SPATIAL CAPABILITY CLASSIFICATION AND LAND EVALUATION STUDIES FOR RICE PRODUCTION ON SELECTED WETLAND SOILS IN EKITI STATE, NIGERIA

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ABSTRACT: *The evaluation of wetland soils is essential for understanding their suitability for various agricultural practices, particularly in regions where soil properties significantly influence land management decisions. This study focuses on the spatial capability classification and land evaluation of selected wetland soils in Ekiti State, Nigeria, with a particular emphasis on rice production. Wetland soils in this region are characterized by distinct physical and chemical properties that affect their agricultural potential. The use of both parametric and non-parametric approaches in land suitability assessment allowed for a comprehensive analysis of the land's potential, factoring in both inherent soil qualities and the potential for improvement through human intervention. The research utilized a combination of Land Capability Classification (LCC) and Land Suitability Classification (LSC) methods to assess soil characteristics such as texture, organic matter content, drainage capacity, and nutrient availability. These evaluations were further supported by the Geographic Information System (GIS) and remote sensing technologies, which provided spatial data and generated suitability maps. The results indicate a range of soil suitability classes, from highly suitable (Class I) to unsuitable (Class VIII) for rice cultivation, although the drainage condition which is essential for effective water management indicated moderate suitability (S2) in all the locations. Notably, sites such as Ise, Isan, and Ikole demonstrated highly suitable conditions (S1) for rice production, characterized by optimal soil textures. In contrast, Ifaki exhibited marginal suitability (S3) due to lower pH levels and cation exchange capacity (CEC), highlighting potential challenges in nutrient retention that could adversely impact crop yield. The results of this study offer valuable insights for land use planning and agricultural development, contributing to sustainable land management practices and mitigating erosion risks, especially in regions identified as having moderate to severe erosion hazards and also enhanced food security in the region. Additionally, it emphasizes the need for continuous soil assessments to monitor changes in soil properties and adapt agricultural strategies accordingly.*

KEYWORDS: Spatial, evaluation, wetland, classification.

INTRODUCTION

Wetland soil evaluation plays a pivotal role in determining the suitability of land for various uses, particularly in environments where soil properties significantly influence land management practices. As outlined by Babalola *et al*. (2011), the evaluation process involves assessing key soil characteristics, such as texture, organic matter content, and drainage capacity. These factors are essential for understanding how wetland soils behave under different environmental conditions and for determining their potential to support various land uses, including agriculture, forestry, or urban development. Critical considerations in this evaluation include the depth of the water table, flooding frequency, and soil aeration, all of which influence the sustainability of land management practices. A thorough understanding of these soil characteristics aids in the conservation of wetland ecosystems and the preservation of biodiversity. A systematic approach known as Land Capability Classification (LCC) is widely used to assess the inherent characteristics of land and its capacity to support different land uses in a sustainable manner.

Gashaw *et al*. (2018) described LCC as a method that evaluates a range of factors, including soil properties, topography, climate, and drainage, to classify land into categories based on its suitability for various purposes. This classification typically involves assessing soil type, depth, texture, and drainage, along with slope, climate, and vegetation cover. The outcome of this assessment provides insights into the land's ability to support different uses sustainably. Ippolito *et al*. (2021) further explained that LCC categorizes land into several classes, ranging from highly suitable (Class I) to unsuitable (Class VIII) for specific land uses. Class I lands, for example, are characterized by fertile soils, favorable topography, and adequate water supply, making them ideal for intensive agricultural production. Conversely, Class VIII lands may have severe limitations, such as poor soil quality or steep slopes, rendering them unsuitable for most forms of development. LCC also considers the long-term viability of land uses, factoring in potential challenges such as climate change, population growth, and land degradation. This forward-looking approach is crucial for preserving valuable land resources for future generations while balancing competing demands. In addition to LCC, Land Suitability Classification (LSC) is another method used to evaluate and categorize land based on its suitability for different types of land use or development. Unlike LCC, which focuses on inherent land qualities, LSC takes into account both natural attributes and human interventions, such as irrigation, drainage, and land management practices (Hamzeh *et al*., 2014). Mugiyo *et al.* (2021) noted that LSC evaluates a broader range of factors, including soil characteristics, climate, topography, hydrology, land tenure, infrastructure, and socio-economic considerations. The classification process integrates quantitative data with qualitative assessments, resulting in categories that range from highly suitable to unsuitable for various uses. Geographic Information Systems (GIS) and remote sensing technologies are frequently employed in LSC to analyze spatial data and generate suitability maps, providing visual representations of land suitability across landscapes (De Paul Obade & Lal, 2013). These maps serve as valuable tools for land use planning, natural resource management, and sustainable development. According to Xu *et al*. (2023), LSC helps decision-makers to identify the most suitable locations for different activities, optimize land utilization, and minimize potential conflicts between competing land uses. This process also informs policies and strategies aimed at promoting efficient resource allocation, environmental conservation, and socio-economic development. This research advocates for integrated land management approaches that balance agricultural needs with environmental conservation, ensuring the sustainability of wetland

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ecosystems. The objective of this study is to evaluate the spatial capability classification and land evaluation studies for rice production of selected wetland soils in Ekiti State, Nigeria

MATERIALS AND METHODS

Description of Study Area

Ekiti State is situated in the southwestern part of Nigeria and entirely within the tropics. It is located at longitudes 40°51′ and 50°451′ east of the Greenwich meridian and latitudes 70°151′ and 80°51′ north of the Equator. Ekiti experiences a tropical climate with distinct wet and dry seasons. The dry season spans from November to early March and the rainy season starts from late March to early April to October. The distribution is bimodal with peaks in June and September, such that the wet season is divided into two by a dry spell in the late July to mid-August (August break). Mean annual total rainfall is about 1387 mm and the average number of rainy days is about 112 per annum. Temperature is almost uniform throughout the year with little deviation from mean annual of 27^0C; February and March are the hottest months with mean temperature of 28^0C and 27^0C. The state is generally an undulating part of the country Nigeria with a characteristic landscape that consists of old plains broken by step-sided out-crops that may occur singularly or in groups or ridges. The study area falls within the Precambrian Basement of Nigeria which is underlain by migmatite-gneiss, schist rocks and granitoids. Migmatite-gneiss unit which is of Archaean-Paleoproterozoic age accounts for its dominant parts. The schist is restricted to the North-Western part of Ekiti (Akinola & Talabi, 2023). Literature reveals that several works of various interests and extents by different authors have been reported in the area (Rahaman, 1976; Oyinloyea & Obasi, 2006). The vegetation of the sites is forest mix with various types of bush growth, grasses and creepers. Tropical forest exists in the south, while savannah occupies the northern peripheries.

