DOES THE NEXUS BETWEEN REMITTANCES, AND ECOLOGICAL FOOTPRINT MATTER FOR ENVIRONMENTAL SUSTAINABILITY IN AFRICA?

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Abstract

This study examines the effect of the nexus between remittances and ecological footprints on environmental sustainability in Africa for 19 African countries between 1990 and 2021. Both the Augmented Mean Group and Common-Correlation Effect Mean Group estimator, show that remittances and economic growth have a positive effect on ecological footprint. More so, there exists bidirectional causality between remittances, economic growth, and ecological footprint while unidirectional causality runs from ecological footprints to foreign direct investment and foreign direct investment to economic growth. To promote environmental sustainability, individual governments, and regional blocs, must ensure the trade-off and prioritization of net-zero emissions goals in Africa to move beyond mere policy documentation and into non-fossil fuel revenue-dependent and strict market regulation on remittances to promote green consumptions and sustainable livelihoods in Africa.

Keywords: Ecological footprint, Migrant Remittances, Foreign Direct Investment, Economic Growth, Environmental Sustainability, CO_2 $emissions$, Africa

JEL Classification: Q5

1. INTRODUCTION

The concern for environmental sustainability has led to different global attempts and propositions, ranging from the Intergovernmental Panel on Climate Change to the Sustainable Development Goals, in mitigating human activities on the increased greenhouse gas emissions, deforestation, pollution, resource depletion, and degradation of the ecosystem. Economic growth tends to increase the demand and pressure on the environment for resources to meet both the industrial and domestic needs of humans. Ahmad et al. (2020) and Usman and Hammar (2021) confirm the significance of economic growth to increasing environmental degradation. In the analysis of environmental sustainability, foreign direct investment (FDI) has also been proven to be both a "pollution haven", where, in the pursuit of lower costs, FDI increases environmental degradation, and a "pollution halo", where FDI helps reduce environmental degradation through the transfer of greener technology (Kivyiro and

Arminen, 2014; Musah et al., 2022; Rahman et al., 2019). In recent times, remittance flows from migrants to their home countries have gained considerable attention, as they now surpass all other sources of external finance including FDI, official development assistance, and portfolio investment flows to Low-and middle-income countries excluding China, reaching $597 billion in 2021 KNOMAD (2022). This makes the macroeconomic potential of remittances important for environmental sustainability, as remittances can help stabilize income and consumption, improve financial development, and play other macroeconomic roles. This study seeks to explore the nexus between remittances, and ecological footprints in Africa. In contrast to previous studies that have mostly used CO_2 emissions to justify environmental quality, this study uses ecological footprints as a proxy for environmental sustainability. The ecological footprints analysis consist of six measures covering forest land, fishing grounds, cropland, carbon footprint, grazing land, and built-up land, hence ecological footprints tends to provide a wider measure of environmental quality against the limited scope of CO_2 emissions commonly used in previous studies Ulucak and Apergis (2018); Usman and Hammar (2021). To the best of my knowledge, this study will be the first to employ ecological footprints analysis in the exploration of the nexus between remittances, and environmental sustainability in Africa. (Asumadu-Sarkodie and Owusu (2016); Kivyiro and Arminen (2014); Muhammad (2019); Musah et al. (2020); Shahbaz et al. (2013). This study will overcome the error of miss-measurement of remittances in previous studies Cazachevici et al. (2020) through the introduction of FDI into the analysis. Moreover, this study will contribute to the little available literature on the effect of remittances on ecological footprints, as to the best of my knowledge, only one study, Yang et al. (2021) has examined the relationship between remittances and ecological footprint for the BICS countries. The Augmented mean Group Eberhardt and Teal (2011), Common-Correlated Effects mean group (Bond and Eberhardt (2013); Pesaran (2006), and Dumitrescu and Hurlin (2012) causality estimator, are employed to show how remittance inflows, FDI, and economic growth influence ecological footprint in Africa.

The article is arranged as follows: the "literature review" section, articulates the theoretical framework and current state of knowledge on the nexus between remittances, FDI, economic growth, and the environment. The following section, "model construction and methodology" presents the data, model specification, and econometrics procedure. "Results and discussion" section presents the results and interpretation of the econometrics. The final section contains the conclusion and policy recommendations from the study.

2. LITERATURE REVIEW

This section is divided into two sub-sections: the first is the theoretical framework on how remittances influence environmental sustainability, the second summaries empirical studies on remittances, FDI, economic growth, and environmental sustainability.

