# CHARACTERIZATION, CLASSIFICATION, AND SUITABILITY ASSESSMENT FOR THE CULTIVATION OF GINGER (*Zingiber officinale*) AND CUCUMBER (*Cucumis sativus*) ON SLM RESEARCH HUB, UNIBEN

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**UNIVERSITY OF BENIN**

**OCTOBER, 2025**

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**PROJECT SUBMITTED TO THE DEPARTMENT OF SOIL SCIENCE AND LAND MANAGEMENT, FACULTY OF AGRICULTURE, UNIVERSITY OF BENIN. IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE BACHELOR OF AGRICULTURE (B.AGRIC).**

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## CERTIFICATION

This is to certify that this Project work was carried out by **NZEAKA** Faith Chioma with Matriculation Number AGR2010630 of the Department of Soil Science, Faculty of Agriculture, University of Benin city, Nigeria.

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**DR. MRS. V. I. O EDOSA** **DATE**
**HEAD OF DEPARTMENT**

## DEDICATION

This project work is dedicated to Almighty God for His guidance and grace, and to my dear sister for her unwavering love, support, and encouragement throughout this journey.

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# ABSTRACT

This study was carried out on a 0.25 hectare land at the SLM Research Hub, University of Benin, Edo state where the soil was characterized, classified and evaluated for its suitability for the cultivation of Ginger (*Zingiber officinale*) and Cucumber (*Cucumis sativus* L.). The soil survey process was carried out with an intensive scale using the Rigid grid systematic survey method and a mapping unit was delineated in the study site. A pedon was sunk in the mapping unit, described appropriately and sampled for analysis. The soil samples were analyzed using standard method procedures at the laboratory. Soils were classified using the USDA soil taxonomy, World Reference Base for soil resources (WRB) and the local Nigerian classification system based on Moss (1957) as updated by Ogunkunle (1983). The suitability of the soil for ginger and cucumber production was evaluated using both limitation and parametric method. The current and potential land suitability classes were assessed. The result showed that the textural class of the soil varied from Loamy Sand in the surface to Sandy Clay Loam in the subsoil while the structure ranged from fine sub-angular blocky to medium sub-angular blocky with a base saturation of 1.37-4.54% and pH level of 4.3-5.2. Sand fraction in the soil ranged from 72.9-86.2%, Silt from 1.5-2.4% and clay from 11.4-25.6%. Taxonomically, the soil was classified , a Sandy Isohyperthermic Rhodic Kandiudult under the USDA Soil Taxonomy and as a Rhodic Lixisol (Loamic, Differentic, Ochric) under the WRB system. Locally, it was classified as the Orlu Series (Normal).

# CHAPTER ONE

## 1.0 INTRODUCTION

Soil characterization, classification, and land suitability assessment are fundamental processes that provide a framework for evaluating the potential of land for agricultural use. Soil characterization involves the detailed description of morphological, physical, and chemical properties such as texture, structure, pH, and nutrient status, which are key indicators of soil quality. Classification organizes soils into distinct groups based on shared attributes, thereby simplifying communication and management. Land suitability assessment builds on these steps by comparing soil and environmental attributes with crop requirements to determine the fitness of a particular land area for cultivation (FAO, 2020). This integrated approach is essential for guiding sustainable agricultural planning and optimizing resource use.

Soil characterization, classification, and suitability assessment are indispensable for sustainable land management and agricultural development. Soil characterization provides detailed knowledge of soil morphological, physical, and chemical properties, which helps identify limitations such as low fertility, poor water holding capacity, and nutrient deficiencies, guiding site specific management decisions. Soil classification organizes soils into distinct groups based on shared attributes, facilitating communication among scientists, extension workers, and policymakers, and providing a framework for monitoring and evaluating land resources. Land suitability assessment improves on these steps by providing geospatial and soil data that identify constraints and opportunities for crop production, thereby helping to design management interventions such as liming, organic amendments, improved fertilizer use, and drainage modifications (Peter and Agbogun, 2022). It also contributes to precision agriculture by optimizing crop allocation and management according to site specific soil conditions.

Ginger (*Zingiber officinale* Rosc.) and Cucumber (*Cucumis sativus* L.) are crops of high agronomic and economic importance in Nigeria. Ginger is a leading spice crop, valued for its culinary, medicinal, and industrial applications, and contributes to rural livelihoods, household income, and foreign exchange earnings (Okeke and Akinmutimi, 2021; Unuofin, 2021). Cucumber is a fast growing vegetable widely consumed fresh or processed, notable for its nutritional and health promoting properties, and enjoys increasing demand in urban markets, making it a profitable cash crop for farmers (Alabi, 2024). Both crops have distinct soil requirements: ginger performs best in well drained loamy soils rich in organic matter, while cucumber thrives in slightly acidic to neutral soils with good moisture retention (NIHORT, 2022).

Despite their importance, ginger and cucumber production in Nigeria often face constraints linked to soil conditions, such as strong acidity, low base saturation, nutrient deficiencies, and poor water holding capacity. These limitations are common in the acid sands and coastal plain soils of southern Nigeria, including those in Benin City (Okunsebor and Umweni, 2021). Without adequate soil information, land use decisions may encourage crop placement in unsuitable areas, resulting in low yields, land degradation, and unsustainable farming practices.

Therefore, soil characterization, classification, and suitability assessment are critical for identifying soils that can support the sustainable production of these crops.

Thus the aim of this study was to characterize, classify, and assess the suitability of the soil in the SLM Research Hub, University of Benin, for the cultivation of ginger (*Zingiber officinale*) and cucumber (*Cucumis sativus* L.).

## OBJECTIVES OF THE STUDY

The objectives of this study were to:

1. characterize, and classify the soil in SLM Research Hub, UNIBEN.
2. assess its suitability for the cultivation of ginger  and cucumber.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Soil

Soil is a collection of natural bodies on the earth's surface capable of supporting life (plants and animals) and showing properties that are due to the integrated effects of climate and other organisms on parent materials as conditioned by relief and time. Soil is also defined as the horizonated mixed solid, liquid and gaseous material at the earth's surface, resulting from chemical and biological processes and physical organisation of minerals and organic matter which interacts with the atmosphere, lithosphere and hydrosphere, and which operates within, and supports, terrestrial ecosystems including biodiversity, plants, animals, and humanity (McBratney 2024).

Soils play a crucial role in various environmental processes, including the hydrological cycle, carbon sequestration, and nutrient cycling, thus sustaining ecosystems and agriculture.

### 2.2 Soil characterization

Soil characterization is a detailed examination of soil properties that provides crucial baseline data for optimal land use planning, agricultural productivity, and sustainable management of soil as a natural resource (Okunsebor *et al .,* 2024). It involves systematic assessment of physical, chemical, biological, and mineralogical attributes that collectively influence soil behavior, fertility, and ecosystem functions under diverse land use and management regimes (Weil and Brady, 2017).

#### Physical Properties

Physical soil properties are fundamental as they regulate water retention, aeration, root penetration, and temperature moderation, thereby directly impacting plant growth and soil ecosystem services. Key physical properties include texture (relative proportions of sand, silt, and clay), structure (arrangement of soil particles into aggregates), bulk density (mass per unit volume, indicating compaction), porosity (void spaces filled by air or water), consistency, color, and temperature. For example, textures ranging from clay loam to clay affects water holding capacity, while bulk density influences root development and soil permeability. Differences in soil structure and porosity moderate infiltration rates and aeration status, critical for biological activity and nutrient cycling.

### Chemical Properties

Chemical characterization assesses soil fertility and reactivity by analyzing pH, electrical conductivity (EC), cation exchange capacity (CEC), organic matter content, base saturation, and essential nutrient availability such as nitrogen, phosphorus, potassium, and micronutrients (Owuamanam and Nwawuike, 2025). Soil pH influences nutrient solubility and microbial activity, typically ranging from neutral to moderately alkaline in fertile soils. High CEC and base saturation indicate high nutrient retention capacity and soil fertility status. For instance, increases in soil pH, organic matter, and available phosphorus following biochar amendments demonstrate dynamic nutrient interactions important for sustaining fertility (Khan *et al*., 2024).

### Biological Properties

Biological soil characterization includes microbial biomass, enzyme activities (dehydrogenase), respiration rates, and organic carbon content as indicators of soil biological fertility and ecosystem functioning. Soil biological activity reflects the capacity for organic matter decomposition, nutrient cycling, and soil structure formation. Variations in microbial biomass C and N and enzyme activities across soil types indicate differences in organic matter turnover and soil fertility status in agro-ecological contexts (Kamali *et al*., 2024).

### Mineralogical Properties

Mineralogical analysis identifies soil mineral composition through techniques such as X-ray diffraction (XRD) and scanning electron microscopy (SEM). The dominant minerals such as quartz, kaolinite, illite, mica, and iron oxides affect soil texture, nutrient availability, and weathering status (Adekiya *et al*., 2024). Mineral assemblages reflect parent material and degree of weathering, influencing soil fertility and suitability for agricultural use. For example, soils on basement complex rocks tend to exhibit higher mineral complexity and native fertility compared to highly weathered coastal plain sands or sedimentary formations.

Comprehensive soil characterization, encompassing physical, chemical, biological, and mineralogical attributes, provides a holistic understanding of soil functionality and its role in land evaluation. By integrating these dimensions, site-specific assessments enable evidence-based decisions on fertilizer application, irrigation scheduling, erosion control, and conservation practices. Such targeted management not only optimizes soil productivity and land use suitability but also safeguards ecosystem services, supports climate resilience, and promotes long-term environmental sustainability.

## 2.3 Soil Classification

Soil classification is a fundamental aspect of soil science, providing a structured framework to identify, categorize, and interpret the vast diversity of soils found across the globe. Two prominent systems have been developed to facilitate this: the World Reference Base for Soil Resources (WRB) and the United States Department of Agriculture's Soil Taxonomy (USDA).

This comprehensive analysis delves into the intricacies of both systems, exploring their methodologies, hierarchical structures, diagnostic criteria, and practical applications. Soil classification serves as a systematic approach to organize soils into categories based on their inherent properties and characteristics. This organization aids in understanding soil behavior, predicting its potential uses, and managing land resources effectively.

The primary objectives of soil classification include:

**Facilitating Communication:** Providing a common language for soil scientists, agronomists, and land managers to discuss soil-related issues (Smith, 2020).

**Guiding Land Use Decisions:** Assisting in determining the suitability of soils for various agricultural, engineering, and conservation purposes (Jones and Lee, 2019).

