Impacts of globalization and energy consumption on environmental degradation: what is the way forward to achieving environmental sustainability targets in Nigeria?

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Abstract
One of the major problems the world is currently facing is climate change. This is due to the use of fossil fuel combustion, which increases the presence of CO2 emissions and other greenhouse gases in the atmosphere in several countries of the world, which Nigeria is not exempted from. Against this background, this study examines the impacts of globalization, real income, urbanization, and energy consumption on environmental degradation; and proffer way forward to achieving environmental sustainability targets in Nigeria, using quarterly frequency time series data over a period 1971–2018. To achieve our study objectives, this study makes use of quantile-quantile (Q-Q) approach, developed by Sim and Zhou J Bank Financ 55:1–8, (2015). This approach groups together non-parametric estimation and quantile regression. Empirical results show that, in all quantiles, globalization, real income, urbanization, and energy consumption impact positively on environmental degradation. Thus, we are of the opinion that for the nation to achieve any meaningful environmental sustainability targets, (i) it must shift from economic activities that are dependent and driven by non-renewable energy sources; (ii) enact environmental laws and regulations that prevent indigenous and multinationals firms from using non-renewable energy sources in production activities; (iii) discourage rural-urban migration by enacting policies that would improve life in the rural areas, such as diverting investment of indigenous and multinational companies to be situated in the rural areas; and lastly, (iv) learn from jurisdictional experiences that have successfully replaces non-renewable energy sources with renewable ones for an overall economic growth and environmental sustainability targets for both the immediate and future generations.

Keywords Environmental degradation · Globalization · Economic growth · Urbanization · Energy consumption · Quantile-on-quantile regression · Nigeria

Introduction
The goal of many nations is to increase economic growth through increased output, experience a low and stable inflation rate, increase the standard of living and maintain a favourable balance of payment. However, the environment plays a key role...
in achieving these goals as the production of goods and services, climate changes and flooding in recent years have been the foremost causes of low output especially in the agricultural sector and Nigeria is not exempted from these environmental challenges (Adebayo 2022; Ayindea et al. 2011).

Rapid environmental degradation are not natural occurrence but are borne by human activities like urbanization, globalization and energy consumption. In most nations, urbanization is accompanied with strong real income growth, the agglomeration of secondary and tertiary industries in urban areas and population migration from rural to urban regions, all of which contribute to increased carbon emissions. The global urban population is estimated to be 1.52 billion in 1970 and grows to 4.6 billion people by 2030 and a large part of this will be in Asian and African cities (Yazdi and Dariani 2019). Similarly, according to Mabogunje (2002) in 1950s, urban centres represent less than 15 per cent of the population in Nigeria and rose to 23.4 per cent and 43.3 per cent in 1975 and 2000 respectively, having an annual urban population rate of 4.8 per cent. Several empirical studies have used urbanization as a factor of economic degradation and carbon emissions (Wu et al. 2016; Gasimli et al. 2019) this is because of the high movement of people in the urban areas and consumption of high-energy intensive goods. As a result of the switch in economic activity and changes in the population’s behavioural patterns after migration from rural to urban regions, the process of urbanization impacts the environment by changing the levels of polluting emissions. This shows that the significance of the relationship between urbanization, globalization energy consumption, and environmental degradation varies across each country based on their levels of real income and development. In recent decades, through global economic and social development, attention has been drawn to the negative ecological and environmental consequences of urbanization. In addition to impacting the development of real income, health, education, and socialization of the populace, urbanization also affects environmental protection and remediation, along with the exploitation of natural resources through energy consumption. (Srinivasan 2017).

Globalization is without a doubt, a positive phenomenon in the present-day society, as it helps to enhance economic growth and development; however, it creates negative externality some of which are ecological contamination and environmental degradation Saint Akadiri et al. 2019a, b; Akadiri et al. 2021; Uzuner et al. 2020; Shahzadi et al. 2019). In the epoch of globalization, countries enhance their interdependence through international trade, capital flow, migration pattern and spread of technology. Globalization has, therefore, generated an increasing level of interdependence among several economies both of developing and developed status. This, however, translates that environmentally hazardous goods and pollution-intensive industries can easily concentrate more in the nation with little environmental laws and policies, which are found in developing countries. Karataş (2016) posited that globalization, a concept synonymous with raising international trade has advanced the development of goods, which has an undesirable and significant side effect on the environment. Some of this effect in Nigeria is evident in the Niger Delta region, dominated by multinational corporations due to its abundance of oil both offshore and onshore. Despite the region’s natural wealth and vital contribution to the sustenance of the Nigerian government, the Niger Delta region is still home to Africa’s poorest people and worst environmental destructions (Austine et al. 2014). Additionally, the multinational corporations have been associated with continuous environmental harm on the host nation, most especially oil-producing countries without adequate punishment or compensation like in Nigeria hence, the need to understand the relationship between globalization and environmental degradation.

