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The Human Well-being and Environmental Degradation Nexus in Africa

Samson Aladejare (aladejare4reel2000@gmail.com)
Federal University Wukari https://orcid.org/0000-0002-2464-026X

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Samson Adeniyi Aladejare
Department of Economics
Federal University Wukari, Nigeria
E-mail: aladejare4reel2000@gmail.com

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Abstract

Environmental degradation continues to attract interest from academics, policymakers, and other stakeholders. However, empirical studies have been limited, particularly in the choice of human well-being indicators. Therefore, this study extends the literature by broadening the nexus between human well-being and environmental degradation in 29 African countries from 1970 to 2019. Preliminary tests adaptable to effects of cross-sectional dependency and heterogeneity in panel dataset were adopted, alongside the cross-sectional auto-regressive distributed lag model and the Dumitrescu-Hurlin causality approach. Findings from the study showed that the adopted human well-being indicators such as globalisation, life expectancy and human capital development were environmentally enhancing both in the short and long term. In contrast, growth in income was found to be environmentally degrading in the short and long term. At the same time, urbanisation was only environmentally detrimental in the long term with no significant short-term effect. Natural resource rent which served as a control variable, was environmentally degrading both in the short and long term. Also, a bidirectional association between human well-being and environmental degradation was confirmed. Consequently, this study implies a win-win symbiotic nexus between the environment and human well-being in African countries.

Keywords: Human well-being; Environment; Degradation; CS-ARDL; Causality; Africa.
JEL Classifications: I31, N57, O55, Q2, Q3.

1. Introduction

The African continent has long been known for continued growth in poverty and environmental degradation; hence, governments, policymakers, researchers, and international organisations have continued to seek ways to ameliorate these challenges. For instance, the United Nations Sustainable Development Goals (SDGs) launched in 2015 has poverty eradication as its top priority; while other goals like achieving a sustainable environment and globalisation evolve around it (Asongu and Odhiambo, 2019; Sarkodie and Strezov, 2019; Dhrifi et al., 2020; Dada and Fanowopo, 2020; Aladejare et al., 2020). Similarly, the first ambition of the African Union's 2063 agenda is to guarantee a wealthy Africa based on inclusive growth and sustainable development by wiping out poverty in the continent (African Union Commission, 2015).

Human well-being will have to be enhanced if the challenge of poverty in the continent is to be tackled. However, this might not be without cost to the environment. The reason is that human well-being is naturally associated with ecological factors. Therefore, the effectiveness of the environmental management policy is a determining factor in human interaction with the environment. Although a positive symbiotic nexus between human well-being and environmental quality is highly desirable, the combined quest of these objectives does not demand that the two at all times be mutually reinforcing. Intuitively, on many occasions, trade-offs are bound to occur, mainly where there are no well-designed policy actions (UNDP, 2011). The reason is that pressures on conventional human development components, including health, wealth and education, are more likely to grow due to rising human exploitation of environmental resources from urbanisation and globalisation (Kassouri and Altintas, 2020). It was for this purpose, the SDGs were conceived to strike a balance between human well-being enhancement and halt mounting pressure on environmental resources. Nevertheless, achieving these goals still constitutes a fundamental challenge for African countries.

Drawing from the above, a broad human development plan that incorporates issues of urbanisation and globalisation should promote environmental sustainability in Africa. Therefore, understanding the association between human well-being and the environment is particularly compelling for Africa, where various economic and social factors can substantially contribute to resource depletion both in the short and long term. For instance, a significant point from the Rio convention on climate change bordered on enhancing human well-being through poverty alleviation, but achieving this can only be through efficient use of environmental resources. A major challenge for African countries has remained the simultaneous tackling of poverty and reduction in environmental degradation. To further bolster this point, Dhrifi et al. (2020) noted that although economic development serves to lower poverty in developing countries, it also exerts pressure on ecological resources and processes.

On the other hand, poverty levels can also be aggravated by environmental degradation when resources for enhancing human well-being are channelled to combat environmental challenges (Asongu et al., 2019; Asongu and Odhiambo, 2019). Likewise, when there is the scarcity of resources, individuals could be forced to engage in activities that are degrading to the environment, which may have long-term consequences on the well-being of the populace. For instance, environmental degradation in a country impacts the investment opportunities available within and outside the country. Consequently, employment and income will fall, and poverty will become prominent. Furthermore, environmental degradation by soil erosion and flooding can result in food insecurity, a rise in unemployment and lower income. Ecological degradation can also diminish human productivity by adversely impacting on life expectancy of the populace through the rise in communicable and incommunicable diseases, and poor social and economic amenities (Rich, 2017; Boogaard et al., 2017; Sarkodie, 2018; Asongu and Odhiambo, 2019).

Although human well-being and environmental degradation have often constituted the core attention of environmentalists and stakeholders, the linkage process between these targets still remains uncertain in extant literature. Most studies have often relied on the environmental Kuznets curve (EKC) framework to dissect the impact of human economic activities on environmental quality (Destek et al., 2018; Adzawla et al., 2019; Kong and Khan, 2019; Aladejare, 2020a). However, studies have also noted the flaw of economic growth when used as an indicator for social welfare in the environmental degradation-economic growth/development nexus (van den Bergh and Botzen, 2018; Kassouri and Altintas, 2020). The most prominent proxy for economic growth in the environmental literature has been the gross domestic product (GDP), which denotes the aggregate monetary value of all final goods and services produced annually within a country. However, this measure does not intensively encompass human well-being components such as income level, human health, and the educational level of the society associated with the comprehension of environmental issues. Against this backdrop, the human development index (HDI) was proposed as a metric of human welfare. Its computation encompasses life expectancy, income, and educational level. However, the HDI's measure of human well-being can be flawed since it neglects other critical public policy indicators that alongside its conventional components impact on human well-being. These indicators include globalisation and urbanisation; their impact on human well-being have continue to grow due to the realisation of the potentials in collective pooling of resources between and within countries. Consequently, the need to assess the nexus between broader indicators of human well-being and the environment is crucial for related policy enhancement.

