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To Evaluate the Effects of Land Degradation on Selected Flood Plains Around Wukari Area, Taraba State

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ABSTRACT
Land degradation is a major constraint to sustainable agricultural production, particularly in floodplain ecosystems that support intensive farming. This study evaluated the effects of physical land degradation on selected floodplains around Wukari, Taraba State, Nigeria. Three floodplain locations (Gindin Dorowa, Newsite, and Tsokundi) were selected for field assessment and soil sampling. Soil samples were analyzed for selected physical properties, including particle size distribution, moisture content, bulk density, total porosity, and water-holding capacity using standard laboratory procedures. Data obtained were subjected to analysis of variance (ANOVA), and treatment means were separated at the 5% probability level. The results revealed significant variations among the study locations. Location A was characterized by the highest sand content (61.84%) and the lowest bulk density (0.90 g cm^{-3}), indicating greater susceptibility to erosion despite lower soil compaction. Location B recorded the highest bulk density (1.59 g cm^{-3}), reflecting severe soil compaction and reduced structural quality resulting from intensive land use. Location C exhibited comparatively better soil structural conditions due to its higher clay content and moderate bulk density. The overall assessment indicated that Location B experienced the greatest degree of physical land degradation, while Location A was primarily vulnerable to erosion because of its coarse soil texture. The study demonstrates that soil physical properties are effective indicators for evaluating land degradation in floodplain environments and highlights the need for sustainable land management practices, including controlled grazing, reduced tillage, erosion control measures, and improved vegetation cover to minimize further degradation and sustain agricultural productivity.

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INTRODUCTION

Land degradation is one of the most serious environmental challenges limiting agricultural productivity under both rainfed and irrigated farming systems. It has received considerable global attention because of its adverse effects on soil productivity, food security, ecosystem functioning, and sustainable agricultural development. Land degradation refers to the deterioration of the physical, chemical, biological, and ecological quality of land resulting from natural processes and unsustainable human activities (Kabiru, 2023; EOSDA, 2025). Major forms of degradation include soil erosion, nutrient depletion, salinization, acidification, compaction, desertification, and pollution.

Globally, land degradation has reduced the productive capacity of agricultural soils. For example, Eswaran (2019) reported that approximately 75 t ha^{-1} of productive soil is lost annually through degradation in Zimbabwe, accompanied by annual nutrient losses of about 22 kg N, 3 kg P, and 15 kg K ha^{-1}. Such losses substantially reduce soil fertility, crop productivity, and environmental quality.

Land degradation occurs when the productive capacity of soil declines because of deterioration in its biological, chemical, physical, and hydrological properties, often accelerated by water erosion, wind erosion, and mass movement (LADA and FAO, 2025). Healthy soils are fundamental to sustainable agriculture because they store nutrients and water, support diverse microbial communities, and provide a suitable medium for plant growth. Soil organic matter plays a central role in maintaining soil structure, nutrient cycling, and long-term productivity (Obalum et al., 2017). Although alternative production systems such as hydroponics are increasingly being adopted, soil-based agriculture continues to account for more than 90% of global food production.

In Nigeria and many tropical regions, land degradation is characterized by soil erosion, nutrient depletion, compaction, salinity, and soil acidity. These problems are largely associated with continuous cultivation, bush burning, overgrazing, deforestation, and poor land management practices (Yusuf et al., 2015; Mohammed et al., 2019). Among these, soil erosion remains one of the most destructive forms of degradation because it removes fertile topsoil, alters landforms, and reduces soil nutrient reserves (Al-Kaisi et al., 2022).

Floodplains are naturally fertile landscapes that support intensive agricultural production because of periodic deposition of nutrient-rich sediments. However, increasing cultivation, flooding, and unsustainable management practices have accelerated land degradation in many floodplain ecosystems. Despite their agricultural importance, limited information exists on the extent and effects of land degradation within the floodplains surrounding Wukari, Taraba State. Therefore, this study was conducted to evaluate the effects of land degradation on selected floodplains in the study area with a view to providing information that will support sustainable land management and agricultural productivity

Land degradation has become a major challenge to agricultural production in Nigeria and across the world. Increasing population pressure has intensified the exploitation of land resources, resulting in declining soil quality and reduced agricultural productivity. Human-induced activities such as continuous cultivation, excessive fertilizer application, inappropriate tillage practices, poor drainage, overgrazing, and uncontrolled flooding have accelerated the degradation of agricultural lands (Muchena et al., 2005; Yusuf et al., 2015).

