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Global Journal of Commerce & Management Perspective

Research Article

Implication of Globalization on Ecological Footprint: Evidence from Sub-Saharan Africa

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ABSTRACT

The world is increasingly becoming a global village with the attendant implications on the earth's biological capacity. Thus, it becomes imperative to empirically examine the impact of "globalization" on the "ecological footprint" of Sub-Saharan Africa. The investigation of the globalization and other macroeconomic variables impacts on the ecological footprint of 41 Sub-Saharan Africa countries using a dataset from 1990 to 2019, by employing PMG and CS-ARDL estimators is this study aim. Our findings show that dejure and defacto globalization and renewable energy consumption have a positive and significant impact on ecological footprint, while economic growth, population and foreign direct investment (FDI) revealed a negative and significant effect on ecological footprint in the long-run. In addition, only population and FDI were found to have a positive and significant causal effect on ecological footprint in the short-run, while renewable energy consumption was found to have a negative causal effect on ecological footprint in the short-run. Finally, the study suggests some policy implications of our findings that would assist the policy makers in the SSA countries to reduce the over-exploitation of resources with the aim of achieving environmental sustainability.

Keywords: Earth's biological capacity; globalization; environmental quality; CS-ARDL; Sub-Saharan Africa

INTRODUCTION

In the last three decades, notable two approaches have dominated the natural resources research. First is based on the school of thought of those scholars that investigates impact of natural resources on economic growth. Second approaches are those that take into account, the implication of economic growth on the environment [1].

In this study, we investigate whether globalization and some other macroeconomic indicators in Sub-Saharan Africa (SSA) region impacts on the ecological footprint of the region. With the world increasing getting expanded and the World becoming a global village, notably in the last three decades, it is evident in the literature that the world has already gone above its limits in terms of the utilization of resources, which is corroborated with numerous environmental indicator measurement among, which is the development of "ecological footprint". In reference to "global Footprint Network (GFM)" data, as at 2012, the global consumption is above 50% of the Earth's biological capacity. In addition, the record also shows that only 60 out of 199 countries reported have biological capacity than their ecological footprint. This implies that 139 countries are in deficit, and this is an indication that it becomes imperative to understand factors that could have impact on the ecological footprint, most especially in the SSA region that consist of mostly developing countries. Also in 2013, GFN posited that "the planet's ecological services were being used 1.6 faster than they were renewed [2].

All around the world, an increased shift is underway towards renewable energy. For instance, as at 2011, about 10% of the energy consumption in U.S came from renewable resources, which is projected will grow up to 45% by the year 2035. As at 2020, renewable energy is contributing about 19% of the energy used and projected to reach about 38% by 2050 (U.S, Energy Information Administration, 2020). This change is being necessitated by the climate change. According to Outka, the effect of energy production on the land is significant. Though,

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Received date: July 11, 2021; **Accepted date:** October 13, 2021; **Published date:** October 22, 2021

Citation: Odugbesan JA, Olowu G, Miyapyen SB (2021) Implication of Globalization on Ecological Footprint: Evidence from Sub-Saharan Africa, Global J Comm Manage Perspect 10: p058

the demand for renewable energy requirement at the moment is small, but with the expansion in the level of advancement of renewable energy, more land is required for renewable energy and this will increase the possible effect on the ecological capacity. Despite the significance of ecology and carbon foot print in this era of globalization, the area of the study remains unexplored by scholars, especially in the SSA region [3].

The investigation of the economic growth influence on the quality of environment and natural resources abound in the literature. One of the hypothesis is the "Environmental Kuznets' Curve (EKC)", which postulated the inverse-U-shaped relationship between degradation of environment and economic growth. Most of studies in this category employed a "one-dimensional" quality of environmental quality indicators like CO2, waste, emissions, and so on, and often the impact of the economic growth on the environment have been assessed in the country where production and consumption happened. In spite of this, it is apparent that the impact of economic activities on the quality of environment is multi-dimensional instead of one-dimensional. In addition, in this present globalized world, there have been rapid changes in the production and consumption location. This thus makes it imperative to assess environmental degradation and exploitation of natural resources, not only in the location where consumption takes place, but the location where the production takes place owing to the fact that trading internationally and flows of capital enables the possibility of importing instead of producing some goods that could be destructive to the ecology [4].