2.1 THEORETICAL PERSPECTIVE

This study will employ the five-stage interaction mechanism establishing a theoretical linkage between remittances and environmental sustainability developed by Ahmad et al. (2019). In the first stage, remittances increase household income as they are mostly sent to support family members in their home country (Cuong and Linh (2018); Mondal and Khanam (2018); Osili (2007). In the second and third stages, the increase in household income induced by remittance inflow boosts aggregate consumption and savings of household members in the receiving countries. This also increases bank deposits and savings for the financial sector in the home economy as financial transactions will adjust upward (Clemens and Tiongson, 2017; Sierminska and Takhtamanova (2012). In the fourth stage, industrial production increases due to increased demand for goods and services created by increased household income induced by remittance inflow. This leads to an associated increase in the operation of the financial sector as bank deposits and savings adjust upward. The financial sector increases its operational base, grants more loans to businesses, and finances other capital projects in the domestic economy. In the fifth stage, both an increase in industrial production and financial sector performances boosts economic activities. As economic activities increase, more pressure is placed on the environment to supply natural resources, which increases environmental pollution, resource depletion, deforestation, climate change, waste generation, land degradation, and water scarcity (Bakhsh et al., 2017; Fotis and Pekka, 2017; Shahbaz et al., 2013). The effect of remittances and economic growth on the environment can be assessed through ecological footprint. Ecological footprint measures the impact of human activity on the environment by estimating the amount of biologically productive land and sea area needed to provide the renewable resources consumed and to absorb the wastes generated by a given population. Through the five-stage-interaction mechanism, the role of remittances and economic growth on the environment can be assessed using ecological footprints as a proxy.

2.2 EMPIRICAL EVIDENCE

This section summarizes relevant empirical analysis on the nexus between remittances, FDI, economic growth, and ecological footprint for environmental sustainability. This section has also been divided into three parts.

Remittances and the environment

Previous studies on how remittances affect environmental sustainability mostly considered CO_2 emissions as the only proxy to ascertain the state of environmental sustainability in different regions of the world. However, CO_2 emissions only describe the emission of gases while ecological footprint contains six different kinds of measurement on the human use of bio-productivity: forest land, fishing grounds, cropland, carbon footprint, grazing land, and build-up land. To the best of my knowledge, only the study of Yang et al. (2021) uses ecological footprint to determine the role of remittances on environmental sustainability for the BICS countries. Yang et al. (2021) concluded that remittances immensely contribute to environmental deterioration for the BICS countries as the elasticity of remittances was found positive and significant on the ecological footprint in their study. However, other studies that use CO_2 emissions to uncover the influence of remittances on the environment have mixed findings. A number of studies show that remittance inflow worsens the state of the environment (Ahmad et al. (2020); Ali Shah et al. (2023); Khan et al. (2020); Md. M. Rahman et al. (2021), while others conclude that remittances can help promote environmental sustainability as they were found to have a significant negative effect on CO_2 emissions (Sharma et al. (2018); Zafar et al. (2022). In a global study of 97 countries, Yang et al. (2020) reported that remittances increase CO_2 emissions. However, Edwards (2022) concluded that higher remittance inflow will bring about improvement in the state of the environment, as remittances have a negative and significant relationship with greenhouse gas emissions using a panel data analysis for 127 countries. Li et al. (2022) also found that remittances have a negative impact on environmental sustainability in Ghana.

Foreign direct investment and the environment

Foreign direct investment (FDI) is another vital source of external finances for low- and middle-income countries. Similar to the role of remittances, FDI can influence environmental sustainability, positively or negatively. FDI will increase capital inflow in the receiving economy, and this will adjust industrial production upward, leading to economic growth. Through economic growth, FDI can contribute to worsening the state of the environment in the presence of industrial pollution, resource extraction, and exploitation. FDI can also be used to promote green investment, green technology, and higher environmental standards that will advance environmental sustainability. This twin role of FDI on environmental sustainability has led to the debate on the pollution haven hypothesis, where FDI negatively affects environmental sustainability, and the pollution halo hypothesis, where FDI enhances environmental sustainability. The study of Usman et al. (2020), confirms the pollution halo hypothesis while the results of a number of studies supported the pollution haven hypothesis, as FDI increases CO_2 emissions (Khan et al. (2020); Musah, Adjei Mensah, et al. (2022); Musah, Owusu-Akomeah, et al. (2022); Z. Rahman et al. (2019); Zmami and Ben-Salha, (2020). Gharnit et al. (2019) concluded that for 54 African countries FDIs have been harmful to environmental sustainability. Aghasafari et al. (2021) also found FDI degraded environmental sustainability in the Middle East and North Africa. Assi (2018) also confirmed the pollution haven hypothesis for the Ivory Coast. Kivyiro and Arminen (2014) found FDI supported the pollution haven hypothesis in Kenya, and Zimbabwe, but in the Democratic Republic of Congo, South Africa, and Zambia support for the halo hypothesis was apparent.