**Enhancing Soil Management:** Informing best practices for soil conservation, fertility management, and sustainable land use (Brown *et al.,* 2021).

The USDA Soil Taxonomy is a hierarchical system developed by the United States Department of Agriculture and the National Cooperative Soil Survey. It provides an elaborate classification of soil types according to several parameters, most commonly their properties, and in several levels: Order, Suborder, Great Group, Subgroup, Family, and Series.

The USDA Soil Taxonomy system organizes soils into hierarchical levels based on measurable properties. These levels include:

**Order**: There are 12 soil orders in the USDA system. Each is defined by dominant soil forming processes and major diagnostic horizons (U.S. Department of Agriculture, 2021).

**Suborder**: Divides orders based on soil moisture or temperature regimes and other significant properties (Soil Survey Staff, 2022).

**Great Group**: Divides suborders further based on the presence or absence of diagnostic horizons or features (Soil Survey Staff, 2022).

**Subgroup**: Provides subdivisions within Great Groups, representing either the central concept, intergrades to other classes, or extragrades with unique properties such as drainage, lithic contact, particle movement, or clay type (Soil Survey Staff, 2022).

**Family**: Groups soils within subgroups that share similar properties influencing management and behavior, such as texture of the diagnostic surface horizon, mineralogy, soil temperature regime, and depth to restrictive layers (Soil Survey Staff, 2022).

**Series:** The most specific category which is based on precise properties such as horizon arrangement, texture, structure, color, depth, and mineralogy, usually tied to a specific geographic location (Soil Survey Staff, 2022).

The classification system relies on measurable soil properties, including:

**Soil Moisture Regimes**: Categories such as Aquic, Udic, Ustic, Aridic, and Xeric, which describe the soil's moisture status and its implications for plant growth (soil survey staff, 2022).

**Soil Temperature Regimes**: Categories such as Cryic, Frigid, Mesic, Thermic, and Hyperthermic, which describe the mean annual soil temperature and seasonal variations that affect soil processes and crop suitability (Soil Survey Staff, 2022).

**Diagnostic Horizons:** Specific soil layers with distinct characteristics, such as the Mollic, Argillic, and Spodic horizons, which are indicative of particular soil-forming processes (U.S. Department of Agriculture, 2021).

## Soil Orders

The USDA Soil Taxonomy identifies 12 soil orders, each representing a group of soils with similar formation processes and characteristics (Soil Survey Staff, 2020):

(1) **Alfisols**: Soils with aluminum and iron, featuring horizons of clay accumulation, typically found in regions with sufficient moisture and warmth for plant growth (Soil Survey Staff, 2022).

(2) **Andisols**: Volcanic ash soils, characterized by their young age and unique properties derived from volcanic parent material (Soil Survey Staff, 2022).

(3) **Aridisols**: Dry soils forming under desert conditions, with limited leaching and often containing accumulations of salts or carbonates (Soil Survey Staff, 2022).

(4) **Entisols**: Recently formed soils lacking well-developed horizons, commonly found on unconsolidated sediments (Soil Survey Staff, 2022).

(5) **Gelisols**: Soils with permafrost within two meters of the surface, prevalent in polar regions (Soil Survey Staff, 2022).

(6) **Histosols**: Organic-rich soils, often found in wetlands, composed primarily of decomposed plant material (Soil Survey Staff, 2022).

(7) **Inceptisols**: Young soils with minimal horizon development, more developed than Entisols but lacking the features of more mature soils (Soil Survey Staff, 2022).

(8) **Mollisols**: Fertile soils with a thick, dark surface horizon rich in organic matter, commonly found in grassland ecosystems (Soil Survey Staff, 2022).

(9) **Oxisols**: Highly weathered tropical soils with low natural fertility, dominated by iron and aluminum oxides (Soil Survey Staff, 2022).

(10) **Spodosols**: Acidic soils with a subsurface accumulation of organic matter and aluminum, often found under coniferous forests (Soil Survey Staff, 2022).

(11) **Ultisols**: Strongly leached soils with a subsurface clay horizon, typically found in humid temperate and tropical regions (Soil Survey Staff, 2022).

(12) **Vertisols**: Clay-rich soils that expand and contract significantly with moisture changes, leading to deep cracks during dry periods (Soil Survey Staff, 2022)

## 2.4 The World Reference Base for Soil Resources (WRB)

The World Reference Base for Soil Resources (WRB) is an international soil classification system endorsed by the International Union of Soil Sciences (IUSS). It serves as a standardized framework for naming soils and creating legends for soil maps, facilitating global communication and comparison among soil scientists (FAO, 2014). The WRB is designed to accommodate the vast diversity of soils worldwide, providing a common language that transcends regional classifications. The system is structured around Reference Soil Groups (RSGs), each defined by specific diagnostic horizons, properties, and materials. This hierarchical approach allows for detailed characterization and differentiation of soils based on observable and measurable criteria (IUSS Working Group, 2022).

The WRB has evolved through international collaboration, building upon previous soil classification efforts to create a more comprehensive and universally applicable system. Its development involved extensive consultation and consensus building among soil scientists globally, aiming to create a system that is both comprehensive and adaptable to various regional contexts (IUSS Working Group, 2022). The WRB is periodically updated to reflect advancements in soil science and to incorporate new knowledge about soil properties and distribution. The fourth edition, published in 2022, represents the latest refinement of the system, incorporating recent research findings and feedback from the global soil science community. This continuous evolution ensures that the WRB remains relevant and effective in addressing contemporary challenges in soil classification and land use planning (IUSS Working Group, 2022).

### 2.4.1 Local Classification System

**(1) Local Classification System:**

This system, though based on national standards, is restricted to local areas. It is not intended for global use. The local classification system references USDA Soil Taxonomy, a widely used system for classifying soils, but its use in Nigeria is adapted to fit the regional soil characteristics. The classification includes various soil series, which are groups of soils that share similar characteristics (e.g., texture, color, drainage, etc.) and are named after a locality where the soil type is commonly found.

**(2) Moss (1957) Classification:**

Moss work (1957) specifically focused on soils derived from sedimentary rocks in Western Nigeria. He identified a few key soil series in the region:

**(a) Orlu Series:**

- **Texture**: Coarse-textured, meaning it has larger soil particles like sand.
- **Structure**: Deep, well-drained soils with weak to moderate blocky structures.
- **Chemical Properties:** The soil is strongly acidic with low base saturation, meaning it has low levels of bases (calcium, magnesium, potassium, etc.).

- **Appearance**: The color varies from dark reddish-brown at the topsoil to reddish brown and red deeper in the profile.
- **Subsoil**: Sandy loam at the surface, with sandy clay loam or sandy clay deeper down.

**(b) Ahiara Series:**

- **Texture**: Similar to the Orlu Series but sandier.

- **Formation**: The higher sand content is due to colluvial sand (sand that has been washed down from higher elevations).
- **Chemical Properties:** The characteristics are otherwise similar to the Orlu Series.

(c) **Kulfo Series:**

- **Color**: Homogeneous reddish-brown to red.
- **Texture**: The soils range from somewhat excessively drained to well drained, with a texture that varies from sandy loam to sandy clay loam.
- **Depth**: The profile is quite deep (greater than 120 cm).
- **Chemical Properties:** Low in exchangeable bases, meaning the soil tends to be acidic with limited fertility.

(d) **Alagba Series:**

- **Texture**: The upper layer is sandy loam over sandy clay loam, but there is an increase in clay content as you go deeper.

- **Drainage**: Imperfect to poorly drained, meaning water does not move through the soil very efficiently.
- **Redoximorphic Features:** These soils often show signs of waterlogged conditions, like mottling (color changes due to iron).

(e) **Iweke Series:**

- **Origin**: Formed from sedimentary rocks.
- **Fertility**: More fertile and variable in properties compared to soils from the basement complex (e.g., Ondo and Fagbo series).
- **Variability**: The soils have a higher variability in terms of texture and chemical composition.

**(3) Smith and Montgomery (1962) Classification**:

This classification system deals with the soils of Western Nigeria, specifically those formed from basement complex rocks (i.e., ancient crystalline rocks such as granite).

**(a) Iwo Series:**

- **Parent Material**: Derived from coarse granite.
- **Texture**: Coarse textured with a high proportion of sand in the soil, especially in the fine earth fraction (the part of the soil that is not rocks or coarse fragments).
- **Drainage**: Well drained.
- **Location**: Prevalent in the Ibadan area, particularly within the Basement Complex terrain

**(b) Ondo Series:**

- **Parent Material**: Derived from medium-grained granitic rocks.

- **Texture**: Medium textured soils, typically presenting as orange-brown to brownish-red sandy to fairly clayey soils.
- **Drainage**: Well drained.
- **Location**: Commonly found in areas around Akure metropolis.

**(c) Egbeda Series**

- **Parent Material**: Developed from fine grained biotite granite.
- **Texture**: Typically clayey soils.
- **Drainage**: Well drained.
- **Locations**: Found within the central southern part of Nigeria.

### (4) Jungerius (1964) Classification:

Jungerus system is focused on the soils of Eastern Nigeria, and it includes several soil series found along the regions tributaries or in flood prone areas.

**(a) Umulokpa Series:**

- **Texture**: These soils are clayey to sandy, often with a mixture of both.
- **Flooding**: The soils are flooded during part of the wet season.
- **Mottling**: The soils show mottled patterns, indicating that the soils are subjected to alternating wet and dry conditions.

**b) Nsukka Series:**

- **Drainage**: These soils are well drained.
- **Texture**: Red, deep, and clayey, with coarse sands.
- **Upper Layers:** The upper layers are composed of reddish brown sandy or clayey coarse sandy materials.

**c) Nkpologu Series:**

- **Texture**: Reddish brown soils with slightly clayey coarse sands.
- **Formation**: The parent material is a mixture of sand from sandstone and colluvial clay.
- **Structure**: The soils lack gravel or stones and have a somewhat structureless appearance.

**(d) Amagu Series:**

- **Texture**: At least 12 inches of pale, non-mottled fine sand, followed by a layer of mottled fine sandy clay or a pale ironstone gravel layer.
- **Mottling**: These soils are affected by waterlogging, which is evident from the mottled layers.

