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Environmental deforestation and climate variability in Nigeria

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ABSTRACT
This study examined the impact of deforestation on climate change vice-versa. Data were sourced from Mongabay and World Development Indicators from 1990-2018. The study utilized a pairwise granger causality test. From the result, unidirectional causality between forest areas and climate-change in Nigeria (world) was observed, there is an absence of statistical estimates that support the existence of causality between primary forest loss (tree cover loss) and climate change in Nigeria. The p-values are more than 5%. The study admits that although deforestation is an enabler of climate change, in Nigeria there is no causality background to support the literature. But the study finds a trace of change in the forest area to a change in climate change in Nigeria. On the other hand, a 1% change in climate change does not influence forest areas. Hence, this study recommends that investment in drone surveillance, adequate personnel training, and timely funding should be directed to forestry supervision and regulation to improve data collection and control of events in the forest areas in the country.

KEYWORDS
climate change; deforestation; climate feedback; forest transition theory

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INTRODUCTION

The incessant dynamics of fire e.g. Chicago wildfire, Turkey, the volcanic eruption in Las Palma, and other worldwide tree losses to the unforeseen natural and non-natural disasters have raised concern about the worsening state of tree cover losses and its implication on climate change. Globally, forests cover 31% of the planet (McGregor, 1937). Global Forest Watch admitted that in 2010, 3.92Gha of tree cover was available globally, by 2020, it lost 25.8Mha of the tree cover with deforestation (DF) being the dominant enabler.

Forests represent the storehouse of carbon and are a large player in the earth's climate system (Brack, 2019). Taxonomy of forest resources ranges from Mangrove in the south to Desert Scrub in the north, between these extremes situates broad classification of climax rain and climax mixed deciduous forests (McGregor, 1937). Deforestation has gravely become a burning global topic because of the increasing consequence of global demand for energy use, industrial resources, and other economic activities which exert undue pressure on the content and context of global forest resources (Carlson, Curran, Ratnasari, Pittman, Soares-Filho, Anser, Trigg, Gaveau, Lawrenece & Rodrigues, 2012).

Nigeria's biodiversity is threatened by the sheer extent of evolving logging activities, poaching activities, urbanization as well as government policies. Table 1 presents data on Nigeria's biodiversity which is in danger of annihilation following the deforestation trend.

Biodiversity Data in Nigeria

Animal/Plant	Species Count
Birds	864
Amphibians	117
Reptiles	203
Fishes	775
Mammals	285
Vascular Plants	4715

Source: Mongabay data

Another related issue faced by the country's biodiversity is forest cover losses. Over 13 billion hectares of forest-cover is lost which produces about 17% of aggregate yearly GHG emissions (GHGEs) (IPCC, 2007). Every year 46,000-58,000 square miles of forest are lost to deforestation. This in effect reduces the ecological capacity and biodiversity sufficiently required to sustain the environment (Bennett, 2017). According to FAO (2020) an estimated 10mhs/annum between 2015 and 2020, a decline from 16mhs/annum in the 1990s. In aggregate primary global forest infrastructure has declined by over 80 million since 1990. In more revealing data, Butler (2021) posited that the destruction of global tropical forests releases 2.64 billion tons of carbon, an amount equating with annual emissions of 570 million automobiles in 2020. Fig. 1 provides a trend of global tree cover loss from 2002-2020. Although there is a decline, the problem of deforestation is however topical.

