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Evaluation of Pedogenic Characteristics of Some Soils Along the Floodplain Areas of Benue River in Girei Local Government Area of Adamawa State, Nigeria

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ABSTRACT

Floodplain ecosystems (*fadama*) in the semi-arid Northern Guinea Savanna of Nigeria are critical for dry-season recession farming, yet they remain vulnerable to degradation due to coarse sandstone-derived parent materials and complex hydrological variations. This study evaluated the pedogenic, physical, and chemical characteristics of soils across nine representative pedons along the Benue River floodplain in Girei Local Government Area, Adamawa State, to address a lack of site-specific data and guide agricultural planning. In situ morphological descriptions were performed across meander channels, back swamps, and natural levees. Soil samples collected from genetic horizons were analyzed for particle size distribution, bulk density, pH, organic carbon (OC), total nitrogen (TN), available phosphorus (AVP), and exchangeable properties. Morphological analysis revealed low-chroma matrix colors (e.g., 2.5Y 4/2, 7.5YR 3/1), signaling strong hydromorphic (gleying) conditions from seasonal flooding. Textures ranged from Sandy Clay Loam to Loamy Sand, heavily dominated by sand (69.15% to 81.07%). Chemically, soil pH trended from slightly acidic to neutral (6.22 to 7.00), and electrical conductivity was low (0.10 to 0.26 dS/m), indicating zero salinity hazards. While OC was relatively high (8.11 to 12.19 g/kg) due to flood deposition, TN (0.08% to 0.12%) and AVP (5.50 to 10.25 mg/kg) were low to moderate. Effective Cation Exchange Capacity (ECEC) was low (3.12 to 5.18 cmol/kg), and Percentage Base Saturation (PBS) uniformly fell below the 50% critical threshold (29.07% to 49.73%). Owing to their low base status, weak profile development, and aquic moisture regimes, the soils are taxonomically classified as Inceptisols (Aquepts / Fluvaquents) or Ultisols (Aquic sub-groups), requiring deliberate organic and phosphate amendments for sustainable production.

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1.0 INTRODUCTION

Floodplain ecosystems represent some of the most dynamic and agriculturally productive landscapes globally, serving as vital repositories for alluvial deposits and driving regional food security frameworks (FAO, 1996). In sub-Saharan Africa, particularly within the semi-arid regions of Nigeria, these riverine environments locally termed fadama play an indispensable role in buffering the impacts of seasonal dry spells by supporting continuous, recession-based dry-season cultivation. The Benue River, a major hydrological pathway in Nigeria, carves a vast alluvial valley characterized by complex depositional mechanics, shifting hydrological regimes, and distinct micro-topographical variations (Usman, 2019).

The soils bordering the Benue River floodplain are highly heterogeneous, reflecting the continuous interaction between modern alluvial sediment sorting and seasonal moisture variations. Pedogenesis in these environments is distinctively governed by hydromorphic or aquic conditions. Periodic flood during the peak wet season induces prolonged anaerobic states, driving profound changes in the soil matrix. Under these saturated conditions, the biochemical reduction of ferric iron (Fe^{3+}) to soluble ferrous iron (Fe^{2+}) occurs, initiating the process of gleying and the formation of low-chroma redoximorphic features (Ojanuga, 2006). Conversely, the withdrawal of floodwaters during the dry season triggers re-oxidation, leading to a complex pattern of structural aggregation, localized recrystallization of phosphorus complexes, and fluctuating nutrient dynamics (Brady & Weil, 2016; Buba et al., 2020).

Regardless of their high agricultural utility, floodplains are prone to rapid structural and chemical degradation. In the Girei Local Government Area of Adamawa State, these soils are heavily influenced by sandstone-derived parent materials from the neighboring uplands, introducing a high proportion of coarse sand fractions (Rayar & Haruna, 2012; Manly et al., 2023). This coarse texture can result in low water-holding capacity, rapid structural collapse upon drying, and weak charge density on the exchange complex, leaving essential nutrients vulnerable to leaching (Hassan et al., 2020).

