Received: 16 May 2020 | Revised: 12 June 2020 | Accepted: 16 August 2020
DOI: 10.1002/pa.2444

ACADEMIC PAPER

WILEY

Moderation of ecological footprint with FDI and agricultural sector for a better environmental performance: New insight from Nigeria

Edmund Ntom Udemba

Faculty of Economics Administrative and Social science, Istanbul Gelisim University, Istanbul, Turkey

Correspondence
Edmund Ntom Udemba, Faculty of Economics Administrative and Social science, Istanbul Gelisim University, Istanbul, Turkey.
Email: eddy.ntom@gmail.com; eudemba@gelisim.edu.tr

Following the fact that above average contribution to the Nigerian economic growth come from petroleum industry and agriculture which are dominated by multinational companies, the author undertakes the task to unveil the level of emission from these sectors. The current paper adopts FDI and agricultural sector as among the vital indicators in determining the position of Nigeria in climate change. This study builds on the ecological footprint in accounting for environmental performance of Nigeria. Basic contribution of this paper is in its two-stage analyses of ARDL regression and causality with both ecological based and growth based models. This unveils both the economic and ecological footprint implication to the environment. The findings of this paper are: a positive (elasticity) relationship between economic growth (GDP) and ecological footprint is established in both the short run and long run. Negative and significant relationship is uncovered between FDI and ecological footprint. Negative association between agricultural sector and ecological footprint in both long run and sort run. The relationship that exist between these variables (energy use and population) and ecological footprint are positive which means unfavorable implication to the environmental performance. Moreover, the findings according to Granger causality are: a uni-directional causality passing from economic growth to ecological footprint, from energy use to ecological footprint, and also from population to ecological footprint. Also, a one-way transmission is established amongst economic growth and energy use, and between economic growth and population. This is in conformity with the expectations of the author, and has established a nexus among the selected variables (population and energy transmitting to economic growth, while economic growth and energy transmitting to ecological footprint). With these findings especially from FDI and agriculture, the authorities of the country are expected to build a sustainable policy framework in promoting, regulating and sustaining the trend with mindset of maintaining a healthy environment.

1 | INTRODUCTION

The recent global development in the areas of climate changes and environmental degradations that are considered sparks to the global warming. A target has been placed on countries by United Nations Intergovernmental Panel on Climate Change come 2050 for the cut of carbon emissions. This has drawn massive attention and contribution from different scholars towards ameliorating the problem pose to the entire globe. Nigeria is named one of the top six greenhouse gas emitters in Africa, but the more commendable effort from the country which is the ratification of 2015 Paris Agreement has shown its effort towards emission control. In the case of Nigeria involvement in

FIGURE 1 The agricultural industry has a large environmental impact. *Sources*: World atlas

emission and the reduction of the emission, many authors have viewed the issue from different perspectives. The two common areas that researchers have effectively investigated are excessive economic activities without much concern to the adverse effect to the environment, and social-economic activities such as urbanization. Also, many have considered pollution in different categories such as carbon emission, methane, biomass and other industrial activities. Pollution and Environmental degradation in Nigeria can be induced from many sources if holistically viewed the source. The two sectors in Nigeria that remain under-researched on their scale of emission promotion are agricultural sector and industrial (oil exploration and natural gas flaring) sector.

Agriculture sector has proven to be one of the major boosters and sustainers of Nigerian economic performance over a period of time with commendable figures. Most rural Livelihood and households are sustained via agriculture in Nigeria. More than 80% of rural population in Nigeria are benefiting either directly or indirectly from agriculture both in food provision and income via sales and employment. Currently, the authorities in the country have focus more on the agricultural sector in meeting the set target of 2020. Vision 2020 of the country has been set aside for the achievement of its five (5) points agenda of food security, natural resources and growth agenda which it is believed that agriculture will remain a major driver of the country's economic performance and growth beyond the set date. The antecedents of the contribution of the agricultural sector to Nigeria economic performance shows that the sector is among, if not the major sustainer of the economy asides oil and gas sector. According to Nigeria Bureau of Statistics (2007) Nigeria recorded economic inducement from agricultural sector as follows: 47% of GDP growth in 1990 and 2007 which made it the largest contribution from a single sector in that period, and the GDP and agricultural growth were 6 and 7.2% respectively in the following year. Agriculture is vital in sustenance of human life via food and crop production but the practices related with the farming have environmental impacts. The success of the agricultural sector is not left without its impact to the environmental quality. The agricultural practice involves in enhancing global warming through deforestation, pollution, and environmental degradation. The agricultural practice in the country involves both the mechanized and traditional kinds of farming. These two practices emit pollution in one way or the other. Chemicals such as fertilizers and pesticides are widely applied to the soil for the sole purpose of enhancing the quality and quantity of agricultural products, and this practice alone pollute the environmental quality and harm human and animal wildlife through the water run-off from the soil. With the invention of machines in farming operations, energy utilization has been on the acceleration. This involves fossil fuel consumption by the heavy equipment such as tractors. It is expected that the gas-oil consumption by the introduced mechanized system of farming will increase the emission. There will be increase in deforestation for the availability of tillable lands for farming purpose which exposes the environment to the dangers of climate change via excessive and unutilized carbon emission because of insufficient trees within the environment. Constructions of infrastructure and irrigation programs equally amounts to increased consumption of energy due to mechanization. The greatest significant of global warming intrigued with agriculture is associated with nitrous oxide, methane, phosphorus, nitrate, ammonia, and untapped carbon oxide, all of which are ecological footprints released into the climatic atmosphere from agricultural practice (Figure 1).

Moreover, the petroleum industry and its activities are negatively impacting the environment and health quality of the communities where it is located. The petroleum and gas operations involve mining, refining the crude oil, and flaring of natural gases. These activities impact both to environment and the climate change. The extraction of crude oil actively engages the ground through drilling rigs and wells that extents to the pocket of the oil bed. During this drilling activities, the oil is likely to fill the rock layer, causes spillage, and spread throughout open areas and water bodies like oceans and rivers. This impact negatively to the aquatic life by killing the water animals and fishes through its toxic material. The spillage of this content to the surface of the earth causes ham to both the soil and the atmosphere. The agricultural input is affected via the damage on the surface and quality of the soil and the atmosphere and water is contaminated. The ecology is equally affected through clearing of forests and land for adequate space for the drilling purpose.

1.1 | Nigerian petroleum industry

Nigerian oil sector as it comprises oil exploration and illegal refining of the oil and the flaring of natural gas is another source of carbon emission to the countries. Nigeria has been identified as among, if not the largest Africa's oil producer and the second oil reserves in Africa after Libya (Uyiosa, 2015). According to the National Bureau of Statistics, Nigeria remains the 10th largest crude oil reserves in the world. The petroleum sector remains the only sector that contributes close to 80–90% towards the economic growth of Nigeria. The contribution towards the GDP is viewed from the angle of revenue to the central government and its export earnings. Aside from contributing towards the economic performance of the country, petroleum is essential to both the transportation industry and homes, and industrial operations. The majority of petroleum operations take place in the south–south (Niger Delta) region of the country with strategic location is Ogoni. Despite the benefits of the product and the sector towards the economic growth of Nigeria, the product has equally makes the country vulnerable both to the economy and the environmental factor. Niger delta region and Ogoni community in particular remains the ugly face of Nigerian petroleum industry. The oil spillage in the region is detrimental to the country's economy and environment. The spillage has created the problem of poor nutrition, lack of clean water sources, and environmental in the region and the country at large. According to UN Environmental Program (UNEP, 2009), it will cost the country at least a hundred billion dollars and about 30 years to clean up this damage to the region. The report identified 1,000 km^2 area polluted by the oil spillage in Ogoni land.