This study addresses three areas that have not been exhaustively investigated in the literature. First, we employ the multi-dimensional ecological footprint data as compiled by Global Footprint Network to assess the environmental quality and depletion of natural resources. Second, we addressed the effects of renewable energy consumption on the ecological footprint in SSA region. Lastly, the multi-dimensions of globalization index (Dejure and De-facto), which has not been previously used in the literature were employed to determine its impact with other variables on the ecological footprint with a panel data analysis of 41 SSA countries in the period 1990 – 2019. The remainder of the paper is structured as follows: next section (section 2) addressed the review of previous relevant empirical studies. Section 3 presents the study methodology, and the findings, which are discussed and presented in Section 4, while conclusion and policy implications rounded up the paper in section 5.

Literature Review

The phenomenon called globalization is the dispersion or diffusion of capital, goods and services, technical knowledge, technology, humans themselves and the labor across national borders and divide. It also creates integration among nations, states and various markets, which in turn give rise to availability of varieties of people, ideas, information, goods and services.

Globalization is a "double edged sword" that provokes both positives and negatives notions to various nations and markets within varying circumstances because of its direct effect on the political, economic factors and the society generally. Globalization creates the condition that ensures potential job markets are widen and deepened. It creates bigger market opportunities by quick industrialization, and high commercialization. These in turn gives payoffs such as reduced poverty and inequality, environmental quality, which helps the overall economic growth of countries in the long run [5].

Two theories dominate the globalization discourse. Firstly, the neo liberals, who argued that globalization brings about creativity that encourages advancement in technology, and scientific development, through investment and external labor across the nations. The consequences of these also lead to temporal but significant job losses especially low skilled labor. The second theory from the hegemony school of thought sees globalization as the creation of new world order characterized by institutions like the World Bank, International Monetary Fund and the world Trade Organization. They argue that institutions create avenue for capitalist ideas of unrestricted market forces that breeds development and also affect in some negative ways the capacities and control of most developing countries. These create over exploitation of natural resources, environmental pollutions, neo-colonization, disregard for environmental practices that only seek self-interest and profit to the detriment of future generations [6].

Accordingly, Dreber, cited in Savina improved the literature of globalization by developing the KOF indices. This helps illuminate the analytical pathway to greater knowledge about the process of globalization. He developed the KOF globalization index, which is a composite indicator measuring globalization for every nation-state of the world along the political, social and economic dimensions. These indicators, which were updated in 2008, Savina argues aligns with the debate that globalization is a new and an unfolding process. Therefore, the knowledge of such process needs to be improved upon. Arguably, globalization is fast in some countries, and slow in others (Sub-Saharan African countries). This led to the revision of the KOF globalization index, where the economic variable was further sub-divided into the trade flows and the financial flows on the one hand, while on the other hand, a distinction between the defacto and the dejure globalization. Whereof, the defacto measures the actual international flows and activities, the dejure is focused on the measure of policies and conditions that facilitates or supports the flows and activities of globalization. Employing the revised KOF globalization index by Savina, this research revisits fresh evidences from the Sub-Saharan African countries to analyze the flows and activities as well as the policy structures, tax regimes and the regulatory framework in the Sub-region [7].

Ecological footprint is a resultant effect of all human activities, how much of nature has been utilized and left for further consumption or production. It is a measure of the addition of all ecological assets. It is a great indicator for how nature has been exploited, giving rise to a detailed view of exchange of a demand and supply ability of nature for human existence, and their commercial activities. The Ecological Footprint serves as a mirror that reflects the incapacity of monetary analyses to capture the consequences of the accelerating depletion of natural capital stocks of land, sea and air. This indicator helps reveal the pressures human are exerting on nature. It helps to

tract and project the consumption of living resources also and the level of carbon-waste of human population. It also draws a focus on the direct, indirect production and consumption activities of nature [8].

