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Characterization, Classification and Suitability Assessment of Nigerian Soils: A Review

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Abstract
Effective soil management and conservation may be impossible without accurate soil characterization, classification and interpretation in relation to particular crop requirements. Proper management of soils is therefore indispensable because of its linkage to environmental protection, hunger eradication/food security, economic growth and poverty reduction among others. Research efforts on soil characterization, classification and suitability assessment for perennial crops are accumulating and have created opportunity for an extensive summary and future perspectives. The review shows that southwestern Nigerian soils underlain by metamorphic rocks of the Basement complex have been grouped into eight associations. Nigeria's southern soils consist of sandstone-siltstone intercalation, shale, basalt and basement complex material. The findings also demonstrated that while the Nigerian soils were moderate to marginally suitable, they had the potential to be highly suitable for growing different perennial crops provided the inherent limitations are taken care of. The dominant soil limitations recurring across the ecological zones include low fertility, unfavourable texture, slope, low CEC/ECEC, and dry season. Information on land evaluation for perennial crops in Northern part of the nation is limited. Thus, further studies should be carried out in the area with a view to encouraging establishment of tree crops by farmers. It was concluded that inadequate knowledge on suitability evaluation could lead to farmers cultivating soils that are unsuitable for their crops. Therefore, soil characterization and evaluation before crop production is very much recommended to avoid poor agronomic practices, excessive production costs, and low yields.

Keywords: Soil characterization, land evaluation, soil formation, perennial crop, Nigeria

Introduction
Soil is an essential non-renewable resource that needs to be treasured and preserved for its productive ability, contribution to food security and maintenance of ecosystem services. It constitutes the foundation of life on Earth and its conditions are directly influenced by the activities carried out on it. Therefore, the sustainable management of the world's agricultural soils to satisfy demands of the growing population becomes very important (FAO, 2015). Areola (1990) stated that without soil, there cannot be anything called life because the survival and continuous existence of man globally depend on it. According to Olayinka (2009), tropical soils are fragile, characterized by low-activity clay, low cation exchange capacity and low base saturation, resulting in low productivity. The soils are highly weathered, leached and acidic

with high rates of organic matter decomposition and mineralization which deplete the inherent soil fertility. Proper management of soils is therefore indispensable because of its linkage to environmental protection, hunger eradication/food security, economic growth and poverty reduction.

Effective soil management and conservation may be impossible without accurate soil characterization, classification and interpretation in relation to particular crop development requirements. The process of characterizing and classifying soils provides valuable insights into their morphological, physical, chemical and mineralogical characteristics, which mitigate the negative effects of soil diversity and support precision agriculture (Sharu *et al.,* 2013). Lack of understanding of the significance of evaluating the suitability of agricultural land continues to be one of the key issues facing agricultural growth in developing nations. This has led to low yield, poor agronomic practices, and excessive production costs (Aderonke and Gbadegesin, 2013).

Numerous research attempts are ongoing to advance land use pattern that will guarantee conservation of the agricultural land resources and ensure viable agricultural production that can ensure national food security (Ojeniyi, 2019). Research efforts on soil characterization, classification and suitability assessment for perennial crops are accumulating and have created opportunity for an extensive summary, and identification of future prospects as this is essential for agricultural planning and sustainable land-use management. Identification of the potential agricultural capability of soils is needed to prevent farmers cultivating soils that are unsuitable for their crops. This study therefore reviewed the existing information on soil formation, soil classification systems, land evaluation principles, and suitability studies for perennial crops across different regions of Nigeria.

Concept of soil and its uses

One of the fundamental natural resources needed for life is soil. The concept of soil varies with end users. Civil engineers view soil as the material that supports and influences the behaviour of earthen structures such as bridges, buildings, pavements while geologists take soil as a product of weathering in relation to its composition or mineral resources (Amusan *et al*., 2006). To a farmer, it is just a medium that will nurture and provide water to the crops while a miner considers it as a kind of irrelevance that must be removed. According to Stephen *et al.* (2012), hydrologists thought of soil as a big reservoir that hold water for rivers and streams. However, soil is well known for being a medium for the growth of plants and for directly or indirectly supplying food and fiber to animals. According to Soil Survey Staff (1998), soil is the group of natural bodies that make up parts of the earth's surface and support plants. Its characteristics result from the combined activities of living organisms and climate, which operate on parent material over time, as conditioned by relief.