In environmental or ecological research, majority of the studies have limited their research with just one indicator (such as carbon emission, sulfur dioxide, fine smoke and other pollutant emissions) in ascertaining the quality of environment. Climate change is not just triggered by a part of the geographical or biological agents but by different stocks as relates to exploration, mining, gas flaring, deforestation and excavation of natural resources (Ulucak and Lin, 2017). Many scholars have used different indicators to measure environmental performance making it shallow in revealing the real cause of the global warming. Viewing from the perspective of Galli (2015) and Global Footprint Network (2018), ecological footprints total all the man's activities on Earth which has to do with geographical and biological occupation of the space. Considering the contents of the ecological footprints which is not single in nature but in group (such as deforestation, mining, extraction of natural resources, flaring of gases, agricultural practice like mechanization with adoption of chemicals), it is always better to investigate the climate change as instigated by poor environment with ecological footprints. Ecological footprint is not just a single indicator but a grouped or indexed form of indicators that have the combination of all the possible elements of pollution. According to Yilanci et al. (2019), ecological footprint is the total of six components which are the croplands, grazing land, fishing grounds, forest land, built-up land and carbon footprints. This supposes every activity on the soil both from agricultural operation, and crude oil and gas exploration. Hence, it does not make much sense building on only one indicator when measuring environmental dilapidation.

Upon this, the present study builds on the ecological footprint in accounting for environmental performance of Nigeria. To the authors knowledge, only a few studies (Solarin and Bello, 2018; Ulucak and Lin, 2017; Yilanci et al., 2019) have utilized ecological footprint in measuring the environmental quality with other approaches quite different from this current study. The uniqueness of this study is the application of different approaches (*ARDL Bounds testing with structural break*) to expose the involvement of Nigeria in the emission production and reduction. The basic contribution of this paper is the utilization of ecological footprint based model to show the vivid state of environmental performance. This was complimented with Granger causality to throw more to implication of economic growth to the ecological performance of the country. This study unveils both the economic and ecological footprint implication to the environment. Also, following the fact that above average contribution to the Nigerian economic growth come from petroleum industry which is dominated by multinational companies, the current paper adopts FDI as among the vital indicators in determining the position of Nigeria in climate change. Another uniqueness of this paper is seen from a country-specific research which mirrors down the investigation to just one country, and to give a vivid and clear picture of the findings on a particular country. Most works on African countries have been organized in a panel structured manner without country-specific analyses. To the knowledge of author, this current study will be among the few, if not the first, that have given priority in researching the case of Nigeria separately without merging it with other African countries (Figures 2 and 3).

The remaining parts of this study are positioned as follows: Section 2, empirical literature and theoretical background with hypothesis; Section 3, data and methodological presentation; Section 4, empirical outcomes and discussion; Section 5, conclusion and the policy implication of the study.

FIGURE 2 Adverse effect to environmental quality via the crude oil spillage in Nigeria. *Source:* Legit

FIGURE 3 A petroleum refinery spewing out toxic fumes into the air. *Source*: World atlas

2 | LITERATURE REVIEW

The literature on carbon emission and the various indicators used in measuring the impact and the reduction of the emission have generated more concern and readiness to curtail the climate change. Many researchers have investigated the pollution and the risk associated with it in different capacities with different approaches but yet to come up with a unified finding. Here, are some of the literature that have investigated the pollution with different findings with various variables such as economic growth, agriculture, FDI, energy use and population. Balsalobre-Lorent et al. (2018) found in his study the presence of N-shaped link among income and carbon emission. In his work, triangular studies of Chinese economic growth with pollution, Udemba (2019) found appositive relationship between income and pollution. Bekun et al. (2019) found in their work for south Africa a positive link among income and carbon emission. Bakhish et al. (2017) in their studies for Pakistan initiate adverse link with carbon emission. For the case of Ghana, Anaman et al. (2015) initiate a negative association among income and carbon emission. Udemba et al. (2019) in their Indonesian study found that causality passing to economic growth from carbon emission.

However, many studies have investigated the association between carbon emission and FDI and found contradictory results. Sarkodie and Strezov (2019) did a study on emission with FDI and found pollution heaven. They found energy utilization impacting the economic growth because of the heavy impact on energy use from FDI. Examination of the impact of carbon emission and FDI was done by Shahbaz et al. (2019) for (MENA). They found N-shape association between FDI and carbon emission. Pazienza (2015) found adverse relationship between Investment and pollution. Ajide and Adeniyi (2010) found in their study for Nigeria a positive relationship. Omri (2013) found a positive link between FDI and pollution. Ben Kheder and Zugravu-Soilita (2008) establish in their works for China that FDI induces emission. Also, Udemba et al. (2019) in their research for the case of Indonesia establish adverse link among FDI and emission. Talukdar and Meisner (2001) found adverse link among FDI and pollution for the developing countries.

Also, Sarkodie and Phebe (2016) found increase in energy consumption with a corresponding increase in pollution. Ramanathan (2006) found a positive relationship between pollution and fossil fuel consumption. Al-Mulali et al. (2015) found a positive relationship between carbon emission and energy use. Fahri et al. (2015) initiate a positive link among agriculture and emission for the case of Turkey. Also, Behera and Dash (2017) initiate a positive link among agriculture and emission. While, Valentini et al. (2013) initiate adverse link between agriculture and emission for the case of G20 nations. Again, Dogan (2016) for Turkey; M. Liu et al. (2017) for ASEAN; Ullah e al. (2018) for Pakistan found positive relationship between agriculture and pollution. Few studies have used the ecological footprint as an indicator for investigating the environment and pollution. Wackernagel et al. (1999) initiate a positive link among population and ecological footprint. Al-Mulali et al. (2015) studied the EKC hypothesis with ecological footprint as an indicator of environmental performance on 93 countries. They found an overturned U-shaped relationship between ecological footprint and income level for developed countries. Al-Mulali et al. (2015) for the 14 MENA countries found that ecological footprint, energy, urbanization, merchant liberalization, manufacturing expansion and political steadiness are impacting each other in the long run. The causality findings show causality between ecological footprint and other variables. Ozturk et al. (2016) utilized EKC hypothesis for the case of 144 countries and found a negative relationship between the ecological footprint and the selected variables. This result is indicative mostly for the case of developed countries. Ulucak and Lin (2017) studied the stationarity of the ecological footprint and its components. They found that cropland footprint and bio-capacity are stationary whereas ecological footprint, carbon footprint, grazing land footprint, and ecological deficit are non-stationary. Solarin and Bello (2018) did a stationarity research of ecological footprint on 128 countries, and found non-stationary for ecological footprint for 96 countries. Katircioğlu and Katircioğlu (2018) investigate a group of top 10 visiting destination, and the implication of ecological footprint. They found environmental performance induced by the tourist's activities. Ozcan et al. (2019) researched on environmental policies for the low, middle and high income countries with ecological footprint indicator, and found a mean-reverting behavior on ecological footprint for all developed countries.