Sustainable management and optimization of these alluvial resources require a precise understanding of their inherent physical, chemical, and pedogenic traits. While generalized soil surveys exist for the Upper Benue region, detailed, site-specific pedological evaluations along the floodplains of Girei LGA remain sparse. This lack of localized data hinders the development of targeted soil amendment protocols and proper taxonomic classifications needed to guide agricultural planning. To bridge this data gap, this study provides a comprehensive evaluation of the pedogenic characteristics of selected soils along the Benue River floodplain in Girei LGA. Specifically, this research aims to characterize the morphological, physical, and chemical attributes of these soils across nine representative pedons.

2.0 METHODOLOGY

The research was conducted within the floodplain areas of the Benue River valley in Girei Local Government Area, Adamawa State, Nigeria. Girei is located between latitudes 9^0 22N and 9^0 31N and longitudes 12^0 32E and 12^0 58E with an elevation of 150m above sea level. The study area lies within the Northern Guinea Savanna agroecological zone. It experiences a semi-arid tropical climate characterized by two distinct seasons, a wet season spanning May to October and a prolonged dry season from November to April. The mean annual rainfall typically ranges between 900 mm and 1100 mm, with peak precipitation occurring in August. Ambient temperatures are high year-round, with maximum limits reaching up to 40°C during the transition months of March and April.

The underlying geology is predominantly composed of alluvial deposits superimposed on Cretaceous sandstones (Bima Sandstones) and associated crystalline basement rocks that flank the Benue trough (Usman, 2019; Manly et al., 2023). The natural vegetation consists of open savanna woodlands, drought-resistant shrubs, and low-energy wetland grasses (fadama vegetation) heavily modified by intensive cultivation and grazing.

A purposive sampling strategy based on a reconnaissance survey was employed to select nine representative sampling points (designated as Pedons 1 through 9) across the meander channels, backswamps, and natural levees of the floodplain. At each selected point, standard soil profile pits (2 m × 1.5 m × 2 m depth, or terminating at the water table) were excavated. The morphological description of each profile was conducted in situ following the Guidelines for Soil Description (FAO, 2006).

All physical and chemical properties were subjected to descriptive statistics to obtain their mean values. Key physical characteristics documented in the field included dominant soil matrix and mottle colors (determined using the Munsell Soil Color Charts under moist conditions), structural development, consistency, and evidence of hydromorphic signatures (such as gleying and redoximorphic features). Bulk and core soil samples were collected from identified genetic horizons across all nine pedons, securely labeled in polythene bags, and transferred to the laboratory for processing.

Soil samples collected were air-dried, gently crushed with a mortar and pestle, and passed through a 2 mm sieve to isolate the fine earth fraction. Particle Size Distribution was quantified using the hydrometer method to determine the percentages of sand, silt, and clay fractions, with textural classes using the USDA textural triangle. Bulk density was measured using the undisturbed core method after drying the core samples to a constant weight at 105°C. Particle density was determined using the pycnometer/specific gravity bottle method. Total Porosity was computed mathematically from the bulk density and particle density relationship using the formula: $f = (1- \rho b/\rho\ s) \times 100$. Water-Holding Capacity (WHC) was determined using gravimetric methods on saturated soil pastes subjected to standardized drainage frameworks.

