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Research Article

Soil characterisation and land suitability evaluation of teaching and research farm, kwara state university, malete

Kabir Kayode Adebayo*, **Toyeeb Abayomi Abioye, Adesina Abdulkabir Wahab, Yusuf Folohunsho Abdulkareem**

Department of Crop Production, Faculty of Agriculture, Kwara State University, Malete, Kwara State, Nigeria.

Abstract: Characterisation, classification, and land suitability analysis are fundamental to land potentials for agricultural purposes and management decisions, planning, and utilisation, providing a link between resource assessment and the decision-making process. This study was conducted to characterise and evaluate the land suitability for maize and soybean cultivation. Two soil profiles were dug based on topographical variations, and soil characterisation followed FAO guidelines. Soil samples were collected from genetic horizons for laboratory analyses. Surface samples (0–25 cm) were also collected across the sites. Morphological, physical and chemical properties were assessed using appropriate methods. The results revealed a textural variation from loam to sandy clay loam in Pedon 1, and sand to sandy clay loam in Pedon 2. Surface soil pH values ranged from 6.25 to 6.75, indicating a moderately acidic condition, favourable to most crops and soil microorganisms. However, the soils exhibited low levels of available phosphorus, exchangeable bases, and cation exchange capacity (CEC), while climatic factors such as rainfall, temperature and humidity were not limiting. Also, no land unit was classified as highly suitable (S1) for maize or soybean. Most areas were rated as marginally suitable (S3) due to fertility constraints and topography. In order to improve land productivity, soil fertility-enhancing practices are recommended.

Keywords: Characterisation, classification, soil, land evaluation, suitability

1. Introduction

Characterisation, classification, and analysis of land suitability are fundamental to land potential for agricultural purposes, management decisions, planning and utilisation, providing a link between resource assessment and the decision-making process (Smith et al., 2020). It is concerned with the selection of suitable land for clearly defined objectives such as cropping, irrigation, and other management (Jones et al., 2021). Soil characterisation supplies useful information for the assessment and monitoring of the behaviour of soils. It also provides an introduction to the management requirements of the major soils both in the present and future (Garcia et al., 2023). It is salient that the land which will be used for agricultural production according to its magnitude for optimisation and sustainability of soil productivity (Adeyemo et al., 2023).

Land suitability is the function of crop requirements and land characteristics. It is an estimation of how well the land unit qualities match the requirements of a particular type of land use (Chen et al., 2022). Soil characterisation and suitability evaluation also allow for the identification of major limiting factors for a particular crop production, and it enables decision-makers to develop a crop management system for increasing land productivity in a sustainable manner (Zhang et al., 2023). Land suitability classification quantifies, in broad terms, the extent to which land qualities match crop requirements under defined inputs and management practices. It is based on understanding crop requirements, prevailing conditions, and applied soil management approaches (Wu et al., 2023).

* Corresponding author:
Email: kabir.adebayo@kwasu.edu.ng

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Therefore, land suitability evaluation is a requisite to the utilisation of available land resources for specific land use in a sustainable manner.

Land suitability status is based on intrinsic properties of soils (parent materials, soil texture, and depth), and characteristics that can be altered by human management (drainage, salinity, nutrient concentration, and vegetation cover (Yang et al., 2024). Land suitability classification attempts to resolve problems that may be associated with land degradation and the wrong allocation of land to uses. It is the actual or potential fitness of a given tract of land for a defined use and considers the economic and sociopolitical factors during land evaluation. Land suitability classification is applied to clearly defined land uses (Adewole et al., 2023).

Soils of Kwara State University's Teaching and Research Farm, Malete, have been in use for multiple purposes, with little or no updated information on the physical and chemical properties of the soil. Thus, inadequate information on the soil resources of any region contributes to the problem of soil degradation and that of world food crises, among others, due to wrong uses and poor management practices. The information on the properties of the soils of Kwara State University's Teaching and Research Farm needs to be documented and it is on this premise that the study was carried out to obtain detailed characterisation of the physical and chemical properties of the soil mapping units of Malete soils and give out a taxonomic classification of the soils as indicated in the criteria of the USDA soil Taxonomy. Therefore, the objective of this study is to characterise and evaluate the land suitability of Kwara State University's Teaching and Research Farm, Malete, Kwara State, Nigeria, for maize (Zea mays) and soybean (Glycine max) cultivation.