Field Work and Soil Sampling

A pedon (1.5 m wide x 1.0 m long x 1.5 m deep) was established at each study site. The pedon locations were Geo-referenced with Global Positioning System (GPS). Each pedon was described following the procedure described in the USDA Soil Survey manual (Soil Science Division Staff, 2017). The soil morphological properties were observed and described for each horizon in the pedons. A cylindrical core sampler was used to collect samples for bulk density by driving the sampler either vertically or horizontally into the soil surface; then the sampler was carefully removed with its contents and wrapped before oven drying. 500 g soil representative sample was collected from each of the designated horizon. They were packed into polythene bags, neatly labelled and taken to the laboratory for analysis.

Laboratory Analysis

The soil samples collected from soil profiles were properly labeled and taken to the laboratory, where they were;air-dried. They were gently crushed to break up the peds and subsequently sieved with a 2 mm sieve. Materials that passed through the sieve were labeled ‘fine earth’ (< 2 mm) fractions; the fine earth (material < 2 mm) was weighed and separated for further analysis. The following parameters on soil physical and chemical properties were determined:

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Particle size distribution was determined by Gee and Bauder's (1986) method. The Bulk density was determined by Grossman and Reinsch's (2002) method, and organic carbon was determined using Walkley and Black's method, as described by Nelson and Sommers (1982), and was converted to OM using a coefficient of 1.724. Total Nitrogen (N) was determined using Kjeldahl's method of nitrogen determination Bremmer (1966). Available Phosphorus (P) was determined by Bray's method (Kuo, 1996). Other chemical properties were also calculated below.

Percentage exchangeable bases was calculated using the formula:

$$\text{Exchangeable bases BS (\%)} = \frac{\text{Exchangeable base saturation}}{\text{CEC}} \times \frac{100}{1}$$

Base saturation (BS) percentage was calculated using the formula:

$$\text{\% B.S} = \frac{\text{Total exchangeable bases}}{\text{ECEC}} \times \frac{100}{1}$$

Exchangeable sodium percentage (ESP) was calculated as the proportion of the ECEC occupied by sodium cations as follows:

$$\text{ESP} = \frac{\text{Exchangeable sodium}}{\text{ECEC}} \times \frac{100}{1}$$

Land Suitability Evaluation (LSE)

Parametric Square-Root Method

The parametric method of FAO (1976) employed by Ogunkunle (1993) and Udoh and Ogunkunle (2012) was used to assess the suitability of the soils for lowland rice. Each land characteristic with relevance on the land use potential was allocated a numerical value, ranging from 100 (for the highest potential) to 40 or less (for the lowest potential) based on the extent to which the land characteristic met the requirements of the crop. Then, all the scores of the relevant characteristics were combined into an overall index of current and potential productivity.

Land characteristics were divided into quality groups (Table 1). These include climate-c (annual rainfall, annual temperature, and mean relative humidity), topography-t (slope), wetness-w (oxygen availability-drainage), soil physical characteristics-s (rooting condition-soil depth, structure, texture) and fertility-f (nutrient availability and retention-pH, organic matter, available P, exchangeable K, Mg, Ca, total N, CEC and base saturation). It is assumed that members of the same group have strong correlation among members. For instance, texture and structure in soil physical characteristic group are strongly correlated. CEC and base saturation in fertility group are also correlated. Therefore, only one member of each group and the most limiting factor was used to calculate the index of productivity because of the Leibig's law of the minimum, which states that 'growth is controlled not by the total amount of resources available but by the most insufficient resource (limiting factor). In calculating the index of potential productivity (IP_P), fertility values such as K mole fraction, Mg:K ratio, and other fertility characteristics, which can easily be corrected by the application of fertilizer(s) are not considered in rating for the fertility land quality group, but these are considered when rating

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for Current/Actual productivity (IP_c) (Udoh & Ogunkunle, 2012). The suitability classes S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), N1 (currently not suitable) and N2 (potentially not suitable) are equivalent to index of productivity value of 100–75, 74–50, 49–25, 24–12.5 and 12.4–0 respectively. The limiting factors of each pedon was rated in percentage and the index of suitability of each profile was computed using the equation:

$$IP = A \; x \sqrt{\frac{B}{100}} \; x \frac{C}{100} \; x \; \frac{D}{100} \; x \; \frac{E}{100} \; x \; \frac{F}{100}$$

where: IP = Index of Productivity

A = Overall lowest characteristic

B, C, D, F = The lowest characteristic ratings for each land quality group.

B. Non Parametric Approach

For the non-parametric method (FAO, 1976), pedons were placed in suitability classes by matching their land characteristics with the agronomic requirements of rice. The non-parametric method is a qualitative approach that involves the use of expert knowledge and experience to evaluate the suitability of land. It is based on the assumption that the expert has an in-depth understanding of the factors that affect land suitability and can use this knowledge to evaluate the land.

Land Capability Classification

Land capability classification (LCC) used was the method by Klingebiel and Montgomery (1961), modified by USDA (2017) (Table 2). Soil limitations were used to place the soils into different classes with classes I–IV as arable and V–VIII as non-arable. The classification would depend more on the severity of the limitations than the number of limitations (FAO, 1983).

Spatial Data Analysis: Spatial data analysis was done with ARCGIS 10.7. This was used to develop the spatial distribution maps for the study area using interpolation technique.