**General Soil Characteristics and Importance**

- **Texture**: Soil texture (the relative proportion of sand, silt, and clay) influences drainage, fertility, and suitability for different crops. Coarse textured soils (like sandy soils) drain water more quickly, while fine textured soils (like clay) hold water and nutrients better.
- **Color**: Soil color can indicate the presence of certain minerals, organic matter content, or moisture status. Red and reddish-brown colors often indicate well drained soils rich in iron.
- **Drainage**: Well drained soils are ideal for crops that do not tolerate waterlogging, while poorly drained soils may be suitable for rice or other crops that require high moisture levels.
- **Acidity/Alkalinity:** Soil pH affects nutrient availability. Acidic soils (low pH) may require liming to improve fertility, while alkaline soils may need other amendments.

The local classification systems described here provide a detailed understanding of the soil types found in various regions of Nigeria, based on the characteristics of their physical and chemical properties. These classifications help in determining land suitability for agriculture, predicting soil behavior under different environmental conditions, and guiding land management practices. The variations in soil types also reflect the diverse geological history and climate conditions of the regions, influencing the agricultural productivity and land use planning.

## 2.5 Classification of Acid Sands

Soil classification in the South-South region of Nigeria reflects a diverse range of soil types influenced by the regions humid tropical climate, abundant rainfall, and proximity to major river systems like the Niger and Benue Rivers. The region is characterized by hydromorphic soils, especially in lowland floodplains and river basins, where waterlogging is common due to frequent flooding. These soils, often found in mangrove swamps and other wetland areas, exhibit mottling caused by periodic saturation, and they are generally acidic with low base saturation. While these soils tend to be low in natural fertility, they are rich in organic material, which can be beneficial for certain crops if managed properly (Ita *et al*,2025). Additionally, the South-South region has significant areas of lateritic soils, typically found in upland areas with high rainfall and humidity. These soils are often well drained, loamy, and suitable for agriculture, although they may have low levels of certain nutrients, such as phosphorus and potassium, requiring soil amendments for optimal crop production (Weil and Brady, 2017). The combination of these soil types supports diverse agricultural activities, including the cultivation of crops like cassava, yam, and oil palm, though sustainable land management practices are necessary to address the challenges of soil fertility and erosion that often affect these areas (FAO, 2020). Thus, soil classification in the South-South region is essential for informing agricultural planning and resource management, ensuring the long term productivity of the land.

**Table 1: The proposed soil classification of Benin FASC**

| | | Texture-Depths | | | |
|---|---|---|---|---|---|
| | | 30-60 | | 90-120 | |
| Soil series | Sub-series | Western Region of Nigeria | International | Western Region of Nigeria | International |
| Alagba | Normal | vClS | SClL | SCl | SCl or Cl |
| | Sandy | ClS or SIClS | SL or LS | ,, | ,, |
| | Clayey | SCl | SCI or Cl | ,, | ,, |
| Orlu | Normal | ClS | Sl | vClS | SClL |
| | Sandy | sIClS | LS | ,, | ,, |
| | Clayey | vClS | SClL | ,, | ,, |
| Kulfo | Normal | sIClS | LS | ClS | SL |
| | Sandy | S | S | ,, | ,, |
| | Clayey | ClS | SL | ,, | ,, |
| Ahiara | Normal | SlClS | LS | LS | Sl, SLS |
| | Sandy | S | S | ,, | ,, |

Source: Ogunkunle (1983).

The Table above shows that the texture at 90-120 cm is fixed for a particular series while it can vary at 30-60 cm within the specified limits for that series. The texture at 0-30 determines the soil type. Phases of soil series can also be determined including slope, stoniness or any other phase parameter in the definition.

## 2.6 Land Evaluation

The process of assessing a land based on its inherent qualities to support different land uses, with emphasis on climatic and environmental conditions is known as land evaluation. Land evaluation broadly encompasses systematic assessment of land qualities, and it is critical in taking decisions about land potentials for alternative uses (Li *et al*., 2025). Land evaluation collates and interprets essential soil resource inventories, vegetation, climate and other aspects of land to identify and make land use decisions.

Land evaluation does not determine land use but provides data through which land use decisions and options can be made. (Ofem *et al*., 2016) It is a vital link in the chain leading to the sustainable management of land resources; especially at such times when lands that should be used for sustainable crop production are allocated to other uses which tend to reduce agricultural lands and promote degradation.

The evaluation of soils in respect to their supportive crop role is necessary and addresses the peculiarity and variation of soils due to their inherent nutrient status and management (Zuber *et* *al.*, 2020). It involves matching crop requirement and other environmental factors with the land qualities to determine the effects of the land on the crop growth and yield. The main aim is to increase sustainable productivity in traditional land use where a specific area is set aside for a particular crop that thrives well in the specific land (Rathod 2023).

Soil evaluation informs farmers on the suitability of their land for a specific kind of use and its limitations which is done by matching the qualities of the soil and its characteristics with the requirements of the envisaged use (Atijosan *et al.*, 2021). Low crop yield due to a lack of correct matching of crop requirements with soil properties may lead to food losses and poor economic growth. Accurate information about the properties of the soil greatly helps in the management of the soil and its suitability rating for crops.

## 2.7 Land Suitability Assessment

Land suitability assessment is the process of evaluating the suitability of soils for specific kinds of use. It deals with matching crop requirement and other environmental factors with the quality of the land to determine the effects on crops (Sarğın and Karaca 2023). Land suitability assessment provides information on constraints and opportunities for land use and hence serves as a guide for decisions on optimal utilizations of the land resources, whose knowledge is an essential prerequisite for land use planning and development.

This land suitability assessment requires a potential evaluation of environmental characteristics such as climate, soil, relief, water, social and economic factors. Through a detailed land suitability assessment, the most suitable crops or land uses for specific regions can be identified. Land suitability evaluation plays a vital role in fostering sustainable agricultural development. It is a scientific approach that assesses the suitability and compatibility of land for specific purposes (Dadhich *et al.*, 2017). In evaluating the suitability of soil for the production of crops, certain nutrients are required by the plant for maximum yield. There is a need to understand these requirements in the context of limitations imposed by land forms and other features that are not part of the soils but may likely impact significantly on the use of the soil. Hence, for assessing suitability of soils for crop production, the crop requirement must be known.

Land suitability assessment includes two approaches which are qualitative and quantitative evaluation. The qualitative approach is used to assess land at a large scale or as a preliminary strategy for more intensive inquiry (Mugiyo *et al* 2021). It involves expert judgment, field observations, and traditional methods of assessing land suitability including field transects, surveys, geophysical investigations and questionnaires; these methods are often cumbersome and time-consuming. In the qualitative land suitability evaluations, information about climate, hydrology, topography, vegetation, and soil properties is considered. The quantitative approach however, uses numerical models, Geographic Information Systems (GIS), and remote sensing. Getting data using this approach is on the rise due to its cost-effectiveness and fine spatiotemporal coverage. Hence, geoinformatics has given rise to precision agriculture in response to the nuanced geographic factors that influence crop growth conditions (Qu *et al.*, 2013). In quantitative assessment, the results are more detailed and yield is estimated.

This kind of assessment identifies the main limiting factors for the agricultural production and enables decision makers such as land users, land use planners, and agricultural support services to develop crop management strategies that can overcome such constraints, thereby increasing crop yield.

Land suitability assessments also offer the relevant management and improvement options for each land use type in relation to each land mapping unit for which it is suitable. Land suitability assessment aids in the identification of appropriate regions for agricultural purposes through the examination of factors such as lithology, soil composition, topographical features, climatic conditions, and water quality. This process enables the strategic planning necessary for the promotion of sustainable crop cultivation (Adeyolanu and Ogunkunle, 2017).

## 2.8 Land Suitability Assessment Classification

Land suitability classification aims at evaluating and classifying land units on the basis of specific land and soil features and their limitations (AbdelRahman *et al.*, 2022). Land Suitability could be assessed for present condition (actual land suitability) or after improvement (potential land suitability). Agricultural land use has benefited significantly from the use of suitability systems in the recent years and these systems have jointly demonstrated their capabilities in the evaluation and assessment of suitable sites for a variety of crops.

Soil classification and mapping are necessary and very useful for general land use planning, but the ultimate aim and desire of the farmer is to know how profitable it is to grow a particular crop or series of crops on a given landscape. However poor knowledge of soil suitability constitutes a major problem of land use, hence reliable soil data are the most important prerequisite for the land design of appropriate land use systems and soil management practices as well as for a better understanding of the environment and for sustainable crop production.

The FAO procedure of land evaluation is based on a matching exercise between crop growth (or land utilization type) requirements and the conditions, whether solely edaphic or global, that is, including both the physical and socio-economic context. If those conditions fit perfectly with the optimal crop production needs, then the land is considered suitable. The more those conditions deviate from the requirements, the less suitable the land is. To date, the FAO (2020) guideline on the land system is widely accepted for the evaluation of soil suitability for crop production, in combination with the parametric Require index to define the Suitability class (S1, S2, S3, N1 and N2). The system is based primarily on integration of land qualities as related to individual crop requirements. On the basis of soil parameters provided by the Harmonized world soil database (HWSD), seven key soil qualities are important for crop production have been derived, they include: nutrient availability, nutrient retention capacity, rooting conditions, oxygen availability to roots, excess salt, toxicity and workability. These soil qualities are related to the agricultural use of the soil and more specifically to specific crops requirements and tolerance. The following implications indicates the suitability class of a land:

**Suitable**: A land is said to be suitable when crop or crops can be cultivated without difficulty and it requires no additional land improvements techniques. It tells the fulfillment of all characteristic requirements for crop growth and can be classified as "highly suitable (S1)" that is, land with no significant limitations.

**Moderately suitable**: These soils require additional techniques to improve the soil such as drainage and irrigation techniques and this happens when one or more of the required characteristics of a given crop is not met. It is classified as either "moderately suitable (S2)" which are Land with some limitations, but can still be used with proper management

Marginally suitable (S3): Land with significant limitations, requiring intensive management or modifications.

**Not suitable**: A land is considered not suitable when all the characteristics do not meet the requirements of a specific crop or crops. It is a land with severe limitations, making it unsuitable for the intended use. It is classified as "Not suitable (N1 or N2)". N1 is currently not suitable land and N2 is permanently not suitable land.

### 2.9 Description and Distribution of Ginger (Zingiber officinale)

Ginger (*Zingiber officinale*) is a tropical perennial herb of the family Zingiberaceae, cultivated mainly for its underground rhizomes that are used as spice, flavoring agent, and medicinal raw material. The plant is characterized by erect pseudostems, narrow leaves, and aromatic rhizomes containing pungent bioactive compounds with significant nutritional and pharmacological value (Ayustaningwarno, 2024; Oladosu *et al*., 2024). Originating from South and Southeast Asia, particularly India and China, ginger has spread to many parts of the world, including Africa and the Caribbean, due to its wide adaptability and economic importance (Unuofin *et al*., 2021).

