

## Impact of Land Utilisation Types and Soil Depth on Selected Soil Properties in Derived Savanna Region of South East, Nigeria

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### ABSTRACT

If land use practices are not properly managed, they can lead to soil degradation over time, resulting in poorer soil health and unsustainable crop productivity thus this study investigated the impact of land utilisation and soil depth on selected soil properties. Three land use types (grassed area, cassava and rice farms) each measuring about 250 sq/m were selected and mapped for the study. Auger and core soil samples were collected from each of the land use types in three replicates at 0-20 cm, 20-40 cm and 40-60 cm depths after which the collected samples were subjected to laboratory analysis. The laboratory results were further subjected to statistical analysis using ANOVA to determine significant differences at 5% probability level. From the results obtained, the soils belonged to clay textural class. Bulk density ranged from 1.60-2.10 g/cm<sup>3</sup> and increased down the depth. Total porosity was highest at 0-20 cm depth under land use types. Saturated hydraulic conductivity (Ksat) of the soil was generally low and falls in the range of 0.010-0.09 cm/hr. The pH of the soil ranged from 4.84-5.87 showing very strongly to moderately acidic soils. Organic carbon were generally low (0.26- 1.32%) and was highest at 0-20 cm depth under cassava farm which decreased down the depth. The effective cation exchange capacity (ECEC) of soils under various land use types and across the depths ranged from 3.53-8.33 cmol/kg with higher concentration observed at 0-20 cm depth. The values obtained in this study were generally low however the study has demonstrated the importance of depth in soil nutrient availability and distribution as well as the need to improve soil productivity and plant growth through good management practices.

**Published Online:**  
**August 15, 2025**

**KEYWORDS:** Climate, conservation; land use; profile; texture; soil management.

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### INTRODUCTION

Land use is described as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it (Ufot *et al.* 2016) and among the factors that could influence the user's preference is the soil condition of the field which can be identified by analyzing the soil properties and comparing with the standards. These soil properties combine to determine the type of plants that will grow in a soil or in a particular region (USDA, 2004). However, unsustainable land use and land cover changes have been recognized as the main factors in the process of land resource degradation (Nyssen *et al.*, 2004). Again, rise in population growth is believed to influence the type of land use and the rate of expansion of specific land use type (Lambin *et al.*, 2001). Changes in land use have been reported to affect soil texture through modification in the sand, silt and clay contents (Lal, 1996) as well as soil structure and other soil properties which in turn have implying effects on the soil microbial activity and soil organic carbon dynamics (Boivin *et al.*, 2009). Past studies have reported depth distribution of soil nutrients to usually indicate their maximum availability at the top surface which declines with increasing soil depth (Nnabude *et al.*, 2016). The continuous agricultural land exploitation on the expense of loss of the natural environment could also lead to severe land degradation and to reduce this trend the need for an effective land use management for crop production requires understanding of soil properties

In order to harness the fertility of the available soil resources understanding the distribution of soil nutrients in profile of diverse land use practices remains very vital hence the study looked at the impact of land utilisation on selected soil properties for appropriate soil management.

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## MATERIALS AND METHODS

### Description of the studied area

The study was conducted within the Faculty of Agriculture Annex of Nnamdi Azikiwe University, located in Ifite Ogwari area of Anambra State and lies within latitude 06°4' N and 06°60'N and longitudes 06°57'E and 06°95'E. The area is among the major agricultural producing towns of Anambra State having cassava, yam, plantain, rice and okro as the major grown crops in the area. According to FDALR (1990), Ifite Ogwari soils are of Imo shale geologic formation and belonged to clay textural class (Nwosu and Nweke, 2024). The area falls within the transition zone which according to Chukwu (2007) is derived savannah with some patches of rainforest. Two main seasons of dry and wet seasons prevail in this area with an average annual rainfall of 2737.4 mm based on 2022 data by Nigeria meteorological Agency though rainfall onset and cessation period have varied recently. The average temperature and relative humidity of the area 35°C and 74% respectively.

### Selection and History of Land use types studied

There are soil degradation challenges that impacts the soil properties in this area hence the three most common land use practices (cassava farm, rice farm and grassed area) were selected for the study. On each of the land use types an area of about 200sqm was mapped for a detailed study after interviewing the land owners on the land utilisation history which were recorded as follows: (a) Rice farm - The farm lies within longitude 6.964627815 °E and latitude 6.638649932 °N which has been under lowland rice cultivation for over 10 years and is usually rain fed; Planting is usually done through broadcasting method while chemical fertilizer is heavily used in the cultivation process (b) Grassed Area-This area of land lies within longitude 6.9592472 °E and latitude 6.639056404 °N having been under grass cover for an estimated period of 3 years with spear grass, bahamas grass and couch grass as the dominant grass species (c) Cassava Farm - The land lies within longitude 6.954165859 °E and latitude 6.636870969 °N having been under continuous cassava cultivation which sometimes is mixed with maize and yam for over 5 years.