Hence, this study proposed the use of life expectancy, human capital development, income, urbanisation, and globalisation as broader metrics of human well-being. To properly gauged the linkage between the adopted human well-being metrics and environmental resources, the ecological footprint per capita, which evaluates the demand for regenerative capacity, is adopted as a comprehensive measure for ecological degradation. There is growing acceptability of the ecological footprint measure in the literature as an adequate representation of the concept of environmental sustainability due to its broad components (Kassouri and Altintas, 2020; Nathaniel, 2020; Aladejare, 2020a; Nathaniel, 2021; Erdogan et al., 2021; Aladejare, 2022).

Based on empirical evidence, no study has combined the interaction of the above metrics of human well-being with the adopted environmental degradation measure. Hence, this study extends the literature by decomposing the HDI components (life expectancy, income and education) and broadening the well-being indicators to incorporate urbanisation and globalisation, that have either improved or marred environmental degradation measured by ecological footprint per capita between 1970 and 2019 for 29 African countries. Natural resource rent is used as a control variable due to the resource-dependent nature of African economies. African governments rely heavily on receipts from their natural resources to deliver on development projects necessary for enhancing human well-being, but with potentially adverse environmental effects due to poor extractive processes. Thus, establishing trade-offs and synergies between human well-being and environmental degradation can improve the execution of decision-making processes toward balancing the human well-being-environmental degradation nexus in Africa. The econometric technique applied in this study includes panel cross-sectional unit root and cointegration test and panel cross-sectional augmented autoregressive distributed lag (CS-ARDL) model. A Dumitrescu and Hurlin causality test was further employed to determine the causal direction between the variables.

The focus of this study is on African countries for the following reasons. First, countries in the continent have been witnessing a rapid shift from ecological surplus to ecological deficit due to the significant economic growth of the region in the last decade. The continent's economy has consistently grown by 5% annually over the last decade; it is also believed to be as urbanised as China and has as many cities of over a million persons as Europe (Future Agenda, 2022). Therefore, feasible policies are needed to comprehend the well-being implications of this ecological deficit to minimise or reverse the current ecological path in African countries. Second, Africa is a wealthy agrarian continent; it also has a prosperous extractive sector that constitutes about 30% of the world's minerals reserves (UNEP, 2022). Africa has 40% of the world's gold deposits and is endowed with about 90% of the world's chromium and platinum (Aladejare, 2020b; UNEP, 2022). Similarly, Africa's rich oil and natural gas reserves make up 12% and 8% of the world's total reserves, respectively (UNEP, 2022). Consequently, the use of poor agricultural techniques and over-reliance on primary commodities presents significant environmental challenges for the continent and the world. Therefore, the quest to achieve a balance between improving human well-being and reducing environmental degradation should be a significant plan for policymakers in the continent.

Key findings from this study showed that while an increase in urbanisation leads to environmental degradation only in the long term, growth in natural resource rents and income promote environmental degradation both in the short and long term. In contrast, an increase in globalisation, life expectancy, and human capital development reduced environmental degradation both in the short and long term. Furthermore, evidence from the causality test indicates a significant level of bidirectional nexus between human well-being and the environment.

The sequence of this study takes the following order. After the introduction in Section one, Section two presents the literature review, Section three is the study's data and methodology, Section four contains results and analyses, and Section 5 concludes the study with policy directives.

2. Literature Review

2.1 Theoretical review

From a theoretical view, two contrasting hypotheses have often been postulated. The first is the synergy approach in which countries can achieve a win-win solution that promotes environmental quality and human well-being. This encouraged the deployment of the HDI as an alternative means for assessing welfare effect in the literature. In furtherance of this concept, there is an evolving school of thought that environmental sustainability should be integrated into the concept of human development (Biggeri and Mauro, 2018; Perez-Foguet and Lazzarini, 2019). Hence, the introduction of a new concept known as sustainable human development (Kassouri and Altintas, 2020). Sustainable human development relates to widening available human opportunities without jeopardising environmental sustainability (Biggeri and Mauro, 2018). By marrying the concepts of human development and ecological sustainability together, this new framework rejuvenated various interests by scholars and stakeholders in evaluating the current compromising path between environmental sustainability and human development enhancement (Bravo, 2014; Biggeri and Mauro, 2018).

Another theoretical perspective is the trade-off approach, whereby exploration of environmental resources has a negative impact on human well-being. In this approach, the nexus between human well-being and environmental quality is valid when environmental pollution mars human well-being, and further exacerbate ecological impairment (Barbier and Hochard, 2018; Zhou et al., 2019; Kassouri and Altintas, 2020). It is important to stress that ecological services are essential to the well-being of any society. For instance, human health is dependent on freshwater supply for agriculture, drinking, and recycling of wastes. Rural communities are directly and heavily reliant on good water supplies. Likewise, humans are dependent on productive terrestrial and marine ecological products for a vital supply of medicinal aids, food and climate regulation, which constitute core inputs in their well-being. Based on those mentioned above, environmental degradation may adversely impact the ecological balance and have destructive effects on human well-being. Similarly, the quest for improved human well-being by a country may exert undue pressures on the natural environment of that country and create an ecosystem sustainability problem even for neighbouring countries (Coulthard et al., 2011; Kassouri and Altintas, 2020).

From the above contrasting perspectives, we can say that the general resource management policy in African countries, will significantly determine the effect their current path of human well-being enhancement will have on their environment.

2.2 Empirical review

Interactions between human well-being and environmental degradation have not been exhaustively researched by extant studies, especially in the choice of human well-being and environmental indicators. Thus, existing studies have also not been able to achieve a common front on the nature of the relationship between human well-being and environmental degradation, especially in developing countries. A brief review of studies along common submission is provided below.