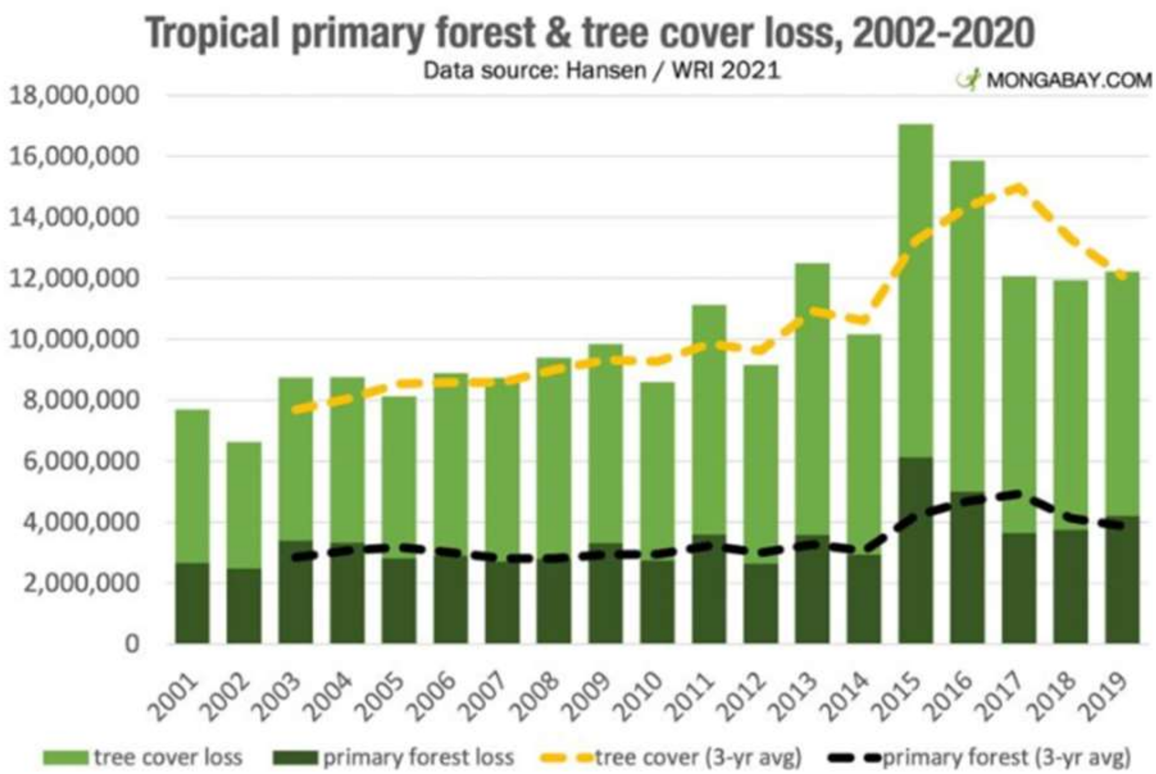
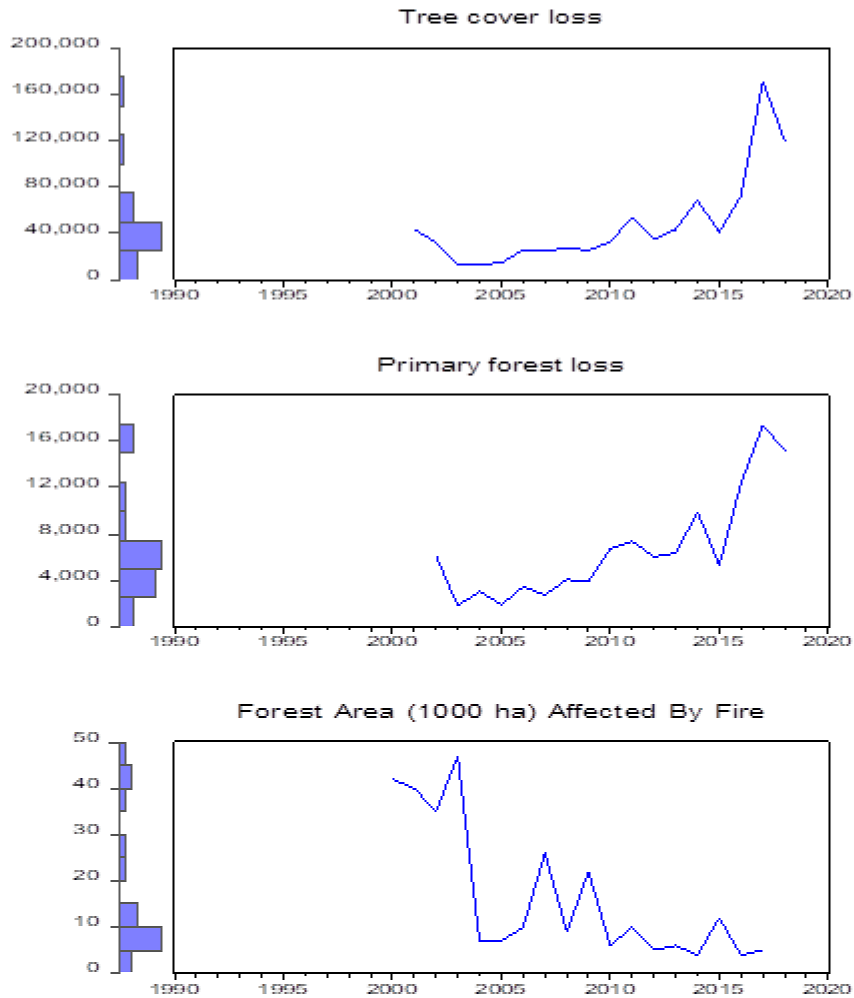


FIGURE 1: Tree Cover Loss Trend
Source: Butler (2021)

In Table 2, forest areas affected by fires have declined from the maximum of 47.00 per 1000 ha in 2003 to 5.0 0 per 1000 ha in 2017, but not without potential risk due to evolving global climate change problem. The Forest area in Nigeria is 216,270 sq. km equivalent to 8.86Mha. Forest area gradually fell from 247.297sq.km to 216,270 sq. km (World Bank, 2020; Knoema, 2020). This decline translates to about 14% forest loss between 2001 and 2020. Between 2010 to 2017, Nigeria lost about 738Kha of tree cover. According to IITA (2020) state of deforestation is put at 3.5% per year equaling about 350,000-400,000 hectares of forest land per year. EIA (2018) asserted that more than four million trees worth half a billion USD were logged in Nigeria between January 2017 to March 2018. Fig. 2-4 below portrays the dimensions of forest cover and tree losses and forest area affected by the fire. Although, the trend shows a decreasing behavior. It is no less significant to downplay the grave danger of unreported cases of deforestation.



