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URBANIZATION AND ENVIRONMENTAL SUSTAINABILITY IN CAMEROON: AN AUTO-REGRESSIVE DISTRIBUTED LAG MODEL TECHNIQUE

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Abstract:
The relationship between urbanisation and the environment has elevated much public attention recently. Therefore, this study examined the effect urbanisation has on environmental sustainability in Cameroon using time series data from 1991 to 2018. To establish this, the study adopted the STIRPAT framework, the Principal Components Analysis and Autoregressive Distributed Lag Technique for data analysis. The models were tested for stationarity by applying the Phillip-Peron test. Results indicated that urbanization and trade openness had positive and significant effects on environmental sustainability in the long-run but negative in the short-run, thus, supporting an inverted U-shaped EKC. The study therefore, recommended that Cameroon revisits its trade

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policies and urban planning strategies and implement policies that will discourage dirty technology and encourage technological innovations (green) so as to improve energy efficiency which will go a long way to improve environmental sustainability.

JEL: R10; R51; Q01

Keywords: environmental sustainability, autoregressive distributed lag model, principal component analysis, environmental Kuznets curve, pollution haven, Porter's hypothesis

1. Introduction

The 20th century became a century considered as the 'Century of City' where more than half of the world's population became predominantly urban as more and more persons began migrating to urban centres (UN Habitat, 2009). The world's urban population for the first time took toll in 2007 when it grew passed 50% and in 2014, it was already about 54% (United Nations, 2014). This change in urban population growth has been accompanied by increase in the world's population as a result of increase mortality rates and increase life expectancy due to technological advancements in the medical field. By mid of the 20th century, these estimates doubled to 30%. Today, the world's population is increasing yearly by 80 to 85 million people and at a growth rate of 1.5% with the highest percentage experienced in Asia and developing countries in Africa (Audi & Amjad, 2016).

By 2030, the world's population is predicted to reach 4,6 billion with more than 60% of this figure living in urban areas leading to an up rise in the production of CO_2 emission which threatens environmental sustainability (The Nature Conservancy, 2008; Shahbaz et al., 2015; Waziri et al., 2018). According to reports by the United Nations, about 66% of the world's population that is, approximately 2.5 billion people will be living in urban areas by 2050 with about 90% to 95% of this increase concentrated in low and middle-income countries like Asia and Africa (UNW-DPAC, 2010; UN, 2014; Effiong, 2016; Ladu et al., 2019).

According to United Nations statistics as cited in Li & Liu (2014), urban centres own up to 75% of all the carbon emission. From this percentage, 17.5 % is shared by traffic from the transport sector which is the main circulatory system in every economy (Jeyhun et al., 2017). It is worth nothing that traffic accidents are the 9th main cause for death rates globally with a majority of these accidents occurring in developing countries (Koosha & Masoud, 2015). High CO_2 emissions in urban areas is due to increasing energy demands for fuel-using vehicles, construction, operations, maintenance of existing infrastructures and services like housing, water supply, bridges and roads (Parikh & Shukla, 1995; Madlener & Sunak, 2011). The housing sector for example consumes 1/5th of the world's material and flow of energy (Horvath, 2004) as cited in (Lasvauxa et al., 2016).

However, the growth in energy utilisation has posed two major worries; firstly, the depletion of non-renewable energy which are readily available (oil, gas, petroleum and coal). This growth in non-renewable energy produces fossil fuel which is responsible for the emission of greenhouse gases such as CO_2, nitrous oxide and methane. The second worry that the increasing use of energy poses is global warming which stems from the continuous emission of gases into the atmosphere and the huge rate of deforestation (Apergis & Danuletiu, 2014; Sadorsky, 2018; Yazdi & Dariani, 2019).

The top-ranking CO_2 and other pollutants emitting developing countries in Africa are Nigeria, Ghana, Cameroon, Madagascar, Mauritius, Uganda, and South Africa. Consequently, 72% of these countries are seriously facing environmental and health hazards coming from toxic air pollution which is the cause of almost 500.000 deaths in Sub-Saharan Africa (SSA) yearly (WHO, 2016). This is because the use of non-renewable energy is the main driving force for economic growth and the cheapest source used by the industrial sector in developing countries (Destek & Aslan, 2017). Between 2005 to 2015 CO_2 emissions in SSA stood at 2.6% emanating from primary fuel utilisation (WHO, 2016). However, these emissions do not always figure in the cost of production of industries thereby neglecting the negative externalities that come from environmental pollution. These have intensified climate change and environmental issues which are responsible for the economic and social consequences experienced in this region (Menyah & Wolde-Rufael, 2010; Kivyiro & Arminen, 2014; Esso & Keho, 2016).

African despite been blessed with a huge potential for renewable energy such as wind, solar and biomass, is still living in a nightmare on how to cost effectively exploit these sources as it accounts only for an insignificant figure on a global scale. In SSA, coal accounted for up to 56% of electricity generation, gas and petroleum were each 9%, hydro was 22% while nuclear was just 3%. The remaining renewable energy sources in this region such as wind, solar, and geothermal accounted just 1% (AEO, 2014) and from this percentage unclean use of charcoal and wood fuel constituted the largest share. There is therefore the dire need for Africa to design and implement policies that will increase the utilisation of renewable energy sources like wind, solar, geothermal and clean biomass (Maji et al., 2019).

However, in an attempt to cure environmental sustainability issues caused by rising urbanisation rates, much attention has been given internationally and nationally towards the impact of urbanization on natural resource utilization and the quality of the environment since the first 1979 United Nations Conference on the Environment held in Stockholm, the Rio de Janeiro in 1992, Johannesburg in 2002, Copenhagen in 2009 and Durban in December 2011 (Saidi & Hammami, 2014). As part of the global fight to improve on environmental sustainability, a comprehensive agreement on climate was held in Paris in 2015 known as the Conference of Parties of the United Nations Framework Convention for Climate Change which led to the signing of many treaties encouraging countries to try as much as they could to reduce temperatures to 2 °C above the pre-industrial levels by the year 2020 and to reduce urban greenhouse emissions to up to 3.7 gigatons annually by 2030 (European Parliament, 2016; Niu & Lekse, 2017).

