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ASSESSING THE IMPACT OF AGRICULTURAL PRACTICES ON ENVIRONMENTAL SUSTAINABILITY IN NIGERIA

Bright Oluwatomilola OLUNUSI[1,2*]

[1]Department of Earth and Environment, Boston University Arts & Sciences, Boston, Massachusetts, 02215, United States
[2]Department of Wildlife and Ecotourism, University of Ibadan, Ibadan, Oyo State, 200284, Nigeria

*Correspondence: bolunusi@bu.edu

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ABSTRACT. This study investigates environmental sustainability and growth trends in Nigeria over a 30-year period (1991–2020), focusing on key indicators such as agriculture value added, forest area, employment in agriculture, employment in industry, and renewable energy consumption. Time series analysis reveals a linear increase in deforested land and agricultural expansion, alongside a decline in agricultural employment, which stabilised around 2013. Employment in the industry showed a dip until 2011, then increased steadily. Gender-disaggregated data highlights a notable disparity in agricultural employment, with significantly more males engaged compared to females. Using regression analysis with leaps, autoregressive distributed lag models, and Granger causality tests, the study identifies strong associations between deforested land and predictor variables such as agricultural land percentage, employment in industry, and renewable energy consumption. The results show that these variables significantly predict deforestation. Interestingly, a significant negative association was found between employment in agriculture and deforestation, although causality tests indicated no significant causation, suggesting a nuanced relationship influenced by factors like land-use conflicts and climate change. These findings highlight the nexus between socio-economic factors and environmental outcomes, emphasising the need for targeted policies to address deforestation, promote sustainable land management, and reduce gender disparities in agriculture. This research provides valuable insights for policymakers and stakeholders aiming to foster sustainable development and inclusive economic growth in Nigeria and across Africa.

Keywords: agricultural land-use change; deforestation; economic development; environmental sustainability; renewable energy; time series analysis.

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INTRODUCTION

The environmental implications of agricultural practices and land-use change pose significant challenges to the pursuit of sustainable growth in Africa. Land-use conflicts and climate change have been identified as key factors exacerbating agricultural land-use change in the region (Baarsch *et al.*, 2020; Ihemezie and Dallimer, 2021). This phenomenon often involves the abandonment of old cropland in favour of new terrain, leading to the conversion of forest reserves into farm settlements (Asifat *et al.*, 2019). Predictions indicate a concerning trend, with projections suggesting a significant decrease in forest cover and an increase in bare ground and agricultural land by 2030 (Khadijat *et al.*, 2021).

The consequences of deforestation and forest depletion extend beyond mere land-use changes. Biodiversity loss is intensified as wildlife habitats are destroyed, posing threats to vulnerable African species such as elephants, gorillas, and chimpanzees (Adeyemi and Ayinde, 2022; Fotang *et al.*, 2021). Furthermore, forest depletion has dire effects on ecosystem services, particularly carbon sequestration. Sutton *et al.* (2016) highlight the substantial economic losses resulting from impaired ecosystem services due to deforestation, amounting to over 6.3 trillion US dollars or 8.3% of global gross domestic product (GDP) in 2016. Forests play a crucial role as carbon sinks, absorbing carbon dioxide from the atmosphere and mitigating climate change. However, the loss of forests diminishes this natural carbon storage capacity, leading to increased greenhouse gas emissions and further exacerbating climate change (Fotang *et al.*, 2021).

Therefore, sustainable land management practices are essential for addressing environmental challenges, preserving biodiversity, and mitigating climate change impacts while promoting economic development. Efforts to combat deforestation, promote reforestation and afforestation initiatives, and adopt sustainable agricultural practices are crucial for achieving these objectives. Additionally, policies and interventions aimed at enhancing environmental conservation and promoting sustainable land management practices are essential for ensuring the long-term well-being of both ecosystems and human societies in Africa.

Amidst the ongoing agricultural land-use change in Africa, gender disparities persist in agricultural land ownership and management, significantly limiting women's participation and perpetuating inequality within the sector (Slavchevska *et al.*, 2021). In Nigeria, for instance, most agricultural plots are managed by men, who also control a significant portion of the output, with registered land predominantly in men's names (Food and Agriculture Organisation, 2019). These disparities hinder women's competitiveness and interest in agricultural productivity and sustainability (Uduji *et al.*, 2020), underscoring the urgency of addressing gender inequalities to foster inclusive economic development.

In addition to gender inequality, prioritising technological innovation is essential for shaping agricultural development and sustainability.