It is evident in the literature that the investigation of the relationship between "globalization" and "ecological footprint" has been receiving tremendous attention from researchers. For instance, the study of Figge utilized a panel study of 171 countries for investigating the nexus between "ecological footprint" (EF) and "globalization" where the KOF index was used as a measure of globalization. Their results gave various linkages, of different dimensions of globalization. While social globalization helps in the reduction of ecological footprint of consumption, economic globalization is a great aid of EF of consumption while overall "globalization" and the dimension of "political globalization" shows no significant impact on the EF of consumption. Furthermore, on their empirical panel study to explain the effect of globalization on EF, Figge, use another proxy of "Maastricht Globalization Index 2012" edition as a measure of globalization, their result shows a positive relationship between "globalization" and "ecological footprint"[9].

A more recent research by Ahmed, using the "Bayer and Hanck cointegration test" and the "autoregressive distributive lag bound test", to explain nature of relationship between "globalization" and the "ecological footprint" between the years 1971 to 2014. Their findings revealed that although globalization is a great precursor and aid of energy consumption, human population density and carbon footprint it is not a great determinant of "ecological footprint". Examining the nexus of economic growth and ecological footprint Clark, argue that while most developed nations carry out their economic activities in aid of growth through foreign direct investment to developing nations. These engagements have greatly outsourced and transferred their carbon emission problems, ecological footprint issues to their host nations when engaging in production and commercial activities. These actions gives the developed nations justifications, claims of reduction of emission and impact on ecological footprints in their own countries while they are actually transferring these burdens to host countries mainly the developing and emerging economies which consist mostly of Sub-Saharan Africa nations with less stringent regulations, environmental laws towards production activities [10].

More also, using autoregressive distributive lag bound test with structural breaks between the year 1971 to 2014, Danish, revealed that significant record of economic growth as it relates to human capital and biocapacity. The result shows that economic growth has a resultant effect on ecological footprint that contributes to environmental pollution and degradation while causality analysis suggests there is no causality regarding the relationship between economic growth and the ecological footprint. In addition, while investigating the effect of economic activities and growth via foreign direct investment on nations. Solarin & Al-mulali on study of 20 nations explained that economic growth shows a significant negative effect on ecological footprint thereby increasing environmental degradation when foreign direct investment serves as contributory factor of economic growth of nations.

Destek & Sarkodie, argue that the relationship between ecological footprint and economic growth is an inverted U-shaped relationship, while investigating the various element of ecological footprint of industrialized countries. This is supported by Destek & Sinha, which also shows a U-shaped link between "ecological footprint" and economic growth while investigating EKC hypothesis curve for ecological footprint in 24 countries. Udemba, states that the relationship between ecological footprint and economic activities reveal a growth-induced pollution. The research clearly shows a positive relationship between foreign direct investment of economies, energy use, and ecological footprint. This shows that both energy use and foreign economic activities are positively related to the ecology but gives an established negative effect on the environment and clearly supports the pollution haven hypothesis. In trying to study the kind of relationship that exist between renewable energy, Gross Domestic Product, Urbanization and trade openness and ecological footprint in developed countries Al-Mulal using fixed effect regression, difference and system GMM approaches states clearly that renewable energy has a positive impact on ecological footprint. A research by Ozturk while studying impact of income from tourism, urbanization, primary energy consumption, and trade openness on ecological footprint for 144 countries over the period 1988 to 2008 also shown that within EKC framework energy consumption greatly increases ecological footprint.

While investigating if income growth relocates ecological footprint using the impact of per capita GDP, trade openness, biological capacity, population density, industry share, per capita energy use, and environmental regulation on ecological footprint. Asici & Acar stated that the effect of per capita energy use on per capita production of footprint is negative, but has a positive impact on per capita import footprint. Tiwari analyzed the comparative performance of impact of renewable and non-renewable energy on economic growth in Europe and Eurasian countries. They argue that while the growth rate of non-renewable energy consumption has a negative impact on economic growth, an increase in renewable energy consumption has a positive impact on the economic growth of the nations. Marinas on a study of causality relationship between renewable energy and economic growth in Central and Eastern European countries from 1990 to 2014, found that there a bi-directional causality exist in the long run between the both in all the countries individually and as a group. A recent study by Venkatraja, using a panel estimation of BRIC (Brazil, Russia, India and China) countries from 1990 to 2015, to understand the effect of renewable energy consumption on economic growth supports the growth hypothesis. Their findings state that when renewable energy consumption reduces in the share of total energy it aids economic growth, but when it is on the increase it has a negative effect on economic growth.

