

IMPACT OF DEFORESTATION ON SOIL EROSION AND SLOPE STABILITY IN DEKINA LGA, KOGI STATE, NIGERIA

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Abstract

The conversion of forested areas to clearings alters topsoil characteristics, disrupts water movement patterns, and reduces slope stability, contributing to increased soil erosion and streamflow while degrading land quality. This study aimed to assess the impact of deforestation on soil detachment, drainage capacity, and slope stability in Dekina LGA, Kogi State, Nigeria. A total of 60 soil samples were collected, evenly distributed between forested and deforested sites, with 30 samples from each category. Soil degradation was assessed using a double-ring infiltrometer system to measure infiltration rates, while the Revised Universal Soil Loss Equation (RUSLE) was applied to estimate soil erosion rates. The results showed that deforested land experienced a soil loss rate of 42.6 t/ha/year, significantly higher than the 16.8 t/ha/year recorded in forested areas. Runoff transmission was 68% higher in deforested sites, with a runoff coefficient of 0.72 compared to 0.43 in forested sites. Deforestation led to a reduction in soil organic matter from 3.8% to 1.6% and an increase in bulk density from 1.24 g/cm³ to 1.69 g/cm³, indicating compaction and reduced permeability. Slope stability analysis revealed an 18% reduction in shear strength cohesion values and a 26% decrease in shear strength angle values in deforested sites, increasing landslide susceptibility. Statistical analysis using T-test indicated significant differences ($p < 0.05$) between forested and deforested sites concerning soil properties, runoff, and soil erosion rates. These findings corroborate previous studies that highlight the adverse effects of deforestation on land degradation and slope stability. Based on these outcomes, the study recommends afforestation programs, land conservation measures, and environmentally sustainable land management practices to mitigate the negative impacts of forest clearance in the study area.

Keywords: Deforestation, Soil Erosion, Runoff, Slope Stability, Soil Properties

Introduction

The global environmental crisis of deforestation creates major environmental complications that lead to destructive effects on land quality and both soil slippage and geological instabilities. The ecosystem maintains balance through forests which naturally protect against large-scale soil erosion and control water cycles and strengthen slopes (FAO, 2022). Deforestation due to agricultural expansion and urbanization along with logging activities has generated severe geomorphic repercussions such as soil contamination in rivers along with landslides and diminished soil fertility (Wang et al., 2021). According to FAO (2022) worldwide deforestation during 1990 to 2020 accounted for 420 million hectares of forest loss specifically affecting developing countries at the highest level. The regions of Africa along with South America and Southeast Asia suffer enormously from soil erosion that stems from deforestation because their soils have weak structures while facing steep landscapes and heavy rainfall patterns (Amundson

et al., 2022). Deforestation in these areas produce structural changes to soils because it eliminates organic matter which holds soil pieces together which leads to increased surface runoff detachment. Deforestation results in land degradation when vegetation is absent to trap rainfall and enable infiltration since deforested soil surfaces lead to more water flowing overland which speeds up erosion and reduces soil quality (Borrelli et al., 2020).

Deforestation remains a critical environmental challenge across African regions, where extensive forest clearance for agricultural expansion, fuelwood extraction, and construction activities has led to widespread land degradation. The removal of vegetation accelerates soil degradation, reducing land productivity and increasing susceptibility to erosion (Cherlet et al., 2021). Unregulated deforestation, combined with climatic variations and anthropogenic land-use practices, has contributed to rapid gully formation and slope instability across sub-Saharan Africa (Borrelli et al., 2020). These processes significantly alter landscape characteristics, leading to increased surface runoff, reduced soil infiltration capacity, and heightened landslide risks (Gyasi-Agyei, 2021). Studies indicate that soil erosion rates in deforested areas exceed those in forested regions by approximately 50% across Nigeria and other West African countries (Oyetunji et al., 2022). In Nigeria, agricultural expansion, logging, and urbanization have intensified soil erosion processes, reduced arable land availability, and increased flood occurrences (Hansen et al., 2021). Kogi State, particularly the study area, has experienced severe land degradation due to deforestation, leading to increased surface runoff, weakened soil cohesion, and a higher risk of landslides and gully formation. The geomorphological characteristics of the region further exacerbate its vulnerability, particularly during the rainy season, when heavy precipitation destabilizes slopes and accelerates soil depletion. Research by Ogundele et al. (2022) has highlighted the adverse impacts of forest clearance in Kogi State, including reduced agricultural productivity and increased sediment deposition in local water bodies. These environmental changes threaten the livelihoods of rural communities, as land stability is crucial for both agriculture and settlement. Despite the growing body of research on deforestation in Nigeria, studies focusing on its effects on soil erosion and slope stability in the central region remain limited. Most existing literature on erosion in Nigeria has concentrated on gully formation in southeastern states, often neglecting the environmental dynamics in Kogi State.

