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LAND EVALUATION AND MANAGEMENT OF TWO WETLAND SOILS FOR RICE PRODUCTION IN NIGERIA.

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ABSTRACT: *Nigeria's rapidly growing population has increased pressure on land use. The demand for food has risen geometrically, alongside the growing need for essential infrastructure and basic amenities. Consequently, the competition for land to meet these needs has led to the loss of fertile soils. Land evaluation, which involves assessing land performance for a specific use, aims to ensure that land is allocated appropriately and sustainably. This study was conducted to evaluate the performance of two wetland soils and determine appropriate soil management strategies for lowland rice production. The experiment was carried out at two locations: the Teaching and Research Farm, Federal University Oye-Ekiti, Ikole-Ekiti (Location 1), and the Ondo State Ministry of Agriculture, Ikare Zonal Office (Location 2). Soil morphological and chemical properties were analyzed for land suitability evaluation. The results revealed that both locations were currently not suitable for lowland rice cultivation. However, with proper soil management, specifically improved drainage, the application of fertilizers containing nitrogen (N), phosphorus (P), and potassium (K), and the adoption of appropriate conservation tillage, the sites could be upgraded to marginally or moderately suitable for lowland rice production.*

KEYWORDS: Land suitability, management, rice, soil, and wetland.

INTRODUCTION

One of the major land use challenges in Nigeria is the inability to allocate land appropriately. It is concerning that much of Nigeria's fertile cultivable soil is being lost to basic amenities such as roads, buildings, schools, industries, hospitals, and recreational centers. Meanwhile, vast expanses of rocky or hilly areas that are less suitable for agriculture are left undeveloped, while fertile lands are used for urban and rural settlements. Proper land use planning, particularly through land evaluation, is an essential tool for addressing the misuse of agricultural land for non-agricultural purposes. Land evaluation helps to assess the suitability of land for both agricultural and non-agricultural activities. According to Ogunkunle (1987), Sys (1985), Dent and Young (1981), and Ajayi et al., (2025). Land evaluation is the assessment of land performance when used for a specific purpose. It involves conducting and interpreting surveys on soils, climate, vegetation, and other land characteristics relative to potential uses. Land evaluation may be qualitative or quantitative. A qualitative evaluation categorizes land as highly suitable, moderately suitable, marginally suitable, or not suitable, while a quantitative evaluation provides numerical estimates such as expected crop yield. Suitability can also be assessed as current or potential. Current suitability reflects the land's capacity in its present state, while potential suitability considers the land's productivity after improvements (Dent &Young, 1981). Most peasant farmers in Africa, who contribute about 70% of agricultural production, engage in farming without assessing land suitability for their intended crops, which often results in poor yields. Wetland soils, which remain saturated for most of the year, offer great potential for lowland rice production. Rice varieties that tolerate waterlogged conditions can be cultivated in lowland ecologies, reducing competition with upland crops. However, the potential of wetland soils in Nigeria remains underutilized, with limited agricultural development. Fasina (2005) reported "wetland soils for rice production formed from three major land forms which included: inland depressions, floodplains, and coastal plains". The total land area suitable for rice production in Nigeria is estimated at 4.6–4.9 million hectares, including uplands, rain-fed and irrigated lowlands, deep water, and mangrove swamp ecologies (Umar et al., 2014). Upland rice cultivation occupies about 30% of this area, totaling approximately 140,000 hectares (Jaquot & Courtois, 1987).

MATERIALS AND METHODS

The experiment was conducted at two sites located in different agro-ecological zones of Southwestern Nigeria. The first site was the Federal University Oye-Ekiti Teaching and Research Farm (Ikole Campus), Ekiti State, while the second site was the Ondo State Ministry of Agriculture Experimental Site in Ikare Akoko, Ondo State. Both locations are situated in the southwestern region of Nigeria (Figure 1). The characteristics of each wetland site are described below:

Location 1: Ikole-Ekiti

This site lies between latitudes 7°48′14.16″ N and 7°48′13.31″ N, and longitudes 5°29′35.74″ E and 5°29′37.07″ E (Figure 1). Ikole-Ekiti experiences a tropical humid climate with distinct wet and dry seasons. The wet season spans from March to November, with annual rainfall of approximately 1,300 mm occurring over more than 40 rainy days. Rainfall distribution is bimodal, peaking in June and September, with a short dry spell in late July to mid-August (August break). Average temperature ranges between 22°C and 32°C. The site has a gentle

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slope of 2 - 3% and an elevation of 509.04 m above sea level. The vegetation is typical of dry humid secondary forest and fallow regrowth, dominated by *Gliricidia sepium*, *Imperata cylindrica*, *Andropogon tectorum*, and *Asteracantha longifolia*. Other commonly found species include *Chromolaena odorata*, *Bidens pilosa*, *Sida* spp., *Talinum triangulare*, and *Solanum nigrum*. The land had previously been cultivated with yams and vegetables before being left fallow.