Investments in technology and infrastructure are crucial for improving agricultural productivity and addressing food security challenges (Andrianarimanana and Yongjian, 2021; Olunusi, 2024). Climate change poses a significant threat to agricultural sustainability, particularly in vulnerable regions like the Sahel, emphasising the need for innovative solutions to mitigate these challenges (Baarsch *et al.*, 2020). Furthermore, organic fertiliser subsidies in West Africa have the potential to enhance food production while reducing the environmental impacts associated with conventional chemical fertilisers (Sane *et al.*, 2021).

Nigeria serves as an exemplary case for this study due to its significant agricultural sector, diverse ecosystems, and pronounced socio-economic challenges. Nigeria's agricultural sector is pivotal to its economy, employing a large portion of the population and contributing substantially to GDP (FAO, 2024). However, the country faces severe environmental sustainability issues, including deforestation, land degradation, and biodiversity loss (Adeyemi and Ayinde, 2022; Fotang *et al.*, 2021). Additionally, the agricultural sector faces challenges such as soil degradation, low productivity, and limited adoption of sustainable practices (Adeyemi and Ayinde, 2022; Zingore *et al.*, 2015), further worsening environmental health. Hence, the selection of Nigeria allows for a detailed examination of these critical issues. The country's varied geographical features and climatic zones provide a comprehensive setting to study the impacts of agricultural practices and land-use changes on environmental sustainability.

Several studies on agricultural sustainability and environmental impacts often lack a comprehensive approach that integrates socio-economic variables, gender disparities, and technological innovations (Baarsch *et al.*, 2020; Ihemezie and Dallimer, 2021). There is a dearth of information about specific factors influencing the rapid decline in forest cover in Nigeria. Many articles that focus on the causes of environmental decline were either centred on carbon dioxide or, if they studied deforestation as their dependent variable, were broader in approach, often combining data from different countries and making comparisons that are not as detailed. This study zooms in on Nigeria, providing a detailed examination of this specific context. By examining the interconnectedness of these factors and their effect on environmental sustainability in Nigeria, this study provides a more holistic view of the challenges and suggests potential solutions for policymakers. Furthermore, the study is timely because of the urgent need to address climate change impacts and promote sustainable development in Nigeria (Olunusi, 2024).

Ultimately, this research has practical implications for evidence-based policymaking and intervention strategies aimed at advancing environmental sustainability and inclusive economic growth in Nigeria. It also contributes to a better understanding of sustainable development in Africa and provides guidance for future interventions to promote these goals.

Theoretical explanation of variables in the model and their impact on deforestation

1. Employment in Agriculture: Employment in agriculture indicates the portion of the labour force engaged in farming activities. Theories of economic development, such as structural transformation, suggest that as economies grow, labour moves from agriculture to industry and services (Lewis, 1954). However, in Nigeria, a significant proportion of the population remains in agriculture, highlighting its importance, but also presenting challenges related to productivity and rural development. High employment in agriculture often necessitates the expansion of farmland, which can lead to deforestation as forests are cleared for agricultural use (Ihemezie and Dallimer, 2021).

2. Employment in Industry: Employment in industry represents the workforce involved in manufacturing, mining, and construction. Theories of industrialisation and economic development underscore the role of the industrial sector in driving economic growth and generating employment (Kaldor, 1966). In Nigeria, the gradual shift to industrial employment can indicate changes in the economic structure and the effectiveness of industrial policies (Oyelaran-Oyeyinka and Gehl Sampath, 2009). Increased industrial activity can indirectly impact deforestation through infrastructure development and resource extraction, leading to forest land conversion.

3. Renewable Energy Consumption: Renewable energy consumption measures the use of renewable sources such as solar, wind, hydro, and biomass. Sustainable development theories advocate for transitioning from fossil fuels to renewable energy to reduce greenhouse gas emissions and mitigate climate change (Stern, 2008). In Nigeria, promoting renewable energy is vital for reducing emissions and supporting development (Oyedepo, 2012). However, the expansion of renewable energy infrastructure, particularly biomass, can lead to deforestation if not managed sustainably.

4. Agricultural Land: Agricultural land refers to areas used for crop production and livestock grazing. Theories of land use and agricultural economics examine the balance between agricultural productivity and environmental sustainability (Boserup, 1965). Expanding agricultural land to meet food production needs often results in deforestation and land degradation. In Nigeria, managing the expansion of agricultural land with sustainable practices is crucial for maintaining food security and environmental health (Ihemezie and Dallimer, 2021; Olunusi, 2024).