2.1 | Theoretical framework

Majority of the environmental studies are based on Environmental Kuznets Curve (EKC). The EKC was first utilized in testing the relationship between income inequality and economic growth by Simon Kuznets in the year 1955. After the first application of the EKC, other scholars such as Shafik and Bandyopadhyay (1992) and Panayotou (1997) started applying this theory in environmental analyses. This theory is fashioned in a three-stage postulation which has been built on by many authors to justify the economic developmental stages and trend that impact the environment in different scales. This development stages initiate different relationships between economic growth and pollution. First, the pollution grows together with economic growth to a certain point of awareness among the people. As Grossman and Krueger (1991) put it, pollution is generated and grow or increase with economic growth. This first stage is called scale effect stage which is characterized as a stage with competitive economic growth mindset. Before the exiting of this stage, the focus is always in achieving greater economic growth with less concern to the environmental effects of the economic operation. This awareness comes with the benefit of structural changes that come with economic development stems from economic growth. The mases are beginning to acknowledge the importance of healthy environment through social factors with increased level of development. This stage is considered a technological advanced effect/stage which equip and accord the people with right information about the importance of balancing growth with healthy environment. Also, research and development programs are initiated which will help in sensitization of the masses. As put by Komen et al. (1997), the country at this stage is considered rich country with access to investments into research and development programs, and technological development goes hand in hand with economic advancement. At this point, the relationship between the economic growth and pollution is considered negative and favorable to environment. This will launch the composition effect stage where it is assumed that the country is developed and can be able to moderate and regulate economic operation to balance with healthy environment. At this stage, both the public authorities and firms increased their engagements in the service sector. Vukina et al. (1999) stated that at this stage, pollution level is possible not increase to scale with economic growth if the output is altered. The EKC theory is usually associates developing economies and exposes the scale of pollution that associate with any economy in different stages of growth. AS part of the theory, the author has decided to investigate the Nigerian ecological footprint with an eye on the economic performance as it involves agriculture and investment.

3 | DATA AND METHODOLOGY

3.1 | Data

With the exception of ecological footprint, the data applied in this study are all gotten from World Development Indicator (WDI, 2019 updated). The ecological footprint was sourced from the 2019 updated Global Footprint Network and it comprises: built-up land; carbon emission; cropland; fishing grounds; forestry products and grazing land. The author utilized Nigeria annual data dated 1981–2018 for the study. The following variables are all inclusive in the data used in this study: ecological footprint (per capita), GDP per capita (constant 2010 US$), energy use (kg of oil equivalent per capita), agricultural sector (forestry, fishing and value added % GDP), Foreign Direct Investment, net inflow (% GDP) and urban population. Except the agricultural sector and FDI that are already in percentage form, all other variables are transformed into logarithm.

3.2 | Methodology

The author adopts different methods of estimations and analyses in this research, and the methods comprises: descriptive statistics, test for stationarity, lag selection, Autoregressive Distributive Lag (ARDL) with Bounds testing, and Granger test. The descriptive statistics was utilized to assess the normality and fitness of the data through kurtosis, Jarq-Bera and skewness. Unit root testing is among the methods adopted by the author to confirm the stationarity of the Nigerian data applied in this work. Both the conventional approaches, and the more encompassing approach which exposes the shock in the economy are adopted for unit root estimation. Systems such as augmented Dickey–Fuller (ADF, 1979), Perron (1990), Kwiatkwoski–Philips–Schmidt–Shin (KPSS, 1992) are used for the unit root testing. ADF-structural break test by Perron (1990) was used to test for the permanent shock that might induce the stationarity of the variables. The Akaike Information Criterion (AIC) was adopted in optimal lag selection. Autoregressive Distributed Lag (ARDL) with Bounds testing for long run and cointegration analysis (Pesaran et al., 2001) are adopted in estimation and empirical analyses of this work for the confirmation of the long run link among the selected variables. The EKC has been identified as among the adopted theoretical backgrounds of this study. The adoption of EKC is done with a deviation from the traditional believe of utilizing the increasing or multiples of GDP to identify the increasing or decreasing relationships that points at EKC. This present study chose to deviate from the traditional basis of the EKC to a more linearized form bearing in mind of the existence of the nitrated form of GDP to the order I(1) in unit root estimation. It has been proven that the early studies which adopted EKC failed to recognize the problem of where the integrated process is having a unit root (Cheng et al., 2014; Wagner, 2008). Having found integrated form of GDP at order I(1), the author undertakes the linearized form of the model specification bearing in mind the impact of economic growth on the environment.

3.3 | Model specification

This study builds on the assessment of Nigeria effort towards the reduction of emission and maintaining a commendable environmental normalcy. Emission is captured with ecological footprint, and the indicators that were selected to determine the emission are GDP, agriculture, FDI, and energy use and urban population. The author is interested in ascertaining the influence of the selected variables on the ecological footprint, and for this purpose, a linear relationship framework was implemented for a direct of the regressors (GDP, FDI, AGRIC, energy and population) on the dependent variable (ecological footprint). For the purpose of long term linear relationship amongst the selected variables, the model specification is framed on ARDL-Bounds approach. The model according to Pesaran and Shin (1998) and Pesaran et al. (2001) are as follows:

$$\begin{aligned}\Delta \mathrm{LEFP}_t = {} & A + \chi_1 \mathrm{LEFP}_{t-1} + \chi_2 \mathrm{LGDP}_{t-1} + \chi_3 \mathrm{FDI}_{t-1} + \chi_4 \mathrm{AGRIC}_{t-1} \\ & + \chi_5 \mathrm{LEU}_{t-1} + \chi_6 \mathrm{LPOP}_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta \mathrm{LEFP}_{t-i} \\ & + \sum_{i=0}^{q-1} \delta_2 \Delta \mathrm{LGDP}_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta \mathrm{FDI}_{t-i} \\ & + \sum_{i=0}^{q-1} \delta_4 \Delta \mathrm{AGRIC}_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta \mathrm{LEU}_{t-i} \\ & + \sum_{i=0}^{q-1} \delta_6 \Delta \mathrm{LPOP}_{t-i} + \mathrm{ECM}_{t-i} + \varepsilon_t, \end{aligned} \tag{1}$$

$$\begin{aligned}\Delta \mathrm{LGDP}_t = {} & A + \chi_1 \mathrm{LEFP}_{t-1} + \chi_2 \mathrm{LGDP}_{t-1} + \chi_3 \mathrm{FDI}_{t-1} + \chi_4 \mathrm{AGRIC}_{t-1} \\ & + \chi_5 \mathrm{LEU}_{t-1} + \chi_6 \mathrm{LPOP}_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta \mathrm{LEFP}_{t-i} \\ & + \sum_{i=0}^{q-1} \delta_2 \Delta \mathrm{LGDP}_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta \mathrm{FDI}_{t-i} + \sum_{i=0}^{q-1} \delta_4 \Delta \mathrm{AGRIC}_{t-i} \\ & + \sum_{i=0}^{q-1} \delta_5 \Delta \mathrm{LEU}_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta \mathrm{LPOP}_{t-i} + \mathrm{ECM}_{t-i} + \varepsilon_t, \end{aligned} \tag{2}$$

$$\Delta FDI_t = A + \chi_1 LEFP_{t-1} + \chi_2 LGDP_{t-1} + \chi_3 FDI_{t-1} + \chi_4 AGRIC_{t-1} + \chi_5 LEU_{t-1} + \chi_6 LPOP_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta LEFP_{t-i} + \sum_{i=0}^{q-1} \delta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta FDI_{t-i} + \sum_{i=0}^{q-1} \delta_4 \Delta AGRIC_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta LEU_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta LPOP_{t-i} + ECM_{t-i} + \varepsilon_t, \quad (3)$$

$$\Delta AGRIC_t = A + \chi_1 LEFP_{t-1} + \chi_2 LGDP_{t-1} + \chi_3 FDI_{t-1} + \chi_4 AGRIC_{t-1} + \chi_5 LEU_{t-1} + \chi_6 LPOP_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta LEFP_{t-i} + \sum_{i=0}^{q-1} \delta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta FDI_{t-i} + \sum_{i=0}^{q-1} \delta_4 \Delta AGRIC_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta LEU_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta LPOP_{t-i} + ECM_{t-i} + \varepsilon_t, \quad (4)$$

