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Effect of Land Use Types on Soil Carbon Sequestration and Hydraulic Properties around Kunvyi Area, Taraba State, Nigeria

[*1]Muhammad Adamu Aliyu, [2]Galadima J.M and [1]Yaseer Khallah Ibrahim

Department of Soil Science and Land Resoures Management, Faculty of Agriculture, Federal University Wukari, Taraba State, Nigeria.
Department of Soil Science, Faculty of Agriculture, Bayero University Kano, Kano State, Nigeria.

*Corresponding authors' email: aliyum440@fuwukari.edu.ng

ABSTRACT
This study evaluated the effects of contrasting land use types on soil organic carbon sequestration and selected physical, chemical and hydraulic properties in Kunvyi, Wukari Local Government Area, Taraba State, Nigeria. Soil samples were collected at 0–30 cm depth from five land use types: arable land, mango plantation, fallow land, rice field and forest land. Selected soil physical, chemical and hydraulic properties were determined using standard laboratory procedures. Data were subjected to analysis of variance, and treatment means were separated using the least significant difference at the 5% probability level. Significant differences occurred among land use types in most soil properties. Fallow land had the highest sand content (88.40%), whereas rice field had the highest clay content (27.47%). Bulk density was greatest under forest land (1.63 g cm^{-3}), while total porosity was highest under fallow and arable lands. Forest land recorded the greatest available water content (14.86%), whereas mango plantation had the lowest (12.67%). Saturated hydraulic conductivity was highest under arable land (37.78 mm h^{-1}). Among chemical properties, fallow land recorded the highest total nitrogen, available phosphorus and exchangeable potassium. Soil pH remained relatively stable across land uses. Rice field had the highest soil organic carbon stock (18.68 Mg ha^{-1}), followed by arable land (16.21 Mg ha^{-1}). Correlation analysis revealed strong positive relationships between organic carbon and clay, organic carbon stock and organic carbon, and total porosity and total nitrogen. The findings demonstrate that land use and associated management practices substantially influence soil fertility, carbon storage and hydraulic functioning. Conservation-oriented management, residue retention and appropriate fallow practices are therefore recommended for maintaining soil quality in the study area.

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INTRODUCTION

Soil is a fundamental component of terrestrial ecosystems and performs critical functions in food production, water regulation, nutrient cycling and carbon storage. These functions are strongly influenced by land use and management practices, particularly in tropical environments where intensive cultivation, vegetation removal and inadequate soil management can accelerate soil organic matter depletion and structural degradation. Changes in land use can alter the quantity and quality of organic inputs, soil aggregation, pore-size distribution, nutrient cycling and water transmission, thereby affecting both soil fertility and hydrological functioning. Soil organic carbon (SOC) represents an important component of soil organic matter and plays a central role in maintaining soil quality. It contributes to aggregate formation, nutrient retention, microbial activity and water storage, while also representing a major terrestrial carbon reservoir with implications for climate-change mitigation. The amount of carbon retained in soil is influenced by vegetation type, biomass production, residue return, decomposition rates, soil texture and management practices (Lal, 2020; FAO, 2021). Land uses associated with continuous cultivation may reduce SOC through repeated soil disturbance, enhanced mineralization, erosion and removal of crop residues, whereas systems with greater organic inputs and reduced disturbance can promote carbon accumulation and stabilization. The influence of land use extends beyond carbon dynamics to the hydraulic behaviour of soils. Soil hydraulic properties, including field capacity (FC), permanent wilting point (PWP), available water content (AWC) and saturated hydraulic conductivity (Ksat), regulate infiltration, water storage, drainage and plant water availability. These properties are closely related to soil texture, bulk density, aggregation, pore-size distribution and organic matter content (Hillel, 2004; Brady & Weil, 2017). Consequently, changes in vegetation cover and soil management can modify soil structure and pore characteristics, thereby influencing the movement and retention of water within the soil profile. In tropical and subtropical regions, agricultural intensification, deforestation and expansion of cultivated land have contributed to substantial modifications of soil properties. In Nigeria, these processes are particularly important within the Guinea Savannah, where agricultural land is subjected to recurrent cultivation, residue removal, grazing and seasonal moisture fluctuations. Such pressures can progressively alter soil organic matter dynamics and physical quality, with consequences for agricultural productivity and environmental sustainability. Although several studies have examined land use effects on soil properties in different parts of Nigeria, information remains limited for many agricultural landscapes of Taraba State. Kunvyi village in Wukari Local Government Area represents a heterogeneous agricultural landscape comprising arable fields, rice fields, fallow areas, forest remnants and perennial plantations. The coexistence of these land use systems provides an opportunity to examine how contrasting vegetation and management regimes are associated with differences in soil carbon storage, nutrient status and hydraulic behaviour.