Source: Author's Computation from EViews

Scholars versed position shows the deep controversy about the complexity and causality between climate change and deforestation (CC and DF) is hotly debated. The literature is ambiguous around the route of causality amongst CC and DF. But clearly, scholars recognize that DF is a major and significant contributor to climate change (Gorte & Sheikh, 2010), generates 10-20% of global CO2 emissions (IPCC, 2014), and also causes warmer and drier climates (O'Brien, 1996). Micciolo (2017) described the link amongst CC and DF change as a destructive circular relationship. According to Jakuboski (2012) trees constitute a formidable foundation of the carbon cycle through the alteration of CO2 in the atmosphere into oxygen, through photosynthesis channels, and the decarbonization process. Thus, the continuous markdown in the quantity of trees often incentivize a reduction of the trees capacity to restore the environment.

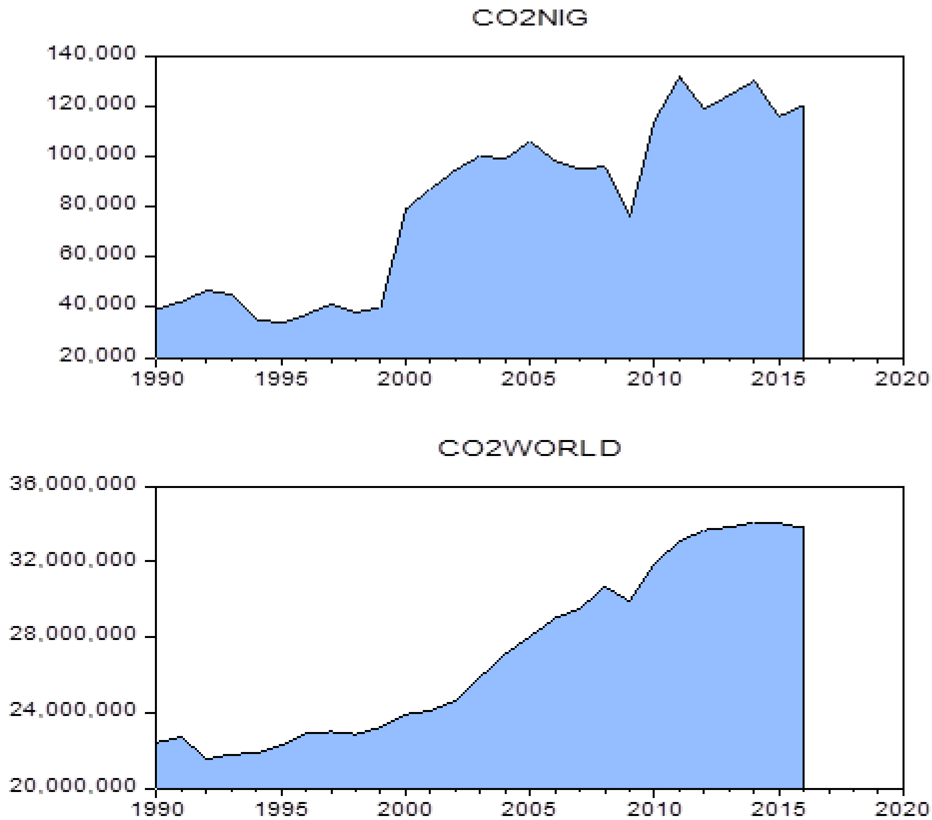
Longobardi, Montenegro, Beltrami, and Eby (2016) posited that deforestation relates to the growing CO2 rate by the fluctuations it creates on the external energy and mass balance. Statistically, Asner (n.d.) asserts that tropical DF generates 20% of annual comprehensive gas from GHGEs. Global concern on deforestation is stimulated through the United Nations Framework Convention on Climate Change (UNFCCC) Reduced Emission from Deforestation and Degradation (REDD) target. The REDD recognizes GHGEs and deforestation measurement through the DF rate (forest cover) and carbon stock.