Economic Growth and the Environmental

Economic growth has been the major driver of global emissions since the beginning of the industrial age (IEA, 2022). Increased economic activities have led to over-exploitation of natural resources, deforestation, pollution, and environmental degradation. The environmental Kuznets curve (EKC) hypothesis has been mostly utilized to explore the relationship between economic growth and environmental quality (Ahmad et al. (2020); Brown et al. (2020); Destek & Sarkodie, (2019); Dogan et al. (2020); Konan and Aklobessi (2021); Tachega et al. (2021). Shahbaz et al. (2013) found economic growth increased CO_2 emissions in South Africa over the period 1965-2008 and Appiah et al. (2017) revealed that economic growth contributed to increased CO_2 emissions in Ghana between 1970 and 2016. More recently, Musah et al. (2021) also affirmed the conclusion that economic growth increases the rate of CO_2 emissions for North African countries.

3. MODEL CONSTRUCTION AND DATA

To demonstrate the nexus between remittances, FDI, and economic growth on the ecological footprint for environmental sustainability in Africa, a liner economic model is expressed as follows:

$$EE = f\,(RM, FD, GDP) \qquad \text{(i)}$$

Where EE represents ecological footprint (a proxy for environmental sustainability), RM signifies remittances, FD is FDI, and GDP equals GDP per capita (a proxy for economic growth). Both FD and GDP serve as the control variables in this model.

The underlying model can further be expressed as a panel version of the econometrics procedure intended, where

$$EE_{it} = \alpha_O + B_1 RM_{it} + B_2 FD_{it} + B_3 GDP_{it} + €_{it} \qquad \text{(ii)}$$

Where the subscript i represents a cross-section of the African countries included in the panel data analysis (Algeria, Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Egypt, Gabon, Ghana, Kenya, Lesotho, Mali, Morocco, Nigeria, Rwanda, Senegal, Sierra Leon, South Africa, Togo, and Tunisia); t indicate the number of years considered in this study (1990-2021); α_O is the intercept parameter; B_k (K=1,2,3) which are the parameters for the estimate of EE which are to be predicted. The above equation (ii) is also transformed into the log function, to be able to interpret the elasticity for the estimated parameters.

$$Inee_{it} = \alpha_O + B_1 Inrm_{it} + B_2 Infd_{it} + B_3 Ingdp_{it} + €_{it} \qquad \text{(iii)}$$

Where $Inee_{it}$ represents the dependent variables and the natural logarithm of the ecological footprint. A positive figure on $Inee_{it}$ can be interpreted as negatively affecting environmental sustainability in Africa, while a negative figure will be interpreted as improving environmental sustainability in Africa. The African countries and the period of 1990-2021 chosen for this study, was based on data availability, as other African countries have many missing observation.

Table I reports the variables, symbols, units of measurement, and data sources for all the variables used in this study. Where GFN refers to the Global Footprint Websites and WDI refers to the World Bank Indicators where respective data will be sourced.

Table 1: *Description of Variables*

Variables Source	Symbol	Measure
Ecological Footprint GFN (2023)	Inee	Global hectares of Land per capital
Remittances WDI (2023)	Inrm	Personal remittances received (current US$)
Foreign Direct Investment WDI (2023)	Infd	Foreign Direct Investment (BOP, current US$)
Economic Growth WDI (2023)	Ingdp	GDP per capita (constant 2015 US$)

Source: Author Computation.

Table 2 shows the statistical characteristics of the variables in the dataset. nrm has the highest mean with a value of (19.421) and a std. Dev (0.364), followed by Infd with a mean value of (19.173) and a std. Dev of (2.343), Ingdp (7.270) and a std. Dev of (0.816), and Inee with a mean value of (0.278) and a std. Dev of (0.364). Considering the Min and Max values of Inrm and Infd, we can deduce that there exist significant disparities in Remittance and FDI across the African countries in this study. Also, all the variables can be seen to be positively skewed except for Infd which is negatively skewed with a value of (-1.353). More so, all the variables are Leptokurtic since they have a positive kurtosis peak and a value higher than 3 except for Ingdp with a value of (2.300). The outcome of the descriptive statistics of the dataset will necessitate further preliminary analysis to ensure the reliability and robustness of the estimation outcome of the model.

Table 2: *Descriptive Statistics*

Variables	Mean	Std. Dev.	Min	Max	Skewness	Kurtosis
Inee	0.278	0.364	-0.570	1.392	0.609	3.896
Inrm	19.421	2.233	10.206	24.173	0.514	4.021
Infd	19.172	2.343	6.908	24.444	-I.353	7.337
Ingdp	7.270	0.816	5.249	9.101	0.283	2.300

Source: Author Computation.

Note: Min and Max show the Minimum and Maximum values of all variables; Std. Dev is the standard deviation.