$$\Delta LEU_t = A + \chi_1 LEFP_{t-1} + \chi_2 LGDP_{t-1} + \chi_3 FDI_{t-1} + \chi_4 AGRIC_{t-1} + \chi_5 LEU_{t-1} + \chi_6 LPOP_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta LEFP_{t-i} + \sum_{i=0}^{q-1} \delta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta FDI_{t-i} + \sum_{i=0}^{q-1} \delta_4 \Delta AGRIC_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta LEU_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta LPOP_{t-i} + ECM_{t-i} + \varepsilon_t, \quad (5)$$

$$\Delta LPOP_t = A + \chi_1 LEFP_{t-1} + \chi_2 LGDP_{t-1} + \chi_3 FDI_{t-1} + \chi_4 AGRIC_{t-1} + \chi_5 LEU_{t-1} + \chi_6 LPOP_{t-1} + \sum_{i=0}^{\rho-1} \delta_1 \Delta LEFP_{t-i} + \sum_{i=0}^{q-1} \delta_2 \Delta LGDP_{t-i} + \sum_{i=0}^{q-1} \delta_3 \Delta FDI_{t-i} + \sum_{i=0}^{q-1} \delta_4 \Delta AGRIC_{t-i} + \sum_{i=0}^{q-1} \delta_5 \Delta LEU_{t-i} + \sum_{i=0}^{q-1} \delta_6 \Delta LPOP_{t-i} + ECM_{t-i} + \varepsilon_t. \quad (6)$$

From Equations (1) to (6), the variables are presented in their short forms as follows: EFP = ecological footprint, GDP = economic growth, FDI = foreign direct investment, AGRIC = agricultural sector, EU = energy use, and POP = population. Δ, χ_1 and δ_1 denote the first difference of the selected variables, the long run and short run coefficients of the variables respectively. ECM_{t-1} represents the error correction model which shows quick in convergence over a long path. Long run equilibrium/cointegration is determined with Bounds testing by comparing the *F* statistics and critical values of the upper and lower bounds. Cointegration exist when the *F* stats is greater than the upper bound. If the *F* stats is less than the upper bounds, it means there is no cointegration, but when the *F* stats fall in between the lower and upper bounds, it remains inconclusive. The null hypothesis for the Bounds testing is advocating that there is no cointegration while the alternative is in support of the existence of cointegration. The Hypothesis is expressed as: H_0: $\chi_1 = \chi_2 = \chi_3 = \chi_4 = 0$ (when *F* stats < both bounds) against H_1: $\chi_1 = \chi_2 = \chi_3 = \chi_4 \neq 0$ (when *F* stats > both bounds).

4 | EMPIRICAL RESULTS AND DISCUSSION

The empirical analyses and the findings are displayed in this session with their interpretations shown and discussed. The first step taken by the author is the estimation and analyses of descriptive statistics, followed by the stationarity test supported with structural break analyses as well.

4.1 | Descriptive statistics

Table 1 displays the economic growth and energy use as variables with the highest mean and median respectively with FDI and ecological footprint making the least in the statistics. The same trend is seen in maximum and minimum values with economic growth and energy use taking the highest values in the maximum, with FDI and

TABLE 1 Summary of statistics

	EFP	GDP	AGRIC	FDI	EU
Mean	1.093473	1758.613	22.86120	1.571703	641.5333
Median	1.169696	1,548.288	22.04733	1.266578	698.8326
Maximum	1.383641	2,563.900	36.96508	5.790847	798.6302
Minimum	0.000000	1,324.297	12.24041	0.257422	0.000000
Std. dev.	0.279299	439.8797	4.764365	1.243151	225.5234
Skewness	−3.184516	0.655490	0.438553	1.705011	−2.462322
Kurtosis	13.13279	1.830744	4.422711	5.937832	7.301437
Jarque-Bera	226.7936	4.885897	4.422913	32.07691	67.69459
Probability	0.000000	0.086904	0.109541	0.000000	0.000000
Sum	41.55196	66,827.29	868.7255	59.72473	24,378.27
Sum Sq. dev.	2.886301	7,159,284	839.8694	57.18066	1,881,850
Observations	38	38	38	38	38

Abbreviations: AGRIC, agricultural sector; EFP, ecological footprint; EU, energy use; FDI, foreign direct investment; GDP, economic growth.

ecological footprint making the least in the minimum. The result shows both negative and positive numbers in the case of skewness with all below three which satisfied the normality property of the data.

4.2 | Test for unit root

The test of unit root is essential especially in a time series study. Non adherence to this may lead to misleading finding in the

TABLE 2 Stationarity test

	@ LEVEL		First Diff		
Variables	With Intercept	Intercept & Trend	With Intercept	Intercept & Trend	Decision
ADF					
LNEFP	−0.0165	1.1657	−5.783***	−6.164***	I(1)
LNGDP	−0.5591	−1.463	−3.5901**	−3.4485*	I(1)
LNEU	−0.5075	−1.0602	−5.8339***	−6.0803***	I(1)
AGRIC	−2.4185	−1.8100	−6.6855***	−7.1808***	I(1)
FDI	−3.8952***	−3.7971**	−7.8842***	−7.8444***	MIXED
LNPOP	1.1918	−0.1477	1.9059**	−1.2730	I(1)
PP					
LNEFP	−0.0449	0.0069	−5.7829***	−6.1636***	I(1)
LNGDP	−0.1053	−2.9276	−3.4997**	−3.3114*	I(1)
LNEU	−0.5812	−1.0602	−5.8338***	−6.2159***	I(1)
AGRIC	−2.6395*	−2.0621	−5.7771***	−8.3069***	I(1)
FDI	−3.8178***	−3.7084**	−13.5541***	−17.9485***	I(1)
LNPOP	18.8521***	4.0685	1.7598**	−1.2875	MIXED
KPSS					
LNEFP	0.1896	0.1752**	0.3501*	0.1350*	
LNGDP	0.5889**	0.1767**	0.3772*	0.1376*	
LNEU	0.2939	0.1448*	0.2566	0.1165	
AGRIC	0.3319	0.2131**	0.5000**	0.2858***	
FDI	0.1533	0.1424*	0.3502*	0.2747***	
LNPOP	0.7282**	0.1992**	0.6933**	0.1761**	

Note: a: (*) significant at 10%; (**) significant at 5%; (***) significant at 1%. b: *p* value according to (1) MacLean and MacKinnon (1996) one-sided *p* values; (2) KPSS (1992).
Source: Authors computation.

TABLE 3 Structural break test

Variable	ADF	*p*-Value	Lag	Break Date	CV(1%)	CV(5%)
Level						
LNGDP	−3.164	.933	3	1990	−5.719	−5.176
LNEFP	−5.366	<.03**	3	2013	−5.719	−5.176
LNENERGY	−23.461	<.01 ***	3	2014	−5.719	−5.176
AGRIC	−7.029	<.01 ***	3	2005	−5.719	−5.176
FDI	−6.664	<.01 ***	3	1994	−5.719	−5.176
LNPOP	−2.273	>.99	3	1998	−5.719	−5.176
First Diff						
LNGDP	−4.665	.168	3	2001	−5.719	−5.176
LNEFP	−12.563	<.01 ***	3	2015	−5.719	−5.176
LNENERGY	−42.548	<.01***	3	2014	−5.719	−5.176
AGRIC	−6.164	<.01***	3	2002	−5.719	−5.176
FDI	−9.842	<.01***	3	1995	−5.719	−5.176
LNPOP	−6.212	<.01***	3	1990	−5.719	−5.176

Note: a: (*) significant at 10%; (**) significant at 5%; (***) significant at 1%.
Source: Authors computation.

