

SUSTAINABLE MANAGEMENT OF FADAMA SOILS IN DERIVED SAVANNA: CHARACTERIZATION, CLASSIFICATION, LAND EVALUATION, AND SUITABILITY FOR HOT PEPPER CULTIVATION

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Abstract: This study assessed the sustainable management potential of Fadama soils in the Derived Savanna of Nigeria through characterization, classification, and land suitability evaluation for hot pepper cultivation. The study was conducted at the Federal University Oye-Ekiti Teaching and Research Farm, where two representative soil profiles were described and sampled for physical and chemical analyses. Water samples from the soil profile and a nearby stream were also analyzed. The soils were moderate to deep (79–160 cm), with textures ranging from loamy sand to sandy loam and generally acidic pH. The soils were classified as Arenic Endoqualfs and Arenic Eutrudepts (USDA) and as Reductic Clayic Gleysols and Eutric Arenic Cambisols (WRB). Land suitability evaluation indicated that the soils are currently not suitable (N2) but potentially marginally suitable (S3) for hot pepper cultivation, with observed yields ranging from 0.9 to 1.97 t ha⁻¹. Improved soil fertility management, regular soil testing, drip irrigation, and conservation practices are recommended to enhance the sustainable utilization of Fadama soils for pepper production.

Keywords: Fadama soils, land suitability evaluation, soil characterization, soil classification, sustainable soil management, hot pepper cultivation.

INTRODUCTION

The global challenge of food insecurity can be alleviated through improved and sustainable soil resource management (Lal *et al.*, 2021). In sub-Saharan Africa, rapid population growth has outpaced food production since the late 1960s, leading to food shortages (Akinbode *et al.*, 2022). Increased land competition for industrialization, housing, and grazing, along with unsustainable land use practices, has further exacerbated land degradation and reduced agricultural productivity (Hossain *et al.*, 2020). Wetlands play a vital role in agriculture, serving as a major source of food production and water supply. In Nigeria, wetlands are critical for dry-season farming, supporting crops like pepper through irrigation (Husain and Sharma, 2022). Findings by Nyamadzawo *et al.* (2015) revealed that smallholder farmers increasingly rely on wetlands for year-round cultivation to improve income and food security. Despite their agricultural potential, wetlands are often underutilized or mismanaged, leading to degradation and reduced productivity (Eniolorunda *et al.*, 2017). Proper utilization of wetlands is crucial for sustaining their ecological functions and supporting agricultural development. A key challenge in agriculture is the lack of scientific knowledge among local farmers regarding soil properties and management. Farming by trial-and-error leads to soil degradation, nutrient depletion, and poor crop yields (Esmail and Oelbermann, 2022). Understanding soil characteristics is essential for effective land management and sustainable use.

Soil classification and characterization provide valuable information for land-use planning, ensuring that soils are used appropriately to maximize productivity while preventing environmental degradation (Gomiero, 2016). Soil surveys generate critical data for land evaluation, guiding decisions on suitable crops and management practices. In Nigeria, major soil classification systems include the USDA Soil Taxonomy (Soil Survey Staff, 2014) and the FAO-UNESCO Soil Classification System (FAO, 2006). Previous studies on Nigerian soils have categorized them based on parent materials, emphasizing the need for region-specific classification to enhance productivity (Mesele *et al.*, 2024). Proper classification and mapping of wetland soils will provide valuable insights for optimizing land use in the study area. Soil degradation, including compaction, flooding, and nutrient loss, results from poor land-use decisions and lack of soil data (Chalise *et al.*, 2019). The increasing dependence on upland soils and neglect of wetlands underscores the need to evaluate their agricultural potential. Consequently, this study focuses on a representative wetland in Ikole-Ekiti, located at latitude 7°78'33"N and longitude 5°51'67"E, within the humid tropics. The area experiences a mean annual rainfall of 1600–1700 mm from April to November, peaking between June and September, and a dry season from December to March. Mean annual temperature averages 26.0°C, with total annual sunshine of about 2000 hours, averaging 5 hours daily. Understanding the soils of this area is critical for assessing their suitability for sustainable

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pepper cultivation. Thus, the research aims to characterize, classify, and assess the suitability of wetland soils for sustainable pepper production.

MATERIALS AND METHODS

Soil and water sampling

The physiographic position, surface water level and soil colour was used to representative portions on the landscape and soil profile was dug in each of the identified portion, described and sampled. Soil morphological properties were described following the procedure described in the USDA soil survey manual (Soil Survey Staff, 2014). Soil samples collected was taken to the laboratory for analysis. Water samples were collected from the nearby river and profile pits.

Field experimentation

Hot pepper was planted in each of the representative portions of soils of the pedons and the yield was evaluated. Ridges were made at 75 cm spacing. Pepper seedlings raised in the nursery for six weeks were transplanted at a spacing of 20 and 40 cm within the row. The experiment was laid out in randomized complete block design; the pedons represent the treatments, and pepper was planted on four plots at each pedon to represent the replicates. All cultural practices were carried out following the standard procedures. Total fresh fruit yield per hectare was collected per plot. Data collected was analyzed with mean and bar charts to compare the yield of pepper at the pedons.