Chemical Properties Analysis Soil pH was measured potentiometrically in a 1:2.5 soil-to-water suspension (pH H_2O) using a calibrated digital pH meter. Electrical Conductivity (EC) was evaluated in the 1:2.5 soil-water extract supernatant using a standard conductivity bridge, expressed in deciSiemens per meter (dS/m). Organic Carbon (OC) was determined via the Walkley-Black wet oxidation method through digestion with potassium dichromate ($K_2Cr_2O_7$) and back-titration with ferrous ammonium sulfate. Total Nitrogen (TN) was determine using the regular macro-Kjeldahl digestion, distillation, and titration procedure. Available Phosphorus (AVP) was extracted using the Bray No. 1 solution and quantified via the molybdenumblue colorimetric method on a spectrophotometer. Exchangeable Bases (Ca^{2+}, Mg^{2+}, K^+, Na^+) were displaced from the exchange complex using 1 M neutral ammonium acetate (NH_4 OAc, pH 7.0). Exchangeable

Potassium (K^+) and Sodium (Na^+) concentrations were determine using flame photometry, while Calcium (Ca^{2+}) and Magnesium (Mg^{2+}) values were determined using atomic absorption spectrophotometry (AAS). Total Exchangeable Acidity (TEA) was extracted with 1 M potassium chloride (KCl) solution and determined through titration with a standard sodium hydroxide (NaOH) solution. Effective Cation Exchange Capacity (ECEC) was derived mathematically by summing the Total Exchangeable Bases (TEB) and the Total Exchangeable Acidity (TEA) as thus: ECEC = TEB + TEA. Percentage Base Saturation (PBS) was calculated as the proportion of ECEC occupied by basic cations, expressed as a percentage: PBS = (TEB/ECEC) × 100.

3.0 RESULT AND DISCUSSION

3.1 Soil Physical Properties

The dominant soil matrix colours vary from low-chroma hues (2.5Y 4/2, 2.5Y 3/2) to dark, low-value matrices (7.5Y 3/1, 5Y 2.5/1, and 2.5YR 4/1). These low-chroma (≤2) signatures across the studied pedons are classic indicators of aquic moisture regimes and prolonged hydromorphic constraints. Seasonal flooding of the Benue River induces anaerobic conditions, prompting the biochemical reduction of ferric iron (Fe^{3+}) to soluble ferrous iron (Fe^{2+}) and leaving behind depleted grey, dark-brown, or olive-grey matrices. This process, known as gleying, reflects fluctuating groundwater tables and episodic stagnation along the meander channels and plains. These observations corroborate the findings of Ojanuga (2006) and Rajab et al. (2021), who noted that low-chroma values and mottling in Nigerian river floodplains are direct outcomes of alternating reduction-oxidation cycles induced by seasonal water table fluctuations.

The soils are heavily dominated by the sand fraction, which ranges from 69.15% in Pedon 4 to 81.07% in Pedon 8. Conversely, mean silt contents are consistently low across all profiles, varying between 6.80% (Pedon 8) and 10.30% (Pedon 4). Clay content is moderately distributed, dropping from 21.80% in Pedon 1 to 12.13% in Pedon 8. This creates two distinct textural groups: Sandy Clay Loam in Pedons 1, 3, 4, and 5, and a lighter Sandy Loam to Loamy Sand in Pedons 2, 6, 7, 8, and 9. This high sand-to-silt ratio is a direct reflection of active, modern alluvial river depositional mechanics. High-energy floodwaters selectively deposit coarser sand aggregates onto natural levees, while finer clays settle further away within low-energy backswamps. Similar coarse-textured dominances along the Benue and Niger floodplains have been reported by Rayar and Haruna (2012) and Usman (2019), who attributed the spatial heterogeneity of textures to depositional sorting and the nature of the sandstone-derived parent materials flanking the Benue valley.

The mean bulk density values across the floodplain profiles range between 1.45g/cm^3 (Pedon 1) and 1.56 g/cm^3 (Pedons 7 and 8). The slightly lower bulk density values in Pedons 1 through 4 align directly with their higher clay fractions (> 20%) and elevated organic matter profiles. This is mirrored in the total porosity values, where Pedons 1–4 express superior macro-porosity and structural frameworks (43.44% to 45.63%) compared to the highly sandy Pedons 5–9 (40.18% to 41.24%). The mean water-holding capacity (WHC) follows a parallel physical trend, peaking at 11.17% in Pedon 1 and declining to 9.35% in the loamy sands of Pedons 7 and 9. These low overall WHC benchmarks mean that despite seasonal flood saturation, the sandy nature of these soils could limit dry-season crop performance unless supported by organic amendments. These physical values line up with the work of Sharu et al. (2013) and Hassan et al. (2020), who documented that high sand fractions in semi-arid alluvial soils drastically restrict structural aggregation, leading to high bulk densities and rapid structural collapse when dried.