TABLE 4 ARDL assessments of EFP equation

Variables	Coefficients	SE	*t*-Statistics	*p*-Value
Short-path				
D(LGDP)	0.000790	0.000153	5.158764	.0002***
D(FDI)	−0.015475	0.003551	−4.357413	.0009***
D(AGRIC)	−0.009023	0.002476	−3.644900	.0034***
D(LEU)	6.47E−05	3.86E−05	−1.675291	.1197
D(LPOP)	3.10E−07	6.31E−08	4.902289	.0004***
CointEq(−1)*	−0.422273	0.066489	−6.351053	.0000***
Long-path				
LGP	0.000790	0.000279	2.832	.0151**
FDI	−0.015475	0.006156	−2.513709	.0272**
AGRIC	−0.009023	0.004945	−1.824734	.0930**
LEU	6.47E−05	5.52E−05	−1.172695	.2637
LPOP	3.10E−07	9.69E−08	3.194203	.0077***
C	−0.572073	0.230592	−2.480890	.0289**
R^2	0.996568			
Adj. R^2	0.990275			
F statistics	158.371			
p value	.000000			
D. Watson	2.6			
Bound test (long-path)				
F statistics	4.75***	*K* = 5, @ 1%	I(0)bound = 3.41	I(1)bound = 4.68
t statistics	−6.4***	*K* = 5, @ 1%	I(0)bound = −3.4	I(1)bound = −4.8
Wald test (short-path)				
R^2	0.991947			
Adj^2	0.983894			
F statistics	123.2***			
p value	0.000			
Serial correlation test				
F statistics	2.745794			
R^2	12.40709			
p value	0.1120			
Heteroscedasticity test				
F statistics	0.2246			
R^2	0.2601			
p value	1.0000			

Note: *, **, ***Denotes rejection of the null hypothesis at the 1, 5 and 10%.
Source: Authors computation.

analyses. For this purpose, the current paper adopted the conventional approaches such as augmented Dickey–Fuller (ADF, 1979), Perron (1990), Kwiatkwoski–Philips–Schmidt–Shin (KPSS, 1992) towards the testing of unit root with, ADF structural break test. Structural break was added to the unit root test to uncover the shocks that are likely to impact on the stationarity of the variables which the conventional tests approaches may account as stationarity.

The findings of the unit root are displayed in Table 2 affirmed the stationarity and non-stationarity at level and first difference. This established a mixed order of integration in the data.

On the structural break test, the result as displayed in Table 3 uncovers shocks in the following years: 1990; 1994; 1995; 1998; 2001; 2002; 2005; 2013; 2014 and 2015. Notable shocks that took place in Nigeria were well accommodated and portrayed in the findings of the break result. Within the periods of 1990s and 2000s, the economic performance and growth of Nigeria have faced some notable shocks both from the policy and exogenous factors. Nigerian economic performance was trapped in the external debts and debt servicing shocks in 1993 and 1994 periods. These shocks brought setbacks to the economic performance of the country. Deregulation policy of the revealed years (1998; 2001; 2002; 2005; 2013) in the service and telecommunication sector brought about serious positive shock to the economy by attracting many foreign investors into the sector. Shocks from the energy and petroleum sector in the year 2011 and 2014 as a result militant disruption of oil explorations and global oil price shock equally brought about structural change. Because of the militants' activities predominantly in the region where oil explorations are carried out, the quantity of oil produced in that year was seriously affected coupled with the oil price shock of 2014. This constitute a structural shock to Nigerian economic performance and growth.

4.3 | ARDL-Bounds cointegraton test and diagnostic estimates

The outputs of both the ARDL Bounds/cointegration and the diagnostic tests are shown in Table 4. Both the R^2 and the adjusted R^2 are 0.996568 and 0.990275 respectively, and this suggests the goodness of the fit of the regression. This means that 99.7% approximately of the dependent variable is explained by the regressors (GDP, FDI, AGRIC, energy use and population). The rest of the variations in the model are accounted by the error term. The result shows that the value of Durbin Watson at 2.6 falls within the required, and accepted range for the determination of absence of autocorrelation. This shows the absence of autocorrelation problem in the model and estimation. With the diagnostic tests, the problems of heteroscedasticity and serial correlation are not detected in the model and estimation. The results of the CUSUM and CUSUM square with the blue lines inside the red lines show the stability and reliability of the model. Furthermore, both *F* stats and *T* stats of Bounds testing result at 1% shows the existence of cointegration and long run relationship among the variables. With the Akaike Information Criterion (AIC), optimal lag selection result is three which is considered the best lag for this analyses (Shahbaz, 2015). The speed of adjustment in the long run was confirmed with the error correction model at −0.4333 and highly significant at 1%. This shows existence of long run relationship and equilibrium amongst the variable and the ability to adjust and re-establish equilibrium at 43.3%. The results of the linear ARDL estimates are as follows: a positive (elasticity) link between income (GDP) and ecological footprint is established in both the short run and long run. This in line with a priori, and the fundamental theory of EKC which postulates environmental implication of a three-stage economic growth theory in developing economies. This finding means that Nigeria economic growth is accelerating at the detriment of the ecological surroundings. Hence, as economy is growing the environmental degradation is equally increasing. Numerically, a 1% increase in economic growth is expected to increase ecological footprint by 0.07% (0.000790). This is in agreement with the studies of Udemba (2019) for China; Udemba et al. (2019) for Indonesia; Udemba et al. (2020) for China; Jenny and Sara (2016) and Mesagan (2015) for Nigeria; Bello and Abimbola (2010) for Nigeria. An interesting finding which somewhat deviate from growth stimulus is established between FDI and the ecological footprint. Adverse and substantial connection is uncovered among FDI and ecological footprint. This is a controversial finding which contradict the expectation of the author. It is believed that FDI from the angle of oil based investment in the country is capable of inducing pollution and environmental decline, but the reverse is the case. In summary, this finding exposes pollution halo hypothesis (PHH) for the case of Nigeria, where Investments arrival enhances economy as well as impacts energy utilization, and abate ecological footprint in the host nation. This is a success trend for Nigeria. Numerically, a 1% increase in FDI is expected to reduce the ecological footprint by 1.5% (−0.015475). This finding supports the findings by Udemba et al. (2019) for the Indonesia; Bello and Abimbola (2010) for Nigeria; and Soysa and Neumayer (2004), He et al. (2006), Huang et al. (2019), and Tamazian et al. (2009), Asumadu-Sarkodie & Owusu, (2016), Omoregie (2019), Soysa & Neumayer (2004). Another interesting finding is the negative association between agricultural sector and ecological footprint in both long run and sort run. Quite interesting that the two focal variables (FDI and AGRIC) of testing the ecological footprint of Nigeria are both impacting favorably to the environmental performance of the country. This does not mean that there is no emission from the sector. It could be possible that the mode of agricultural operation in Nigeria is still well regulated, and there are no much heavy energy utilizing machines in agricultural operation in the country. Numerically, a 1% increase in agriculture will reduce the ecological footprint by 0.9% (−0.009023). This finding is in consonance with the findings of X. Liu et al. (2017) for ASEAN countries; Udemba et al. (2019) for Indonesia; and Demena and Afesorgbor (2019) and Haug and Ucal (2019). The findings from both the energy use and population are all positive. The relationship that exist between these variables (energy use and population) and ecological footprint remains positive which means unfavorable implication to the environmental performance. For the case of energy use, it is not significant both in the short run and long run, while that of population is highly significant even at 1%. This supposes the composition of the Nigerian economy as a developing economy with less high tech, and its engagement in energy utilization is low to compare with other developed nation. As for the case of population, the finding is in line with the feature of the country. Nigeria is the most populous nation in west African region with about 200 million populations, and above average of its population engage in farming and herder business capable of emitting pollution. The finding in energy use is in consonance with the findings of Udemba et al. (2020) for China; Udemba, 2019 for China; and Al-Mulali et al. (2015), Ozturk et al. (2016), and Bekun et al. (2019), while the findings for the population is in line with the findings of Ghanem (2018), Engelman (1995), Knapp and Mookerjee (1996), Shi (2001, 2003), Neumayer (2004), Gans and Jöst (2005), and Curran and de Sherbinin (2004) (Figures 4 and 5).