From the literature mentioned, three conclusions arise. First, studies have revealed that there is a relationship between renewable energy consumption, globalization, economic growth and ecological footprint in various countries with mixed results. Second, even though several researchers have investigated the associations between the renewable energy consumption, globalization, economic growth as different entities individually

on ecological footprint, literature studying their implication on ecological footprint within Sub Saharan African countries bearing in mind that these countries are mostly developing countries are as of the time of writing, are nonexistent in the literature. The objective of this article is thus intended to fill this gap.

METHODS

This study employed a panel data that comprises of forty-one (41) "Sub-Saharan Africa" countries, which covers the period from 1990 to 2019. The period covered and the countries included are subject to the availability of data in respect of the variables utilized in the study. In our study, ecological footprint was used as dependent variable, while globalization and renewable energy consumption were utilized as the dependent variables. Meanwhile, some macroeconomic variables like renewable economic growth, foreign direct investment, and population were used as control variables. The ecological footprint (EF) was described as a "reliable tool for measuring environmental pressure exerted by human activities on our eco-system for consumption as well as waste absorption". The variable was measured as the effect of human activities in global hectares per person, and the data was taken from "Global Footprint Network 2020 Dataset" (GFN). The globalization index which measures the globalization for every country around the globe along the three dimensions of social, economic, political was considered. Meanwhile, the revised index which distinguishes between de facto and de jure globalization was used in this study. De facto globalization "measures actual international flows and activities" while de jure globalization "measures policies and conditions that, in principle, enable, facilitates and foster flows and activities". The data was sourced from "KOF Swiss Economic Institute" databank. The renewable energy consumption was measured as the total percentage of total energy consumption; the economic development was measured using "Gross capita product" (GDP constant 2010US$); foreign direct investment was measured as the "international inflow percentage of GDP), while the population is the total population. Meanwhile, these data were sourced from "World Bank Development Indicators".

Our study considered the panel ARDL/PMG to be one of the frequent used heterogeneous panel data estimators, however, Chudik & Peasarn and Wooldridge has criticized the model based on its inability to address the "cross-sectional dependency" issue. Thus, study of Cavalcanti and Chudik & Pesaran was followed and employed "Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL)" in addition to the panel ARDL/PMG. According to Chudik & Pesaran "the linear and average cross-sectional of both the dependent and independent variables were combined to capture the cross-sectional correlation in the error term". These authors echoed further that both the "mean group (MG)" and "pooled mean group estimation (PMG) are utilized in the CS-ARDL estimation. Meanwhile, note of earning was sounded that the "time dimension" (T) should be sufficient enough so as to enable the cross-country unit to be calculated for each. In addition, for the validity of the estimations to be guaranteed, the lagged cross-section average should be sufficient enough for inclusion.

Moreover, extant literature suggests that time series equations are estimated separately for each unit in the MG estimates, while the coefficients for individual units can be estimated as the "unweighted average" of the calculated coefficients. The studies opined that there is absence of restrictions that could be imposed by MG on the cross-sectional parameters. Thus, different intercepts and coefficients could exist, owing to the affordability of the highest degree of heterogeneity by the MG. However, the technique was criticized on the ground that when the small cross-country dimension (N) is small, it might be inefficient. Moreover, Arnold and Samardandi opined that MG is prone to any unit outliers who could alter the greatly mean of the "unit coefficients". Based on this viewpoint, the panel ARDL/PMG is considered to be an alternative. Over the years, this approach has been employed widely in several empirical studies owing to its being an intermediate process between the "mean" and "pooling methods" of estimations. According to Cavalcanti, Odugbesan & Rjoub, and Odugbesan & Rjoub two steps procedure are involved in the estimation of PMG. First is the estimation of "long-term slope coefficients" together from the individual units in the panel via concentrated likelihood techniques. Secondly, the intercept, "short-term coefficients", the "speed of adjustment", and the "error variance" are estimated through "maximum likelihood" on an individual basis owing to the long-term slope coefficient estimation. Odugbesan and Rjoub stressed that the "PMG are restricted to be homogeneous across the cross-sections", but allows for heterogeneity. Similarly, Samargandi observed that some consistency in the estimation of short-term coefficients across units averaging each of the units coefficients are being provided in the use of PMG approach owing to its "lagged cross-units dimensions".