Laboratory analysis

Soil samples collected from the soil profiles were air-dried, crushed with a porcelain pestle and mortar, and sieved to remove materials greater than 2 mm (gravel). The less than 2 mm materials were analyzed in the laboratory for soil physico-chemical properties following the methods suggested by IITA (1979). Water samples were analyzed for sodium, calcium and magnesium following the procedure of APHA (2017). The analyses were carried out in the research laboratory of the Soil Science and Land Resources Management Department, Federal University Oye Ekiti.

Soil classification

The soil classification was carried out using the USDA system- Soil Taxonomy (Soil Survey Staff 2014) and World Reference Base for Soil Resources the FAO/UNESCO (FAO, 2014).

Irrigation capability classification

This was carried out using the parametric approach of Sys *et al.* (1991). This method is based on the morphology and physical and chemical properties of soil. In the parametric method, the land is evaluated according to numerical indexes. In this classification system, a degree, whose rate is from 0 to 100, is given to any land characteristic through comparing them with the tables of

soil requirements (Tables 1a to 1g). The specified degrees are used to measure the land index, which is a multiplicative index that combines ratings assigned to soil units and other physical conditions that affect the land use (Olsen, 1981). The suitability index for irrigation (C_i) was computed using the equation:

$$C_i = A \times \frac{B}{100} \times \frac{C}{100} \times \frac{D}{100} \times \frac{E}{100} \times \frac{F}{100}$$

Where C_i = Suitability index for irrigation, A = Soil texture rating,

B = Soil Depth rating, C = CaCO_3 Status, D = Electrical Conductivity,

E = Drainage rating, F = Slope rating

The suitability classes S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), N1 (currently not suitable) and N2 (permanently not suitable) are equivalent to index of productivity value of >80, 60-80, 45-60, 30-45 and <30 respectively.

Irrigation water quality assessment

Sodium adsorption ratio is calculated by the equation (Collins and Jenkins, 1996))

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

This ratio measures the relative concentration of sodium, calcium, and magnesium.

Electrical conductivity is closely related to the sum of the cations (or anions) determined by chemical analysis and, therefore, correlates well with the value for dissolved solids (Wicox, 1995). Based on EC value, irrigation water is classified into 5 different classes i.e., class 1 (<250) Excellent, class 2 (250-750) Good, class 3 (750-2000) Permissible, class 4 (2000-3000) Doubtful, class 5 (>3000) unsuitable for irrigation).

Kelly's Ratio was computed by dividing sodium ion concentration versus calcium and magnesium ion concentrations (Kelley, 1940)

$$KR \equiv \frac{Na^+}{Ca^{2+} + Mg^{2+}}$$

Concentrations of all ions were expressed in meq/l. Waters with a KR value <1 are regarded as suitable for irrigation, while those with higher values are considered unsuitable, i.e., the ions are classified into two classes: class 1 (<1) suitable and class 2 (>1) unsuitable for irrigation.

The magnesium hazard was calculated as per Raghunath (1987). If the value is < 50.0, it is classified as non-hazardous, and a value exceeding 50.0 will cause a magnesium hazard.

$$\text{Magnesium Hazard} = \frac{Mg^{2+}}{Ca^{2+} + Mg} \times 100$$

Where Ca^{2+} and Mg^{2+} are concentration of respective ions

Where, all ionic concentrations are expressed in mmolc/L.

Table 1a

Suitability Index for Irrigation Suitability Indices (Ci) classes

Capability Index	Class	Definition	Symbol
>80	I	Highly suitable	S ₁
60-80	II	Moderately suitable	S ₂
45-60	III	Marginally suitable	S ₃
30-45	IV	Currently not suitable	N ₁
<30	V	Permanently not	N ₂

Source: Sys (1985)

Table 1b

Rating of soil depth for irrigation

Soil depth [cm]	Rating for surface Irrigation	Rating for sprinkler Irrigation	Rating for drip Irrigation
< 20	25	30	35
20-50	60	65	70
50-80	80	85	90
80-100	90	95	100
>100	100	100	100

Table 1c

Rating of CaCO₃ for irrigation

CaCO ₃ (%)	Rating for surface Irrigation	Rating for sprinkler Irrigation	Rating for drip Irrigation
< 0.3	90	90	90
0.3-10	95	95	95
10-25	100	100	95
25-50	90	90	80
>50	80	80	70

Table 1d

Rating of salinity for irrigation

EC [ds m ⁻¹]	Rating for surface Irrigation		Rating for sprinkler Irrigation		Rating for drip Irrigation	
	C, SiC, SiCL, S, SC Textures	Other Textures	C, SiC, SiCL, S, SC Textures	Other Textures	C, SiC, SiCL, S, SC Textures	Other Textures
< 4	100	100	100	100	100	100
4-8	90	95	95	95	95	95
8-16	80	50	85	50	85	50
16-30	70	30	75	35	75	35
>30	60	20	65	20	65	25