The roles of soils vary. It serves a variety of purposes. Some of these include functions relating to agricultural productivity, environmental quality, natural ecosystems, building foundation, and raw material sources. One of these responsibilities that is arguably the most well-known and understood is agricultural production (Stephen *et al.,* 2012). One of the most obvious functions of soils is to provide food for humans and feed for animals. In addition to serving as the foundation for plants to stay upright, soils are home to a wide variety of soil creatures (Nielsen *et al.,* 2015). The soil serves as a storehouse for water and nutrients, meeting the demands of plants as they develop. They are a significant source and sink of greenhouse gases and also contribute to the composition of the atmosphere. We must manage soils for their long-term sustainability, health and productivity because of these critical responsibilities. If soil is not valued, there are serious repercussions for humanity. Soil affects human health directly through inhalation or ingestion of its products, and indirectly via the quality and quantity of food produced by soil-based agriculture. If infections or toxic substances make their way into the food chain, the consequence could be detrimental to human's health (Brevik, 2009). Since unhealthy soils will yield unwholesome plants, soils must be managed properly to guarantee they continue to serve people in their many ways.

Soil formation in southwestern Nigeria

According to Smyth and Montgomery (1962), metamorphic rocks of the Basement complex, the majority of which are extremely old due to the pre-Cambrian epoch, cover the whole region of southwest Nigeria. The basement complex, according to Don-Leet and Judson (1971), is the oldest recognizable rock in any region that is undifferentiated, primarily sialic, crystalline metamorphosed, and frequently, though not always, pre-Cambrian. Research on the surface of Pedi sediment over saprolite was the main focus of earlier attempts to understand the genesis, mineralogical, physical and chemical characteristics of soil that emerged in the basement complex of the southwest region of the country (Fasina *et al.,* 2015). Banjoko and Ogunwale (1980) discovered that pedogenic processes and nature of parent materials seemed to be the principal factors that have controlled the genesis of soils derived from the basement complex of southwestern Nigeria. Their sand, silt and clay mineralogy implied that particular processes such as addition, translocation, losses and transformation possibly played a vital role in the profile development. Soils developed on basement complex rocks and basalt have vastly different physical and chemical characteristics. Parent materials have an impact on the color, texture, structure and nutrient status of soil. When basalt and granite soils were compared, it was found that the majority of the minerals in the former weathered into kaolinite, ferric hydroxides or hydrous oxides and some aluminum hydroxides. These soils will be well-structured, heavy in clay and low in sand. In contrast, granites weather much more slowly, producing soils that are poor in iron, less well-structured and high in fine sand, much of which is quartz and a mixture of micaceous and kaolinitic clays (Ezenwa, 1987; Aki and Ofem, 2024). In the basement complex area, Moorman (1981) reported that a robust correlation existed among topographic position and soil genesis. Topographic position influences soil depth, drainage, runoff, erosion, and ultimately soil formation and development. Landscape placements are strongly connected with a variety of soil characteristics, including sand, clay, pH, organic carbon contents and distribution (Wang *et al.,* 2000).

The soils of central western Nigeria had been classified into associations and fascs using geographical and taxonomic criteria. The first criterion used in the identification of the soils was drainage. Though, further criteria were considered along with drainage, morphological features were used primarily in classifying the soils into series. The soils of southwestern Nigeria have been grouped into eight associations (Iwo, Ondo, Egbeda, Itagunmodi, Okemesi, Mamu, Jago and Origo) using the close relationship which exist in the area between soil morphology and the nature of underlying rock (Smyth and Montgomery, 1962; Ojeniyi, 2019). Table 1 shows summary of the soils associations/parent rock and the soil series.