Meanwhile, Cavalcanti and Samargandi opined that some conditions like existence of long-term relationship among the variables of interest should be fulfilled before using PMG approach. This condition can be ascertained through the examination of the negative and significance of the "error correction term" (ECT) coefficient. In addition, "the dynamic specification should be largely augmented so that the independent variables can be considered exogenous". Moreover, the residuals emanating from the estimation must be "serially uncorrelated". But, some studies suggested that the selection of the preferred estimation between MG and PMG approaches should be in reference to the imposition of "homogenous slopes" for the "long-term parameters" results.

In reference to a study, it was suggested that, "if the long-term coefficients are, in fact, not equal across countries, the MG estimates of the mean of long-term coefficients are consistent restrictions while the PMG estimates are inconsistent". But, "if the homogeneity restrictions are valid, estimators that impose cross-country constraints dominate the heterogeneous ones in terms of efficiency". But in reference to Smargandi, "when the long-run coefficients are the same for individual units, both MG and PMG estimates are consistent, which only the latter is efficient". Subsequently, in order to ensure consistency and

efficient of our estimates in reference to previous studies, our study consider PMG approach to be the best available compromise. Thus, our study empirical model is based on the panel "ARDL and CS-ARDL model specifications". The panel "ARDL model's error correction model" is mathematically presented as follows:

$$\Delta y_{it} = \omega_i + \alpha_i(y_{i,t-1} - \theta_i' x_{i,t-1}) + \sum_{j=1}^{p-1} \emptyset_{ij} \Delta_{yi,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \varepsilon_{it} \quad (1)$$

where in equation (1) yit is the ecological footprint (EF) for country i at time t. xit is a 6x1 vector of explanatory variables; defacto globalization (KOFGIDF), dejure globalization (KOFGIDJ), renewable energy consumption (REC), and some control variables; foreign direct investment (FDI), economic growth (GDP_CON), and population (POP). θi denote "the long-term equilibrium relationship between xit and yit while ϕij and δij capture the short-term dynamics between variables". αi represents "the speed of adjustment of the economic development to the long-term equilibrium". Meanwhile, terms in parenthesis denotes the cointegration relationship between xij and yit.

Irrespective of the exogeneity or otherwise of the independent variables, the "slope heterogeneity" is being accounted for together with different "orders of integration" in the variables in the conventional panel ARDL (Odugbesan, 2019; Odugbesan & Rjoub, 2020a). Meanwhile, some studies observed that if the "cross-sectional correlations" in the errors are not accounted for, there could be some problems (Odugebsan & Rjoub, 2019; Phillips and Sul, 2003). In view of this, Chudik et al. (2013) posits that the problem could be addressed through the use of panel CS-ARDL which it is believed to be sufficient owing to its augmentation of the right-hand side variables set with "cross-sectional averages" of the independent variables, dependent variables, and series of their lagged values. These additional terms are meant to address the "cross-sectional correlations in the error term". Thus, the equation (1) is modified and presented as follow:

$$\Delta y_{it} = \mu_i + \alpha_i(y_{i,t-1} - \theta_i' x_{i,t-1} + \alpha_i^{-1} \gamma_{i1} \bar{y}_t + \alpha_i^{-1} \Lambda_i' \bar{x}_t) + \sum_{j=1}^{p-1} \emptyset_{ij} \Delta_{yi,t-j} + \sum_{j=0}^{q-1} \delta_{ij} \Delta x_{i,t-j} + \sum_{j=0}^{p-1} \upsilon_{ik} \Delta \bar{y}_{t-j} + \sum_{j=0}^{q-1} \Lambda_{ik} \Delta \bar{x}_{t-j} + \varepsilon_{it} \quad (2)$$

The cross-section average of yit and xit are denoted by ȳt and x̄t. In equation (2), the "short-term" and "long-term" traits of the "cross-sectional correlation" are discerned. Moreover, there is inclusion of only the level parts of "cross-sectional averages" in the "long-term equilibrium" relationship in brackets. The "long-run coefficients" linked with yit and xit, which is θi, as well as the rate of adjustment back to equilibrium", αi, are the main coefficients of interest. Meanwhile, the short-run coefficients, ϕij, and δij should be reported to ensure completeness.