C, clay; SiC, silty clay; SiCL, silty clay loam; S, sand; SC, sandy clay

Table 1e

Rating of drainage classes for irrigation

Drainage Classes	Rating for surface Irrigation		Rating for sprinkler Irrigation		Rating for drip Irrigation	
	C, SiC, SiCL, S, SC Textures	Other Textures	C, SiC, SiCL, S, SC Textures	Other Textures	C, SiC, SiCL, S, SC Textures	Other Textures
Well Drained	100	100	100	100	100	100
Moderately Drained	80	90	90	95	100	100
Imperfectly Drained	70	80	75	85	80	90
Poorly Drained	60	65	65	70	70	80
Very Poorly Drained	40	65	45	65	50	65



Drainage Classes	Rating for surface Irrigation		Rating for sprinkler Irrigation		Rating for drip Irrigation	
	C, SiC, SiCL, S, SC Textures	Other Textures	C, SiC, SiCL, S, SC Textures	Other Textures	C, SiC, SiCL, S, SC Textures	Other Textures
	Drainage Status Not Known	70	80	70	80	70

C, clay; SiC, silty clay; SiCL, silty clay loam; S, sand; SC, sandy clay

Table 1f

Rating of slope for irrigation

Slope classes [%]	Rating for surface Irrigation		Rating for sprinkler Irrigation		Rating for drip Irrigation	
	non-terraced	terraced	non-terraced	Terraced	non-terraced	terraced
0-1	100	100	100	100	100	100
1-3	95	95	100	100	100	100
3-5	90	95	95	100	100	100
5-8	80	90	85	95	90	100
8-16	70	80	75	85	80	90
16-30	50	65	55	70	60	75
>30	30	45	35	50	40	55

Table 1g

Rating of Textural Classes for Irrigation

Texture	Rating for Surface Irrigation					Rating for Sprinkler Irrigation					Rating for Drip Irrigation				
	Fine gravel (%)		Coarse gravel (%)			Fine gravel (%)		Coarse gravel (%)			Fine gravel (%)		Coarse gravel (%)		
	< 15	15-40	40-75	15-40	40-75	< 15	15-40	40-75	15-40	40-75	< 15	15-40	40-75	15-40	40-75
CL	100	90	80	80	50	100	90	80	80	50	100	90	80	80	50
SiL	100	90	80	80	50	100	90	80	80	50	100	90	80	80	50
SCL	95	85	75	75	45	95	85	75	75	45	95	85	75	75	45
L	90	80	70	70	45	90	80	70	70	45	90	80	70	70	45
SiL	90	80	70	70	45	90	80	70	70	45	90	80	70	70	45
Si	90	80	70	70	45	90	80	70	70	45	90	80	70	70	45
SiC	85	95	80	80	40	85	95	80	80	40	85	95	80	80	40
C	85	95	80	80	40	85	95	80	80	40	85	95	80	80	40
SC	80	90	75	75	35	95	90	80	75	35	95	90	85	80	35
SL	75	65	60	60	35	90	75	70	70	35	95	85	80	75	35
LS	55	50	45	45	25	70	65	50	55	30	85	75	55	60	35
S	30	25	25	25	25	50	45	40	30	30	70	65	50	35	35

C, clay; SiC, silty clay; SiCL, silty clay loam; S, sand; SC, sandy clay

Land suitability evaluation

The suitability of the soils for pepper was carried out using the parametric approach modified by Ogunwale (1993). The limiting factor of each of the soil was rated in percentage, and index of suitability of each pedon was computed using the equation:

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

Where: IP= Index of Productivity; A = Overall lowest characteristic; B, C, D, F = the lowest characteristic ratings for each land quality group (Table 2). The suitability classes S1 (highly suitable), S2 (moderately suitable), S3 (marginally suitable), N1 (currently not suitable), N2 (permanently not suitable) are equivalent to index of productivity value of 100-75, 74-50, 49-25, 24-12.5, 12.4-0 respectively.

Qualitative suitability evaluation

The yield performance of crops in the soils was compared to suitability evaluation ratings obtained to establish the actual suitability of the soils for pepper.

RESULTS AND DISCUSSION

Morphological Properties

The effective soil depth of pedon A is 79 cm, indicating moderately deep soil (Table 3). The colour indicates a transition from well-aerated surface horizons to poorly drained subsurface layers. The Ap and AB horizons exhibit a dark color (10YR 2/1, 7.5YR 3/1), likely due to high organic matter content, which enhances soil fertility and aggregate stability (Sharma and Baral, 2021). Babalola *et al.* (2019) noted that it can also be attributed to humification resulting from melanization. The Bt and Btg horizons show greyish hues (7.5YR 5/1,

2.5Y 5/1) and mottles, indicative of prolonged water saturation and iron reduction (Soil Survey Staff, 2014). Mottles were found in pedons and it range from few fine faints in the surface horizon and crumbs fine distinct, many medium distinct, few fine distinct in the subsurface horizons. The dominance of sandy clay loam (SCL) and clay (C) textures in deeper layers contributes to waterlogging and restricted root penetration, leading to poor drainage (Debele *et al.*, 2018). Gley was present, suggesting gleization, which further supports the observation. The structure was generally weak and blocky.