MATERIALS AND METHODS

This study aims to contribute to understanding the trends in environmental sustainability and growth in Nigeria over a 30-year period (1991–2020, selected based on data availability), using key indicators such as agriculture value added, forest area, employment in agriculture, GDP per capita, CO_2 emissions, and renewable energy consumption (World Bank, 2024).

Data Analysis

1. Time Series Analysis: Time series analysis was initially employed to observe trends for each selected variable over the study period.

2. Correlation Analysis: Correlation analysis was performed to identify the strength and direction of relationships between all the variables.

3. Leaps Method Regression Analysis: The model included independent variables such as employment in agriculture, agricultural land, employment in industry, renewable energy consumption, and GDP per capita, with deforestation as the dependent variable. The inclusion of these variables is justified by their known impacts on forest loss. The leaps package (Lumley, 2024) was used for model selection. The leaps function from this package allows for the selection of the best subset of predictors based on the Cp criterion.

The initial full model can be represented as follows:

Deforested_land_percentage~CO_2_emissions+Employment_agriculture_percentage+GDP_per_capita_PPP+Agricultural_land_percentage+Employment_industry_percentage+Renewable_energy_consumption (1)

4. Autoregressive Distributed Lag (ARDL) Model: ARDL models were used to capture the dynamic relationship between the variables over time. The dynlm package (Zeileis, 2019) was used to perform the ARDL analysis.

The following formula was used for the ARDL model:

Deforested_land ~ L(CO_2_emissions_kg_per_GDP, 1) + L(GDP_per_capita_PPP, 1) + L(Employment_agriculture_percent, 1) + L(Agricultural_land_percent, 1) + L(Employment_industry_percent, 1) + L(Renewable_energy_consumption, 1) (2)

where L (variable, 1) denotes the variable lagged by one period.

5. Granger Causality Test: Granger causality tests were conducted to determine the directional influence of the variables on forest loss. The Granger causality test determines whether past values of one time series can be used to predict another time series. The tests were performed using the grangertest function from the lmtest package in R.

The time series data for deforestation and the predictor variables (CO_2 emissions, GDP per capita, employment in agriculture, agricultural land, employment in industry, and renewable energy consumption) were log-transformed to stabilise variance and normalise the data.

The following formula was used for each test:

Model: log(Deforested_land_ts)~ Lags(log(Predictor_variable_ts), order) (3)

where order = 1 specifies the number of lags included in the model.

The specific tests conducted were as follows: CO_2 emissions and deforestation; agricultural land and deforestation; employment in industry and deforestation; renewable energy consumption and deforestation; GDP per capita and deforestation; and employment in agriculture and deforestation.

Statistical Software

All analysis and visualisation were performed using R version 4.3.1 (R Core Team, 2024).

Research Questions and Hypotheses

Research Question 1: How have socio-economic and environmental factors in Nigeria evolved over the past three decades, specifically regarding forest area, employment in agriculture/industry, and renewable energy consumption?

Hypothesis 1: Significant trends exist in the loss of forests, employment in agriculture/industry, and renewable energy consumption in Nigeria from 1991 to 2020, reflecting changes in socio-economic and environmental conditions over time.

Research Question 2: What factors contribute to forest loss in Nigeria?

Hypothesis 2: Employment in industry positively correlates with forest loss, while renewable energy consumption exhibits an inverse relationship with forest loss. Additionally, increased employment in agriculture and expansion of agricultural land contribute to higher levels of forest loss.

RESULTS

Figure 1 displays a linear increase in the percentage of deforested land from 1991 to 2020, aligning with a consistent expansion of agricultural land over the same period. Moreover, it reveals a decline in the population employed in agriculture over the years, with stabilisation around 2013. Interestingly, the percentage of employment in the industry remained steady from 1991 to 2004, experienced a dip until 2011, and then rose steadily from 2011 to 2020.