Table 3 contains the result from the pairwise correlation matrix. Given the decision criteria of variables with a value of (0.85) coefficient and above are mostly collinear and yield a spurious estimate Gujarati and Porter (2009); Kock and Lynn (2012); Lee (2006). The dataset does not suffer from the problem of multicollinearity, since the coefficient value of all the variables is less than the value of (0.85),

Table 3: *Correlation Matrix*

	Inee	Inrm	Infd	Ingdp
Inee	1			
Inrm	0.196*	1		
Infd	0.401*	0.544*	1	
Ingdp	0.749*	0.330*	0.593*	1

Source: Author Computation.

*Note: ***,**,* show the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively.*

Table 4 further presents a robustness test for the presence of multicollinearity in the model to overcome the spuriosity of the estimate. Since the mean VIF value for all the explanatory variables is (1.62), and is less than 10, we can also conclude, that the dataset does not suffer from the problem of multicollinearity following the decision criterion of Kock and Lynn (2012).

Table 4: *Variance Inflation Factor Analysis Result*

Variable	VIF	1/VIF	Mean VIF
Inrm	1.89	0.529	1.62
Infd	1.55	0.644	
Ingdp	1.43	0.699	

Source: Author Computation.

3.1 ECONOMETRIC METHODOLOGY

The econometric approaches to be utilized in this study are subject to the test of cross-sectional dependency and slope heterogeneity to verify the appropriate econometric procedure that will yield a reliable and unbiased elasticity estimate. Secondly, there is a need to confirm the order of stationarity among the variables, using the second-generation unit root test. Thirdly, the study will test for cointegration to determine whether there exist long-run associations between the variables. If the long-run relationship is validated, the study can then estimate a long-run regression test to obtain the elasticities for Inee in the model. Also, the study will use another long-run regression estimator to serve as the robustness check for this study. Finally, the study can then, determine the causal relationship between the variables. STATA 15 will be used for the econometric analysis.

Cross-sectional dependency (CSD) test

One major problem with panel data analysis is the issue of CSD. CSD occurs due to the close similarities within the cross-sectional units in the panel dataset, in terms of geographic factors, resource endowment, trades, laws, culture, and other factors. This makes macroeconomic shock in one cross-sectional unit exert a similar influence on the other cross-sectional units within the panel data set. As these African countries are similar in terms of geography, resources, economics, and law, we expect some forms of CSD problem in the panel dataset. Hence, following Khan et al. (2020); Xue et al. (2021), the CSD test Pesaran (2004) is used to confirm the presence of CSD in the dataset. The null hypothesis for Pesaran's CSD test is cross-sectional independence and can be expressed as:

$$CD= \sqrt{\frac{2}{N(N-1)}} \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} T_{ij}\, \hat{\rho}_{ij}^{2} \rightarrow N\,(0,\,1) \qquad \text{(iii)}$$

Table 5 shows the results for the Pesaran's CSD test statistics, and at a 1% level of significance, the null hypothesis of cross-sectional independence is rejected. Therefore, confirming that there exists a sort of cross-sectional dependence among the series. This is justifiable for the African nations included in this study since their economic structure is similar, and they mostly belong to the same regional blocs, whose policies are jointly implemented.

Table 5: *(Pesaran, 2004) Cross-sectional dependency test*

Variables	CSD-Statistic	Probability
Inee	9.38***	0.00
Inrm	41.64***	0.00
Infd	41.78***	0.00
Ingdp	46.80***	0.00

Source: Author Computation.

*Note: ***,**,* show the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively.*

Slope heterogeneity (SH) test

Given the presence of CSD in the dataset, the SH was also ascertained, as the slope coefficient of variables can differ across the cross-sectional units, and failure to account for such will yield biased elasticity estimates in the model (Munir et al., 2020**).** This study uses the Pesaran and Yamagata (2008) slope homogeneity (SH) test statistics. The SH test predicts two test statistics ($\tilde{\Delta}$ and $\tilde{\Delta}\, adj$) under the null hypothesis of slope homogeneity, meaning the slope coefficient of the cross-sectional units in the panel dataset is the same, and a rejection of the null hypothesis would affirm that there exists slope heterogeneity in the dataset, which indicate that, the slope coefficients of the cross-sectional units are different across the cross-sectional units.

Table 6 presents the result from the Pesaran and Yamagata (2008) SH test statistics**.** The statistical significance of the Pesaran and Yamagata (2008) SH test**,** at a 1% significance level, rejects the null hypothesis of cross-section independence, therefore confirming the existence of slope heterogeneity among the variables in the model.

Table 6: *Pesaran and Yamagata (2008) Slope homogeneity test*

Test	Statistic	p-Value
$\tilde{\Delta}$	21.370***	0.000
$\tilde{\Delta}$ adj	23.422***	0.000

Source: Author Computation.

