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Assessment of Soil Degradation in Response to Land Use Change in Federal University of Agriculture Abeokuta, Ogun State, Nigeria

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Abstract

Soil degradation is a worldwide concern that poses significant threats to the physical, chemical and biological conditions of soil leading to food insecurity and instability of ecosystems. Therefore, assessing and monitoring soil degradation especially in the teeming developing population countries such as Nigeria calls for urgent attention. Hence, this study was carried out in the Federal University of Agriculture Abeokuta and randomized method was used in the collection of the soil samples with the aid of Dutch auger at different depths (0 - 15 cm and 15 - 30 cm) across the studied area. The collected soil samples were processed and subjected to standard laboratory techniques to assess the soil conditions of the studied area. The results showed that particle size analysis of the studied soils were dominated with sandy clay loam textural class while soil pH ranging from strongly acidic to near neutral. On one hand, bulk density varied with the existing land use especially with built-up and continuous cropping areas occupying the most degraded soil properties when compared to that of the forested areas. Notably, chemical soil properties such as total nitrogen, available phosphorus, and potassium were below critical threshold levels particularly areas with the unchecked human activities. Consequently, the soil quality index analysis classed the soil of the area as moderately to poorly degraded soils connected to deforestation, continuous use of the land without adding appropriate fertilizer coupled with prevailing pressure of climate change actions. The findings underscore the urgent need for sustainable land use cover management practices, suggesting strict compliance with the Land Use Act in protecting the prevailing loss of vegetative cover of the studied area.

Keywords: Soil degradation; Land use change; Soil nutrients; Soil quality index.

1. Introduction

Soil degradation, defined as the decline in soil quality due to natural or anthropogenic factors, is a global environmental crisis threatening food security, biodiversity, and ecosystem resilience (FAO, 2015). Globally, over 33 percent of soils are degraded, with Sub-Saharan Africa experiencing severe losses due to unsustainable land use practices (UNDP, 2022). Consequently, soil degradation is the decline in soil characteristic originated by consistent inappropriate land use practices. Additionally, it is a severe universal ecological crisis and also aggravated by climate change actions (Amusan *et al.,* 2017). Disturbingly, soil degradation is one of the most serious threats facing mankind which not only weakens the productive capability of an ecosystems but also affects food security. Particularly in Nigeria, where rapid human population growth, urbanization, and agricultural intensification have accelerated soil degradation, reducing land productivity and sustainability (Amusan *et al.,* 2017).

Moreover, land use change (LUC) is one of the primary driver of soil degradation, deteriorating the soil properties (Lal, 2015). Conversion of natural ecosystems e.g., forests to other land uses such as croplands or built-up areas without adhering to appropriate land use Act disrupts the physical, chemicals and biological conditions of soil (Borrelli *et al.,* 2020). This situation spotlights the Federal University of Agriculture Abeokuta (FUNAAB), which may be lacking land use patterns. Such changes affect soil nutrients leading to food insecurity through the physical, chemical, and biological soil properties particularly at temporal landscapes for site-specific management (Tobore *et al.,* 2024). Specifically, physical degradation of soil refers to the deterioration of soil structure and texture among others, impairing its capability to support plant growth and regulate hydrological processes relating to drivers including erosion, compaction, and loss of porosity (Borrelli et al., 2017). Whilst chemical and biological degradation involves acidification, salinization, heavy metal contamination (Adekiya *et al.,* 2019), and declines in soil organic matter etc. Hence, proper assessment of the soil conditions that is physical, chemical and biological can adequate and timely assist in providing valuable information on land use management policies and strategies while aiding sustainable food productivity. Hence, a critical task aimed at contributing to United Nations Sustainable Development Goal 2. As a result, the specific objectives of this study were to: (1) assess soil physical, chemical and biological properties of the area (2) assess the soil degradation status of the area using Amacher soil quality index. Consequently, serving as a good indicator for assessing soil quality and addressing the gap of soil degradation in response to land use change in FUNAAB.