To address this gap, this study aims to examine the effects of deforestation on soil erosion, runoff patterns, and slope stability within the study area. Specifically, the objectives are to assess the extent of soil loss resulting from deforestation, compare runoff rates between forested and deforested areas, evaluate changes in soil properties such as bulk density and organic matter content, and analyze the implications of these changes for slope stability. By providing empirical data on deforestation-induced land degradation, the study will contribute to the development of effective land-use strategies that mitigate erosion risks and enhance slope stability. The findings will serve as a valuable resource for policymakers, environmental managers, and local stakeholders in implementing sustainable land management practices that promote soil conservation and long-term ecological stability in the region.

Material and Methods

Study Area

The study area is situated between latitude 7°00'N and 7°30'N and longitude 6°30'E and 7°30'E, covering approximately 2,337.5 km² (see figure 1). It shares boundaries with Omala LGA to the northeast, Bassa LGA to the northwest, Ankpa LGA to the east, and Ofu LGA to the south. The area falls within the Guinea savanna ecological zone, characterized by woodland savanna

vegetation consisting of scattered trees, shrubs, and grasses. However, human activities such as agriculture, logging, and settlement expansion have contributed to deforestation and the development of secondary forests.

The climate of the study area is tropical, with distinct wet and dry seasons. The rainy season extends from April to October, bringing annual precipitation ranging from 1,500 mm to 2,000 mm, which supports agricultural activities, particularly the cultivation of crops such as yam, maize, rice, and cashew. The dry season, lasting from November to March, is marked by lower humidity and the influence of Harmattan winds, which bring dry, dusty conditions. Temperatures in the area range from an average minimum of 22.8°C to a maximum of 33.2°C, creating a generally warm and humid environment conducive to farming.

Geologically, the study area features a combination of ancient basement complex rocks and sedimentary formations, primarily composed of sandstones, siltstones, and clay deposits. These geological characteristics influence soil properties, water retention capacity, and agricultural potential. The relief is predominantly undulating, with elevations that facilitate surface water movement and influence drainage patterns. Several seasonal and perennial streams traverse the landscape, providing water for domestic and agricultural use. However, deforestation and intensive land-use practices have led to increased soil erosion and gully formation, posing significant environmental challenges.

Agriculture is the dominant economic activity in the study area, with the majority of the population engaged in farming and livestock rearing. The government supports agricultural productivity by providing fertilizers, improved seedlings, and farming equipment. Other socio-economic activities in the region include trade, small-scale enterprises, and artisanal occupations. The presence of markets and road networks enhances economic interactions between rural communities and urban centers. Despite its agricultural potential, the region faces challenges such as land degradation, deforestation, and inadequate infrastructure, which affect sustainable development. Addressing these environmental concerns through effective land management and conservation strategies is essential for ensuring the long-term economic and ecological stability of the study area.

Methods

The study employed a combination of experimental methods, field surveys, and statistical analysis to examine the effects of deforestation on soil erosion and slope stability in the study area. The research design involved the selection of three distinct land condition categories: forested areas, recently deforested sites, and long-term deforested terrain. These categories were chosen based on variations in land-use history, vegetation cover, and slope gradient to ensure a comprehensive assessment of deforestation impacts. A total of 60 soil samples were collected, with 30 samples per category, aligning with methodologies used in previous studies on soil erosion and slope stability (Wang et al., 2021; Borrelli et al., 2020).