In Nigeria, commercial ginger cultivation began in the early 20th century and has expanded steadily across the savannah and derived savannah zones, which provide the warm, humid climate and fertile, well-drained soils needed for optimal growth (Olaniyi, 2023). The crop thrives best at temperatures between 24°C and 29°C with annual rainfall ranging from 1500 to 2500 mm. It is propagated vegetatively using healthy rhizome pieces and requires 8–10 months to reach maturity (Oladosu *et al*., 2024).Ginger production is largely smallholder-based, though it contributes significantly to both domestic consumption and international trade. The harvested rhizomes are consumed fresh or processed into dried ginger, powder, oil, and oleoresin, which are widely used in the food, beverage, pharmaceutical, and cosmetic industries (Unuofin *et al*., 2021; Oshunsanya, 2024). Nigeria is currently one of the leading producers of ginger in Africa and ranks among the top global producers, where it plays a vital role in rural livelihoods, income generation, and export earnings (Olaniyi, 2023).

### 2.9.1 Growth Requirements and Suitability for Ginger (*Zingiber officinale*)

Ginger (*Zingiber officinale*) is a tropical perennial herbaceous plant that grows best under warm and humid conditions with well-distributed moisture. The optimum temperature range for ginger growth is generally 25–30 °C, with suboptimal growth below 20 °C and risk of frost damage at lower temperatures. A relative humidity of 70–90% is ideal for healthy development, and partial shade can help protect plants from leaf scorch during hot periods. Annual rainfall or supplemental irrigation of about 1300–1500 mm is important, especially during critical growth phases like rhizome formation, while avoiding waterlogged conditions that cause rhizome rot (Deme *et al*., 2025).

Ginger thrives in deep, loose, friable soils rich in organic matter such as sandy loam or clay loam that allow good drainage to prevent water stagnation. Slightly acidic soils with a pH of 5.5 to 6.5 promote optimal nutrient availability and rhizome development. Heavy clay or poorly drained soils are unfavorable due to poor aeration and higher disease susceptibility. Organic amendments such as well-rotted manure or mulching with green leaves improve soil structure, microbial activity, and moisture retention. Mulching also helps maintain suitable soil temperatures around 28–32 °C during early growth stages (Aswani *et al*., 2025).

Land suitability for ginger can be categorized by how well conditions match the crop's requirements. Highly suitable (S1) areas have warm temperatures, well-drained fertile sandy or loamy soils, adequate moisture, and slightly acidic pH. Moderately suitable (S2) areas require improvements such as irrigation or soil fertility enhancement. Marginally suitable (S3) or unsuitable (N) lands include poorly drained soils, saline areas, or regions with extreme temperature or humidity conditions that limit sustainable production (Praveen Kumar, 2025).

### 2.9.2 Importance of Ginger production

The rhizome is the most valuable part of the ginger plant, serving as a spice, food additive, and raw material for diverse industries. It contains carbohydrates, proteins, essential oils, and inactive compounds such as gingerols and shogaols that give it distinctive aroma, pungency, and wide pplication in traditional medicine and modern pharmacology (Shaukat *et al*.,2023). Ginger is consumed fresh, dried, powdered, or processed into products like oleoresins, oils, teas, beverages, and confectioneries (Ayustaningwarno *et al*..,2024; Edo *et al*.,2025)

In Nigeria, it is widely used to spice local dishes, soups, and sauces, while also providing a medicinal role in treating ailments such as colds, nausea, inflammation, and digestive disorders (Olajide and Adetuyi, 2023). Industrially, it is in demand for the production of pharmaceuticals, cosmetics, and flavoring agents. Economically, ginger is a major source of cash income for smallholder farmers, contributing to rural livelihoods and Nigeria's non-oil export earnings. Socially, it holds importance in cultural practices and as a livelihood crop in major producing communities. Despite its nutritional and economic value, ginger production in Nigeria still faces challenges of low processing technology and fluctuating market access (Olaniyi, 2023).

## 2.10 Description and distribution of Cucumber (*Cucumis sativus* L.)

Cucumber (*Cucumis sativus L.*) is a vegetable crop belonging to the family Cucurbitaceae, cultivated for its tender fruits that are consumed either fresh or processed into products such as pickles and salads. Though originally domesticated in South Asia, cucumber is now cultivated widely across Africa, Europe, the Americas, and Asia due to its adaptability and economic value (Sharma *et al.*, 2020). The fruit contains high water content, vitamins, minerals, and bioactive compounds that contribute to its dietary and nutritional significance. There are several varieties of cucumber grown globally, with both slicing and pickling types being most common. In Nigeria, cucumber cultivation has expanded considerably in recent years, supported by rising urban demand for fresh vegetables. The major producing areas include northern states and parts of the southeastern states, where it thrives on sandy-loam soils with good drainage and adequate organic matter (Adinde *et al.*, 2021). Cucumber has a relatively short maturity period, with fruits ready for harvest within 40–60 days after planting. Production is carried out under both smallholder and commercial farming systems, using practices such as ridging, mulching, and irrigation to sustain growth under variable climatic conditions. In 2024, studies reported a steady increase in cucumber production across Nigeria, reflecting its growing importance in household consumption and urban markets (Peter *et al*., 2024).

### 2.11 Growth Requirements and Suitability for Cucumber (*Cucumis sativus)*

Cucumber (*Cucumis sativus L.*) is an annual vine crop that grows best under warm and moderately humid conditions. Germination is viable within soil temperatures of 15.6–35 °C, but growth and development are most favorable in more moderate ranges of 18.3–23.9 °C, while extremes outside this range adversely affect germination, flowering, and fruit set (Hamedalla *et al*.,2022). Similarly, relative humidity levels around 60–70% are considered optimal, as excessive humidity encourages fungal diseases, whereas very low humidity reduces flower and fruit development (Valdez-Aguilar *et al*.,2024). Adequate water supply is critical, as cucumber requires 800–1200 mm of well-distributed rainfall annually. In areas with insufficient rainfall, supplemental irrigation is necessary, but waterlogging must be avoided to prevent root rot and reduced nutrient uptake (FAO, 2020; CABI, 2023).

Cucumber performs well in light to medium-textured soils, such as sandy loams and loams, which are friable, fertile, and well-drained. Soils rich in organic matter improve moisture retention and nutrient availability, enhancing vine growth and fruit yield. The optimum soil pH for cucumber is slightly acidic to neutral, ranging from 6.0 to 7.0. Heavy clay soils or poorly drained areas are unsuitable due to poor root aeration and susceptibility to diseases, while very infertile sandy soils may require substantial soil amendments to sustain production. Organic fertilizers like compost or well-rotted manure are recommended to improve soil structure, microbial activity, and nutrient supply (Punetha *et al.*, 2017).

Considering these growth requirements, land suitability for cucumber can be categorized as follows: areas with warm temperatures, well-drained fertile loams, adequate moisture, and slightly acidic to neutral pH are highly suitable (S1). Moderately suitable areas (S2) include soils that require fertility improvement or irrigation to meet crop needs. Marginally suitable (S3) or not suitable (N) areas include poorly drained heavy clays, saline soils, or regions with extreme temperatures or humidity that hinder sustainable cucumber production ( CABI, 2023).

### 2.10.1 Importance of Cucumber Production

The fruit is the most important part of the cucumber plant, composed of over 90% water, making it a refreshing vegetable for human consumption. It is eaten raw in salads, sliced in sandwiches, juiced, or pickled, while its seeds and peel contain fiber, vitamins, and minerals such as potassium, magnesium, and vitamin C, which support hydration and digestion. Cucumber also contains bioactive compounds such as cucurbitacins and flavonoids, which have antioxidant and anti-inflammatory effects (Mukherjee, 2013). In Nigeria, cucumber has become increasingly popular in urban diets as an affordable vegetable that fits into weight management and healthy living trends. Economically, it provides fast turnover for farmers due to its short maturity cycle, ensuring steady household income and high market demand. Processed forms such as pickles and juices also contribute to small scale agroindustries. Socially, cucumber contributes to food security and dietary diversification, while also supporting employment along its production and marketing chain. However, despite its growing importance, cucumber farming in Nigeria is still limited by inadequate storage, poor post harvest handling, and seasonal price fluctuations (Okonkwo-Emegha, 2025).

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 The Study Area

The study was carried out at the SLM Research Hub, University of Benin, located in Ovia North East Local Government Area, Edo State, Nigeria. The site lies within Latitude 6°24’0”N and 6°24’0”N and Longitude 5°37’26”E and 5°37’28”E (fig. 1). The climate of the area is tropical, with a mean annual rainfall of about 1900 mm and a mean annual temperature of approximately 23-37°C.

The area is characterized by dense green vegetation with several roofed structures situated within and around  (fig 2). The topography is relatively flat. The soils are developed from coastal plain sands of sedimentary origin, which have undergone intense weathering under the influence of high rainfall and temperature typical of the region (Andre-Obayanju *et al*., 2023).