### Soil sample collection

Auger and core soil samples were randomly collected from each of the land use types in three replicates at 0-20 cm, 20-40 cm and 40-60 cm depths. The core sampler measured 5cm by 5cm in both diameter and height. The collected soil samples were bagged, properly labelled, air dried for laboratory analysis. Auger soil samples were used to determine the particle size distribution and selected chemical properties of the soil while the core soil samples were used to determine selected physical properties of soil.

### Laboratory soil Analysis

- i. Particle Size Distribution: The hydrometer method as described by Gee and Or 2002 was used to determine the particle size distribution while the soil texture was determined using the USDA Textural triangle.
- ii. Bulk Density was determined by core method as described by Grossman and Reinsch (2002)
- iii. Soil Total Porosity was calculated from the bulk density as shown in this equation:

$$\text{Total porosity (\%)} = 1 - \frac{\text{Bd}}{\text{pd}} \times 100 \quad \text{----- (1)}$$

Where Bd =Bulk density, Pd =particle density (2.65g/cm<sup>3</sup>) iv. Saturated Hydraulic conductivity ( $k_{\text{sat}}$ ) was determined by the constant head permeability procedure according to Young (2001). Darcy's equation for vertical flow of liquid was used for the

computation of K as shown in the equation:  $K_{\text{sat}} = \frac{QL}{AT\Delta H}$  ----- (2)

Where, Q is water discharge (cm), L is length of soil column, A is the interior cross-sectional area of the volume of soil not occupied by soil column (cm), H is the head pressure difference causing the flow and it is dimensionless, T is the time of flow measured in seconds.

- v. Soil pH was measured electrometrically by glass electrode in pH meter in both KCI (1 N) and distilled water suspension using a soil: liquid ratio of 1: 2.5 (International Institute for Tropical Agriculture, 1979)
- vi. Soil organic carbon was determined using the wet dichromate oxidation method of Walkley and Black (1934).
- vii. Total Nitrogen (TN): This was determined by the Kjeldahl digestion method according to Jackson (1965).
- viii. Effective Cation Exchange Capacity (CEC). This was determined by 1N ammonium acetate extraction method.

### Statistical analysis

Data collected was subjected to factorial analysis of Variance using SPSS 13.0 (SPSS Inc., Chicago, IL, USA). Separation of means for statistical difference was done by the least significance difference (LSD) at 5% probability level.

## Results

### Particle Size Distribution

The result obtained showed that soils under grassland, cassava farm and rice farm had the highest sand, silt and clay contents with respective values of 349 g/kg, 235g/kg and 466 g/kg. Clay particle was the most dominant soil particle with the highest value hence the soils under land use types belonged to clay textural class. As regards soil depth, the highest sand and clay contents were obtained at 20-40cm depth while 0-20cm depth recorded the highest silt content. Again, higher clay particle was observed at the sub

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surface soil which could be as a result of the translocation of clay particles from the top soil layer down the depth through the eluviation and illuviation processes as reported by the Ojanuga, (2003). The particle size distribution result showed significant differences in under land use types and across soil depths. The increased clay fraction in all the soil depths and land use types could be associated to any or both of elluviationilluviation process, erosion, rate of fine particle deposition, farm management practices and biological activities taking place in the studied area

**Table 1: Particle size distribution under land**

Land Use	Sand	Silt	Clay	Textural Class	SCR
	←-----→ %				
Cassava farm	30.8	23.5	45.7	Clay	0.53
Grassed Area	34.9	22.9	42.2	Clay	0.52
Rice farm	30.0	23.4	46.6	Clay	0.48
LSD (P<0.05)	*	*	*		ns

**Note:** SCR-Silt Clay Ratio, ns- not significant

**Silt Clay Ratio (SCR)**

SCR shows the weathering stage of the soil and further helps in the classification of tropical soils. The lower the SCR the more weathered the soils are. The result obtained showed that SCR under land use types ranged from 0.48- 0.53 with the highest value obtained under cassava farm. SCR had non constant decrease as the depth increased however highest and lowest SCR was obtained at 0-20 and 20-40 cm depths. The decrease in values of SCR as the depth increased in this study corroborates with an earlier study by Lal (2000b) who stated that SCR for a majority of tropical soils decline with depth and that the ratio may range widely from soil to soil even within the same toposequence. The decrease could equally indicate that sub surface soils are more weathered than the surface soils. Generally, SCR values under land use types and at different depths were statistically similar and could suggest the young age of the soils within the area; this was in line with the report of Nweke *et al.*, (2021) who opined that young parent material usually have SCR greater than 0.26.

