suitability Classes	Area (km^2)	Area (ha)	Percentage (%)
Highly Suitable	6979.72	697972	36.49
Moderately Suitable	7660.55	766055	40.09
Marginally Suitable	3420.26	342026	17.88
Currently Not Suitable	228.57	22857	1.18
Permanently Not Suitable.	835.65	83565	4.36
Total	**19124.75**	**1912475**	**100**

Table 4 shows that the total study area is 19124.75 km^2, 36.49% (6979.72 km^2) is highly suitable (S1), and 40.09% (7660.55 km^2) is moderately suitable (S2). The combination of highly and moderately suitable areas suggests the study area is conducive to large-scale sorghum farming. Additionally, 17.88% (3420.26 km^2) is marginally suitable (S3), while areas currently not suitable (N1) and permanently not suitable (N2) cover 1.18% (228.57 km^2) and 4.36% (835.65 km^2) respectively. Notably, the permanently unsuitable areas (4.6%) are characterized by factors like large water bodies, poor nutrient soils, complex topography, rocks, bare lands, buildings, and developments (see Tables 4 and 5). The land suitability analysis indicates that over 80% of the study area is high to moderately suitable for sorghum production, suggesting favourable conditions for large-scale farming. However, approximately 22% of the area is marginally, currently, or permanently unsuitable due to factors such as poor soil quality, complex topography, and infrastructural development. Farmers in highly and moderately suitable areas can capitalize on the conducive conditions for sorghum cultivation, while those in less suitable areas may need to consider alternative crops or implement soil improvement strategies to enhance productivity. The findings underscore the importance of site suitability analysis in informing agricultural decision-making and optimizing resource allocation for sustainable farming practices. Specific local government areas, like Chanchaga, exhibit lower suitability due to rapid infrastructural development. Notably, Gbako, Bida, Mokwa, Katcha, and Wushishi were identified as the best locations for sorghum production. Unsuitable areas are characterized by significant infrastructural development, poor soil, high slopes, large water bodies, high elevation, and rock outcrops. Suitable areas have flat slopes, proximity to water, minimal infrastructure, and good soil conditions, consistent with prior research (Kihoro *et al.*, 2013). The study validates the effectiveness of the Analytical Hierarchy Process (AHP) and its combination with Weighted Overlay (WO) for site suitability analysis (Al-Mashreki *et al.,* 2011; Pramanik, 2016; Ahmad, 2022; Mercan & Acıbuca, 2023; Ruyida *et al.*, 2023).