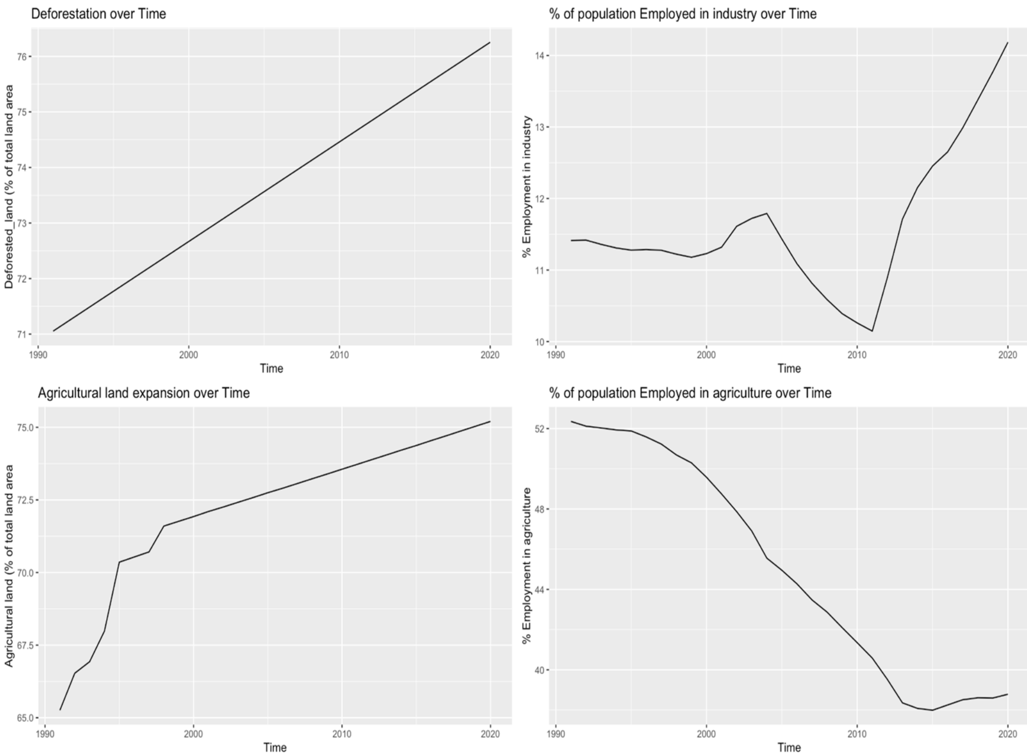

Figure 1 – Time series analysis for deforestation, agricultural expansion, employment in agriculture and industry from 1991 to 2020

Figure 2 illustrates employment in agriculture and industry disaggregated by gender. It reveals that there is no significant difference in the employment of males versus females in the industry, as their percentages are very close to one another. However, there is a notable disparity in the percentage of males employed in agriculture compared to females, with a significantly higher proportion of males engaged in agricultural activities.

The regression analysis using the leaps method identified employment in agriculture, agricultural land percentage, employment in industry, and renewable energy consumption as significant predictors of forest loss (*Table 1*). Employment in agriculture had a significant negative impact on forest loss ($p < 0.001$), while agricultural land percentage and employment in industry both had significant positive impacts ($p < 0.001$). Renewable energy consumption showed marginal significance ($p = 0.0597$). The final model explained 99.35% of the variance in forest loss (Adjusted R-squared = 0.9922) with an overall F-statistic of 735.5 ($p < 2.2e-16$), indicating a strong fit. CO_2 emissions were not a significant predictor in the model ($p = 0.6433$).

Figure 2 – Time series analysis for female vs male employment in agriculture and industry

Table 1 – Regression analysis (Leap and Cp model selection) for predicting forest loss

Predictor variable	Estimate	Standard error	t value	Pr (> |t|)
Intercept	62.90701	2.53783	24.788	<2e-16***
CO_2_emissions_kg/GDP	-0.91816	1.95775	-0.469	0.6433
Employment_agric_%	-0.19615	0.03517	-5.577	9.73e-06***
Agricultural_land_%	0.16151	0.02149	7.515	9.37e-08***
Employment_industry_%	0.31470	0.03989	7.888	4.04e-08***
Renewable_energy_%	0.05208	0.02635	1.976	0.0597
Residual standard error: 0.1397 on 24 DF	Multiple_R^2: 0.9935	Adjusted_R^2: 0.9922	F-stat: 735.5 on 5 and 24 DF	P-value: <2.2e-16

Very similar to the results in *Table 1*, the ARDL model for predicting forest loss, as shown in *Table 2*, reveals that employment in agriculture, agricultural land percentage, and employment in industry are significant predictors. \

Specifically, higher agricultural land percentage and employment in industry are associated with increased forest loss.

Renewable energy consumption shows a marginal significance.

The model explains 99.36% of the variance in forest loss, indicating a strong fit, with an F-statistic of 593.4 ($p < 2.2e-16$).

The Granger causality tests indicate that agricultural land, employment in industry, and renewable energy consumption are significant predictors of deforestation in Nigeria (*Table 3*).

These variables show significant causality relationships with deforestation, suggesting that changes in these factors can forecast changes in deforestation rates.