A better understanding of these relationships is important for developing management strategies capable of maintaining soil productivity while improving carbon retention and water-use efficiency. Therefore, this study evaluated the effects of selected land use types on soil organic carbon sequestration and selected physical, chemical and hydraulic properties in Kunvyi, Wukari Local Government Area, Taraba State, Nigeria. The study aimed to evaluate the effects of land use types on soil organic carbon sequestration and selected hydraulic properties in Kunvyi, Wukari Local Government Area, Taraba State, Nigeria.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in Kunvyi village, along the Wukari–Jalingo road in Wukari Local Government Area of Taraba State, Nigeria. The study area lies approximately between latitude 07°50′38″ N and longitude 09°46′44″ E. Wukari Local Government Area covers approximately 4,308 km² and is characterized by a tropical savannah environment with distinct wet and dry seasons.

Rainfall generally begins around April and continues until October, whereas the dry season extends from November to March. Mean annual rainfall is approximately 1,300 mm, while mean air temperature ranges from about 20 to 37 °C. The Harmattan period generally occurs between December and February and is associated with dry and dusty northeasterly winds.

The landscape is predominantly undulating, with agricultural fields interspersed with natural vegetation, plantations and fallow areas. The area is used extensively for crop and livestock production. Major crops include maize, sorghum, rice, soybean, millet, cowpea, cassava, yam, sesame, groundnut and Bambara groundnut. Livestock production, particularly cattle, sheep and goats, also forms an important component of the local farming system.

The natural vegetation consists mainly of savannah grasses, shrubs and scattered trees, with species including Imperata cylindrica, Panicum maximum, Cynodon dactylon, Commelina benghalensis and Eleusine indica. Tree species occurring within the broader landscape include Azadirachta indica, Mangifera indica, Gmelina arborea and Eucalyptus species.

Land Use Survey and Soil Sampling

A reconnaissance survey was conducted to identify representative areas under five major land use types: arable land, mango plantation, fallow land, rice field and forest land. Sampling locations were selected based on the dominant land use and known management history.

Soil samples were collected from the 0–30 cm depth, representing the surface soil layer most directly affected by vegetation cover and land management. Both disturbed and undisturbed samples were collected. Disturbed samples were air-dried, gently disaggregated and passed through a 2-mm sieve before laboratory analysis. Undisturbed core samples were retained for determination of bulk density, moisture retention and saturated hydraulic conductivity.

Laboratory Analysis

Particle Size Ditribution

Particle size distribution was determined by the hydrometer method following Gee and Bauder (1986). Organic matter was oxidized using hydrogen peroxide, after which the soil suspension was dispersed and hydrometer readings were taken at specified settling times. Percentages of sand, silt and clay were calculated and the corresponding textural classes determined using the USDA soil textural triangle.

Clay (%) = $\frac{Wc}{W} \times 100$,

Silt (%) = $\frac{Wsi}{W} \times 100$ and

Sand (%) = 100 – (% silt + % clay)

Bulk Density and Total Porosity

Bulk density was determined using the core method described by Blake and Hartge (1986). Core samples were oven-dried at 105 °C to constant mass, and bulk density was calculated as the ratio of oven-dry soil mass to core volume.

Bulk density (in gcm^{-3}) = $\frac{\text{weight of Oven−dried Soil}}{\text{Volume of Soil}}$

Total porosity was calculated from bulk density and an assumed particle density of 2.65 g cm^{-3} using: Obi (2000).

Porosity % = $\frac{\text{Particle Density − Bulk Density}}{\text{Particle Density}}$ x 100

Where TP is total porosity (%), BD is bulk density (g cm^{-3}), and PD is particle density (g cm^{-3}).