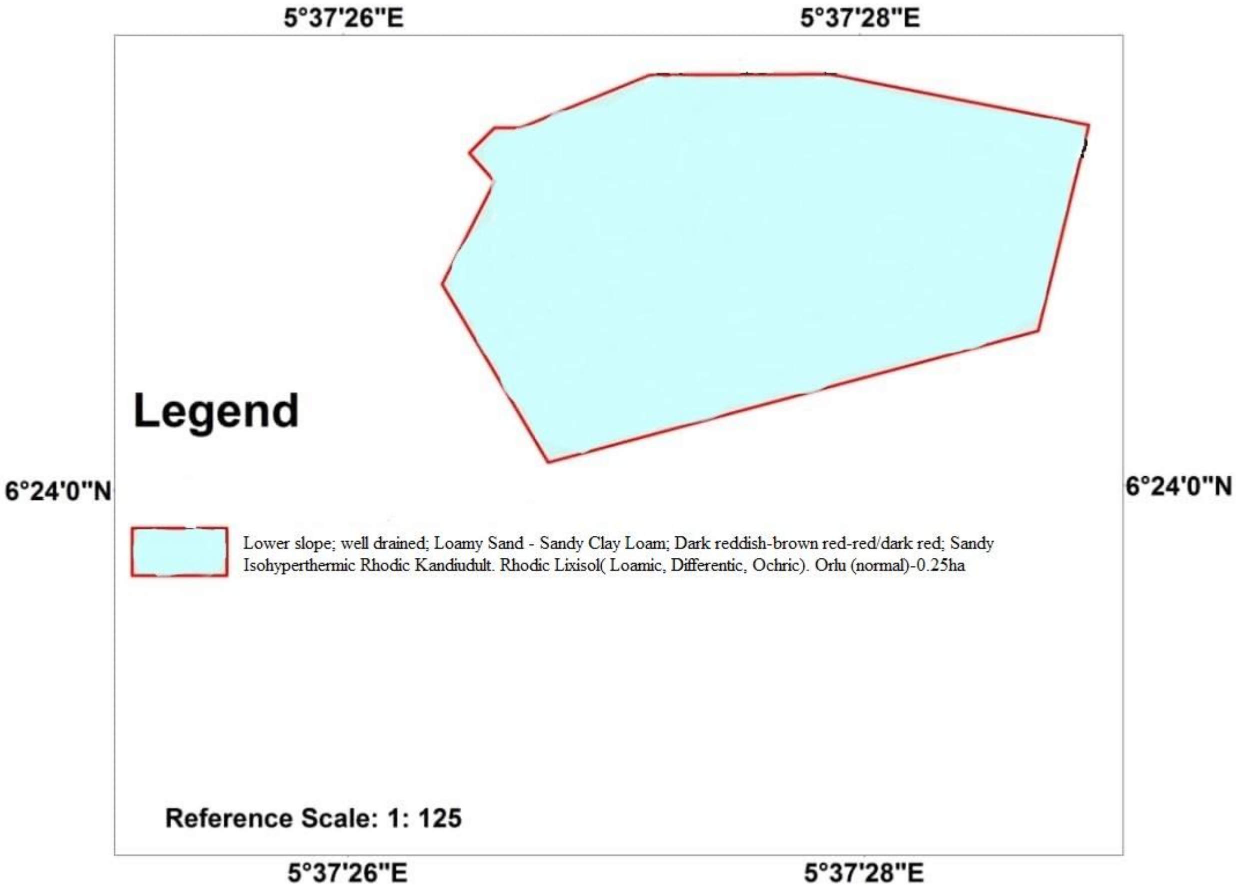

Fig 1: Location map of the site

Fig 2: Google imagery of study area

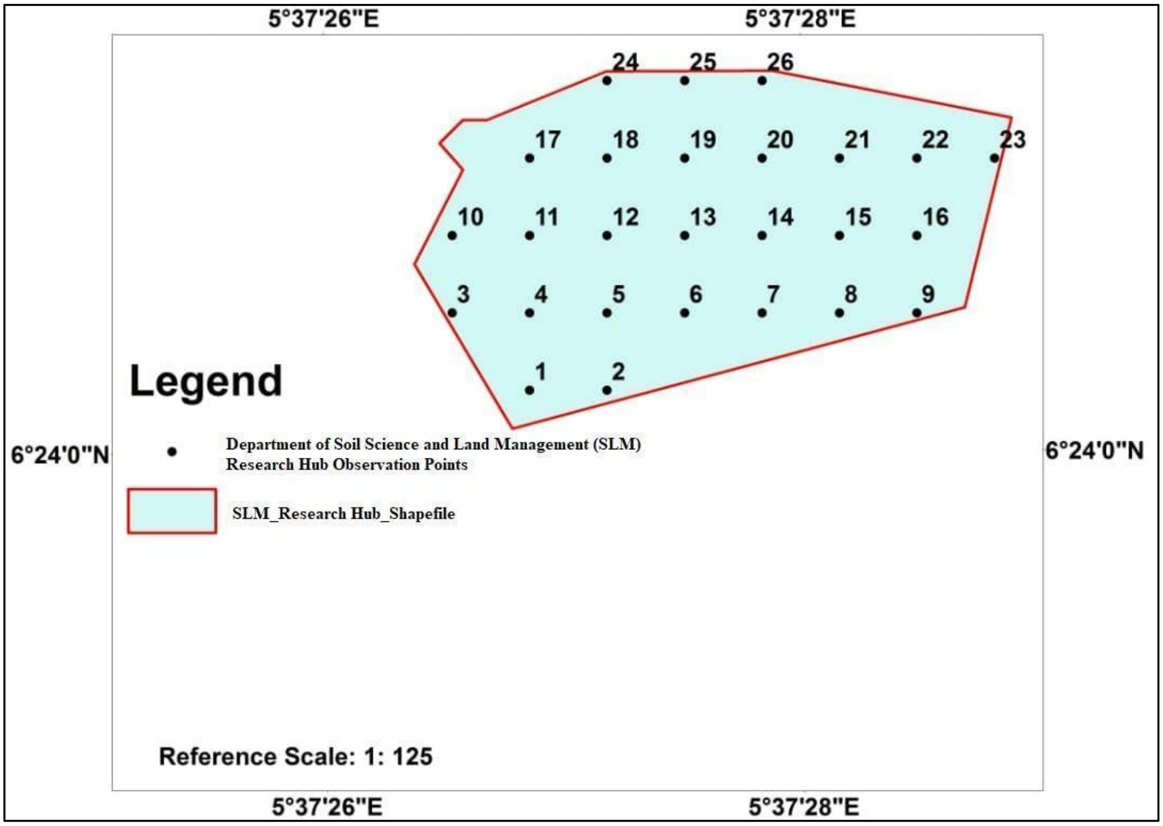

Fig 3: Observation points of study area

## 3.2 Field work

Soil survey on the field was carried out using the rigid grid method at an intensive scale. Observation points were geo-referenced with a Global Positioning System (GPS) to ensure systematic coverage of the area. At each observation point (fig. 3) was examined using an auger at standard depths of 30 cm, 60 cm, 90 cm, and 120 cm. The morphological properties of the soils, such as color, texture, structure, and consistency, were carefully examined and recorded on a standardized soil proforma sheet. The pedon was described following the guidelines of FAO (2006), and soil samples were taken from the bottom upwards. Each sample was placed in a labeled polythene bag, air dried, and stored in preparation for subsequent laboratory analysis.

## 3.3 Laboratory Analysis

The soil samples from each horizon were air dried and passed through a 2mm sieve. The sieved samples were analysed for some physical and chemical properties. Particle size distribution was determined by the hydrometer method (Gee and Or, 2002) after the removal of organic matter content with hydrogen peroxide and dispersion with sodium hexametaphosphate (International Institute for Tropical Agriculture - IITA, 1979). Available P was determined by Bray-1 method (Olsen and Sommers, 1982). The pH was determined with glass electrode pH meter in soil: soil and water at ratio 1:1 (Maclean, 1982). Exchangeable Bases (Na, K, Ca and Mg) were extracted with neutral normal ammonium acetate (NH4OAC at pH 7.0); Na and K were determined by flame photometer while Ca and Mg were determined by atomic absorption spectro photometer (Thomas, 1982). Total N was determined by Macro Kjedhal method (Bremner, 1996). Exchangeable Acidity was determined by titration method (Anderson and Ingram, 1993). Organic Carbon was determined by Walkley Black method (Page, 1982). Effective Cation Exchange Capacity (ECEC) was obtained by the summation of Exchangeable Bases and

Exchangeable Acidity (Tan, 1996). Base Saturation was calculated by dividing the sum of Exchangeable Bases (Na, K, Ca and Mg) by the ECEC and multiplying the quotient by 100.

### 3.4 Statistical Analysis

The data collected were statistically analyzed using Genstat (version 8.1). The variability of soil properties across different horizons within the pedons was assessed using the coefficient of variation (CV). The coefficient of variation was categorized following the method outlined by Wilding *et al*. (1994), where a CV of less than 15% indicates low variation (LV), a CV between 15% and 35% indicates moderate variation (MV), and a CV greater than 35% indicates high variation (HV).

### 3.5 Soil Map

Based on the field and laboratory results, a soil map was produced at a scale of 1:125

### 3.6 Soil Classification

Data obtained from the field and laboratory analyses were used to classify the soils in the appropriate local series using Moss (1957) as updated by Ogunkunle (1983). The local classification was correlated with the USDA Soil Taxonomy (Soil Survey Staff, 2014) and World Reference Base for soil hmmm Resources (IUSS, 2015).

### 3.7 Land Suitability Evaluation

This was done using the both limitation and parametric (index of productivity) (storie, 1976; Ogunkunle, 1993) of the FAO (1979) framework. The pedon was placed in suitability class by matching its characteristics and qualities with the established requirements for ginger (USDA 2003 and Annal of Botany 2001) , as modified by Abagyeh *et al*. (2022) and cucumber production (NBSS and LUP 1994) , as modified by Alabi *et al.* (2024). In accordance with the principle of the law of minimum which states that performance is always determined by the least favourable factor or plant nutrient in the lowest supply, the aggregate suitability class of the pedon was obtained. The land qualities considered for evaluation of ginger and cucumber was climate (c), soil physical properties (s), wetness (w), topography (t) and soil fertility (f).

Parametric method was done by calculating the index of productivity using the square root model. Scores were given to land qualities of each pedon and index of productivity was calculated using formula:

$$IPC = A\sqrt{(B/100 * C/100 * D/100 * E/100)} \text{——Eq. 2 (Sys, 1985)}$$

Where IPC = index of productivity,

$\sqrt{}$ = Square root,

A= overall least rating characteristics rating, B, C ---E is the least rating characteristics for each land group quality;

c= climate, s= slope, t = topography, w= wetness and f= fertility.

Each characteristic was first rated as follows: No limitation: 100-85 (S1); Moderate limitation: 84-60 (S2); Severe limitation: 59-40 (S3); Very Severe limitation: 39-0 (N).

The index of productivity for each pedon was expressed from the rating of each characteristic of land qualities of each group, using the lowest rating. Index of productivity classes were rated as follows: Highly Suitable (S1) 100-75, Moderately suitable (S2) 74-50, Marginally suitable (S3) 49-25 and Non suitable (N) 24-0 (Ogunkunle 1993).

# CHAPTER FOUR

## 4.0 RESULTS AND DISCUSSION

The pedon results integrate soil characterization data with both land suitability evaluation and soil classification. Suitability was assessed for Ginger (Zingiber officinale) using the USDA (2003) and Annal of Botany (2001) guidelines, as modified by Abagyeh *et al*. (2022), and for Cucumber (Cucumis sativus L.) based on the NBSS and LUP (1994) framework, as modified by Alabi *et al.* (2024). Furthermore, pedon classification was conducted using three distinct taxonomic systems: a local classification (Ogunkunle, 1983), the USDA Soil Taxonomy (Soil Survey Staff, 2014), and the World Reference Base for Soil Resources (IUSS Working Group WRB, 2022).