*Note: ***,**,* show the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively.*

Panel unit root (PUR) test

The presence of CSD in the dataset will allow for the adoption of Pesaran (2007) second-generation PUR estimator using the cross-sectionally Augmented Dickey-Fuller (CADF), and the cross-sectionally Augmented Im-Pesaran-Shin (CIPS) panel unit root tests in line with Xue et al. (2021); Zeraibi et al. (2021). These PUR estimators are tested under the null hypotheses of non-stationarity, and the rejection of the null hypotheses will infer that the variables are stationary. More so, it's believed that the second-generation PUR gives a reliable stationarity estimate in the presence of CSD. Li et al. (2021) and Wang et al. (2020). Also, worth noting is that the CIPS test is based on the CADF unit root test and the regression model for the CADF test can be specified as follows:

$$\Delta\gamma_{it} = \alpha_i+\rho_i y_{it-1}+\beta_i\bar{y}_{t-1}+\sum_{j=0}^{k}\gamma_{ij}\,\Delta\bar{y}_{it-1}+\sum_{j=0}^{k}\delta_{ij}\,y_{it-1}+\varepsilon_{it} \quad \text{(iv)}$$

Where α_i, k, and $\bar{y}_t$are the deterministic term, lag order, and the cross-sectional mean of time t. Also, the t-statistics are computed using the ADF statistics for each cross-section. More so, taking the average of the CADF statistics for each cross-section unit will give the CIPS statistics as follows;

$$\text{CIPS} = (\frac{1}{N})\sum_{i=1}^{N} t_i\,(N,T) \quad \text{(v)}$$

Panel cointegration (PC) test

The Westerlund (2007) PC test, which is capable of handling CSD is applied to determine whether cointegration exist among the variables. The Westerlund (2007) PC test account for two groups' estimate: $G_t, and\ G_\propto$, and are predicted under the null hypothesis of non-cointegration while the two-panel test: $P_t, P_\propto$ are predicted under an alternative hypothesis of cointegration among the panel series. The Westerlund (2007) PC can be expressed as:

$$\Delta Y_{it}=\delta' d_t+\propto_i(Y_{it-1}-\beta'_i X_{it-1})+\sum_{j=1}^{P_i}\propto_{ij}\Delta y_{it-j}+\sum_{j=-p_i}^{P_i}Y_{ij}\,\Delta x_{i,t-j}+\mu_{it} \quad \text{(vi)}$$

Where ΔY_{it} contains deterministic trend and indicate the unit of cross–sections and time dimensions.

Panel Regression (PR) Analysis

Given the presence of CSD and SH in the dataset, common PR estimators like the generalized method of moments (GMM), random effect, and fixed effect would give a biased estimate, since these estimators assume the slope coefficient to be homogenous, which is not the case in this analysis. Hence, following Khan et at.(2020) and Xue et al.(2021), the Augmented Mean Group (AMG) of Eberhardt and Teal (2011) is used to predict the elasticity. The AMG estimator is capable of controlling for the effect of CSD, SH, and PUR and also predicts the elasticity for the individual countries included in the panel dataset Eberhardt and Teal (2011). The AMG estimator is only a long-run elasticity estimator and hence, does not predict the short-run elasticities.

The AMG estimator involves a two-step procedure.

AMG-stage 1: $\Delta y_{it} = \propto_i + b_i \Delta x_{it} + c_i f_t + \sum_{t=2}^{T} d_t \, \Delta D_t + \varepsilon_{it}$ (vii)

AMG-stage 2: $\hat{b}_{AMG} = N^{-1} \sum_{i=1}^{N} \hat{b}_i$ (viii)

Where f_t is the unobserved common factor, while y_{it} and $x_{it}$are the observables. $b_i$as the country-specific estimates of coefficients, d_t is the time dummies, and $\hat{b}_{AMG}$ is the AMG estimator.

We also use the Common-Correlated Effects Mean Group (CCEMG) estimators Bond and Eberhardt (2013); Pesaran (2006) to serve as the robustness check for the AMG estimator. The CCEMG estimator is also capable of controlling for the effect of CSD, SH, and PUR and also predicts the elasticity for the individual countries included in the panel data Bond and Eberhardt (2013) and Pesaran (2006)

Panel Causality (PC) Test

After using the AMG and the CCEMG estimator to account for the long-run elasticities, we then use the Dumitrescu and Hurlin (2012) PC test to account for the causal association between Inee and other explanatory variables, since the conventional Granger (1969) PC test will assume slope homogeneity and yield a bias estimate. The Dumitrescu and Hurlin (2012) causality test control for CSD using a bootstrapped approach and also allows for causality between a pair of stationary variables in at least one of the cross-sectional units. The Z-bar Statistics under the Dumitrescu and Hurlin (2012) causality test can be expressed as:

$$\bar{Z}_{N,T}^{HNC} = \frac{\sqrt{N}}{\sqrt{Var(\widetilde{W}_{i,T})}} [W_{N,T}^{HNC} - \mathrm{E}\widetilde{W}_{i,T}] \quad \text{(ix)}$$

4. RESULTS AND DISCUSSION

Table 7 presents the results of the PUR test employed in this study. Both the CIPS and CADF unit root test confirm the stationarity of the variables, as the null hypothesis of nonstationary were rejected across the two PUR unit root test in their First difference. Although Inee, Inrm, and Infd were found stationary at a level while Ingdp was found stationary only at the First difference. The stationary of the variables will prevent spurious outcomes for the model estimates, which indeed is the advantage of using the second-generation PUR test over the first-generation PUR, as CSD is accounted for in the former PUR estimators.