Soil Moisture Retention

Soil water content at saturation, field capacity and permanent wilting point was determined using a pressure plate membrane apparatus following Klute (1986). Field capacity was measured at 33 kPa, while permanent wilting point was measured at 1,500 kPa.

Available water content was calculated as:

Saturation (%) = $\frac{\text{Saturation weight − weight of container}}{\text{wet weight − weight of container}}$ x 100

Where AWC is available water content, FC is field capacity and PWP is permanent wilting point.

FC (%) = $\frac{\text{Field capacity weight − weight of container}}{\text{initial weight − weight of container}}$ x 100

PWP (%) = $\frac{\text{PWP weight − weight of container}}{\text{Initial weight − weight of container}}$ x 100

Saturated Hydraulic Conductivity

Saturated hydraulic conductivity was determined using the constant-head permeameter method described by Reynolds et al. (2002). Saturated soil cores were subjected to a constant hydraulic head, and the volume of water passing through the soil column over a known period was measured. Saturated hydraulic conductivity was calculated from the measured flow rate, hydraulic gradient and soil-column dimensions.

$K_{sat} = \frac{VL}{ADHt}$

Soil pH

Soil pH was determined potentiometrically in a soil–water suspension using a calibrated pH meter. The electrode system was calibrated with standard buffer solutions before measurement.

Total Nitrogen

Total nitrogen was determined using the Kjeldahl digestion and distillation procedure described by Bremner and

Mulvaney (1982). Soil samples were digested with concentrated sulphuric acid in the presence of catalyst, followed by distillation and titration of the released ammonium.

%Nitrogen=

$$\frac{\text{HCl in sample} - \text{blank (in mls) x N of HCl x 100 x 0.014 gN/meq}}{\text{10 grams sample}}$$

Available Phosphorus

Available phosphorus was determined using an appropriate soil extraction procedure followed by colour development and spectrophotometric determination. The concentration of phosphorus was expressed in mg kg^{-1} soil.

Exchangeable Potassium

Exchangeable potassium was extracted using neutral ammonium acetate and determined using a flame photometer following standard soil analytical procedures.

Soil Organic Carbon

Soil organic carbon was determined using the Walkley–Black wet oxidation procedure as described by Nelson and Sommers (1982). Soil organic matter was subsequently estimated from organic carbon using the conventional conversion factor.

$$\% \text{ O C} = \frac{AN\ (0.003)(100)}{W}$$

Soil Organic Carbon Stock

Soil organic carbon stock was calculated from organic carbon concentration, bulk density and sampling depth using: with appropriate unit conversion to Mg ha^{-1}, where SOCS is soil organic carbon stock, BD is bulk density, Z is soil depth and C is soil organic carbon concentration.

Statistical Analysis

The effects of land use type on measured soil properties were evaluated using one-way analysis of variance (ANOVA). Where significant differences occurred, treatment means were separated using the least significant difference (LSD) test at the 5% probability level. Pearson correlation analysis was used to evaluate relationships among selected physical, chemical and hydraulic properties. Statistical analyses were performed using Statistix version 16.

RESULTS AND DISCUSSION

Soil Physical and Hydraulic Properties

Particle Size Distribution

Significant differences ($p \leq 0.05$) occurred among land use types for sand, silt and clay contents (Table 1). Sand content was highest under fallow land (88.40%) and lowest under rice field (65.53%). Conversely, rice field recorded the highest clay content (27.47%), whereas fallow land had the lowest (8.70%). Forest land recorded the highest silt content (10.27%).

The predominance of sand across most land uses indicates that the soils are generally coarse-textured, with the exception of the rice field, which was classified as sandy loam. The differences in particle-size distribution should, however, be interpreted cautiously because texture is principally an inherent soil property. The observed variation among sampling locations may reflect differences in parent material, microtopography, erosion, deposition and pedogenic processes rather than being solely attributable to contemporary land use.

The relatively high clay content of the rice field may have important implications for its water-retention behaviour and carbon stabilization. Clay particles provide extensive reactive surfaces capable of protecting organic compounds from decomposition through organo-mineral associations. The strong positive correlation between clay and organic carbon ($r = 0.76$, $p \leq 0.05$) and between clay and organic carbon stock ($r = 0.83$, $p \leq 0.05$) in Table 3 supports this interpretation.