Table 1: Land requirements for suitability classes for lowland rice cultivation

Land Qualities	Rate	95-100	70-94	55-69	40-54	20-39	0.00-19
	Class	S11	S12	S2	S3	N1	N2
Climate	c						
Mean Annual Rainfall	mm	>1000	900-1000	800 – 900	600 – 800	500 – 600	< 500
Mean Annual Max. Temp.	°c	>25	22-25	20-22	18-20	16 – 18	< 16
Relative Humidity	%	>75	70-75	65-70	60 – 65	< 60	-
Topography	t						
Slope	%	< 2	3-4	5–6	7-8	9 – 10	> 10
Drainage	w						

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Wetness		WD (ID)*	MWD (ID)*	MD	ID (WD)*	PD (WD)*	PD (WD)*
Flooding		F0	F0	F1	F1	F2	F3
Soil Physical Properties	s						
Texture		L (LC)*	Lfs (SLC)*	LS (SL)*	S	S	S
Structure		Cr (SAB)*	Cr (SAB)*	SAB (Cr)*	SAB (Cr)*	Col (Cr)*	Col (Cr)*
Coarse Fragments (0.50cm)	%	<3	3-5	5 – 10	10 – 15	>15	-
Soil Depth	s	>75	65 – 70	50 – 65	35 – 50	30 – 35	<30
Soil Fertility	f						
pH	water	5.5 – 6.5	5.0-5.5	4.5 – 5.0	4.0 – 4.5	<4.0	
CEC	(cmolkg-1 clay)	> 16.0	12 – 16.0	8 – 12.0	5.0-8.0	<5.0	-
Base Saturation	%	> 80	70 – 80	50 – 70	40 – 50	25 – 35	<25
Nitrogen	%	> 2.0	1.5 – 2.0	1.0 – 1.5	0.5 – 1.0	<0.5	
Avail. P	$mgkg^{-1}$	> 20	15 – 20	8 – 15	5 – 8	3 – 5	<3
Exractable K	$cmolkg^{-1}$	> 0.50	0.3 – 0.5	0.20 – 0.30	0.10 – 0.20	<0.1	
Micro-nutrients	0.5NHCl						
Iron	mgkg-1	>4.5	3.5 – 4.4	2.5 – 3.5	1.5 – 2.5	1.0 – 1.5	<1.0
Zinc	‘ ’	2.0 – 2.5	1.5 – 2.0	1.0 – 1.5	0.8 – 1.0	0.6 – 0.8	<0.6
Mn	‘ ’	1.5 – 1.7	1.0 – 1.5	0.8 – 1.0	0.6 – 0.8	0.5 – 0.6	<0.5

Source: Sys *et al.* (1993); Ajiboye *et al.* (2011)

Key: * = Ratings for lowland rice production: SAB – Subangular blocky; Col. – Columnar, Cr – Crumb; WD – Well drained; MWD – Moderately well drained; ID – Imperfectly drained; PD – Poorly drained; L – Loam; SL – Sandy loam; LS – Loamy sand; Lfs – Loamy fine sand; SCL – Sandy clay loam; C – Clay; F0 – Rarely Flooded; F1 – Flooding Expected; F2 – Irregularly Flooded; F3 – Regularly Flooded; C – Clay; CL – Clay Loam; LS – Loamy Sand; SL – Sandy Loam; LCS – Loamy Clay Sand; CS – ClayS; S–Sand

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Table 2: Land capability classification system

Properties	Land capability class- Degree of limitations, Restrictions or hazards							
	I	II	III	IV	V	VI	VII	VIII
Erosion hazard (e)								
[1]Erosion	None or Slight	Moderate	Severe	Very Severe	None or Slight	Not class-determining		
[2]Slope Angle (%)	1	3	5	10	18	35	≥35	
Excess Water (w)								
[1]Drainage class	Well or Moderately	Moderately or Somewhat poorly	Somewhat poorly or poorly	Poor	Not class-determining			
[2]Flooding	None	Rare	Occasionally moderate	Frequent Severe	Frequent –Prevents normal production of crops			
Soil Limitation(s)								
[1]Salinity (EC- dS/m)	<1	1-2	≤3	>3	4-8	8-16	>16	
[2]Rock outcrop, stone and Boulders	<0.1	≥0.1 to <3	≥3 to <15	≥15 to <50	≥15 to <50	≥15 to <50	≥50 to <90	≥90
[3]Effective Soil depth (cm)	>90	45-90	22.5-45	7.5-22.5	<7.5		0	0
[4]ECEC (Cmol/kg) Clay	25-40	12-25	6-12	>5	≤5	2	1	0
[5]Surface Texture Class	SL, SCL, CL or LS (if less than 20in thick)	LS, S or SC, C (if <60% clay)	C (≥60% clay i.e HC)	COS, HC	VCOS		Not class-determining	
Climate (c)								
[1]Effective precipitation (mm)	≥1117.6	≥787.4 to <1117.6	≥635 to<787.4	≥482.6 to <635	Not class-determining	≥284 to 482.6	<284	Not class-determining
[2]Nature of Climate	Humid climate. Rainfall evenly distributed	Humid Climate. Dry spells occasionally occur	Crop yield frequently reduced by drought in subhumid climate	Crop yields frequently reduced by drought in semi-arid climate	Semi-Arid climate	Arid Climate		

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RESULTS AND DISCUSSIONS

Table 3: Land characteristics/qualities of the study locations

Land qualities	Ilawe	Igbara-Odo	Efon	Ido-Ile	Ise	Ikere	Ado	Ijan	Ifaki	Ido	Ayede	Isan	Ikole
Climate (C)													
Annual Rainfall (mm)	1387	1387	1300	1300	1355	1345	1381	1370	1370	1370	1370	1300	1393
Mean Annual Temperature°C	28	28	28	28	28	28	28	28	28	28	28	28	28
Relative humidity (%)	74	74	76	74	73	73	76	76	74	73	73	65	76
Topography (t)													
Slope (%)	4	4	4	3	4	3	3	4	4	4	3	4	4
Wetness (w)													
Drainage	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp	Imp
Soil physical properties (s)													
Texture	SL	SC	SL	SCL	SCL	SCL	SL	SL	LS	SL	SL	SL	SL
Coarse fragment	100	85	85	85	85	85	85	100	100	85	100	85	85
Soil depth	130	130	95	85	52	135	130	105	90	95	65	80	79
Fertility (f)													
Soil P^H	4.90	4.34	5.46	5.18	5.02	5.83	4.90	4.34	4.75	5.30	7.02	5.57	5.46
CEC (cmol/kg)	5.78	8.89	4.97	10.7	9.87	9.05	5.18	6.29	5.01	6.93	5.35	4.76	19.5
Base saturation	68.17	72.92	79.08	65.85	93.51	90.28	83.00	87.27	87.21	96.54	80.58	64.70	97.53
Nitrogen (%)	4.76	2.38	1.96	2.94	2.8	2.24	1.96	1.68	2.52	2.38	2.52	2.66	1.26
Available P (mg/kg)	6.91	25.49	14.26	31.54	15.77	28.08	8.13	23.62	11.74	14.45	5.63	5.63	12.66
Extractable K (cmol/kg)	0.18	1.46	0.14	0.63	0.46	0.29	0.17	0.58	0.22	1.96	0.14	0.21	0.32
Iron (mg/kg)	32.60	29.20	10.54	13.08	5.62	60.87	19.54	15.26	37.50	29.58	14.63	18.06	7.87
Zinc (mg/kg)	7.52	7.13	10.66	18.64	8.08	9.1	9.76	13.02	13.72	10.58	8.56	8.08	1.90
Mn (mg/kg)	3.07	2.57	6.64	9.64	5.62	8.14	5.88	8.13	5.42	8.52	7.42	7.56	4.13