2. Materials and methods

The experimental site that was used for this research was located at the Teaching and Research Farm, Kwara State University (KWASU), Malete, Kwara State, Nigeria. The farm has a latitude of 8071' N and a longitude of 4°44' E at 365 above sea level (Plate 1). The KWASU's Teaching and Research Farm, Malete, consists of approximately 1,400 hectares and is eight kilometres north of the agriculture buildings. The climate is characterised by distinct wet and dry seasons with a mean annual temperature that ranges from 25 to 28.9 °C. In addition, the annual mean rainfall is about 1,150 mm, exhibiting a double maximal pattern between April and October of every year. The wet season is between April and October, while the dry season starts in November and ends in March. The soil at the Teaching and Research Farm, KWASU, Malete, is loamy sand and slightly acidic (Wahab et al., 2018). The present vegetative cover of the site can now be regarded as savannah woodlands. Two soil profiles were dug across the study area, based on the topography of the land. The soil profiles were described using the guidelines of FAO. Sampling of each soil profile was carried out according to the pedogenic horizons. Also, surface samples (0 cm-25 cm) were collected across the study area. Morphological, physical and chemical properties were assessed according to the USDA Soil Survey Manual (Soil Survey Staff, 2023). The soil samples were analysed for soil texture, pH, organic carbon, total N, extractable P, exchangeable bases, exchangeable acidity

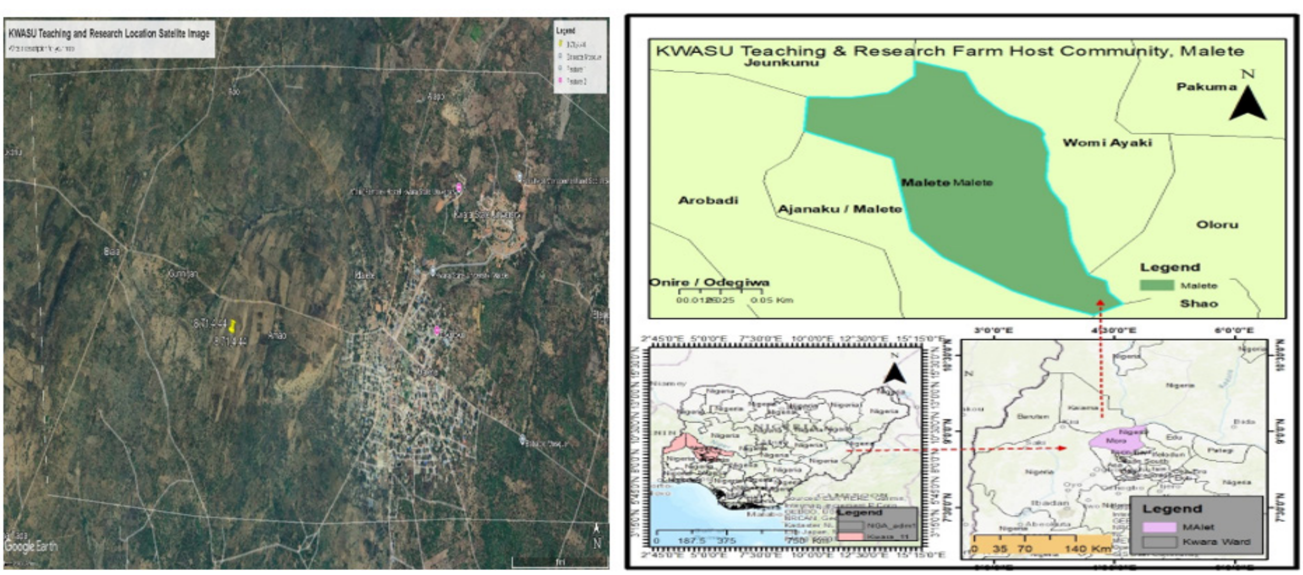

Plate 1: Map of the study area

Table 1: Physical and morphological properties of the soils in Teaching and Research Farm, KWASU, Malete.

HORIZON	Depth (cm)	% sand	% silt	% clay	Textural Class	Soil Colour
Pedon 1	0 - 27	88	2	10	LS	Yellowish brown (10YR 5/6)
	27 - 47	86	4	10	LS	Bright Yellowish Brown (10YR 6/8)
	47 - 104	58	8	34	SCL	Orange (7.5YR 6/8)
	104 - 150	66	0	34	SCL	Orange (7.5YR 6/6)
Pedon 2	0 - 30	90	6	4	S	Dull Yellowish Brown (10YR 5/4)
	30 - 47	90	4	6	S	Yellowish Brown (10YR 5/8)
	47 - 80	84	8	8	LS	Bright Yellowish Brown (10YR 6/8)
	80 - 136	70	6	24	SCL	Orange (10YR 6/6)

and Micronutrients. Soil texture was determined by the Bouyoucous hydrometer method (Juo, 1998) with sodium hexametaphosphate as the dispersing agent. Soil pH was measured electrometrically in a 1:1 solution in H2O. Organic carbon was determined by the Walkey-Black dichromate wet oxidation method as outlined by Herrera (2013).