With the failures of these former attempts by world bodies to significantly curb the global issues of climate change especially those concerning the developing countries;

the United Nations came up with the Sustainable Development Goals (SDGs) which came in to supplement the Millennium Development Goals (MDGs). The SDGs goals have integrated climate change as one of the important pillars in achieving sustainable development (United Nations, 2018) as cited in (Mondal, 2019). The 17 Goals of the SDGs laid actions that countries would take in order to attain sustainable development by 2030. The 7th goal lays emphasis on access to affordable, reliable, modern and sustainable energy by every country (Güney, 2019).

Specifically, Cameroon with an estimated population of 26.5 million in 2020 and an annual growth rate of 2.6% is projected to reach 50 million by 2050 (UN, 2012; IEA, 2016; World Population Review, 2020). This increase in population has led to rapid increase in the rate of urbanization. The urbanisation rate is currently 3.63% while 56.37% of the total population is already living in urban centres as against 39% in 1990, indicating a stable growth. This growth rate and the ensuing growth in urban population comprises a major driving force for the increasing rate of energy use and supporting the enormous rise in household incomes which encourages the increasing demand for energy consuming appliances for cooling, heating, lighting, powering and transporting.

Cameroon has the third largest hydropower potential in Africa after the Democratic Republic of Congo and Ethiopia but 90% of the population uses traditional solid fuels in the residential sector for heating, lighting and cooking while, industries consume about 90% of hydro energy (Djouedjom & Zhao, 2018). It is rather unfortunate that hydropower which is the main source of electricity generation (75%) in Cameroon is not sufficient enough to maintain power supply constantly especially in the dry season when water levels become very low hence, reason for the consistent power outage experienced in the country.

This massive use of non-renewable energy produces fossil fuels which consequently increases CO_2 emissions in Cameroon. In 2012, combustible fuel stood at 7.531 million metric tonnes rising to 14.480 million of tonnes in 2018. These emissions according to MINEP (2005) are attributed to the rate of energy utilisation; industrial development and land use (Fondja, 2013; Nkengfack et al., 2014; Muh et al., 2017). Therefore, poor planning of urban centres coupled with the use of traditional energy in Cameroon has led to several challenges such as poor waste management, poor drainage, pollution of drinking water which leads to water borne diseases, air pollution which is responsible for the many respiratory diseases. Other diseases such as lung cancer, tuberculosis and eye problems are prone in the country.

Poor urban planning has also led to unsustainable exploitation of biodiversity and loss of habitat due to the huge and increasing demand of land for construction of roads, industrial and residential buildings. The continuous rising urban population has pushed the population towards the periphery through the process of suburbanisation. More so, the loss in land cover through the process of urbanisation has led to the loss of land for construction thereby forcing the population to seek for settlement in the periphery which are often prone to landslides and flood.

Reducing non-renewable energy utilisation and promoting a more sustainable environment in the midst of economic growth is a key mission in Cameroon. Specific efforts have been made by the government to achieve the stated global targets. As part of its nationally determined contribution (NDC), the government has committed to 25% electricity generation from modern/renewable sources by 2035. The Energy Sector Development Plan 2030 has set a target of 75% total and 20% rural electrification rates by 2030. Cameroon has committed to reducing greenhouse gas emissions by 32% through the energy-related Intended Nationally Determined Contributions (INDCs). For example, law N°2011/022 which governs the electricity sector in Cameroon aims at organising the renewable energy sector. To meet up with the growing demand in electricity, the government is planning to install additional 2500 MW between 2012 and 2020, and 298 MW from thermal sources.

Despite the above efforts, Cameroon is still experiencing poor urban planning coupled with a massive use of unclean energy. This rise in unclean energy possess energy security issues in Cameroon and therefore threatens environmental sustainability. Hence, the relationship between urbanisation and environmental sustainability is timely because this relationship is still timid in the literature of Cameroon. Therefore, this study sought to give answer to the question below:

- To what extent does urbanisation affect environmental sustainability?

2. Research Objective

1. To examine the extent to which urbanisation affect environmental sustainability.
2. To make recommendations.

2.1 Research Hypothesis

Ho: Urbanisation has no significant effect on environmental sustainability.

2.2 Significance of the Study

The empirical relationship between urbanisation and environmental sustainability in Cameroon is still vague. As a result, the findings of this study are expected to add to literature especially as it reinvestigates on the issue of environmental sustainability in Cameroon which many studies have not yet exploited profoundly.

This study is specifically important at the present era of 'sustainable development'. After adopting the Sustainable Development Goals (SDGs), most of the emerging and developing economies are now participating in the global transition towards environmentally friendly low-carbon energy system. Therefore, this paper on the relationship between urbanisation and environmental sustainability in Cameroon is a very timely decision.

3. Theoretical Issues

This study builds its theoretical underpinning from the ecological modernization theory, the compact city theory, urban environmental transition theory, and finally the environmental Kuznets curve theory all of which establish a link between urbanisation and the environment. Furthermore, a wanton of related literature has been carried out in different parts of the world using diverse techniques as presented below:

Li & Ma (2014) applied a pressure-state-response model to investigate the relationship between urbanization, economic development and environmental change. They established environmental quality indices for 30 administrative regions in China from 2003 to 2011 and employed panel data analysis. Their results revealed a remarkable Inverted-U-shaped relationship between urbanization rate and changes in regional environmental quality.

Furthermore, Azama & Khan (2015) examined the relationship between urbanization and environmental degradation for four countries from the South Asian Association for Regional Cooperation regions namely India, Bangladesh, Sri Lanka, and Pakistan. Annual time series data over the period of 1982–2013 were used. They used the least squares technique for parameters estimation. Mixed results were revealed between the impact of urbanization on the environment for different countries. For Bangladesh and India, the relationship between urbanization growth and environment was significantly negative, while, the impact of urbanization on environment was significantly positive in case of Sri Lanka and insignificantly positive for Pakistan.

Hafiz et al., (2016) on their part explored the relationship between urbanization, CO_2 emissions and energy consumption in South Asia for the period 1983 to 2013 using Panel Co-integration and Granger causality approach. The results revealed a long-run relationship between CO_2, energy consumption and urbanization. The empirics also indicated that energy consumption and economic growth played a significant role in degrading the environment while trade is improving its quality. Bidirectional causality exists between CO_2 and energy, and between urbanization and CO2 emissions both in the short and long run.