Imp - Imperfectly drain; SL - Sandy Loam; SC - Sandy Clay; SCL - Sandy Clay Loam; LS - Loamy Sand.
Source: Metrological, field and laboratory data

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Land Capability Classification

The erosion hazard (e) assessment indicated varying degrees of erosion across the studied locations (Table 3). Moderate erosion was observed at Efon, Ido Ile, Ise, Ikere, Ado, Ijan, Isan, and Ikole, suggesting a moderate risk of soil loss. In contrast, severe erosion was noted in Ilawe, Igbara Odo, Ifaki, Ido, and Ayede, highlighting a higher risk of soil degradation in these areas. Mehwish *et al*. (2024) declared that these findings underscore the importance of implementing erosion control measures, such as contour farming and terracing, in highly vulnerable regions to mitigate soil erosion. The slope angle revealed that all locations are in Class II, indicating moderate slope gradients. Similar studies by Asmamaw and Mohammed (2019) reported that moderate slope angle suggests a balanced terrain that may be suitable for various land uses, although proper soil conservation practices should still be applied to prevent erosion on sloping lands. Excess water (w) assessment indicated poor drainage conditions (Class II1) in most locations, with exceptions at Efon and Ido Ile categorized under Class 11 (imperfect). Moreover, severe flooding (Class 111) was encountered in all locations, indicating a high vulnerability to waterlogging and flood hazards (Zhang *et al*., 2021). The author moved on to suggest that poor drainage and flooding can restrict agricultural activities and may pose risks to infrastructure and human settlements. Soil limitation parameters indicates the absence of salinity (Class 1) which suggests favorable conditions for agriculture according to Ammari *et al*. (2013), and the presence of rock outcrops, stones, or boulders (Class 11) which may pose challenges for certain land uses, requiring appropriate soil management practices as per Scarciglia *et al*. (2020).

The effective soil depths varied across locations, with most pedons observed to have effective soil depth (Class 1). However, pedons at Ido Ile, Ise, Ayede, Isan, and Ikole exhibited shallower soil depths (Class 11), indicating limitations for root penetration and water storage capacity. The ECEC (clay) was classified under Class 111 at Igbara Odo, Efon, Ido Ile, Ise, Ayede, and Isan, Class 1V at Ilawe, Ado, Ijan, Ifaki, and Ido, and Class 11 at Ikole. The ECEC (clay) shows different classifications in all the locations, indicating variations in nutrient retention capacity. The dominant texture at the surface was sandy loam (1), which is generally conducive to agriculture. However, some locations exhibited a sandy clay loam texture (11), which may influence soil drainage and nutrient retention. The climate classification indicated a humid climate (Class 11) across all locations, with effective precipitation categorized as Class 1. According to Hossain *et al*. (2020), these climatic conditions are favorable for various agricultural activities but may also pose challenges such as erosion and disease pressure, necessitating appropriate land management practices. The aggregate LCC rating shows that the $I11e^{1}w^{1,2}s^{4}$ rating at Igbara Odo and Ayede suggests that these locations encountered severe erosion (e), poor drainage (w), and moderate limitations (s) in soil parameters. The $IVe^{1}w^{1,2}s^{4}$ rating at Ifaki and Ido indicates severe erosion (e), poor drainage (w), and moderate soil limitations (s). Pedons at Ise, Ikere, Isan, and Ikole, rated $II1ew^{1,2}s^{4}$, show moderate erosion (e), imperfect drainage (w), and moderate soil limitations (s). Efon and Ido Ile, rated $I1Iw^{2}s^{4}$, point to moderate erosion (e), imperfect drainage (w), and moderate soil limitations (s). Ado, rated $IVw^{2}s^{4}$, faces severe erosion (e) and poor drainage (w), emphasizing the need for erosion control measures and drainage improvements. Ilawe, rated $IVe^{1}w^{1,2}s^{4}$, exhibits severe erosion (e) and poor drainage (w), suggesting limitations for various land uses.

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Table 4: Land capability classification of soils of the study location

Properties	Ilawe	Igbara	Efon	Ido ile	Ise	Ikere	Ado	Ijan	Ifaki	Ido	Ayede	Isan	Ikole
Erosion harzard (e)													
[1]Erosion	III	III	II	II	II	II	II	II	III	III	III	II	II
[2]Slope Angle (%)	II	II	II	II	II	II	II	II	II	II	II	II	II
Excess Water (w)													
[1]Drainage class	III	III	II	II	III	III	II	III	III	III	III	III	III
[2]Flooding	III	III	III	III	III	III	III	III	III	III	III	III	III
Soil Limitation (s)													
[1]Salinity (EC-dS/m)	I	I	I	I	I	I	I	I	I	I	I	I	I
[2]Rock outcrop, stone and Boulders	I	II	I	II	I	I	I	I	I	I	I	I	I
[3]Effective Soil depth (cm)	1	I	I	II	II	I	I	I	I	I	II	II	II

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[4]ECEC (Cmol/kg) Clay	IV	III	III	III	III	III	IV	IV	IV	IV	III	III	II
[5]Surface Texture Class	II	II	I	I	I	I	I	I	II	I	I	I	I
Climate (c)													
[1]Effective precipitation (mm)	1	1	1	1	I	I	1	1	1	1	1	1	1
[2]Nature of Climate	II	II	II	II	II	II	II	II	II	II	II	II	II
Aggregate capability	IVs^{4}e^{1}w^{1,2}	IIIe^{1}w^{1,2}s^{4}	III w^{2}s^{4}	III w^{2}s^{4}	III w^{1,2}s^{4}	III w^{1,2}s^{4}	IV w^{2}s^{4}	IV w^{1,2}s^{4}	IVe^{1}w^{1,2}s^{4}	IVe^{1}w^{1,2}s^{4}	IIIe1 w^{1,2}s^{4}	III w^{1,2}s^{4}	III w^{1,2}s^{4}