Total nitrogen was determined by the Micro-Kjeldahl method (Bremner & Mulvaney, 1982). Whereas extractable P was determined by the ammonium molybdate blue method (Bray & Kurtz, 1945). Exchangeable bases were determined by using the 1N NH4OAc (pH 7.0) method. The FAO (2023), an essential structure for soil suitability evaluation, was used. Land characteristics recognized on the field were merged with those that were determined in the laboratory to make the preferred land qualities, which were used as the basis for the land assessment. A numerical rating of the land characteristics on a normal scale from a maximum (normally 100) to a minimum value (20) was employed. If a land characteristic was optimal for the considered land utilisation type, the maximal rating of 100 was attributed; if the land characteristic was unfavourable, a minimal rating of 20 was applied.

3. Results and discussion

3.1. Soil Physical and Morphological Properties

Table 1 shows the physical and morphological properties of the soil of the Teaching and Research farm, Kwara State University, Malete (Plate1). Pedon 1 extends to a total depth of 150 cm, and 4 distinct horizons were identified. Pedon 1 had colour variations between yellowish brown (10 YR 5/6) in the surface soil to a range of bright yellowish brown (10 YR 6/8) in the subsurface soil. The texture suggests that the upper layers are predominantly sandy with a small proportion of silt and clay, indicating a loamy soil (LS) in the first two horizons. Loamy sand is known for its good drainage and ease of cultivation, though it may require more frequent watering and fertilisation due to its lower capacity to retain water and nutrients. The soil was well drained at the time of sampling, but few distinct orange mottles (10YR 6/8) were observed at a depth of 47-104 cm. With an increase in depth (104-150 cm), the mottles became coarser and more prominent with an orange colour (7.5YR 6/6). This Pedon had a loamy sand (LS) epipedon overlying a sandy clay loam (SCL) in the subsoil. This Pedon had high sand content, low silt content, which was observed to be zero (0) in the fourth depth and clay content increases with depth, which indicates better water retention and potentially greater fertility, although it may also lead to reduced drainage and more compacted soil conditions. The third and fourth horizon, from 47-104 cm and 104 to 150 cm respectively, continues with a Sandy Clay Loam texture, which is beneficial for deeper-rooting plants but may require careful management to prevent waterlogging or root growth restrictions. The colour changes in Pedon 1 from Yellowish Brown (10YR 5/6) in the uppermost horizon to a Bright Yellowish Brown (10YR 6/8) in the second horizon, indicating well-aerated conditions. The deeper horizons show an orange hue (7.5YR 6/8 and 7.5YR 6/6), which may suggest oxidation processes occurring in these layers, likely due to variations in moisture content and mineral composition.

Pedon 2 reaches a total depth of 136 cm and is also divided into 4 horizons. The colour of the Pedon also varies across the horizons, ranging from dull yellow brown (10YR 5/4) on the surface, which could indicate slightly higher organic matter content, to Yellowish Brown (10YR 5/8) in the subsoil. The Pedon has a sand

(S) texture on the surface horizon and subsoil (30-47cm depth), indicating a high proportion of sand particles with minimal clay and silt.

This sandy texture promotes excellent drainage but may require frequent irrigation and fertilisation to maintain crop productivity. This is in line with a previous study, which found that the amount of clay content increases with the increasing depth of soil (Atofarati et al., 2012), which is due to clay eluviation in the soil. This agrees with the amount of clay content in the study area, which had an increasing pattern with the depth of soil throughout all profiles. The textures of surface horizons in the watershed were relatively coarser, and the textures of subsurface horizons were also relatively finer (Table 1). This also supports the findings of Buol et al. (2013), who recorded a higher clay to silt ratio, which they noted could be recorded in areas where there is removal of finer particles; these indicate that there was a relatively higher erosion problem at the upper slope position (Pedon 1) of the Anzecha watershed. Meanwhile, bright yellowish brown (10YR 6/8) was observed in the third horizon, from 47 to 80 cm, indicating a shift to a Loamy Sand (LS) texture. This slight increase in silt and clay content, coupled with the slight decrease in sand content, could enhance the soil's nutrient and water retention capabilities, making it slightly more fertile than the upper sandy layers.