Effiong, (2016) investigated the environmental impact of urbanization for 49 African countries from 1990 to 2010. Using the STIRPAT framework, the semi-parametric panel fixed-effects regression technique, and two atmospheric air pollutants (CO_2 and PM10) emissions, the evidence from results indicated that urbanization reduces environmental pollution with this reduction more pronounced with PM10 but weaker for CO_2 emissions.

Afawubo & Nguedem (n.d) analysed the relationship between urbanization, industrialization and CO_2 emissions in a panel of 142 countries over the period 1960-2014. Results revealed that in low-income countries, there was no significant relationship between industrialization, urbanization and CO_2 emissions in the short-run, while in long-run, urbanization and industrialization were positively correlated with CO_2 emissions. In upper-middle-income countries, only urbanization had a significant correlation in short-run, but in long-run, both industrialization and urbanization had significant effects on CO_2 emissions. In lower-middle-income countries, only industrialization was lightly correlated with CO_2 emissions in the long-run. Industrialization and urbanization in 1-period lag have significant correlation with CO_2 emissions in high-income non-OECD countries in short-run. Concerning OECD countries, urbanization in 1-period lag and industrialization are correlated with CO_2 emissions in short-run, while in long-run only industrialization had a significant correlation.

Niu & Lekse (2017) examined the carbon emission effect of urbanization at regional level in China. The authors applied the dynamic spatial Durbin panel model to find out that the contribution of urbanization to carbon emissions can be positively affected when regional policy makers collaborate to focus on spill over effects to simultaneously manage the scope, diversity, and complexity of economic and environmental issues from the perspective of creating a balance between rapid urbanization and relevant regional factors.

Doran & Ryan (2017) analysed the impact of economic development and urbanisation on CO_2 emissions in Ireland over the period 1970 to 2011. Using a vector error correction model and impulse response functions, their findings suggested that in the short run economic growth leads to higher levels of CO_2 emissions but in the long run, economic growth lowers emissions. Also, urbanisation in Ireland has contributed to lower levels of CO_2 emissions.

Jeyhun et al. (2017) examined the impacts of urbanization, energy consumption and real GDP on atmospheric pollution from automobile transport in Azerbaijan using a STIRPAT framework. The Augmented Dickey-Fuller test and the Autoregressive Distributed Lags Bounds Testing approach to co-integration were employed. Estimated results indicated that the highest impact on pollution among the variables was urbanization which was found to be positive and statistically significant. Energy consumption also had a positive and statistically significant impact on emission.

Salim & Shafiei (2017) investigated the effects of urbanization, renewable and non-renewable energy consumption, trade liberalization, and economic growth on pollutant emissions and energy intensity in selected Asian developing countries from 1980 to 2010. They applied the autoregressive distributed lag bound testing approach and employed the mean group estimation methods. Results identified population, affluence, and non-renewable energy consumption as the main factors responsible for pollutant emissions in Asian countries. This study's results support the EKC hypothesis and revealed that renewable energy, urbanization, and trade liberalization reduce emissions.

Weber & Sciubba (2018) using a dataset of 1062 regions within 22 European countries, analysed the effect of population growth on carbon dioxide emissions and urban land use change between 1990 and 2006. Data was analysed using panel regressions, spatial econometric models, and propensity score matching whereby, regions with high population growth were matched to otherwise highly similar regions exhibiting significantly less growth. They found a considerable effect from regional population growth on carbon dioxide emissions and urban land use increase in Western Europe.

Zheng & Walsh (2018) evaluated the relationship between urbanization, trade openness, energy consumption and PM2.5 in the Chinese economy using Fixed effect, fixed effect instrumental, and system generalized method of moments techniques for 29 provinces over the period 2001–2012. Results demonstrated that PM2.5 is a continuous process whereby previous period had positive effect on the current level of PM2.5. The EKC hypothesis was not supported and temperature was not a crucial factor affecting the amount of PM2.5. They also found that urbanization was beneficial in decreasing PM2.5. PM2.5 from neighbouring regions has an important impact in increasing the local PM2.5. International trade, heavy industry and private cars are contributors to PM2.5 level as well.

Mansoor & Sultana (2018) examined the relationship between CO_2 emission, economic growth, population and energy consumption in Pakistan from 1975-2016. The study adopted the IPAT hypothesis and applied the ARDL bounds testing approach to estimate short and long run elasticities. The results confirmed that population growth and energy demand both increase CO2 emission, while the relationship between GDP and CO_2 emissions was negative in the long-run.

In a similar study, Shaheen et al. (2018) investigated whether gross domestic product (GDP), energy consumption and urbanization affect CO_2 emissions from 1972-2014 in Pakistan. The empirical estimates of the ARDL affirmed that energy consumption and GDP were the main drivers of the pollution in Pakistan. Specifically, in the long run, energy consumption and GDP intensify CO_2 emissions significantly.

Hanif (2018) explored the impact of economic growth, urban expansion and consumption of fossil fuels, solid fuels, and renewable energy on environmental degradation in developing economies of Sub-Saharan Africa. The study adopted a system GMM on a panel of 34 emerging economies for the period 1995 to 2015. The results revealed that the consumption of fossil and solid fuels for cooking and expansion of urban area were significantly contributing to carbon dioxide emissions, on one end, and stimulating air pollution, on the other. The results also confirmed an EKC in middle and low-income economies of Sub-Saharan Africa.

In a more recent study in Cameroon, Mbella et al., (2019) investigated the interrelationship between population growth and environmental degradation using times series data from 1980-2016. They applied the difference GMM estimation technique and observed that population growth exerted a positive significant influence on the environment and the environment affected population growth negatively over the period of analysis. With respect to the structure of the economy, they found that agricultural and manufactured valued added positively affect environmental degradation while the service sector showed a negative influence.

Gu & Zhu (2019) selected the East Zhejiang region in China to study the interaction effects between technology-driven urbanization and eco-environment by computing novel indices for factors such as the degree of urbanization, environmental pressure, environmental protection, and environmental quality from 2005 to 2014 by adopting a data-intensive systemic approach. An inverted "U" structure and panel vector autoregressive model were constructed to show that given the acceleration of technology-driven urbanization, its surrounding eco-environment is still likely to be under greater pressure.