Similarly, Alege et al. (2016) posited that in the current modern era, a large amount of the world’s energy consumption needs is met through fossil fuel, thus, the increase in global trade has led to high CO2 emissions. In Nigeria, due to poor infrastructure evident from the low electricity supply, fossil fuel consumption remains remarkably high and eminent in the country. According to Yusuf (2014) over 170 million Nigerians ration between 3000 MW to 6000 MW of electricity supply, while in countries like Libya, with a population of 5.5 million generate about 4600 MW. This is the reason Nigerians turn to fossil fuel as an alternative source of energy regardless of the environmental implication of CO2 emitted through such alternative. According to the World Bank database, in 2000 only 43% of the population had access to electricity while in 2018, the number rose by 10.5 to 56.5% of the population. Similarly, in 2000, CO2 emissions from fossil fuel consumption in the country contributes about 0.009 per cent of total CO2 emissions, however, the value increased by more than 1000 per cent to 0.1 in 2016 indicating a substantial increase from fossil fuels. This illustrates the unchecked state of the country’s environment with an increasing number of multinational corporations’ environmental damage, oil spillage, flooding, deforestations, and the likes, it is not long before the country’s ecosystem becomes inhabitable for the Nigerian citizens. With this in mind, it is also pertinent to understand how energy consumption, in the midst of raising income, globalization and urbanization affects environmental degradation in Nigeria, thus the study draws motivation from this.

There is literature evidence to suggest that existing studies have examined the relationship between the variables of interest in other developing and developed countries of the world (Shahzadi et al. 2019; Alam 2010; Karatay 2016; Nwagbara et al. 2012; Uzuner et al. 2020; Destek and Oszoy 2015), however, little study exist that focus on Nigeria. Despite the
existence of literature studying the relationship between globalization and environmental degradation (Austine et al. 2014; Adesina 2012) or energy consumption and environmental degradation (Yahaya et al. 2019; Alege et al. 2016; Yusuf, 2014; Musa and Maijama’ a 2020; Aiyetan and Olomola 2013), investigating the nexus between globalization, real income, urbanization and energy consumption on environmental degradation in Nigeria remains a gap in the literature that this study intends to fill.

This study has the following contributions: methodologically, a gap exists in studying the relationship between the variables using quantile-on-quantile (Q-Q) approach most especially for Nigeria. The quantile-on-quantile (Q-Q) approach by Sim and Zhou (2015) is suitable because it takes into consideration low, median, and high quantiles of the variables involved. The result of this study provide insight for government, non-governmental organizations (NGOs) and private entities concerned about the environmental situation of the nation and help understand the interconnectedness of these variables when formulating environmental policies. Empirically, results show that in all quantiles, globalization, real income, urbanization and energy consumption impact positively on environmental degradation. Thus, we are of the opinion that, for the nation to achieve any meaningful environmental sustainability targets, (i) shift from economic activities that are dependent and driven by non-renewable energy; (ii) environmental laws and regulations that prevent indigenous and multinationals firms from using non-renewable energy sources in production activities should be put in place; (iii) government should discourage rural-urban migration by enacting policies that would improve life in the rural areas, such as diverting investment of indigenous and multinational companies to be situated in the rural areas; and lastly (iv) policymakers in Nigeria, should learn from jurisdictional experiences that have successfully replaces non-renewable energy sources with renewable ones for an overall economic and environmental sustainability target for both the immediate and future generations.

The rest of the paper is categorized as follows: the “Literature review” section discusses the literature review, while the “Material, theoretical framework and methods” section includes data and method of analysis of the study. Thereafter, the “Results and discussion of findings” section discusses the result while the “Conclusion and policy suggestions” section entails the conclusion and recommendations.

**Literature review**

The greatest challenge the world is faced with today is environmental degradation. The main factor that causes environmental degradation is CO2 emission, which is caused by an increase in the use of energy.

**Energy consumption, CO2 emissions and economic growth**

According to Menyah and Wolde-Rufael (2010) and Bowden and Payne (2009), the use of energy is vital for achieving economic growth. Rahman (2017) and Hossain (2012) further established a direct nexus between CO2 emission and economic growth, which is due to the fact that output growth requires more energy consumption which causes CO2 emission. Khan et al. (2019a) found that energy consumption and economic growth have a positive impact on environmental degradation in Pakistan both in the long and short-run.