2.2.1 The win-win studies

Empirical studies such as Steinberger and Roberts (2010) employed the pooled ordinary least square (OLS) in concluding that human development indicators such as life expectancy, income level, literacy rate, and HDI for 156 countries can be moderately enhanced without impacting negatively on the environment. Similarly, Bedir and Yilmaz (2016) assessed the causality association between carbon emissions and human development for 33 Organisation for Economic Cooperation and Development (OECD) countries. Submission deduced from the study affirmed that reduction in carbon emissions does not affect human development. Kais and Sami (2016) used the generalised method of moment (GMM) to show that urbanisation and trade openness, reduce environmental degradation for North Asia and European countries.

Based on a panel dynamic OLS (PDOLS) and panel fully modified OLS (PFMOLS), Charfeddine and Mrabet (2017) concluded that urbanisation, life expectancy and fertility rate reduce the ecological footprint of 15 Middle

East and North African (MENA) countries. In a related study, and by employing the stochastic impacts by regression on population, affluence and technology (STIRPAT) technique, Abdallh and Abugamos (2017) confirmed that urbanisation reduces carbon emissions for 20 MENA countries. Zaman and Moemen (2017) employed the fixed effect (FE) and GMM procedures and concluded that no carbon emission effect from human development exist in 90 different countries. Using a system-GMM for MENA countries, Tran et al. (2019) showed that human development has no significant effect on carbon emissions in developed countries. However, the same effect was not validated for developing countries. Chen et al. (2019) employed the dynamic seemingly unrelated-cointegration regression (DSUR) to conduct a study for 16 Central and Eastern European countries. Empirical findings from the study showed that human capital reduces EF. By adopting qualitative technique, Biswas (2020) showed that environmental literacy and attitude are major predictors of a healthy lifestyle in an emerging economy. Dumor et al. (2021) applied the dynamic ARDL approach for a study on East African countries and found that increase in HDI, has no significant effect on carbon emissions both in the short and long term.

2.2.2 The trade-off studies

In contrast, studies such as Awad and Abugamos (2017) investigated the relationship between income and carbon emissions for 20 MENA countries. The study employed the parametric and semi-parametric FE model for its analysis. Evidence from the study showed an initial trade-off between both variables, which was later replaced with a win-win scenario. Sarkodie (2018) used the panel cointegration, fixed and random effect estimators, and causality technique for 17 African countries. The study divulged that human development components related to food production, birth and fertility rate were significantly degrading the environment by increasing EF and carbon emissions. Nyangena et al. (2019) employed a parametric and non-parametric FE model to determine that urbanisation promotes carbon emissions in East African countries. A different study by Taghizadeh-Hesary et al. (2020) used the GMM approach to conclude that carbon emissions are enormously responsible for undernourishment and death rates in 18 Asian countries.

By using the interactive FE (IFE) and the common correlated effect mean group (CCEMG) for a panel study of 13 MENA countries, Kassouri and Altintas (2020) examined the existing interaction between HDI and environmental quality measured by EF. The study found that there is a substantial trade-off between both variables. Zafar et al. (2020) adopted the PDOLS and PFMOLS for 17 Asian countries and concluded that education, urbanisation, and income worsen environmental quality. Nathaniel (2021) used the augmented mean group (AMG) panel-correlated standard errors (PCSE) and the Driscoll and Kraay (DK) methodologies for a panel of Next-11 countries. Findings from the study showed that while HDI, financial development and urbanisation degrade the environment, natural resource rent and globalisation promote environmental quality by reducing EF. Hence, the existence of a trade-off effect in the countries examined. In a study for 39 sub-Saharan African countries, Akinlo and Dada (2021) used the dynamic GMM to showed that carbon emissions enhanced poverty, measured by HDI and life expectancy. Aladejare (2022) studied the five richest African economies, and employed the feasible generalised least squares (FGLS) technique. Findings from the study showed that globalisation and urbanisation reduce environmental degradation (measured by EF, methane and carbon emission), while natural resource rents and human capital development significantly promote it.

2.2.3 Literature gap

From the above contrasting reviews, it is evident that the relationship between human development and environmental degradation is still debatable. A major contending issue is evident in the measurement indicators deployed. For instance, in measuring environmental degradation, a significant number of studies have relied on carbon emissions, while only a handful has opted for the broader EF indicator. This study also adopts the EF indicator due to its robust suitability to the resource-based composition of African economies. Furthermore, many studies have employed the HDI as a proxy for human well-being. While a few others have adopted other human well-being indicators such as urbanisation, education, trade openness, fertility, death and birth rate, etc. For a robust measure, this study explored human well-being from the individual perspective of life expectancy, human capital development, income, urbanisation, and globalisation, while controlling for natural wealth with resource rents. The HDI is increasingly proving to be a narrow measure of human well-being since it fails to incorporate recent crucial human factors such as globalisation and urbanisation that can enormously impact well-being. In terms of estimation technique, many studies neglected the cross-sectional nature of the subject matter, which could bias their outcomes. Recent studies that have corrected this flaw are scant. Hence, this study extends the literature based on these identified fronts.

3. Methodology

3.1 Data sources and variable description

By employing data observation between 1970 and 2019, this study assessed the nexus between human well-being and environmental degradation in 29 African countries. These countries include Algeria, Benin, Botswana, Burkina Faso, Burundi, Cameroun, Congo Republic, Congo democratic, Cote d'Ivoire, Egypt, Gabon, Gambia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Morocco, Niger, Nigeria, Rwanda, Senegal, Sierra-Leone, South Africa, Togo, Tunisia, and Zambia. Aside the fact that these countries constitute the richest in income and resources amongst the 54 countries of Africa, their choice is also based on data availability.

As prior noted, the indicator for environmental degradation used in this study is the EF, which is increasingly adopted in recent energy and environmental-related analyses as a robust measure of environmental quality. EF uniquely accounts for the unit of various natural areas necessary for the growth of an economy. These natural areas encompass cropland, forest products, carbon space, built-up land, fishing grounds, and grazing land. Another justification for the EF measure is related to the destructive tendencies extractive activities could have on natural areas, such as loss of biodiversity, pollution of surface water, groundwater, and soil erosion.