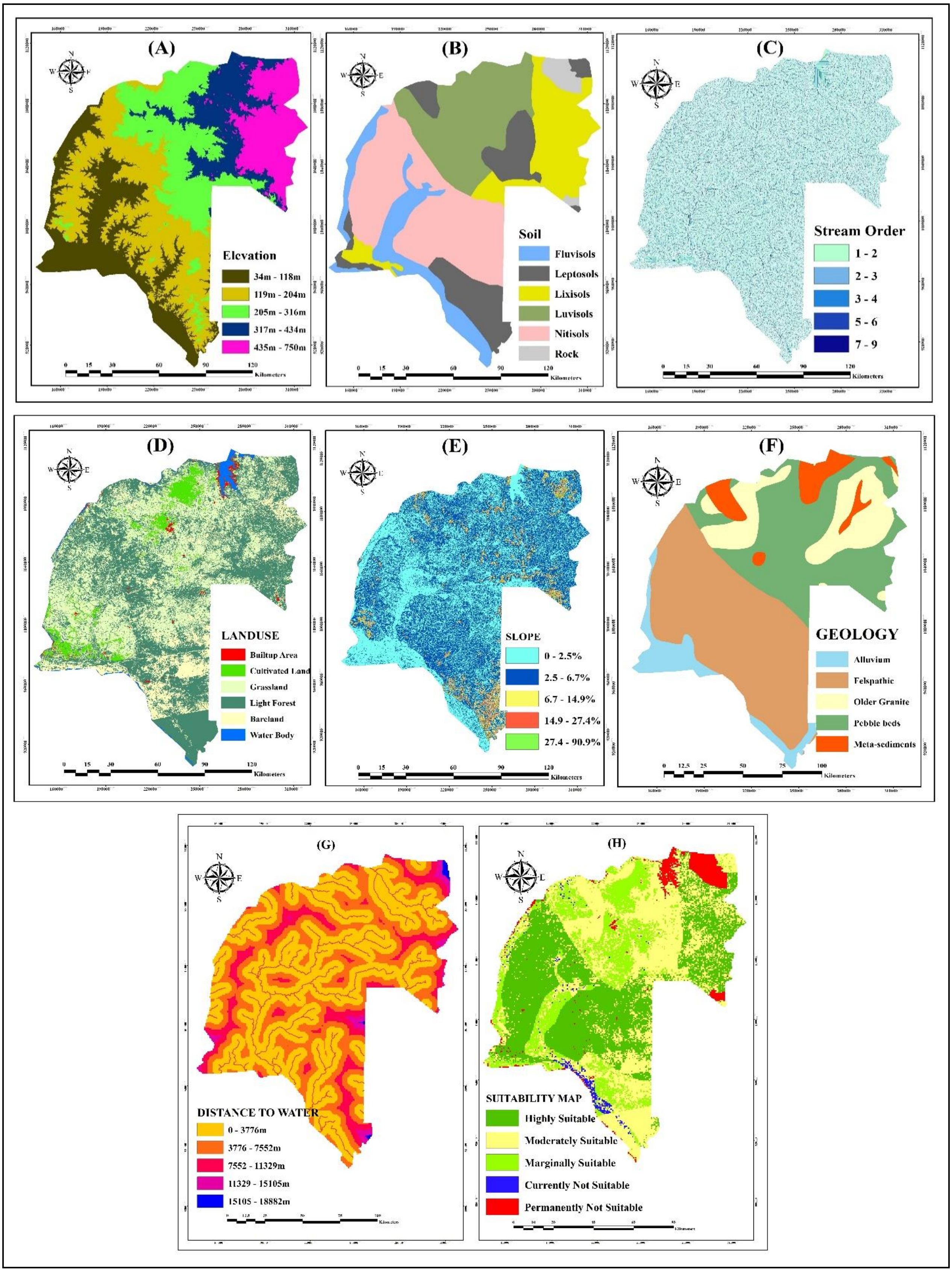

Figure 5: Result of Merged Criteria (A=Elevation, B=Soil, C=Stream Order, D=Land Use, E=Slope, F=Geology, G=Stream Order and H=Final Suitability Map).

Table 5: Area Distribution of Criteria in the Study Area

SN	Criteria	Class (Sub-Criteria)	Area (ha)	Area (%)
1	Slope	0% - 2.5%	787000.1	43.4
		2.51% - 6.78%	616840.2	32.3
		6.79% - 14.98%	323260.1	16.9
		14.99% - 27.46%	124620.3	6.5
		27.47% - 90.95%	27860.1	1.5
2	Geology	Alluvium	194110.3	10.2
		Felspathic sandstone and siltstone	595351.0	31.1
		Older Granite	134831.0	7.1
		Undifferentiated basement complex with pebble beds	827912.2	43.3
		Undifferentiated meta-sediments	160260.1	8.4
3	Land use	Built up Area	157859.4	1.0
		Cultivated Land	994026.4	5.0
		Grassland	678493.4	35.5
		Light Forest	871661.4	46.0
		Open land Rock	224109.1	12.0
		Water Body	242833.8	1.00
4	Elevation	34 – 118	701878.3	36.7
		119 – 204	499155.9	26.1
		205 – 316	380582.5	19.9
		317 – 434	330858.1	17.3
5	Stream order	0 - 1st	1290920.6	67.5
		1st - 2nd	313645.9	16.4
		2nd - 4th	154910.4	8.1
		4th - 6th	130048.3	6.8
		6th - 9th	19,124.7	1.2
6	Soil	Fluvisols	374845.1	19.6
		Leptosols	124310.9	6.50
		Lixisols	302171.1	15.8
		Luvisols	719090.6	37.6
		Nitisols	392057.3	20.5
7	Distance to stream	0 – 1600m	1114972.9	58.3
		1600 – 3200m	386319.9	20.2
		3200 – 4800m	307908.4	16.1
		4800 – 6300m	72674.1	3.80
		6300 – 7900m	30599.6	1.60