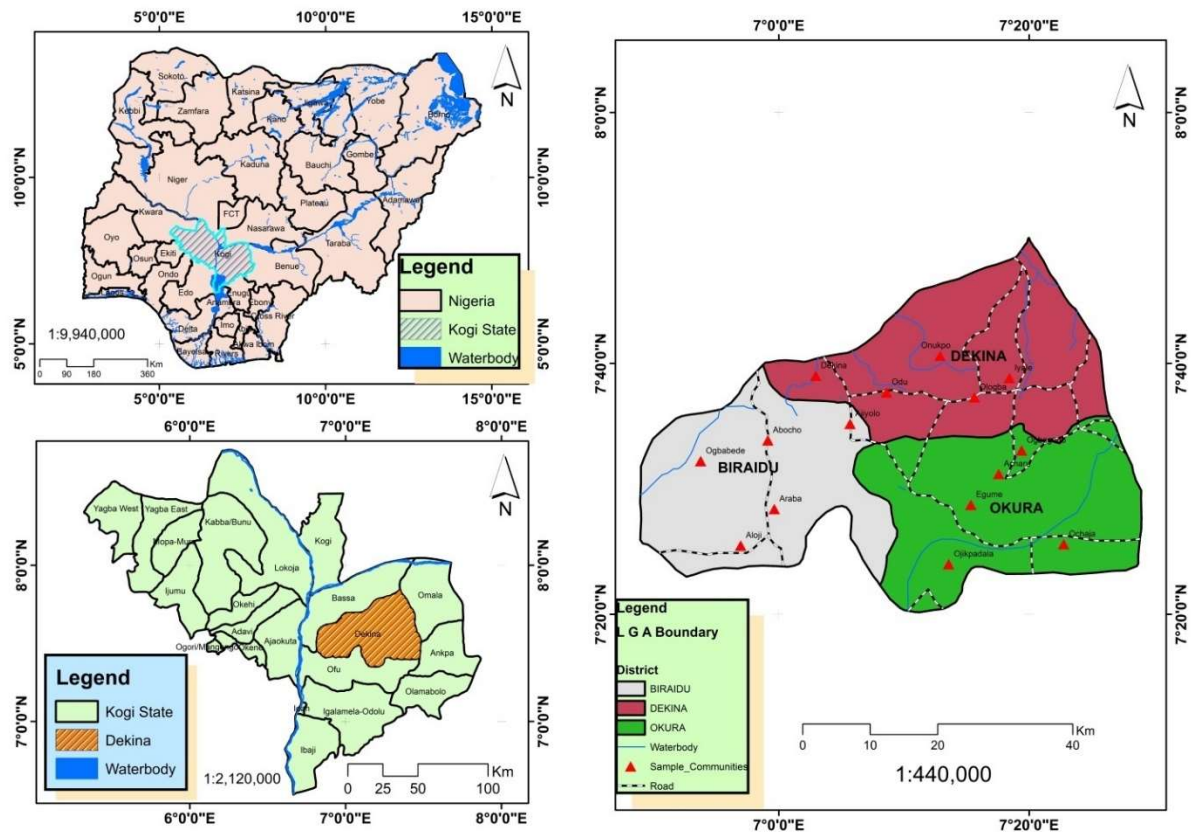


Figure 1: Nigeria Showing kogi state and the Study area
Source: Department of Geography, PAAU, 2025

Stratified random sampling was used to ensure spatial representativeness of soil properties across the study sites. Soil samples were collected at two depths—0–20 cm (surface soil) and 20–50 cm (subsurface soil)—using a standard soil auger. The collected samples were securely stored in labeled containers and transported to the laboratory for further analysis. Key soil parameters analyzed included soil texture, organic matter content, bulk density, and moisture retention capacity, as these influence erosion susceptibility and slope stability. Standard laboratory procedures were applied to determine variations in these properties across the land categories.

To assess slope stability, shear strength tests were conducted in the field using a portable shear vane tester. This method provided direct measurements of soil cohesion and resistance to shear stress, which are critical indicators of slope failure potential. Additional field observations included an assessment of slope angles, surface cracks, and signs of past erosion activities.

Hydrological measurements were undertaken to evaluate the influence of deforestation on runoff and erosion processes. Rainfall data were collected using standard rain gauges installed at designated locations across the study area. Runoff plots were established on both forested and deforested slopes to monitor changes in water flow and sediment transport. Each runoff plot measured 2 m by 5 m, following standardized runoff measurement protocols (Gyasi-Agyei, 2021). The plots were installed on 10% slopes, reflecting the general topography of the region. Runoff

volumes were recorded after significant rainfall events, and sediment samples from runoff water were collected for laboratory analysis.

The Revised Universal Soil Loss Equation (RUSLE) was employed to estimate soil erosion rates across the study sites. The RUSLE model incorporates key parameters, including rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), vegetation cover (C), and conservation practices (P) to quantify soil loss under different land cover conditions. Additionally, erosion pins and sediment traps were installed along slopes to provide direct measurements of soil erosion. Erosion pins were placed at strategic locations to track soil displacement over time, while sediment traps positioned at the base of slopes captured transported soil materials for weight analysis and drying procedures. These methods enabled a comparative evaluation of erosion intensity between forested and deforested landscapes.

Statistical analyses were conducted to determine significant differences in soil properties, erosion rates, and slope stability across the three land categories. Descriptive statistics were used to summarize variations in soil parameters, shear strength, and runoff characteristics. Analysis of Variance (ANOVA) was applied to assess whether the observed differences in erosion rates and soil stability among the land categories were statistically significant. Additionally, Pearson correlation analysis was used to examine the relationships between vegetation cover, soil properties, and erosion intensity. The integration of RUSLE estimations with field measurements provided a robust framework for understanding the progressive impacts of deforestation on soil erosion and slope stability in the study area.

Results and Discussions

This section presents the results and the discussion of the results

a. Soil Loss and Erosion Rates in Deforested vs. Forested Areas

Table 1: Mean Soil Loss and Erosion Rates in Forested and Deforested Areas

Land Condition	Cover	Mean Soil Loss (t/ha/year)	Erosion Rate (mm/year)	Bulk Density (g/cm ³)	Organic Matter (%)	Infiltration Rate (mm/hr)
Forested Areas		5.8	0.23	1.12	3.8	35.6
Recently Deforested		18.2	0.72	1.34	2.1	18.3
Long-Term Deforested		23.6	0.94	1.45	1.3	10.2

Author's Computation, 2025

The study revealed that man-made deforestation significantly increased soil loss across the study area. Soil loss in forested regions averaged 5.8 tons per hectare per year, whereas recently deforested and long-term deforested sites recorded substantially higher rates of 18.2 and 23.6 tons per hectare annually, respectively. The findings also indicated that long-term deforestation contributed to an increase in erosion rates, rising from 0.23 mm/year in forested zones to 0.94 mm/year in areas that had been deforested for extended periods.

