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Farming Practices and Sustainability of Forest Ecosystems in Ikom Education Zone, Cross River State, Nigeria

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Abstract

Agricultural expansion remains one of the most significant drivers of forest ecosystem degradation in sub-Saharan Africa. This study examined the relationship between farming practices and forest ecosystem sustainability in Ikom Education Zone, Cross River State, Nigeria. Specifically, the study investigated the predictive influence of agroforestry practices and deforestation/slash-and-burn agriculture on forest sustainability. A survey design was adopted, and data were collected from 309 farmers using a validated questionnaire (test–retest reliability = .89). Simple linear regression analysis was conducted at the .05 significance level. Results indicated that agroforestry significantly predicted forest ecosystem sustainability, $R = .704$, $R^2 = .495$, $F(1, 307) = 805.80$, $p < .001$, explaining 49.4% of the variance. Conversely, deforestation/slash-and-burn practices significantly predicted reduced forest sustainability, $R = .796$, $R^2 = .634$, $F(1, 307) = 1424.02$, $p < .001$, accounting for 63.4% of the variance. Findings suggest that while agroforestry enhances ecological stability, slash-and-burn practices substantially undermine forest resilience. The study recommends scaling up agroforestry extension services and strengthening regulatory frameworks to discourage destructive land-use practices. The findings contribute to sustainable land management discourse in tropical forest ecosystems.

Keywords: agroforestry, deforestation, slash-and-burn agriculture, forest sustainability, sustainable land management, Nigeria

1. Introduction

Forest ecosystems in tropical regions are under increasing pressure due to agricultural intensification and population growth. In Nigeria, forest degradation is strongly linked to land conversion for agriculture, logging, and urban expansion (Evans, 1992; Ladipo, 2010). Cross River State, recognized as one of Nigeria's biodiversity hotspots, has experienced notable forest cover loss associated with peasant farming and unsustainable land preparation techniques.

Although agriculture remains central to rural livelihoods, its ecological implications vary significantly depending on the farming system adopted. Agroforestry systems are increasingly

recognized as ecologically integrative land-use models, whereas slash-and-burn agriculture has been widely associated with soil degradation, biodiversity loss, and carbon emissions (Giardina et al., 2000; Meyfroidt et al., 2010).

Despite extensive conceptual discussions, empirical evidence linking specific farming practices to measurable indicators of forest ecosystem sustainability in southern Nigeria remains limited. This study addresses this gap.

2. Theoretical Framework

This study is anchored in three complementary theoretical perspectives:

2.1 Sustainable Development Theory

Rooted in the Brundtland Commission framework, Sustainable Development Theory emphasizes meeting present needs without compromising future generations. Within forest-dependent communities, sustainability requires balancing agricultural productivity with ecological resilience. Agroforestry reflects this integrative model, combining production and conservation objectives.

2.2 Socio-Ecological Systems (SES) Theory

SES theory conceptualizes forests and farming communities as interconnected adaptive systems. Agricultural decisions influence ecological feedback loops such as nutrient cycling, carbon sequestration, and hydrological regulation. Destructive practices disrupt system equilibrium, whereas diversified systems such as agroforestry enhance adaptive capacity.

2.3 Forest Transition Theory

Forest Transition Theory posits that forest loss initially increases during agricultural expansion but may stabilize or reverse with sustainable land management innovations. Agroforestry represents a transitional pathway toward forest recovery without compromising food security.

Together, these frameworks explain how farming practices function as drivers of ecological resilience or degradation.

3. Literature Review

3.1 Agroforestry and Forest Sustainability

Agroforestry is widely conceptualized as a sustainable land-use system that deliberately integrates woody perennials such as trees and shrubs with crops and/or livestock within the same land management unit (Owunubi & Otegbeye, 2002). Unlike conventional monocropping systems, agroforestry mimics natural forest structures by creating multi-layered vegetation systems that enhance ecological stability while maintaining agricultural productivity. This structural diversity allows agroforestry systems to function as semi-natural ecosystems, thereby contributing to both conservation and livelihood objectives.