4.4 | Diagnostic tests (CUSUM and CUSUM of squares)

4.4.1 | Granger causality estimate

The author adopts Granger causality test in this study to mirror down the direct transmission and relationship amongst the

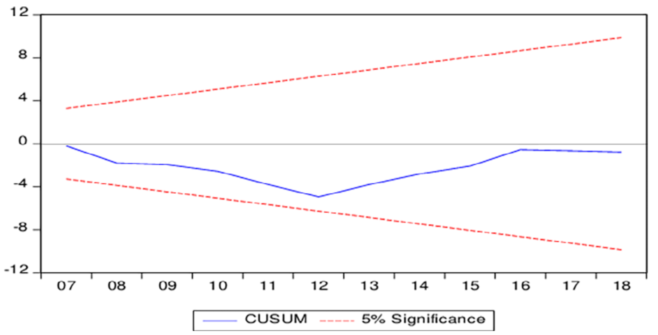

FIGURE 4 CUSUM residual graphical plot

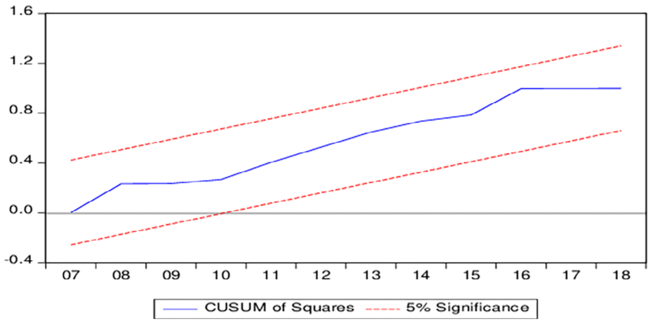

FIGURE 5 CUSUM square residual graphical plot

variables. The ARDL linear regression analyses have done well in establishing the associations amongst the variables, but not sufficient enough to portray the direct transmission between the variables. The regression deals with the dependence of one variable on other variables. It does not necessarily imply causality or the direction of the influence. For the purpose of direct impact and transmission, the current study adopts Granger causality and the estimate is shown at Table 5.

From the Granger causality output as portrayed in Table 5, it is observed that there is alignment between the findings from the regression estimates and the Granger causality findings. The good part of the Granger causality is the ability to determine the direction of the impact amongst the variables. Hence, there a uni-directional transmission passing from income (GDP) to ecological footprint, from energy use to ecological footprint and also from population to ecological footprint. These findings have this trend and implication from the regressors (GDP, energy use and population) to the dependent variable (ecological footprint). Furthermore, a one-way transmission is established amongst economic growth and energy use, and between economic growth and population. Thus, economic growth transmitting to energy use, while population is transiting to economic growth. This is in conformity with the expectations of the author, and has established a nexus among the selected variables (population and energy transmitting to economic growth, while economic growth and energy transmitting to ecological footprint). This finding is in line with

TABLE 5 Causality test

Null Hypothesis	Causality	*F* statistics	*p*	Remark Paths	Decision
EFP does not Granger cause GDP	YES	0.694	.5074	Uni-direction	REJECT H_0
GDP does not Granger cause EFP		8.810	.009***	GDP→EFP	
EU does not Granger cause EFP		10.81	2E−14***	Uni-direction	REJECT H_0
EFP does not Granger cause EU	YES	0.093	.9110	EU→EFP	
FDI does not Granger cause EFP		0.521	.599	Uni-direction	ACCEPT H_0
EFP does not Granger cause FDI	NO	0.558	.578	FDI≠EFP	
AGR does not Granger cause EFP		0.827	.447	Uni-direction	ACCEPT H_0
EFP does not Granger cause AGR	NO	0.192	.827	AGR≠EPP	
POP does not Granger cause EFP		3.524	.0418**	Uni-direction	
EFP does not Granger cause POP	YES	1.495	.2400	Pop→EPP;	REJECT H_0
EU does not Granger cause GDP		1.899	.167	Uni-direction	
GDP does not Granger cause EU	YES	2.900	.070*	GDP→EU;	REJECT H_0
FDI does not Granger cause GDP		0.95063	.3975	NEUTRAL	ACCEPT H_0
GDP does not Granger cause FDI	NO	1.53641	.2311	GDP≠FDI	
AGR does not Granger cause GDP		1.281	.2921	NEUTRA	
GDP does not Granger cause AGR	NO	0.76272	.4749	GDP≠AGR;	ACCEPT H_0
POP does not Granger cause GDP		10.7788	.0003***	NEUTRAL	
GDP does not Granger cause POP	YES	1.04943	.3622	Pop→GDP	REJECT H_0

Note: The statement under null hypothesis are all definition of hypothesis which will be valid or not based on the outcome of *p* value and expressed in the decision. The decision is made at 5%. The remark paths clearly show the direction of the causal effects (bi-directional or unidirectional).

*$p < .10$.

**$p < .05$.

***$p < .01$.

the finding from Udemba (2019) for China; Udemba et al. (2019) for Indonesia, and Udemba et al. (2020) for China.

5 | CONCLUSION AND POLICY RECOMMENDATION

The present study builds on the ecological footprint in accounting for environmental performance of Nigeria. The uniqueness of this study is the application of different approaches (*ARDL Bounds testing with structural break*) to expose the involvement of Nigeria in the emission production and reduction. The basic contribution of this paper is the utilization of ecological footprint based model to show the vivid state of environmental performance. This was complimented with Granger causality to throw more to implication of economic growth to the ecological performance of the country. This study unveils both the economic and ecological footprint implication to the environment. The findings of this study according to the linear ARDL regression are: a positive (elasticity) link between income (GDP) and ecological footprint is established in both the short run and long run. This in line with a priori, and the fundamental theory of EKC which postulates environmental implication of a three-stage economic growth theory in developing economies. Adverse and substantial link is uncovered among FDI and ecological footprint. This is a controversial finding which contradict the expectation of the author. Another interesting finding is the negative association between agricultural sector and ecological footprint in both long run and sort run. Quite interesting that the two focal variables (FDI and AGRIC) of testing the ecological footprint of Nigeria are both impacting favorably to the environmental performance of the country. The relationship that exist between these variables (energy use and population) and ecological footprint are positive which means unfavorable implication to the environmental performance. Moreover, the findings according to Granger causality are: a uni-directional transmission is passing from income (GDP) to ecological footprint, from energy use to ecological footprint, and also from population to ecological footprint. These findings have trend and implication from the regressors (GDP, energy use and population) to the dependent variable (ecological footprint). Furthermore, a one-way transmission is established amongst economic growth and energy use, and between economic growth and population. Thus, economic growth transmitting to energy use, while population is transiting to economic growth. This is in conformity with the expectations of the author, and has established a nexus among the selected variables (population and energy transmitting to economic growth, while economic growth and energy transmitting to ecological footprint). This finding is relevance to other African countries that are richly endowed with oil and are mostly into farming.