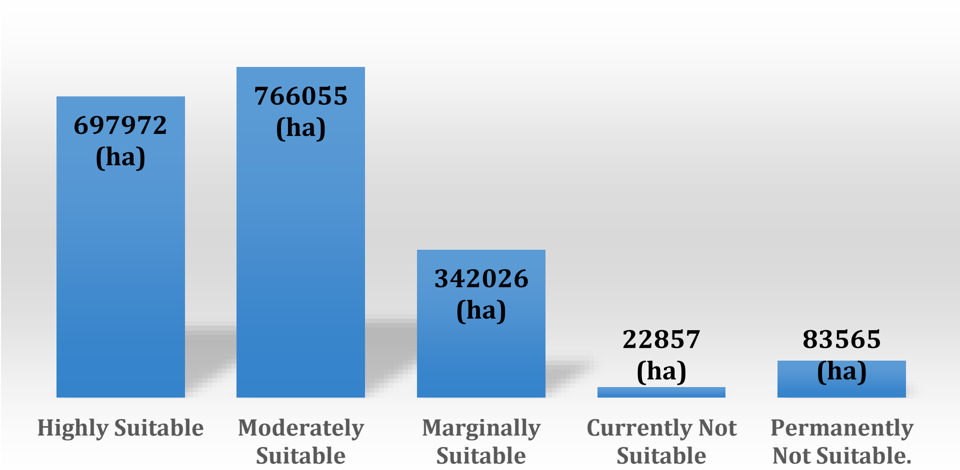

Figure 6: Suitability distribution in hectare for Sorghum production

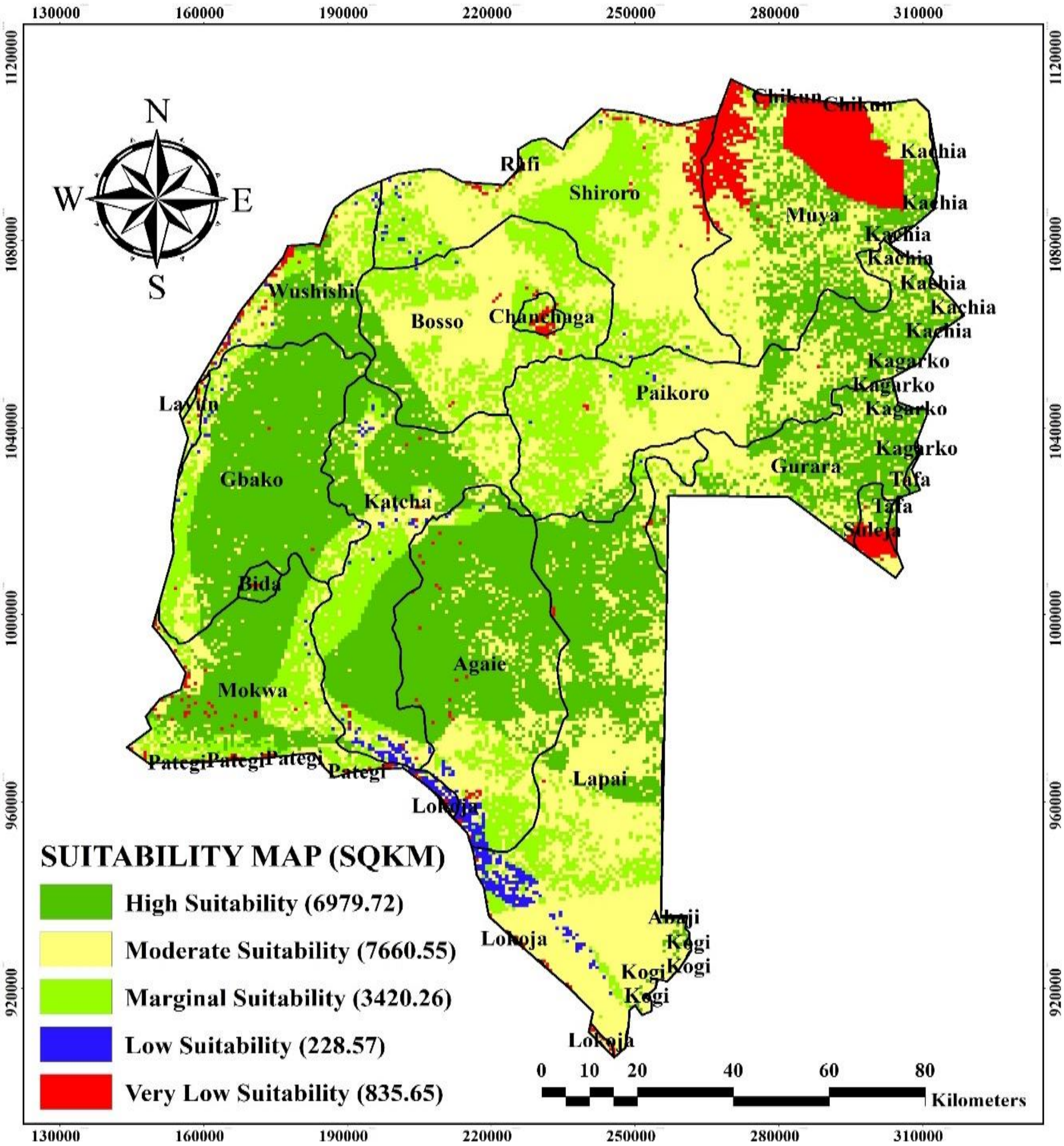

Figure 7: Site Suitability Map for Sorghum Production

CONCLUSION

The site suitability analysis for sorghum cultivation in the study area resulted in five classes: highly suitable, moderately suitable, marginally suitable, currently not suitable, and permanently not suitable. The findings reveal that 36.46% (697,972 hectares) of the total area is highly suitable, 40.09% (766,055 hectares) is moderately suitable, 17.88% (342,026 hectares) is marginally suitable, 1.18% (22,857 hectares) is currently unsuitable, and 4.36% (83,565 hectares) is permanently unsuitable for sorghum production (figure 6 and 7). The study incorporated parameters recommended by FAO and USDA, along with additional factors like stream order, geology, and distance from streams, using geospatial techniques for analysis. The resulting suitability map shows that Bako, Bida, Mokwa, Katcha, and Wushishi as the most suitable areas for sorghum cultivation. The study underscores the efficacy of GIS and MCE in analysing diverse spatial data layers for accurate suitability mapping. This study's application of GIS-based MCE provides valuable insights for agricultural investors, government planning, researchers, and farmers in decision-making processes. The study highlights the need for government policies encouraging large-scale sorghum production, identifying specific areas as highly suitable. Recommendations include careful avoidance of areas classified as unsuitable, addressing underutilization of land, and further studies incorporating additional criteria for enhanced efficiency and reliability in geospatial suitability mapping. The methodology used can be extended to analyse suitability for other crops.

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