On the other hand, CO_2 emissions, GDP per capita, and employment in agriculture do not significantly predict deforestation, indicating that their past values do not provide useful information for forecasting deforestation in this context.

The correlation matrix in *Appendix A* reveals several important relationships between variables related to sustainable land use. For example, Forest area percentage and agricultural land percentage exhibit a strong negative correlation (-0.91), suggesting that as agricultural land expands, forest area tends to decrease significantly. Additionally, forest area percentage is negatively correlated with employment in industry (-0.53), implying that increased industrial employment is associated with reduced forest cover. There is also a positive correlation between renewable energy consumption and forest area percentage (0.70), indicating that regions with higher renewable energy use tend to preserve more forest land.

DISCUSSION

Land-Use Change

The linear increase in the percentage of deforested land and the expansion of agricultural land reflect the significant environmental implications of agricultural practices in Nigeria, which was also highlighted by Khadijat *et al.* (2021).

Land-use conflict emerges as a primary driver of agricultural land-use change (ALUC) in Nigeria, exacerbated by factors such as government land-use policies, urban infrastructure development, and poverty (Ihemezie and Dallimer, 2021).

Conflicts and terrorism further disrupt agricultural activities, amplifying the challenges faced by farmers (Ani *et al.*, 2021). Similar land-use conflicts are observed in other African countries like Ghana, highlighting the broader regional implications of these challenges.

However, the environmental gains from ALUC, such as increased agricultural productivity, may be offset by ecological consequences such as deforestation (Ihemezie and Dallimer, 2021). Tropical forests, including those in Nigeria, play a crucial role in carbon sequestration, yet anthropogenic activities contribute to significant carbon emissions and forest degradation (d'Annunzioin *et al.*, 2015; Ebenezer, 2015; FAO, 1999; Oyerinde *et al.*, 2015). Overexploitation of grassland, for instance, leads to forest resource degradation, soil erosion, and loss of biodiversity (Adeyemi and Ayinde, 2022).

Deforestation contributes to biodiversity loss and ecosystem degradation and exacerbates greenhouse gas emissions, further exacerbating climate change (Fotang *et al.*, 2021).

This poses a significant challenge to global agriculture, particularly in Sub-Saharan Africa, where population growth is projected to increase food demand substantially (Ezeh *et al.*, 2020; Lutz and Kc, 2010). Meeting this demand requires balancing competing agendas and policy targets while ensuring sustainability, equity, and resilience in food systems (Godfray *et al.*, 2010; Van Ittersum *et al.*, 2016).

The importance of undisturbed mature forests as core habitats for wildlife, such as chimpanzees, underscores the need for forest conservation and management (Fotang *et al.*, 2021). While secondary forests may provide habitats, high human activity often deters wildlife, emphasising the importance of preserving primary forests for biodiversity conservation.

Overall, addressing land-use conflicts, promoting sustainable agricultural practices, and enhancing forest conservation efforts are crucial for mitigating environmental degradation and fostering sustainable development in Africa.

Table 2 – Autoregressive distributed lag model for predicting forest loss

Predictor variable	Estimate	Standard error	t value	Pr (> |t|)
Intercept	66.7496503	8.3458150	7.998	4.31e-08***
L(CO_2_emissions_kg/GDP, 1	-0.7060896	2.0373973	-0.347	0.73207
L(GDP_per_capita_PPP, 1)	-0.0001582	0.0003268	-0.484	0.63287
L(Employment_agric_%, 1)	-0.2348442	0.0875618	-2.682	0.01331*
L(Agricultural_land_percent, 1)	0.1413270	0.0470679	3.003	0.00635**
L(Employment_industry_%, 1)	0.3058057	0.0445159	6.870	5.27e-07***
L(Renewable_energy_%, 1)	-0.0527999	0.0268234	1.968	0.06119
Residual standard error: 0.142 on 23 DF	Multiple_R^2: 0.9936	Adjusted_R^2: 0.9919	F-stat: 593.4 on 6 and 23 DF	P-value: 2.2e-16

Table 3 – Granger causality test results predicting forest loss

Predictor Variable	F-statistic	P-value	Causality
CO_2 emissions	0.4919	0.4893	No
GDP per capita	1.8618	0.1841	No
Employment in agriculture	1.3595	0.2542	No
Agricultural land	50.1319	1.6127e-07	Yes
Employment in industry	18.3281	2.2388e-04	Yes
Renewable energy consumption	5.1324	0.0320	Yes

Employment patterns

The observed decline in agricultural employment, coupled with the rising trend in industrial employment, reflects ongoing transformations in Nigeria's labour market, which is similar to the findings of Tachega *et al.* (2021). However, this shift is not solely driven by economic factors but is also influenced by social and security-related issues, particularly in conflict zones. Violence in conflict zones displaces millions of people, leading to abandoned farms and strained resources (Ani *et al.*, 2021). Fear among farmers due to conflicts with cattle herders has forced many to reduce the scale of their farming operations as a security measure. This fear and insecurity contribute to a loss of interest in farming, driving rural-urban migration and ultimately shrinking the agricultural labour force (Ihemezie and Dallimer, 2021).