Having seen how agricultural sector and foreign direct investment inflows in Nigeria economic can be of great help in curtailing ecological footprint with reference to ARDL findings, it will be logical for the authorities of the country to build a sustainable policy framework in promoting, regulating and sustaining the trend with mindset of maintaining a healthy environment. Also, from our findings, energy use can be seen having double implications towards ecological footprint and economic growth, policies that will see to the moderation and sustainable energy should be framed. Such policies that are anchored on advocate for cleaner energy consumption (e.g., adoption of renewable energy such as solar, hydropower, geothermal and wind energy) should be promoted. Lastly, activities from the Nigeria petroleum industry should be guarded and regulated and monitored by the authorities so as to moderate the emission rate into the environment.

COMPLIANCE WITH ETHICAL STANDARDS

The author wishes to disclose here that there are no potential conflicts of interest at any level of this study.

ORCID

Edmund Ntom Udemba https://orcid.org/0000-0003-4191-0767

REFERENCES

Afesorgbor, S. K., & Demena, B. A. (2019). The effect of FDI on environmental emissions: Evidence from a meta-analysis. *Energy Policy*, 111192.

Ajide, K. B., & Adeniyi, O. (2010). FDI and the environment in developing economies: Evidence from Nigeria. *Environmental Research Journal*, *4* (4), 291–297.

Al-Mulali, U., Saboori, B., & Ozturk, I. (2015). Investigating the environmental Kuznets curve hypothesis in Vietnam. *Energy Policy*, *76*, 123–131.

Anaman, K. A., Twerefou, D. K., & Appiah-Konadu, P. (2015). Impact of international trade on the quality of the natural environment: A case study of Ghana from 1970 to 2010.

Asumadu-Sarkodie, S., & Owusu, P. A. (2016). Carbon dioxide emissions, GDP, energy use, and population growth: A multivariate and causality analysis for Ghana, 1971–2013. *Environmental Science and Pollution Research*, *23*(13), 13508–13520.

Asumadu-Sarkodie, S., & Owusu, P. A. (2016). Multivariate co-integration analysis of the Kaya factors in Ghana. *Environmental Science and Pollution Research*, *23*(10), 9934–9943.

Bakhsh, K., Rose, S., Ali, M. F., Ahmad, N., & Shahbaz, M. (2017). Economic growth, CO_2 emissions, renewable waste and FDI relation in Pakistan: New evidences from 3SLS. *Journal of Environmental Management*, *196*, 627–632.

Balsalobre-Lorente, D., Shahbaz, M., Roubaud, D., & Farhani, S. (2018). How economic growth, renewable electricity and natural resources contribute to CO_2 emissions? *Energy Policy*, *113*, 356–367.

Behera, S. R., & Dash, D. P. (2017). The effect of urbanization, energy consumption, and foreign direct investment on the carbon dioxide emission in the SSEA (south and southeast Asian) region. *Renewable and Sustainable Energy Reviews*, *70*, 96–106.

Bekun, F. V., Alola, A. A., & Sarkodie, S. A. (2019). Toward a sustainable environment: Nexus between CO_2 emissions, resource rent, renewable and nonrenewable energy in 16-EU countries. *Science of the Total Environment*, *657*, 1023–1029.

Bello, A. K., & Abimbola, O. M. (2010). Does the level of economic growth influence environmental quality in Nigeria: A test of environmental Kuznets curve (EKC) hypothesis. *Pakistan Journal of Social Sciences*, *7* (4), 325–329.

Bello, M. O., Solarin, S. A., & Yen, Y. Y. (2018). The impact of electricity consumption on CO_2 emission, carbon footprint, water footprint and ecological footprint: The role of hydropower in an emerging economy. *Journal of Environmental Management*, *219*, 218–230.

Ben Kheder, S., & Zugravu-Soilita, N. (2008). *The pollution haven hypothesis: a geographic economy model in a comparative study*.

Cederborg, J., & Snöbohm, S. (2016). *Is there a relationship between economic growth and carbon dioxide emissions?*

Charnovitz, S. (2010). Trade and climate change: A report by the United Nations environment programme and the World Trade Organization by UNEP and the WTOGeneva: WTO, 2009. *World Trade Review*, *9*(1), 273–281.

Cheng, S. C., Wu, T. P., Lee, K. C., & Chang, T. (2014). Flexible Fourier unit root test of unemployment for PIIGS countries. *Economic Modelling*, *36*, 142–148.

Curran, S. R., & de Sherbinin, A. (2004). Completing the picture: The challenges of bringing "consumption" into the population–environment equation. *Population and Environment*, *26*(2), 107–131.

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association*, *74*(366a), 427–431.

Dogan, N. (2016). Agriculture and environmental Kuznets curves in the case of Turkey: Evidence from the ARDL and bounds test. *Agricultural Economics*, *62*(12), 566–574.

Engelman, R. (1995). Imagining a stabilized atmosphere: Population and consumption interactions in greenhouse gas emissions. *The Journal of Environment & Development*, *4*(1), 111–140.

Fahri, J., Biesenthal, C., Pollack, J., & Sankaran, S. (2015). Understanding megaproject success beyond the project close-out stage. *Construction Economics and Building*, *15*(3), 48–58.

Galli, A. (2015). On the rationale and policy usefulness of ecological footprint accounting: The case of Morocco. *Environmental Science & Policy*, *48*, 210–224.

Gans, O., & Jöst, F. (2005). *Decomposing the impact of population growth on environmental deterioration: Some critical comments on a widespread method in ecological economics* (no. 422). Discussion Paper Series.

Ghanem, S. K. (2018). The relationship between population and the environment and its impact on sustainable development in Egypt using a multi-equation model. *Environment, Development and Sustainability*, *20*(1), 305–342.

Grossman, G. M., & Krueger, A. B. (1991). *Environmental impacts of a North American free trade agreement (No. w3914)*. National Bureau of Economic Research.

Haug, A. A., & Ucal, M. (2019). The role of trade and FDI for CO_2 emissions in Turkey: Nonlinear relationships. *Energy Economics*, *81*, 297–307.

He, J., Chen, H. P., & Bi, G. B. (2006). An endogenous growth model based on product-adding innovations and human capital. *The Journal of Quantitative & Technical Economics*, *23*, 127–136.

Huang, Y., Chen, X., Zhu, H., Huang, C., & Tian, Z. (2019). The heterogeneous effects of FDI and foreign trade on CO_2 emissions: Evidence from China. *Mathematical Problems in Engineering*, *2019*, 1–14.

Katircioğlu, S., & Katircioğlu, S. (2018). Testing the role of urban development in the conventional environmental Kuznets curve: Evidence from Turkey. *Applied Economics Letters*, *25*(11), 741–746.

Knapp, T., & Mookerjee, R. (1996). Population growth and global CO_2 emissions: A secular perspective. *Energy Policy*, *24*(1), 31–37.

Komen, M. H., Gerking, S., & Folmer, H. (1997). Income and environmental R&D: Empirical evidence from OECD countries. *Environment and Development Economics*, *2*(4), 505–515.

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics*, *54*(1–3), 159–178.

Liu, M., Huang, Y., Ma, Z., Jin, Z., Liu, X., Wang, H., … Kinney, P. L. (2017). Spatial and temporal trends in the mortality burden of air pollution in China: 2004–2012. *Environment International*, *98*, 75–81.

Liu, X., Zhang, S., & Bae, J. (2017). The impact of renewable energy and agriculture on carbon dioxide emissions: Investigating the environmental Kuznets curve in four selected ASEAN countries. *Journal of Cleaner Production*, *164*, 1239–1247.