Empirical evidence consistently demonstrates that agroforestry improves soil quality and ecological resilience. Tree components contribute to increased soil organic matter through leaf litter decomposition and root biomass turnover, enhancing soil aggregation and nutrient availability (De Koning et al., 2011; Kuntashula et al., 2014). The presence of deep-rooted woody perennials facilitates vertical nutrient redistribution, whereby nutrients leached into deeper soil layers are reabsorbed and returned to the surface through litter fall. This process reduces nutrient loss and improves soil fertility over time.

Furthermore, agroforestry systems significantly reduce soil erosion. Tree canopies intercept rainfall, thereby minimizing the kinetic energy of raindrops that typically dislodge soil particles in exposed fields. Root systems stabilize soil structure and enhance infiltration rates, reducing surface runoff. In tropical regions characterized by intense rainfall events, these functions are particularly critical for maintaining long-term soil productivity.

Beyond soil conservation, agroforestry contributes to carbon sequestration and climate regulation. Trees capture atmospheric carbon dioxide through photosynthesis and store it in biomass and soil organic carbon pools. This dual carbon storage capacity positions agroforestry as an important nature-based climate mitigation strategy, particularly in developing countries where forest loss is ongoing. By integrating trees into farming systems, agroforestry reduces pressure on natural forests while simultaneously enhancing on-farm carbon stocks.

Studies further show that tree–crop integration enhances nutrient cycling efficiency and stabilizes microclimatic conditions (Hagen et al., 2013; Liu et al., 2015). Tree canopies moderate extreme temperatures by providing shade, reduce evapotranspiration rates, and improve humidity retention. These microclimatic benefits can increase crop yields under climate variability and reduce vulnerability to drought stress. Such adaptive benefits are especially relevant in sub-Saharan Africa, where smallholder farmers face increasing climate uncertainties.

Agroforestry also promotes biodiversity conservation. The presence of diverse plant species provides habitats for birds, insects, and soil microorganisms, thereby supporting ecological functions such as pollination, pest control, and decomposition. Compared to monoculture systems, agroforestry landscapes exhibit higher species richness and ecological complexity, contributing to landscape-level conservation goals.

From a socio-economic perspective, agroforestry enhances livelihood diversification and resilience. Miluka et al. (2010) highlighted that agroforestry systems generate multiple income streams, including timber, fuelwood, fruits, fodder, and medicinal products. This diversification reduces dependence on single crops and buffers households against market and climate shocks. In forest-adjacent communities, agroforestry may reduce reliance on destructive forest extraction by providing alternative sources of forest products within farm boundaries.

The literature positions agroforestry as a multifunctional land-use strategy capable of reconciling agricultural production with forest conservation. Its ecological benefits extend beyond farm-level productivity to broader ecosystem services, including watershed protection, carbon sequestration, biodiversity conservation, and climate regulation. Consequently, agroforestry is frequently recommended as a sustainable alternative to land-clearing agricultural practices in tropical forest zones.

3.2 Slash-and-Burn Agriculture and Forest Degradation

Slash-and-burn agriculture, also referred to as shifting cultivation or fire-fallow cultivation, involves clearing vegetation and burning biomass to prepare land for cultivation. The combustion process releases nutrients locked in plant tissues into the soil in the form of ash, temporarily enhancing soil fertility. While this method has historically been practiced in low-density populations with long fallow periods, contemporary demographic pressures have shortened fallow cycles, undermining ecological recovery processes.

Although ash deposition can provide short-term nutrient enrichment, the long-term ecological consequences are largely detrimental. Giardina et al. (2000) found that nutrient gains following burning are transient, with rapid nutrient leaching and loss occurring shortly after cultivation begins. The combustion process reduces soil organic matter, disrupts microbial communities, and diminishes soil structure stability. Over successive cycles, soil fertility declines significantly, leading to lower productivity and prompting further forest clearing.