These activities contribute to soil compaction, erosion, waterlogging, soil acidity, nutrient depletion, and the accumulation of soluble salts, thereby reducing land capability and suitability for sustainable crop production. Although these problems are widely recognized, there is limited documented information on the nature and extent of land degradation affecting the floodplains around Wukari, Taraba State. This information gap limits the development of appropriate land management strategies. Consequently, there is a need to assess the extent of land degradation in the study area to provide baseline information for sustainable management and conservation of these productive floodplain ecosystems.

This study was undertaken to address the limited information on land degradation within the floodplains of Wukari, Taraba State. The findings will contribute to the understanding of the occurrence and severity of land degradation in the study area and provide scientific evidence for future research.

The results are expected to assist farmers, researchers, extension agents, and policymakers in developing and implementing sustainable land management practices aimed at reducing further degradation. In addition, the study will provide baseline information for monitoring changes in land quality and promoting improved agricultural productivity and environmental sustainability within the floodplain ecosystem.

The aim of this study is to assess and compare the extent of physical land degradation across selected floodplains in the study area and to identify appropriate management practices for mitigating land degradation and promoting sustainable floodplain management..

MATERIALS AND METHODS

Study Area

The study was conducted at three locations within Wukari Local Government Area (LGA) of Taraba State, Nigeria, namely Gindin Dorowa, Newsite, and Tsokundi. The study area lies within the Northern Guinea Savanna agro-ecological zone of northeastern Nigeria. The locations are situated between Latitude 7°50′36.65″N and 7°50′51.19″N, and Longitude 9°45′49.21″E and 9°46′21.48″E, at an average elevation of approximately 155 m above sea level

Climate and Vegetation

Wukari LGA experiences a tropical savanna climate characterized by distinct wet and dry seasons. Mean annual temperatures range from 26 to 32°C, with the highest temperatures occurring between February and April, when temperatures may exceed 34°C. Annual rainfall ranges from approximately 861 to 1,300 mm, with more than 120 rainy days per year. Rainfall generally begins in April, peaks between June and August, and declines towards October (Gani et al., 2022).

The natural vegetation consists mainly of Guinea Savanna species, dominated by tall grasses such as Andropogon gayanus, Stylosanthes gracilis, and Pennisetum purpureum. Common tree species include Daniellia oliveri, Parkia biglobosa, and Prosopis africana. These climatic and vegetation characteristics influence soil development, land use, and the susceptibility of floodplain soils to physical degradation.

Farming Practices

Agriculture is the predominant economic activity in the study area. Farmers practice mixed farming involving crop production and livestock rearing. Major crops cultivated on the floodplains include rice, banana, sugarcane, pepper, potato, and maize, while upland areas are mainly used for the cultivation of Bambara groundnut, guinea corn, cassava, soybean, millet, cowpea, yam, sesame, and groundnut. Cattle are the dominant livestock species reared in the area. During the prolonged dry season, grazing activities expose the soil surface to direct solar radiation, thereby increasing the risk of soil physical degradation.

Socio-economic Characteristics

The inhabitants of the study area are predominantly farmers, fishermen, and livestock keepers. Farming is practiced throughout both the rainy and dry seasons due to the availability of water within the floodplain. A few residents are also engaged in trading and other small-scale businesses. Information on the socio-economic characteristics of the study area was obtained through personal observations and informal interviews with community members.

Field Investigation

Field investigations were conducted using rain boots, field overalls, a field notebook, measuring tape, spade, Abney level, camera, and other relevant field equipment. The assessment focused on indicators of physical land degradation, including evidence of soil erosion, surface crusting, compaction, sediment deposition, slope characteristics, vegetation cover, and other visible land surface conditions.

Each of the three study locations comprised three sampling sites. Field observations were carried out before the onset of the rainy season and repeated at the beginning of the rainy season to evaluate changes in land surface conditions. The severity of physical land degradation was classified as low, moderate, high, or very high based on field observations.

Field Topography

The study area is characterized by gently undulating terrain interspersed with extensive floodplains. Surface materials consist mainly of alluvial deposits, silt, clay, and gravelly sediments depending on location.