Results and Discussion

The summary of the descriptive statistics as presented in Table 1 shows the mean, maximum, minimum, and standard deviation. As presented, the "ecological footprint" per person ranges from 0.002 to 14.41 with an average of 2.78. The de jure globalization ranges from 18.01 to 72.61 with an average of 43.10, while de factor ranges from 18.01 to 80.83 with a mean value of 45.15.

Table1: Descriptive statistics

Variables	Mean	Maximum	Minimum	Std. Dev.	Obs.
EF	2.78	14.41	0.002	2.03	1230
FDI	12.72	567.83	-8.70	60.84	1230
GDP_CON	1986.48	20532.05	-0.97	2741	1230
KOFGIDJ	43.10	72.61	18.19	10.48	1230
KOFGIDF	45.15	80.83	18.01	10.11	1230
POP	17,859,007	200,963,599	337,950	26553682	1230
REC	69.59	98.34	5.35	23,50	1230

Unit Root Test

Though, the validity of panel ARDL approach is certain irrespective of the order of integration of the variables, i.e I(0) or I(1), however, the variables predictive potential should not lost. Thus, our study employed both LLC and IPS root tests with the view of ensuring that no variables in our model is I(2) and ensures the validity of our model, even though some studies has shown the lack of unit root test in the pre-estimation for ARDL approach. The results for the unit root tests are presented in Table 2. The table shows that the LLC confirms all the variables to be stable at level, with the exception of GDP_CON and POP which becomes stable at first difference. Meanwhile, IPS confirms EF, FDI, and KOFGIDJ to be stable at level while GDP_CON, KOFGIDF, POP and REC becomes stable at first difference. In summary, it is evident that based on the two tests, the variables in our model are either I(0) or I(1), and none is I(2), which is an indication that the model used in this study is correct.

Table2: Unit Root Tests

	Levin, Lin & Chu t*		Im, Pesaran and Shin W-stat	
Variable	Level	1ST Diff.	Level	1ST Diff.
EF	-7.16***	-	-10.89***	-
FDI	-8.78***	-	-9.01***	-
GDP_CON	-7.89	-12.58***	-8.73	-14.93***
KOFGIDF	-3.53***	-	-0.09	-30.02***
KOFGIDJ	-12.09***	-	-4.06***	-
POP	-18.23	-1.53**	18.31	-3.02**
REC	-2.41**	-	-0.043	-26.35***

Ho: Panels contains unit roots. ***indicate 1% significance level

Westerlund Panel Cointegration test

In order to maintain a consistent long-term equilibrium between the variables utilized in this study with the aim of preventing a false gradient in our estimation, the "Westerlund Cointegration Test" was performed to estimate the joint integration. This test consist of four tests, which are the Gt and Ga (first two test) that test the null hypothesis with no common integration, and the Pt and Pa (the second two tests) that combines in at least one unit to test the alternative hypothesis. The results from these tests are presented in Table 3 which shows that the economic development as the dependent variable has a long-term integrative relationship with governance effectiveness, natural resources, and security threats. This is as a result of the three of the tests that reject the zero hypothesis and suggest an existence of long-term relationship. Suffice to say that, the "Westerlund Panel Cointegration Test" shows that the variables in our model complement each other.

Table3: Westerlund Panel Cointegration Test

Test	Panel
Gt	-3.40*
Ga	-5.43**
Pt	-18.01**
Pa	-8.55

**, * indicate 1% and 5% significance level respectively

The long-run and short-run estimates

Based on the results obtained from the Westerlund panel cointegration test which gives an indication of a long-run relationship among the variables; thus, we proceeded to investigate the long-run and short-run causal relationship of the each regressor with the ecological footprint. In doing this, we applied both PMG and CS_ARDL approach. As stated earlier, owing to the sensitivity of the MG to the unit outliers, we consider PMG estimation and the result derived from the ECM specification in equation (1) are presented in Table 4 (column 2).