Fan et al. (2019) using empirical multiple linear regression in a simultaneous equation model analysed empirically the relative sustainability evaluation of urbanization on Water–Energy–Food nexus by incorporating a weighting coefficient of each identified variable, and the nexus implication was assessed in model simulation at different scenarios considering the population growth, agro-technology advancement, energy structure improvement, and available water resources. In the simulated results, three observations were found: the rural area is more sustainable than the urban one; the sustainability for both the investigated areas is significantly subject to their water supply and demand; and food production was found to have a less important effect on sustainable development of the urban area.

Domguia & Njangang (2019) examined the relationship between agricultural growth and environmental quality in Cameroon by applying the ARDL Bound Testing Approach which was based on the framework of the environmental curve of Kuznets and the Ricardian model. The results of the study showed a U-shaped relationship between agricultural growth and environmental quality thereby supporting the EKC. This showed that it is difficult for agricultural production to take place without having a negative effect on the quality of the environment. They finally showed that rising temperatures have a U-shaped impact on farm income.

Yazdi & Dariani (2019) examined the dynamic causal relationships between CO_2 emissions, energy consumption, economic growth, trade openness and urbanisation for the period 1980–2014 using the pooled mean group (PMG) approach and panel Granger causality tests for Asian countries. The study found a long-run relationship among the variables and revealed that urbanisation increases energy consumption and CO_2 emissions. Environmental quality is considered a normal good in the long run. The Granger causality test results supported that there is a bidirectional causal relationship between economic growth, urbanisation and CO_2 emissions. Consumption was greater than the impact on CO_2 emissions in the eastern region and some evidence supported the compact city theory.

Gasimli et al. (2019) examined the nexus between energy, trade, urbanization and environmental degradation in Sri Lanka. The bounds testing approach confirmed a long-term relationship among carbon emissions, energy consumption, income, trade openness, and urbanization. The results of the study did not confirm the presence of the EKC but rather found that energy consumption leads to carbon emissions in both the long term and the short term. Trade openness is degrading environmental quality. The results also confirmed that urbanization had significant and negative effect on carbon emissions.

From the above span of empirical reviews, it shows that there are gaps which this present paper seeks to fill. In the literature on the relationship between urbanization and environmental sustainability, a majority of prior empirical studies to the best of my erudition failed to acknowledge the fact that urbanization is not just a function of the urban population but a function of other elements which this present paper wishes to expose by composing an index with the help of the Principal Component Technique. Also, this paper brought out a comprehensive measure for urbanisation by including other attributes such as improved drinking water, employment in industrial and service sectors, electricity production, CO_2 emissions, agricultural land, and access to electricity with the help of the Principal Component Technique.

Furthermore, with respect to measures for environmental sustainability, CO_2 has been the major element but in the present study, environmental sustainability was measured by composing an index from the Principal Component Analysis Technique. The concept of environmental sustainability in this present era should not just be limited to particulate matter and/or CO_2 emissions but a function of other elements. Therefore, this study seeks to fill this gap by including other measures of environmental qualities such as nitrous oxide, improved drinking water, forest areas, electricity production, energy intensity and others.

Finally, so far this is the first study been carried out in Cameroon on the relationship between urbanization and environmental sustainability. Studies in Cameroon have focused on CO_2 emission as a measure for environmental sustainability and also urban population as a measure for urbanization. This study therefore seeks to contribute to knowledge by composing indices for these two variables using the Principal Component Analysis Technique.

These gaps have therefore provoked this study on the urbanisation and environmental sustainability relationship in Cameroon.

4. Methodology

4.1 The Autoregressive Distributed Lag (ARDL) Model

This estimation technique is out to establish a short-run and long run effects of urbanization and environmental sustainability in Cameroon. This technique has been chosen because of the many advantages it presents. In the first place, according to Pesaran et al (2001), it can be applied to time series data irrespective of the fact the data may be stationary at level I (0), first difference I (I) or a combination of both. Secondly, this technique is suitable for analysing small sample sizes. Furthermore, it can even be applied when the order of integration of variables are unknown before the Cointegration test. Besides, the lag modification as applied in the ARDL model produces fair estimates of the long run and an effective t-statistics coefficient in the presence of endogeneity because it controls for serial correlation and residual correlation. The basic equations of our model are therefore expressed as follows;

$$lnEST_t = \beta_{01} + \beta_{11} lnURB_t + \beta_{12} lnEU_t + \beta_{13} lnTRADE_t + \varepsilon_{1t} \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

The equations for the ARDL Bound testing approach to estimate the long run estimates for environmental sustainability is given by;

$$\Delta lnEST_t = \beta_1 + \sum_{i=1}^{P} \beta_{11}\, \Delta\ lnEST_{t-i} + \sum_{i=0}^{q} \beta_{12}\, \Delta\ lnURB_{t-i} + \sum_{i=0}^{P} \beta_{13}\, \Delta\ lnEU_{t-i} + \sum_{i=0}^{P} \beta_{14}\, \Delta\, lnTRADE_{t-i} + \delta_{11} lnURB_{t-i} + \delta_{12} lnEU_{t-i} + \delta_{13} lnTRADE_{t-i} + \varepsilon_{1t} \ldots\ldots (2)$$

where,

Δ is the first difference operation, $\varepsilon_{1t,}$ is the residual terms. $\beta_{11}, \beta_{12}, \beta_{13}, \beta_{14}$ are the error correction dynamics; δ_{11}, δ_{12} and δ_{13} are long run relationships. The null hypothesis to be tested is Ho: $\delta_{11} = \delta_{12} = \delta_{13} = 0$ and alternative hypothesis Ho: $\delta_{11} \neq \delta_{12} \neq \delta_{13} \neq 0$ indicating long run relationship between the variables measured by the F-value. In this case, if the F-value exceeds the upper bound critical value, the null hypothesis of no Cointegration is rejected, and if it falls between the lower and upper bound, the results are inconclusive.