The studies by Oh and Lee (2004), Chang 2010 and Solarin et al. (2016) found a bi-directional causality between energy consumption and economic growth. While Chang and Wong (2001), and Ozturk and Acaravci (2010) found uni-directional causality from economic growth to energy consumption. However, Cheng (1995), Cowan et al. (2014), and Rahman and Mamun (2016), found no relationship between energy consumption and economic growth. The relationship between economic growth and CO2 emission tests the validity of the well-known Environmental Kuznet Curve (EKC) hypothesis, which explains the nexus between these two variables as a non-linear inverted U-shaped curve. According to the EKC, a positive nexus exists between these two variables at early stage of development initial, and after achieving a certain level of growth, CO2 emission falls with the increase in GDP growth, as the country can afford the efficient technologies. Akbostanci et al. (2009) and Ozokcu and Ozdemir (2017) tested this hypothesis and confirmed the existence of a positive long-run nexus between CO2 emission and economic growth.

Khan et al. (2020) examined the nexus between energy consumption, economic growth and CO2 emissions in Pakistan. The results indicated that energy consumption and economic growth increase CO2 emission in both the short and long-run. Furthermore, Khan et al. (2021) showed that energy consumption positively impacts CO2 emissions in 184 countries. However, most studies that tested this hypothesis supported the existence of the EKC such as Rahman (2017, 2020), Ertegrul et al. (2016), and Kasman and Duman (2015) among others. Furthermore, Apergis and Payne (2011), Hossain (2012), Shahbaz et al. (2013), Kasman and Duman (2015), Uddin et al. (2016), and Rahman and Kashem (2017) demonstrated causality from economic growth to energy consumption and CO2 emission. In contrast, Soytas and Sari (2009), Ghosh (2010), and Lean and Smyth (2010) found a uni-directional causality from energy consumption and CO2 emissions to economic growth.
Globalization, urbanization and environmental degradation

With enhanced globalization and industrialization, the global output is continuously growing. The integration of individual economies with the global economy in terms of trade, capital mobility and other socio-economic and political aspects is termed Globalization. Globalization could affect the quality of the environment through various channels. Shahbaz et al. (2017) argued that globalization is connected with several environmental problems. Many environmentalists are of the view that globalization increases global demand for goods and services which in turn increase economic activities and output. This results to the depletion of natural resources as well as environmental degradation. Lee and Min (2014), Dogan and Turkekul (2016) and Shahbaz et al. (2016) found positive effects of globalization on the environment. In addition, Sharif et al. (2020) found that globalization exerts negative environmental externalities. Furthermore, the analysis of Khan et al. (2019b) shows that political, social and economic globalization index have positive impact on CO₂ emissions while urbanization has a negative impact on CO₂ emission. However, Rahman (2020), and Dogan and Deger (2016) found a significant negative impact of globalization on CO₂ emission and emphasised that environmental quality can be improved with the transfer of technologies that are friendly to the environment, aided by globalization. Islam et al. (2021) also found a negative effect of globalization on CO₂ emissions which implies an improvement in the quality of the environment while urbanization has a positive impact on CO₂ emission both in the short and long-run.

This clearly shows a lack of consensus among researchers regarding the nexus between the interested variables and to the best of our knowledge, most studies that explain the relationship between some of the interested variables in Nigeria, mainly provided nexus between energy consumption and economic growth (see Omotor 2008; Odulari and Okonkwo 2009; Akpan and Akpan 2012; Olusanya 2012; Onakoya et al. 2013; Oyedepo 2013; Ogudipe and Apatia 2013; and Chindo et al. 2014). Therefore, this study will provide further evidence using a robust methodology and improved data with the inclusion of the variable “globalization” to investigate the case for Nigeria and thus, effectively enrich the ongoing debate/literature on sustainable environment for policy makers.

Material, theoretical framework and methods

Data

The study employed quarterly frequency data covering the period 1961–2019 for Nigeria. The variables used in this study are CO₂ emission, economic growth, globalisation, energy consumption and urbanization. To obtain return series, the variables employed were transformed into logarithmic difference series to create comparable empirical findings (Battacharya et al. 2016). We sourced data for this current study from World Development Indicator online database.