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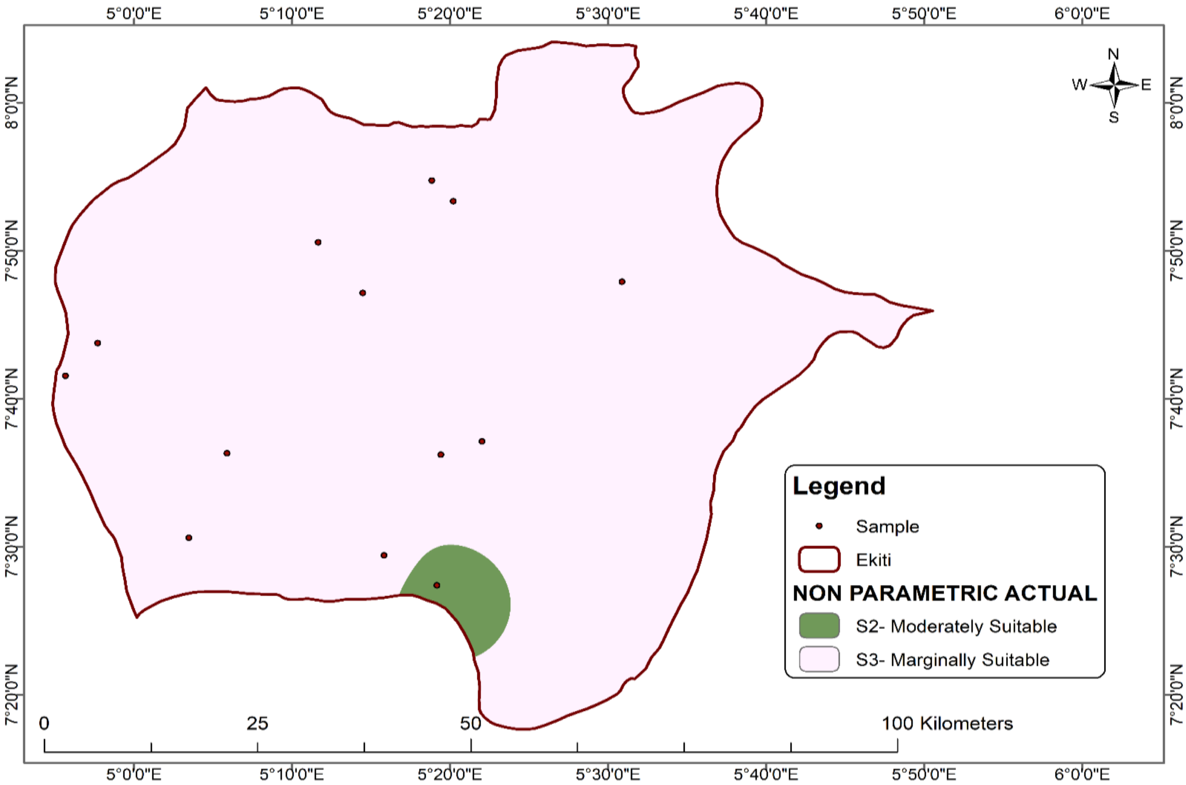