4.2 Model Specification

In assessing the relationship existing between urbanisation and environmental sustainability in Cameroon, the study chooses variables following the STIRPAT framework and extended by the Environmental Kuznets Hypothesis as adopted by Bekhet et al., (2020). From the selected variables we develop the following models to analyse the relationship between urbanization, and environmental sustainability. We begin with the simple identity equation;

$$I = P \times A \times T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The above equation indicates that environmental impacts (I) which in our case is environmental sustainability is the product of population (P), per capita affluence (A) and technology (T). This model was later on criticised but in a bid to correct its shortcomings, it was extended to the STIRPAT (Stochastic Impacts by Regression on Population, Affluence, and Technology) model;

$$I = aP^{\alpha} \times A^{\beta} \times T^{\chi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where, a represents the coefficient of the model; α , β and χ are the elasticity of the environmental impact to P, A and T, respectively. The above equation is converted into log-linear specification (which helps to eliminate heteroscedasticity and volatility from the model) and also permits us to include other variables to investigate the relationship between urbanization and environmental sustainability.

The specification of the effects of the various driving forces of environmental change (urbanisation, trade openness and gross fixed capital formation) on environmental sustainability in Cameroon has been inspired by other empirical studies

(Li & Ma, 2014; Azama & Khan, 2015; Effiong, 2016; Afawubo & Nguedem, n.d; Niu & Lekse, 2017; Doran & Ryan, 2017; Gu & Zhu, 2019) followed by the STIRPAT framework and the EKC hypothesis modelled in a logged equation as follows:

$$lnEST_t = \beta_{01} + \beta_{11} lnURB_t + \beta_{12} lnEU_t + \beta_{13} lnTRADE_t + \varepsilon_{1t} \ldots\ldots\ldots\ldots\ldots. (5)$$

Where the variables are as defined on Table 1 below and ln is the natural logarithm. A priori, it is expected that the parameters $\beta_{01} \neq 0, \beta_{11}<0$, $\beta_{12}<0$ and $\beta_{13}<0$.

Next, while keeping only the significant coefficients, the long run estimates are used to construct the Error Correction Term (ECT) for the estimation of a short-run relationship. This is established as follows;

$$\Delta lnEST_t = \beta_1 + \sum_{i=1}^{P} \beta_{11}\, \Delta\, lnEST_{t-i} + \sum_{i=0}^{q} \beta_{12}\, \Delta\, lnURB_{t-i} + \sum_{i=0}^{P} \beta_{13}\, \Delta\, lnEU_{t-i} + \sum_{i=0}^{P} \beta_{14}\, \Delta\, lnTRADE_{t-i} + \eta_1 ECT_{t-i} + \varepsilon_{1t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where, η1 is the speed of adjustment, ECT_{t-i} is the lagged error correction term which must be negative and also significant.

Table 1: Definition, Measurement, Denotation, and Sources of Variables

Variable	Proxy and measurement	Denotation	Source
Environmental Sustainability Index (EST)			
Reducing Stresses	Nitrous oxide emissions (thousand metric tons of CO_2 equivalent)	**NOE**	WDI
	Forest area (% of land area)	**FORSA**	WDI
	Fertility rate, total (births per woman)		WDI
Reducing Human Vulnerability	Improved water source (% of population with access)	**IWS**	WDI
Social and Institutional Capacity	Terrestrial and marine protected areas (% of total territorial area)	**TMPAL**	WDI
	Energy intensity level of primary energy (MJ/$2011 PPP GDP)	**EIL**	WDI
	Electricity production from hydroelectric sources (% of total)	**ELEPROD**	WDI
Global Stewardship	CO_2 emissions (metric tons per capita)	**CO_2**	WDI
Urbanisation Index (URB)			
Spatial expansion	Agricultural land (% of land area)	**ALA**	WDI
	Terrestrial and marine protected areas (% of total territorial area)		WDI
Economy	Per capita GDP		WDI
	Employment in agriculture (% of total employment)	**AEMP**	WDI
	Employment in industry (% of total employment)	**IEMP**	WDI
	Self-employed, total (% of total employment)	**SEMP**	WDI

Public Services	Improved water source (% of population with access)	**IWS**	WDI
	Access to electricity (% of population)	**AELEC**	WDI
Society/lifestyle	Population in urban agglomeration (% of total population)	**URB**	WDI
Other Variables			
Other Variables	Energy Utilisation	**EU**	WDI
	Trade openness	**TRADE**	WDI

Source: Author's Conceptualisation, 2020.

5. Results

5.1 Principal Component Analysis

In reducing the dimensionality for both environmental sustainability and urbanisation, we establish the eigenvalues and proportion of variance to be able to select which component retains the most information in a large set as presented below.

5.2 Environmental Sustainability Index

Table 2: Eigenvalues and Proportion of Variance for Environmental Sustainability Indicators

Component	Eigenvalue	Difference	Proportion	Cumulative
PC1	5.46656	4.46405	0.7809	0.7809
PC2	1.00251	0.728021	0.1432	0.9242
PC3	0.274492	0.113656	0.0392	0.9634
PC4	0.160835	0.102007	0.0230	0.9863
PC5	0.0588282	0.0223309	0.0084	0.9947
PC6	0.0364973	0.0362258	0.0052	1.0000
PC7	0.000271532	-	0.0000	1.0000

Source: Computed by Author (2020) using Stata13.

Table 2 presents the eigenvalues, their corresponding variations and the cumulative scores for each component. The first component with eigenvalue 5.47 has the highest variation (78%) associated to PC 1, while the next PC that is, PC 2 associated with eigenvalue 1.002 represents the second highest variation (14%). The succeeding component has eigenvalue of 0.27 and associated with a variation of 3%. In this same order, the variation decreases as we move down to the 7th component with eigenvalue of 0.00027 and having a zero proportion of variation.

Table 3: Principal Components (eigenvectors)

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Nitrous oxide emission	0.4129	-0.0184	0.3557	-0.0865	-0.5345	0.6396	-0.0178
Forest area	-0.4219	0.0155	-0.2362	0.0809	0.1003	0.5182	0.6935
Terrestrial and marine protected areas	0.4094	-0.0380	0.2291	0.4784	0.6964	0.2534	-0.0179
Energy intensity	0.3942	0.0949	0.4378	0.7101	-0.3334	-0.1689	-0.0013

Electricity production from hydroelectric sources	-0.3851	-0.0723	0.7139	-0.4896	0.3088	0.0410	-0.0077
CO2 emissions	0.0473	0.9917	0.0338	-0.0895	0.0680	0.0240	0.0009
Improved water source	0.4218	-0.0181	0.2503	-0.0720	-0.0899	-0.4769	0.7200

Source: Computed by Author (2020) using Stata13.