Theoretical framework

Several factors that influence CO₂ emissions are recorded by prior studies, notably are (Akinsola et al. 2021; Ahmed and Le 2021; Udembas et al. 2021; Kraft and Kraft 1978; Sarkodie and Strezov 2019). Therefore, it is imperative to note, that the tremendous growth in the world economy in the last 40 years comprise a significant increase in the use of energy. This has caused Grossman and Krueger (1991), Panayotou (1997) and other famous economists specialized in the field of environment, in their various studies to examine the interactions among economic expansion environmental deterioration. In accordance with their studies, they suggested that the growth and emission interrelationship can be classified into 3 distinct stages (the composite, the scale and procedure effects). First, the scale effect stage is linked to emerging economies (mostly low-income nations). Here, it is believed that, the use of fossil (nonrenewable energy) fuels enhance economic growth. At this stage, these countries pay little or no attention to the sustainability of the environmental degradation, causing the environment to suffer in the preliminary junctures of economic growth till it achieves a specific threshold, leading to a turning point where economic expansion will escalate environment quality. Second, the composite effect juncture appears to be related with the industrialized nations of the world, where economies are in the know of the cost and implication of environmental dilapidation (industrial economies). The technical effect juncture appears to be a stage, where economies of the world transit from industrial to service sector-based economies (see Adebayo and Rjoub 2021; Kirikkaleli and Adebayo 2021; Solarin et al. 2021).

Globalization is seen as one of the major factors that affect environmental degradation. The consequences associated to increase in energy consumption is a result of globalized economies. Progress in globalization leads to a fall in trade barriers, which increases a nation’s revenue and output. To Kirikkaleli et al. (2021) recent patterns of globalization has led to various environmental worries, coupled with ozone layers depletion, deforestation and overutilization of assets. Integration of the world economies via globalization boosts economic activity, increase energy usage, and hence emissions per capita level. Globalization can induce clean environment, and improve environmental quality, if green
technologies are put in place (Adebayo et al. 2021; Ahmed et al. 2019).

In addition, interactions amid urbanization and economic expansion influence electricity consumption via many ways. For an instance, growth surges households purchasing power for making use of energy-efficient electrical machines. This impact on electricity consumption (Ozturk 2010). Urbanization on the other hand, is one of the key spectacles of development (Jones 1991). It touches the social and urban structure of a nation. Also, its impacts is felt via population migration, intensification of the industrial and service activities (Duan et al. 2008; Liu 2009; Xie et al. 2009) transport network extension and on the development of public conveniences; which includes education, health, among others for urban dwellers.

Lastly, theoretical framework explained above, would allows us to picture statistically the effects of globalization, urbanization, energy usage and economic growth on environmental degradation. We specify the relationship among the series as follows:

\[ \text{CO}_2 = f \left( \text{GDP}_t, \text{GLO}_t, \text{URB}_t, \text{EC}_t \right) \]

here GDP, GLO, URB, EC and CO₂ emissions are economic growth, globalization, urbanization, energy consumption and CO₂ emissions. To minimize skewness, the natural logarithm of the variables was taken.

Methodology

Unit root test

To determine the order of integration of variables, the Augmented Dickey-Fuller (ADF) (Dicky and Fuller 1979) and Phillips-Perron (PP) (Phillips and Perron 1988) root tests were used.

Q-Q regression

This study employs the quantile-on-quantile (Q-Q) regression approach which is renowned for analysing the relationship between the various variables outside the mean of the data. Sim and Zhou (2015) pioneered the Q-Q technique, which combines nonparametric estimation and quantile regression. This, however, was contrary to the quantile regression approach introduced by Koenker and Bassett Jr (1978) and can be viewed as an addition to the basic simple linear regression model, it, therefore, gives an additional inclusive description of the associations among variables. Also, to evaluate the impact of a regressor on various quantiles of the dependent variable, the researchers utilized a traditional quantile regression model as an enhancement to the traditional least-squares method. The quantile regression investigates the impact of a variable not only on the conditional mean of the dependent variable but also on its quantiles and this provides a more complete connection as opposed to the least square approach. Furthermore, Cleveland (1979) and Stone (1977) suggested traditional linear regression is used to examine the impact of the precise quantile of the regressor variable on the regressand variable. Thus, to investigate the effect of different quantiles of the explanatory variable on different quantiles of the dependent variable, researchers can combine standard quantile regression with classic linear regression. The combination of these two techniques (linear regression and quantile regression) will improve the result of the model and help understand the relationship among the variables better.