However, the fourth horizon, extending from 80 to 136 cm with an orange hue (10YR 6/6), is classified as Sandy Clay Loam (SCL), indicating a drastic increase in clay content from 8% - 24%. A textural change was observed in Pedon 1 from loamy soil in the surface to sandy clay loamy in the subsoil, and from sandy to sandy clay-loamy in Pedon 2. This connotes that according to Lal and Shukla (2004), the textural class, porosity, and the amount of organic matter influence the drainage class of soils; thus, such parameters may be favourable for drainage conditions. According to (Ritung et al., 2007), well-drained to moderately well-drained soils are ideal for the production of crops, and thus the study area was ideal for crop production according to its drainage class and absence of flooding at any time of the year. This deeper layer will have better water retention and nutrient-holding capacity, but may require careful management to prevent issues related to compaction and poor drainage. Furthermore, the colour variations observed suggest differences in soil moisture and aeration, with the deeper layers possibly experiencing different oxidation conditions.

3.2. Chemical Characteristics of the Soil

The pH in Pedon 1 ranges from moderately acidic to near-neutral, with values between 5.75 and 6.75 in distilled water (Table 2). The surface horizon (0 - 27 cm) has the highest pH value (6.75), indicating less acidity, which is favourable for most crops. As depth increases, the pH decreases, thereby becoming more acidic, particularly in the fourth (104 - 150 cm) horizons, which have the lowest pH value of 5.75. The result agrees with the findings of Herrera (2013), who reported decrease in soil acidity decreased with the increase of soil depth due to fewer hydrogen ions that were released from a low amount of organic matter to be decomposed in the depth of soil, and acidic soil also promoted the accumulation of aluminium ions. Lime application may be considered if the soil is to be used for crops sensitive to acidity. However, a reversed pattern of pH variation was noticed in the second Pedon, where the highest value (6.75) was recorded in the fourth horizon of the Pedon, and the lowest value (6.25) was recorded in the first horizon of the Pedon, which reveals that the pH of the second Pedon ranges within the acidic/neutral region. As per ratings of Kileo (2010), the surface soil pH value at Pedon 1 (6.75) was moderately alkaline, and Pedon 2, which ranged from 6.25 to 6.75, was also moderately alkaline; meanwhile, according to Herrera (2013), pH ranges from 6 to 7.5 are preferable for most plants and soil microorganisms.

The total exchangeable acidity was moderate for all the Pedons, ranging from 0.20 to 0.3 cmol/Kg. The total Nitrogen of Pedon 1 and 2 was within the medium range (0.13 – 0.26 %) and (0.12 – 0.22 %), respectively, except for the fourth horizon in Pedon 1 (0.04%) and the third horizon in Pedon 2 (0.03 %), respectively. The horizons in Pedon 1 and Pedon 2 demonstrate a low content of organic carbon, ranging from 0.07 – 0.59% in Pedon 1 and 0.04 – 0.50 % in Pedon 2. The low content of organic carbon exhibited might be due to the lack of trees around the place to shed leaves that might form litter on the ground. The available phosphorus was moderate in the first Pedon, ranging from 125.75 – 158.53 mg/kg, while a lower amount was recorded in the second Pedon, ranging from 50.06 – 53.14 mg/kg, which are still sufficient for most crops but may require monitoring to prevent depletion over time.

Exchangeable bases, such as Calcium (Ca), Magnesium (Mg), Sodium (Na), and Potassium (K), are generally stable throughout the profile, with minor variations. Calcium levels are slightly higher in the deeper horizons, while Potassium shows an increasing trend with depth, peaking in the fourth horizon (104 -

Table 2: Chemical Properties of the Soils at Teaching and Research Farm, KWASU, Malete, Kwara State

Profiles	Depth	pH (H2O)	O.C	N	Avail. P	Ca	Mg	Na	K	Exchange. Acidity	CEC	B.S
	(Cm)		(%)		(ppm)	(Cmol/Kg)						(%)
PEDON 1	0 - 27	6.75	0.59	0.26	142.5	8.65	1.05	0.76	1.56	0.2	12.22	98.36
	27 - 47	6.4	0.33	0.15	125.75	8.85	0.25	0.76	1.64	0.23	13.73	98.03
	47 - 104	6.05	0.29	0.13	158.53	9.2	1.25	1.53	2.03	0.26	14.27	98.17
	104 - 150	5.75	0.07	0.04	155.68	8.5	2.95	2.03	2.19	0.26	15.93	98.36
PEDON 2	0 -30	6.75	0.5	0.22	53.14	10	1.95	0.76	1.64	0.23	12.49	98.42
	30 - 47	6.6	0.28	0.12	50.31	8.85	0.7	0.76	1.95	0.23	13.39	98.15
	47 - 80	6.45	0.04	0.03	51.32	9	1.6	0.76	1.8	0.23	14.58	98.28
	80 - 136	6.25	0.26	0.12	50.06	9.95	1.5	1.53	1.95	0.3	15.23	98.03