2. Materials and Methods

2.1 Study area

The study was conducted at the Federal University of Agriculture, Abeokuta, located in Ogun State, southwestern Nigeria. The university is situated between latitudes 7°13' and 7°15' N and longitudes 3°26' and 3°28' E. The region experiences a humid tropical climate with distinct wet and dry seasons. The wet season lasts from April to October, while the dry season extends from November to March. The mean annual rainfall ranges from 1,100 mm to 1,300 mm, supporting both natural vegetation and agricultural activities. Average temperatures fluctuate between 26°C and 30°C, with relative humidity between 60% and 80% (Adejuwon, 2012). The landscape consists of undulating terrain with gentle slopes, which influence surface runoff and erosion patterns. The underlying geology is dominated by Precambrian basement complex rocks, contributing to the development of Ferric Luvisols, the predominant soil type in the area (Areola, 1982). These soils are moderately fertile but vulnerable to degradation due to improper land use practices. The natural vegetation comprises tropical rainforest and derived savanna, but significant portions have been altered due to urban expansion, farming activities, and infrastructural development (Oyinlola and Adesina, 2017).

2.2 Sampling and Laboratory Analysis

A comparative approach was adopted to assess soil degradation across different land use types. The study focused on three major land use cover: natural forest, cultivated farmland, and built-up areas. Natural forest served as a control, representing minimally disturbed soils while the cultivated farmland and built up area served as the test for degradation. A random sampling technique was employed to ensure that soil samples were collected from diverse locations within each land use type without bias (Morgan, 2005).

Soil sampling points were tied with Global Positioning System (GPS) device (Borrelli *et al.,* 2020) collected at two (0 -15 cm and 15 - 30 cm) depths. The 0–15 cm, representing the topsoil most affected by land use changes, and 15–30 cm, thus providing insights beyond 0 - 15 cm topsoil degradation effects. At each sampling point, three sub-samples were taken and mixed to form a composite sample. A total of 33 composite samples were collected, with 11 from each land use types. The following parameters were analyzed: Soil bulk density (Oven dried method), Soil pH (distilled water and KCl), total Nitrogen (Kjeldahl, 1883), organic carbon (Walkley-Black, 1934), exchangeable cations (Calcium, magnesium, potassium, and sodium) by Ammonium Acetate extraction method (Jackson, 1958), and available Phosphorus was done Bray-1 method (Roger and Kurtz, 1945).

2.2 Data Analysis

Descriptive data analysis was carried out with the analyzed soil of the area. The soil properties were subjected to Soil Quality Index (SQI) for assessing the physical, chemical and biological properties of the area studied (Amacher *et al.,* 2007).

3. Results and Discussions

3.1 Descriptive statistics of the studied soil

The chemical analysis of the studied soils revealed important variations in nutrient concentrations across different land use types. The soil pH of the studied soil in distilled water ranged from 5.35 to 7.56, with a mean of 6.62 as shown in Table (1). Thereby, indicating soil was predominantly dominated with slightly acidic to neutral. Conversely, soil pH measured in potassium chloride (KCl) ranged from 4.13 to 6.29, with an average of 5.53, reflecting more acidic conditions particularly in built-up and cultivated areas. The soil pH values suggesting increased acidification, which could likely due to continuous cropping, organic matter depletion, and inappropriate fertilizer application. Furthermore, exchangeable bases exhibited considerable variability, signaling nutrient imbalances which could also be influenced by prevailing changes in land use cover and management practices. For example, calcium content ranged from 2.05 to 9.92 cmol/kg (mean = 4.58 cmol/kg), magnesium ranged from 0.79 to 3.84 cmol/kg (mean = 1.96 cmol/kg), while potassium varied from 0.12 to 0.55 cmol/kg (mean = 0.28 cmol/kg), and sodium from 0.22 to 0.66 cmol/kg (mean = 0.37 cmol/kg). These nutrients were unevenly distributed, with farmlands showing signs of depletion likely caused by nutrient leaching under continuous cultivation. Also, organic carbon content, a key indicator of soil fertility, with average content of 0.90 %, ranging from low 0.61 % to as high as 1.76 %. The lowest values were recorded in continuously farmed areas, indicating organic matter loss. Similarly, total nitrogen concentration average content was 0.15 %, with low value of 0.04 %. Available phosphorus showed the most disparity, ranging from 2.78 mg/kg to 33.6 mg/kg, falling below the critical threshold of 8 mg/kg. This reflects phosphorus deficiency, which could be attributed to high fixation in acidic soils or inadequate fertilization practices.