One of the most significant environmental consequences of slash-and-burn agriculture is soil erosion. Burning removes protective vegetation cover, exposing soil surfaces directly to rainfall impact and wind action. In tropical environments with intense precipitation, this exposure accelerates topsoil loss and promotes gully formation. The removal of nutrient-rich topsoil further compounds fertility decline and increases sedimentation in nearby water bodies.

Okese (2021) identified additional environmental risks, including biodiversity loss, habitat destruction, and increased susceptibility to wildfires. Burning eliminates not only targeted vegetation but also beneficial soil organisms and wildlife habitats. Repeated fires can alter species composition, favoring fire-resistant species and reducing overall ecosystem diversity. Moreover, uncontrolled burns may spread beyond intended farm boundaries, contributing to large-scale forest fires and landscape degradation.

Laurence et al. (2006) documented similar ecological consequences in Central Africa, linking agricultural expansion and logging activities to forest fragmentation and wildlife population declines. Fragmentation disrupts ecological connectivity, isolates species populations, and reduces genetic diversity. As forest patches become smaller and more isolated, ecosystem resilience declines, increasing vulnerability to climate change and anthropogenic pressures.

Slash-and-burn agriculture also contributes to atmospheric greenhouse gas emissions. Biomass burning releases carbon dioxide, methane, and nitrous oxide, all of which contribute to global warming. In regions where forest conversion is extensive, these emissions represent a significant component of national carbon budgets. Unlike agroforestry systems that sequester carbon, slash-and-burn practices result in net carbon release.

Socio-economically, the unsustainability of slash-and-burn systems creates a cycle of land degradation and poverty. As soil productivity declines, farmers are compelled to clear new forest areas, perpetuating deforestation. Shortened fallow periods limit natural regeneration processes, reducing the land's long-term carrying capacity. These dynamic underscores the urgent need for sustainable alternatives that maintain productivity without continuous forest encroachment.

While slash-and-burn agriculture may offer short-term productivity benefits, the cumulative ecological impacts soil degradation, biodiversity loss, carbon emissions, and forest fragmentation significantly undermine forest ecosystem sustainability. Contemporary literature therefore advocates for the transition toward conservation-oriented systems such as agroforestry and conservation agriculture to mitigate environmental degradation in tropical forest regions

4. Methodology

The research used a survey design. The study was carried out in Ikom Education Zone of Cross River State. The farming population is the major focus of this study, this is because they are those who engage on the different agricultural practices which this study intends to investigate. The multi-stage sampling procedure was used to select a total number three hundred and thirty-three (10%) respondents from six wards in two LGAs, Yakurr and Obubra. Data was collected using a researcher made questionnaire titled farming practices and sustainability of forest ecosystems questionnaire (FPASFES). The instrument was divided into two sections: section A which include their L.G.A, sex, age, marital status, occupation, educational attainment while section B elicits information on the variables, agro-forestry, slash burn/deforestation and sustainability of forest ecosystem. The instrument was validated by experts and the reliability coefficient of .89 was obatained through test-retest method indication that the instrument was consistent in measuring what it purpoted to measure. The instruments were administered by the researcher with the help of the farmer's association secretaries in the respective communities who were trained on the instrument administration. At the end of the exercise, the researcher collected the instruments from the respondents. Out of three hundred and thirteen questionnaires administered, only three hundred and nine were successfully retrieved and used as the sample of the study.

Presentation of result

4. 1 Hypothesis one

There is no significant relationship between the practice of agro-forestry and sustainability of forest ecosystems.

The independent variable in this hypothesis is the practice of agro-forestry; while the dependent variable is sustainability of forest ecosystems. Simple regression analysis was the employed to test this hypothesis. The result of the analysis is presented in Table 1.