Similar trends have been observed in Europe and North America, where factors such as shrinking agricultural labour forces, migration, and economic opportunities influence employment patterns (Ihemezie and Dallimer, 2021). Moreover, the low wages in the agricultural sector deter labour from other sectors, further exacerbating the decline in agricultural employment (Andrianarimanana and Yongjian, 2021). Consequently, labour migration in Africa tends to be predominantly rural–urban rather than urban-rural or rural-rural.

However, despite advancements in industrialisation and technology, the immobility of labour in many Sub-Saharan African countries limits the full realisation of the benefits of these improvements (Andrianarimanana and Yongjian, 2021). While local economies may benefit from technological advancements, the regional economy may suffer a decrease in welfare if labour remains immobile and unable to capitalise on these improvements. Therefore, strategies to diversify employment opportunities and address security-related issues are crucial for achieving sustainable economic growth in Nigeria and across Africa (Adeyemi and Ayinde, 2022).

Gender disparities in agriculture

The gender disparities observed in agricultural employment, as seen in our results and confirmed by studies like Slavchevska *et al.* (2021), underscore the systemic challenges women face in accessing agricultural resources and opportunities. With limited participation in agriculture, women encounter barriers that perpetuate inequality within the sector and impede overall agricultural productivity (Uduji *et al.*, 2020). Addressing these disparities requires multifaceted approaches that prioritise women's empowerment and enhance their access to land, resources, and markets (Ayoade and Thota, 2023). However, in regions like Niger and Nigeria, where statutory and customary systems offer fewer protections for women's land rights, discriminatory practices persist (FAO, 2019). Customary laws often favour men in land inheritance, leaving women with limited access to land and resources. For instance, under Islamic law in Northern Nigeria, women inherit only half of what their male counterparts receive, exacerbating land ownership disparities (FAO, 2019). Social pressures further marginalise women, leading them to relinquish their land rights. These legal and cultural barriers might explain why our results showed significant disparities in agricultural employment between males and females. Despite women being the main agricultural producers, their access to resources and opportunities remains restricted, reflecting the broader gender inequalities prevalent in the agricultural sector. Addressing these disparities is essential for promoting inclusive economic development and sustainable agriculture in Africa.

Predictors of deforestation

The result shows that agricultural land percentage is a significant predictor of deforestation, as evidenced by both regression models and Granger causality tests. The positive association between agricultural land expansion and deforestation indicates that increases in agricultural land are directly associated with higher deforestation rates. This is because forests are often cleared to make room for farmland (Ihemezie and Dallimer, 2021). Market and economic pressures, coupled with land-use conflicts, incentivise farmers to clear forest vegetation to increase food production (Adeyemi and Ayinde, 2022). Additionally, the pressure to clear forests can be linked to cropland abandonment, which is driven by land-use conflicts (Ihemezie and Dallimer, 2021). Consequently, forest degradation intensifies as more land is converted to agriculture and grassland, threatening the existence of forest reserves (Adeyemi and Ayinde, 2022). Human activities such as commodity-led deforestation, urbanisation, and wildfires further exacerbate forest loss, leading to habitat destruction and fragmentation (Curtis *et al.*, 2018; Fotang *et al.*, 2021).

The analysis revealed that both employment in industry and renewable energy consumption are significant predictors of deforestation. Employment in industry showed a significant positive relationship with deforestation, suggesting that industrial activities contribute to forest loss, a finding reinforced by the Granger causality test, which indicated significant causation. Similarly, renewable energy consumption, while nearly significant in the regression model, was shown by the causality test to significantly predict deforestation, indicating that higher renewable energy consumption might be linked to forest loss. This is likely due to the land clearance required for renewable energy infrastructure projects such as hydropower dams and biofuel plantations (Adeyemi and Ayinde, 2022). Industrial activities, including logging, mining, and urbanisation, also disrupt natural ecosystems and contribute to forest loss (Estrada *et al.*, 2017).