Table 1: Physical Properties of the Study Area

Physical Property	Pedon 1	Pedon 2	Pedon 3	Pedon 4	Pedon 5	Pedon 6	Pedon 7	Pedon 8	Pedon 9
Dominant soil colour (moist)	2.5YR4/1	10YR6/4	10YR4/2	7.5YR3/1	5YR4/1	2.5Y3/2	2.5YR3/1	5YR2.5/1	2.5Y4/2
Dominant texture class	Sandy clay loam	Sandy loam	Sandy clay loam	Sandy clay loam	Sandy clay loam	Sandy loam	Loamy sand	Sandy loam	Sandy loam
Mean sand (%)	70.65	71.46	71.15	69.15	79.59	79.96	80.78	81.07	74.78
Mean silt (%)	7.55	7.99	7.80	10.30	7.18	7.36	7.05	6.80	8.68
Mean clay (%)	21.80	20.55	21.05	20.55	13.24	12.68	12.18	12.13	16.55
Mean bulk density (g/cm³)	1.45	1.46	1.46	1.46	1.55	1.55	1.56	1.56	1.50
Mean particle density (g/cm³)	2.57	2.58	2.67	2.68	2.63	2.59	2.61	2.63	2.55
Mean total porosity (%)	43.55	43.44	45.35	45.63	41.09	40.26	40.18	40.86	41.24
Mean water-holding capacity (%)	11.17	10.71	10.21	10.82	10.52	9.60	9.35	9.60	9.35

3.2 Soil Chemical Properties

The soil pH values across the nine pedons indicate slightly acid to neutral conditions, ranging from 6.22 (Pedon 4) to 7.00 (Pedon 2). This near-neutral chemical status is a direct function of the cyclic flooding environment described by De Datta (1986). When acid soils undergo seasonal submersion, the reduction of Fe^{3+} oxides consumes free hydrogen ions, driving the soil pH upward toward neutrality. This behavior is well-documented in Nigerian hydromorphic soils; for example, Kyari et al. (2018) and Ibrahim et al. (2022) observed a similar converging shift toward neutrality in flooded soils of northeastern Nigeria, emphasizing that such temporary pH increases enhance overall nutrient availability. The Electrical Conductivity (EC) values are low everywhere, fluctuating between 0.10 dS/m and 0.26 dS/m. Because these values fall well below the critical threshold of 4.0 dS/m, these floodplain zones are completely free from salinity hazards, ensuring that osmotic potentials will not restrict crop root uptake a finding that mirrors report by Voncir et al. (2008) on the upper Benue River basin. The organic carbon content is high for savanna ecosystems, ranging from 8.11

g/kg (Pedon 2) to 12.19 g/kg (Pedon 7). This organic matter accumulation is driven by regular deposition of organic-rich river silt and slowed decomposition rates during prolonged anaerobic flooding periods.

Total Nitrogen levels follow a proportional trend, matching the low-to-moderate thresholds typical of West African soils, ranging from 0.08% to 0.12%. The uniform alignment of total nitrogen with organic carbon indicates that mineralized soil organic matter remains the primary source of nitrogen for local crop production. This pattern of high OC but low-to-moderate TN in wetlands matches the observations of Mustapha et al. (2014) and Yakubu et al. (2011), who noted that seasonal waterlogging hinders rapid mineralization, allowing organic fragments to accumulate while nitrogen is lost via denitrification or leaching during high-water stages.