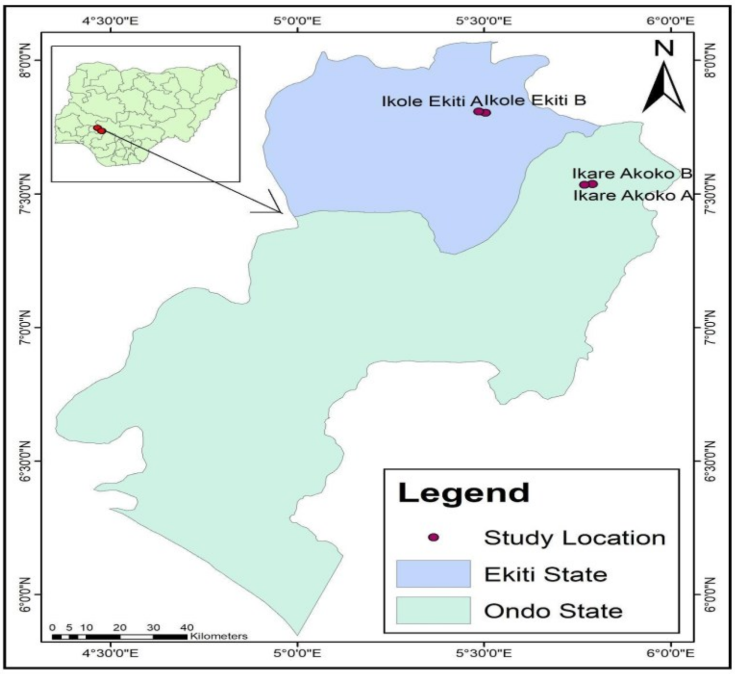
Location 2: Ikare-Akoko

The second site is located between latitudes 7°32′34.16″ N and 7°31′33.63″ N, and longitudes 5°46′04.81″ E and 5°45′04.66″ E (Figure 1). Ikare-Akoko falls within the drier forest zone in northern Ondo State and experiences a shorter rainy season. Rainfall occurs over a total of 60–70 days, spread between May and October, with a pronounced dry spell in August. Annual rainfall ranges between 900 and 1,000 mm. The average slope ranges from 2 - 4%, and elevation is approximately 229.9 m. The vegetation is characteristic of derived savannah. The annual mean maximum and minimum temperatures are 29.7°C and 20.8°C, respectively. Cropping systems in the area include dry-season cultivation of yams, maize and vegetables.

SOIL SAMPLING AND LABORATORY ANALYSIS

Soil profile pits were sited in each location based on slope gradient, weed distribution patterns, and water movement. Two profile pits were dug per location, and soil samples were collected from the surface layer (0–50 cm) of each profile. The collected samples were taken to the laboratory for both physical and chemical analyses. Land characteristics used for the land suitability evaluation included climatic factors, soil physical properties, and nutrient availability in the topsoil.

Figure 1. Soil map of the study area



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RESULTS AND DISCUSSION

Morphological Characteristics of Location 1 (Ikole-Ekiti) and Location 2 (Ikare Akoko) Pedons

Both locations exhibited similar morphological characteristics, including color, presence of mottles, texture, and soil structure. In Pedon 2 at Site 1 and both pedons at Site 2, dark surface colors in the first two horizons suggested high organic matter content. However, Pedon 1 at Ikole-Ekiti showed reddish coloration, indicating the presence of oxidized ferric iron oxides. These observations agree with Nsor and Ibanga (2008), who linked dark brownish colour to high organic matter levels. The general non-sticky consistency in the surface and some subsurface horizons suggested high sand and organic matter content, while sticky layers indicated higher clay proportions. Soil texture across all pedons was predominantly sandy, predisposing the soils to leaching due to large pore spaces and low nutrient and water retention. This aligns with Chude et al. (2011), who noted similar behavior in sandy soils. Thus, sustainable soil conservation practices, such as minimum tillage, crop rotation, organic manure application, and cover cropping, are essential to maintain productivity. Few concretions and many roots were observed in the upper horizons of all pedons, indicating that deep and shallow-rooted arable crops like yams, rice, maize, and vegetables could thrive under improved management.