Furthermore, the influence of climate variability on deforestation, through flooding, temperature, storms, heatwaves, and fire weather channels, etc, is given less attention by scholars. Scholars opine that temperature changes affect the precipitation-transpiration mechanism and the quality of environment that therefore influence the nutrient uptake and growth behaviour of trees. According to FAO (1995) climate change disrupts the circulation of vegetation. Fossil fuels cause global warming that in turn pose serious implications for agriculture, fisheries, forestry, and human development.

The volume of GHGEs can distort global temperature. The variation in GHGEs in the soil parameters could inject a positive effect (CO_2 fertilization effect through photosynthesis) and negative effects (pollen sterility, reduction on yields, change in earth humidity, increase in pest and disease) on the forest as well as the microbial activity in soils (Grace, 1991; Easterling, 1990). Unfortunately, the worldwide external temperature in July 2021 was 1.6oF (0.93oC) above the 20th century average of 60.4oF (15.8oC). The value of the earth's temperature in July 2021 was higher than the record set in 2016-2020 by 0.02o F (0.01oC). By the upsurge in the average international temperature, variations in the magnitude of the forests condition remain disturbing (Lindsey, 2021)

According to Bennett (2017) Deforestation pressure is triggered by slash-and-burn agriculture, raising of cattle, logging activities, and housing called urban sprawl. These activities cause DF, as well as generate climate change. Loss of trees leads to soil erosion, loss of biodiversity, reduction in the quantity of transpiration which could lead to drought, and land-use change releases about 5 billion tons of CO_2. In terms of slash-and-burn agriculture practices through fires produce 10% of climate change. Fire lead to carbon dioxide and biomass burning affects the earth's atmosphere.

From the foregoing nexus that connects DF and CC. It is consequently imperative to explore the cause and effect between deforestation and climate change to extend the existing nexus on the influence of CC and DF vice versa. This is for the fact that figs. 5-6 displays the real hazard of CC which is increasing at increasing.



Source: Author's Computation of Climate Change in Nigeria and World (proxy by CO_2)

It is against this backdrop that this study seeks to scrutinize the cause and effect amongst CC and DF which could provide signals for mitigation and adaptation strategy. Thus, the focus of this study is to explore the causality between climate change and deforestation in Nigeria. The motivating question becomes does causality exist between climate change and deforestation in Nigeria?

This paper is decomposed into five sections namely I. Introduction, II. Literature Review III. Data and Methodology IV. Results and Discussion, and V. Summary, Policy Implication, and Recommendations.

LITERATURE REVIEW

(1) Conceptual Framework

Climate Feedbacks

The concept of climate feedback underpins the robust cause and effect upon which DF and CC are premised. Climate feedbacks support the focus of the study as it recognizes that a one percent significant change in any element of the climate-system alters the equilibrium of the total earth system. Two parameters employed to decipher this analysis include the interrelatedness of positive feedback loops that connect the system of the earth that eventually causes movement whenever disruption occurs in the climate architecture emanating from the corresponding interactions with the earth. The GHGEs in the atmosphere are handled, regulated, and managed by the biogeochemical cycles. The size of carbon in the atmosphere is shrinking through seafloor accumulation of marine sediments and the plant accumulation of biomass is increased through DF and sweltering of fossil fuels.

Secondly, a decline in snow and ice cover which helps to organize the solar energy transmission back to the atmosphere usually increases warming. Also, trees and plants save CO2 from the troposphere in their lives, wood, and roots. Thus, deforestation causes a downward trend in the tree base to store this CO2 hence, their absence causes the unimpeded transmission of solar into the earth that signals warming hence climate change.

(2) Theoretical Review

Forest Transition theory

developed by Mather (1992) was originally based on the works of Whitaker (1940) and Friedrich (1904) with concerted emphasis to capture the paths and sequence through which depletion of natural resources could occur. The theory shows the degree of change that occurs in the forest cover over time. According to Angelson (2009) four rate of forest cover change is amenable to time which includes high forest cover and low DF rate, high forest cover and high DF rate, low forest cover and low DF rate, and low forest cover, negative DF rate. Perz (2007) posited that forest transition theory is U-shaped or a reverse curve. Similarly, Grainger (1995) decomposed the U-shaped model into intertemporal analysis i.e. forest decline and forest recovery. Grainger (1995) is consistent with Lambin and Meyfroidt (2010). Lambin and Meyfroidt (2010) defined FTT to mean the timely shifting of forest cover. This theory, therefore, defined forest cover depletion as expressed in terms of time. In another related term, it is perceived to imply movement from deforestation to reforestation or from a time of forest cover shrinking to a time of growing forest areas (Mather, 1992). Scholars have conceptualized FTT into different paths namely forest scarcity path, economic development path, state forest policy path, and globalization path (Yeo & Huang, 2013).