Table 3 presents the results of eigenvectors for the various indicators pertaining to different components representing a linear combination of the original seven variables with their respective coefficients. Based on the KMO (Kaiser-Meyer-Oklin) test, the Kaiser–Guttman rule and the scree plot test, the first and second components. Going by the first component, forest areas and improved water sources have the highest values (0.42 and -0.421 respectively) in the environmental sustainability index. This therefore means that more emphasis should be focused on forest areas and improved water sources as far as environmental sustainability is concerned. The second component shows that CO_2 has a very high value of 0.991 which shows that it also matters as far as environmental sustainability is concerned just as it has been adopted by many studies to capture environmental degradation.

Table 4: Scale Reliability Test

Variable	Kaiser-Meyer-Olkin (kmo)
Nitrous oxide emission	0.9676
Forest area	0.7900
Terrestrial and marine protected areas	0.8934
Energy intensity	0.9009
Electricity production from hydroelectric sources	0.8561
CO_2 emissions	0.2346
Improved water source	0.7794
Overall	0.8522
Scale reliability	0.6243

Source: Computed by Author (2020) using Stata13.

Table 4 presents the KMO (Kaiser-Meyer-Olkin) test which is out to confirm if principal component regression was a suitable tool for producing the environmental sustainability index. Based on the figures on the table, all variables had KMO greater than the limit except for CO2 emission with a KMO less than the limit. This variable has been maintain here based on a priori hypothesis criterion. Meanwhile, an overall KMO of 0.62 indicates that the variables were linearly corrected therefore, PCA was a suitable tool.

5.3 Urbanisation Index

Table 5: Principal components/correlation

Component	Eigenvalue	Difference	Proportion	Cumulative
PC1	8.32854	7.97336	0.9254	0.9254
PC2	0.355174	0.222826	0.0395	0.9649
PC3	0.132349	0.0258776	0.0147	0.9796
PC4	0.106471	0.0434292	0.0118	0.9914
PC5	0.0630417	0.0509036	0.0070	0.9984
PC6	0.0121382	0.0103344	0.0013	0.9997
PC7	0.00180381	0.00131786	0.0002	0.9999
PC8	0.000485948	0.000485948	0.0001	1.0000

Source: Computed by Author (2020) using Stata13.

In a similar fashion, the first component with eigenvalue 8.33 has the highest variation of 93% corresponding to PC1, while the next PC that is, PC2 associated with eigenvalue 0.36 represents the second highest variation of 4%. The succeeding component has eigenvalue of 0.13 presenting a variation of 1%. We notice that as we move down to higher components right up to the 8th component, variation has reduced to 0.000485948 which correspondingly gives a zero proportion of variation.

Table 6: Principal Components (eigenvectors)

Variable	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Agricultural land	0.3234	0.5048	0.3500	0.2448	-0.4524	0.5009	0.0432	-0.0256
Terrestrial and marine protected areas	0.3297	-0.1147	0.7582	0.1472	0.4109	-0.3166	-0.0986	0.0538
Employment in agriculture	-0.3410	-0.2600	0.2081	0.0974	-0.0469	0.2578	0.0477	0.3005
Employment in industry	0.3375	0.3415	-0.2283	-0.1037	-0.0164	-0.3543	0.2673	0.6935
Service employment	0.3417	0.2371	-0.2023	-0.0957	0.0646	-0.2309	-0.1359	-0.5758
Self-employed	-0.3215	0.4789	-0.1725	0.5648	0.5583	0.0767	-0.0287	0.0117
Improved water source	0.3405	-0.2219	-0.1122	-0.0948	0.4220	0.4476	0.6486	-0.1190
Access to electricity	0.3207	-0.4488	-0.2781	0.7354	-0.2420	-0.1371	-0.0085	0.0108
Population in urban agglomeration	0.3430	-0.1074	-0.2159	-0.1422	0.2675	0.4225	-0.6889	0.2815

Source: Computed by Author (2020) using Stata13.

Going by the first component, agricultural employment, service employment, improved water sources and urban population produce the highest values (while agricultural employment produce a negative coefficient (-0.341), service employment, improved water sources and urban population present positive coefficients respectively (0.341, 0.340 and 0.343)) in the urbanisation index. This therefore means that more emphasis should be focused on agricultural employment, service employment, improved water sources and urban population as far as urbanisation is concerned. Based on the second component, agricultural land (0.50) and self-employment (0.48) should also be considered because they present very high coefficients. Therefore, agricultural land and self-employment also matter as far as urbanisation is concerned.

Table 7: Scale reliability test

Variable	Kaiser-Meyer-Olkin (kmo)
Agricultural land	0.8193
Terrestrial and marine protected areas	0.7165
Employment in agriculture	0.6958
Employment in industry	0.6915
Service employment	0.6967
Self-employed	0.9236
Improved water source	0.7541
Access to electricity	0.9510
Population in urban agglomeration	0.7567
Overall	0.7641
Scale reliability	0.9356

Source: Computed by Author (2020) using Stata13.

Based on Table 7, the overall value of KMO is very high with a percentage of up to 94% which indicates that all the variables were linearly corrected therefore making PC a suitable tool.

5.4 Unit Root Test Results

Table 8: Phillips-Perron Test for Unit Root

		Levels				First Difference			Remark
Variable	Statistic	1%	5%	10%	Statistic	1%	5%	10%	
EST	-0.019	-3.736	-2.994	-2.628	-4.085 *	-3.743	-2.997	-2.629	I(1)
URB	0.430	-3.736	-2.994	-2.628	-4.914*	-3.743	-2.997	-2.629	I(1)
EU	-0.462	-3.736	-2.994	-2.628	-4.349*	-3.743	-2.997	2.629	I(1)
TRADE	-0.867	-3.736	-2.994	-2.628	-6.356*	-3.743	-2.997	-2.629	I(1)

Source: Computed by Author (2020) using Stata13.