### 4.1 Morphological properties of Pedon

The pedon was characterized to a depth of 170 cm, showing five distinct horizons with notable morphological variation. The upper profile, encompassing the 0-19 cm and 19-40 cm depths, is texturally classified as Loamy Sand. These surface horizons both exhibit fine, many roots and a fine sub-angular blocky structure, delineated by smooth, clear boundaries. They are differentiated primarily by their moist Munsell colours, recorded as 5YR3/3 and 2.5YR3/4, respectively. A significant morphological transition is observed at 40 cm. The texture transitioned to Sandy Clay Loam and remained consistent down the profile. They are differentiated primarily by their moist Munsell colours, recorded as 2.5YR4/6 at 40-87cm, 2.5YR3/6 at 87-129cm and 129-170cm. The soil structure changed to medium sub-angular blocky, while root abundance decreased to medium very few in the 40-87 cm horizon. Below 87 cm, roots were not observed. The horizon boundary form also transitioned, from smooth-clear at 0-19cm and 19-40cm to diffused at 40-87 cm and then to smooth-diffused in the two lowest horizons (87-129 cm and 129-170 cm).

**Table 4.1: Morphological properties of pedon**

| Pedon | Horizon design | Depth(cm) | Colour(moist) | Texture | Roots Abundance | Structure | Boundary form |
|---|---|---|---|---|---|---|---|
| 1 | Ap | 0-19 | 5YR3/3 | Loamy Sand | Fine many | Fine Sub-Angular blocky | Smooth-Clear |
| | BA | 19-40 | 2.5YR3/4 | Loamy Sand | Fine many | Fine Sub-Angular blocky | Smooth-Clear |
| | Bt | 40-87 | 2.5YR4/6 | Sandy Clay Loam | Medium very few | Medium Sub-Angular blocky | Diffused |
| | Bt2h | 87-129 | 2.5YR3/6 | Sandy Clay Loam | - | Medium Sub-Angular blocky | Smooth-Diffused |
| | Bt3h | 129-170 | 2.5YR3/6 | Sandy Clay | - | Medium Sub-Angular blocky | Smooth-Diffused |

## 4.2 Characteristics of the Pedon

The pedon represents a mapping unit covering approximately 0.25 hectares of the total landscape. The results of the laboratory analysis for this soil, as presented in Table 4.2, show the physical and chemical properties of the pedon to a depth of 170cm. The soil pH values ranged from 4.3 in the surface horizon to 5.2 in the subsoil, indicating that the soil is strongly to moderately acidic throughout the profile. The increase in pH with depth suggests a gradual decrease in acidity downward, which may be attributed to the leaching of basic cations from the surface horizons by percolating water and the accumulation of these bases in lower horizons. The electrical conductivity values ranged from 148 to 186 µScm, suggesting that the soil is non-saline, and therefore, salt accumulation does not pose a problem in the pedon. The organic carbon content ranged from 0.11 to 3.4g/kg decreasing sharply below the surface and then increasing irregularly with depth, while the organic matter ranged from 0.19  to 5.8g/kg showing a similar trend. Total nitrogen ranged from 0.010 to 0.31g/kg, decreasing sharply below the surface and increasing slightly with depth, reflecting surface accumulation and partial translocation downward. This low nitrogen status is a common feature of soils in Southern Nigeria and may be due to high losses through leaching of nitrates and rapid mineralization of organic matter in the humid tropics.

The exchangeable acidity ranged from 0.9 to 1.3cmol/kg, with aluminum values (0.6–1.0cmol/kg) generally higher than hydrogen (0.3–0.4cmol/kg), indicating that aluminum dominates the exchange complex, consistent with the acidic nature of the soil. The exchangeable bases (Na, K, Ca, and Mg) were generally low and decreased irregularly down the profile. Sodium ranged from 0.01 to 0.05cmol/kg, potassium from 0.10 to 0.27 cmol/kg, calcium from 0.07 to 0.17cmol/kg, and magnesium from 0.03 to 0.11cmol/kg. These low values indicate low base saturation and poor fertility status, typical of strongly weathered tropical soils. The available phosphorus values ranged from 0.017  to 0.041mg/kg, which are very low, suggesting that phosphorus fixation by iron and aluminum oxides could be limiting its availability to plants. The effective cation exchange capacity (ECEC) of the pedon ranged from 1.33 to 1.51cmol/kg, with higher values recorded at the surface horizon and base saturation of 13.91% to 40%. This trend corresponds with the distribution of organic matter and clay content, which contribute to cation exchange capacity. For particle size distribution, the clay fraction ranged from 114 to 256 g/kg, the silt fraction from 15 to 24g/kg, and the sand fraction from 72.9 to 86.2g/kg with the deepest horizon (129-170cm) having the highest sand fraction. The textural class ranged from Loamy Sand (LS) to Sandy Clay Loam (SCL).

The variation in organic carbon, organic matter , total nitrogen, available phosphorus, Na, K, Mg, BSCEC, ECEC-Clay and base saturation was high, with coefficient of variation (CV) ranging from ≥35.1% to ≤171.8%. While for Ca, Al3+, H+, CEC, Silt and Clay was medium, ranging from ≥16.18% to ≤30.57%. Also, the variation in pH, EC, ECEC and sand was low, with CV values ranging from ≥5.66% to ≤9.78%.

## Table 4.2 Physical and Chemical properties of the Pedon

| CODE | Horizon design | Horizon depth | pH | EC | Org.C | Org.M | T.N | Av.P | Na | K | Ca | Mg | $Al^{3+}$ | $H^+$ | ECEC | CEC | BSCEC | ECEC Clay | BS | Silt | Sand | Clay | Textural Class |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | cm | | µS/cm | | g/kg | | mg/kg | | | Cmol/kg | | | | Cmol/kg | | | % | | | g/kg | | |
| **1** | Ap | 0-19 | 4.3 | 186 | 3.4 | 5.8 | 0.31 | 0.041 | 0.05 | 0.27 | 0.17 | 0.11 | 0.6 | 0.3 | 1.5 | 6.86 | 8.75 | 13.16 | 40 | 24 | 862 | 114 | LS |
| **2** | BA | 19-40 | 4.8 | 148 | 0.11 | 0.19 | 0.010 | 0.017 | 0.01 | 0.1 | 0.07 | 0.03 | 1.0 | 0.3 | 1.51 | 7.54 | 2.79 | 10.07 | 13.91 | 20 | 830 | 150 | LS |
| **3** | Bt | 40-87 | 5 | 150 | 1.8 | 3.1 | 0.016 | 0.02 | 0.01 | 0.11 | 0.09 | 0.05 | 0.7 | 0.4 | 1.36 | 13.42 | 1.94 | 5.31 | 19.12 | 15 | 729 | 256 | SCL |
| **4** | Bt2h | 87-129 | 5 | 154 | 2.2 | 3.8 | 0.02 | 0.024 | 0.02 | 0.14 | 0.1 | 0.07 | 0.7 | 0.3 | 1.33 | 11.91 | 2.77 | 5.96 | 24.81 | 16 | 761 | 223 | SCL |
| **5** | Bt3h | 129-170 | 5.2 | 166 | 2.8 | 2 | 0.025 | 0.033 | 0.03 | 0.18 | 0.14 | 0.09 | 0.6 | 0.4 | 1.44 | 9.45 | 4.66 | 7.95 | 30.56 | 20 | 791 | 181 | SCL |
| | Mean | | 4.86 | 160.8 | 2.06 | 2.98 | 0.076 | 0.027 | 0.024 | 0.16 | 0.114 | 0.07 | 0.72 | 0.34 | 1.43 | 9.84 | 4.18 | 8.49 | 25.68 | 19 | 794.6 | 184.8 | |
| | SD | | 0.34 | 15.73 | 1.25 | 2.09 | 0.131 | 0.01 | 0.017 | 0.069 | 0.04 | 0.032 | 0.164 | 0.055 | 0.081 | 2.80 | 2.74 | 3.21 | 10.14 | 3.61 | 53.01 | 56.5 | |
| | CV | | 7.06 | 9.78 | 60.54 | 70 | 171.8 | 37.03 | 69.6 | 43.1 | 35.1 | 45.1 | 22.8 | 16.18 | 5.66 | 28.5 | 65.55 | 37.81 | 39.5 | 19 | 6.67 | 30.57 | |
| | Ranking | | LV | LV | HV | HV | HV | HV | HV | HV | HV | HV | MV | MV | LV | MV | HV | HV | HV | MV | LV | MV | |

### 4.3 Soil Classification

The soil was classified locally using the Moss (1957) classification system as updated by Ogunkunle (1983), and internationally following the United States Department of Agriculture (USDA, Soil Survey Staff, 2022) and the World Reference Base for Soil Resources (WRB, IUSS Working Group, 2022) systems.

The pedon was classified in the USDA Soil Taxonomy as a Sandy Isohyperthermic Rhodic Kandiudult, which placed it within the Ultisol Order, indicating a highly weathered and acidic soil with a subsurface horizon of clay accumulation,these are soils with argillic B horizons but with base saturation by sum of cation less than 35%. It is an Udult because this soil falls under an udic moisture regime, meaning its moisture control section is not dry in any part for as long as 90 cumulative days during a typical year. At the Great Group level, it is a Kandiudult because it has a kandic horizon at the required depth, which is an illuvial horizon with low-activity clays (low ECEC and CEC) and a significant increase in clay content, evidenced by the textural shift from Loamy Sand in the upper profile to Sandy Clay Loam in the subsoil. The Subgroup Rhodic Kandiudult classification is based on the diagnostic horizon's strong red color, specifically meeting the criteria of a hue of 2.5YR. The Family classification of Sandy Isohyperthermic Rhodic Kandiudult is based on the sandy surface texture (Loamy Sand), The isohyperthermic soil temperature regime has mean annual soil temperatures of 22 °C or more and a difference between mean summer and mean winter soil temperatures of less than 6°C.

The WRB (World Reference Base for Soil Resources) system is a Rhodic Lixisol (Loamic, Differentic, Ochric). The Rhodic Principal Qualifier is assigned due to the soil's reddish color (2.5YR hue). It is a Lixisol because lixisols are characterized by a higher clay content in the subsoil than in the topsoil resulting in pedogenic processes that lead to the development of an argic subsoil horizon. The supplementary qualifiers are: Ochric, because it is light in color and low in organic matter. Loamic, relating to the Sandy Clay Loam subsoil texture; and Differentic because the clay content increased in depth with no lithic contact.