Several studies show that population growth increases deforestation (Rock, 1996), population density positively correlate with deforestation (Katila, 1995), deforestation declines beyond targeted income level as a country moves toward higher per capita income (Grainger, 1995), external debt increases deforestation with positive correlation coefficient (Kant & Redantz, 1997) and non-existence of correlation (Inman, 1993), deliberate attempt to stimulate agriculture terms of trade causes deforestation, structural adjustment policies potentially lead to deforestation pressure, high wages demand causes massive demand for agricultural and forest products (Jones & O'Neill, 1995), technological change is more likely to decrease deforestation, technologies such as irrigation, capital-intensive technologies (Southgate, 1994) while the study that technological progress leads to deforestation through farmers higher wages is captured in Katila (1995). These studies empirically concretize the forest transition theory.

This theory is imperative to elucidate the causality between deforestation and climate change. Transition theory suggests the loss of forest cover over a period that could lead to climate change. Also, transition theory recognizes that deforestation is genuinely a human-environment interconnected issue that leads to climate vulnerabilities. It is against this backdrop; this study pursues to scrutinize the causality between deforestation and climate change in Nigeria.

(3) Empirical Review

Deforestation

Land Rent Theory (LRT)

Von Thunen (1826) developed the land rent approach for DF which is robustly tied to the land value. The underlying philosophy underpinning LRT revolves around the fact that marginal productivity of land and potentials of land productivity should drive land allocation under a free economic system. The LRT has been concretized by Chomitz and Gray (1996) and Walker (2004). Angelson (2007) found that differential utilization of land rent functionally relates to land uses and land cover. Thus, the study concludes that forest product price, application of forest technology, labour wages, and transportation cost strictly explains the forest pattern. More so, spatial land use is explained by the LRT.

Forest Transition theory

Yeo & Huang (2013) using sub-national level data which was subjected to the sequence of evolution in Mississippi. The study found that there is a presence of a continuous cycle of forest movement from one period to the other. At the national level, Hostert et al (2011) adopted country-wide data after adjusting for political change and environmental hazards. The study found that in the Soviet countries, socio-politic-economic realities significantly through technology programmes cause forest transition. Bae et al (2012) using South Korea as a case study. This study attempted the transition theory by investigating the recovery path hence concluded that the government performs land transformation initiatives to restore land through a land covering programme. At the regional level, Munteanu et al (2014) admitted that transition is produced largely by the socio-demographic and institutional issues that impact forest frontiers in the Carpathian region (Eastern and Central Europe).

Environment Kuznets Curve (EKC)

EKC application on DF is centred on the nexus between environment and development. Ceddia et al (2013) sourced data from 1970-2006 in a cross-country study. The study instituted that deforestation is affected by income. Esmaeili and Nasrnia (2014) in estimating the existence of EKC in deforestation found an inverted U-shaped curve for Iran's deforestation. This implies that deforestation is caused by varying degrees of economic development over time. Allen & Barnes (1985) using data sourced from FAO between 1968-1978 found that GDP per capita insignificantly correlates with a total change in the forest. In disagreement with the inverted U-shaped EKC, Culas (2007) found that economic growth is a U-shaped curve related to deforestation using the Asia case, Bhattarai & Hammig (2001) found that an N-shaped curve existing between per capita GDP and deforestation.

(4) Climate Change

General Circulation Model (GCM)

GCM is used to predict global climate change. GCM is based on the law of physics with a mix of cloud development and oceans changes. There are different types of GCMs namely Goddard Institute of Space Science (GISS), National Centre for Atmospheric Research (NCAR), UK Meteorological office (UKHI), Geophysical Fluid Dynamics Laboratory (GFHI), and Canadian Climate Centre (CCC) (Ciesia, 1995). The use of global mean temperature is utilized to predict climate changes. GCMs, describe the climate for equilibrium through the determination of whether doubling $CO2$ occurrence. Thus, GCMs predict temperature, precipitation, climate variability, and storms, etc.

Climate change and Deforestation: Channels

Carbon Release

Betts et al (2004) posited that climate change has the portent instrument to influence the global terrestrial carbon sink and expand the atmospheric $CO2$ concentration.

Wind effects

Extreme wind supply affect crops, forest, animals, and the soil. The wind is a constituent of evapotranspiration and morphological effect. Although studies captured the consequence of moderate wind as an enabler for the control of virus disease (Mercer et al, 2004). Hence, high wind disrupts forest growth.

(5) Summary of Literature Reviewed

The literature is unanimous around the influence of climate change on deforestation vice versa. However, the position of the literature does not attest the debate on causation. This gap is attempted in this study. From the empirical literature, the dimension of debate follows from a theoretical framework. The forest transition theory squares well to capture and evaluate the causation between climate variability and deforestation.