Interestingly, the models showed a significant negative association between employment in agriculture and deforestation, suggesting that higher agricultural employment may be linked to lower deforestation rates. However, the Granger causality test showed no significant causation, indicating a more complex relationship. This may be influenced by factors such as the decline in agricultural employment trends and the expansion of agricultural land due to conflict displacement and climate change (Adeyemi and Ayinde, 2022; Ihemezie and Dallimer, 2021). The rise in industry-based employment since 2011, as shown in *Figure 2*, implies that employment alone is not a direct cause of deforestation because agricultural expansion persists despite the decline in agricultural employment. In contrast, CO_2 emissions and GDP per capita were not significant predictors in the model, and both variables showed no significant causation with deforestation.

Current policy

The implications drawn from the findings of this study underscore the urgent need for comprehensive policy interventions and strategic actions to address the environmental challenges facing Nigeria and Africa as a whole. Currently, the Nigerian government has articulated a comprehensive policy framework to address climate change and promote sustainable development. One of the key initiatives is Nigeria's Government Climate Action Plan for 2021–2030, which encompasses both adaptation and mitigation strategies across crucial sectors such as agriculture, forestry, and energy (Federal Ministry of Environment Department of Climate Change, 2021). This plan aims to enhance resilience, promote sustainable development, and mitigate climate risks by promoting climate-smart crop production, strengthening extension services, and reducing emissions from agriculture and forestry. Looking ahead, the Nigerian government has set a visionary goal for 2050, which includes the widespread adoption of sustainable land-use practices and climate-smart agriculture (2050 Long-Term Vision for Nigeria, 2021).

The above policies and future vision align well with the imperative of achieving sustainable growth. However, a critical challenge lies in the historically ineffective implementation of some of these policies. Addressing this gap is paramount to realising the aspirations set forth in Nigeria's climate action plans and long-term visions.

CONCLUSIONS

Nigeria and Africa are not immune to the various consequences of land degradation; significant losses in forests have been reported, leading to substantial annual reductions in GDP and forested land (Zingore *et al.*, 2015). Our study revealed critical insights into the environmental and economic dynamics of Nigeria. The significant decline in forest area and agricultural employment, coupled with the rise in industrial employment, reflect profound transformations in the labour market influenced by social, economic, and conflict-related factors. However, challenges such as gender disparities in agricultural employment and the immobility of labour in Sub-Saharan Africa pose significant obstacles to achieving inclusive, sustainable development. Overall, these findings emphasise the urgent need for comprehensive policies promoting sustainable land management and addressing gender disparities to achieve environmental sustainability in Nigeria.

To address the multifaceted challenges outlined in this study, it is imperative to implement a range of targeted policies and strategies:

Integration of agricultural land into urban planning

Integrating agricultural land into urban planning is crucial to mitigate land-use conflicts and address the rapid agricultural land-use changes observed in Nigeria and Africa. By incorporating provisions for the protection of agricultural areas into urban land-use policies within government development agendas, it is possible to preserve cropland and prevent their conversion into infrastructural developments (Ihemezie and Dallimer, 2021). This approach involves promoting peri-urban agriculture, where agricultural activities coexist with urban areas, and establishing green corridors to maintain agricultural biodiversity and support food security. By integrating agricultural land into urban planning, policymakers can strike a balance between urban development and agricultural preservation, ensuring sustainable land-use practices and minimising conflicts between competing land uses.

Climate-Smart Agriculture Initiatives

Climate-Smart Agriculture Initiatives are essential for enhancing agricultural productivity while minimising environmental impact, especially in developing countries like Nigeria and across Africa.

These initiatives involve adopting sustainable farming techniques such as agroforestry, conservation agriculture, and precision farming, which have been shown to improve resilience to climate change, enhance soil health, and reduce greenhouse gas emissions (Andrianarimanana and Yongjian, 2021). While developed countries tend to invest more in sustainable agriculture and waste reduction, it is crucial for less developed countries to prioritise the adoption of climate-smart agricultural practices to address food security challenges and environmental sustainability (Olunusi, 2024). These initiatives not only enhance agricultural productivity but also contribute to mitigating the adverse effects of climate change on agricultural systems, thus ensuring food security and livelihood resilience in vulnerable communities.

Fostering collaboration and capacity-building

Addressing gender inequality requires robust institutional capacity and collaboration among diverse stakeholders (Devenish *et al.*, 2023). Collaborative efforts among stakeholders, regardless of their gender, geographical, or professional backgrounds, can help align goals towards sustainable development. Capacity-building initiatives, including training and technical assistance, should target local communities, land managers, and government agencies to support sustainable land management practices and ensure inclusive decision-making processes.