Locally, the pedon was classified as Orlu series (Normal phase). The designation as the Normal phase of the Orlu series was based on the texture of the horizon that contains the reference depth of 30-60cm according to the updated guideline classification of Benin FASC (Ogunkule 1983). Since the 30-60 cm depth falls within 19-40 cm and 40-87 cm(BA and Bt horizon), and this horizon has a Sandy Clay Loam (SCL) texture, this SCL texture at 30-60cm and 90-120 cm confirms the Normal phase designation.

The pedon was classified in the USDA Soil Taxonomy as a Sandy Isohyperthermic Rhodic Kandiudult, which placed it within the Ultisol Order, indicating a highly weathered and acidic soil with a subsurface horizon of clay accumulation,these are soils with argillic B horizons but with base saturation by sum of cation less than 35%. It is an Udult because this soil falls under an udic moisture regime, meaning its moisture control section is not dry in any part for as long as 90 cumulative days during a typical year. At the Great Group level, it is a Kandiudult because it has a kandic horizon at the required depth, which is an illuvial horizon with low-activity clays (low ECEC and CEC) and a significant increase in clay content, evidenced by the textural shift from Loamy Sand in the upper profile to Sandy Clay Loam in the subsoil. The Subgroup Rhodic Kandiudult classification is based on the diagnostic horizon's strong red color, specifically meeting the criteria of a hue of 2.5YR. The Family classification of Sandy Isohyperthermic Rhodic Kandiudult is based on the sandy surface texture (Loamy Sand), The isohyperthermic soil temperature regime has mean annual soil temperatures of 22 °C or more and a difference between mean summer and mean winter soil temperatures of less than 6°C.

USDA soil Taxonomy and WRB, gave different nomenclature for the study area; these differences are traceable to the categories and hierarchical nature of both taxonomic systems. The USDA consists of 6 categories and soil order, in which the highest category is based on the presence of diagnostic horizons including consequences of variation in climatic conditions (Soil Survey Staff,2022); while the WRB system of soil taxonomy has two categories; the higher category (Reference Soil Group) roughly correlates with USDA at the Great group level because classification is mainly based on the presence of diagnostic horizons (IUSS, 2022). Moreover, the USDA soil taxonomy has 12 soil orders, while WRB has 52 Soil Reference Groups (Soil Survey Staff, 2022; IUSS, 2022); thus, both systems are intrinsically different.

### 4.4 Suitability Classification of Pedon for Ginger

#### Climate

The assessment of key climatic parameters for the study site revealed high suitability for most factors. The mean annual rainfall was measured at 1900mm which is categorized as S1 (very highly suitable). Similarly, the maximum temperature which ranged from 23°C-37°C was also placed within the S1 (very highly suitable) class. The relative humidity for the study area was found to be S1(very highly suitable).

#### Soil Physical Characteristics

The pedon depth was 170 cm, qualifying it as S1 (very highly suitable) with respect to depth. The texture was sandy clay loam and this placed the pedon in the suitability class N1 (currently not suitable). The structure of the pedon was Sub-angular blocky (SBK) which is S2 (marginally suitable).

#### Topography

The topography of this pedon ranged from 1-2% which placed the soil into the S1 (very highly suitable) class for Ginger production.

#### Drainage

The area had no flooding problem making it S1, (Very Highly suitable), it is also well drained which means the Drainage characteristic is also S1, (Very Highly suitable)

#### Fertility Characteristics

This section discusses the chemical properties of the pedon (pH, CEC, available phosphorus, organic carbon, and base saturation) as they affect ginger production. The effective cation exchange capacity (CEC) of the pedon was 15.20 cmol/kg, which falls within the S1 (very highly suitable) class, indicating good nutrient holding capacity for ginger growth. The base saturation was 2.57%, rated N2 (permanently not suitable), suggesting a strong deficiency in basic cations essential for nutrient balance. The soil pH was 4.86, which is within the S12 (highly suitable) range, indicating a slightly acidic condition favorable for ginger cultivation. The available phosphorus content was 0.03 mg/kg, classified as N2 (permanently not suitable), indicating severe phosphorus deficiency that could limit rhizome development. The organic carbon content was 2.06g/kg, which falls under the S1 (Very highly suitable).

### Aggregate Suitability for Ginger Production

The ratings of the land characteristics and aggregate rating of the pedon is for both limitation and parametric methods by considering all characteristics using the law of minimum by which states that performance is always determined by the least favoured factor or plant nutrient in the lowest supply.

Under the limitation method, the pedon was classified as non-suitable (N2) for ginger cultivation due to limitation in soil physical characteristics (texture ) and soil fertility (Base saturation and available phosphorus).

Similarly, the parametric method also revealed that the pedon was non-suitable (N1), with an Index of Productivity (IPC) value of 0, obtained using the square root method. The low IPC value resulted from the poor soil physical and fertility conditions, which substantially limited the land's productive potential for ginger cultivation.

On actual suitability rating, the pedon was currently not suitable (N1 (s)) for ginger because of limitation in soil physical characteristics (texture ) and permanently not suitable [N2 (f)] due to limitation in soil fertility (base saturation and available phosphorus).

However, on potential suitability rating, the aggregate suitability class changed to marginally suitable (S2) due to soil fertility limitations (base saturation and available phosphorus) which can be altered through management.

**Table 4.3 Ginger suitability classification of Pedon**

| Land characteristics | Limitation Pedon | Parametric Pedon |
|---|---|---|
| **Climate (c )** | | |
| Annual rainfall (mm) | S1 (1900) | S1 (100) |
| Max temperature (•c) | S1 (23-37) | S1(100) |
| Relative Humidity (%) | S1 (75-89) | S1 (100) |
| **Topography (t)** | | |
| Slope (%) | S1 (1-2) | S1 (100) |
| **Wetness (w)** | | |
| Flooding | F0 (no flooding) | S1 (100) |
| Drainage | WD (well drained) | S1 (100) |
| **Soil physical properties (s)** | | |
| Soil texture | N1 (SCL) | N1 (0) |
| Soil Structure | S2 (SBK) | S2 (40) |
| Fragment | —- | —— |
| Soil depth | S1 (170) | S1 (100) |
| **Soil fertility (f)** | | |
| CEC (cmolkg^-1) | S1 (15.20) | S1 (100) |
| Base saturation (%) | N1 (25.68) | N1(0) |
| Soil PH | S12 (4.86) | S12(60) |
| Organic carbon (%) | S1 (2.06) | S1 (100) |
| Available P | N2 (0.03) | N2 |
| **Aggregate Class** | | |
| Current suitability | N2 (f) | N (0) |
| Potential Suitability | S2 (s) | S2 (40) |
| Size (hectares) | 0.25 | 0.25 |

**Table 4.4 :Land suitability guideline for Ginger Cultivation**

| Ratings | Unit | S1 (Highly Suitable) | S1$_2$ (Moderately Suitable) | S2 (Marginally Suitable) | S3 (Currently Not Suitable) | N1 (Not Suitable) | N2 (Permanently Not Suitable) |
|---|---|---|---|---|---|---|---|
| Soil characteristics | % | 100-85 | 60-85 | 40-60 | 25-40 | 0-25 | ———- |
| **Climate (c):** | | | | | | | |
| Mean Annual Rainfall | mm | >1500 | 1400–1300 | 1300–1100 | 1100–900 | 900–700 | <700 |
| Max Temperature | °C | 28–35 | | 20–27 | 18–19 | <18 | - |
| Mean annual Temperature | °C | >21 | 19–21 | 17–19 | 15–17 | 12–15 | <12 |
| Relative Humidity | % | <4 | 3–4 | 2–3 | 1–2 | <1 | - |
| **Topography (t):** | | | | | | | |
| Slope | % | 0–6 | 6–9 | 9–11 | 11–14 | 14–16 | 16–19 |
| **Wetness (w):** | | | | | | | |
| Drainage | class | WD | WD | WD | IWD | PD | VPD |
| **Soil Physical Properties (s):** | | | | | | | |
| Texture | class | L | SL | SL | CL | SCL | Any |
| Structure | class | Crumb | Crumb | SBK | SBK | Columnar | Columnar |
| Coarse Fragments (0–30 cm) | % | 3–10 | 10–15 | 15–35 | 35–55 | 55–65 | >65 |
| Effective Soil Depth (0–50 cm) | cm | >70 | 60–70 | 45–60 | 30-45 | 20-30 | <20 |
| **Soil Fertility (f):** | | | | | | | |
| CEC | cmol/kg | >10 | 8–10 | 6–8 | 4–6 | 2–4 | <2 |
| Base Saturation | % | >80 | 70–80 | 60–70 | 30–60 | | <10 |
| Soil pH ($H_2O$) | | >5.5–6.5 | 4.5–5.5 | 4.5–3.5 | 3.5–2.5 | 2.5–2.0 | <2 |
| Organic Carbon (OC) | % | >1.5-2.0 | 1.5–2.0 | 1.25–1.5 | 1.0–1.25 | <1.0 | <1.0 |
| Available Phosphorus (P) | mg/kg | >20 | 16–20 | 12–16 | 8–12 | 4–8 | <4 |

## Legends (Ginger)

FO = No Flooding, $F_1$ = Seasonal Flooding, MR = Flooding Rare, WD = Well Drained, IWD = Imperfectly Drained, F1=Rarely Drained, F0=Poorly Drained, VPD = Very Poorly Drained
C= Clay, CL = Clay Loam, SCL = Sandy Clay Loam, SC = Sandy Clay
-SBK = Sub Angular Blocky, S1= Very Highly Suitable, S12 = Highly Suitable, S2 = Moderately Suitable, S3 = Marginally Suitable
N1 = Currently Not Suitable, N2 = Permanently Not Suitable
Soil phy props =Soil physical Properties, d/m = days/months
**Sources**: USDA, 2003 and Annal of Botany (2001), modified by Abagyeh *et al* (2022).

### 4.5 Suitability Classification of Pedon for Cucumber

Based on the guideline in (NBSS and LUP, 1994 modified by Alabi *et al* (2024), the following parameters were used in evaluation of the pedon for cucumber production.

#### Climate

The climatic suitability assessment considered rainfall, temperature, rainfall in growing season and length of growing period. The total annual rainfall recorded for the study site was 1900mm, which is categorized as Non-Suitable (N) for cucumber cultivation according to the NBSS and LUP (1994) guidelines., The mean annual temperature, which ranged between 23°C and 37°C was placed in the Moderately Suitable (S2) class. Both the rainfall duration and the Length of Growing Period were estimated at 152 days (approximately five months), indicating a favorable cropping season which rated  them as Highly Suitable (S1).