150 cm). These nutrients are essential for plant health, and their presence in adequate amounts suggests that the soil in Pedon 1 can support robust plant growth. The percentage Base saturation of the soils was consistently higher than 90%, ranging from 98.03 - 98.42 % with the highest in the first horizon of Pedon 2 and the lowest recorded in the second horizon in Pedon 1 and fourth horizon in Pedon 2, respectively. The low CEC of these soils, coupled with low organic matter, low Nitrogen and available Phosphorus are indications of low inherent soil fertility status, which underscores the need for improved soil management techniques.

The soils in both Pedon 1 and Pedon 2 exhibit characteristics that are generally favourable for agricultural use, with some variations in texture, colour, and nutrient content that may require site-specific management practices. The slightly acidic pH levels in both profiles are within a suitable range for most crops, though lime application may be necessary for acid-sensitive crops. The soil textures, ranging from Loamy Sand to Sandy Clay Loam, suggest that the soils are well-drained and easy to work with, though the higher clay content in the deeper horizons may pose challenges for root penetration and water drainage.

The organic carbon, nitrogen, and phosphorus levels indicate moderate fertility, with potential limitations in nitrogen and phosphorus availability, especially in Pedon 2. Proper fertilisation management, including the application of organic amendments and phosphorus fertilisers, will be essential to maintain soil fertility and ensure optimal crop yields. The level of organic carbon was relatively low on the upper slope positions of the study area (Table 2). This indicated the existence of high organic matter removal rates by erosion on the upper slope position, and the deposition process made in the middle, lower, and toe slope positions to have relatively higher organic matter status. This might have been caused by slope gradient and human influence on soil and water conservation practices at the study watershed. According to the rating of Msanya et al. (2010), the amount of soil organic carbon (0.59% and 0.50) for Pedon 1 and Pedon 2 in surface soil at upper slope position was rated as low level, which requires management practice to improve the amount of organic carbon due to its influence on nutrient recycling, water availability, and soil structure.

The level of available phosphorus in the study area showed a decreasing trend with an increase in soil depth. The highest value (158.53 mg/kg of soil) was recorded at the third horizon of Pedon 1, and the lowest value (50.06 mg/kg of soil) was recorded at the subsurface (fourth) horizon of Pedon 2. (Table 2). Similar to Kileo's (2010) findings, the level of available phosphorus decreased with increasing depth of soil due to phosphorus fixation by clay. This agrees with the values of available phosphorus in the watershed. In addition to that, the values of available phosphorus at the watershed agreed with reference (Pravin et al., 2013), which reported higher available phosphorus in surface soil due to the application of animal manure, compost, and di- ammonium phosphate (DAP) fertiliser to improve the fertility status of farmland.

The level of exchangeable basic cations showed an irregular variation with the depth of soil. Exchangeable

Table 3: Selected chemical properties, Descriptive statistics, and some selected heavy metals for surface soil samples in the study area (KWASU's Teaching and Research Farm, Malete).