DATA AND METHODOLOGY

Secondary data was utilized in this study. The World Development Indicators, Mongabay, and FAO provided the sources for the data.

Model Specification

An attempt is made to investigate the correlation between forest and climate change. This task is important as a rule of thumb to precede the causation analysis. From, the result obtained,

Given that DF = f (CC) (1)

CC = f (DF) (2)

Let DF = Deforestation and CC = Climate Change

$$DF_t = \sum_{i=1}^{n} \alpha_i \, DF_{t-i} + \sum_{i=1}^{n} \beta_j \, CC_{t-j} + \mu_{1t} \quad (3)$$

$$CC_t = \sum_{i=1}^{n} \sigma_i \, DF_{t-1} + \sum_{i=1}^{n} \rho_j \, CC_{t-j} + \mu_{2t} \quad (4)$$

Method of Analysis

Granger causality (1969) is used to measure cause and effect between two variables X and Y. It provides the direction of cause and effect and helps to deepen policy analysis in choosing the most effective variable that takes precedence between two variables. It helps to decipher whether unidirectional, bi-directional, or zero causality exist between the hypothesized variables.

RESULT AND DISCUSSION

In line with the focus of this paper, this study attempts three fundamental questions, what is the causality between climate change in Nigeria (world) and forest area. Does higher primary forest area loss lead to higher climate change in Nigeria? Does tree cover loss affect climate change in Nigeria?

1) What is the causality between climate change in Nigeria (world) and forest area

Ho: Forest area does not granger cause climate change in Nigeria (world)

Ha: Forest area granger cause climate change in Nigeria (world)

TABLE 4

Pairwise Granger Causality Tests
Date: 09/27/21 Time: 14:42
Sample: 1990 2020
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
CO2_NIG_ does not Granger Cause FOREST_AREA	26	0.39170	0.5376
FOREST_AREA does not Granger Cause CO2_NIG_		4.68657	0.0410

Source: Author's Computation from EViews

TABLE 5

Pairwise Granger Causality Tests
Date: 09/27/21 Time: 14:45
Sample: 1990 2020
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
CO2_WORLD does not Granger Cause FOREST_AREA	26	0.08584	0.7722
FOREST_AREA does not Granger Cause CO2_WORLD		7.52511	0.0116

Source: Author's Computation from EViews

The first question this study seeks to answer is whether causality exists between forest area and climate change in Nigeria and world climate change? From tables 4 and 5, the P-values is employed to conclude the existence of causality. From the p-values in Tables 4 and 5, we accept the reject the null hypothesis that forest area does not granger cause climate change in Nigeria (world) and accept the alternative hypothesis that forest area granger cause climate change in Nigeria (world). This is because the corresponding p-value is less than 5% (i.e., 0.0410 < 0.05). Also, the result showed that climate change (proxy by CO2) does not granger cause forest area in Nigeria (world). Hence, we accept the null hypothesis. There is a unidirectional causality between forest area and climate change.
2) Does higher Forest area loss lead to higher climate change in Nigeria?
Ho: Forest area loss does granger cause climate change in Nigeria
Ha: Forest area loss granger cause climate change in Nigeria

TABLE 6

Pairwise Granger Causality Tests
Date: 09/27/21 Time: 14:48
Sample: 1990 2020
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
CO2_NIG_ does not Granger Cause PRIMARY_FOREST_LOSS	14	0.76797	0.3996
PRIMARY_FOREST_LOSS does not Granger Cause CO2_NIG_		1.24290	0.2887

Source: Author's Computation from EViews

The p-value showed that we accept the null hypothesis that there is no statistical evidence to support the fact that forest cover loss leads to climate change as declared in the literature. The p-values are greater than 5%. Thus, there is an absence of causality between deforestation and climate change in Nigeria.
3) Does tree cover loss affect climate change in Nigeria?
Ho: Tree cover loss area does granger cause climate change in Nigeria.
Ha: Tree cover loss granger cause climate change in Nigeria.

TABLE 7

Pairwise Granger Causality Tests
Date: 09/27/21 Time: 14:49
Sample: 1990 2020
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
CO2_NIG_ does not Granger Cause TREE_COVER_LOSS	15	1.55075	0.2368
TREE_COVER_LOSS does not Granger Cause CO2_NIG_		0.06031	0.8102

Source: Author's Computation from EViews

Also, in table 7 there is no statistical justification to accept that tree cover loss granger causes climate change. The p-values are greater than 5%. Hence this study accepts that null hypothesis which states that tree cover loss does granger cause climate change in Nigeria vice versa. This implies that there is an absence of causality between tree cover loss and climate change.

SUMMARY, POLICY IMPLICATION, AND RECOMMENDATIONS

Based on the findings, this study accepts the following hypotheses; Forest area granger cause climate change in Nigeria (world); Forest area loss does granger cause climate change in Nigeria vice-versa; Ho: Tree cover loss area does granger cause climate change in Nigeria.