Table 7: *Panel unit root test*

	CADF test		CIPS test	
	First difference	Level	First difference	Level
Inee	-2.540***	-5.876***	-1.439*	-8.151***
Inrm	-2.335**	-4.953***	-2.101**	-5.372***
Infd	-2.656***	-5.516***	-4.124***	-6.518***
Ingdp	-1.645	-4.391***	0.368	-3.592***

Source: Author Computation.

*Note: ***,**,* show the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively.*

Table 8 shows the results from the Westerlund (2007) PC test, where Inee is taken to be the dependent variable, and the rejection of the null hypothesis in the panel group test and the group-specific tests confirmed the presence of cointegration in the whole panel sample. This certifies the presence of a long-run relationship between Remittances (Inrm), foreign direct investment (Infd), Economic growth (Ingdp), and Ecological footprint (Inee) in the selected African countries from 1990 to 2021.

Table 8: *Westerlund Cointegration test*

Test	Statistics	Value	p-Values
Gt	-1.954	-2.379	0.009***
Ga	-6.274	-0.359	0.360
Pt	-8.404	-3.251	0.001***
Pa	-5.889	-3.013	0.000***

Source: Author Computation.

*Note: ***,**,* show the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively.*

Table 9: *AMG, and CCEMG estimation result*

	AMG						CCEMG		
Lnee	Inrm	Infd	Ingdp			Inrm	Infd	Ingdp	
Panel	0.069**	-0.034	0.376**			0.023**	-0.080	0.299**	
	(0.020)	(0.069)	(0.105)			(0.169)	(0.076)	(0.030)	
Algeria	0.013**	-0.005*	0.156**			0.015**	-0.008*	0.855**	
	(0.014)	(0.003)	(0.122)			(0.135)	(0.004)	(0.209)	
Benin	0.251**	-0.137	0.466			0.178**	-0.062*	-0.530	

	(0.547)	(0.031)	(0.623)			(0.068)	(0.044)	(0.688)	
Burkina Faso	0.103**	0.009	-0.284**			0.107**	0.009	-0.237*	
	(0.021)	(0.087)	(0.085)			(0.270)	(0.011)	(0.255)	
Cameroon	0.029	-0.012*	0.165			0.003	-0.015*	0.218	
	(0.021)	(0.006)	(0.293)			(0.030)	(0.008)	(0.385)	
Cote d'Ivoire	-0.031*	0.013	0.381**			0.105**	0.003	0.380**	
	(0.030)	(0.024)	(0.138)			(0.053)	(0.020)	(0.125)	
Egypt	0.007*	0.024**	0.545**			0.035*	0.023*	0.283**	
	(0.017)	(0.106)	(0.077)			(0.237)	(0.011)	(0.203)	
Gabon	0.128	-0.011	0.265			0.030	-0.009	0.248	
	(0.056)	(0.023)	(0.514)			(0.128)	(0.246)	(0.775)	
Ghana	0.035*	0.029	0.172**			0.048**	0.015	-0.370**	
	(0.030)	(0.020)	(0.314)			(0.025)	(0.192)	(0.291)	
Kenya	-0.053*	-0.029*	0.424			0.021*	0.006*	0.209	
	(0.028)	(0.020)	(0.431)			(0.020)	(0.127)	(0.287)	
Lesotho	-0.124*	-0.030	0.527**			-0.028*	-0.028	0.517**	
	(0.760)	(0.030)	(0.121)			(0.095)	(0.033)	(0.655)	
Mali	-0.040*	0.015*	0.745**			-0.048*	0.003*	0.358**	
	0.018	0.103	0.139			0.032	0.140	0.210	
Morocco	-0.011	0.005	0.514**			0.061	-0.005	0.576**	
	0.657	0.226	0.163			0.055	0.020	0.195	
Nigeria	0.088**	0.057*	-0.292**			0.030**	0.037*	-0.055**	
	0.009	0.019	0.089			0.017	0.019	0.148	
Rwanda	0.019**	-0.002	-0.074			0.022**	-0.004	0.032	
	0.008	0.019	0.774			0.113	0.011	0.134	
Senegal	-0.021	0.004	0.302**			0.004	0.023	0.972**	
	0.190	0.234	0.327			0.223	0.234	0.404	
Sierra Leone	0.008*	0.003	-0.056			0.02**	0.008	0.044	
	0.003	0.005	0.600			0.009	0.007	0.090	
South Africa	0.012*	0.053**	0.521**			0.005**	0.003*	0.840**	
	0.264	0.052	0.164			0.033	0.007	0.248	
Togo	-0.05**	-0.003**	0.057			-0.009**	-0.032*	0.338	
	0.017	0.150	0.210			0.042	0.018	0.381	
Tunisia	-0.167*	-0.086*	0.128**			0.196**	0.109*	0.107**	
	0.193	0.543	0.513			0.184	0.049	0.712	