Table 1. Morphological characteristics of the study sites

Horizon Depth (cm)	Colour (moist)	Mottles	Texture	Structure	Consistence	Inclusion	Sundry
Ikole-Ekiti (Pedon 1)							
0-15	2.5YR 4/8 rd	Cofd	LS	mo, me, sbk	ns, np, fr	r mn	co, mn, ct
15-36	5YR5/836Ye rd	Mfd	LS	mo, cs, sbk	sl.st, fm	r.mn	rco mnct
36-63	5YR/8, rdb	co, cs,d	SL	mo,md,cr	sl.st, fm	Rfw	rfw, mnct
63-84	75YR/5/8srb	co, cr, fa	SL	sr, cs, cr	ns, np	Rfw	rfw, mnFe-Mn, ct
84-102	2.5YR/6/3liy eb	co, md, fa	SL	sr,cr sbk	ns, vp, lo	Rfw	fw nyct
102-107	2.5Y/5/4live	fw,md pr	SL	sr, cs abk	ns, np, lo	Rfw	Fwct
107-141	2.5YR/6/6ve ye	fw. cs, fa	SL	wk,cs, sbk	P,st fm, hd		Fwct
Ikole-Ekiti (Pedon 2)							
0-12	7.5YR4/3 dkb	fw,md d	LS	wk,md cr	ns, np	Rmn	Rco
12-30	10YR3/2 dkb	fw,f fa	SL	mo, cs sbk	fr,sf	Rmn	rco,fw,c t
30-50	10YR5/6srb	co,md d	SL	mo,md,cr	ns, np v fr	Rfw	rfw ny ct
50-81	5Y7/5paye	fw,f, d	SL	wk,f, gr	Ns, np lo	Rfw	rfw, ct
81-115	10YR7/2yeli g	co, md, d	SC	mo, md sbk	St, fm,hd	Rfw	rfw fwct
115- 161	2.5Y7/2lig	ny md, pr	SC	mo, md, sbk	St,fm, hd	Rfw	rfw, fwct

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Ikare (Pedon 1)							
0-10	7.5YR3/3 dkb	co,f,fa	SL	mo, md sbk	St, sl.p	r ny	r, co,ny,ct,
10-20	5YR 3/1 .dk.b	ny, f, d	SCL	mo ,md, sbk	v.st.v.vp	r ny	r co, ny,ct
20-28	5YR4/2dk.rd.g	ny,cs,pr	SCL	mo cs sbk	v.st, v.vp	Rfw	rfw, nyct
28-59	5YR 3/1, v.dkg	co, cs, pr	SCL	mo, cs,cr	v.st v.vp	Rfw	Fw,f.r,ny.Fe-Mn ct
59-110	7.5YR 1/6 g	co md d	LS	wk,md,gr	Np	Rfw	ny.ct
Ikare (Pedon 2)							
0-18	10R 3/2dk.b	Fw, f, fa	SL	wk, f,gr	np,st	r ny	Rco
18-28	10R 2/2 dk.b	fw,f,fa	SL	mo,cs,sbk	np,st	r.ny	r.co
28-38	10YR5/3 f	fw, md ,d	SL	mo, cs ,sbk	St	r.ny	rfw.nyct
38-70	7.5YR 4/4dkb	ny,cs, pr	SCL	Sr,f, abk	Vp.vsk	ny.sn	ny.sn,ny .Fe-mn.ct
70-77	10YR 5/6yeb	ny.f.pr	SC	Sr,f abk	v.st, v.vp	Rfw	rfw,ct

Keys: Mottles: Angular blocky = abk, Brown = b, Coarse = cs, Common = co, Concretion = ct, Crumb = cr, Cultans = ct, Dark = dk, Distinct = d, Faint = fa, Few = fw, Fine = f, Firm = fm, Friable = fr, Granular = gr, grew = g, hard = hd, light = li, loose = lo Many = ny, Medium = md Moderate = mo, Nonplastic = np, Nonsticky = ns, Olive = ve, pale = pa, Prominent = pr, plastic = vp, Red = rd, Root = r, Slightly plastic = sl.p, Slightly Soft = sf, sticky = .st, sticky = sk, stone = sn, Strong = sr, Sub-angular blocky = sbk, yellowish = ye, Very = v, and Weak = wk