The indicators of human well-being as prior establish are life expectancy at birth (LE). Its adoption is based on the intuition that life expectancy is primarily a function of human activities that can either shorten or encourage longevity. Such activities can also promote or reduce ecological well-being. Another indicator is the human capital development (HC) indicator. Its adoption is grounded on the reasoning that the nature of HC policies and strategies existing in a country can either promote or deter the growth of environmental sustainability. Growth in GDP per capita is used to proxy for increase in income level. As income level rises, the demand by individuals for the better things in life also rises, hence, exerting more pressure on the environment. Urbanisation is another human well-being indicator adopted since it can enhance housing, energy, and transport demands, potentially raising fossil fuel consumption and generating more detrimental environmental effects.

Globalisation is crucial to African countries because natural resources exports constitute the principal source of their income. It involves interaction between people in different countries, sharing ideas and information. Consequently, the concept is multifarious since it covers beyond trade openness and capital flows (Gygli et al., 2019); its impact can be extensive, measuring technology transfer from advanced to developing countries. However, the level of trade and investment in foreign technology can promote or reduce the accumulation of "dirty" technology, hence, resulting in globalisation either being environmentally unfriendly or enhancing. The KOF globalisation index, which evaluates globalisation from the economic, social and political perspectives (Dreher et al., 2008), was adopted as an indicator of globalisation.

The aggregate measure of natural resource rents from minerals, coal, forest, oil and natural gas served as a control variable. African countries are abundantly endowed with these natural resources, and their income contributes significantly to the provision of economic and social infrastructure required to aid human well-being. However, these resources' extractive and their over-exploitative processes can be environmentally degrading. All the study variables are described in Table 1.

Table 1: Variable description

Variable	Measurement	Sources	Symbol
Ecological foot print	Global hectares (gha) per capita.	Global footprint network (2022)	EF
Natural resource rent	Total natural resource rents % of GDP	WDI (2022)	NRR
Globalisation	weight in percentage	KOF globalisation index (2021)	GI
Life expectancy at birth	Total human years	WDI (2022)	LE
Urbanisation	Urban population growth (%)	WDI (2022)	UPG
Income	GDP per capita growth (%)	WDI (2022)	YGP
Human capital development	Human capital index	Penn World Table (2021)	HC

Source: Author's computation.

3.2 Model construction

3.2.1 Cross-sectional dependency test

Of recent, there has been a growing consensus on the adverse impact data cross-sectional dependence (CSD) might have on derivable inferences from panel analysis. Some of these challenges include poor model selection and estimated parameters (Gyamfi et al., 2021; Shen et al., 2021). Thus, ignoring the CSD threat of a panel data analysis creates the opportunity for inconsistency and inefficiency in estimated coefficients. The key factors responsible for CSD in panel data analysis are unobserved components, common shocks, and the possibility of residual interdependency (Su et al., 2020). Thus, when handling panel data analysis related to economic or financial integration, globalisation, trade flows, and common economic policies, CSD is most likely to be an issue that demands attention. Consequently, this study conducted four CSD tests which are Breusch and Pagan's (1980) Lagrange multiplier (LM) test, Pesaran's (2004) scaled LM test, Pesaran's (2004) CSD test and the Baltagi et al. (2012) bias-corrected scaled LM test.

The Breusch-Pagan CSD test equation is as expressed below.

$$CSD_{BP} = T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\gamma}_{ij}^{2} \qquad Equ.1$$

where T represent time unit/sample periods, N represents panel cross-sectional size and $\hat{\gamma}_{ij}^{2}$ denote the pair-wise cross-sectional correlation parameters. The Breusch-Pagan LM test is true when the null hypothesis of no CSD for panels with T tending to infinity and N is fixed is accepted. As an advancement, the Pesaran (2004) scaled LM CSD test was developed to handle large panels where T and N tend towards infinity. The test equation is as expressed below.

$$CSD_{Plm} = \sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{\gamma}_{ij}^{2} - 1)\tilde{\ }N(0,1) \qquad Equ.2$$

One major challenge with the Pesaran (2004) scaled LM CSD test is its likely bias in exhibiting significant size distortions for large N and small T. Hence, Pesaran (2004) formulated a more adaptable CSD test that can be relied upon when both T and N tends toward infinity as shown below.

$$CSD_{P} = \sqrt{\left(\frac{2T}{N(N-1)}\right)}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N-1}\gamma_{ij}\right) \qquad Equ.3$$

Baltagi et al. (2012) later developed a biased-scaled LM CSD test based on the assumption of N and T tending to infinity. The test is derived in the context of a fixed effect homogenous panel data model, and its equation is shown below.

$$CSD_{B} = CSD_{Plm} - \frac{2N}{2(T-1)} = \sqrt{\left(\frac{2T}{N(N-1)}\right)}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}(T\hat{\gamma}_{ij}^{2} - 1) - \left(\frac{N}{2(T-1)}\right) \qquad Equ.4$$

Once CSD is confirmed in the dataset, the applicable econometric approaches that treats CSD issue are deployed.

3.2.2 Slope heterogeneity test

Another challenge with panel data analysis is the problem of assuming slope homogeneity, which can bias inferences due to variations in the demographic and economic structure of cross-sections being considered. Hence, conducting a slope heterogeneity test is imperative when dealing with panel datasets. Its essence is to determine whether the parameters of interest are genuinely homogenous or differ across cross-sectional units. For the purpose of determining the presence or absence of heterogeneous slope parameter, this study used the Swamy (1970) test and the Pesaran and Yamagata (2008) adjusted or standardised version.