Table 1: Soil Associations and Series in South western Nigeria

The parent rock	**The soil series**		
	Sedentary	Hill creep parent material	Hill wash parent material
Iwo Association (coarse-grained granites and gneisses)	Iwo*, Ibadan^, Ekiti, Igbajo, Ife, Odeyinka	Balogun*, Asejire^, Akure	Oba*, Iregun*, Apomu^
Ondo Association (medium-grained granites and gneisses)	Fagbo*, Ondo*, Owo^, Odigbo	Igunshin	Oba*, Iregun*, Apomu^
Egbeda Association (fine-grained biotite gneisses)	Egbeda*, Olorunda*, Makun^, Odigbo	NSR	Oba*, Iregun*, Apomu^
Itagunmodi Association (amphibolites)	NSR	Araromi	Itagunmodi*, Owena*, Oba*, Iregun*, Apomu^
Okemesi (quartz schist)	Iwaji, Owo	Erinoke*, Okemesi^, Ipele, Irapa	Etionni, Oba*, Iregun*, Apomu^
Mamu Association (sericite schist)	Mamu	Effon	Oba*, Iregun*, Apomu^
Jago Association- soils affected by seasonally high water table (alluvium and colluvium)	Poorly drained soils: Adio*, Jago^, Matako^, Shasha Swampy soils: Oshun, Ikire		
Origo Association- soils with impeded drainage (diorite-gneiss)	Origo, Majeroku, Mokore, Lagun		
Various	Hardpan soils: Gambari, Ibule, Ijare Eroded soils: Shanroji		

*= clayey series; ^= sandy series; NSR= no series recognized
Source (Smyth and Montgomery, 1962; Ojeniyi, 2019).

Soil Formation in South Southern Nigeria

According to Nsor (2011), Southern Nigeria's soils originated from a variety of parent materials. The region's geology includes garnet mica schist, hornblende gneiss, basalt, and coarse-grained porphyritic granite. Intercalation between sandstone and shale, as well as small basic and intermediate intrusions, can occur occasionally in marshy situations. According to Amajor (1989), the region's geology mostly consists of sandstone-siltstone intercalation, shale, basalt and basement complex material. The basement complex is composed of quartzite, granite, schist and gneiss. Shale, siltstone and sandstone are the primary sedimentary rocks found in the areas of basaltic extrusion in south-south Nigeria, which are primarily located in Ikom and portions of Obubra and Etung Local Government Areas (Eshett, 1987). Aki and Ofem (2024) stated that soils of Ikom were developed on basalt which is an extrusive igneous rock with less than 20% quartz, less than 10% feldspathoid minerals and at least 65% of the feldspars being present in the form of plagioclase. It weathers fast as a result of the oxidation of its mafic minerals to rust-like compounds. Basaltic soils have been described as lateritic, deep with heavy clay in the subsoil and little horizon differentiation (Corbett, 2006). Teitzel and Bruce (1972); Akpan-Idiok *et al.,* 2016 reported that the soils are fertile but deficient in phosphorus and molybdenum while Kparmwang *et al.* (1992) stated that the soils favour agricultural potentials but limited by N, P, S and Mo. According to several studies, the red clay soils that are formed from basalts in the Ikom-Obubra regions have a high subsurface clay concentration, but their chemical characteristics varied because of variations in other soil-forming elements (Eshett, 1987; Akpan-Idiok *et al.,* 2016). The geomorphology of Cross River State includes steep-sided hills of undifferentiated igneous and metamorphic rocks, undulating sandstone plains and ridges, dissected basement complex plains and pediments, level to gently undulating sandy coastal plains, and active flood plains of recent alluvium (Bulktrade and Investment Company Limited, 1989).

Osemwota (2009) reported that Edo State is divided into four distinct sections based on geological formation and soil parent material: the lower Niger valley, the Afemai uplands, the Niger Delta coast line and the Benin lowlands. The State's sedimentary rocks cover over 90% of it. The recent mangrove swamp on the Delta's coastal border and the recent alluvium of the Niger flood plain are examples of sedimentary formations. The Benin formation (Kogbe, 1976) and the Ogoni sands (Anderson, 1967) are Miocene-Pleistocene alluvial deposits of the Niger and its distributaries that made the land forms beneath the coastal plain terrace. It includes coastal plain sands, false bedded sandstone, upper and lower coal measures and the Bende Ameki group. Emomu (2022) and Osemwota (2009) reported that soils of Uhonmora in Edo State developed on Imo shale parent material.