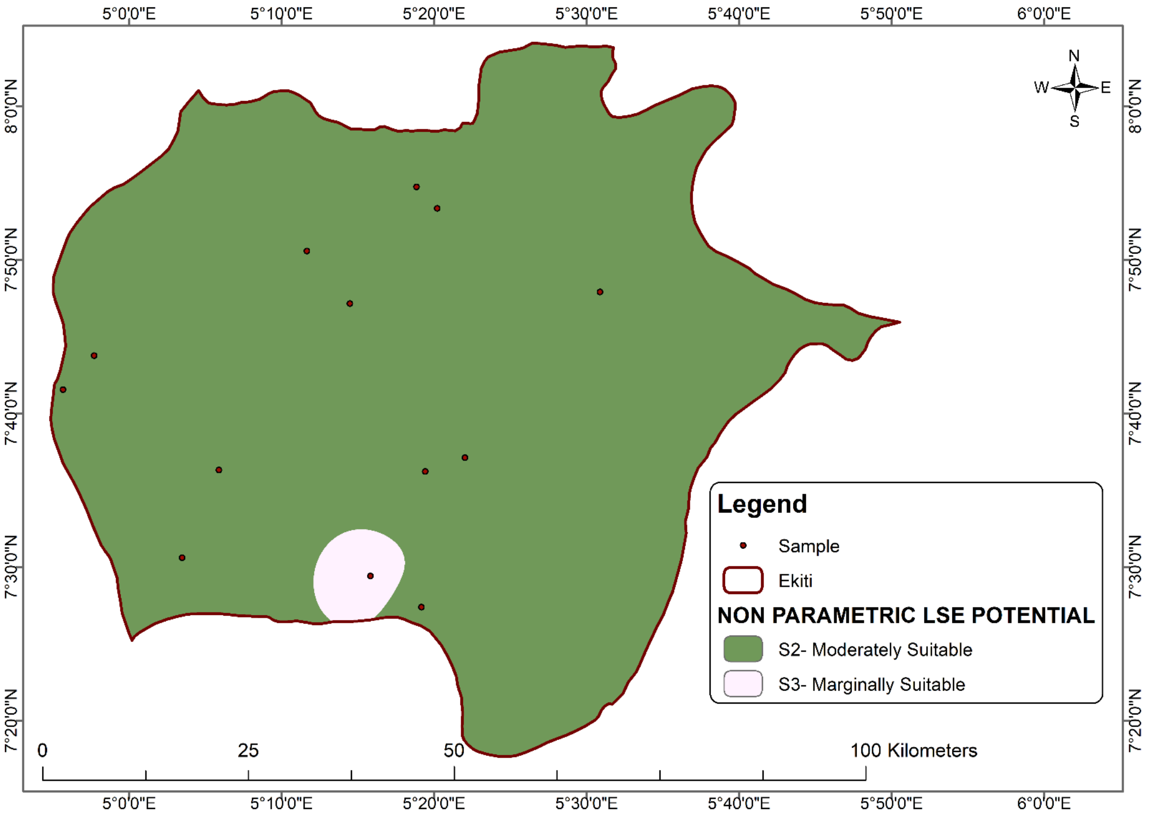

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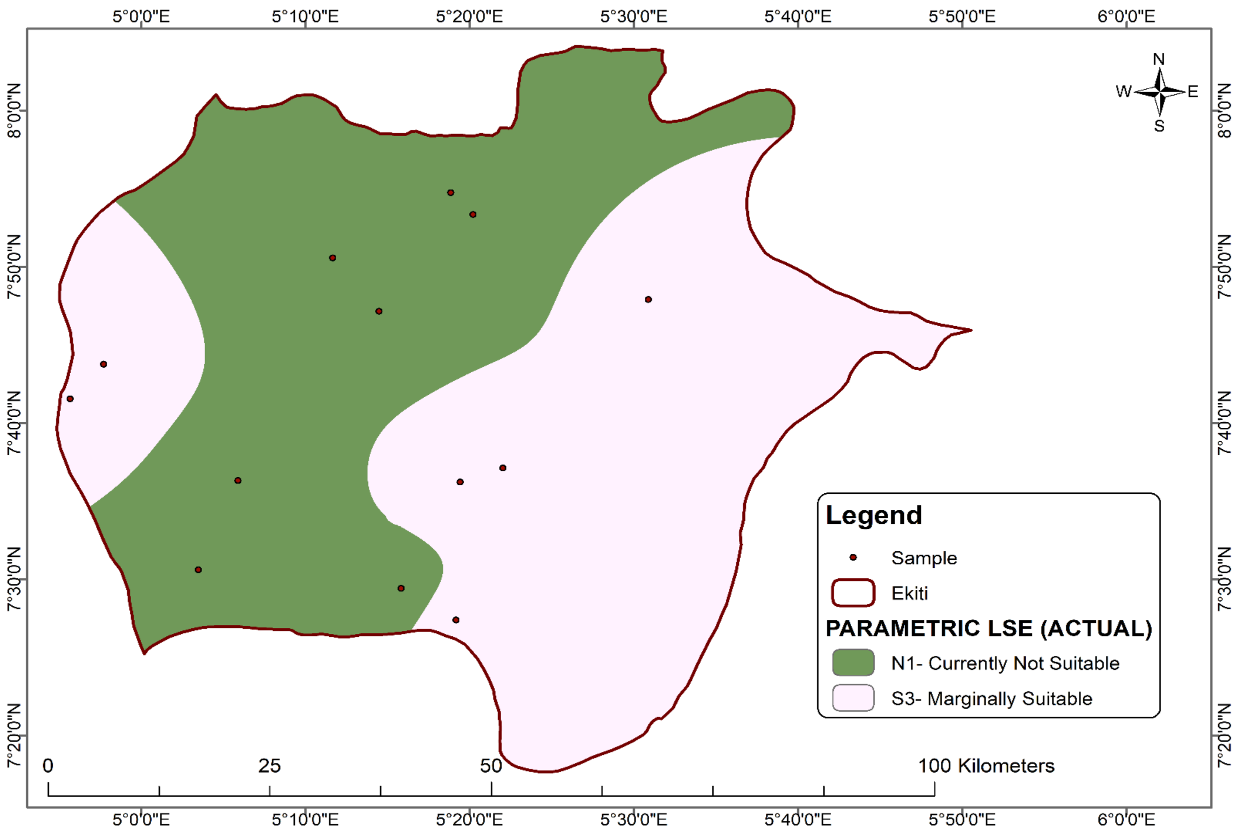