The test statistics for both Swamy (1970) and Pesaran and Yamagata (2008) are represented as:

$$E = \sum_{i=1}^{N}(\varphi_{i} - \varphi_{FEW})'\frac{W_{i}'H_{t}W_{i}}{\sigma_{i}^{2}}(\varphi_{i} - \varphi_{FEW}) \qquad Equ.5$$

$$\tilde{\Delta} = \sqrt{N}\left(\frac{\frac{1}{N}E - R}{\sqrt{2N}}\right) \qquad Equ.6$$

$$\tilde{\Delta}_{Adjusted\ version} = \sqrt{N}\left(\frac{\frac{1}{N}E - R}{\sqrt{\frac{2R(T-R-1}{T+1}}}\right) \qquad Equ.7$$

where E and Δ are test statistics, the Swamy (1970) test is represented by Equation 6 and the Pesaran and Yamagata (2008) adjusted version is as captured in Equation 7. Pooled OLS and FE weighted pooled estimates are denoted by φ_i and φ_{FEW} respectively. Furthermore, H_t and W_i represents identity matrix and matrix covariates, respectively, which deviates from the mean. R represents the number of exogenous or covariates, while σ_i is the estimator for σ_i^2.

3.2.3 Panel unit root test

In the presence of CSD and heterogeneity in the panel dataset, it becomes obvious that mainstream first-generation unit root techniques such as Levin-Lin and Chu (LLC) and I'm, Pesaran, and Shin (IPS), cannot be relied upon to control for CSD effects in the series. Thus, the need to apply robust panel unit root techniques that can mitigate the impact of CSD and also account for heterogeneity in a series. An applicable first-generation panel unit root test that corrects for CSD and allows for heterogeneity is the Madalla and Wu (1999) test employed in this study. A standard set of unit root tests applicable in treating CSD and heterogeneity issues in panel datasets are the second generation unit root tests. In the category are the Pesaran (2003) cross-sectional augmented Dickey-Fuller (CADF) and Pesaran (2007) cross-sectional IPS (CIPS), which were both adopted. The equation form of CADF test statistic is expressed as:

$$\Delta G_{it} = \infty_{it} + \tau_i G_{i,t-1} + \delta_i \bar{G}_{t-1} + \varphi_i \Delta \bar{G}_t + \mu_{it} \qquad Equ.8$$

where ∞_{it}, G_{it} and μ_{it} represents the intercept, study variables and error term, respectively; inserting the first lag expression yields the following equation:

$$\Delta G_{it} = \infty_{it} + \tau_i G_{i,t-1} + \delta_i \bar{G}_{t-1} + \sum_{j=0}^{p} \varphi_{ij} \Delta \bar{G}_{t-j} + \sum_{j=1}^{p} \tau_{ij} \Delta G_{i,t-j} + \mu_{it} \qquad Equ.9$$

where $\bar{G}_{t-j}$ and $\Delta G_{i,t-j}$ denote the intercept, mean of lagged and first difference operator, respectively, across the specific cross-sections. The following function is for the CIPS test statistic:

$$CIPS = \frac{1}{N}\sum_{i=1}^{n} \tau_i\,(N,T) \qquad Equ.10$$

where the coefficient $\tau_i(N,T)$ indicates CADF test statistics which can further be expressed as:

$$CIPS = \frac{1}{N}\sum_{i=1}^{n} CADF_i \qquad Equ.11$$

3.2.4 Panel cointegration test

The error correction model (ECM)-based cointegration technique proposed by Westerlund (2007) is applied to ascertain the long-run nexus between the study variables. This test outperforms traditional cointegration tests such as the Kao and Pedroni by producing reliable estimates of heterogeneity and CSD (Kapetanios et al., 2011). Four test statistics are often presented, comprising two group tests (G_t and G_a) and two panel statistics (P_t and P_a). The Westerlund (2007) equation is expressed as follows:

$$\Delta y_{it} = \Gamma_i' m_t + \zeta_i y_{it-1} + \gimel_i' x_{it-1} + \sum_{j=1}^{Pi} \varrho_{ij} \Delta y_{it-j} + \sum_{j=0}^{Pi} \emptyset_{ij} \Delta X_{it-j} + \epsilon_{it} \qquad Equ.12$$

where $\emptyset$, $\Gamma_t = (\Gamma_{1i}, \Gamma_{2i})'$ and $m_t = (1,t)'$ represents the error correction coefficient, vector of the cointegration relationship between X (regressor) and y (regressand), and the deterministic components, respectively. The equation for the four Westerlund test statistics are:

$$G_t = \frac{1}{N}\sum_{i=1}^{n}\frac{\widehat{\forall_\iota}}{SE(\widehat{\forall_\iota})} \qquad Equ. 13$$

$$G_a = \frac{1}{N}\sum_{i=1}^{n}\frac{t\widehat{\forall_\iota}}{\widehat{\forall_\iota}(1)} \qquad Equ. 14$$

$$P_t = \frac{\widehat{\forall_\iota}}{SE(\widehat{\forall_\iota})} \qquad Equ. 15$$

$$P_a = (\widehat{\forall_\iota})T \qquad Equ. 16$$

where $\widehat{\forall_\iota}$ denotes the OLS estimator, $SE(\widehat{\forall_\iota})$ and $\widehat{\forall_\iota}(1)$ represents the standard error and semi-parametric kernel estimator of $\widehat{\forall_\iota}$ respectively.