Soil formation in northern Nigeria

According to Kefas *et al.* (2021), soils in the northern guinea savanna are mainly developed on the Basement Complex. The complex is made up of migmatite gneiss, schist, older granite and under formed acid dykes and mainly constitutes igneous and metamorphic rocks, and occupy 50% of the Nigerian surface area. Soils in the Nigerian guinea savanna are generally slightly acid, less leached, coarse textured and consist of sandy loam or loam over gravelly clay loam (Esu and Ojanuga, 1985) with lower clay content in the surface soil. Luvisols have been identified as the most common soils in Northern Guinea Savanna of Nigeria (Salako, 2003), while Ogungbile *et al*. (1999) classified similar soils as lithisols.

Yusuf and Yusuf (2008) reported that major soils of Northern Nigeria were grouped into four categories and classified according to the USDA thus: (a) less leached, mature upland soils (Alfisols), classified as Haplustalfs, Paleustalfs and Plinthustalfs, and they are dominant (b) well-drained, shallow, immature soils (Entisols and Inceptisols), classified as Orthents, Psamments, Tropepts, and dominant in distribution (c) Tropical Black Earths (Vertisols), classified as Torrerts, Usterts, moderately dominant, (d) Hydromorphic soils, classified as Tropaquepts (Entisols), Tropaquepts (Inceptisols) and Tropaqualfs (Alfisols) which are less dominant. According to Bawden (1972) as stated by Kefas *et al.,* (2020), the soils in Taraba state, north eastern part of Nigeria are underlain by Basement Complex rocks and dominated by Precambrian granitic and migmatite gneisses with outcrops of the rocks occurring at intervals. Tijani (2023) affirmed the geology of the Mambilla

Plateau, situated in Northeastern Nigeria, to be dominated by Basement complex rocks.
Achukwu *et al*. (2013) compiled a total of 137 soil series mainly from the reports of 1960s to 1970s soil survey. It was discovered that about 80% of the soil series of the Northeastern region were well drained, 2% were imperfectly drained while 16% were poorly drained. Shallow soils which were mostly less than 50 cm to impenetrable layer constituted about 32% and were found mostly on basement complex rocks and sand stone parent materials. Most of the soils were therefore, deep and developed from a wide variety of soil parent material such as aeolian, alluvial, Basement complex rocks and sandstone.

Soil Characterization and Classification

Better understanding of soil characteristics at local and/or large scale is important to deal with definite problems of agricultural production. Soil characterization is central to all soil studies as identifying its physical and chemical properties are necessary for soil classifying. According to Buol *et al*. (2003), the formulation of a soil management plan for the efficient use of limited resources and the transmission of agro-technology has been found to benefit from the research and comprehension of soil qualities and their distribution throughout a region. Soil characterization provides information for a better knowledge of the physical, chemical, mineralogical and microbiological aspects of the soils on which we rely to support homes, society structures, crops, forests, and grasslands (Ogunkunle, 2005). The properties of soil, which are influenced by many soil formation processes and conditions, have a significant impact on soil fertility and land productivity. Having the knowledge of the morphological, physical and chemical properties of soil in relation to additional fertilizer is therefore crucial for recommending the right fertilizer schedule for a variety of crops in order to achieve the best possible yield. Soils vary widely in their characteristics and properties. Colour, texture, structure, consistency and the quantity of roots, carbonates, rocks among others are characteristics of soils. These traits aid scientists in understanding the functioning of the ecosystem and in recommending soil use that has a negligible effect on it (Abay and Sheleme, 2012). Different systems of soil classification have occasionally been used to categorize soils and meaningfully group them together. Adoption of the USDA's current "Soil Taxonomy" classification system, which comprises six categories—order, sub-order, great group, sub-group, family and series—has been recommended globally. Soils are categorized as Entisols, Inceptisols, Alfisols, Vertisols, Ultisols, Oxisols, Aridisols, Histosols, Gelisols and Andisols based on this method (Abay and Sheleme, 2012). Buol *et al.* (2003) stated that forms of soil classification are basically Taxonomic and Technical classification. The purpose of taxonomic classification is to bring out relationships of the most important properties of the soil being classified without reference to any single specified and applied objective. For example, USDA Soil Taxonomy System and the FAO-UNESCO soil classification system or World Reference Base for Soil Resources while Technical classification is aimed at a specific, applied and practical purpose. Such as classifying soils for agricultural or engineering purposes. For example, USDA Land Capability Classification System and the FAO Land Suitability Classification for rainfed agriculture.