Pedon B is 160 cm, indicating a deep soil. Li *et al.* (2021) pointed out that soil depth plays a significant role in impacting water retention, nutrient storage, and root growth. Pedon B presents a contrasting profile with well-drained surface layers (7.5YR 4/3, brown), allowing extensive root proliferation, which enhances nutrient

uptake (Mondal *et al.*, 2024). However, deeper horizons (10YR 6/3, pale brown; 2.5Y 6/3, yellowish brown) indicate leaching, causing reduced fertility (Sanchez-Navarro *et al.*, 2021). According to Blume *et al.* (2016), the brown colours typically suggest the presence of organic matter and minerals, while pale brown and yellowish-brown coloration indicate varying degrees of leaching and weathering (Blume *et al.*, 2016). The mottles were generally coarse and common at the subsurfaces. The transition from sandy loam (SL) to clay (C) in the Bt horizon suggests clay illuviation, which is characteristic of pedogenic development in humid regions (Huang *et al.*, 2022). The structure was weak and ranged from crumbs at the surfaces to sub-angular blocky at the subsurfaces. The imperfect drainage in deeper layers reflects the influence of textural changes on water movement and aeration (Wang *et al.*, 2021).

Table 2

Land requirements for suitability classes for pepper cultivation

Land qualities	Land characteristics	Unit	S1	S2	S3	N
			100	74	49	24
Climate (C)	Annual Rainfall	Mm	750-900	900-1200	500-600 &>1200	<500
	Mean Annual Temperature	°C	25-32	33-35	36-38	>38
Wetness (w)	Soil drainage	Class	Well drained	Moderately to imperfectly drained	Poorly drained	Very poorly drained
Soil physical properties (s)	Texture	Class	L, SCL, CL, SiL	SL, SC, SiC, C(m/K)	C(ss), LS, S	C(ss), LS, S
	Effective soil depth	Cm	>75	50-75	25-50	<25
Fertility (f)	Soil Ph		6.0-7.0	7.1-8.0	8.1-9.0 & 5.0-5.9	>9.0 &<5.0
	Soil organic carbon	g kg ⁻¹	>7.50	5.00-7.50	<5.00	<5.00
	Available P	Mg kg ⁻¹	>20	7-20	3-7	<3
	Exchangeable Potassium	cmol/kg	0.61 – 0.73	0.31-0.60	0.21 -0.3	0.21 – 0.12
Base saturation	Potassium	%	>50	35-50	<35	
	Base saturation	%	>50	35-50	<35	
Topography (t)	Slope	%	<3	3-5	6-10	>10

Table 3

Morphological characteristics

Horizon	Depth (cm)	Colour Moist	Mottles	Texture (field)	Structure	Consistence			Drainage	Other Features
						Wet	Moist	Dry		
Ap	0-4	10YR 2/1 black	fe,fi,fa	LS	Pedon A 3,c,sbk	ss,sp	fi	-	Imperfect	Many coarse roots, few stones
AB	4-10	7.5 YR 3/1 very dark grey	c,fi,ds	LS	3,fi,sbk	vs,sp	fi	-	Imperfect	Many coarse roots
Bt	10-19	7.5YR 5/1 grey	ma,m,ds	SCL	3,fi,abk	vs,vp	vfi	-	Imperfect	Many fine roots, partly decomposed palm nuts

Btg	19-47	2.5Y 5/1 grey	fe,fi,ds	C	3,fi,abk	vs,vp	vfi	-	Poor	Few fine roots, gley
Bg1	47-64	2.5Y 5/1 grey	-	SC	3,c,sbk	vs,vp	vfi	-	Very poor	Gley
Bg2	64-79	2.5Y 5/1 grey	-	C	3,c,abk	vs,vp	vfi	-	Very poor	Few fine roots, gley
Pedon B										
Ap	0-32	7.5YR 4/3 brown	-	SL	1,c,cr	ss,np	vfr	-	Well drained	Many coarse roots
AB1	32-62	2.5Y 6/3 light yellowish brown	c,pr,co	S	1,c,cr	ns,np	vfr	-	Imperfect	Many fine roots
AB2	62-78	10YR 7/3 very pale brown	c,pr,co	LS	1,c,sbk	ns,np	vfr	-	Imperfect	Few fine roots
AB3	78- 113	2.5Y 6/3 yellowish brown	c,ds,co	LS	1,c,sbk	ns,np	fr	-	Imperfect	-
Bt	113- 160	10YR 6/3 pale brown	-	C	3,c,sbk	vs,vp	fi	-	Imperfect	Many stones

^aTexture: Sl = sandy loam; Sc = sandy clay, Scl = sandy clay loam, G = gravelly. ^bStructure: 2 = moderate, 3 = Strong, m = medium; c = coarse, sab = subangular blocky, ab = angular blocky. ^cConsistence: fm = firm; ls = loose, sst = slightly sticky, vst = very sticky; pl = plastic, vpl = very plastic, spl = slightly plastic.