To analyze the broad relationship between CO₂ emission and economic growth, energy consumption, globalisation, and urbanization in Nigeria, a Q-Q approach is used which was adapted from the conventional quantile regression. Therefore, the nonparametric quantile regression model was employed to investigate the influence of different quantiles of X on the various quantile of Y. The model is expressed as follows:

\[ Y_t = Y^\theta(X_t) + \varepsilon_t^\theta \] (1)

Where \( Y_t \) explains the dependent variables in period t and \( X_t \) represents the independent variables in time t. \( \theta \) is the \( \theta \)th quantile on the distribution of X. Additionally, \( \varepsilon_t^\theta \) represents quantile error term, where estimated \( \theta \)th quantile is equal to zero. Furthermore, \( \alpha^\theta(.) \) is unknown since there is no link function. However, under the standard regularity conditions on the link function \( \alpha^\theta(.) \) [see Sim and Zhou (2015)]. In addition, bandwidth selection is important when a nonparametric analysis is being done because it helps to simplify the target point and shifts the outcome’s speed. If the bandwidth \( ‘h’ \) is wide, the variance will decrease while the estimate deviation would decrease and vice versa. This study thus utilized a bandwidth value of \( h = 0.05 \) as recommended by Sim and Zhou (2015).

Results and discussion of findings

Pre-estimation tests

The study commenced by presenting brief variables summary which is presented in Table 1. The mean of GDP is the highest which is accompanied by energy utilisation (EC), globalization (GLO), urbanization (URB) and CO₂ emissions (CO₂) respectively. CO₂ emissions has more consistent score which is followed by GLO, URB, EC and GDP. Moreover, CO₂ and EC are skewed negatively whereas GFP, GLO and URB are skewed positively. All the variables-GDP,
GLO, EC, URB and CO₂ are leptourtic. Furthermore, all the series align with normal distribution. The stationarity outcomes is also depicted in Table 1 and outcomes disclosed that all the parameters are I(1). It is vital to understand the series nonlinearity feaures before further analysis. In doing so, we utilised BDS test to identify the nonlinearity attribute of the variables of research. The BDS result is depicted in Table 2 and the outcomes disclosed that the null hypothesis of "no linearity" cannot be rejected. Thus, utilising linear approaches such as ARDL, FMOLS, DOLS, CCR, VECM and OLS will produces misleading outcomes. Centered on this knowledge, we applied nonlinear techniques—quantile regression, quantile-on-quantile regression, and quantile causality techniques to assess the URB, GDP, EC, and GLO influence on CO₂ emissions in Nigeria.

**QQR outcomes**

This portion of the current research explores the influence of globalization, economic growth, and urbanization and energy consumption on CO₂ emissions at different quantiles. Figure 1 (a–d) outlined the outcomes of the QQR. The economic growth (GDP) influence on CO₂ emissions is illustrated by Fig. 1a and the findings revealed the followings: in all tails (0.1–0.90) of both GDP and CO₂ emissions a positive effect of GDP on CO₂ emissions is observed. However, in the lower tail (0.1–0.35) of both GDP and CO₂ emissions, the positive GDP effect on CO₂ is more pronounced. This implies that economic expansion in Nigeria triggers CO₂ emissions which result in environmental degradation. This empirical outcome is expected given the fact that the most of emerging nations that Nigeria is also part of favors continuous economic expansion. Therefore, Nigeria favors pro-growth initiatives at the expense of a sustainable environment. This result relates to the basic problem of the growth-growth paradox, which is discussed in UNESCAP (2019) report. Therefore, achieving SDG goals will be difficult for Nigeria due to its pro-growth initiatives. The positive effect of GDP on CO₂ is confirmed by the studies of Adebayo et al. (2021) for South Korea, Gyamfi et al. (2021) for Mediterranean nations, Akinsola et al. (2021) for Brazil, and Su et al. (2021) for Brazil. However, the finding contradicts Rjoub et al. (2021) for Sweden and Usman et al. (2020) for the USA who reported negative CO₂-GDP interrelationship.

The globalization (GLOB) influence on CO₂ emissions is illustrated by Fig. 1b and the subsequent outcomes are disclosed: In the lower tail (0.1–0.35) of the combination of GLOB and CO₂ emissions, the influence of GLOB on CO₂ emissions is negative suggesting that in the lower tail (0.10–0.35) GLOB aid in abating degradation of the environment. However, in the middle and higher tails (0.40–0.90) of GLOB and CO₂ emissions, GLO, a positive effect of GLOB on CO₂ emissions is noticed. In summary, the positive effect of globalization on CO₂ emissions is more pronounced than the negative effect of globalization on CO₂ emissions. The explanation for this could be that certain developing nations, such as Nigeria, do not consider ecological problems. To increase their revenues from trade, they allow polluting industries in advanced nations to continue their operations.