The determination of the ARDL model lag order according to Loaya and Ranciere generally involves a trade-off between enough length and "over-extension", which is due to few time-series dimension. It is worthy to note that several studies have applied different approaches to lag selection, and sizeable number of them has imposed a common lag structure for all dimensions, while Arnold and Cavalcanti suggested that the lag selection should be in accordance to information criterion. In view of this, the lag selection in this study is through BIC, which is subject to a maximum lag of 2 on each of the explanatory variables in our model and resulted in the model incorporating a single period lag on each variable as presented in column 2 of Table 4.

Table4: Estimates results of long and short-run effects.

	PMG	CS-ARDL
No. of lagged	1	2
Long-run Equation		
ΔGDP_CON	-0.08(0.07)	-0.034**(0.06)
ΔKOFGIDF	0.016***(0.004)	0.027***(0.005)
ΔKOFGIDJ	0.028***(0.008)	0.036***(0.010)
ΔLnPOP	-0.429** (0.177)	-0.318** (0.167)
ΔREC	-0.349** (0.180)	0.124** (0.097)
ΔFDI	-0.007***(0.002)	-0.010***(0.002)
Short-run Equation		
ECT	-0.88***(.053)	-.754***(.183)
GDP_CON	0.84 (2.69)	0.64 (1.01)
KOFGIDF	0.013(.030)	0.023(.010)
KOFGIDJ	-0.072(0.058)	-0.063(0.077)
LnPOP	103.74(147.37)	87.74**(100.37)
REC	-0..813(1.977)	-0..703**(1.977)
FDI	0.10**(3.37)	0.07**(2.17)
Constant	7.776***(1.386)	0.84 (2.69)
Obs	1143	1143
Pesaran CD	12.411	-0.512
P-Value	0	0.432

Note: *, **, *** denotes 10%, 5%, and 1% significance level respectively. Values in parentheses are standard error.

As presented in Table 4 (column 2) in the upper part, the first model using PMG reveal that all the variables utilized in the model except GDP has a significant long-run causal relationship with ecological footprint. The significance of dejure and defacto globalization is an indication that globalization in SSA countries has reached a level where it could influence the ecological footprint. Moreover, the short-run results as presented in Table 4 (lower part) shows that only foreign direct investment shows a significant causal relationship with ecological footprint in the short-run, meanwhile, the finding revealed that the coefficient is significant at less than 1% confidence level. Lastly, the ECT coefficient (-0.88) is statistically significant at less than 1% Significance level, which indicates that the systems return back to equilibrium in case of a shock that causes disequilibrium, and in addition, reveals a stable long-run cointegration among the variables in the model.

Meanwhile, the validity of the PMG estimation was subjected to "cross-sectionally independent" test in line with the study of Cavalcanti and Chudik & Pesaran which was examined through "cross-section dependence (CD) test". Specifically, according to Odugbesan & Rjoub, the correlation coefficients between the time-series for each of the dimensions in the panel were utilized. CD measurement is standard typically appropriated under the H0 of "cross-section independence"; in this way the H0 is dismissed when the p-value is under 0.05. This means that the PMG assessor inability to address the "cross-unit dependence" delivers the precision of PMG appraisals to responsible to predisposition. To address this deficiency, the CS-ARDL approach is utilized, which includes the consideration of extra slacked cross-sectional midpoints of both the dependent and independent factors in the assessment.

In reference to the studies of Chudik & Pesaran and Eberhardt & Presbitero who suggested a lag length of 2, while Chudik & Pesaran opined that the lag length should not exceed 3, thus, our study selected 2 lags for our estimation. The outcomes are introduced in segment 3 of Table 4. Under the CS-ARDL technique, the H0 of "cross-sectional" reliance in the Pesaran CD test isn't dismissed, which means that any "cross-sectional" reliance brought about by basic components have been tended to when the relapse is enlarged with the slacked cross-sectional midpoints. Inferable from this, the evaluations under the CS-ARDL model is liked in this investigation.