By using the Phillip-Perron test, the null hypothesis which states that a series is non-stationary is tested against the alternative which states stationarity. From table 8, all variables (EST, URB, EU, TRADE) are non-stationary at levels. However, all the variables are 1% significantly stationary at first difference. Thus, we reject the null hypothesis of non-stationarity. This therefore renders all the variables integrated of order one that is, I (1). Therefore, given that the order of integration of all the variables have met the condition for a Bound test (F-statistics) of Cointegration, we can now conveniently follow the next step which is to test for a long-run Cointegration relationship between variables by applying the ARDL-ECM.

5.5 ARDL Bounds Tests Results

We present the test for the existence of a long run relationship between the variables used in the models by using the ARDL bound test approach.

Table 9: ARDL Bounds Tests Results

Model	**I(0)**	**I(1)**	**F-test**
Environmental sustainability model	2.72	3.77	5.869
	3.23	4.35	
	3.69	4.89	
	4.29	5.61	
H0: no levels relationship accept if F < critical value for I(0) regressors. H1: levels relationship reject if F > critical value for I(1) regressors.			

Source: Computed by Author (2020) using Stata13.

The F-statistics for testing the joint null hypothesis of no levels Cointegration relationship between the variables are defined on the table above. The value of the F-statistics exceeds the upper bounds of the critical values. With respect to the F-statistics for Environmental sustainability, energy utilisation and urbanisation models, it shows that F (5.869) > critical (3.77, 4.35, 4.89, 5.61). Thus, the null hypothesis of no levels relationship is rejected. Therefore, there exists long run Cointegration relationships between the variables.

5.6 ARDL Regression Results

Table 10: Results of Environmental Sustainability Model

Variables	**Coefficients**	**Standard Error**	**T**	**P> |t|**
ECT	**-1.697651**	**0.4469306**	**3.80**	**0.009***
Long run Effect				
URB	0.5094021	0.0438253	11.62	0.000*
EU	-0.0001115	0.0011808	-0.09	0.928
LTRADE	1.387884	0.174228	7.97	0.000*
Short run Effect				
LD.EST	0.3581717	0.2897175	1.24	0.263
D1.URB	-0.6615665	0.2534084	-2.61	0.040**
LD.URB	-0.3720098	0.2181977	-1.70	0.139
L2D.URB	-0.1372177	0.1641527	-0.84	0.435
L3D.URB	-0.2119895	0.1467173	-1.44	0.199
D1.EU	-0.0019486	0.00297	-0.66	0.536
LD.EU	-0.0021702	0.0036118	-0.60	0.570
L2D.EU	0.0033902	0.0037714	0.90	0.403
L3D.EU	0.0093076	0.0032139	2.90	0.027**
D1.LTRADE	-1.488601	0.5229906	-2.85	0.029**
LD.LTRADE	-1.323944	0.4749008	-2.79	0.032**
L2D.LTRADE	-0.9308436	0.3672271	-2.53	0.044**
L3D.LTRADE	-0.7117192	0.2579161	-2.76	0.033**
C	-46.71297	12.96759	-3.60	0.011**
Log likelihood 36.388183	**R-squared** 0.9397	**Adj R-squared** 0.7688	**Root MSE** 0.1062	
LD = lag difference D1 = first difference		Level of significance at *1%, **5% and ***10%		

Source: Computed by Author (2020) using Stata13.

The coefficient of ECT is negative (-1.70) and statistically significant at 1%. Thus, 170% of the deviation/disequilibrium in environmental sustainability of the previous year's shock adjusts/restores back to the long run in the current year.

5.7 Long-run Effects

The estimated coefficient of urbanisation is positive (0.51) and statistically significant at 1%. Thus, a unit increase in urbanisation will increase environmental sustainability by 0.51 in the long run all things been equal. Furthermore, the coefficient for trade openness is positive (1.39) and statistically significant 1%. Therefore, a 1% increase in trade openness will increase environmental sustainability by 0.014.

5.8 Short-run Effects

Going by the short run analysis, the coefficient for the first difference of urbanisation is negative (-0.66) and statistically significant at 5%. This means that a unit increase in urbanisation will reduce environmental sustainability by 0.66 in the short run. In a similar way, the short run analysis for energy utilisation reveals that the coefficient of the third lag value for energy utilisation is positive (0.009) and statistically significant at 5%. This result reveals that a unit increase in the third previous year's energy utilisation increases environmental sustainability by 0.009. Furthermore, the coefficient of the first difference of trade openness is negative (-1.49) and statistically significant at 5%. This reveals that a 1% increase in trade openness will decrease environmental sustainability by 0.015 in the short run. Similarly, the coefficient of the first lag difference for trade openness is negative (-1.32) and also statistically significant at 5%. This means that a 1% increase in the previous year's trade openness decreases environmental sustainability by 0.013. Next, the coefficient of the second lag difference of trade openness is also negative (-0.93) and statistically significant at 5%. Thus, increasing the second previous year's trade openness by 1% decreases environmental sustainability by 0.009. Lastly, the coefficient of the third lag difference of trade openness is negative (-0.71) and statistically significant at 5%. This means that a 1% increase in the third previous year's trade openness decreases environmental sustainability by 0.007.

The independent (URB, EU and TRADE) variables account for 94% of the total variations of the dependent (environmental sustainability) variable as revealed by the coefficient of R-square (0.9397). This means that URB, EU and TRADE account for a larger variation in environmental sustainability.