Slope Determination

Slope was determined by measuring the vertical rise and horizontal distance using an Abney level and measuring tape. Percentage slope was calculated as:

$$\text{Slope (\%)} = (\text{Vertical rise} / \text{Horizontal distance}) \times 100$$

General observations on topography, vegetation cover, land use, and visible erosion features were also recorded and representative photographs were taken.

Assessment of Physical Land Degradation

Physical land degradation was assessed through direct field observations and laboratory analysis of selected soil physical properties. Indicators considered included soil erosion, compaction, surface crusting, sediment deposition, vegetation cover, and slope characteristics. These indicators were used to classify the degree of degradation across the study sites.

Laboratory Analysis

Determination of Soil Physical Properties

The collected soil samples were analyzed for selected physical properties, including bulk density, particle size distribution, and water-holding capacity.

Bulk Density

Bulk density was determined using the core (volumetric cylinder) method following the procedures described by ISO (2017) and Casanova et al. (2016). Undisturbed soil cores were collected using a cylindrical metal core, oven-dried at 105°C until constant weight, and weighed. Bulk density was calculated as:

Bulk Density (g cm^{-3}) = Oven-dry mass of soil / Core volume

Moisture content was calculated as:

Moisture Content = (Mass of moist soil − Mass of oven-dry soil) / Mass of oven-dry soil

Particle Size Distribution

Particle size distribution was determined using the Bouyoucos Hydrometer method (Bouyoucos, 1927). The percentages of sand, silt, and clay were determined, and soil textural classes were assigned using the USDA textural triangle.

Water-Holding Capacity

Water-holding capacity was determined as the amount of water retained by the soil relative to its oven-dry weight following the method described by Madhu et al. (2014).

Statistical Analysis

Data generated from the study were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Statistix 10 software. Mean separation was carried out where significant differences existed at the 5% probability level. Results are presented using tables and figures where appropriate.

Particle Size Distribution

The particle size distribution of soils varied among the three study locations (Table 4.1). Location A recorded 3.59% clay, 34.57% silt, and 61.84% sand, and was classified as sandy loam. Location B contained 5.73% clay, 40.41% silt, and 54.77% sand, corresponding to a silt loam textural class. Location C recorded 17.09% clay, 28.13% silt, and 53.86% sand, and was classified as loam.

The predominance of sand in Location A indicates a greater susceptibility to physical degradation, particularly soil erosion. Sandy soils generally possess low water-holding capacity, weak aggregate stability, and limited nutrient retention, making them more vulnerable to erosion and other degradation processes. The high sand content observed in this location may have resulted from the preferential removal of finer particles (clay and silt) through erosion, leaving behind coarse sand particles. This finding agrees with Gani and Awwal (2025), who reported that erosion in upland areas of Wukari resulted in a reduction in clay content due to the redistribution of finer soil particles. Similarly, Ferrara et al. (2020) observed that land degradation alters soil texture through the selective displacement of fine soil fractions.

In contrast, the relatively higher clay content recorded in Location C suggests improved soil aggregation, greater moisture retention, and enhanced structural stability compared with Location A. These characteristics indicate a relatively lower degree of physical degradation. This observation is consistent with the findings of Muhammed et al. (2019), who reported that soils with higher clay contents generally exhibit better structural stability and greater resistance to physical degradation under less disturbed land-use conditions.

Effects of Land Degradation on Soil Physical Properties

Particle Size Distribution

Table1: Effects of Land Degradation on Soil Particle Size Distribution

LDL	Clay (%)	Silt (%)	Sand (%)	Textural
A	3.593±1.89	34.567±10.752	61.840±11.085	Sandy Loam
B	5.727±1.89	40.413±10.752	54.773±11.085	Silt Loam
C	17.093±1.89	28.133±10.752	53.860±11.085	Loam

Table 1 shows the effects of land degradation on soil particle size distribution (clay, silt and sand fractions) across Locations A, B and C.

Soil Moisture Content

Soil moisture content differed significantly ($P < 0.05$) among the three study locations (Table 4.2). Location A recorded the highest moisture content (26.33%), followed by Location B (16.00%), while Location C recorded the lowest value (14.33%).