MacLean, D. A., & MacKinnon, W. E. (1996). Accuracy of aerial sketch-mapping estimates of spruce budworm defoliation in New Brunswick. *Canadian Journal of Forest Research*, *26*(12), 2099–2108.

Mesagan, E. P. (2015). Economic growth and carbon emission in Nigeria. *The IUP Journal of Applied Economics*, *14*(4), 61–75.

Network, G. F. (2018). Country trends. dataset, available at: http://data.footprintnetwork.org/#/countryTrends.

Network, G. F. (2018). *Global Footprint Network*, Advancing the Science of Sustainability.

Neumayer, E. (2004). National carbon dioxide emissions: Geography matters. *Area*, *36*(1), 33–40.

Nigeria. National Bureau of Statistics. (2007). National Account of Nigeria 1981-2006. National Bureau of Statistics.

Omoregie, U. (2015). A developing country's absorptive capacity: the link between FDI and economic growth in Nigeria. *Open Access Library Journal*, *2*(11), 1.

Omoregie, U. (2019). Nigeria's petroleum sector and GDP: The missing oil refining link. *Journal of Advances in Economics and Finance*, *4*(4).

Omri, A. (2013). CO_2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics*, *40*, 657–664.

Ozcan, B., Ulucak, R., & Dogan, E. (2019). Analyzing long lasting effects of environmental policies: Evidence from low, middle and high income economies. *Sustainable Cities and Society*, *44*, 130–143.

Ozturk, I., Al-Mulali, U., & Saboori, B. (2016). Investigating the environmental Kuznets curve hypothesis: The role of tourism and ecological footprint. *Environmental Science and Pollution Research*, *23*(2), 1916–1928.

Panayotou, T. (1997). Demystifying the environmental Kuznets curve: Turning a black box into a policy tool. *Environment and Development Economics*, *2*(4), 465–484.

Pazienza, P. (2015). The relationship between CO_2 and foreign direct investment in the agriculture and fishing sector of OECD countries: Evidence and policy considerations. *Intelektinė Ekonomika*, *9*(1), 55–66.

Perron, P. (1990). Testing for a unit root in a time series with a changing mean. *Journal of Business & Economic Statistics*, *8*(2), 153–162.

Pesaran, M. H., & Shin, Y. (1998). An autoregressive distributed-lag modelling approach to cointegration analysis. *Econometric Society Monographs*, *31*, 371–413.

Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326.

Ramanathan, R. (2006). ABC inventory classification with multiple-criteria using weighted linear optimization. *Computers & Operations Research*, *33*(3), 695–700.

Sbci, U. N. E. P. (2009). Buildings and climate change: summary for decision-makers. *United Nations Environmental Programme, Sustainable Buildings and Climate Initiative, Paris*, 1–62.

Sarkodie, S. A., & Strezov, V. (2019). Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries. *Science of the Total Environment*, *646*, 862–871.

Shafik, N., & Bandyopadhyay, S. (1992). *Economic growth and environmental quality: Time-series and cross-country evidence* (Vol. 904). World Bank Publications.

Shahbaz, M. (2015). Electricity consumption, financial development and economic growth nexus in Pakistan: a visit. *Bulletin of Energy Economics (BEE)*, *3*(2), 48–65.

Shahbaz, M., Balsalobre-Lorente, D., & Sinha, A. (2019). Foreign direct investment–CO_2 emissions nexus in Middle East and north African countries: Importance of biomass energy consumption. *Journal of Cleaner Production*, *217*, 603–614.

Shi, A. (2001, August). Population growth and global carbon dioxide emissions. In *IUSSP conference in Brazil/session-s09*.

Shi, A. (2003). The impact of population pressure on global carbon dioxide emissions, 1975–1996: Evidence from pooled cross-country data. *Ecological Economics*, *44*(1), 29–42.

Solarin, S. A., & Bello, M. O. (2018). Persistence of policy shocks to an environmental degradation index: The case of ecological footprint in

128 developed and developing countries. *Ecological Indicators*, *89*, 35–44.
Soysa, I. D., & Neumayer, E. (2004). False prophet, or genuine savior? In *Assessing the effects of economic openness on sustainable development, 1980–1999*. International Trade.
Talukdar, D., & Meisner, C. M. (2001). Does the private sector help or hurt the environment? Evidence from carbon dioxide pollution in developing countries. *World Development*, *29*(5), 827–840.
Tamazian, A., Chousa, J. P., & Vadlamannati, K. C. (2009). Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. *Energy Policy*, *37*(1), 246–253.
Twerefou, D. K., Appiah-Konadu, P., & Anaman, KA. (2015). *Impact of international trade on the quality of the natural environment: a case study of Ghana from 1970 to 2010*.
Udemba, E. N. (2019). Triangular nexus between foreign direct investment, international tourism, and energy consumption in the Chinese economy: Accounting for environmental quality. *Environmental Science and Pollution Research*, *26*(24), 24819–24830.
Udemba, E. N., Güngör, H., & Bekun, F. V. (2019). Environmental implication of offshore economic activities in Indonesia: A dual analyses of cointegration and causality. *Environmental Science and Pollution Research*, *26*(31), 32460–32475.
Udemba, E. N., Magazzino, C., & Bekun, F. V. (2020). Modeling the nexus between pollutant emission, energy consumption, foreign direct investment, and economic growth: New insights from China. *Environmental Science and Pollution Research*, 1–12.
Ullah, A., Khan, D., Khan, I., & Zheng, S. (2018). Does agricultural ecosystem cause environmental pollution in Pakistan? Promise and menace. *Environmental Science and Pollution Research*, *25*(14), 13938–13955.
Ulucak, R., & Lin, D. (2017). Persistence of policy shocks to ecological footprint of the USA. *Ecological Indicators*, *80*, 337–343.
Valentini, R., Arneth, A., Bombelli, A., Castaldi, S., Cazzolla Gatti, R., Chevallier, F., … Houghton, R. A. (2013). The full greenhouse gases budget of Africa: Synthesis, uncertainties and vulnerabilities. *Biogeosciences Discussions*, *10*(8343), 8413.
Vukina, T., Beghin, J. C., & Solakoglu, E. G. (1999). Transition to markets and the environment: Effects of the change in the composition of manufacturing output. *Environment and Development Economics*, *4*(4), 582–598.
Wackernagel, M., Onisto, L., Bello, P., Linares, A. C., Falfán, I. S. L., García, J. M., … Guerrero, M. G. S. (1999). National natural capital accounting with the ecological footprint concept. *Ecological Economics*, *29*(3), 375–390.
Wagner, J. (2008). Exports, imports, and productivity at the firm level. An international perspective: Introduction by guest editors. *Review of World Economics/Weltwirtschaftliches Archiv*, *144*, 591–595.
WDI, T. (2019). World development indicators (DataBank).
Yilanci, V., Gorus, M. S., & Aydin, M. (2019). Are shocks to ecological footprint in OECD countries permanent or temporary? *Journal of Cleaner Production*, *212*, 270–301.

AUTHOR BIOGRAPHY

Edmund Ntom Udemba is an Assistant Professor at the Faculty of Economics Administrative and social science, Istanbul Gelisim University, Istanbul Turkey. He earned a B.Sc. degree in Economics from Enugu state University in Nigeria. He also has both Masters and Doctorate degrees in Economics from Eastern Mediterranean University, Turkey. He has published several research articles in reputable international academic journals. His areas of interest include Macroeconomics, International Trade and Economics, Energy and Environmental Economics.

How to cite this article: Udemba EN. Moderation of ecological footprint with FDI and agricultural sector for a better environmental performance: New insight from Nigeria. *J Public Affairs*. 2022;22:e2444. https://doi.org/10.1002/pa.2444