3.2.5 Panel estimation procedure

3.2.5.1 The cross-sectional augmented ARDL (CS-ARDL)

When handling analysis involving panel datasets with large N and T, the existence of cross-sectional heterogeneity cannot be ignored (Shen et al., 2020). Therefore, if CSD and heterogeneity are valid, the application of conventional econometric methodologies such as difference GMM, fixed and random effect becomes invalid (Chudik et al., 2017; Chen, 2018). Consequently, to derive the short and long run estimated results, this study deployed the newly developed technique called the CS-ARDL (Chudik et al.,2013).

$$y_{it} = \propto_i + \sum_{i=1}^{p}\vartheta_{i1}\, y_{i,t-1} + \sum_{1=0}^{q}\omega'_{i1}\, X_{i,t-1} + \varepsilon_{it} \qquad Equ. 17$$

The CS-ARDL procedure is well adapted to the issue of CSD, heterogeneity, endogeneity, non-stationarity, and omitted variables in panel data analysis (Chudik et al., 2017; Bindi, 2018). Its framework is built on augmenting the conventional ARDL procedure by incorporating cross-section means of covariates, their lags and the response variable. By transforming Equation 17, the basic CS-ARDL model is as follows:

$$y_{it} = \propto_i + \sum_{i=1}^{p}\vartheta_{i1}\, y_{i,t-1} + \sum_{1=0}^{q}\omega'_{i1}\, X_{i,t-1} + \sum_{1=0}^{q}\omega'_{i,1}\, \overline{Z_{t-1}} + \varepsilon_{it} \qquad Equ. 18$$

$$\bar{Z}_t = (\bar{y}_t, \overline{X'_t}) \qquad Equ. 19$$

$$\varepsilon_{it} = \Pi'_i f_t + \mu_{it} \qquad Equ. 20$$

where Equation 19 represented by $\overline{Z_t}$ is the cross-sectional means for the covariates for the response variable $(\overline{y_t})$ and the regressor $(\overline{X'_t})$. f_t represents the unobserved common factor that creates dependency among cross-sectional units. The common factors are expressed through a detrending process of the cross-sectional means and lagged through Equation 19. Equation 18 is estimated by a pooled mean group (PMG) method, and to derive the long-term parameters, the following equation is used.

$$\widehat{\eta_\iota} = \frac{\sum_{i=0}^{q}\widehat{\omega'_{1\iota}}}{1-\sum_{i=0}^{q}\widehat{\vartheta_{1\iota}}} \qquad Equ. 21$$

Likewise, transforming Equation 17 as revealed in Equation 22 will produce the ECM form of the model (Ditzen, 2019).

$$\Delta y_{it} = \propto_i \left[y_{i,t-1} - \emptyset_i X_{it}\right] - \sum_{i=1}^{p} \vartheta_{i1}\, y_{i,t-1} + \sum_{1=0}^{q} \omega'_{i1}\, X_{i,t-1} + \sum_{1=0}^{q} \omega'_{i,1}\, \overline{Z_{t-1}} + \varepsilon_{it} \qquad Equ.22$$

where:

$$\widehat{\emptyset}_\iota = \frac{\sum_{i=0}^{q} \widehat{\omega'_{1\iota}}}{\widehat{\propto}_i} \qquad Equ.23$$

3.2.5.2 Test for causality

In order to determine the feedback nexus between human well-being and environmental degradation, the Dumitrescu and Hurlin (2012) (D-H) causality technique was used. The D-H causality test is regarded as superior to the traditional vector error-correction model causality because it also incorporates the effects of CSD and heterogeneity into its panel data analysis process. The D-H causality test has two vital statistics: Zbar-statistics and Wbar-statistics. While the Zbar reveals the standard normal distribution of the panel dataset, the Wbar shows the mean. Both test statistics are developed around three causality options: no causality, unidirectional, and bidirectional causality among variables. The D-H causality process is shown by the equation:

$$y_{it} = \xi_i + \sum_{i=1}^{p} \daleth_i^{(p)} y_{i,t-n} + \sum_{i=1}^{p} \lambda_i^{(p)} X_{i,t-n} + \mu_{it} \qquad (Equ.24)$$

where the intercept (ξ_i) and parameters ($\lambda_i = (\lambda_i^{(1)}, \dots, \lambda_i^{(p)}$) remain static; and $\daleth_i^{(p)}$ is the autoregressive coefficient, while $\lambda_i^{(p)}$ the regression parameter.

4. Results and Discussion

4.1 Descriptive statistic test results

Table 2 shows the mean EF for the African countries as 1.47 (gha) approximately. In Table 3, South Africa is revealed has having the highest mean EF of 3.4 (gha), while Malawi has the lowest mean of 0.81 (gha). Thus, indicating that South Africa has the worst case of environmental degradation among the African countries selected. However, the low EF value for Malawi is an indication that the country has the best environmental quality. The average NRR for the African countries is 3.0% of their GDP (Table 2). Evidence in Table 3 reveals that Gabon and Burundi have the highest and lowest NRR per GDP with 26.1% and -0.01%, respectively. The aggregate GI for the countries is 41.24%, suggesting that African countries are increasingly embracing globalisation trends by having favourable globalisation policies and terms, and growing political, social, and economic integration within and outside the continent.

Further evidence in Table 3 shows that Tunisia has the highest GI mean with 57.13%, and Burundi with 27.3% is the lowest. They indicate that Tunisia and Burundi have had more and less international access to trade flows, respectively. However, the mean LE for the African countries is 54.62 years, which falls short of the value for other developing countries such as Latin America and the Caribbean (75.09 years), and Asia (74 years) (WDI, 2022). Table 3 further reveals that Tunisia and Sierra Leone have the highest (68.51 years) and lowest (42.47 years) LE, respectively.