The significantly higher soil moisture content observed in Location A may be attributed to its floodplain position, which is characterized by periodic flooding and sediment deposition that enhance temporary water storage. Although the soil at this location was predominantly sandy, seasonal flooding may have increased moisture retention during the sampling period. Similar observations were reported by Gani and Awwal (2025), who found that floodplain soils in Wukari exhibited considerable variations in soil moisture depending on drainage conditions, flooding frequency, and the degree of soil compaction.

In contrast, the relatively lower moisture contents recorded in Locations B and C suggest reduced water retention, which may be associated with soil structural degradation, increased compaction, or limited infiltration. Physical degradation often alters soil pore distribution, resulting in reduced water storage capacity and uneven moisture availability. Ferrara et al. (2020) similarly reported that degraded soils commonly exhibit irregular moisture distribution due to deterioration of soil structure and changes in pore characteristics.

Overall, the observed variation in soil moisture content among the study locations indicates differences in the degree of physical land degradation and site-specific environmental conditions, particularly topography, drainage characteristics, and soil structural quality.

Bulk Density (BD)

Bulk density varied significantly among the study locations. Location B recorded the highest bulk density (1.5933 g cm^{-3}), followed by Location C (1.2533 g cm^{-3}), while Location A had the lowest value (0.9000 g cm^{-3}). The high bulk density observed in Location B indicates severe soil compaction, which is a common symptom of physical land degradation. Soil compaction reduces pore space, restricts root penetration, limits water infiltration, and decreases soil aeration, thereby adversely affecting plant growth and overall soil productivity. The elevated bulk density in Location B may be attributed to continuous cultivation, livestock trampling, and repeated mechanical disturbance. These findings agree with Gani and Awwal (2025), who reported increased bulk density in cultivated floodplain soils of Wukari as a consequence of anthropogenic activities. Similarly, Kowalska et al. (2018) observed that soil compaction increases bulk density and weakens soil structural stability in degraded landscapes. In contrast, the lower bulk density recorded in Location A suggests better soil aggregation and reduced compaction, although its sandy texture may increase susceptibility to erosion.

Total Porosity (TP)

Total porosity differed significantly across the study locations, with values of 69.00%, 54.33%, and 38.33% recorded for Locations B, C, and A, respectively. Although total porosity is generally expected to decrease as bulk density increases, the high porosity observed in Location B alongside its high bulk density is inconsistent with the typical physical relationship between these properties. This discrepancy may reflect differences in pore-size distribution, soil structural instability, or possible measurement or calculation errors, and therefore should be interpreted with caution. Variations in total porosity among the study sites indicate that land degradation has altered soil structure and pore characteristics. Changes in pore distribution can reduce effective water movement, limit aeration, and impair root development. Ferrara et al. (2020) reported that land degradation disrupts pore continuity and negatively affects soil hydraulic behaviour, while Muhammed et al. (2019) similarly found that continuous cultivation alters soil porosity through structural degradation.

Effects of Land Degradation on Moisture Content, Bulk Density and Total Porosity

Table 2: Effects of Land Degradation on Mst, Bd And Tp

LDL	Mst	BD	TP
A	26.333[a]	0.9000[c]	38.333[c]
B	16.000[b]	1.5933[a]	69.000[a]
C	14.333[b]	1.2533[b]	54.333[b]
SD.E(±)	±2.0458	±0.0891	±3.6768
C.V	5.6800	0.2474	10.208

Key: LDL= land degradation location, Mst =moistoure content, BD= bulk density, and TP= total porosity, the statistical grouping (a, b) shows significant differences among locations, CV=Critical Value for Comparison, SDE=Standard Error for Comparison

Comparison of Degree of Damage

The comparative assessment of the soil physical degradation indicators revealed clear differences in the degree of degradation among the three study locations. Based on the measured physical properties, Location B exhibited the highest level of soil physical degradation. This conclusion is supported by its significantly higher bulk density (1.5933 g cm^{-3}), lower soil moisture content, and evidence of structural deterioration. The high bulk density indicates severe soil compaction, reduced pore space, restricted root penetration, and poor soil aeration, suggesting substantial anthropogenic disturbance resulting from continuous cultivation and intensive land use.