TABLE 1: Simple regression result of the relationship between the practice of agro-forestry and sustainability of forest ecosystems

Model	R	R. square	Adjusted R. Square	Std error of the estimate	
1	.704(a)	.495	.494	2.21757	
Model	Sum of square	df	Mean square	F	p-value
Regression	3962.597	1	3962.597	805.797	.000(a)
Residual	4042.277	3131	4.918		
Total	8004.874	3132			
Variables	Unstandardized regression weight B		Standardized regression weight	Beta weight	t	p-value
(Constant)	14.173		.777		18.237	.000
The practice of agro-forestry	1.027		.036	.704	28.387	.000

* Significant at .05 level.

The simple regression analysis of the relationship between the practices of agro-forestry on the sustainability of forest ecosystems yielded a coefficient of multiple regression (R) of .704 and a multiple regression R-square (R^2) of .495 and an adjusted R^2 of .494. The adjusted R^2 of .494 indicated that the practice of agro-forestry's account for 49.4 % of the variance in sustainability of forest ecosystems in the study area. This finding is a critical indication that the practice of agro-forestry are relatively high in the area of the study. The F-value of the Analysis of Variance (ANOVA) obtained from the regression table was F = 805.797 and the sig. value of .000 (or $p<.05$) at the degree of freedom (df) 1 and 3131. The implication of this result is that the practice of agro-forestry is a significant relate to sustainability of forest ecosystems. The identified equation to understand this relationship was that sustainability of forest ecosystems = 14.173 + 1.027 (the practice of agro-forestry).

Hypothesis two

The practice of deforestation does not significantly sustainability of forest ecosystems.

The independent variable in this hypothesis is the practice of deforestation; while the dependent variable is sustainability of forest ecosystems. Simple regression analysis was employed to test this hypothesis. The result of the analysis is presented in Table 2.

TABLE 2: Simple regression result of the relationship between the practice of deforestation and sustainability of forest ecosystems

Model	R	R. square	Adjusted R. Square	Std error of the estimate	
1	.796(a)	.634	.634	1.88786	
Model	Sum of square	df	Mean square	F	p-value
Regression	5075.242	1	5075.242	1424.018	.000(a)
Residual	2929.632	3131	3.564		
Total	8004.874	3132			
Variables	Unstandardized regression weight B		Standardized regression weight	Beta weight	t	p-value
(Constant)	8.484		.735		11.535	.000
The practice of deforestation	1.289		.034	.796	37.736	.000

* Significant at .05 level.

The simple regression analysis of the relationship between the practices of deforestation on the sustainability of forest ecosystems yielded a coefficient of multiple regression (R) of .796 and a multiple regression R-square (R^2) of .346 and an adjusted R^2 of .634. The adjusted R^2 of .634 indicated that the practice of deforestation accounted for 63.4% of the variance in sustainability of forest ecosystems in the study area. This finding is a critical indication that the practice of deforestation is relatively high in the area of the study. The F-value of the Analysis of Variance (ANOVA) obtained from the regression table was F = 1424.018 and the sig. value of .000 (or $p<.05$) at the degree of freedom (df) 1 and 3131. The implication of this result is that the practice of deforestation is significant relate to sustainability of forest ecosystems. The identified equation to understand this relationship was that sustainability of forest ecosystems = 8.484 + 1.289 (the practice of deforestation).

5. Discussion

The findings confirm that agroforestry significantly enhances forest ecosystem sustainability. This aligns with ecological intensification theory and prior studies demonstrating improvements in soil health, biodiversity, and carbon storage (De Koning et al., 2011; Kuntashula et al., 2014).

Conversely, slash-and-burn agriculture was found to significantly undermine sustainability, corroborating Giardina et al. (2000) and Meyfroidt et al. (2010). The magnitude of its effect suggests that deforestation remains a dominant driver of ecosystem degradation in the study area.

Agro forestry and sustainability of forest ecosystems

The results of the studies revealed that agro forestry has a substantial relationship on Sustainability of forest ecosystems. The null hypothesis was rejected. This means that agro forestry practice significantly relate to sustainability of forest ecosystems. This hypothesis conclusion is in line with the view of Owunubi and Otegbee (2000).