Bulk Density and Total Porosity

Bulk density differed significantly among land use types ($p \leq 0.05$). Forest land recorded the highest bulk density (1.63 g cm^{-3}), whereas arable and fallow lands had the lowest values (1.48 g cm^{-3}). The relatively high bulk density under forest land was accompanied by the lowest total porosity (37.98%), while fallow and arable lands recorded the greatest porosity values (44.28 and 44.15%, respectively).

Bulk density integrates the effects of particle arrangement, organic matter, soil compaction and pore volume. The relatively high value observed under forest land suggests greater soil packing at the sampling depth, potentially associated with localized trampling, limited surface disturbance or site-specific soil characteristics. Importantly, the result demonstrates that forest cover does not invariably correspond to the lowest bulk density; site history and physical disturbance can modify the expected relationship.

The high porosity under fallow land is consistent with the role of biological activity and root development in creating and maintaining soil pores. Fallow vegetation provides continuous root inputs and promotes biological restructuring of the soil, while reduced machinery traffic and tillage allow structural recovery. Arable land also exhibited relatively high porosity, possibly because cultivation temporarily loosens the surface soil. However, repeated cultivation can progressively destabilize aggregates and increase compaction if not accompanied by conservation practices.

The inverse relationship between bulk density and total porosity was particularly strong ($r = -0.97$), confirming the fundamental physical relationship between soil packing and pore space.

Soil Moisture Retention

Field capacity ranged from 21.27% under mango plantation to 23.78% under arable land. Arable, fallow, rice and forest lands were statistically similar, whereas mango plantation recorded significantly lower field capacity. Permanent wilting point ranged from 8.64% under mango plantation to 10.37% under arable land and differed significantly among land uses.

Available water content also differed significantly. Forest land recorded the highest AWC (14.86%), followed by fallow land (14.18%), rice field (13.79%) and arable land (13.42%), while mango plantation recorded the lowest value (12.67%).

The relatively high AWC under forest and fallow land indicates a more favourable balance between water retention and drainage. Organic inputs from vegetation can enhance aggregate stability and create a heterogeneous pore system containing both water-retaining micropores and drainage-supporting macropores. The positive correlation between FC and AWC ($r = 0.76$, $p \leq 0.05$) further confirms that variation in field-capacity water content contributed substantially to differences in plant-available water.

The relatively low AWC under mango plantation may reflect the coarse-textured nature of the soil at that site. With 82.07% sand and only 11.70% clay, the soil has comparatively limited capacity to retain water against gravitational drainage. Thus, the lower AWC should not be attributed solely to plantation management; inherent textural differences are also important.

Saturated Hydraulic Conductivity

Saturated hydraulic conductivity differed significantly among land use types ($p \leq 0.05$). Arable land recorded the highest Ksat (37.78 mm h^{-1}), followed by forest land (34.74 mm h^{-1}) and rice field (34.73 mm h^{-1}), which were statistically similar. Mango plantation and fallow land recorded lower values of 33.76 and 33.40 mm h^{-1}, respectively.

The relatively high Ksat under arable land may be associated with temporarily enhanced macroporosity resulting from cultivation and root activity. However, high Ksat should not necessarily be interpreted as evidence of superior soil quality because rapid transmission of water through coarse pores can also reduce water residence time and storage, particularly in sandy soils.

The relatively high Ksat under forest land despite its greater bulk density suggests that factors other than total porosity, including macropore continuity, root channels and preferential flow pathways, may have contributed to water transmission. Similarly, the moderate Ksat of the rice field may reflect its relatively high clay content and the presence of interconnected structural pores.

The results demonstrate that soil hydraulic behaviour is controlled by the interaction of texture, pore geometry, aggregation, organic matter and management history rather than by a single soil property.