Soil classification makes it easier to compare soil characteristics, organize knowledge, and transfer technology and expertise from one location to another. Singh *et al.* (2013) stated that soil classification for different land uses is the first milestone to create a database for creating land use models. Classification systematically arranges soils into groups or categories based on individual characteristics as well as standards that determine usage decisions. Such a mechanism facilitates international communication concerning soils, soil scientists and those tasked with managing soil resources and conserving land (Abagyeh *et al.,* 2020). According to Nwaloka *et al.* (2019), one of the goals of soil characterization and classification is to provide land users with additional information about land resources. The comprehensive picture of the behaviour of soils in a region can be revealed practically with the use of soil data gathered through a methodical soil survey. These data provide details about the genesis, properties, morphology and classification of soil (Msanya *et al.,* 2016). The expansion of agriculture and the growing need for experimental data necessitate extensive soil characterization studies. This offers the essential data required to develop practical soil categorization systems and evaluate soil fertility in order to identify certain particular soil issues in an ecosystem (Lekwa *et al.,* 2004).

Land evaluation

Prudent use of land resources can be attained by optimizing their uses, which demands land evaluation for alternative land uses. Due to increase in population, the demand for food is on high side and this has led to reduction of soil nutrients as a result of continual stress mount up on the available soil purposed for cultivation. This makes it necessary to assess soil resources in terms of their qualities and potentials for use, which is essential for creating a land-use plan that effectively increases agricultural output (Pulakeshi *et al.,* 2014). Different type of soils supports various land-use systems and need diverse management options for better productivity. Diverse nature of soils is one of the reasons for allocating land to wrong uses. So, understanding the nature of soils and their properties is imperative for optimal, judicious and beneficial use on suitable bases (Jagdish *et al*., 2009). According to Mabogunje (2003), food production in a profitable manner is the aim of each farmer, large scale farm manager together with both local and foreign agricultural institutions. Thus, a farmer should be informed to be efficient, and that includes having the knowledge and information to make a workable plan for farming activities. To fully maximize the potentials of an agricultural land and achieve environmental sustainability, there is need to understand the diverse uses that a land can be put as land use ought not to be based primarily on the needs and demands of users, but rather on the understanding of the suitability of each land for the intended purpose (Nuga and Akinbola, 2015).

The process of comprehending land's potential for optimal use and the sustainability of its productivity is known as land evaluation (Adeboye, 1994). This calls for general understanding of the genesis, morphology and properties of the soil. Oluwatosin (2005) stated that assessing the potential uses of land for industry, forestry, engineering, recreation, agriculture, and conservation is known as land evaluation. In the agricultural context, it refers to the assessment of a particular type of land use, such as extensive grazing, irrigation, rainfed farming, and agriculture.