^dHorizon Boundary: c = clear, s = smooth, ND = not determined.

Physico-chemical Properties of Soils

Pedon A has a pH range of 4.64-6.03, indicating slightly acidic to strongly acidic conditions, which may affect nutrient availability, particularly phosphorus (Zhou *et al.*, 2020). The organic carbon (OC) ranged from 6.91-28.36%, with the highest value in the surface horizon (28.36%), supporting active microbial activity and nutrient cycling (Gurmu, 2019). The total nitrogen (TN) ranged from 0.28 - 1.4 g/kg, with the highest value in the last horizon (1.4 g/kg), possibly due to organic matter accumulation (Table 4). The available phosphorus (AP) ranged from 12.66 to 33.28 mg/kg. Exchangeable bases (EB): Na ranges from 0.48 to 0.56 cmol/kg, K from 0.17 to 0.65 cmol/kg, Ca from 0.05 to 0.32 cmol/kg, and Mg from 2.80 to 12.40 cmol/kg. They were highest in the surface layers, while Mg was found to be highest at the last horizons due to illuviation or possible leaching. In addition, Saleh *et al.* (2025) state that it could be due to underlying parent material rich in Mg-bearing minerals (e.g., dolomite, serpentine, or mafic rocks) releasing Mg into the lower soil horizons. The effective cation exchange capacity (ECEC) ranged from 5.06 - 19.5 cmol/kg, with the highest value in the surface horizon (19.5 cmol/kg). In pedon A, iron (Fe) ranges from 5.11 - 13.22 mg/kg, manganese (Mn) from 3.82 - 6.05 mg/kg, copper (Cu) from 1.32 - 2.76 mg/kg, and zinc (Zn) from 7.62-14.26 mg/kg, with the highest Zn content at surface overlying the last horizon (14.26 mg/kg). According to Hewitt *et al.* (2021), the highest Fe concentration is in deeper layers, indicating possible reduction and gleying processes. Base saturation (BS) remains high (88.93 - 97.53%), reflecting good fertility in surface layers (Minato *et al.*, 2023).

In pedon B, the pH varies from 4.61 to 6.17, indicating similar acidity trends with pedon A. The OC ranged from

4.03 - 11.35%. The TN ranged from 0.7 - 2.38 g/kg and was found to be highest at the subsurface horizon (2.38 g/kg), suggesting possible organic matter leaching or lateral movement (Zhang *et al.*, 2017). The AP ranged from 11.25 - 16.41 mg/kg and was found to have the highest value at the last horizon, suggesting podzolization or leaching effects (Hewitt *et al.*, 2021). EB values are generally lower than in pedon A, with Na ranging from 0.40 - 1.2 cmol/kg, K from 0.09 - 0.22 cmol/kg, Ca from 0.05 to 0.17 cmol/kg, and Mg from 0.40 - 4.20 cmol/kg. This implies lower fertility and nutrient retention, based on similar findings by Huntley *et al.* (2023). However, the ECEC values range from 4.79 - 10.60 cmol/kg, showing moderate fertility. In pedon B, Fe ranges from 6.18 - 13.38 mg/kg, Mn from 4.23 - 6.37 mg/kg, Cu from 1.89 - 2.5 mg/kg, and Zn from 8.85 - 20.74 mg/kg, with a high Zn content at surface overlying the last horizon (20.74 mg/kg), potentially from mineral weathering (Proust *et al.*, 2015). BS varies from 85.57 - 91.98%, indicating good nutrient retention (Minato *et al.*, 2023).

USDA Soil Taxonomy System

Table 5 show that the soils of pedon A were classified at the order level as Alfisols because they have an argillic horizon with base saturation of higher than 35%, pedon B as Inceptisols because it has a cambic horizon with properties that do not meet the requirements for an anthropic, histic, follic, melanic, plaggen or umbric epipedon (Soil Survey Staff, 2014). At the suborder level pedon A was classified as Aqualfs because they have redoxmorphic features (gley) in more than 50% of the pedon. Pedon B was classified as udepts because it is an inceptisol with a udic moisture regime. At the great-group level, pedon A was classified as Edoaqualfs because there

is evidence of endoaquatic saturation; the groundwater fluctuates from the soil surface to below the argillic horizon. Pedon B was classified as Eutrudepts because it is an udepts with a base saturation of more than 60%. At

the subgroup level, pedon A was classified as Arenic Endoaqualfs because it is coarse textured at the top of the argillic horizon, and pedon B is Arenic Eutrudepts because it is coarse textured within 50 cm of the mineral surface.