6. Discussion of Results

In the long run, the positive effect as revealed by urbanization has implications on environmental sustainability on the economy of Cameroon. This positive and significant effect of urbanization on environmental sustainability is consistent with the works of Onoja et al. (2014), Adusah-Poku (2016), Effiong, (2016), Sadia et al., (2017), Salim & Shafiei, (2017), Niu & Lekse (2017), Doran & Ryan (2017), Zheng & Walsh (2018), Gasimli et al., (2019), Domguia & Njangang (2019) and Gu & Zhu (2019). Theoretically, the positive relationship between urbanisation and environmental sustainability is also supported by the arguments put in place by the ecological modernisation theory which posits that at lower stages of development, the quest for high economic growth is prioritized over environmental issues but as a country continuous to develop to higher stages, environmental damage becomes a challenge and hence, more importance is given to environmental issues. In essence, higher urbanization is often linked with a higher rate of economic activities and wealthy residents. These wealthy inhabitants demand more energy-intensive appliances for heating and cooling such as refrigerators, vehicles, TVs, microwaves, electric cookers etc. The energy used by these appliances are mostly non-renewable especially in developing countries producing fossil fuels often responsible for the huge CO_2 emissions in urban centres. Furthermore, the compact city theory known as the 'city of short distance' also supports this finding of positive effect of urbanisation on environmental sustainability. According to this theory, high urbanization will lower environmental pressure as a result of economies of scale in public infrastructure. Therefore, efficient and adequate provision of infrastructure will go a long way to reduce the harmful effect urbanisation has on environmental sustainability. Given that urbanisation in itself is an aspect of sustainable development, it is likely to contribute in the quest for a reduction in poverty by increasing productivity and employment, provision of basic infrastructures and the efficiency of the use of our natural resources. This encourages efficient management and conservation of our resources.

Trade openness also has a positive and significant effect on environmental sustainability in the long run and this result is in line with the empirical findings of Hafiz et al., (2016), Taghavee et al., (2016) and Sorge & Neumann (2017). Trade openness captures the level of international trade on environmental sustainability. Theoretically, this finding is supported by the Porter's hypothesis which suggests that strict and well-designed environmental regulations and policies will encourage clean and efficient technology and hence, increase productivity without much environmental damage (increase environmental sustainability). However, if countries fail to strengthen their environmental regulations, firms which want to avoid the cost of these regulations will take advantage of this and import their dirty technology in those countries. This is known as the Pollution Haven hypothesis.

In the short-run, urbanization significantly affects environmental sustainability negatively contradicting the longrun relationship. This result is consistent with the works of Li & Ma (2014), Afawubo & Nguedem (n.d), Jeyhun et al., (2017), Sadia et al., (2017), Niu & Lekse (2017), Yazdi & Dariani (2019) and Gu & Zhu (2019). Theoretically, the theory of ecological modernisation reveals that urbanisation is a process of social transformation hence, in the first stages of development, economic is prioritized over environmental sustainability so greener technology is slow, research and development is also slow and the level of environmental awareness consciousness is very minimal. At this low level of technology, urbanization which leads to structural changes in the economy through various human activities increases infrastructure usage and energy utilization for industrial activities and transportation services (vehicles). Usually, the rapid increase in infrastructure (roads, housing, industries) is not planned and controlled and as a result, this leads to an upsurge in congestion, deforestation, air and ground water pollution, etc. causing environmental damages.

Trade openness has a negative and significant effect on environmental sustainability in the short run which doesn't corroborates with the longrun relationship. This outcome is in line with the findings of Hafiz et al., (2016), Taghavee et al., (2016), Zheng & Walsh (2018) and Gasimli et al., (2019). Theoretically, this short run relationship is supported by the Porter's hypothesis. According to this theory, countries with weaker environmental regulations become dumping ground for dirty pollution from developed countries who evade the heavy taxation, high legal expenditures and stringent regulations in their home countries (Christman & Taylor, 2001).

7. **Conclusion and Recommendations**

The objective of this study was to assess the impact of urbanization on environmental sustainability in Cameroon. The results uncovered that while the longrun effects of urbanization and trade openness are positive on environmental sustainability, their short-run effects are all negative. Thus, while urbanization and trade openness have positive effects on environmental quality in the longrun, they affect environmental quality negatively in the short-run. This explains a U-shape Environmental Kuznets Curve between urbanization and trade openness on the environment. Furthermore, while the long run effect of energy utilization on environmental sustainability is negative and insignificant, its third lag is positive and significant. This significant result reveals that any meaningful policy to improve on environmental sustainability in the current period should start by implementing energy policies adopted three years back.

Based on the PCA results, urban planners should give priority to factors like agricultural land, employment in agriculture, employment in the service sector, self-employed, improved water sources, population in urban agglomeration when considering better urban planning strategies. Similarly, when considering measures for environment sustainability, priority should be given to elements like forest area, improved water sources and carbon dioxide.

Specifically, urbanisation as an engine for growth encourages the growth of energy utilisation and consequently environmental degradation. As supported by the compact city theory, urban transition and the ecological modernisation theory, there is the need for a strategic urban planning accompanied with basic public infrastructures using green technology that is, infrastructures which are less energy consuming/energy saving and more efficient. To achieve green economy innovation, the government should create public awareness through mass media and also organising workshops and conferences on environmental sustainability. This will go a long way to change urban households' lifestyles and consumption pattern from energy consuming products to energy saving products. Cameroon lacks urban planning which usually causes urban mess. Therefore, awareness should be raised among policymakers at the city level so that they understand how urban planning is done by using professionals such as architects, engineers, lawyers and urban planners.

To reduce the amount of energy utilisation, policies which will bring about well-developed urban transportation network are necessary to reduce the growing utilisation of energy from the transport sector. Therefore, other efficient transportation means such as railways and waterways means of transport. These modes use less energy and are spacious. Therefore, the Ministry of Transport should develop the transport network in a way that all these modes of transport can connect to each other.

Given that trade openness has a positive impact on environmental sustainability, policies discouraging dirty technology at the industrial level should be implemented by imposing stringent environmental regulations (Porter's hypothesis) such as pollution taxes and ensuring that manufactured products meet the legal standards. The Cameroon government needs to strengthen environmental policies to restrict both home based industries and foreign industries to use cleaner production technologies which will help reduce CO_2 emission.

7.1 Limitations of the Study

This study concentrates on macroeconomic variables and uses aggregative data. In Cameroon like any other developing country, it was difficult for the researcher to have data needed for this study especially those needed to build the urbanisation and environmental sustainability index. There exist little or no data even where they existed there were missing data for many consecutive years that is, in cases where data for these economic indicators exist, they are not often updated with time. It takes much time for them to update the data. As such it becomes very difficult to estimate the economic activities in the country. For this reason, the time series was limited only to 28 years and not all variables proposed for the construction of the indices for environmental sustainability and urbanisation were available. To solve this problem, only variables which we could have access to were selected from the World Bank database.

7.2 Areas for Further Research

Future research should focus on the urbanisation and environmental sustainability in a large panel relationship in African in general and Sub-Saharan Africa in particular.

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