Chemical Characteristics of Location 1 (Ikole-Ekiti) and Location 2 (Ikare Akoko) Pedons

Soil pH

Surface pH ranged from 5.6 to 6.4 in the upper 0–36 cm, which may limit the availability of key nutrients such as phosphorus. pH values below 6.4 tend to reduce phosphorus availability, whereas pH values of 6.4–7.0 enhance it (Syngenta, 2018). In Ikole-Ekiti, the subsurface horizons recorded higher pH, likely due to surface accumulation of organic materials. In contrast, lower pH was observed in the subsurface horizons at Ikare Akoko, possibly due to leaching of basic cations, including nitrogen and phosphorus.

Organic Matter

Organic matter content was generally low at both sites, ranging from 1.22% to 2.50%. This deficiency was likely due to seasonal flooding that washes away topsoil and organic residues. The high sand content also limits organic matter retention, a trend supported by Chude et al. (2011) and Mirabito and Chambers (2023).

Total nitrogen levels were low across all pedons and did not meet the recommended 0.21% for rice cultivation in Southwest Nigeria (Fasina et al., 2013). Eluviation and illuviation processes were observed in some subsurface layers, particularly in Site 2, contributing to nitrogen redistribution rather than enrichment.

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Available Phosphorus

Phosphorus levels were also low in the surface horizons and slightly improved at deeper depths, correlating with increasing pH values. The deficiency in total nitrogen likely exacerbated the limited phosphorus availability. Dong & Junyi (2020) confirmed the positive interaction between nitrogen and phosphorus, where nitrogen enhances phosphorus availability and uptake. Thus, nitrogen fertilization indirectly improves phosphorus availability.

Table 2. Chemical properties of soils in Ikole-Ekiti and Ikare Akoko

H. desg.	HD	pH	OC	TN	Av. P	K	Na	Ca	Mg	Ex. Al^{3+}	Ex. H^+	CEC	ECEC	BS	Cu	Fe	Mn	Zn
	(cm)	(H_2O)	(%)		(mg/kg)	(cmol/kg)								(%)	(mg/kg)			
		Pedon 1 (Ikole-Ekiti)																
Oi	0-15	5.7	1.45	0.14	2.26	0.6	0.3	5.0	2.5	1.0	6.8	8.4	16.2	51.85	0.61	101.70	4.63	6.95
Oa	15-36	6.4	0.71	0.04	1.60	0.5	0.4	7.0	2.5	0.2	4.2	10.4	16.8	61.90	1.00	54.70	0.67	3.11
Bhs	36-63	6.4	0.19	0.03	2.09	0.4	0.3	7.0	3.0	0.2	5.8	10.7	16.7	64.07	0.59	20.45	0.34	11.06
Bhs	63-84	6.4	0.26	0.18	2.80	2.1	0.2	8.0	3.5	0.2	9.8	13.8	23.8	57.98	1.97	36.55	15.39	8.57
Bt	84-102	6.5	0.15	0.03	3.24	0.4	0.2	6.5	4.0	0.6	3.4	11,1	15.1	73.51	1.63	100.20	2.05	4.04
E	102-127	6.3	0.19	0.03	3.55	0.3	0.2	5.5	2.0	0.4	5.6	8.0	14.0	57.14	1.08	38.65	0.40	4.33
Bt	127-141	6.0	0.15	0.03	2.93	0.5	0.3	7.0	4.0	0.6	5.4	11.8	17.8	66.29	0.74	14.00	8.87	4.46
		Pedon 2 (Ikole-Ekiti)																
Oi	0-12	5.8	1.78	0.13	4.57	1.3	0.2	11.0	6.0	1.6	5.2	18.5	25.3	73.12	0.75	60.20	2.77	7.61
Oa	12-30	6.0	1.26	0.03	2.44	0.3	0.4	5.5	2.0	0.4	5.2	8.2	13.8	59.42	0.41	13.25	1.18	5.81
A	30-50	6.9	0.26	0.27	1.38	4.9	0.3	11.0	1.5	0.2	5.2	17.7	23.1	76.62	0.41	13.25	38.32	11.35
E	50-81	6.6	0.67	0.04	3.06	0.2	0.2	4.0	1.5	0.2	5.1	7.90	13.2	59.85	1.22	45.45	0.88	4.65
Bgt	81-115	6.0	0.07	0.03	3.15	0.8	0.2	8.0	3.0	0.2	6.6	11.0	17.8	61.80	0.59	98.80	0.32	3.73
		Pedon 1 (Ikare Akoko)																
Oi	0-10	5.8	0.71	0.11	2.80	1.2	0.3	9.0	4.0	0.2	3.0	14.5	17.7	81.92	1.5	170.00	8.33	11.04
Oa	10-20	5.9	0.97	0.04	2.35	0.5	0.4	8.0	5.0	0.4	2.8	3.9	17.1	81.29	0.94	134.65	14.12	5.82
B	20-28	5.3	0.71	0.22	2.04	4.2	0.4	10.0	3.5	0.4	6.0	18.1	24.5	73.90	1.02	197.60	11.30	6.53
Bh	28-59	5.9	1.00	0.07	3.82	0.9	0.3	7.5	3.5	0.4	2.8	12.2	15.4	79.22	1.51	28.20	5.58	4.90
Bg	59-110	6.1	0.30	0.08	4.88	0.4	0.2	9.0	3.5	0.8	8.0	13.1	21.9	59.77	1.68	105.45	25.76	12.77