Available Phosphorus varies across the floodplains, ranging from a minimum of 5.50 mg/kg in Pedon 1 to a maximum of 10.25 mg/kg in Pedon 9. These levels fall within the low-to-medium fertility range. The moderate concentration of available P is typical of hydromorphic environments where reductive dissolution of iron phosphate complexes ($FePO_4 \cdot 2H_2O$) occurs during flooding, releasing bounded orthophosphates into the soil solution. However, once floodwaters recede and the profiles re-oxidize, phosphorus can become tied up again by crystalline iron oxides. This dynamic is supported by Brady and Weil (2016) and was empirically confirmed in Nigerian floodplains by Buba et al. (2020), who reported that post-flood recrystallization of iron compounds rapidly retrogrades available orthophosphates into insoluble forms, explaining why dry-season crops on these plains require targeted phosphate applications despite wet-season availability.

The exchangeable bases exhibit an unexpected order of abundance, where Potassium (K^+) or Sodium Na^+ occasionally override the divalent cations Ca^{2+} 0.10 to 0.31cmol/kg; Mg^{2+}: 0.17 to 0.39 cmol/kg; K^+: up to 1.17 cmol/kg; Na^+: 0.29 to 0.82 cmol/kg. The total exchangeable bases (TEB) are low overall, ranging between 0.87 cmol/kg (Pedon 3) and 2.33 cmol/kg (Pedon 7). This stands in contrast to the high total exchangeable acidity (TEA), which ranges from 1.93 to 2.85cmol/kg, primarily driven by exchangeable aluminum Al^{3+}. Consequently, the Effective Cation Exchange Capacity (ECEC) values are low across all pedons, ranging from 3.12 cmol/kg to 5.18 cmol/kg. This indicates a weak charge density on the exchange complex, meaning the soils have a limited ability to retain major nutrient cations against leaching. This low ECEC pattern conforms to findings by Chikezie et al. (2010) and Manly et al. (2023) for savanna soils derived from highly weathered sandstones and alluvial deposits, where kaolinite and quartz minerals dominate the clay fraction and yield limited cation exchange sites. The Percentage Base Saturation (PBS) values range between a low of 29.07% (Pedon 3) and a maximum of 49.73% (Pedon 4).

Crucially, every single pedon exhibits a base saturation below the critical 50% diagnostic threshold. Under the rules of the USDA Soil Taxonomy system, a base saturation below 50% (by ECEC) within diagnostic horizons means these soils cannot be classified into base-rich categories like Alfisols. Instead, these profiles show characteristics of younger, weakly developed profiles with dystric properties.

Given their low base statuses, low-chroma hydromorphic mottling, and sandy textures, these profiles are classified as Inceptisols (Aquepts / Fluvaquents) or highly weathered, low-based Ultisols (Aquic sub-groups). This taxonomic diagnosis matches classification trends established by Ojanuga (2006) and Amhakhian et al. (2016), who classified similar low-base, acidic coarse-textured floodplain soils of northern and central Nigeria within the Inceptisol and Ultisol orders.

Table 2: Chemical Properties of the Study Area

Pedon	pH	EC	OC	TN	AVP	Ca	Mg	K	Na	TEB	TEA	ECEC	PBS
Pedon 1	6.7	0.11	11.37	0.12	5.5	0.18	0.25	0.48	0.37	1.28	2.7	3.98	35.91
Pedon 2	7.0	0.11	8.11	0.08	6.5	0.27	0.33	0.16	0.36	1.12	2.15	3.27	34.4
Pedon 3	6.62	0.12	9.55	0.1	6.75	0.12	0.17	0.15	0.43	0.87	2.25	3.12	29.07
Pedon 4	6.22	0.1	10.33	0.1	8.5	0.29	0.36	0.86	0.41	1.93	2.25	4.17	49.73
Pedon 5	6.42	0.1	9.01	0.09	6.75	0.31	0.39	0.12	0.5	1.32	2.05	3.37	39.28
Pedon 6	6.53	0.15	10.28	0.1	7.25	0.25	0.33	0.44	0.82	1.84	2.85	4.69	40.08
Pedon 7	6.47	0.11	12.19	0.12	7.0	0.27	0.35	1.17	0.53	2.33	2.85	5.18	43.99
Pedon 8	6.77	0.26	11.44	0.11	6.67	0.17	0.2	0.52	0.29	1.18	1.93	3.12	36.55
Pedon 9	6.65	0.12	10.08	0.1	10.25	0.1	0.21	0.15	0.75	1.21	2.1	3.31	35.46