Table 1: Responses of Soil Physical and Hydraulic Properties to Land Uses of the Study Areas

Land Use Types	Sand %	Silt	Clay	Text. Class	BD (g cm^{-3})	TP (%)	FC	PWP	AWC	Ksat (mm/hr)
ARLU	75.33^{c}	5.40^{b}	19.07^{b}	LS	1.48^{c}	44.15^{a}	23.78^{a}	10.37^{a}	13.42^{a}	37.78^{a}
MAPL	82.07^{b}	6.23^{b}	11.70^{c}	LS	1.57^{b}	40.75^{b}	21.27^{b}	8.64^{b}	12.67^{b}	33.76^{b}
FAL	88.40^{a}	2.90^{c}	8.70^{d}	LS	1.48^{c}	44.28^{a}	23.14^{a}	9.03^{b}	14.18^{a}	33.40^{b}
RIF	65.53^{d}	7.00^{b}	27.47^{a}	SL	1.56^{b}	41.00^{b}	22.36^{a}	9.13^{b}	13.79^{a}	34.73^{a}
FOL	75.00^{c}	10.27^{a}	14.73^{c}	LS	1.63^{a}	37.98^{c}	23.34^{a}	9.03^{b}	14.86^{a}	34.74^{a}
LSD (5%)	4.925	2.623	4.143	-	0.063	2.376	0.172	0.956	1.449	3.776

ARLU = arable land use, MAPL = mango plantation, FAL = fallow land, RIF = rice farm, FOL = forested land, BD = bulk density, TP = total porosity, FC = field capacity, PWP = permanent wilting point, AWC = available water content, Ksat = saturated hydraulic conductivity. Means followed by the same letter (s) within the same column are not significantly different at 0.05 level of probability as determined by LSD.

Soil Chemical Properties

Total Nitrogen

Total nitrogen differed significantly among land uses ($p \leq 0.05$). Fallow land recorded the highest concentration (0.23%), followed by arable land (0.19%) and rice field (0.17%), whereas forest land (0.14%) and mango plantation (0.15%) had the lowest values.

The relatively high nitrogen concentration under fallow land is consistent with greater net accumulation of organic residues and reduced nutrient removal through crop harvest. Fallow vegetation continuously contributes roots, litter and above-ground biomass, which become sources of soil organic nitrogen during decomposition. The lower values under forest and mango plantation may reflect differences in litter quality, decomposition dynamics, biological uptake and nutrient redistribution.

Total nitrogen was strongly correlated with total porosity ($r = 0.82$, $p \leq 0.05$), while its relationship with organic carbon was positive but not significant. This suggests that the association between nitrogen and soil structural condition may involve several interacting processes rather than carbon concentration alone.

Available Phosphorus

Available phosphorus differed significantly among land use types. Fallow land recorded the highest value (13.52 mg kg^{-1}), followed by arable land (10.61 mg kg^{-1}), while mango plantation, rice field and forest land recorded comparatively lower values.

The elevated phosphorus concentration under fallow land may be associated with reduced nutrient removal through harvesting and continued recycling of plant residues. During decomposition, organically bound phosphorus can be mineralized and returned to the soil solution. Fallow vegetation may therefore promote nutrient retention and cycling when biomass is returned to the soil.

The lower phosphorus values under mango plantation and forest land may reflect stronger biological immobilization, differences in litter chemistry or phosphorus fixation processes. Given the acidic-to-near-neutral pH range of the soils, phosphorus availability may also be influenced by interactions with soil minerals and organic matter.

Exchangeable Potassium

Exchangeable potassium differed significantly among land use types. Fallow land recorded the highest concentration (0.40 cmol(+) kg^{-1}), followed by mango plantation (0.34 cmol(+) kg^{-1}), while forest land recorded the lowest value (0.21 cmol(+) kg^{-1}).

The high potassium concentration under fallow land may reflect nutrient recycling and reduced export through crop harvesting. Potassium is not incorporated into complex structural organic compounds to the same extent as nitrogen; consequently, plant residues can release substantial amounts of K during decomposition. Continuous nutrient cycling under fallow vegetation can therefore contribute to maintenance of exchangeable potassium.

The lower concentration under forest land may reflect greater biological uptake, redistribution within vegetation or differences in the mineralogical composition of the soil.