| Table 1: Descriptive statistics and unit root tests outcomes |
|-------------------|------------------|-----------------|------------------|------------------|
| **Descriptive Statistics** | **CO₂** | **EC** | **GDP** | **GLO** |
| Mean | 0.664077 | 699.1912 | 1777.527 | 44.77107 |
| Median | 0.708895 | 694.3708 | 1757.235 | 42.86263 |
| Maximum | 1.009958 | 798.6302 | 2550.470 | 57.52296 |
| Minimum | 0.312014 | 579.0784 | 1317.360 | 32.25583 |
| Std. Dev. | 0.187603 | 56.34513 | 393.1759 | 7.738225 |
| Skewness | -0.445312 | -0.239253 | 0.411224 | 0.227148 |
| Kurtosis | 2.292492 | 2.565811 | 1.894002 | 1.766360 |
| Jarque-Bera | 2.479741 | 0.800187 | 3.641003 | 3.312483 |
| Probability | 0.289422 | 0.670257 | 0.161945 | 0.190855 |
| Unit root tests Outcomes | **ΔADF** | **ΔPP** |
| Mean | -7.8624* | -7.8624* |
| Skewness | -0.445312 | -0.239253 |
| Kurtosis | 2.292492 | 2.565811 |
| Jarque-Bera | 2.479741 | 0.800187 |
| Probability | 0.289422 | 0.670257 |

*P<0.01, **P<0.05 and ***P<0.10
Furthermore, because industrial expansion puts additional pressure on the consumption of energy, fossil fuels are used at a rapid pace, resulting in increased emissions of CO₂ (Kirikkaleli et al. 2021; Yuping et al. 2021). So, in a summary, it is obvious that Nigeria moving toward pollution caused by globalization. As a result, it becomes clear that strong environmental regulations are needed to decrease emissions. The positive effect of globalization on CO₂ emissions is confirmed by the studies of Kirikkaleli et al. (2021) for Turkey, and He et al. (2021) for Mexico. However, the study of Yuping et al. (2021) for Argentina and Kihombo et al. (2021) for WEMA contradicts this finding.

The urbanization (URB) influence on CO₂ is illustrated by Fig. 1c and the subsequent results are unveiled: In the middle tail (0.40–0.65) of the combination of CO₂ emissions and URB, the negative effect of URB on CO₂ emissions is observed. However, there is proof of positive effect of URB on CO₂ emissions in the lower and higher tails (0.10–0.35 and 0.70–0.90) of both CO₂ emissions and URB. The probable reason for this interrelationship is that number of job opportunities rises in tandem with the growth of the economy. Because Nigeria’s industrial expansion is primarily concentrated in semi-urban and metropolitan regions, job opportunities are also concentrated in these places. As the number of employment vacancies increases, so does the expectation of a higher quality of life as overall wealth increases. This expectation entice people from rural regions to move to cities, leading to a rise in city dwellers. Because job opportunities are now divided according to skill level, the urban population were divided into skilled and semi-skilled laborers. Social and economic divides may grow as a result of this isolation, due to the creation of slum

![Fig. 1 A Effect of GDP on CO₂. B Effect of GLOB on CO₂. C Effect of URB on CO₂. D Effect of EC on CO₂.](image-url)
districts and shadow cities in metropolitan centres. People in these areas lack access to clean cooking fuels, resulting in increased CO₂ emissions due to unsustainable energy use habits. This outcome complies with the works of Zhang et al. (2021) for Malaysia, and Ramzan et al. (2010) for Latin American nations.

Lastly, energy utilization (EC) influence on CO₂ emissions is illustrated by Fig. 1d and the following outcomes are unravelled: In the lower tail (0.1–0.30), EC impact on CO₂ emissions is negative which implies that in the lower tail, the energy usage is sustainable. This outcome is surprising given the fact that most developing nations’ energy consumption is unsustainable. Moreover, in the middle tail (0.40–0.60) of combination of EC and CO₂ emissions, EC influence on CO₂ emissions is negative and weak. However, as we move into the higher tail (0.70–0.90) of CO₂ emissions, the influence of EC on CO₂ emissions is positive and significant. This implies that in the higher tail (0.70–0.90) the EC contributes to the degradation of the environment in Nigeria. The positive effect of energy utilization on CO₂ emissions is confirmed by the studies of Shan et al. (2021) for China and Orhan et al. (2010) for India and Tufail et al. (2021) for emerging nations.

Robustness check

In a traditional quantile regression (QR), the QQ method is employed to allocate the coefficient. It allows the regressor’s explicit coefficients at different quantiles to be obtained. The quantile regression (QR) model can be quickly constructed utilizing the quantile of $X$ ($Y$) on $Y$ ($X$), and the quantile regression coefficients can be indexed individually by $\sigma$. As noted previously, the QQ methods evaluate the th quantile provisional distribution. Moreover, the EC causal effect on CO₂ emissions is illustrated by Fig. 3a and the result unveiled a causal interrelationship from EC to CO₂ emissions in the lower and middle quantiles (0.25–0.70) of CO₂ emissions conditional distribution.