Concepts and principles of land evaluation

Land evaluation provides information about the land's potential and limitations and also informs judgments about the best and most efficient use of resources. This information is essential for land use planning and development (AbdelRahman *et al.,* 2016). Crop requirements must be known in order to assess a soil's potential for crop production. Soil fertility characteristics and other factors such as topography, climate, wetness and physical characteristics are essential crop requirements. These elements are connected to how the soil is used for agriculture, particularly to specific crop needs and tolerances (Fischer *et al.,* 2008). The soil is categorized as "highly suitable (S1)" if these properties meet all requirements; if not, it is classified as moderately suitable (S2), marginally suitable (S3), or not suitable (N) (Fischer *et al.,* 2008). Conceptually, land evaluation entails balancing the ecological and management needs of pertinent land use types with the characteristics of the land and soil while taking local economic and social circumstances into consideration (FAO, 1976). There are a number of ways to conduct a suitability assessment. These methods range from FAO framework (1976) – parametric and non-parametric methods to Fuzzy logic modelling (Braimoh, 2000) and that the methods have their weak and strong points. Nevertheless, according to Ajiboye *et al.* (2011), the parametric approach is the most widely used and has been shown to produce results that are as valid as those from Fuzzy logic, but rather subjective. Based on the FAO framework, numerous studies have been carried out in various regions of Nigeria on various facets of land suitability for crop cultivation.

Following the great proportion of farmland categorized as degraded due to improper land use, requirement for wise decision making is becoming gradually imperative (Hulme *et al.,* 2002). Some of the reasons acknowledged for high rates of soil degradation include inadequate availability of soil maps at expected scales, limited soil information to guide decision-making and lack of political will of many governments to provide necessary information at diverse levels for the formation of agricultural plans that would profit particularly resources limited to farmers. Therefore, it is essential to identify and locate different types of soils, evaluate their potentials for specific crop and their alternatives for effective agricultural land use planning (Boukong *et al.,* 2019).

Previous studies on land suitability assessment for perennial crops in Nigeria

The suitability of Nigerian soils for growing different crops has been examined in a number of studies. Some of the studies include the work of Olasoji *et al.* (2022a) who evaluated soils formed in coarse-grained granite and gneiss and assessed their potentials for cocoa cultivation. The findings demonstrated that while the soils were currently only marginally suitable for cocoa production, they had the potential to be highly suitable. Poor fertility—high soil acidity, poor organic matter and low Ca and Mg contents—was their main limiting factor to cocoa production. Olasoji *et al.* (2022b) who assessed 20 acres of land for cocoa cultivation in Yewa North Local Government Area, Ogun State, came to similar conclusions.

In the coastal region of Bodo City, Cross River State, Southern Nigeria, Peter and Gbaraneh (2021) conducted research on soil suitability for cashew and rubber. They came to the conclusion that the soils in the study area were moderately suitable for the production of both cashew and rubber. Approximately 14,000 ha of the entire study area were deemed marginally suitable for rubber cultivation due to limitations in soil fertility (low base saturation) and physical characteristics (texture), while 86,000 ha were determined to be moderately suitable.

Tenkap and Balogun (2020) evaluated the suitability of land for cocoa cultivation in Idanre, Ondo State, using a multi-criteria decision analysis and geographic information system (GIS). According to the results, just 2.18% (42.83591 km^2) of the research area was unsuitable for cocoa production, while 71.34% (1401.79533 km^2) was moderately suitable and 26.48% (520.31876 km^2) was marginally suitable. The main factors limiting the success of cocoa cultivation in the region have been linked to topography, inadequate rainfall and improper land use management, such as unplanned urbanization.

In order to characterize, categorize and assess the land for the intended oil palm production, John and Akpan-Idiok (2019) evaluated a 50-ha plot of land using a combination of traditional and digital survey methodologies. Out of the three mapping units identified, parametrically, mapping units 1 and 2 were marginally suitable while mapping unit 3 was not suitable for the proposed oil palm production. Using the non-parametric method, mapping unit 1 was moderately suitable; unit 2 was marginally suitable while unit 3 was not suitable. Fertility, moisture, the physical characteristics of the soil and topography were the main constraints on the landscape.

In Atakunmosa West LGA of Osun State, Ajiboye *et al.* (2018) evaluated the suitability of three soil series: Itagunmodi, Owena and Araromi. The Araromi soils series were currently unsuitable for cocoa production, while the Itagunmodi and Owena soils series were just marginally suitable. The main constraints on the soils were low ECEC, slope gradient and dry season. Non-acidifying fertilizer sources with sufficient amounts of calcium oxide (CaO) or magnesium oxide (MgO) were recommended.