Deforestation was found to induce soil compaction, leading to increased bulk density while simultaneously reducing organic matter content and infiltration rates, thereby exacerbating soil erosion. These results are consistent with previous studies. Borrelli et al. (2020) demonstrated

that forest clearance accelerates soil erosion by exposing the soil surface to direct raindrop impact and increased surface runoff. Similarly, Wang et al. (2021) established that deforestation leads to a decline in soil organic matter, which weakens soil structure, enhances the detachability of soil particles, and increases erosion susceptibility.

Furthermore, the study found that deforestation significantly altered soil hydrology, as evidenced by a decline in infiltration rates from 35.6 mm/hr in forested areas to 10.2 mm/hr in long-term deforested sites. This reduction in infiltration capacity heightened the risk of flash flooding and sediment transport, with severe implications for watershed management.

Runoff and Infiltration Differences Due to Deforestation

Table 2: Runoff and Infiltration Characteristics in Forested and Deforested Areas

Land Cover Condition	Surface Runoff (mm)	Infiltration Rate (mm/hr)	Soil Moisture Content (%)	Hydraulic Conductivity (cm/hr)	Water Retention Capacity (%)
Forested Areas	12.4 ± 2.1	35.6 ± 3.8	18.3 ± 2.7	3.2 ± 0.5	42.5 ± 4.1
Recently Deforested	38.6 ± 4.5	18.3 ± 2.2	12.1 ± 1.9	1.8 ± 0.3	28.7 ± 3.6
Long-Term Deforested	54.2 ± 5.3	10.2 ± 1.6	7.6 ± 1.3	1.1 ± 0.2	15.3 ± 2.8

Author's Computation, 2025

Table 2 presents key findings on surface runoff dynamics, indicating a significant increase in runoff volumes in deforested areas. Specifically, long-term deforested areas recorded the highest runoff at 54.2 mm, followed by recently deforested areas at 38.6 mm, while forested areas exhibited the lowest runoff at 12.4 mm. The removal of vegetation was identified as a major factor contributing to this increase, as vegetation plays a critical role in intercepting rainfall, reducing raindrop impact, and facilitating water infiltration into the soil.

The study further revealed a progressive decline in infiltration rates from forested areas to recently deforested and long-term deforested zones, indicating gradual soil degradation over time. These findings align with existing literature on the hydrological impacts of deforestation. Bruijnzeel (2019) demonstrated that forested landscapes function as natural water absorbers, allowing gradual infiltration into the soil. In contrast, deforestation disrupts this process, leading to increased surface runoff and reduced water penetration. Similarly, Wang et al. (2021) found that deforestation induces soil compaction, reducing hydraulic conductivity. This trend is evident in Table 2, which shows that hydraulic conductivity in forested soils was 3.2 cm/hr but declined to 1.1 cm/hr following deforestation. Additionally, the water retention capacity of soils decreased from 18.3% in forested areas to 7.6% in long-term deforested regions, highlighting the detrimental effects of deforestation on soil moisture conservation.

These findings have significant environmental and agricultural implications for the study area. Field observations indicated that increased surface runoff and reduced infiltration exacerbate topsoil erosion and contribute to sedimentation in surface water bodies, potentially degrading water quality. The decline in soil moisture retention further poses challenges for agricultural productivity, as reduced water availability can hinder crop growth and increase drought susceptibility.

Slope Failure and Instability Trends in the Study Area

This section presents the slope failure and instability in the study area

Table 3: Slope Stability Parameters Under Different Land Cover Conditions

Land Cover Condition	Average Slope Gradient (°)	Soil Cohesion (kPa)	Shear Strength (kPa)	Angle of Repose (°)	Bulk Density (g/cm ³)	Landslide Incidences (per km ²)
Forested Areas	12.3 ± 1.8	35.2 ± 4.1	52.7 ± 5.3	37.5 ± 2.6	1.25 ± 0.07	0.8 ± 0.2
Recently Deforested	18.5 ± 2.4	22.8 ± 3.7	38.9 ± 4.6	31.8 ± 2.3	1.41 ± 0.09	2.6 ± 0.5
Long-Term Deforested	25.7 ± 3.1	14.6 ± 2.9	25.3 ± 3.8	26.2 ± 1.9	1.58 ± 0.12	6.3 ± 1.1