Locations	pH	OC (%)	OM	N	Avail P (ppm)	Ca (Cmol/kg)	Mg	Na	K	CEC	B. Sat (%)	Cu	Zn Mg/kg	Fe	Mn
OFY															
	6.7	1.03	1.78	0.46	62.2	9.4	0.8	0.76	1.72	13.01	97.46	1.9	19. 19	16.65	4.53
	6.35	0.53	0.92	0.24	157.87	7.75	0.8	0.76	1.72	11.33	97.35	2.63	15.12	7.11	2.9
Mean	6.53[a]	0.78[a]	1.35[a]	0.35	110.04[a]	8.58[a]	0.80[a]	0.76[a]	1.72[a]	11.86[a]	97.41	2.27[a]	17.16[a]	11.88[a]	3.72[a]
Stdev	0.18	0.25	0.43	0.11	47.84	0.83	0	0	0	0.84	0.06	0.37	2.04	4.77	0.81
CV %	2.68	32.05	32.05	31.43	43.47	9.62	0	0	0	6.9	0.06	16.11	11.86	40.15	21.94
Maize															
	6.95	0.77	1.33	0.34	60.01	8.9	2.9	0.76	1.88	14.7	98.23	3.03	18.69	8.54	4.67
	6.75	0.99	1.71	0.44	172.55	10.55	0.85	1.53	1.88	15.11	98.01	2.6	32.07	9.35	3.05
Mean	6.85[a]	0.88[a]	1.52[a]	0.39	116.28[a]	9.73[a]	1.88a	1.15[a]	1.88[a]	14.63[a]	98.12	2.82[a]	25.38[a]	8.95[a]	3.86[a]
Stdev	0.1	0.11	0.19	0.05	56.27	0.83	1.03	0.39	0	0.2	0.11	0.22	6.69	0.41	0.81
CV %	1.46	12.5	12.5	12.82	48.39	8.48	54.67	33.62	0	1.38	0.11	7.64	26.36	4.53	20.98
Soy bean															
	7.75	0.94	1.63	0.42	180.9	14.35	1.1	0.76	1.8	18.34	98.2	4.33	33.51	5.08	2.43
	7.08	0.91	1.57	0.41	162.03	11.05	1.03	0.76	1.68	14.81	98	2.78	28.34	9.05	2.84
Mean	7.41[b]	0.93[a]	1.60[a]	0.42	171.47[a]	12.70[a]	1.06[a]	0.76[a]	1.74[a]	16.26[a]	98.1	3.56[a]	30.92[a]	7.06[a]	2.64[a]
Stdev	0.34	0.02	0.03	0.01	9.44	1.65	0.04	0	0.06	1.77	0.1	0.78	2.59	1.98	0.21
CV %	4.55	2.15	1.87	2.38	5.5	12.99	3.77	0	3.44	10.67	0.1	21.91	8.38	28.04	7.95

calcium varied from the highest 13.5 cmol/kg of soil in the surface horizon of the middle slope position to the lowest 2.7 cmol/kg of soil in the subsurface horizon of the upper slope position. According to Brady and Weil (2012), a lack of excessive leaching leaves basic cations in surface horizons. The mean values of cation distribution were high in some of the surface horizons; these might be successful soil and water conservation practices, as well as the nature of cover crops that inhibit the leaching of basic cations. Whereas the distributions of basic cations were relatively low in surface horizons and high in subsurface horizons, this might be due to the leaching of basic cations. This agrees with Ashena et al. (2016), who reported exchangeable cation content of the soil increased with the soil depth due to leaching of the basic cations. The low levels of exchangeable acidity in both profiles are favourable for plant growth, indicating minimal potential for soil toxicity. The levels of exchangeable bases, including calcium, magnesium, sodium, and potassium, are generally adequate for soil fertility, though the variability in sodium and potassium may require site-specific management.

3.3. Soil Classification

Pedon 1 and Pedon 2 have a clay < 16 cmol/kg; base saturation >50% by NH4OAc at pH <7.0 (Table 2) and ustic moisture regime, Plinthic subsurface horizons and mottling which occupied more than half the volume of the soils. Based on the above properties, the two Pedons are classified as Typic Plinthustalf (According to USDA) and, according to FAO/UNESCO, they were classified as (Plinthosol; Cutanic, Hyperutric). At the soil series level, the two Pedons belong to the Gambari series. Classification at the family level could not be undertaken because the mineralogy was not determined. This gives direction for further studies.

3.4. Land Suitability Evaluation for Maize (Zea mays) and Soybean Production

The organic carbon content in the soil samples ranges from 0.53% to 1.05%, while the organic matter content spans from 0.91% to 1.81% (Table 3). These values are relatively low, implying that the soil may have a limited capacity for retaining moisture and nutrients, which are vital for plant growth. Organic carbon is a crucial component of soil organic matter, which influences soil structure, water retention, and nutrient availability. The low organic matter levels in the soil suggest that the application of organic amendments, such as compost or manure, may be necessary to enhance soil fertility and improve crop yields. This would help in building up the soil's organic matter content, thereby improving its structure, water-holding capacity, and overall fertility.

Total nitrogen values in the soil samples (Table 3) were relatively low, ranging from 0.24% to 0.47%. Nitrogen is an essential nutrient for plant growth, playing a key role in the synthesis of proteins, chlorophyll, and nucleic acids. The low nitrogen content recorded suggests that the soil may not be able to support crops that are highly demanding of high nitrogen without the addition of nitrogen fertilisers. For crops such as maize, wheat, and leafy vegetables, which require substantial amounts of nitrogen for optimal growth, it may be necessary to apply nitrogen-rich fertilisers to ensure healthy crop development and maximise yields. Additionally, incorporating leguminous cover crops that can fix atmospheric nitrogen would be a sustainable approach to improving soil nitrogen content over time.