Table 4

Soil Physico-chemical properties of the study sites

Depth (cm)	pH	TN (g/kg)	PSD (%)			T C	OC (%)	AV. P (mg/kg)	EA		ECEC			EB Mg	BS (%)	Micro Nut. (mg/kg)			
			Sa nd	Silt	Clay				N	K	Ca	Mg	Fe			Mn	Cu	Zn	
Pedon A																			
0-4	5.	0.2	64	18	17	S	28.	12.6	0.	0.	12.	5.6	19	97.	7.8	4.	1.	7.6	
	46	8	6.8	2.8	0.4	L	36	6	48	65	32	40	0	.5	53	7	13	9	2
4-10	5.	1.1	65	17	17	S	26.	33.2	0.	0.	6.2	3.4	10	94.	13.	5.	2.	12.	
	98	2	6.8	2.8	0.4	L	47	8	64	30	17	0	0	.7	02	22	08	4	09
10-19	6.	0.4	67	19	13	S	7.2	10.6	0.	0.	0.	3.2	2.0	5.	91.	8.1	3.	1.	8.7
	03	2	6.8	2.8	0.4	L	5	3	48	17	06	0	0	91	88	2	99	76	3
19-47	4.	0.5	62	12	25	S	6.9	13.7	0.	0.	0.	2.8	4.0	7.	91.	6.9	4.	1.	9.1
	64	6	6.8	2.8	0.4	C	1	5	64	26	05	0	0	75	74		67	32	5
47-64	5.	0.8	72	42.	23	S	11.	14.3	0.	0.	0.	3.4	0.8	5.	88.	7.2	3.	2.	7.8
	11	4	6.8	8	0.4	C	51	8	56	22	08	0	0	06	93	6	82	76	4
64-79	4.	1.4	44	62.	49	C	16.	12.9	0.	0.	0.	3.6	11.	15	96.	5.1	6.	1.	14.
	88		6.8	8	0.4	L	11	7	56	50	10	0	00	.8	45	1	05	87	26
Pedon B																			
0-32	5.	0.7	84	22.	13	L	4.0	13.7	0.	0.	0.	4.2	0.8	6.	85.	8.6	4.	1.	9.8
	3		6.8	8	0.4	S	3	5	40	17	05	0	0	1	57	5	53	97	7
32-62	5.	1.2	86	6.8	12	L	10.	11.2	0.	0.	0.	3.6	0.6	4.	91.	13.	6.	2.	12.
	26	6	6.8		6.4	S	97	5	40	11	08	0	0	79	65	38	12	11	2
62-78	5.	2.3	85	14.	12	L	5.2	10.4	0.	0.	0.	0.4	4.0	4.	91.	6.1	4.	1.	9.5
	84	8	6.8	8	8.4	S	9	7	40	11	08	0	0	99	98	8	23	89	6
78-113	6.	0.7	86	2.8	13	L	11.	14.0	0.	0.	0.	1.2	4.4	6.	85.	12.	6.	2.	20.
	17		6.8		0.4	S	35	6	96	09	12	0	0	77	82	76	37	5	74
113-160	4.	0.8	76	22.	21	S	7.1	16.4	1.	0.	0.	1.2	7.8	10	88.	7.0	5.	2.	8.8
	61	4	6.8	8	0.4	C	9	1	2	22	17	0	0	.6	67	3	14	42	5

TN=total nitrogen, PSD= particle size distribution, AVP=available phosphorus, EA= exchangeable acidity, EB=exchangeable bases, BS=base saturation.

Table 5

Summary of classification of the pedons

Pedon	USDA	WRB
A	Arenic Endoaqualfs	Reductic Clayic Gleysols
B	Arenic Eutrudepts	Eutric Arenic Cambisols

Table 6

Suitability rating for pepper

Land qualities	Land characteristics	Unit	Pedon A	Pedon B
Climate (C)	Annual Rainfall	Mm	S3(49)	S3(49)
	Mean Annual Temperature	°C	S1(100)	S1(100)
Wetness (w)	Soil drainage	class	S3(49)	S2(74)
	Texture	class	S2(74)	S2(74)
Soil physical properties (s)	Effective soil depth	Cm	S1(100)	S1(100)
	Soil pH		S3(49)	S3(49)
Fertility (f)	Soil organic carbon	g kg ⁻¹	S1(100)	S1(100)
	Available P	mg/g	S1(100)	S2(74)
	Exchangeable Potassium	cmol/kg	N (24)	N (24)

Land qualities	Land characteristics	Unit	Pedon A	Pedon B
	Base saturation	%	S1(100)	S1(100)
Topography (t)	Slope	%	S2(74)	S1(100)
Non-Parametric Actual			N2	N2
Non-Parametric Potential			S3	S3
Parametric Actual			N2(8.70)	N2(12.43)
Parametric Potential			S3(25.38)	S3(36.26)

S1 =Highly Suitable; S2 = Moderately Suitable; S3 = Marginally Suitable; N1 = Currently not Suitable; N2 = Permanently not Suitable

FAO/UNESCO Soil Map of the World Reference

In the higher category, pedon A was placed in the Gleysols due to gleyic properties in most parts of the profile, and pedon B was placed in the Cambisols as a result of the presence of a cambic horizon (FAO, 2015). At the lower category, pedon A was classified as Reductic Clayic due to saturation by water causing reducing conditions, the presence of an argillic horizon at the subsoil and increasing clay content down the profile. Pedon B was classified as Eutric Arenic because it has a base saturation of more than 50% and is coarse textured within 100 cm of the soil depth.