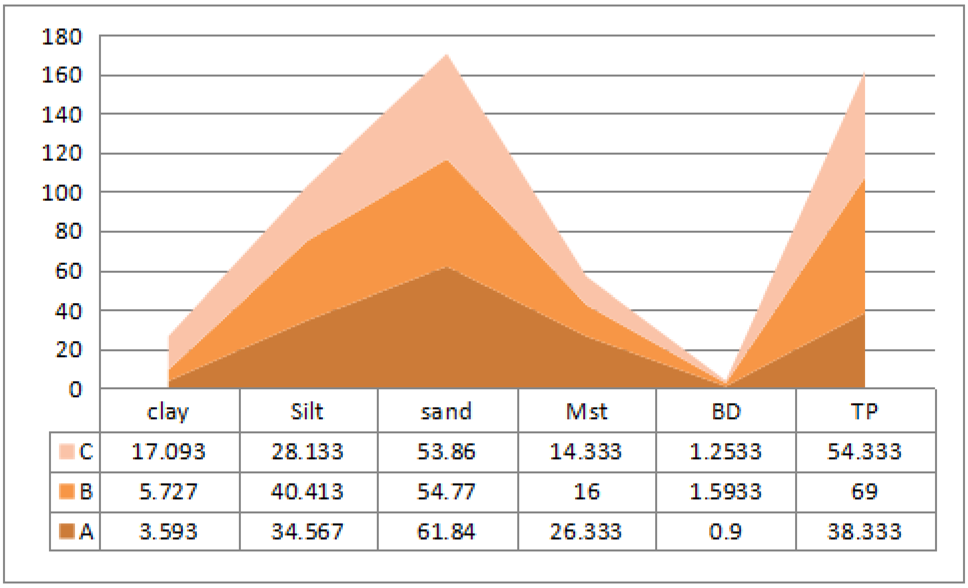

Figure 1: Display the Trend Comparison of Degree of Damage Over Time

Table 3: Overall Percent of Degradation

Parameter	Clay	silt	sand	Mst	Bd	Tp

Most affected location	C (17.093%)	B (40.413%)	A (61.84%)	A (26.333%)	B (1.5933g/cm³)	B (69%)

Although Location A recorded the lowest bulk density, it contained the highest sand fraction (61.84%), indicating a greater susceptibility to erosion. The predominance of coarse soil particles suggests that finer particles such as silt and clay may have been selectively removed through surface runoff, flooding, or other erosive processes. Consequently, despite its favourable bulk density, the soil remains vulnerable to further physical degradation if appropriate conservation measures are not implemented.

Location C exhibited an intermediate degree of degradation. Its loamy texture, moderate bulk density, and relatively balanced particle-size distribution indicate better structural stability than Locations A and B. These characteristics suggest that the soil has retained a comparatively favourable physical condition, although signs of degradation are still evident.

Overall, the severity of soil physical degradation followed the order:

Location B > Location C > Location A

This trend is consistent with the toposequence-based assessment reported by Gani and Awwal (2025), who observed variations in degradation intensity across upland, midland, and lowland positions in Wukari. Their study reported greater soil compaction in cultivated lowland areas and higher erosion susceptibility in upland sandy soils, corresponding to the conditions observed in Locations B and A, respectively. Similarly, Gonzalez-Roglich et al. (2019) reported that land degradation is commonly characterized by increased soil compaction, changes in soil texture, and deterioration of soil structure, all of which were evident in the present study.

CONCLUSION

This study evaluated the effects of physical land degradation on selected floodplains in Wukari Local Government Area of Taraba State using selected soil physical properties as indicators. The results showed that the degree of degradation varied among the study locations. Location B exhibited the highest level of physical degradation, as evidenced by its high bulk density, indicating severe soil compaction and reduced soil quality. Although Location A recorded the lowest bulk density, its high sand content suggests greater vulnerability to soil erosion and reduced moisture and nutrient retention. Location C showed comparatively better soil physical conditions, reflecting lower degradation severity.

The findings demonstrate that variations in soil texture, bulk density, moisture content, and porosity provide reliable indicators for assessing physical land degradation in floodplain ecosystems. If left unmanaged, continued soil compaction and erosion may reduce soil productivity and threaten the long-term sustainability of agricultural production in the study area. Therefore, adopting appropriate soil conservation measures, minimizing excessive tillage and grazing, maintaining vegetation cover, and implementing erosion control practices are essential for improving soil quality and sustaining agricultural productivity in the floodplains around Wukari.

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