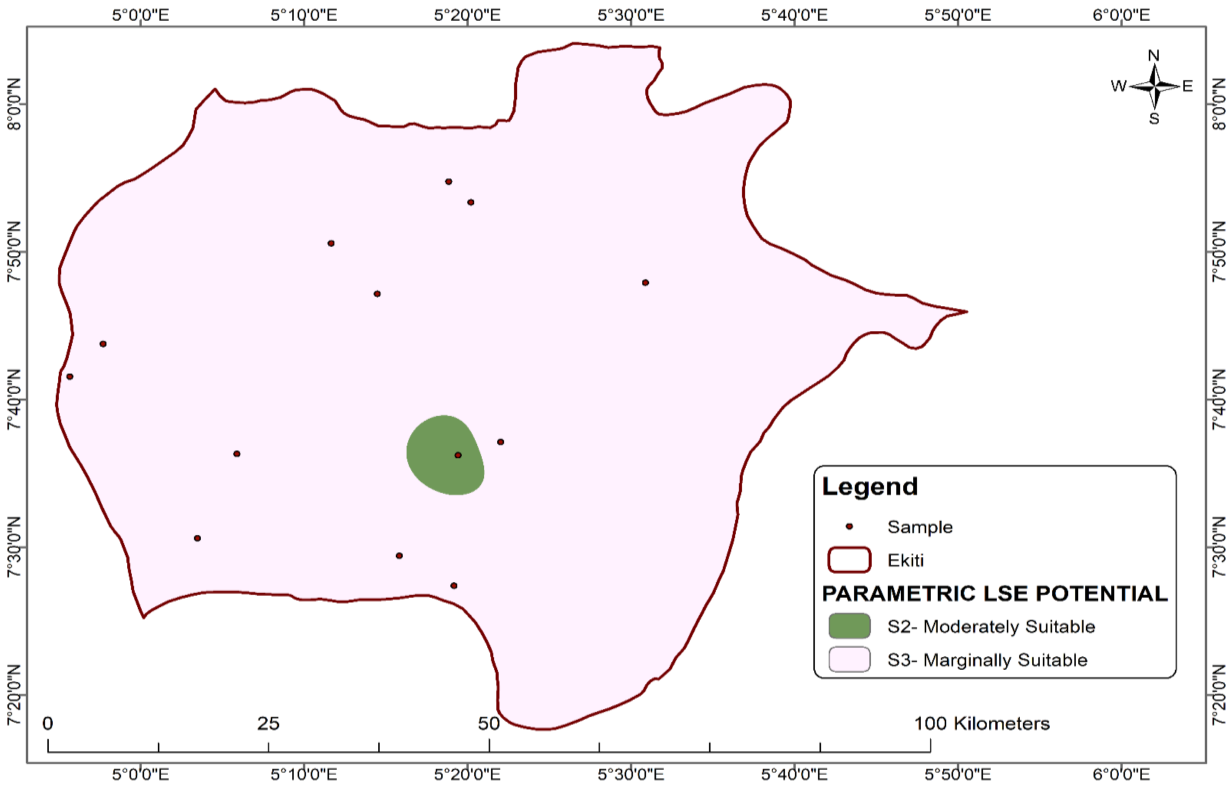

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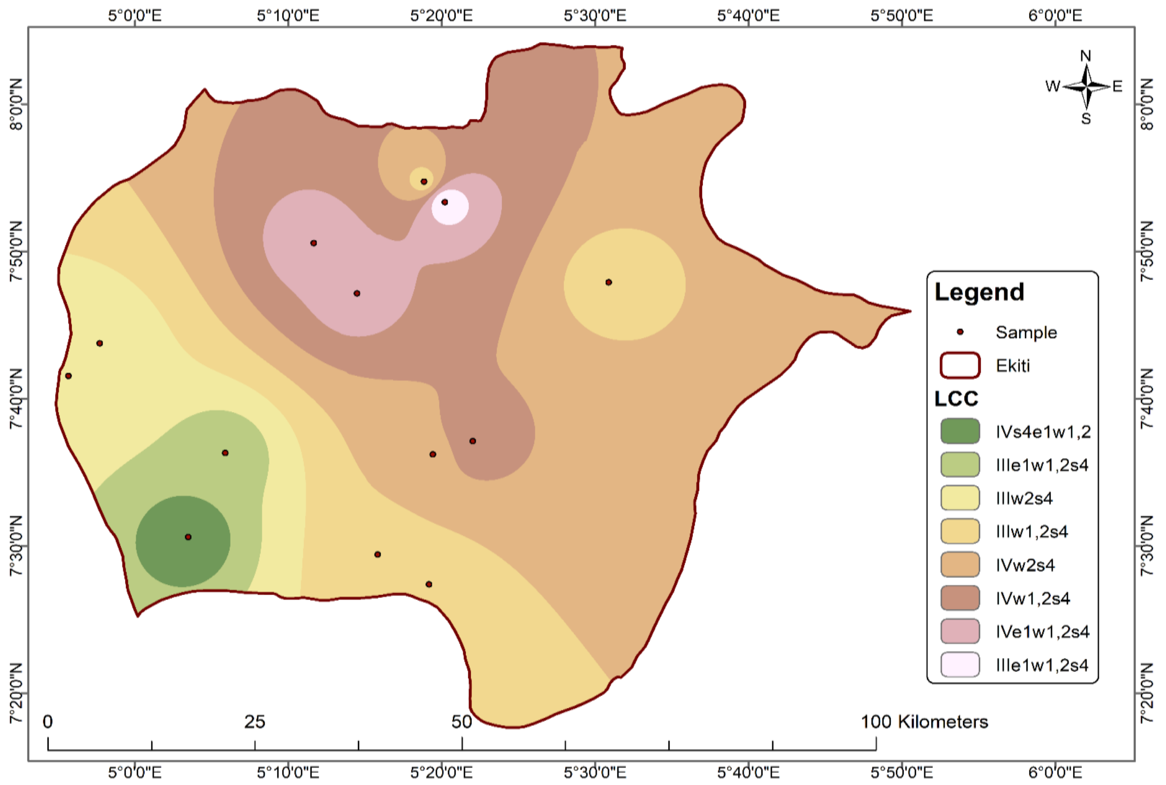

Land Suitability Evaluation for Rice

All the locations, annual rainfall, mean annual temperature, and relative humidity exhibit high suitability (S1) for rice production (Table 4). Similar studies by Fahad *et al.* (2019) indicated that successful rice cultivation requires suitable environmental conditions and soil properties. The ample rainfall (S1) ensures adequate water availability throughout the growing season, while the optimal temperature (S1) and relative humidity (S1) provide favorable conditions for rice growth and development. All the locations had highly suitable slope (S1) and drainage conditions (S1), ensuring efficient water management and minimizing the risk of waterlogging. According to Liu *et al.* (2021), these characteristics are essential for maintaining optimal soil moisture levels and preventing water-related stress in rice plants. The soil physical properties (s) shows that the textures were highly suitable S1 (85) at Ise, Isan, and Ikole, moderate suitability at S2 (60) at Ilawe, Igbara Odo, Efon, Ido Ile, Ijan, Ifaki, Ido, and Ayede, and marginally suitable at Ikere. The structures at Ilawe, Ido Ile, Ijan, Ifaki, and Ayede, were highly suitable for rice production, while coarse fragments and soil depth also showed high suitability (S1) in all the pedons. Soil pH, a crucial fertility factor, was generally highly suitable (S1), with the exception of the pedon at Ifaki, where it was marginally suitable (S3). The CEC was marginally suitable (S3) in all the pedons, with the exceptions of pedons at Ido Ile, Ise, and Ikere which showed moderate suitability (S2).

Diatta *et al.* (2020) stated that poor CEC values suggest challenges in nutrient retention and availability, which can adversely affect rice growth and yield. Base saturation shows high suitability (S1) in all the pedons, except at Ilawe and Igbara Odo (moderate suitability, S2). The suitability scores for the macronutrients elements indicated that nitrogen was highly

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suitable S1 in all the pedons, with few exceptions at Ilawe, Igbara Odo, Ayede, and Isan (moderate suitability, S2). The Av.P shows high suitability (S1) for rice cultivation at Ido Ile, Ikere, Igbara Odo, Efon, and Ijan, moderate suitability (S2) at Ilawe, Ise, Ikere, Ijan, and Ifaki, and marginal suitability (S3) at Ayede and Isan. The micronutrients levels (Fe, Zn, and Mn) were highly suitable S1 (100) for rice cultivation, indicating favorable conditions for rice cultivation. The aggregate suitability analysis provides a comprehensive assessment of the overall suitability of locations for rice cultivation, according to Habibie *et al*. (2021). The parametric method reveals that the actual suitability for rice cultivation is marginally suitable in Ilawe, Igbara Odo, Ado, Ijan, and Ikole, and currently not suitable (N1) in Efon, Ido Ile, Ise, Ikere, Ifaki, Ido, Ayede, and Isan. The potential suitability shows marginal suitability (S3) for all locations except Ado, which has a moderate suitability rating (S2). The non-parametric method suggests that the actual suitability is marginal (S3) in all pedons, except for Ise, which shows moderate suitability (S2). The potential suitability is moderate (S2) for all pedons, except Ikere and Ikole, which are marginally suitable (S3). The major limiting factors identified across all pedons are fertility factors, particularly CEC. This aligns with studies by Minh *et al*. (2020) that fertility factors and low CEC were the major limiting factors in rice cultivation in Southern region of Vietnam and also corroborates with research by Kome *et al*. (2022) who noted that fertility factors and low CEC were the major limiting factors in oil palm production. However, Ilawe faces limitations in both soil physical properties (structure) and fertility. According to Makungwe *et al*. (2021), this suggests that addressing fertility issues, especially CEC, is crucial for enhancing overall rice cultivation suitability in the studied locations.