Suitability Rating for Pepper

Pedons A and B fall into S3 (49) suitability class for annual rainfall as shown in Table 6, indicating marginal conditions due to inadequate moisture availability for optimal crop growth (Umeugokwe *et al.*, 2022). The mean annual temperature is rated S1 (100), signifying optimal conditions for crop production. Soil drainage in pedon A is S3 (49), indicating imperfect drainage that may cause waterlogging, whereas pedon B, classified as S2 (74), has better drainage, supporting root aeration and water movement (Ajayi *et al.*, 2025). Both pedons are classified as S2 (74) for texture, suggesting moderate limitations due to sandy loam and sandy clay loam compositions, which may affect water retention and nutrient holding capacity (Mwendwa *et al.*, 2020). However, the effective soil depth is rated S1 (100) for both pedons, indicating no restriction on root penetration, making them suitable for deep-rooted crops, according to Bodner *et al.* (2021). Soil pH in both pedons is classified as S3 (49), indicating strong acidity, which may reduce nutrient availability (Marzouk *et al.*, 2023). Organic carbon content is S1 (100), reflecting good soil organic matter for microbial activity and nutrient cycling (Ma *et al.*, 2020). Available phosphorus is S1 (100) in pedon A but S2 (74) in pedon B, suggesting optimum Av.P for pedon A and moderate phosphorus deficiency in pedon B. Exchangeable potassium is rated N (24) in both, indicating severe limitations. Base saturation is S1 (100) in both pedons, suggesting good cation retention (Ng *et al.*, 2021). Pedon A is S2 (74) for slope, while pedon B is S1 (100), indicating no slope-related constraints. Overall, for non-parametric suitability both pedons are classified as N2 (Not Suitable) in actual conditions, but their potential suitability is S3 (marginally suitable) with proper amendments. Parametric suitability indices improve from N2 (8.70) to S3 (25.38) in pedon A and from N2 (12.43) to S3 (36.26) in pedon B, indicating better potential with improved management practices.

Irrigation suitability evaluation

The pedons were evaluated for surface, sprinkler, and drip irrigation systems as shown in Table 7. In the evaluation of soil irrigation suitability, pedon A has suitability index (Ci) values of 24.3, 36.55, and 45.13, with ratings of N2 (permanently not suitable), N1 (currently not suitable), and S3 (marginally suitable) for surface, sprinkler, and drip irrigation, respectively. This indicates that drip irrigation is the most suitable method, followed by sprinkler irrigation, although both require good management for sustainable irrigation. This agrees with findings by Barsato *et al.* (2019). Pedon B has suitability index (Ci) values of 64.13, 61.00, and 68.40 for surface, sprinkler, and drip irrigation, respectively, indicating moderate suitability (S2) for all irrigation methods. Although the drip method has the highest value, moderate management is required to achieve higher suitability (Barsato *et al.*, 2019). All pedons fall in classes lower than S1 (highly suitable) due to texture, soil depth, and slope limitations. River water has a sodium adsorption ratio (SAR) value of 0.0993, within the range of 0–10 and classified as class 1 (low sodium), indicating low sodium relative to calcium and magnesium. Profile pit water has a higher value of 3.1706 but is also classified as class 1 (low sodium). This indicates that although sodium concentration is higher than in river water, it remains within acceptable irrigation limits. Both water sources therefore pose low risk of sodium-related soil problems (Tomaz *et al.*, 2020). River water has an electrical conductivity (EC) value of 0.510, below the threshold of 250 and classified as class 1 (excellent). According to Ismayilov *et al.* (2021), the salt concentration is low, making the water suitable for irrigation without risk of excessive salt accumulation. Profile pit water has a slightly higher EC value of 1.163 but still falls within class 1 (excellent). Both water sources therefore indicate good irrigation water quality (Singh *et al.*, 2018). Both river and profile pit water have the magnesium hazard (MH) values below 50, indicating non-hazardous magnesium levels (Singh *et al.*, 2018). Kelly's ratio shows that river water has a value of 0.0497, classified as class 1 (suitable) (FAO, 2015), indicating low sodium hazard (O'Donnell *et al.*, 2020). Profile pit water has a higher KR value of 1.5853, classified as class 2 (unsuitable), suggesting potential sodium-related risks during irrigation (Qadir *et al.*, 2021). Zaman *et al.* (2021) reported that higher KR values may require management practices such as proper drainage and leaching to mitigate sodium problems in soils.