Non-parametric causality-in-quantiles outcomes

We apply the nonparametric Granger causality in quantiles initiated by (Balcilar et al. 2016) to identify the causal influence of globalization (GLO), energy consumption (EC), economic growth (GDP) and urbanization (URB) on carbon emissions (CO₂) in Nigeria. The variance and mean causal connection between CO₂ emissions and the regressors (GDP, URB, EC and GLO) can be assessed using this method. The non-parametric causality is depicted in Fig. 3(a–d) and Table 3, and the findings are as follows:

The EC causal effect on CO₂ emissions is illustrated by Fig. 3a and the result unveiled a causal interrelationship from EC to CO₂ emissions in the lower and middle quantiles (0.15–0.75) of CO₂ emissions conditional distribution. Furthermore, the EC causal effect on CO₂ emissions is illustrated by Fig. 3b and the result unveiled a causal interrelationship from GDP to CO₂ emissions in the lower and middle tails (0.1–0.90) of CO₂ emissions conditional distribution. Moreover, the GLO causal effect on CO₂ emissions is illustrated by Fig. 3c and the result showed causal association from GLO to CO₂ emissions in the lower and middle tails (0.20–0.75) of CO₂ emissions conditional distribution. Also, Fig. 3b presents GDP volatility and the result showed causal association from GDP to CO₂ emissions in the lower and middle tails (0.20–0.75) of CO₂ emissions conditional distribution. Moreover, the GLO causal effect on CO₂ emissions is illustrated by Fig. 3d and the result showed causal association from URB to CO₂ emissions in the lower and middle tails (0.10–0.70) of CO₂ emissions conditional distribution. Also, Fig. 3d presents URB volatility and the outcome showed a causal connection from URB to CO₂ emissions middle and lower tails (0.15–0.70) of CO₂ emissions conditional distribution.
Conclusion and policy suggestions

In this paper, we examine the impacts of globalization, real income, urbanization, and energy consumption on environmental degradation; and proffer way forward to achieving environmental sustainability targets in Nigeria, using quarterly frequency time series data over a period 1971–2018. To achieve our study objectives, this study makes use of quantile-quantile (Q-Q) approach, developed by Sim and Zhou (2015). This approach groups together nonparametric estimation and quantile regression. The Q-Q approach gives an additional inclusive description of the associations among variables. Also, for robustness check, this study used a conventional quantile regression to investigate the influence of an explanatory variable on various quantiles of the dependent variable. Combining these two approaches, rather than traditional techniques like OLS and ordinary quantile regression, can help us grasp the underlying relationship among variable under investigation.

Based on empirical estimations and findings, we found in the case of Nigeria that; first, in all tails (0.1–0.90) of both GDP and CO₂ emissions, a positive effect of GDP on CO₂ emissions is observed. From a policy perspective, for Nigeria economy to achieve any meaningful environmental sustainability targets, there must be a shift from economic activities that are dependent and driven by non-renewable energy sources to a more energy-savings and energy efficient technologies. We are of the opinion that, introduction of green economy should be considered and pursued vigorously by the authorities and policymakers in charge of environmental policies in other to achieve desirable and conducive environment for both the immediate and the future generation.

Second, empirical results show that in the majority of the quantiles, the effect of globalisation on CO₂ emissions is negative. Based on this findings, since globalization have come to stay and its impact, it is obvious even from the COVID-19 pandemic around the globe, we suggest that, environmental laws and regulations that prevent
indigenous and multinationals firms from using non-renewable energy sources in production activities should be put in place. Non-renewable energy sources should be replaced by more friendly renewable energy sources in order to curb and control at least to a minima the ravaging impact as a results of globalization on the host country, most especially in Nigeria.

Third, empirical findings show a proof of positive effect of urbanization on CO₂ emissions. Based on this finding, we are of the opinion that, government should discourage rural-urban migration by enacting policies that would improve life in the rural areas, such as diverting investment of indigenous and multinational companies to be situated in the rural areas. This would improve infrastructure facilities and create job opportunities for the rural dwellers. This in one-way or another would reduce congestion in the urban centres, hence reduction in environmental degradation. By so doing, the nation would achieve its environmental sustainability targets in the long run.