It is important to note that low educational attainment in Africa can hinder labour mobility, impacting the effectiveness of technological improvements (Andrianarimanana and Yongjian, 2021).

Moreover, the study by Bjornlund *et al.* (2020) underscores the importance of Sub-Saharan African countries defining their own development agendas and prioritising local needs over external demands, particularly in the context of historical and contemporary factors influencing agricultural productivity in the region.

Effective governance is paramount for translating the above environmental policies into tangible outcomes. Without transparent, inclusive governance frameworks, the noble goals outlined in these policies risk remaining aspirational rather than transformative. As highlighted by Ogunkan (2022), good governance principles such as engagement, accountability, transparency, and the rule of law are essential for promoting environmental sustainability in Nigeria.

However, the country faces several challenges in this regard, including limited public participation, corruption, and ineffective policy implementation. For instance, Ayoade and Thota (2023) emphasise the critical link between functional education, agricultural transformation, and the industrial revolution, highlighting the importance of investment in education and combating corruption.

Therefore, to address environmental degradation and promote sustainable development, Nigeria must prioritise good governance practices that ensure meaningful public participation, transparent decision-making processes, and effective enforcement of environmental laws and policies. Only through such governance reforms can Nigeria effectively address its environmental challenges and achieve lasting environmental sustainability.

Limitations and future recommendations

Despite the valuable insights provided by this study, there are some limitations that should be acknowledged. One primary limitation is the reliance on available secondary data, which may have restricted the scope of the analysis.

The study utilised data from the World Bank, and while this is a reputable source, the accuracy and completeness of the data are subject to the limitations of the available records. In future research, it is recommended that primary data collection be conducted to make the findings more region-specific and locally relevant.

Additionally, the study’s focus on Nigeria may limit the absolute generalisability of the findings to other regions. Comparative studies involving other African countries could help validate the findings and provide a broader understanding of the issues.

Finally, future research should also explore the impact of other potential variables, such as technological advancements, international trade policies, and climate change adaptation measures, to provide a more rounded view of the factors influencing agricultural sustainability and environmental outcomes.

By addressing these limitations and incorporating the suggested improvements, future research can build on the foundations laid by this study to provide even more robust and actionable insights for policymakers and stakeholders in Nigeria and beyond.

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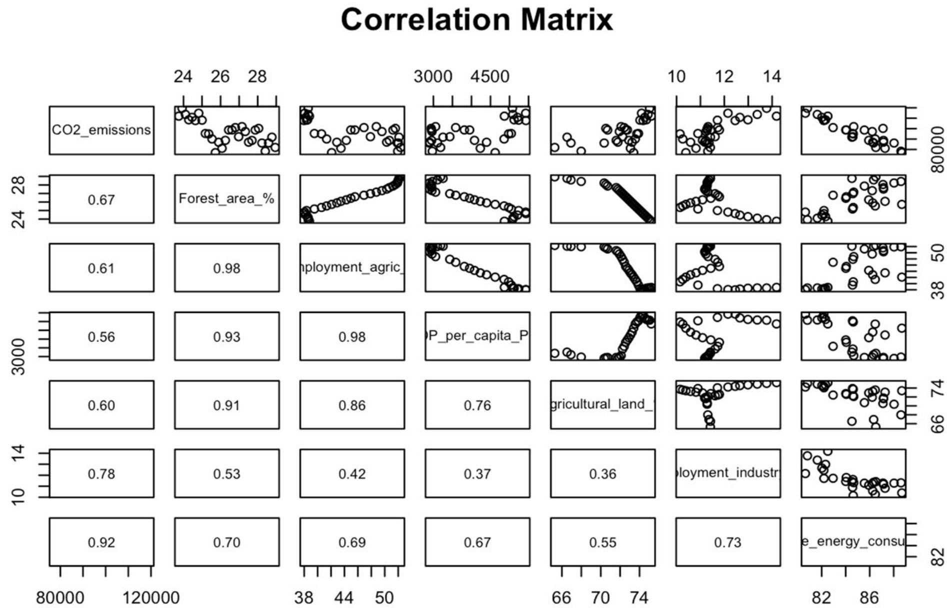

APPENDIX

Appendix A – Correlation analysis for CO_2 emissions, employment in agriculture and industry, agricultural, GDP per capita, deforested land percentages and renewable energy consumption

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