Source: Author Computation.

*Note: ***,**,* show the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively. More so, values in parentheses are the standard error from the AMG, and CCEMG estimation.*

Table 9 provides the long-run elasticity estimate among Inee, Inrm, Infd, and Ingdp, using the Eberhardt and Teal (2011) AMG estimator. The results show that remittances will increase the ecological footprint in Africa, as (a 1%) increase in remittances will cause (a 0.069%) increase in ecological footprint, thereby having a detrimental effect on environmental sustainability in Africa. A similar outcome was also reached for the BICS countries, of which remittances increased ecological footprint Yang et al. (2021). This finding is also in consonant with other studies that use CO_2 emission as a proxy for measuring environmental sustainability in different regions Ali Shah et al. (2023); Khan et al. (2022); Yang et al. (2020), and for BRICS, Asian and other regions Ahmad et al. (2019); Khan et al. (2022); Md. M. Rahman et al. (2021); Z. Rahman et al. (2019). The similarity of these findings can be attributed to the fact that these regions experiencing increased remittance inflow over the years are still heavily dependent on non-renewable energy (fossil fuel) and are unwilling to make the trade-off and transition between economic growth and environmental sustainability. However, a number of studies find remittances to improve environmental sustainability or reduce environmental degradation Edwards (2022); Sharma et al. (2018); Zafar et al. (2022). The presence of SH in our dataset from the Pesaran and Yamagata (2008) SH test necessitates, that there will be a difference in our cross-sectional units. I also find this to be true as the coefficient of Inrm was significant for Algeria, Benin, Burkina Faso, Cote d'Ivoire, Egypt, Ghana, Kenya, Lesotho, Mali, Nigeria, Rwanda, Sierra Leone, South Africa, Togo, and Tunisia, and was insignificant for the remaining countries in the data sample.

Infd is negative and insignificant in the panel result. This signifies that FDI does not hold a significant effect on environmental sustainability in Africa, as the coefficient value for Infd is negative and insignificant on Inee. This conclusion is also similar to the finding of (Usman et al., 2020), where out of the four long-run elasticity estimates employed in their study, three reported FDI to be insignificant on environmental sustainability using ecological footprint as a proxy in Africa. More so, the panel data analysis of Yang et al. (2020) also proved the same, using CO_2 emission as a proxy for environmental sustainability in Emerging and Developing Countries (where 9 of the same African countries were also included in their analysis). However, many studies reached a contrary conclusion in their sample countries (Khan et al., 2020; Musah, et al., 2022; Rahman et al., 2019; Zmami and Ben-Salha, 2020). The present study also confirms that (Infd) was positive and significant for Egypt, Mali, Nigeria, and South Africa; indicative of the fact that at a 1% increase in Infd, environmental sustainability will be negatively impacted in this region, as ecological footprints will increase. While, a 1% increase in Infd, environmental sustainability will be improved in Algeria, Cameroon, Kenya, Togo, and Tunisia since the coefficient of Infd is negative and significant for this region. The Positive (Negative) significance of the coefficient of the individual countries also validates the pollution haven hypotheses, where FDI is not used (used) to promote environmental sustainability in some of these African countries. This finding is also consistent with Khan et al. (2020) and Kivyiro and Arminen (2014).

The present study also, concludes that GDP per capita amplifies environmental sustainability in Africa, given the positive and significant value of Ingdp in the panel result. It means that economic productivity within Africa is largely achieved at the expense of environmental sustainability, since most African countries prioritize the fight against poverty, unemployment, political instabilities, economic productivity, and increased local manufacturing, at the expense and very little concern for environmental sustainability. This conclusion, coincides with the following studies (Ahmad et al., 2020; Chen et al., 2023; Jamil et al., 2021; Rahman et al., 2021; Yang et al., 2020; Zafar et al., 2022; Zeraibi et al., 2021). However, I also observe differences in the slope coefficient, as a 1% increase in GDP per capita will be injurious to environmental sustainability in Algeria, Cote d'Ivoire, Egypt, Ghana, Lesotho, Mali, Morocco, Senegal, South Africa, and Tunisia, it will improve that of Burkina Faso, and Nigeria.