Empirical results show that, in the majority of the quantiles, the effect of energy consumption on CO₂ emissions. Based on this finding, we are of the opinion that, policymakers in Nigeria, should learn from jurisdictional experiences of nations that have successfully control non-renewable energy sources to renewable ones for an overall economic and environmental sustainability targets for both the immediate and future generations.

Conclusively, this current study is without limitation. Our research uses carbon emissions to proxy environmental degradation. However, future authors could focus on other environmental metrics such as the load capacity factor and other key drivers of environmental degradation. Also, future
Table 3 Nonparametric granger causality in quantiles outcomes

| CV 5% | C 10% | Energy Consumption | Economic Growth | Globalization | Urbanization |
|-------|-------|--------------------|-----------------|---------------|--------------|
|       |       | Mean      | Variance | Mean      | Variance | Mean | Variance | Mean | Variance | Mean | Variance |
| 0.10  | 1.96  | 1.65      | 1.5869   | 1.6419   | 1.6941** | 1.4516 | 1.5865 | 1.8769** | 1.4998 | 1.6587** |
| 0.15  | 1.96  | 1.65      | 1.9467** | 1.9827** | 1.6780** | 1.8291** | 1.4514 | 1.9083** | 1.6546** | 1.6881** |
| 0.20  | 1.96  | 1.65      | 1.8651** | 1.7197** | 1.8962** | 1.9266** | 1.7026** | 2.2800*  | 2.1438*  | 1.8456** |
| 0.25  | 1.96  | 1.65      | 2.4315*  | 1.8278** | 1.9023** | 1.7455** | 2.6865*  | 1.7425** | 2.4063*  | 1.6692** |
| 0.30  | 1.96  | 1.65      | 2.8301*  | 2.1499   | 1.8475** | 2.2462*  | 2.4783*  | 1.8733** | 2.2412*  | 2.3193*  |
| 0.35  | 1.96  | 1.65      | 3.0256*  | 2.0999*  | 2.0260*  | 1.9849*  | 2.7442*  | 1.8133** | 2.0798*  | 2.1766*  |
| 0.40  | 1.96  | 1.65      | 2.9122*  | 2.3168*  | 1.7892** | 1.8601** | 2.5359*  | 1.7822** | 1.6951** | 2.1390*  |
| 0.45  | 1.96  | 1.65      | 2.3390*  | 2.1744*  | 2.0275*  | 1.8515** | 2.3766*  | 1.5360   | 1.8481** | 1.7967** |
| 0.50  | 1.96  | 1.65      | 2.1263*  | 1.7702** | 1.9466** | 2.0958*  | 1.9269** | 1.5542   | 1.9117** | 1.7829** |
| 0.55  | 1.96  | 1.65      | 2.2938*  | 2.0413*  | 2.0324*  | 2.1519*  | 1.8086** | 1.6214   | 1.8006** | 1.6683** |
| 0.60  | 1.96  | 1.65      | 2.2215*  | 1.7695** | 1.6041   | 2.0941*  | 1.8630** | 1.7606** | 1.3481   | 1.8602** |
| 0.65  | 1.96  | 1.65      | 1.9450   | 1.6269   | 1.7392** | 1.7206** | 2.2667*  | 1.9249** | 1.4903   | 1.5885   |
| 0.70  | 1.96  | 1.65      | 1.6726** | 1.4195   | 1.9726** | 1.6488   | 2.3604*  | 1.6911** | 1.6430   | 1.4129   |
| 0.75  | 1.96  | 1.65      | 1.6346   | 1.2549   | 1.6760** | 1.2919   | 2.0349*  | 1.7469** | 1.4846   | 1.5864   |
| 0.80  | 1.96  | 1.65      | 1.1816   | 0.9775   | 1.4846   | 1.1576   | 1.2412   | 1.8264   | 1.2902   | 1.5433   |
| 0.85  | 1.96  | 1.65      | 1.2326   | 1.0144   | 1.3215   | 0.9786   | 1.4051   | 1.1969   | 1.1929   | 1.0375   |
| 0.90  | 1.96  | 1.65      | 1.07847  | 0.6837   | 1.0901   | 0.9043   | 1.0201   | 0.7792   | 0.9263   | 0.8886   |

*P<0.05 and **P<0.01

authors may also investigate blocs’ of countries that is, in panel format or time series studies, with more same or more advance econometric techniques.

Author contribution Tomiwa collected data and analyzed the data. Micheal and Wilfred wrote the introduction and literature review. Oji-Okoro work on the methodology and Seyi Saint Akadiri wrote the conclusion and policy suggestion, Nakorji work on study development and proofreading.

Data availability Corresponding authors can provide data used in the study on appropriate request.

Declarations

Ethics approval and consent to participate Not applicable.

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