The available phosphorus content in the soil varies significantly across the samples, ranging from 60.01 ppm to as high as 180.90 ppm. Phosphorus been a crucial nutrient that supports energy transfer, root development, and flower and fruit production in plants. The variation in phosphorus levels indicates that while some soil samples are well-supplied with phosphorus, others may require phosphorus fertilisation, especially for crops with high phosphorus requirements, such as legumes and root crops. The higher phosphorus levels observed in some samples suggest that the soil is highly suitable for crops that benefit from abundant phosphorus, such as beans, peas, and potatoes. However, phosphorus management should be approached carefully to avoid potential environmental issues such as phosphorus runoff, which can lead to eutrophication of nearby water bodies.

The levels of exchangeable cations in the soil, including calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K), are generally adequate, with calcium ranging from 7.75 to 14.35 cmol/kg, magnesium from 0.30 to 2.90 cmol/kg, sodium consistently at 0.76 cmol/kg, and potassium ranging from 1.53 to 1.88 cmol/kg. Calcium levels are very important in maintaining the soil structure and reducing soil acidity, with the higher calcium levels in some samples contributing to improved soil health and productivity. Magnesium, which is essential for chlorophyll production and enzyme activation, shows some variability, with lower levels in certain samples indicating a potential need for magnesium supplementation. Sodium was low across all samples, which is favourable as high sodium levels may lead to soil salinity issues, adversely affecting plant growth and soil structure.

Potassium values, which are critical for various physiological processes in plants, including water regulation and enzyme activation, are consistent and within a range that supports healthy plant growth. The balance recorded for these exchangeable cations was crucial for maintaining the soil fertility and supporting a vast range of crops, with the current levels indicating that the soil is generally well-balanced and capable of sustaining agricultural productivity. Exchangeable acidity, which measures the potential acidity that can be released into the soil solution, is relatively low across the soil samples, ranging from 0.26 to 0.33 cmol/kg. This low level of exchangeable acidity is beneficial for soil health, as it indicates that the soil is not prone to becoming excessively acidic, which could otherwise hinder nutrient availability and crop growth. The low exchangeable acidity suggests that the soil has a good buffering capacity, helping to maintain stable pH levels over time and reducing the need for frequent liming to neutralise acidity.

The soil micronutrient levels, including copper (Cu), zinc (Zn), iron (Fe), and manganese (Mn), fall within the acceptable ranges for optimum plant growth, with copper ranging from 1.64 to 4.33 ppm, zinc from 15.12 to 33.51 ppm, iron from 5.08 to 19.19 ppm, and manganese from 2.43 to 4.67 ppm. Copper levels are adequate to support various plant metabolic functions, including photosynthesis and respiration. Zinc levels are relatively high, especially in some samples, which is beneficial for enzyme function and protein synthesis in plants. High zinc levels are advantageous for zinc-demanding crops such as maize, but care should be taken to avoid zinc toxicity, particularly in sensitive crops. Iron content varies across the samples, with higher levels observed in some, which is essential for chlorophyll synthesis and overall plant health. However, excessively high iron levels can lead to toxicity issues, especially in iron-sensitive crops. Manganese levels are moderate, supporting various enzymatic activities and photosynthesis in plants, but like other micronutrients, should be managed to prevent deficiency or toxicity. The selected heavy metals assessed for this study (Cu, Zn, Fe and Mn) (Table 3) show an unstable trend in the variation obtained across the 3 locations (OFY, Maize and Soybean field). Cu values obtained ranged from 2.27 to 3.56 mg/kg, with the lowest value at OFY, while the highest value was recorded at the soybean field. Although all the mean values recorded were within the permissible limit by the WHO. Zn showed a high value (> 15mg/kg) across all the 3 location, the source for the high content of Zn could be a result of anthropogenic activities (agrochemicals used by farmers that contains high Zn) Fe was moderate to low (7.06- 11.88 mg/kg) across the 3 locations, and the concentration of it could be from parent materials or natural sources during soil formation. The concentration of Mn was also within the permissible limit or threshold by the WHO and FAO. The matching Land and Soil Requirements for suitability rating of Maize and soybeans (Table 4) resulted in the suitability classes of the soil mapping units as shown in Table 4 below, which reveals that the soil pH values across the samples range from 6.35 to 7.75, stipulating that the soil is generally slightly acidic to neutral. Soils within this pH range are considered optimal for most crops, as they allow for the availability of essential nutrients. A pH closer to neutral, such as 7.75 in one of the samples, is particularly ideal for crops that are sensitive to acidic conditions, ensuring maximum nutrient uptake.

The slightly acidic pH in other samples (e.g., 6.35) could be beneficial for acid-loving crops like potatoes and blueberries, while still being suitable for a broad spectrum of other plants. Thus, the pH levels suggest that the soil can support a variety of crops with minimal need for lime to adjust acidity.