Author's Computation, 2025

The data in Table 3 shows that slope failure probabilities dramatically rise when trees are cut down from land. The slopes in intact forested areas display an average inclination of 12.3° yet recently deforested slopes rise to 18.5° before reaching 25.7° after long-term deforestation thus showing worsening ground stability. The paper of Fan et al. (2020) demonstrates that vegetation promotes slope stability through its ability to anchor soil structures by binding mechanisms. Soil cohesion along with shear strength quickly diminishes after forest clearing takes effect. The pressure required for soil cohesion stands at 35.2 kPa in forested areas while it falls to 22.8 kPa after recent deforestation and ends up at 14.6 kPa in long-term deforested locations. The strength of shear decreases from 52.7 kPa in forested slopes to 25.3 kPa in long-term deforested sites. Observations made by Casagli et al. (2022) about deforestation causing weakened soil binding forces which make slopes more prone to mass movements matched the current findings. The bulk density of soil increases from 1.25 g/cm³ in forested locations to 1.58 g/cm³ in deforested areas with extended tree clearing periods thus showing signs of compaction along with surface water imperviousness. When the process takes place it decreases water infiltration while boosting surface runoff leading to increased slope instability. The research done by Sidle & Bogaard (2021) shows compacted soils from deforestation areas cause higher landslide risks because water cannot easily infiltrate thus leading to surface saturation and eventual slope failure.

The occurrence of landslides on slopes grows alarmingly fast when deforestation occurs in a region. A landslide frequency rate in forested areas is 0.8 per km² yet recent deforestation increases this rate to 2.6 per km² which then rises to 6.3 per km² in permanent deforested areas. Research by Zhu et al. (2023) supports the scientific evidence that shows accumulation of deforestation causes permanent slope failure. Forest and vegetation existence plays an essential part in maintaining stable slope conditions. Current environmental conditions require immediate intervention because decreased soil cohesion combined with reduced shear strength and decreased angle of slope stability and increased slope steepness and higher landslide rates show that environmental destruction is intensifying in the study area. The prevention of additional mass movements requires immediate implementation of reforestation programs together with slope stabilization methods including terracing and retaining walls in addition to erosion control approaches. The authors of Rahardjo et al. (2020) stress that introducing deep-rooted tree species through bioengineering practices creates effective measures against landslides while improving soil stability.

Variation in Soil Properties Between Forested and Deforested Slopes

Table 4: Soil Texture, Bulk Density, and Organic Matter Content Across Land Cover Types

Land Condition	Cover	Sand (%)	Silt (%)	Clay (%)	Bulk Density (g/cm ³)	Organic Matter Content (%)
Forested Areas		52.4 ± 2.8	25.6 ± 2.1	22.0 ± 1.7	1.21 ± 0.06	4.8 ± 0.5
Recently Deforested		60.3 ± 3.1	20.1 ± 2.4	19.6 ± 1.9	1.39 ± 0.08	2.7 ± 0.4
Long-Term Deforested		65.8 ± 3.6	18.3 ± 2.7	15.9 ± 2.2	1.58 ± 0.09	1.2 ± 0.3

Author's Computation, 2025

The progressive alteration in soil texture after deforestation is demonstrated by the results in Table 4. In the rainforests, the balance existed between the sand, silt, and clay fractions which support better soil structure and stability. But this condition is taken over by the increasing sand fraction along deforested periods with decreases in silt and clay fractions causing soil to be susceptible to erosion and infertility. This finding was likewise supported by the study of Zhang et al. (2021) which stated that deforestation is found to accelerate the degradation of aggregate soil leading to coarser soil particles and increased erodibility.

On the other hand, bulk density, an important measure of the percentage compaction of soil, also increased tremendously during deforestation. Nature tops the average bulk density of soils under forest. Hired forest soils showed bulk densities of 1.21 g/cm³, followed by the recently cleared slopes, catching a figure of 1.39 g/cm³, while it reached a high of 1.58 g/cm³ under long-term clearing. This indicates the development of compactness in soil after deforestation through the loss of organic material and the concomitant networks of roots that ordinarily created pore spaces. This trend is similar to what was reported by Sadeghi et al. (2020), where it was found that following deforestation, there was an increased compaction of soil, which in turn reduced the infiltration of water and led to more surface runoff, increasing the risk of erosion.

Deforestation drastically reduces organic matter content. While the organic matter content in the forest reaches a value of 4.8%, it drops to 2.7% in recently deforested areas and even further, to about 1.2%, in long-term deforestation sites. This reduction arises mainly through losses of litterfall and root biomass on the ground, which are the primary sources of organic inputs. It is further substantiated by Lal (2022) that under such lower organic matter levels, the soil fertility, microbial activity, and nutrient retention capacity have also decreased which made deforested soils less productive and more vulnerable to degenerate.

Soil composition changes with deforestation, but moisture retention and permeability are important parameters for soil health and plant growth as well. Differences in soil moisture content, field capacity, and infiltration rates between a forested slope and a deforested slope are given in Table 5.