On other hand, bulk density varied across the different land use types and slope positions (Table 2). Overall, the built-up area recorded the highest bulk density values, followed by farmland, while the forest had the lowest values. In the forest land use, bulk density decreased downslope, with values of 1.54 g/cm³ at the upper slope, 1.45 g/cm³ at the middle slope and 1.40 g/cm³at the lower slope. Similarly, the farmland bulk density was relatively high across all slope positions, with values of 1.59 g/cm³ (upper slopes), 1.52 g/cm³ (middle slope) and 1.52 g/cm³ (lower slopes). The built-up area exhibited the highest bulk density, with 1.74 g/cm³ at the upper slope, 1.62 g/cm³ at the middle slope, and 1.70 g/cm³ at the lower slope. Overall, these findings reveal a pattern of moderate to severe nutrient degradation driven by land use intensification and unsustainable soil management in the study area.

Table 1: Descriptive statistics of the chemical properties of the studied area

Abbreviation: CV, Coefficient of variation; SD, Standard deviation; SV, Sample Variance: pH, Hydrogen potential; Ca, Calcium; Mg, Magnesium; K, Potassium; Na, Sodium; TN, Total nitrogen; SOC, Soil organic carbon; P, Available phosphorus

	pH (H_2O)	pH (KCl)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	TN (%)	SOC (%)	P (mg/kg)
Mean	6.62	5.53	4.58	1.96	0.28	0.37	0.15	1.90	7.99
CV	7.70	7.96	43.01	60.20	46.43	27.03	40	59.47	85.48
Median	6.67	5.52	4.18	1.45	0.24	0.35	0.15	1.49	5.86
Standard Deviation	0.51	0.44	1.97	1.18	0.13	0.10	0.06	1.13	6.83
Sample Variance	0.26	0.19	3.87	1.39	0.02	0.01	0.003	1.29	46.64
Kurtosis	0.48	2.39	0.93	-1.44	-0.03	1.50	-0.59	-0.04	8.10
Skewness	-0.22	-0.83	1.09	0.60	0.99	1.05	0.20	0.93	2.67
Range	2.21	2.16	7.87	3.05	0.43	0.44	0.23	4.15	30.82
Minimum	5.35	4.13	2.05	0.79	0.12	0.22	0.04	0.61	2.78
Maximum	7.56	6.29	9.92	3.84	0.55	0.66	0.27	4.76	33.6

Table 2: Bulk density results for the upper, middle and lower slopes across the studied areas.

Forest	Bulk density (g/cm^3)
Upper	1.54
Middle	1.45
Lower	1.40
Farmland	
Upper	1.59
Middle	1.52
Lower	1.53
Built-up	
Upper	1.74
Middle	1.62
lower	1.70

3.2 Assessment of Soil Properties

The assessment of soil properties in response to land use change was conducted using the Amacher Soil Quality Index (SQI). The index categorizes soil degradation into four levels: 1 (none to slightly degraded), 2 (moderately degraded), 3 (highly degraded), and 4 (very highly degraded). For the built-up areas, the upper slope position showed slight degradation in nitrogen (N) with a score of 1, while phosphorus (P) and potassium (K) were also moderately degraded with scores of 2 each. Organic carbon (OC) and pH were slightly degraded indicating mild acidification of studied soil both scoring 1. At the middle slope position within the ceremonial area, nitrogen remained moderately degraded (2), but other parameters including phosphorus, potassium, organic carbon, and pH were all slightly degraded (slightly acidic to near neutral), each recording a score of 1. The lower and valley positions in the ceremonial area displayed slight degradation across all chemical properties, with each parameter scoring 1. However, the valley slope recorded moderate degradation in potassium (score of 2), suggesting some nutrient imbalance or leaching effects.