Owunubi and Otegbeye, (2002) averred that agroforestry is a multiple land use system where agricultural crops and perennials are grown on the same land management unit, this encompasses the spectrum of land use system where woody perennials are deliberately interlaced or combined with agricultural crops and animals on a spatial or temporal arrangement. Most scholars who advocate for his farming system had always held tenaciously to the effectiveness of the faming system in soil conservation advantage or primary benefits. Most authors believe that agro-forestry system where food crops are grown with woody plants may affect several bio-physical and bio-chemical processes that determines the health of the soil substrate (Hagen, Svavarsdottir, Nilsson, Tolvanen, Raulund-Rasmussen & Aradottir, 2013; Liu, Bergkvit & Ulen, 2015; Aronson, Hansen, Thomsen, Ogaard, Känkänen & Ulén, 2016).

It is observed that the agro-forestry system helps in the amelioration of soil erosion, soil fertility loss, improve soil structure and also serve as habitats for forest ecosystem and all the biological resources therein. Out these other benefits as listed above, the watershed is protected and this contributes to the water cycle where green plants are used as a traveling route for water vapor from the soil back into the atmosphere. Other environmental services like nutrient recycling, carbon sequestration, habitat for wildlife and microorganisms, sources of fuel wood, gas exchange (oxygen and carbon dioxide) during photosynthesis among other has been listed as the benefits of agroforestry systems (De Koning, Aguinaga, Bravo, Chiu, Lascano, Lozada & Suárez, 2011; Kuntashula, Van Der Horst & Vermeylen, 2014).

Miluka, Carletto, Davis and Zezza, (2010) found another benefits of agro-forestry to include maintenance or increased organic matter, diversity of farmer's benefit (crop production, income, wood and animal husbandry). Diversities could also come in form of continuous degeneration of roots and decomposition of liters, nitrogen fixation, enhancement of the physical properties such as soil structure, porosity, and moisture retention through extensive root system and canopy cover.

The authors further said these could enhance efficient nutrient use as the tree root system can intercept, absorb and recycle nutrients in the soil that would have otherwise been lost through leaching (Ellis, 2008; Sirén & Parvinen, 2015; Vasco & Sirén, 2018).

Nigeria is blessed with a large area or land and vegetaion, but the use of this important resource has been abused, not sustainably used or managed. Ladipo (2010) pointed out that the forest has been treated in the past by many rural dwellers as inexhaustible. Recently, everyone now realize that forest is at the verge of going into extinction if nothing is done to reverse the unsustainable use. Evans (1992) is of the view that the depletion of forest reserves in Nigeria is due to hunger for more agricultural land that could be used for food production, shining cultivation, as well as urbanization. It is a known fact that Agriculture, forestry and urban development remained the three major uses to which land is subjected.

Slash and burn/deforestation

The results of the studies revealed that slash and burn/deforestation practice significantly hinders the sustainability of forest ecosystems. This hypothesis conclusion is in line with the view of Okose, (2021).

Okese, (2021) in a paper titled slash and burn: the negative effects on agriculture and environment, observed that slash and burn is the practice where a farmer clears a piece of farmland and set the residual vegetation on fire to burn and make the land easily accessible and convenient for planting and other farm activities, Farmers have used this technology for centuries and they still use it today. It is observed that in the face of population increase, there is the increasing demand for food and fodder, shelter and medicine to meet both the dietary, health and shelter need of these population. This author was categorical in the assertion that slash and burn is not a good practice and farmers must do well to avoid it for the following reasons;

1. Burning leaves the land bare, exposing the land to erosion: Burning vegetation residues after slashing or deforesting expose the surface of the soil to direct contact with sun light, rains, wind and glacier. Exposed soil surface erode easily with rainfall and wind, leaving gullies on the field, making the soil porous and infertile. Erosion takes away the fertile pats of the topsoil. More so, the vegetation becomes difficult to regenerate.