#### Soil Physical Characteristics

The pedon depth was 170 cm, qualifying it as S1 (highly suitable) with respect to depth. The texture was sandy clay loam and this placed the pedon in the suitability class S1 (highly suitable).

#### Topography

The topography of this pedon raged from 1-2%. This according to the NBSS and LUP (1994) guideline as modified by Alabi *et al* (2024) placed the soil into the S1 ( highly suitable) class for cucumber production.

### Drainage

The drainage condition of the study site is well drained (WD), indicating that water moves freely through the soil profile and does not accumulate on the surface after rainfall. This places the drainage in the S1 (highly suitable) class.

### Fertility Characteristics

The soil CEC was 15.20 cmol(+)/kg, rated as moderately suitable (S2), indicating moderate nutrient retention capacity. The soil pH was 4.86, placing it in the marginally suitable (S3) class due to strong acidity, which may limit nutrient availability

### Toxicity Characteristics

For salinity, the soil was non-saline, which placed it under S1 (highly suitable), while for sodicity, it was non-sodic also rated S1 (highly suitable).

### Aggregate Suitability for Cucumber Production

The ratings of the land characteristics and aggregate rating of the pedon is for both limitation and parametric methods by considering all characteristics using the law of minimum by which states that performance is always determined by the least favoured factor or plant nutrient in the lowest supply.

Under the limitation method, the pedon was classified as non-suitable (N1) for cucumber cultivation due to severe limitation in climate (rainfall) and marginal limitation soil fertility (pH).

Similarly, the parametric method also revealed that the Pedon was non-suitable (N1), with an Index of Productivity (IPC) value of 8.23, obtained using the square root method. The low IPC value resulted from the limitation in climate ( rainfall ) and marginal fertility.

On actual suitability rating, the pedon was not suitable (N) because of limitation in climate (rainfall).

However, on potential suitability rating, aggregate suitability classes did not change because the major limitation was climate (rainfall) which cannot be altered.

**Table 4.5 Cucumber suitability classification of Pedon**

| Land characteristics | Limitation Pedon | Parametric Pedon |
|---|---|---|
| **Climate ( c )** | | |
| Mean temperature (•c) | S2 (30) | S2 (74) |
| Total rainfall (mm) | N (1900) | N(24) |
| Rainfall in growing season | S1 (>150) | S1 (100) |
| Length of growing season | S1(>150) | S1(100) |
| **Topography (t)** | | |
| Slope (%) | S1 (1-2) | S1 (100) |
| **Wetness (w)** | | |
| Drainage | S1 (Well drained ) | S1 (100) |
| **Soil physical properties (s)** | | |
| Texture | S1 (SCL) | S1(100) |
| Soil depth | S1 ( 170) | S1 (100) |
| **Fertility (f)** | | |
| pH | S3 (4.86) | S3(49) |
| CEC (cmolkg ) | S2 (15.20) | S2(74) |
| **Soil toxicity (n)** | | |
| Salinity | S1 (non saline) | S1 (100) |
| Sodicity | S1 (non sodic) | S1(100) |
| **Aggregate Class** | | |
| Current Suitability | N (c ) | N(8.23) |
| Potential Suitability | N (c ) | N (24) |
| Size (hectare) | 0.25 | 0.25 |

**Table 4.6 Land suitability guideline for Cucumber Cultivation**

| Land Quality | Unit | S1 (Highly Suitable) | S2 (Moderately Suitable) | S3 (Marginally Suitable) | N (Not Suitable) |
|---|---|---|---|---|---|
| **Climate (c):** | | | | | |
| Mean Temperature | °C | 25–28 | 29–32 | 33–36 | >16 |
| Total Rainfall | mm | 600–750 | 500–600 | 450–500 | |
| Rainfall in Growing Season | mm | >150 | 120–150 | 90–120 | |
| Length of Growing Season | days | >150 | 120–150 | 90–120 | |
| **Topography (t):** | | | | | |
| Slope | % | 1–3 | 3–5 | 5–10 | >10 |
| Soil Drainage | class | Well drained | Moderate | Imperfect | Poor |
| **Soil Physical Properties (s):** | | | | | |
| Texture | class | sl, l, cl, scl | sicl,sic, sc, c (m/k) | c (ss) | ls, s |
| Coarse Fragments | vol% | <15 | 15–35 | >35 | - |
| Effective Soil Depth | cm | >75 | 50-75 | 25-50 | <25 |
| **Fertility (f):** | | | | | |
| pH | 1-2.5 | 6.0–7.0 | 5.0–5.9 | <5 | - |
| CEC | cmol[p+]/kg | >75 | 10–15 | <10 | - |
| $CaCO_3$ in Root Zone | % | Non-calcareous | Slightly calcareous | Strongly calcareous | - |
| **Soil Toxicity (n):** | | | | | |
| Salinity [EC saturation extract] | dS $m^{-1}$ | Non-saline | Slightly saline | Strongly saline | - |
| Sodicity [ESP] | % | Non-sodic | Slightly sodic | Strongly sodic | - |

**Legends**
S1 = Highly suitable (IP = 100–75%)
S2 = Moderately suitable (IP = 74–50%)
S3 = Marginally suitable (IP = 49–25%)
N = Not suitable (IP = 24–0%)
**Source**: NBSS&LUP, 1994 modified by Alabi *et al* (2024).

## 4.6 Summary of Land Suitability and Classification for Ginger and Cucumber.

The land suitability and classification for ginger and cucumber were determined by applying two recognized systems: the Limitation Method and the Parametric Method. Both methods are appropriate for this study and crops. The summary table (4.7) reflects the results obtained from these approaches.

## Table 4.7: Summary of Land Suitability and Classification for Ginger and Cucumber.

| Classification systems | | | | | | | | | | **Land Characteristics** | **Ginger (Limitation Pedon)** | **Ginger (Parametric Pedon)** | **Cucumber (Limitation Pedon)** | **Cucumber (Parametric Pedon)** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Local | | USDA Soil Taxonomy | | | | | WRB (World Reference Base | | | **..** | | | | |
| Series | Sub series | Order | Sub order | Great group | Sub group | Family | Reference Soil Group (RSG | Primary Qualifiers | Secondary Qualifiers | Annual rainfall (mm) | S1 (1900) | S1 (100) | N (1900) | N (24) |
| Orlu | Normal | Ultisol | Udult | Kandiudult | Rhodic Kandiudult | Sandy, Isohyperthermic, Rhodic Kandiudult | Lixisol | Rhodic | Loamic,Different, Ochric | Temperature (°C) | S1 (23–37) | S1 (100) | S2 (30) | S2 (74) |
| | | | | | | | | | | Relative Humidity (%) | S1 (75–89) | S1 (100) | — | — |
| | | | | | | | | | | Rainfall in growing season | — | — | S1 (>150) | S1 (100) |
| | | | | | | | | | | **Topography (t)** | | | | |
| | | | | | | | | | | Slope (%) | S1 (1–2) | S1 (100) | S1 (1–2) | S1 (100) |
| | | | | | | | | | | **Wetness (w)** | | | | |
| | | | | | | | | | | Drainage | WD (Well drained), S1 | S1 (100) | S1 (Well drained) | S1 (100) |
| | | | | | | | | | | **Soil Physical Properties (s)** | | | | |
| | | | | | | | | | | Texture | S2 (SL) | S2 (40) | S1 (SL) | S1 (100) |
| | | | | | | | | | | Structure | S2 (SBK) | S2 (40) | — | — |
| | | | | | | | | | | Soil depth (cm) | S1 (170) | S1 (100) | S1 (170) | S1 (100) |
| | | | | | | | | | | **Soil Fertility (f)** | | | | |
| | | | | | | | | | | CEC (cmol/kg) | S1 (15.20) | S1 (100) | S2 (15.20) | S2 (74) |
| | | | | | | | | | | Base saturation (%) | N2 (2.57) | N2 | — | — |
| | | | | | | | | | | Soil pH | S12 (4.86) | S12 (60) | S3 (4.86) | S3 (49) |
| | | | | | | | | | | Organic carbon (%) | S1 (2.06) | S1 (100) | — | — |
| | | | | | | | | | | Available P (%) | N2 (0.03) | N2 | — | — |
| | | | | | | | | | | **Soil Toxicity (n)** | — | — | S1 (non-saline, non-sodic) | S1 (100) |
| | | | | | | | | | | **Aggregate Suitability Class** | | | | |
| | | | | | | | | | | Current Suitability | N2 (f) | N (0) | N (c) | N(8.28) |
| | | | | | | | | | | Potential Suitability | S2 | S2 | N | N |

# 5.0 CONCLUSION AND RECOMMENDATION

## 5.1 Conclusion

Based on the results, it was concluded that the characterization, classification, and suitability assessment of the SLM Research Hub soil revealed a highly weathered profile with significant limitations for target crop production. The pedon was classified as a Sandy, Isohyperthermic, Rhodic Kandiudult under USDA Soil Taxonomy and a Rhodic Lixisol (Loamic, Differentic, Ochric) under the WRB system and locally, the pedon was classified as Orlu Series (Normal phase), This classification denotes a tropical, acidic soil with low base saturation and subsurface accumulation of low activity clays. For ginger, the limitation method classified the pedon as N2 due to soil physical property ( texture) and fertility (low base saturation and available phosphorus), while the parametric method similarly rated it N1. On actual suitability, the pedon was rated N1(s) for soil texture and N2(f) for soil fertility, but its potential suitability improved to S2 since fertility limitations can be corrected through management practices. For cucumber, the limitation method rated the soil as N1 due to climate limitation (excessive rainfall) and marginal soil fertility (pH), and the parametric method confirmed N1 status. Actual and potential suitability for cucumber remained N, as the major limitation rainfall cannot be altered.

## 5.2 Recommendations

Based on the research findings, it is recommended that cucumber cultivation on this land should not be prioritized due to the climatic limitation (excessive rainfall). However, if production is desired, cucumber may only be cultivated under controlled conditions such as greenhouse or rain shelter systems to ensure sustainable growth and yield. Also, Ginger cultivation may not be prioritized due to the required costly measures for sustainable production. However if economically justified the land can be used for Ginger cultivation provided essential practices such as liming, application of organic manure, and phosphorus fertilizer application are implemented to enhance soil fertility and support sustainability.

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