In the forest land use area, the upper slope showed slight degradation in nitrogen (1) and moderate degradation in phosphorus (2), potassium (1), and organic carbon (1). Interestingly, the pH recorded a score of 2, indicating moderate degradation and potential soil acidity development. The middle slope in the forest zone exhibited moderate nitrogen degradation (2), while all other parameters scored 1, indicating slight degradation. The lower slope followed a similar trend with moderate degradation in potassium (score of 2) and slight degradation for other parameters. In the valley slope of the forest area, potassium and organic carbon both recorded moderate degradation (score of 2), while nitrogen, phosphorus, and pH showed slight degradation with

4. Conclusion

Adequate understanding of the land use cover change and its significant influence on physical, chemical and biological conditions of the soil are essential to food security and sustainable environment. This study was aimed at assessing soil degradation in response to land use change at the Federal University of Agriculture Abeokuta, Ogun State, Nigeria. The land use cover revealed that the forest land decreases indicating that the studied area currently experiencing unchecked human actions. The soil quality index criteria analysis made it easy and accurate in mapping the degradation of the studied soils. The soil quality index classed the degradation of the area into none to slightly degraded to moderately degraded soil for the studied area. It is therefore recommended that the development of sustainable land-use practices needs to be adopted while ensuring sustainable environment for optimum food productivity, and food security.

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References

Adejuwon, J. O. (2012). Climate and climate variability. In *Nigeria in Maps*. Ibadan University Press.

Adekiya, A. O., Agbede, T. M., Ojeniyi, S. O., Ewulo, B. S., and Osunde, A. O. (2019). Impact of tillage methods on soil properties, growth, and yield of maize in the derived savanna zone of Nigeria. *Archives of Agronomy and Soil Science*, 65(3), 395–409.

Amacher, M. C., O'Neill, K. P., and Perry, C. H. (2007). Soil vital signs: A guide to monitoring soil quality. *United States Department of Agriculture, Forest Service, Gen. Tech. Report NRS-22*, 1–86.

Amusan, A. A., Olayinka, A., and Abegunde, V. O. (2017). Land degradation pattern and drivers in southwestern Nigeria. *African Journal of Environmental Science and Technology*, 11(4), 149–156.

Areola, O. (1982). Soil and vegetation. In *Nigeria in Maps* (pp. 13–15). Hodder and Stoughton.

Bello, N. J., Yusuf, A. A., and Oyekunle, O. E. (2021). Effects of different land use systems on soil properties in derived savanna of Nigeria. *Nigerian Journal of Soil Science*, 31(1), 56–66.

Borrelli, P., Robinson, D. A., Fleischer, L. R., Lugato, E., Ballabio, C., Alewell, C., Meusburger, K., and Panagos, P. (2017). An assessment of the global impact of 21st-century land use change on soil erosion. *Nature Communications*, 8(1), 1–13.

Borrelli, P., Robinson, D. A., Panagos, P., Lugato, E., Yang, J. E., Alewell, C., and Montanarella, L. (2020). Land use and climate change impacts on global soil erosion by water (2015–2070). *Proceedings of the National Academy of Sciences*, 117(36), 21994–22001.

Bray, R. H., and Kurtz, L. T. (1945). Determination of total, organic, and available forms of phosphorus in soils. *Soil Science*, 59(1), 39–46.

FAO. (2015). *Status of the World's Soil Resources: Main Report*. Food and Agriculture Organization of the United Nations.

FUNAAB Report. (2021). Land use transition and development planning report. *Federal University of Agriculture Abeokuta*.

Jaiyeoba, I. A. (2003). Changes in soil properties due to continuous cultivation in Nigerian semiarid savannah. *Soil and Tillage Research*, 70(1), 91–98.

Lal, R. (2015). Restoring soil quality to mitigate soil degradation. *Sustainability*, 7(5), 5875–5895.

Morgan, R. P. C. (2005). *Soil Erosion and Conservation* (3rd ed.). Blackwell Publishing.

Oshunsanya, S. O., Adeniran, A. A., and Adekalu, K. O. (2019). Soil compaction and crop productivity in agricultural fields of southwestern Nigeria. *Nigerian Journal of Soil Science*, 29(1), 42–52.

Oyinlola, M. A., and Adesina, F. A. (2017). Vegetation and land use dynamics in a university campus: The case of Federal University of Agriculture, Abeokuta, Nigeria. *Journal of Geography and Regional Planning*, 10(6), 142–154.

Tobore A. AAA. Shohan, A Oludare, S. Alsulamy, AA. Kafy, KM. Khedher (2024). Spatial analysis of land cover changes for detecting environmental degradation and promoting sustainability. *Kuwait journal of science* 51(2), 100197, 2024.

UNDP. (2022). *Africa Human Development Report: Accelerating Climate Resilient Development*. United Nations Development Programme.