Table 2: Aggregate descriptive statistic

Variable		Mean	Std. Dev.	Min	Max	Observations
EF	Overall	1.469	0.705	0.629	4.915	N = 1450
	Between		0.569	0.809	3.427	n = 29
	Within		0.430	0.542	4.768	T = 50
NRR	Overall	3.003	7.704	-47.503	52.948	N = 1450
	Between		5.780	-0.967	26.098	n = 29
	Within		5.202	-47.001	38.037	T = 50
GI	Overall	41.242	11.300	14.149	70.479	N = 1450
	Between		7.674	25.297	57.123	n = 29
	Within		8.414	21.001	62.779	T = 50
LE	Overall	54.621	8.661	26.172	76.88	N = 1450
	Between		6.258	42.469	68.511	n = 29
	Within		6.097	30.870	73.722	T = 50
HC	Overall	1.552	0.417	1.007	2.939	N = 1450

	Between Within		0.302 0.293	1.083 0.634	2.134 2.504	n = 29 T = 50
YGP	Overall Between Within	7.915	8.704 6.861 5.503	-25.785 -1.751 -18.934	58.650 32.381 43.739	N = 1450 n = 29 T = 50
URB	Overall Between Within	4.481	1.996 1.137 1.654	-1.477 2.260 -2.903	17.499 7.319 16.073	N = 1450 n = 29 T = 50

Source: Author's Estimated Output

The mean HC is 1.55, as shown in Table 2, while South Africa with 2.13 and Burkina Faso with 1.08 are the countries with the highest and lowest HC, respectively (Table 3). Another evidence in Table 2 indicates that the mean rate of YGP for the nations is 7.92%. Further evidence in Table 3 shows Algeria has the highest mean rate of YGP (20.35%), and Congo DR. (-1.75%) with the lowest mean rate. URB aggregate mean rate is 4.48% for the countries (Table 2), while further result in Table 3 shows Botswana has having the highest URB mean rate (7.32%) and Egypt the lowest mean rate (2.26%). This outcome suggests that urbanisation growth is the fastest and slowest in Botswana and Egypt, respectively.

Table 3: Summary statistics of cross-sections

		EF	NRR	GI	LE	HC	YGP	URB
Algeria	Mean Std. Dev.	1.575 0.473	1.327 4.657	44.615 8.343	66.650 8.343	1.684 0.380	20.349 7.880	3.480 0.867
Benin	Mean Std. Dev.	1.192 0.112	0.967 2.986	36.392 8.782	53.400 5.817	1.356 0.246	6.105 2.546	5.061 1.413
Botswana	Mean Std. Dev.	2.649 0.421	5.301 5.888	46.204 6.906	58.112 5.258	2.115 0.586	2.628 1.816	7.319 4.572
Burkina Faso	Mean Std. Dev.	1.260 0.103	1.992 2.927	35.213 9.500	50.498 6.103	1.083 0.083	8.587 2.628	5.948 1.777
Burundi	Mean Std. Dev.	0.952 0.160	-0.007 4.962	25.297 8.579	50.557 5.447	1.196 0.100	16.153 8.634	5.614 0.784
Cameroon	Mean Std. Dev.	1.189 0.137	1.091 5.360	39.410 6.472	52.722 2.959	1.588 0.246	7.139 2.370	4.944 1.499
Congo DR.	Mean Std. Dev.	0.923 0.083	18.498 8.522	32.951 7.611	50.809 5.046	1.417 0.199	-1.751 5.181	4.219 0.511
Congo Republic	Mean Std. Dev.	0.957 0.100	0.737 6.445	41.633 6.616	55.666 3.968	1.741 0.314	32.381 14.731	3.984 0.645
Cote d'Ivoire	Mean Std. Dev.	1.401 0.569	0.099 4.739	43.612 6.161	51.569 2.999	1.335 0.201	5.087 1.773	4.568 1.614
Egypt	Mean Std. Dev.	1.453 0.335	2.962 2.352	55.166 9.757	64.609 6.218	1.829 0.48	11.330 7.0450	2.260 0.441
Gabon	Mean Std. Dev.	1.801 0.414	26.098 10.550	47.551 4.224	58.475 4.713	1.924 0.531	1.065 9.853	4.825 1.572
Gambia	Mean Std. Dev.	1.337 0.703	0.314 3.626	39.944 7.961	52.698 6.923	1.276 0.182	3.271 1.255	5.725 1.384
Ghana	Mean Std. Dev.	1.560 0.553	1.356 4.430	45.696 9.561	56.639 4.213	1.924 0.372	8.949 3.574	3.923 0.662
Kenya	Mean Std. Dev.	1.283 0.267	1.209 3.912	44.844 7.462	57.303 4.353	1.808 0.325	3.900 1.212	5.199 1.519
Lesotho	Mean Std. Dev.	1.313 0.181	5.825 2.452	40.318 6.648	52.377 5.607	1.841 0.204	2.716 5.684	3.994 1.853
Madagascar	Mean Std. Dev.	1.325 0.305	-0.967 3.981	34.037 8.874	55.391 7.072	1.447 0.174	4.551 1.955	4.902 0.544
Malawi	Mean Std. Dev.	0.809 0.083	8.026 2.464	35.642 7.703	48.426 6.872	1.526 0.209	1.279 4.793	4.985 1.751
Mali	Mean Std. Dev.	1.617 0.842	1.790 4.943	37.677 7.942	46.741 7.681	1.140 0.097	5.534 2.004	4.675 0.625
Mauritania	Mean Std. Dev.	2.568 0.515	0.096 4.511	37.151 8.138	59.001 4.114	1.454 0.185	9.703 7.700	5.589 2.633
Morocco	Mean	1.321	2.552	52.833	65.800	1.453	1.975	2.928

	Std. Dev.	0.277	3.511	10.106	7.699	0.272	2.161	0.897
Niger	Mean	1.825	-0.585	31.243	47.515	1.094	6.263	4.708
	Std. Dev.	0.652	5.395	7.907	8.568	0.069	2.767	1.504
Nigeria	Mean	1.314	1.274	44.938	47.156	1.433	14.903	4.746
	Std. Dev.	0.753	6.235	8.147	3.477	0.272	8.228	0.545
Rwanda	Mean	0.823	2.501	30.678	49.922	1.372	7.388	5.907
	Std. Dev.	0.131	9.877	11.099	11.716	0.228	2.800	3.994
Senegal	Mean	1.519	0.632	47.198	56.133	1.271	2.680	3.720
	Std. Dev.	0.602	3.293	9.214	8.085	0.173	0.976	0.711
Sierra-Leone	Mean	1.233	0.420	31.776	42.469	1.315	11.837	3.338
	Std. Dev.	0.501	7.014	8.201	5.732	0.175	3.551	1.315
South Africa	Mean	3.427	0.410	50.373	58.660	2.134	5.677	2.679
	Std. Dev.	0.257	2.282	14.625	3.608	0.336	2.836	0.452
Togo	Mean	1.246	0.348	40.932	54.528	1.524	10.130	4.244
	Std. Dev.	0.645	5.434	8.161	3.520	0.247	4.465	0.889
Tunisia	Mean	1.678	2.631	57.129	68.511	1.766	6.172	2.687
	Std. Dev.	0.370	3.173	7.928	7.420	0.464	4.110	1.165
Zambia	Mean	1.061	0.200	45.555	51.671	1.962	13.540	3.781
	Std. Dev.	0.258	4.032	7.964	5.624	0.356	7.638	1.620