Soil Reaction

Soil pH did not differ significantly among land use types ($p > 0.05$). Soil pH in water ranged from 6.25 to 6.42, while KCl pH ranged from 5.20 to 5.56. The narrow range of pH values suggests that land use had not substantially modified soil reaction at the sampled depth.

The slightly acidic to near-neutral reaction is generally favourable for the availability of many plant nutrients and for microbial activity. The absence of significant differences may indicate comparable parent material and buffering conditions across the sampling locations. It also suggests that differences observed in nutrient status and carbon storage were not primarily associated with major changes in soil acidity.

Soil Organic Carbon and Carbon Stock

Soil organic carbon concentration differed significantly among land uses. Rice field and arable land recorded the highest values (0.80 and 0.73%, respectively), whereas mango plantation recorded the lowest concentration (0.49%). Soil organic carbon stock followed a similar pattern, with rice field recording the highest stock (18.68 Mg ha^{-1}), followed by arable land (16.21 Mg ha^{-1}). Mango plantation had the lowest stock (11.17 Mg ha^{-1}).

The relatively high carbon stock under rice cultivation may reflect the substantial contribution of rice roots, stubble and crop residues to the soil. Periodic waterlogging can also restrict oxygen availability and slow decomposition, potentially favouring retention of organic carbon. However, the magnitude of this effect depends on water regime, residue management and soil mineral characteristics.

The high carbon stock under arable land suggests that crop residue return and organic inputs may contribute to carbon retention where they are adequately incorporated into the soil. Conversely, the low stock under mango plantation may be associated with lower carbon inputs to the sampled surface layer, differences in biomass allocation and decomposition conditions.

Importantly, the high carbon stock in the rice field should not automatically be interpreted as evidence that rice cultivation is universally superior for carbon sequestration. Carbon stock is influenced by bulk density, carbon concentration, depth and water regime, and long-term carbon sequestration requires assessment of carbon persistence and changes over time.

The strong positive correlations of organic carbon with clay (r = 0.76), organic carbon stock with clay (r = 0.83), and organic carbon stock with organic carbon concentration (r = 0.97) indicate that both mineral protection and carbon concentration were important determinants of carbon storage in the study soils.

Table 2: Responses of Soil Chemical Properties to Land Uses of the Study Area

Land Use Types	N (%)	P (mg/kg)	K (Meg/100g)	pH (H_2O)	pH (Kcl/1:2:5)	OC (%)	OCS	OM (%)
ARLU	0.19^b	10.61^b	0.28^c	6.25^a	5.20^a	0.73^a	16.21^b	1.26^a
MAPL	0.15^c	7.99^c	0.34^b	6.28^a	5.45^a	0.49^e	11.17^d	0.84^c
FAL	0.23^a	13.52^a	0.40^a	6.25^a	5.35^a	0.62^c	13.87^c	1.07^b
RIF	0.17^b	8.58^c	0.26^c	6.42^a	5.23^a	0.80^a	18.68^a	1.37^a
FOL	0.14^c	8.42^c	0.21^d	6.42^a	5.56^a	0.56^d	13.73^c	1.12^b
LSD (5%)	0.024	1.161	0.040	0.195	0.122	0.044	1.033	0.184

ARLU = arable land use, MAPL = mango plantation, FAL = fallow land, RIF = rice farm, FOL = forested land, N = nitrogen, P = phosphorus, K = potassium, OC = organic carbon, OCS = organic carbon stock, OM = organic matter. Means followed by the same letter (s) within the same column are not significantly different at 0.05 level of probability as determined by LSD.

Relationships among Soil Properties

Pearson correlation analysis revealed several important relationships among the measured soil properties (Table 3).

Sand exhibited a very strong negative correlation with clay (r = −0.95), which is expected because these particle-size fractions collectively constitute the mineral fraction of the soil. Sand was also negatively correlated with organic carbon (r = −0.61) and organic matter (r = −0.63), indicating that finer-textured soils tended to contain greater concentrations of organic materials.

Clay showed significant positive relationships with organic carbon (r = 0.76), organic carbon stock (r = 0.83) and organic matter (r = 0.70). These relationships support the important role of clay in SOC stabilization. Clay minerals provide reactive surfaces that can physically protect organic compounds and facilitate organo-mineral associations, thereby reducing their accessibility to microbial decomposition.