The biophysical characteristics of a few sites in Delta State were examined by Osayande *et al.,* (2016), who also evaluated the areas' suitability for growing oil palm, coconut and raphia. Three of the seven sites were found to be unsuitable for oil palm production, with the sandy subsoil texture being the main limitation. Nonetheless, all of the sites were appropriate for cultivating raphia and coconut. The sites were categorized as unsuitable for palm cultivation overall, with the soil fertility rating being the only restriction that can be corrected.

Kappo *et al.* (2015) used geospatial tools, a soil diagnostics study, and a multi-criteria evaluation to determine the suitability of the land in Ife Central LGA, Osun State, for growing cocoa. It was reported that 54.38% (77.29 km^2) of the research region was not suitable, whereas 19.44% (28.26 km^2) and 25.67% (36.45 km^2) were moderately and marginally suitable, respectively. Low organic matter, cation exchange capacity, nitrogen, phosphorus and soil textures were some of the limitations influencing the crop production. In order to boost output and encourage sustainable cocoa production, the study suggested adequate soil management and nutrient enrichment.

Information on land evaluation for perennial crops in Northern part of the nation is limited. Rather, many researchers focused on suitability of the soils for arable crops. Foli (2012) admitted that agricultural production in the Nigerian northern guinea savanna is focused on crop and livestock production. Crop production in the area is dominated by cereals (millet, sorghum, maize and wheat) and legume (cowpea, groundnut and soybean) production. However, Osujieke *et al*. (2025) examined selected soils of Mambilla plateau for cocoa cultivation. Only one soil profile pit was shallow among the twelve established across the area. Most were deep, greater than 150 cm. The result showed that most soil units were marginally suitable or moderately suitable, with a few classified as currently or permanently not suitable. This confirms the hypothesis that portions of the Mambilla Plateau are suitable for cocoa cultivation, though suitability varied considerably due to inherent limitations. Climate and topography were generally favourable for cocoa production, while the identified limitations include low CEC, poor drainage, and suboptimal soil texture. These limitations influence nutrient availability, water retention, and root penetration, all of which are critical for cocoa growth. However, the potential suitability assessment highlights significant opportunities for improvement. Targeted soil management strategies, such as applying non-acidifying fertilizers and incorporating organic matter could elevate over 50% of the land units to higher suitability classes. Table 2 summarizes the dominant soil constraints affecting perennial crop suitability across Nigeria and the management strategies.

Table 2: Suitability class and major soil limitation across Nigeria

Location	Crop Type	Suitability class	Major soil limitations	Recommended management strategies
Southwest	cocoa	moderate, marginal and not suitable	Poor fertility, topography, inadequate rainfall, improper land use management, such as unplanned urbanization.	Application of appropriate and/or non-acidifying fertilizer, organic matter incorporation, and adequate soil management.
South south	cashew and rubber	moderately and marginally suitable	poor texture, poor fertility, moisture and topography	
	oil palm	marginally and not suitable		
	coconut and raphia	moderately suitable		
North	cocoa	moderately, marginally and not suitable	low CEC, poor drainage, and suboptimal soil texture.	

Conclusion

Better understanding of soil characteristics at local and/or large scale is important to deal with definite problems of agricultural production. Soil characterization and classification provide land users with information about land resources. Research efforts on soil characterization, classification and suitability assessment for perennial crops in Nigeria were reviewed. The study established that while the Nigerian soils were moderate to marginally suitable, they had the potential to be highly suitable for growing different perennial crops provided the inherent limitations are taken care of. The dominant soil limitations recurring across the ecological zones include low fertility, unfavourable texture, slope, low CEC/ECEC, and dry season. The findings identified the limited availability of perennial crop suitability studies in northern Nigeria. Thus, further studies are suggested in the area with a view to encouraging establishment of tree crops by farmers. Soil management practices such as application of appropriate fertilizer and nutrient enrichment were generally recommended for sustainable crop production across the nation.

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