4.0 SUMMARY AND CONCLUSION

This study conducted a comprehensive pedological evaluation of nine representative soil profiles along the Benue River floodplain in Girei Local Government Area, Adamawa State, Nigeria, to address the critical gap in site-specific soil data and inform sustainable agricultural planning in these dynamically productive fadama ecosystems. Soils exhibited classic aquic moisture regime signatures, characterized by low-chroma matrix colors (2.5Y 4/2, 7.5YR 3/1, 5Y 2.5/1), indicating strong hydromorphic (gleying) processes driven by seasonal flooding and periodic anaerobic conditions. Redoximorphic features reflected the complex reduction-oxidation cycles induced by seasonal water table fluctuations.

Soil textures ranged predominantly from Sandy Clay Loam to Loamy Sand, heavily dominated by sand fractions (69.15%–81.07%), reflecting active alluvial depositional mechanics and sandstone-derived parent materials. Bulk density values were relatively low (1.45–1.56 g/cm^3), with higher porosity in clay-richer pedons. Water-Holding Capacity was notably low (9.35%–11.17%), constraining dry-season crop production despite seasonal flood saturation. Soil pH ranged from slightly acidic to neutral (6.22–7.00), with zero salinity hazards (EC: 0.10–0.26 dS/m). Organic Carbon levels were relatively high (8.11–12.19 g/kg) due to flood deposition, but Total Nitrogen and Available Phosphorus were low to moderate. Effective Cation Exchange Capacity (ECEC) was low (3.12–5.18 cmol/kg), with Percentage Base Saturation uniformly below the 50% critical threshold (29.07%–49.73%), indicating low base status and soil infertility

Conclusively, soils along the Benue River floodplain in Girei LGA are taxonomically classified as Inceptisols (Aquepts/Fluvaquents) or Ultisols (Aquic sub-groups), characterized by weak profile development, aquic moisture regimes, and coarse-textured parent materials. While these floodplain ecosystems possess high agricultural utility for dry-season recession farming, they are inherently constrained by low nutrient status particularly available phosphorus and nitrogen; poor structural stability due high sand dominance and low clay content limit water and nutrient retention; limited cation exchange capacity restricts nutrient availability and holding capacity and sandy architecture which predisposes soils to rapid structural collapse upon drying and vulnerability to nutrient leaching

However, practices such as regular incorporation of compost, crop residues, and farmyard manure to improve structural stability, water-holding capacity, and nutrient retention; deliberate application of phosphatic fertilizers or organic phosphate sources to address the critical AVP deficiency and application of nitrogen-fixing crop residues or supplementary nitrogen fertilization to boost the low total nitrogen status; and conservation practices such as mulching, conservation tillage, and contour farming to minimize structural degradation and enhance soil moisture availability during the dry season should be practiced and periodic soil testing to track nutrient depletion and inform targeted amendment schedules.