Organic carbon was strongly correlated with organic matter (r = 0.90), while organic carbon stock was very strongly correlated with organic carbon (r = 0.97) and organic matter (r = 0.93). These relationships are expected because SOC constitutes a major component of soil organic matter and directly contributes to calculated carbon stock.

A significant positive relationship occurred between field capacity and available water content (r = 0.76), indicating that soils retaining more water at field capacity generally contained greater quantities of plant-available water. Ksat was positively correlated with PWP (r = 0.60), although this relationship should be interpreted cautiously because hydraulic conductivity and water retention are controlled by complex pore-size distributions.

Total porosity showed a strong positive correlation with total nitrogen (r = 0.82) and a strong negative correlation with bulk density (r = −0.97). The latter relationship reflects the mathematical and physical dependence of pore space on soil packing. Total porosity was also negatively correlated with silt (r = −0.80) and pH (r = −0.55).

Overall, the correlation matrix demonstrates that soil carbon dynamics, texture, structural condition and water behavior are interconnected. However, correlation does not establish causality; therefore, the observed relationships should be interpreted as associations among soil properties rather than direct evidence that one property caused changes in another.

Table 3: Pearson's Correlation Among soil Properties of the Land Use Types

	Sand	Silt	Clay	OC	OCS	OM	pH	N	MWD	FC	PWP	AWC
Sand	1											
Silt	-.57*	1										
Clay	-.95*	.28	1									
OC	-.61*	-.12	.76*	1								
OCS	-.71	.02	.83*	.97*	1							
OM	-.63*	.11	.70*	.90*	.93*	1						
pH	-.48	.67*	.31	.13	.23	.18	1					
N	.43	-.73	-.22	.31	.14	.17	-.42	1				
MWD	-.10	-.26	.22	.37	.39	.24	.21	.32	1			
FC	.02	-.02	-.02	.26	.25	.31	.10	.13	-.15	1		
PWP	-.16	-.13	.24	.48	.42	.40	.02	.31	-.29	.33		

	Sand	Silt	Clay	OC	OCS	OM	pH	N	MWD	FC	PWP	AWC
AWC	.00	.14	-.06	.08	.14	.16	.24	-.09	.20	.76*	-.25	1
Ksat	-.32	.04	.36	.33	.33	.21	.09	-.11	-.27	.45	.60*	.02
BD	-.33	.76*	.09	-.35	-.14	-.11	.49	-.79*	-.04	-.18	-.37	.15
TP	.34	-.80*	-.08	.34	.14	.09	-.55*	.82*	.10	.18	.38	-.15

N = nitrogen, OC = organic carbon, OCS = organic carbon stock, OM = organic matter, MWD= mean weight diameter, BD = bulk density, FC = field capacity, PWP = permanent wilting point, AWC= available water content, Ksat = saturated hydraulic conductivity, TP = total porosity. Correlation analysis was carried out at 0.05 % probability level

CONCLUSION

The study demonstrated that land use systems in Kunvyi significantly influenced several soil physical, chemical and hydraulic properties at the 0–30 cm depth. Significant differences occurred in particle-size distribution, bulk density, total porosity, permanent wilting point, available water content and saturated hydraulic conductivity. Fallow and arable lands generally exhibited lower bulk density and greater total porosity, while forest land recorded the highest available water content. Arable land recorded the highest saturated hydraulic conductivity. Chemical properties were also substantially influenced by land use. Fallow land had the highest total nitrogen, available phosphorus and exchangeable potassium, indicating the importance of vegetation regeneration and nutrient recycling in maintaining soil fertility. Soil pH, however, remained relatively stable across the land use systems. Soil organic carbon and carbon stock varied significantly, with the rice field recording the highest carbon stock, followed by arable land, while mango plantation had the lowest. The correlation analysis further demonstrated strong associations between soil texture and carbon storage, particularly the positive relationships of clay with organic carbon and organic carbon stock.

Overall, the findings indicate that land use and associated management practices are important determinants of soil fertility, carbon storage and hydraulic functioning in the study area. Maintaining soil organic inputs, minimizing unnecessary disturbance and promoting practices that enhance structural stability are essential for sustaining soil productivity and environmental functions.

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