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Table 4: Land suitability classification of soils of the study location

Land qualities	Land characteristic	Unit	Ilawe	Igbara-Odo	Efon	Ido ile	Ise	Ikere	Ado	Ijan	Ifaki	Ido	Ayede	Isan	Ikole
Climate (C)	Annual Rainfall	Mm	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)
	Mean Annual Temperature	°C	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)
	Relative humidity		S1ii (85)	S1ii (85)	S1i (100)	S1ii (100)	S1ii (85)	S1ii (85)	S1i (100)	S1i (100)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1i (100)
Topography(t)	Slope	Class	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)
Drainage	Wetness	Class	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S2 (60)
Soil physical properties (s)	Texture		S2 (60)	S2 (60)	S2 (60)	S2 (60)	S1ii (85)	S3 (45)	S1ii (85)	S2 (60)	S2 (60)	S2 (60)	S2 (60)	S1ii (85)	S1ii (85)
	Structure		S1i (100)	S2 (60)	S2 (60)	S1i (100)	S2 (60)	S2 (60)	S2 (60)	S1i (100)	S1i (100)	S2 (60)	S1i (100)	S2 (60)	S3 (45)

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	Coarse fragment		S1i (100)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1ii (85)	S1i (100)	S1i (100)	S1ii (85)	S1i (100)	S1ii (85)	S1ii (85)
	Soil depth		S1i (100)	S1i (100)	S1i (100)	S1i (100)	S2 (60)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1ii (85)	S1i (100)	S1i (100)
Fertility (f)	Soil P^H		S1i (100)	S1ii (85)	S1i (100)	S1ii (85)	S1ii (85)	S1i (100)	S1i (100)	S1i (100)	S2 (60)	S1i (100)	S1i (100)	S1i (100)	S1ii (85)
	CEC	cmol/kg	S3 (45)	S3 (45)	S3 (45)	S2 (60)	S2 (60)	S2 (60)	S3 (45)	S3 (45)	N1 (30)	S3 (45)	N1 (30)	S3 (45)	S1ii (85)
	Base saturation		S2 (60)	S2 (60)	S1ii (85)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1ii (85)	S1ii (85)	S1i (100)	S2 (60)	S2 (60)	S1i (100)
Macro nutrient	Nitrogen	%	S1i (100)	S2 (60)	S1ii (85)	S1ii (85)	S2 (60)	S2 (60)	S1ii (85)	S2 (85)	S1i (100)	S1ii (85)	S1i (100)	S1i (100)	S1ii (85)
	Available P	mg/kg	S2 (60)	S1ii (85)	S1ii (85)	S1i 100)	S2 (60)	S1i (100)	S2 (60)	S1ii (85)	S2 (60)	S2 (60)	S3 (45)	S3 (45)	S1ii (85)
	Extractable K	cmol/kg	S3 (45)	S1ii (85)	S3 (45)	S3 (45)	S1ii (85)	S3 (45)	S3 (45)	S1ii (85)	S3 (45)	S1ii (85)	S3 (45)	S1ii (85)	S2 (60)

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Micronutrient	Iron	Mg/kg	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)
	Zinc	Mg/kg	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)
	Mn	Mg/kg	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)	S1i (100)
Agg. Suitability															
Parametric	Actual		23 (N1)	23 (N1)	25 (S3)	25 (S3)	37 (S3)	20 (N1)	30 (S3)	25 (S3)	15 (N1)	23 (N1)	15 (N1)	23 (N1)	25 (S3)
	Potential		40 (S3)	40 (S3)	43 (S3)	43 (S3)	47 (S3)	30 (S3)	51 (S2)	43 (S3)	40 (S3)	40 (S3)	40 (S3)	40 (S3)	32 (S3)
Non-Parametric															
	Actual		45 (S3)	45 (S3)	45 (S3)	45 (S3)	60 (S2)	45 (S3)	45 (S3)	45 (S3)	30 (S3)	45 (S3)	30 (S3)	45 (S3)	45 (S3)
	Potential		60 (S2)	60 (S2)	60 (S2)	60 (S2)	60 (S2)	45 (S3)	60 (S2)	60 (S2)	60 (S2)	60 (S2)	60 (S2)	60 (S2)	45 (S2)
	Major limiting factors		F	F	F	F	F	F	F	F	F	F	F	F	SF

Aggregate suitability class scores: S1 = 75-100; S2 = 50-74; S3 = 25-49; N1 = 15-24; N2 = 0-14;

S1 - Highly Suitable; S2 - Moderately Suitable; S3 - Marginally Suitable; N1 - Currently Not Suitable; N2 - Permanently Not Suitable

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CONCLUSION

The evaluation of wetland soils in Ekiti State shows their varying suitability for rice cultivation. The study found that the drainage condition for all the locations was moderately suitable (S2). Additionally, most locations, including Ise, Isan, and Ikole, exhibited highly suitable conditions (S1) for rice production, characterized by optimal soil textures. However, certain areas, such as Ifaki, showed marginal suitability (S3) due to lower pH levels and CEC, indicating potential nutrient retention challenges. The Land Capability Classification (LCC) method effectively categorized these soils, highlighting the need for tailored management practices to enhance fertility and productivity. This research underscores the critical role of continuous soil assessment in informing sustainable agricultural practices, ensuring that wetland ecosystems are preserved while maximizing agricultural output. Ultimately, the findings advocate for integrated land management strategies that balance agricultural needs with environmental conservation in Ekiti State.

RECOMMENDATIONS

Targeted soil management practices should be implemented to improve nutrient retention, particularly in areas with marginal cation exchange capacity and pH levels. The use of organic amendments should be promoted to enhance soil fertility and structure, especially in less suitable locations. Additionally, encouraging farmers to adopt sustainable agricultural practices, such as crop rotation and cover cropping, will help maintain soil health. Continuous monitoring and assessment of soil health should also be prioritized to adapt to changing environmental conditions.

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