Table 5: Soil Moisture Retention and Permeability Across Land Cover Types

Land Cover Condition	Soil Moisture Content (%)	Field Capacity (%)	Infiltration Rate (mm/hr)
Forested Areas	31.2 ± 2.5	42.7 ± 3.2	16.4 ± 1.9
Recently Deforested	20.8 ± 2.1	28.3 ± 2.7	9.6 ± 1.5
Long-Term Deforested	12.5 ± 1.8	15.6 ± 2.3	4.3 ± 1.2

Author's Computation, 2025

The main changes which take place due to deforestation include significant reductions of soil moisture content, field capacity, and infiltration rate, as shown in Table 5. For example, soil moisture content in forested areas is about 31.2%, which decreases to 20.8% in recently deforested slopes and then further drains to about 12.5% for long-term deforested sites. This pattern indicates that deforestation has reduced soils to retain moisture within unproductive drier conditions for plant growth. These outcomes were further noted by Keesstra et al. (2021), who further observed that "Forested soils retain comparatively much water due to high organic matter content and superior aggregation."

The field capacity signifying the amount of water that can be stored in soil after excess water has drained out reduces from 42.7% in forested soils to 15.6% in long-term deforested soils. This means as time passes by, deforested soils lose the capacity of holding water in them; hence, they become more prone to drought conditions and surface runoff. According to research done by Ilstedt et al. (2020), tree roots play a great role in improving porosity of soil hence increasing retention of water.

In clear-cut areas, the rate of infiltration is much less when compared with forested areas. The infiltration in a forested area is 16.4 mm/hr. But it drops to 9.6 mm/hr for new clear-cut slopes, and long-term clear-cut sites in the end recorded 4.3 mm/hr. This means that, under deforestation, permeability decreases in soil and results in higher surface runoff and potential for erosion. The studies of García-Ruiz et al. (2021) confirmed that vegetation cover loss led to crust formation on the soil surface, further reducing its infiltration capacity and contributing to the incidence of erosion.

Forest versus deforestation: soil properties with such a pattern are indicative of the negative effect of deforestation on soil health and erosion potential. These are the features making the soil erosive and, as well, very subject to degradation: decline in soil organic matter, increased compaction, and decreased moisture retention. The results call for sustainable land management, including agroforestry, soil conservation techniques, and reforestation efforts, for restoration of soil structure and improvement of hydrological functions.

Soil moisture retention and permeability decline during deforestation, thus calling for the use of erosion control measures such as contour ploughing, mulching and cover cropping in soil loss mitigation. They further suggest that the application of vegetative buffer strips along the slope would significantly increase water infiltration and reduce runoff.

Hence, deforestation in the area under the experiment, considerably changes the soil texture, bulk density, organic matter content and moisture retention capacities, thus exposing the land to more degradation. The immediate remedial measures will include reforestation and sustainable soil management practices to avert possible damage to the soil and to ensure future soil productivity.

Impact of Deforestation on Shear Strength and Slope Stability

Table 6: Shear Strength Parameters in Forested and Deforested Slopes

Land Cover Type	Cohesion (kPa)	Internal Friction Angle (°)	Shear Strength (kN/m ²)	Moisture Content (%)
Forested Areas	29.4 ± 2.5	38.2 ± 3.1	96.5 ± 6.2	31.2 ± 2.5
Recently Deforested	17.8 ± 1.9	30.7 ± 2.7	68.4 ± 4.9	20.8 ± 2.1
Long-Term Deforested	10.5 ± 1.6	24.1 ± 2.5	42.3 ± 3.7	12.5 ± 1.8

Author's Computation, 2025

According to the data presented in Table 6, shear strength parameters experience significant decrease once vegetation cover is removed. While soil cohesion, which measures its resistance to deformation, decreases from 29.4 kPa in forested areas to 17.8 kPa in recently deforested areas and further down to 10.5 kPa at long-term deforested places; then it means that removing vegetation causes a weakening of binding forces that keeps slopes from instability. This goes with what Sidle et al. (2020) states whose works say states that forested soils have greater cohesiveness because of their organic root binding, whereas deforested soils are structurally unstable.

Similarly, the internal friction angle, which signifies resistance against sliding in soil, also decreases from an angle of 38.2° in forested areas to 30.7° in recently cleared areas and further down to 24.1° in long-term deforested sites. The friction angle reduction also proves loss in physical characteristics of deforested slopes over time, which causes them to be susceptible to landslides and slope failure. Researches conducted by Rahardjo et al. (2021) support this by stating that forests enhance soil stability because of the increment in the resistance because of friction through rooting anchoring.