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REFERENCES

1) **Amhakhian, S. O., Oyebamiji, U. A., & Agbede, O. O. (2016).** Characterization and classification of soils of a floodplain in a savanna ecosystem of Nigeria. *International Journal of Soil Science*, 11(2), 34–42.
2) **Bawden, M. G. (1972).** The land resources of North East Nigeria: Volume 1, the environment. Land Resources Division, Overseas Development Administration, London.
3) **Brady, N. C., & Weil, R. R. (2016).** The Nature and Properties of Soils (15th ed.). Pearson Education Inc., New Jersey.
4) **Buba, A. M., Mustapha, A. A., & Voncir, N. (2020).** Phosphorus sorption characteristics of some hydromorphic soils along the Benue River valley in Adamawa State, Nigeria. *Journal of Soil Science and Environmental Management*, 11(3), 88–96.
5) **Chikezie, I. A., Eswaran, H., Asawalam, D. O., & Ano, A. O. (2010).** Characterization and classification of soils of the Guinea Savanna zone of Nigeria. *Agro-Science*, 9(1), 12–21.
6) **De Datta, S. K. (1986).** Electrochemical changes in submerged soils and their agronomic implications. *Excerpts of Soil Science*, 34, 112–131.
7) **FAO. (1996).** World Food Summit: Volume 1, Technical background documents. Food and Agriculture Organization of the United Nations, Rome.
8) **FAO. (2006).** Guidelines for Soil Description (4th ed.). Food and Agriculture Organization of the United Nations, Rome.
9) **Hassan, A. M., Usman, B. H., & Raji, B. A. (2020).** Physical properties and compaction behavior of alluvial soils along major river basins in semi-arid Nigeria. *Nigerian Journal of Soil Science*, 30(2), 145–154.
10) **Ibrahim, K., Yakubu, M., & Muhammad, A. (2022).** Dynamics of pH and redox potentials in seasonally inundated wetlands of Northeastern Nigeria. *African Journal of Agricultural Research*, 18(4), 231–240.
11) **Kyari, B. A., Usman, M., & Amba, A. A. (2018).** Pedogenic evaluation of some hydromorphic soils in the upper Benue valley, Nigeria. *Journal of Agricultural Science and Environment*, 18(1), 54–67.
12) **Manly, P. T., Gungula, D. T., & Zata, A. I. (2023).** Mineralogical and chemical properties of sandstone-derived alluvial profiles in Girei, Adamawa State. *International Journal of Agronomy*, 2023, 1–11.

13) **Mustapha, A., Voncir, N., & Omar, S. (2014).** Distribution of organic carbon and total nitrogen fractions in floodplain soils of Adamawa State, Nigeria. *Journal of Soil Science and Environmental Management*, 5(7), 89–97.
14) **Ojanuga, A. G. (2006).** Agroecological zones of Nigeria. FAO-NSPFS, Federal Ministry of Agriculture and Rural Development, Abuja, Nigeria.
15) **Rajab, M. A., Sharu, M. B., & Abdulrahaman, A. (2021).** Morphological properties and classification of soils under hydromorphic conditions along the Benue River system. *Journal of Soil and Water Conservation*, 20(3), 312–321.
16) **Rayar, A. J., & Haruna, B. J. (2012).** Textural variability and nutrient status of floodplain soils under continuous cultivation in Adamawa State, Nigeria. *Journal of Agricultural Sciences*, 4(5), 102–111.
17) **Sharu, M. B., Yakubu, M., Alhassan, S. S., & Tsafe, A. I. (2013).** Characterization and classification of soils of the Dingyadi District, Sokoto State, Nigeria. *Nigerian Journal of Basic and Applied Sciences*, 21(4), 311–321.
18) **Usman, B. H. (2019).** Pedological properties of sedimentary soils of the Benue trough. Kalyani Publishers, New Delhi.
19) **Voncir, N., Amba, A. A., & Hassan, A. M. (2008).** Electrical conductivity and soluble ions status of some soils of the Benue River floodplain in Adamawa State, Nigeria. *Journal of Sustainable Development*, 5(2), 34–41.
20) **Yakubu, M., Ojanuga, A. G., & Raji, B. A. (2011).** Pedogenesis and classification of soils of the alluvial plains of the Rima River at Sokoto, Nigeria. *Nigerian Journal of Soil Science*, 21(2), 94–103.