**Table 2: Particle size distribution at various soil depth**

Soil Depth(cm)	Sand	Silt	Clay	SCR
	←-----→ %			
0-20	31.8	24.8	43.6	0.56
20-40	34.3	19.4	45.8	0.42
40-60	30.1	24.5	45.4	0.54
LSD(P< 0.05)	*	*	*	ns

**Note:** \* -significant, ns- not significant, SCR-Silt Clay Ratio

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### Bulk Density

As per land use types, the results showed that the soils of cassava farm had the highest BD with a value of  $1.90 \text{ g cm}^{-3}$  while the soils of rice farm had the lowest BD with a value of  $1.73 \text{ g cm}^{-3}$ . The bulk density of soil under cassava farm was significantly higher when compared to other land use types and may be attributed to the continuous cultivation of the cassava farm. As regards soil depth (Table 5), the values obtained increased with an increased depth of which 40-60 cm depth recorded the highest value of  $1.90 \text{ g cm}^{-3}$  while 0-20 cm depth recorded the lowest with a value of  $1.62 \text{ g cm}^{-3}$ ; the lower BD observed at the upper layer could be as a result of organic matter deposits usually observed at the surface soil. Again, the observed high BD could be related to soil compaction due to textural characteristics of the soil as well as structural breakdown due to low organic matter content as reported by the work of Akamigbo and Igwe (1990) who observed high bulk density of similar soils. The result of bulk density as obtained in this study could further be associated with the depth of tillage operations, texture, and organic matter content of the soils. Nweke (2018), asserted that organic matter content influenced bulk density and is likely to be observed in a shallow soil depth tillage practice especially in tropical soil like Nigerian soil where the major implement for tillage operations is wooden hoe that doesn't cut deeper into the soil layer hence leading to hard pan in some cases.

### Total Porosity

Total porosity was highest under rice farm with a value of 34.57% and lowest under cassava farm with a value of 29.47%. Again, highest total porosity was obtained at 0-20 cm depth with a value of 38.78% and lowest at 40-60 cm depth with a value of 28.40%. The lowest total porosity value obtained under cassava farm could suggest reduction in the soil's ability to store water and air exchange due to associated high density. Significant differences were observed in total porosity of soil amongst the land use types and probably may be associated to variations in soil management practices. According to Landon (1991) the favourable total porosity of clay content soil is about 50% and above to sustain and regulate the activities of soil biota, enhance good water infiltration and aeration. However, this submission was in contrast with the findings of this study with values of total porosity less than 50% which could suggest soils with water logging problem

**Table 3: Selected soil properties under land use practices**

Land Use	BD ( $\text{g/cm}^3$ )	TP (%)	Ksat( $\text{cm/hr}$ )	pH	OC (%)	TN (%)	ECEC ( $\text{cmol/kg}$ )
Cassava farm	1.90	29.47	0.04	5.79	1.12	0.09	7.24
Grassed Area	1.74	34.27	0.01	5.65	1.00	0.08	6.59
Rice farm	1.73	34.57	0.01	5.16	0.36	0.03	5.00
LSD (P<0.05)	*	*	*	*	*	*	*

**Note:** \* -significant, ns- Not significant, BD- Bulk density, TP- Total porosity, Ksat- Saturated hydraulic conductivity, OC- organic carbon, TN- Total nitrogen, SAR- Sodium adsorption ratio, ECEC-Effective cation exchange capacity

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**Table 4: Selected soil properties at various soil depths**

Depth (cm)	BD (g/cm <sup>3</sup> )	TP (%)	Ksat(cm/hr)	pH	OC (%)	TN (%)	ECEC (cmol/kg)
0-20	1.62	38.78	0.02	5.72	1.00	0.09	6.40
20-40	1.86	31.14	0.02	5.44	0.89	0.06	5.71
40-60	1.90	28.40	0.04	5.45	0.59	0.05	4.51
LSD (P<0.05)	*	*	*	*	*	*	*

**Note:** \* -significant , BD- Bulk density, TP- Total porosity, Ksat- Saturated hydraulic conductivity, OC- organic carbon, TN- Total nitrogen, SAR- Sodium sorption ratio, ECECEffective cation exchange capacity

**Hydraulic conductivity (Ksat)**

From the result obtained, hydraulic conductivity was 0.04 cmhr<sup>-1</sup> under cassava farm, 0.01 cmhr<sup>-1</sup> under grassland and 0.01 cmhr<sup>-1</sup> under rice farm. Cassava farm had the highest hydraulic conductivity with a value of 0.04 cmhr<sup>-1</sup>, grassland and rice farm had the lowest hydraulic conductivity with equal values of 0.01 cmhr<sup>-1</sup>. Significant differences were observed in hydraulic conductivity of soil across the depths; the study further observed an increase in Ksat value down the depth with 40-60 cm recording the highest value of 0.04 cmhr<sup>-1</sup>. The observed lower hydraulic conductivity obtained under rice farm was in line with the findings of Eshett (1994) who reported soils of paddy rice production to usually have low hydraulic conductivity due to puddling and traffic pan formation. The hydraulic conductivity of soil as observed in this study were generally low which is an indication of the soil inability to transmit water due to water logging and textural characteristics of the studied area.