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		Pedon 2 (Ikare Akoko)																
Oi	0-18	5.7	1.04	0.11	3.68	0.8	0.2	6,5	3.0	0.4	8.4	10.5	19.3	54.37	1.15	36.20	6.15	3.72
Oa	18-28	5.6	0.45	0.03	2.04	0.7	0.2	7.5	3.5	0.8	6.0	11.9	18.7	63.61	0.52	7.05	0.52	5.00
A	28-38	5.3	0.71	0.22	4.48	4.2	0.4	10.0	3.5	0.4	6.0	18.1	24.5	73.90	1.02	19.25	0.50	6.10
E	38-58	5.9	1.00	0.07	1.55	0.9	0.3	7.5	3.5	0.4	2.8	12.2	15.4	79.22	1.51	28.20	11.83	5.97
Bt	58-70	6.1	0.19	0.10	1.29	1.1	0.4	11.0	6.5	0.4	3.2	18.9	22.5	84.03	0.64	16.80	7.09	5.30
Bt	70-77	6.0	0.37	0.22	3.82	1.4	0.3	9.5	5.0	0.4	2.8	16.2	19.4	83.54	0.73	17.05	3.57	3.99
Bt	77-94	6.5	0.52	0.14	3.02	1.4	0.4	8.0	6.0	0.4	6.8	15.8	23.0	68.70	0.61	101.70	16.06	12.19

OC = Organic carbon, OM = Organic matter, TN = Total nitrogen, Ex. =Exchangeable, CEC = Cation exchange capacity, ECEC = Effective CEC, and BS = Base saturation, HD = Horizon depth, H. desg. = Horizon designation

Cation Exchange Capacity (CEC)

CEC values were low to moderate, reflecting the sandy texture and low organic matter content of the soils. As confirmed by Rayment and Higginson (1992) and Hazleton and Murphy (2007), soils with high sand content typically have low CEC, limiting their ability to retain nutrients. Consequently, potassium and magnesium levels were also low due to potential nutrient leaching and continuous cropping pressure.

Percentage Base Saturation

Base saturation values in Pedons 1 and 2 at Ikole-Ekiti were moderate to high at the surface horizon, exceeding 50%, which classifies these soils as Alfisols according to USDA (2014). Similar patterns were observed in the Ikare Akoko pedons, with values of 79.04% and 57.29% for Pedons 1 and 2, respectively. These base saturation levels are typical of soils in the drier forest zones of southwestern Nigeria.

Land Suitability Evaluation

The land suitability assessment revealed that all pedons across both locations were not currently suitable (N) for lowland rice cultivation, based on current soil conditions (Table 3). However, their potential suitability varied between marginal (S3) and moderate (S2), depending on site-specific improvements. In terms of climate, all pedons were classified as highly suitable (S1) for both rainfall and temperature. However, land/soil physical properties such as flooding and drainage were marginally suitable (S3) across all sites. Soil slope was moderately suitable (S2) in pedons 1 at both locations but marginally suitable (S3) in pedons 2. Soil depth was highly suitable (S1) in all pedons except pedon 2 at Ikare Akoko, which was moderately suitable (S2). Soil texture was consistently moderately suitable (S2) across all pedons. Regarding nutrient availability in the topsoil, pH was highly suitable (S1) in Ikole-Ekiti pedons and moderately suitable (S2) in Ikare Akoko pedons. Organic carbon was not suitable (N) in pedon 1 at Ikole-Ekiti and marginally suitable (S3) in the other three pedons. Total nitrogen was marginally