3.5. Suitability Ratings of Land Characteristics for Maize (Zea mays) and Soybeans Production

Soil mapping units with the suitability classes of the area are shown in Table 4. The mean annual temperature of the study area was optimal or near optimal, the same as relative humidity, length of dry season, slope and base saturation. The OFY soils (operation feed yourself area) had shown a textural class ranging between loams/sandy soil to sandy-clay loam, thus, considered moderately suitable (S2) for the cultivation of maize and soybeans. However, the soil texture for optimum performance of maize and soybeans is clay loam or loam (Sys, 1985). However, the topography and low fertility (slightly) levels had limited the soils in the area to a moderately suitable (S2tf) subclass for the production of maize and soybeans. Drainage status of some parts of the farmland where Maize and Soybeans were cultivated was marginally suitable (S3wf) subclass. These qualities (drainage, topography and low fertility) have limited the suitability of the Pedons to the marginally

Table 4: Suitability Ratings of Land Characteristics for Maize (Zea mays) and Soybeans Production.

Land Characteristics	OFY	Maize	Soybeans
Climate (c)			
Annual Rainfall (mm)	100 (S_1)	100 (S_1)	100 (S_1)
Mean Annual Max. Temp. (^{0}C)	100 (S_1)	100 (S_1)	100 (S_1)
Relative Humidity (%)	100 (S_1)	100 (S_1)	100 (S_1)
Length of Dry Season (days)	100 (S_1)	100 (S_1)	100 (S_1)
Topography (t)			
Slope (%)	74 (S_3)	85 (S_2)	70 (S_3)
Wetness (w)			
Drainage	95 (S_2)	80 (S_2)	74 (S_2)
Flooding	100 (S_1)	100 (S_1)	80 (S_2)
Soil Physical Properties (s)			
Texture/Structure	90 (S_2)	90 (S_2)	90 (S_2)
Coarse Fragments (0-50cm)	90 (S_2)	100 (S_1)	100 (S_1)
Fertility (f)			
CEC (cmolkg^{-1}clay)	12 (S_2)	15 (S_2)	16 (S_2)
Base Saturation (%)	97 (S_1)	98 (S_1)	98 (S_1)
pH (water)	6.53 ($S_{1)}$	9 (S_2)	7 (S_1)
OM (%)	1.3 (S_2)	2 (S_1)	2 (S_1)
Avail. P(mgkg^{-1})	63 (S_3)	60 (S_3)	67 (S_3)
Extractable K (cmolkg^{-1})	1.7 (S_1)	2 (S_1)	2 (S_1)

Key: FO – No Flooding, F1 – Seasonal Flooding, MR – Flooding Rare; C - Clay, CL – Clay Loam, LS – Loamy Sand, SL – Sandy Loam, LCS- Loamy Clay Sand, CS – Clay Sand, S – Sand S1-Highly suitable S2 – Moderately suitable S3 – Marginally suitable N1 – Currently not suitable; OFY: Operation filed yourself land area, Maize: part of the farm land where Maize are cultivated, Soy bean: part of the farm land where soy bean are cultivated.
Source: Adesemuyi, 2014 (modified).

suitable subclass S3tf and S3wf for maize and soybeans production. The imperfect drainage status of pedons in the maize and soybeans farmland has hindered their productivity to a moderately suitable class (S2); also, seasonal flooding (major limitation) has substantially lowered the soil's suitability for maize and soybeans cultivation into a marginally suitable (S3wf) subclass (Table 4). Foregoing, none of the pedons was considered highly suitable for maize and soybeans cultivation in the study area. All the soils in the study area were classified into the marginally suitable (S3f) subclass due to their low nutrient status.

4. Conclusion and recommendation

The study revealed significant variations in soil properties across the different horizons of both pedons. The results for the suitability assessment revealed that certain qualities and characteristics (mean annual temperature, relative humidity and base saturation) were optimum for the production of maize and soybeans; however, there was no highly suitable (S1) land for maize and soybeans in the study area. Mostly, all the soils in the study area were classified into the marginally suitable (S3f) subclass due to their low nutrient levels. The OFY (operation feed yourself farmland) was marginally suitable (S3tf) due to topography and low soil fertility in the area. Maize and soybean farmland were also classified into the marginally suitable (S3wf) subclass, and this was due to the seasonal flooding. However, to enhance the productivity levels of these lands (OFY, maize and soybean farmland) for optimum production, farm management techniques that will improve the soil nutrient levels and structures are highly recommended. Further research should be conducted into the long-term effects of these soil properties on crop yield.

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