The policy implication of this study means that available data do not provide sufficient statistical evidence to argue that deforestation in Nigeria leads to climate change. But the result raises the issue of unidirectional causality and zero causality in the literature. It is wise to state that perhaps due to the paucity of data, the result could not guarantee the causality that exists between climate change and deforestation. Thus, there is a need for fiscal policy to control and regulate forest areas in Nigeria. This is because the decline in forest areas would lead to higher climate change vice versa. This conclusion is based on the negative correlation that exists between forest areas and climate change.
This study, therefore, recommends the following (i) Adequate fiscal policy and regenerative policy to replenish the forest area to increase the capacity of the forest to trap CO2 releases. (ii) Government must set up legislation on the protection of forest areas in order to criminalize the activities of wood logging trends in the country and the indiscriminate access of forest areas by unauthorized persons, (iii) adequately fund high-tech and Drone activities to improve surveillance in the forest areas

REFERENCE

[1] Allen, J. C. & Barnes, D. F. (1985). The causes of deforestation in developing countries. *Annals of the Association of American Geographers,* 75 (2), 163-184.

[2] Angelsen, A. (2007). Forest cover change in space and time: Combining the von Thunen and forest transition. *World Bank Policy Research Working Paper,* No. WPS4117

[3] Angelsen, A. (2009). Introduction, In Angelsen, A., Brockhaus, M., Kanninen, M., Sills, E., & Sunderlin, W. D. (Eds.), *Realizing REDD+: National Strategy and policy options.* Bogor: Centre for International Forestry Research (CIFOR).

[4] Angelsen, A., & Kaimowitz, D. (1999). Rethinking the cause of deforestation: lessons from economic models. *The World Bank Research Observer,* 14 (1), 73-98.

[5] Anser, G. P. (n.d.). Measuring carbon emissions from tropical deforestation: An overview. *Environmental Defense Fund,* 1-10.

[6] Bae, J. S., Joo, R. W., & Kim, Y-S (2012). Forest transition: towards a more comprehensive theoretical framework. *Land Use Policy,* 29 (1), 198-207.

[7] Bennett, L. (2017). Deforestation and climate change. *Climate Institute,* 1-10, August, 18.

[8] Betts, R. A., Cox, P. M., Collings, M., Harris, P. P., Huntingford, C., & Jones, C. D. (2004). The role of ecosystem-atmosphere interactions in simulated Amazonian precipitation decrease and forest dieback under global climate warming. *Theor. Appl. Climatol,* 78, 23-34.

[9] Bhattarai, M., & Hammig, M. (2001). Institutions and the Environment Kuznets Curve for deforestation: A cross-country analysis for Latin America, Africa, and Asia, *World Development,* 29 (6), 995-1010.

[10] Brack, D. (2019). Forest and Climate Change: Background analytical study. *Global Forest Goals and UN Forum on Forests,* 1-56, March,

[11] Butler, R. A. (2021). Global forests and Planetary Boundaries. *Mongabay*, 1-8.

[12] Carlson, K. M., Curran, L. M., Ratnasari, D., Pittman, A. M., Soares-Filho, B. S., Anser, G. P., Trigg, S. N., Gaveau, D. L. A, Lawrence, D. & Rodrigues, H. O. (2012). Committed carbon emissions, deforestation, and community land conversion from oil palm plantation expansion in West Kalimantan, Indonesia, *Proceedings of the National Academy of Science of the United States of America,* 109 (19), 7559-64.

[13] Ceddia, M. G., Sedlacek, S., Bardsley, N. O., & Paloma, S. G. (2013). Sustainable agricultural intensification or Jevons paradox? The role of public governance in tropical South America, *Global Environment Change,* 23 (5), 1052-1063.

[14] Chomitz, K. M., & Gray, D. A. (1996). Roads, land use, and deforestation: A spatial model applied to Belize, *The World Bank Economic Review,* 10 (3), 487-512.

[15] Culas, R. J. (2007). Deforestation and the environment Kuznets curve: An institutional perspective, *Ecological Economics,* 61 (2-3), 429-437.

[16] Duguma, Atela, Minang, Ayana, Gizachew, Nzyoka and Bernard (2019)

[17] Easterling, W. E. (1990). Climate trends and prospect in natural resource for the 21 century, *American Forestry Association,* 32-55.

[18] Esmaeili, A. & Nasrnia, F (2014). Deforestation and the Environment Kuznets curve in Iran. *Small-scale forestry,* 13(3), 397-406.

[19] FAO (1995). Forestry Statistics Today for tomorrow. Rome

[20] FAO (2001). The state of the World's Forest 2020. Rome

[21] FAO (2006). Deforestation cause global warming. Rome

[22] FAO (2020). Global Forest resource assessment 2020 report, Nigeria. Rome.