The outcomes introduced in segment 3 of Table 4 shows that the assessed coefficient of ECT (- 0.754) is negative and significant, which is predictable with past examinations that for a framework to show the capacity of getting back to equilibrium in the reason for a stun, the ECT coefficient should be negative and the p-value less than 0.05. The negative coefficient and meaning of the ECT coefficient of our evaluations means that our framework will return back to equilibrium for the situation there is stun in the model. Also, the negative and meaning of the ECT coefficient show a stable "long-run cointegration" among the factors in the assessment. The appraisals result, as introduced in upper piece of Table 4 (segment 3) shows KOFGIDF, KOFGIDJ and REC to have positive and huge coefficients. The outcome shows that a change in de facto globalization, de jure globalization and renewable energy consumption will significantly cause positive and significant changes in the ecological footprint of SSA countries in the long-run at 1%, 1%, and 5% significance level respectively, while GDP_CON, POP and FDI reveals a significant negative causal relationship with ecological footprint in the long-run. The positive and significant causal relationship found in this study is consistent with the position of some studies that opined that globalization increase environmental quality, but contradict those studies that demonstrates a negative contribution of globalization to ecological footprint and those that could not find a relationship between globalization and ecological footprint. The examination of the implication of renewable energy consumption (REC) on ecological footprint from model 2 reveals that the variable has a positive and significant causal relationship with ecological footprint. The result suggests that a change in REC will trigger about 0.124% increase in the ecological footprint of SSA countries. This finding is in congruent with previous studies that established similar results. Moreover, economic growth (GDP_CON) was found to have a negative and significant causal relationship with ecological footprint the finding is consistent with some previous studies who have established similar result. Though, Destek & Sarkodie and Destek & Sinha observed that the relationship is an inverted U-shaped. Meanwhile, the positive causal relationship found in our study contradicts the position of Solarin & Al-Mulal and Udemba who found negative relationship between GDP and ecological footprint in their studies. Uniquely in contrast to the PMG technique for the short-run, the CS-ARDL shows POP, REC and FDI to have a huge causal relationship with environmental impression in the short-run. It is qualified to take note of that the utilization of CS-ARDL model, as introduced in segment 3 of Table 4 proposes that the issues of "cross-section" midpoints to a great extent lessens lingering cross-section reliance, as apparent in the CD measurement (-0.512) and p-value (0.432). This means that results from the CS-ARDL assessment are substantial and without any inclination.

CONCLUSION

Though, several studies have empirically examined the relationship between globalization and ecological footprint, but the investigation of dejure and defacto globalization has not been empirically investigated, especially within the context of SSA countries. The previous studies findings of studies that examined the effect of total globalization index on ecological footprint have been mixed. This issue was addressed in this study in line with the suggestion position of Gygli that reviewed the globalization index and developed the two indexes. Hence, we investigate the implications of these variables together with economic growth, renewable energy consumption, population, and foreign direct investment as control variables using a panel data of 41 SSA countries from 1990 to 2019 and employed Westerlund panel cointegration test, PMG and CS-ARDL estimators. Our finding indicates that the globalization has a significant causal relationship with ecological footprint in SSA countries. In addition, economic growth, population, renewable energy consumption and foreign direct investment show to be significant drivers for ecological footprint. Meanwhile, while dejure and defacto globalization and renewable energy consumption mitigate ecological footprint, economic growth, population, and foreign direct investment seems to be a significant factors that triggers ecological footprint in SSA countries.

This study has some policy implications. It is recommends that policy makers in SSA countries should formulate policies that will control the exploitation of natural resources within the region; this will ameliorate the excessive pressure on the environment as revealed from our finding. The increase in SSA countries population is growing geometrically with the attendant implication on the use of natural resources, hence the need for population control with the region. Moreover, SSA countries interaction with other nations should be strengthening, and policy for intensification on environmental awareness should be put in place. Meanwhile, the policy to analyze the environmental viability of foreign investment should be put in

place by the policy makers, and in addition actions should be taken to safeguard businesses that are deploying outdated technologies. The foreign investors should be encouraged to use cleaner technology, as well as investing in cleaner energy projects through the provision of incentives. To sum it up, environmental policies in SSA countries should focus on enhancing people's awareness on the danger of over exploitation of natural resources, so that the achievement of environmental sustainability within the region would not be a mirage. Future studies should replicate this model on a country-specific context of countries within SSA.

List of abbreviations

CS-ARDL: Cross Sectional Autoregressive Distributed Lag

ECT: Error Correction Term

EKC: Environmental Kuznet Curve

FDI: Foreign Direct Investment

GDP: Gross Domestic Product

GFN: Global Footprint Network

MG: Mean Group

PMG: Pooled Mean Group

SSA: Sub-Saharan Africa

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