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suitable (S3) across all sites. Available phosphorus was not suitable (N) in any of the pedons. Exchangeable potassium was moderately suitable (S2) in Ikole-Ekiti and highly suitable (S1) in Ikare Akoko. CEC was moderately suitable (S2) in Ikole-Ekiti and marginally suitable (S3) in Ikare Akoko. Base saturation was moderately suitable (S2) in most pedons but highly suitable (S1) in pedon 1 at Ikare Akoko. ESP was generally highly suitable (S1), except in pedon 1 at Ikare Akoko (S2).

Table 3. Suitability class scores of the pedon in the study area (Parametric)

Land Characteristics	Ikole-Ekiti 1	Ikole-Ekiti 2	Ikare Akoko 1	Ikare Akoko 2
Climate				
Rainfall (mm)	S1(95)	S1(95)	S1(95)	S1(95)
Temperature (°C)	S1(95)	S1((95)	S1(95)	S1(95)
Land/soil physical property				
Flooding	S3(40)	S3(40)	S3(40)	S3(40)
Drainage	S3(40)	S3(40)	S3(40)	S3(40)
Slope (%)	S2(85)	S3(40)	S2(85)	S3(40)
Soil depth (cm)	S1(95)	S1(95)	S1(95)	S2(85)
Soil Texture	S2(85)	S2(85)	S2(85)	S2(85)
Nutrient availability (topsoil)				
pH	S1(95)	S1(95)	S2(85)	S2(85)
Organic Carbon (%)	N(20)	S3(40)	S3(40)	S3(40)
Total Nitrogen (%)	S3(40)	S3(40)	S3(40)	S(40)
Available P (mg kg^{-1})	N(20)	N(20)	N(20)	N(20)
Exchangeable K (cmol kg^{-1})	S2(85)	S2(85)	S1(95)	S1(95)
CEC (cmol kg^{-1})	S2(85)	S2(85)	S3(40)	S3(40)
Base Saturation (%)	S2(85)	S2(85)	S1(95)	S2(85)
ESP (%)	S1(95)	S1(95	S2(85)	S1(95)
Current aggregate suitability	N(20)	N(20)	N(20)	N(20)
Potential aggregate suitability	S2(85)	S3(40)	S2(85)	S3(40)

S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N = not suitable

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Table 4. Land suitability evaluation (non-parametric)

Land Characteristics	Ikole-Ekiti Pedon 1	Ikole-Ekiti Pedon 2	Ikare Akoko Pedon 1	Ikare Akoko Pedon 2
Climate				
Rainfall (mm)	S1	S1	S1	S1
Temperature (°C)	S1	S1	S1	S1
Land/soil physical property				
Flooding	S3	S3	S3	S3
Drainage	S3	S3	S3	S3
Slope (%)	S2	S3	S2	S3
Soil depth (cm)	S1	S1	S1	S2
Soil Texture	S2	S2	S2	S2
Nutrient availability (topsoil)				
pH	S1	S1	S2	S2
Organic Carbon (%)	N	S3	S3	S3
Total Nitrogen (%)	S3	S3	S3	S3
Available P (mg kg^{-1})	N	N	N	N
Exchangeable K (cmol kg^{-1})	S2	S2	S1	S1
CEC (cmol kg^{-1})	S3	N	S3	S3
Base Saturation (%)	S2	S2	S1	S2
ESP (%)	S1	S1	S2	S1
Current aggregate suitability	N	N	N	N
Potential aggregate suitability	S2	S3	S2	S3

S1 = highly suitable, S2 = moderately suitable, S3 = marginally suitable, N = not suitable

CONCLUSION

Field studies were conducted at two sites: the Federal University Oye-Ekiti Teaching and Research Farm (Ikole Campus) and the Ondo State Ministry of Agriculture Experimental Site, Ikare Akoko. Both sites are located in Southwestern Nigeria. Soil morphological and chemical properties were assessed for land evaluation, considering climate, physical properties, and topsoil nutrient availability. Results showed that both locations are currently not suitable for

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lowland rice production but have potential suitability if improved. Key interventions include proper drainage, application of N, P, and K fertilizers, and adoption of conservation tillage to reduce nutrient leaching. Recommended cultural practices include early planting, selection of lodging-tolerant lowland rice varieties, and timely fertilizer application to enhance productivity under improved conditions.

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