Yield of pepper in the pedons

The yield performance of pepper in the pedons is presented in Figure 1. In pedon A, 0.9 t ha⁻¹ was recorded and 1.97t ha⁻¹ in pedon B. These values are lower than 2 t ha⁻¹ average yield postulated by Hass *et al.* (2021) concept for conventional habanero pepper farming in Nigeria. The poor performance could be as a result of high-water table, poor drainage, acidic nature of the soils and low exchangeable potassium (Okebalama *et al.*, 2024). Pepper have been reported to be susceptible to water stress (Tanaskovik *et al.*, 2017). Pepper performed better in pedon B than A, this is in agreement with the suitability assessment of the pedons for pepper in which their aggregate actual suitability ratings were N2 (12.43) and N2 (8.70) for pedons B and A respectively while the potential was S3 (36.26) and S3 (25.38). Hence, the suitability index of the actual and potential ratings of pedon B were higher than A.

CONCLUSION

The Fadama soils of the Derived Savanna in Ikole-Ekiti exhibit moderate to deep profiles with loamy sand to

sandy loam textures and slightly to strongly acidic pH, reflecting limited natural fertility in some horizons. Surface layers are enriched in organic carbon, while exchangeable potassium is low, indicating nutrient constraints for hot pepper. Pedon A and B were classified as Arenic Endoaqualfs and Arenic Eutrudepts (USDA) and Reductic Clayic Gleysols and Eutric Arenic Cambisols (WRB). Land suitability evaluation revealed that both soils are currently not suitable (N2) for hot pepper but possess marginal potential (S3) under improved management, including fertilization, drainage control, and irrigation. Observed pepper yields (0.9–1.97 t ha⁻¹) align with these limitations. Irrigation assessment showed drip irrigation was most suitable, while water quality parameters indicated low sodium hazard and good irrigation suitability. Effective utilization of these soils requires integrated soil fertility management, adoption of suitable irrigation methods, and conservation practices to enhance crop productivity and ensure the sustainable management of Fadama soils.

Table 7

Irrigation suitability index values (Ci) and suitability classes of the irrigation methods

Land qualities	Pedon A			Pedon B		
	Surface irrigation	Sprinkler irrigation	Drip irrigation	Surface irrigation	Sprinkler irrigation	Drip irrigation
Horizon 0-30						
Soil texture	75	90	95	75	90	95
Soil depth	90	95	100	100	100	100
CaCO ₃	100	100	95	95	95	95
Electrical conductivity	100	100	100	100	100	100
Drainage	40	50	50	70	75	80
Slope rating	90	95	100	90	95	100
Suitability index values (Ci)	24.3	36.55	45.13	64.13	61.00	68.4
Suitability Class	N2	N1	S3	S2	S2	S2

Table 8

Irrigation water value and classes

Parameters	River water	Profile pit	Value/Range	Water class
SAR	0.0993	3.1706	0-10	Class 1(low sodium)
EC	0.510	1.163	<250	Class 1(excellent)
MH	0.2212	0.4286	<50	Non-Hazardous
KR	0.0497	1.5853	<1&>1	River water-Class1(suitable for irrigation) and Profile Pit-Class 2(unsuitable for irrigation)

SAR = sodium adsorption ratio; EC = electrical conductivity; MH = magnesium hazard; KR = Kelly's Ratio

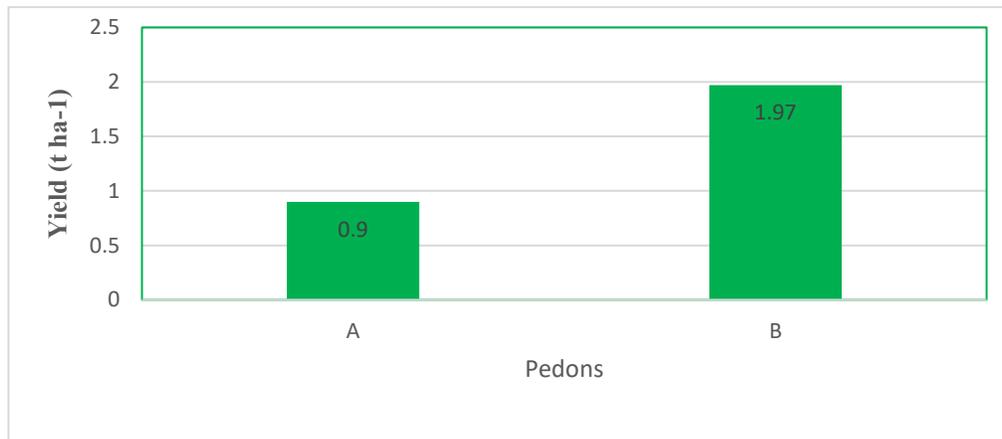


Fig. 1. Yield performance of pepper.

AUTHORS CONTRIBUTIONS

Conceptualization: A.S.F., T.S.B., and J.O.O.; Methodology: A.S.F., T.S.B.; and J.O.O.; Data collection: B.M.F., S.O.A., and O.A.; Data validation: T.S.B.; Data processing: B.M.F., S.O.A., and O.A.; Writing—original draft preparation: A.S.F., T.S.B.; Writing—review and editing: B.M.F., T.S.B.; C.A.O., D.C.O., and K.J.O..

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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