2. The practice of slash and burn agriculture is not sustainable: Formerly, when slash and burn agriculture was used predominantly by farmers, they practiced and rotation where after cultivating or farming on a particular portion of land fora given period of time and the soil fertility is loss, they move to another land allowing the former to fallow for some time before coming back there. When the land is burnt severally for agricultural purposes, it takes between 10-25 years, sometimes 40 years, before the soil can recover from the loss of fertility. However, the practice of leaving land for a long time to fallow or regain its

fertility is becoming burdensome, especially as the human population surges daily, with its concomitant demand for food.

3. Burning reduces organic matter contents in the soil: The vegetation residues on the soil creates a certain shade which helps to keep soil moisture in the soil. This helps the activities of some very beneficial insects and microorganisms to improve he soil through nutrient recycling. These residues also improve the aeration of the soil. They defecate into the soil, their fecal deposit is a source of major soil fertility, hence when they are burnt to death, these services are destroyed. The decomposition of the vegetation residue also fertilizes the soil adding organic materials or manure to the soil, helping to improve soil fertility content for maximum crop productivity.

4. It is an extra cost to production: Burning becomes an additional activity in farming and therefore comes with a cost. When you do not burn, you reduce total cost of production and you save time too. Why not save energy and time for a better practice?

5. Burning might cause bushfires: Uncontrolled burning on farms has been a major cause of bushfires spreading to destroy vast areas of forests, plantations and other properties in Ghana and across the globe. Farmers, annually are troubled with litigation concerning fires that burnt their farms or another's farm. Slash and burn has been a major cause of deforestation worldwide. Avoiding burning of residual vegetation after slashing can save one from all these troubles while we protect our forest cover. It goes a long way to improving climatic conditions.

Okese, (2021) therefore concluded in this review that “Slash and burn” is not a sustainable practice. Adopting sustainable agricultural technology like no-till under conservation agriculture is a better substitute for slash and burn in our current climatic rends and food demands, this comes with very noticeable soil improvements. Declines of forest wildlife from overhunting have been severe in much of tropical Africa and are likely to rise sharply in most rural communities as physical accessibility to forests increases and the demand for forest and wild life resources are always in high demand to feed the human population. The need for the destruction of the forest ecosystem through peasant or subsistent agriculture including the high profitability of exploitative land uses like logging, the illegal encroachment of loggers and hunters into nature reserves, political instability in the surrounding region and limited Infrastructure for socio-economic development has exacerbated the rate of forest ecosystem destruction.

Giardina, Sanford and Dockersmith (2000) carried out a study on the effects of slash and burning on the ecosystem nutrient during the land preparation phase of shifting cultivation, found that the most commonly observed features of slash and burn agriculture is the temporary increase in nutrient availability, which is short term. Studies of shifting cultivation always site the incorporation of nutrient-rich ash from the slash and burn from consumed aboveground biomass into soil as the reason for his change. This study found that during slash and burn system, the soil

heating mechanism of nutrient released is most often assumed to be of minor importance in the field. The authors posited that very few have plans for above and belowground nutrient fluxes in the tropics.

6. Implications for Policy and Practice

- Scale up agroforestry extension programs.
- Introduce incentives for tree-based farming systems.
- Strengthen enforcement of anti-deforestation policies.
- Promote conservation agriculture as an alternative to burning.

7. Conclusion

Agroforestry promotes forest ecosystem sustainability, whereas slash-and-burn practices significantly accelerate degradation. Transitioning toward sustainable farming systems is essential for ecological resilience in tropical forest zones.

Recommendations

The following recommendations were made based on the study's findings:

1. It was recommended that Sustainable farming practices such as shifting cultivation farming and bush fallowing should be encouraged in order to sustain forest ecosystems.
2. It was recommended to effectively sustain forest ecosystems by combining environmentally friendly farming practices, more research should be carried out.

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