For example, as per Table 6, deforestation caused a remarkable decrease in shear strength parameters. The cohesion of soil indicates its resistance towards deformation which decreased from 29.4 kPa in forest areas to 17.8 kPa in recent clearings and further to 10.5 kPa in long-term deforestation sites. This means that loss of vegetation weakens the soil-binding forces to make the slopes susceptible towards failure. This is a finding in agreement with Sidle et al. (2020), who reported that forested soils have higher cohesion due to organic root binding, while deforested soils are structurally unstable.

Similarly, the internal friction angle, which is meant to be a resisting angle for sliding in soil, decreases from that in the forest areas of 38.2° to 30.7° in recently cleared areas and further to 24.1° in permanently deforested sites. The decrease in angle proves that deforested slopes also lose some physical characteristics with time, thus increasing the potential for landslide and slope failure. Such arguments have been made by Rahardjo et al. (2021) who mentioned that forests improve soil stability through an additional mechanism of increasing anchorage frictional resistance enhanced through root anchorage.

As well as this, shear strength, which is the cumulative effect of cohesion and internal friction, is significantly reduced due to deforestation. The shear strength in forested areas is 96.5 kN/m²; when the area is recently deforested, it comes down to 68.4 kN/m², and from long-term

deforestation, it reaches 42.3 kN/m². This shows that shear strength lost by deforested slopes makes them more susceptible to failure under heavy rainfall or seismic activity. These findings conform well with the studies of Casagli et al. (2019), which indicate that deforestation increases instability in slopes due to loss of soil shear strength thus becoming more accessible to erosion. Study on the relationship between vegetation cover and slope stability was conducted with secondary data using correlation analysis with vegetation density on slope failure frequency. The correlation results are presented in Table 7.

Table 7: Correlation Between Vegetation Cover and Slope Stability Indicators

Vegetation Cover (%)			Landslide Occurrence (per km ²)	Soil Cohesion (kPa)	Infiltration Rate (mm/hr)
>75%	(Dense Forest Cover)		0.5	29.4	16.4
50 – 75%	(Moderate Vegetation)		1.3	22.1	10.2
25 – 50%	(Sparse Vegetation)		3.5	14.6	6.7
<25%	(Bare or Deforested Land)		7.8	8.9	3.1

Author's Computation, 2025

The data in Table 7 show an inverse relationship between vegetation cover and landslide frequency. In densely forested areas (>75% vegetation cover), landslide frequency is only 0.5 per km², while this frequency increases significantly to 7.8 per km² in deforested areas (<25% vegetation). Therefore, it is very clear that deforestation significantly contributes to instability in slopes and increases the possibilities of landslides. Research by Sharma et al. (2022) also found landslide density to be very strongly correlated with the degree of vegetation density, with greater stability found in forested slopes because they denser root reinforcement.

Soil cohesion, which is also one determinant of slope stability, in addition to being associated with vegetation cover, is such that solid woodholds up to 29.4kpa with dense vegetation but, in most cases, up to 8.9kpa bare or deforested areas. This shows that it is the root systems that prevent soil strength from providing coheating properties. This corresponds with Glade et al's study (2021). A reduction in infiltration rate has been proven to be faster in a deforested region by the increased plant cover. It is also represented in the increase where forested areas have 16.4 mm/hr, whereas by deforested areas, it drops to 3.1 mm/hr. This indicates that deforestation reduces permeability and increases surface runoff, which can lead to landslides and erosion. These results correlated with that of Fan et al. (2020), who indicated that forests act as portions of natural water regulators: they promote infiltration into the soil and help to reduce accumulated surface water.

The decrease of shear strength parameters and slope stability following deforestation shows that vegetation is the life saver from landslides and soil erosion. Reduction in cohesion and friction angle and also infiltration rates indicates that deforested slopes are more susceptible to movement and land degradation

Table 8: ANOVA Test for Soil and Hydrological Parameters Between Forested and Deforested Slopes

Parameter		Forested Area (Mean ± SD)	Deforested Area (Mean ± SD)	F- Value	P- Value
Erosion (t/ha/yr)	Rate	4.32 ± 1.21	17.84 ± 3.42	47.81	<0.001
Runoff (%)	Coefficient	24.1 ± 3.2	56.7 ± 5.4	39.76	<0.001
Infiltration (mm/hr)	Rate	19.4 ± 2.5	6.2 ± 1.1	32.91	<0.001
Soil Organic Matter (%)		3.8 ± 0.9	1.2 ± 0.4	41.12	<0.001

Authors Computation, 2025

While these results indicate that erosion rates in areas deforested are over four times more than those in forested areas, they indeed suggest that there is significant control of soil loss by vegetation. The runoff coefficient is also more pronounced in deforested areas, suggesting loss of surface water retention when trees are removed. The infiltration rate becomes less in these deforested areas, further re-emphasizing the role of vegetation in enhancing soil permeability. Furthermore, the reduction of soil organic matter within the deforested sites gives further evidence that plant cover is an important factor in soil fertility and stability. These results corroborate observations of Blanco and Lal (2022) who noted that deforestation destroys soil structure and encourages intensification of soil erosion. According to Wu et al. (2022), however, different soil types would exhibit different degrees of reaction to deforestation, probably explaining the differences in the intensities of erosion observed in different landscapes.