[23] FAO (2020). State of the World's Forests 2020. *FAO*

[24] Global Forest Watch Data 2020

[25] Gorte, R. W., & Sheikh, P. A. (2010). Deforestation and climate change. *Congressional Research Service*, 1-41.

[26] Grace, J. (1991). Vegetation and climate: A tenuous link in modern ecology: Basic and applied aspects. *Elsevier,* 711-722.

[27] Grainger, A. (1995). The forest transition: An alternative approach, *Area,* 27 (3), 242-251.

[28] Granger, C. W. J. (1969). Investigating causal relationship by econometric models and cross-spectral methods. *Econometrica*, 37 (3), 424-438.

[29] Hostert, P., Kuemmerle, T., Prishchepov, A., & Sieber, A. (2011). Rapid land use change after socio-economic disturbances: the collapse of the Soviet Union versus Chernobyl. *Environment Research Letters,* 6(4), 1-23.

[30] Inman, K. (1993). Fueling expansion in the third world: population, development, debt, and the global decline of forests. *Society & Natural Resources*, 6(1), 17-39.

[31] IPCC (2007). *Climate Change 2007*: *Synthesis Report.* Geneva, Switzerland.

[32] Jakuboski, S. (2012). Deforestation and global warming. *Green Science,* 1-13, May, 19.

[33] Jones, D. W. & O'Neill, R. V. (1995). Development policies, urban unemployment, and deforestation: The role of infrastructure and tax policy in a two-sector model. *Journal of Regional Science,*35, 135-53.

[34] Kant, S. & Redantz, A. (1997). An econometric model of tropical deforestation. *Journal of Forestry Economics*, 3, 51-86.

[35] Katila, M. (1995). Modeling deforestation in Thailand. Paper presented at IUFRO, World Congress, Tampere, Finland.

[36] Knoema, (2020). Data on Forest Area

[37] Kuznets, S. (1955). Economic growth and income inequality, *American Economic Review,* 40 (1), 1-28.

[38] Lambin, E. F. & Meyfroidt, P. (2010). Land use transitions: Socio-ecological feedback versus socio-economic change. *Land Use Policy*, 27 (2), 108-118.

[39] Lindsey, R. (2021). Earth's hottest month was record hot in 2021. *Climate.gov/news-feature*, August 16.

[40] Longobardi, P., Montenegro, A., Beltrami, H., & Eby, M. (2016). Deforestation induced climate change: Effects of spatial scale. *PLos ONE,* 11(4), 1-23.

[41] Mather, A. S. (1992). The forest transition, *Area,* 24 (4), 367-379.

[42] McGregor, W. M. (1937). Forest types and succession in Nigeria. *Empire Forestry,* 16 (2), 234-242.

[43] Mercer, K. L., & Perales, H. (2004). Evolutionary response of landraces to climate change in centers of crop diversity. *Evolutionary Applications,* 3(5-6), 480-493.

[44] Micciolo, M. P. (2017). The lungs of our land: Deforestation and climate change's destructive circular relationship. *Environment Law Journal*, 28, 1-71

[45] Munteanu, C., et al (2014). Forest and agricultural land change in the Carpathian region- A meta-analysis of long-term patterns and drivers of change. *Land Use Policy,* 38, 685-697.

[46] O'Brien, K. L. (1996). Tropical deforestation and climate change. *Progress in Physical Geography: Earth and Environment.* September, 1

[47] Perz, S. G. (2007). Grand theory and context-specificity in the study of forest dynamics: Forest transition theory and other directions. *The Professional Geographer,* 59 (1), 105-114.

[48] Southgate, D. (1994). Tropical deforestation and agricultural development in Latin America. In Brown, K & Pearce, D. (eds.) the cause of tropical deforestation, the economic and statistical analysis of factors giving rise to the loss of tropical forests, 134-44. London: University College London Press.

[49] UNFCCC (2006). *Background paper for the workshop on reducing emission from deforestation in developing countries,* 1(1a), 1-25. Rome.

[50] Walker, R. (2004). Theorizing land-cover and land-use change: The case of tropical deforestation. *International Regional Science Review,* 27 (3), 247-270.

[51] Whitaker, J. R. (1940). World view of destruction and conservation of natural resources, *Annals of the Association of American geographers,* 30 (3), 143-162.

[52] White, H. & Sabarwal, S. (2014). Quasi-experimental design and methods. *UNICEF Methodological Briefs Impact Evaluation No. 8,* 1-25.

[53] Yeo, I-Y, & Huang, C. (2013). Revisiting forest transition theory with historical records and geospatial data: A case study from Mississippi, *Land Use Policy,* 32, 1-13.