**Soil pH**

The pH of soil under land use types ranged from 5.16-5.79 and was in the order cassava farm> grassland>rice farm while it ranged from 5.44-5.72 across the depths. Based on the level of acidity, the pH falls in the range of strongly to moderately acidic. The acidic nature of soils under the land use types studied could be a natural reflection of the parent material as reported by Nwosu *et al.* (2020) as well as the very high annual rainfall recorded in the region which facilitates extensive leaching of basic cations leaving behind an impoverished soil predominated by acidic cations (Onweremadu, 2007).

**Soil organic Carbon**

The results showed that organic carbon was highest under cassava farm with a value of 1.12% followed by grassland with a value of 1.00 % while rice farm had the lowest organic carbon content with a value of 0.36 % . Cassava farm had 12% more of organic carbon when compared with grassland. Significant differences were observed in organic carbon contents under land use types which could be associated to variation in residue management, tillage methods, continuous cropping as well as cultivation with different tillage implements as collaborated by the report of Nweke and Ilo (2019). The organic carbon content of soil as obtained in this study was generally low. According to Fullen and Catt (2004) soils with <5% organic matter content is highly erodible. As regards soil depth, organic carbon was highest with a value of 1.00 % at 0-20cm depth and lowest at 40-60cm depth with a value of 0.59 %. The obtained results showed a decrease of organic carbon content down the soil depth; similar observation was made by the work of Nnabude *et al.* (2016). The higher organic carbon at the topsoil against the sub soil could be due to its position in the soil profile; which allows for direct input of organic litter (Sahrawat, 2004). Soil organic carbon has the ability to disperse or aggregate the soil but it is dependent on the threshold level of the organic carbon in the soil as well as the ratio at which it occurs with other aggregating agents.

**Total Nitrogen**

For total nitrogen, cassava farm had 0.09%, grassland had 0.08% while rice farm had 0.03%. Cassava farm recorded the highest total nitrogen content while rice farm recorded the lowest. With regards to soil depth, the result showed a significant difference across the depths which decreased as the depth increased with the highest value of 0.09 % obtained at 0-20 cm depth. The obtained result of total nitrogen across the depths showed close relationship with the recorded value of organic matter; this observation is in line with the submission of Ubuoh *et al.* (2013) who reported that the highest total nitrogen available at the topsoil is a confirmation of structural relationship with organic matter with more than 75% of total nitrogen derived from organic matter. Based on this study,

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the total nitrogen content of soils were generally low. The study of Nweke (2015) and Nwosu *et al.* (2020) found low soil total nitrogen content in their study which they partly attributed to loss of nutrient at the epipedon. Landon (1991) rated total nitrogen content of <0.1% to be very low and 0.1-0.2% to be low.

### Effective Cation Exchange Capacity (ECEC)

The results showed ECEC values of 7.24 cmol/kg, 6.59 cmol/kg and 5.00 cmol/kg respectively under cassava farm, grassland and rice farm. ECEC value obtained under cassava farm was significantly higher when compared to other land use types. Based on depth, highest ECEC value of 6.40 cmol/kg was recorded at 0-20cm depth which decreased down the soil depth with a value of 4.51 cmol/kg being the lowest obtained at 40-60 cm depth. ECEC of a soil shows how well a soil can hold onto and store cations, so a soil with a high CEC would be able to hold more nutrients than a soil with low CEC. Furthermore, Low ECEC soils are more likely to develop potassium and magnesium deficiencies while high ECEC soils are less susceptible to leaching losses of these cations. Based on Landon (1991) rating for CEC, CEC value >40 cmol/kg is very high concentration, 25-40 cmol/kg is high, 15-25 cmol/kg is moderate, 5-15 cmol/kg is low and <5 cmol/kg is very low hence the CEC values as obtained in this study were low. Nweke (2015) in his study stated that the low CEC of an ultisol in southeastern Nigeria could be due to low clay and organic matter concentration in the soil. Generally, surface soils had higher ECEC values compared to sub surface soil which could be attributed to high litter accumulation and decomposition/mineralisation at the surface soil. There were significant differences in ECEC under land use types and across soil depths which may be attributed to the leaching process as well as proportion of clay content; this observation was in line with the findings of Muche *et al.* (2015).

## CONCLUSION

The study observed significant differences in the studied soil properties across the land use practices. The obtained values were generally low and could be associated with management practices in each of the land use hence the need for appropriate and effective conservation measures for optimum soil productivity.

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