Table 9 also presents the findings from the robustness test for the long-run elasticity estimate using the CCEMG estimator developed by Pesaran (2006). The result reported by the CCEMG estimator Pesaran (2006) is consistent with the findings from the AMG estimator Eberhardt and Teal (2011). The results show that both remittances, and economic growth will increase ecological footprint in Africa, by the positive signs associated with the elasticity parameter of Inrm (0.023), and Ingdp (0.299) in the panel results, while FDI remains negative and insignificant with an elasticity parameter of Infd (-0.080).

Table 10: *Pairwise Dumitrescu-Hurlin panel causality test results*

Null Hypothesis Inference	W-stat	Zbar-Stat	Prob
Inrm→Inee Inee↔Inrm	2.262	3.197	0.014***
Inee→Inrm	4.121	8.214	0.000***
Infd→Inee Inee→Infd	3.103	0.902	0.304
Inee→Infd	4.306	2.054	0.050**
Ingdp→Inee Inee↔Ingdp	2.370	3.490	0.027**
Inee→Ingdp	3.367	6.179	0.032**
Inrm→Infd Inrm≠Infd	2.607	0.436	0.420
Infd→Inrm	1.424	-1.067	0.330
Ingdp→Inrm Ingdp↔Inrm	3.655	6.957	0.000***

Inrm→Ingdp	3.847	7.474	0.000***
Infd→Ingdp Infd→Ingdp	2.139	-0.043	0.057*
Ingdp→Infd	6.097	4.316	0.960

Source: Author Computation.

*Note: ***,**,* show the coefficients are significant at the 1%, 5%, and 10% level of significance, respectively. Also, "→" denotes the null hypothesis that one variable does not homogeneously cause another variable, while "↔" signifies bidirectional causality among two variables; "≠" signifies no causality, and "→" means unidirectional causality among two variables.*

Table 10 reports the causality between the variables, using the Dumitrescu and Hurlin (2012) PC test. The results show bidirectional causality between Inee and Inrm. The mutual connection between ecological footprint and remittance is not only indicative of the fact that increased remittance inflow negatively impacts environmental sustainability in this region, but ecological footprint also driver remittance inflow. A unidirectional causality also runs from Inee to Infd, which is consistent with Usman et al. (2020). The bidirectional causality between Inee and Ingdp means that economic growth dampens environmental sustainability in these regions, and this also resonates with Zeraibi et al. (2021). A unidirectional causality also runs from Infd to Ingdp, as FDI is instrumental in the economic performance of this region. More so, a bidirectional causality also exists between Ingdp and Inrm, which is a result of more remittance inflow boosting household income, consumption and improving living conditions, thereby boosting aggregate economic performances in this region, while better economic performances in this region, may redirect the use of remittances into promoting other macroeconomic activities like capital investment. The results also show no causality between Inrm and Infd, which could mean that both remittances and FDI to this region, are sent for two distinctive purposes such as remittances being sent to support family members where FDI is sent strictly to propel investment purpose.

5. CONCLUSION AND POLICY IMPLICATIONS

This study has examined the effect of the nexus between remittances, FDI, economic growth and ecological footprint on environmental sustainability using a sample of 19 African countries for the period of 1990-2021. Based on the robustness of the Augmented Mean Group and Common-Correlation Effect Mean Group estimator, remittances and economic growth will be significantly harmful to environmental sustainability in this region, since they both have a positive association with ecological footprint. Furthermore, bidirectional causality exists between remittances, economic growth, and ecological footprint, while a unidirectional causality runs from ecological footprint to FDI and FDI to economic growth. Furthermore, no causality was established between remittances and FDI.

In line with these findings, the following policy options are recommended for individual governments, regional blocs, and international partners to improve environmental sustainability in Africa.

1. Budget Diversification: Even though many African countries have pledged alliances for the net zero emission goal, their total dependence on fossil fuel revenue will not make the goal of environmental sustainability achievable in this region. Hence, the government must choose to diversify its revenue away from total dependency on fossil fuels by capitalizing on other green resources, products and services to generate revenues.
2. Strict market regulations and monitoring of remittances inflow, to channel its contribution to promoting green consumptions and sustainable livelihoods.
3. Government should encourage and enforce clean energy investment for the key players in the economy. Through financial incentives and subsidies, key players in the economy will be encouraged to adopt clean energy utilizations and other sustainable practices in their engagement. While, renewable portfolio standards, carbon pricing mechanism and public procurement policies will enforce the uses of more clean energy in the domestic economy.
4. Government should also prioritize eco-taxes and environmental fees mechanism to discourage the importation and consumption of environmentally harmful products into Africa.
5. Government can also promote and incentivize private sector investment in research and development that will facilitate technological innovation to promote eco-friendly production and an ecologically conscious society in general.

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