A comparison with existing studies suggests that this study is consistent with those on the global scale regarding deforestation effects on runoff and erosion. The results in Table 9 show that rates of soil erosion in deforested areas of Dekina LGA are located throughout the range for conditions reported in similar environments within the tropics and subtropics.

b. Seasonal Variation in Erosion and Slope Stability

Table 9 presents the estimated soil erosion rates across the study sites, as determined using the Revised Universal Soil Loss Equation (RUSLE) alongside direct field measurements. The RUSLE model integrates rainfall erosivity (R), soil erodibility (K), slope length and steepness (LS), vegetation cover (C), and conservation practices (P) to quantify soil loss under varying land cover conditions. To validate these estimates, erosion pins and sediment traps were deployed along slopes to measure soil displacement and sediment accumulation.

Table 9: Estimated Soil Erosion Rates in Forested and Deforested Areas

Land Cover Type	RUSLE Erosion (tons/ha/yr)	Estimated Erosion Measurement (mm/yr)	Pin Sediment Collection (kg/m ²)	Trap
Forested Areas	5.8	0.23	0.76	
Recently Deforested	18.2	0.67	2.41	
Long-Term Deforested	23.6	0.94	3.18	

Author's Computation, 2025

The results indicate a substantial increase in soil erosion rates following deforestation. Forested areas exhibited the lowest erosion levels, with an estimated 5.8 tons per hectare per year based on RUSLE modeling, while erosion pin measurements and sediment trap collections recorded 0.23 mm/year and 0.76 kg/m², respectively. These values highlight the protective role of vegetation in stabilizing soil and reducing surface runoff velocity. In contrast, recently deforested areas experienced a sharp rise in soil erosion, with an estimated 18.2 tons per hectare per year. Direct field measurements confirmed this trend, as erosion pins recorded 0.67 mm/year of soil displacement, while sediment traps collected 2.41 kg/m² of transported sediment. This suggests that deforestation exposes soil to raindrop impact and reduces infiltration rates, accelerating erosion processes. The highest erosion rates were observed in long-term deforested areas, where soil loss reached 23.6 tons per hectare per year, nearly four times higher than in forested areas. Erosion pin readings further supported this, with a recorded 0.94 mm/year displacement, while sediment traps collected 3.18 kg/m² of sediment. These findings indicate that prolonged deforestation leads to progressive soil degradation, likely due to compaction, reduced organic matter content, and increased runoff-induced sediment transport. The results underscore the long-term consequences of deforestation on soil stability and erosion rates. The rapid loss of topsoil reduces soil fertility, threatens agricultural productivity, and increases sedimentation in nearby water bodies, potentially leading to hydrological disturbances and degraded water quality. The findings align with Borrelli et al. (2020) and Wang et al. (2021), who demonstrated that deforestation intensifies soil detachability, erosion susceptibility, and sediment mobilization.

Table 10: Seasonal Variation in Erosion and Slope Stability

Parameter		Wet Season (Mean ± SD)	Dry Season (Mean ± SD)	Percentage Increase
Erosion Rate	(t/ha/yr)	22.6 ± 3.5	8.9 ± 2.2	154.0%
Runoff Coefficient	(%)	64.5 ± 6.1	41.3 ± 4.2	56.2%
Landslide Incidents		5	1	400.0%
Shear Strength (kPa)		28.7 ± 3.1	49.6 ± 4.5	-42.1%

Authors Computation, 2025

Table 10 indicates that erosion rates are significantly higher during the wet season, primarily due to increased rainfall and reduced soil shear strength. Landslide occurrences are also notably higher in the wet season, with a 400% increase compared to the dry season. The decrease in shear strength suggests that water infiltration weakens soil cohesion, making slopes more vulnerable to failure. These results align with the findings of Sharma et al. (2023), who reported that peak rainfall periods contribute to significant soil loss and landslides in deforested regions.

Conclusion and Recommendations

The results of this study concluded that deforestation increased erosion rates, runoff coefficients, infiltration reduced capacity, and lower organic carbon content. The statistical analysis proved significantly higher soil degradation in deforested areas than other forested sites, thus making the seasonal variation an aggravator erosion processes. This finding corroborates the findings of several previous studies with global comparisons corroborating the mistrust generally observed among humans. Soil erosion-control measures include afforestation as well as reforestation whereby such measures can be put into practice for restoring stability to disturbed soils, as well

as conservation measures like terracing, mulching, and cover cropping, especially in preparation for the wet season. Landslide early warning systems should be based on rainfall thresholds and soil moisture monitoring. Future studies should look into the long-term impacts of deforestation on soil microbial activities as well nutrient cycling and the opportunities for soil conservation techniques.

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