Source: Author's Estimated Output

4.2 Correlation and CSD test output

Table 4 reveals a weak correlation between most study regressors, except the correlation between GI and LE. Consequently, a variance inflation factor (VIF) test was performed, and the estimate as presented in the lower panel of Table 4. The mean VIF value for the study regressors is 1.90, thus, indicating the existence of a low correlation between the study regressors and less severity of multicollinearity issues.

Table 4: Correlation matrix

	EF	NRR	GI	LE	YGP	HC	URB
EFP	1						
NRR	-0.008	1					
GI	0.306	0.079	1				
LE	0.302	0.061	0.746	1			
YGP	-0.105	-0.221	-0.029	0.046	1		
HC	0.358	0.141	0.727	0.568	0.037	1	
URB	-0.052	0.070	-0.464	-0.334	-0.042	-0.401	1
	VIF	1/VIF					
GI	3.45	0.290					
LE	2.27	0.441					
HC	1.31	0.455					
URB	1.10	0.762					
NRR	1.06	0.912					
YGP	1.02	0.945					
Mean VIF: 1.90							

Another result, as contained in Table 5, shows that the estimated CSD test offers substantial proof of CSD in the panel dataset. Evidence from the four tests conducted validated the rejection of the null hypothesis of no CSD for the variables in the panel study. Hence, it is imperative to adopt econometric procedures that account for CSD in their estimation process.

Table 5: CSD test output

Variable	**Breusch-Pagan LM**	**Pesaran scaled LM**	**Bias-corrected scaled LM**	**Pesaran CSD**
EF	5685.316***	185.268***	184.972***	19.433***
NRR	687.001***	9.861***	9.565***	8.061***
GI	18143.62***	622.469***	622.173***	134.635***
LE	12385.88***	420.411***	420.115***	100.067***
YGP	1895.996***	52.289***	51.993***	18.686***
HC	18018.83***	618.089***	617.793***	133.395***

URB	5889.303***	192.426***	192.130***	42.876***

Note: *** indicates statistical significance at 1%. H_o: No cross-section dependence
Source: Author's Estimated Output

4.3 Slope heterogeneity Test

Table 6 captures the estimated results for slope heterogeneity in the parameters. The null hypothesis of homogenous slope parameters was rejected against the alternative view based on the output. By validating the presence of slope heterogeneity in the parameters is evidence that the level of emissions, income growth, human capital development, urbanisation, level of globalisation and natural resources rents differs among African countries.

Table 6: Slope heterogeneity Test

Test-Statistics	Value	P-value
$\bar{\Delta}$	8.281	0.000***
$\bar{\Delta}_{adjusted}$	9.698	0.000***
H_0	Slope coefficients are homogenous	

Note: *** indicates statistical significance at 1%. H_o: Homogenous slope parameters.
Source: Author's Estimated Output

4.4 Panel unit root and cointegration test

The validation of CSD and slope heterogeneity in the variables necessitated the application of unit root tests that incorporates both CSD and heterogeneity into the unit root process. Table 7 summarises the unit root results for both the first and second-generation unit root techniques. The Maddala and Wu, and Pesaran CIPS unit root tests have the null hypothesis of first order series integration. This hypothesis was accepted for only EF and HC. Similarly, the Pesaran CADF unit root test's alternative hypothesis of stationary at first difference was also upheld for only EF and HC. Other series were found to attain stationarity at levels in the three tests.

Table 7: Unit root test output

	First generation unit root		Second generation unit root				
Variable	Maddala and Wu (1999)		Pesaran's CADF (2003)		Pesaran's CIPS (2007)		
	Without trend	With trend	Without trend	With trend	Without trend	With trend	Decision
EF	56.130	51.370	-5.310***[b]	-5.508***[b]	0.817	0.242	I(1)
NRR	515.135	470.322***	-4.558***[a]	-2.580***[a]	-7.312***	-15.840***	I(0)
GI	13.813	63.047	-2.700***[a]	-2.989***[a]	-5.327***	-3.972***	I(0)
LE	610.467***	95.059***	-4.118***[a]	-4.415***[a]	5.923	7.624	I(0)
YGP	212.380***	118.608***	-2.681***[a]	-2.991***[a]	-5.218***	-3.250***	I(0)
HC	23.129	58.108	-1.393	-2.665**[b]	2.137	4.327	I(1)
URB	95.241***	70.908	-2.399***[a]	-2.599*[a]	-3.746***	-0.900	I(0)
H_0	Series is I(1)		Series is non-stationary		Series is I(1)		

Note: a and b represents stationarity at the level and first difference, respectively, while *, **, *** indicate statistical significance at 10%, 5% and 1%, respectively.
Source: Author's Computation.

Table 8 contains the outcome of the Westerlund CSD cointegration test. Based on the output for the four test statistics, the null hypothesis of no cointegration was rejected. Hence, concluding that long-run associations exist between variables in the model.

Table 8: Westerlund CSD cointegration Test

Statistic	**Value**	**Z-value**	**Robust P-value**
G_t	-3.661	-4.622	0.000***
G_a	13.119	2.391	0.000***
P_t	-14.805	-0.864	0.000***
P_a	-9.691	2.170	0.000***
H_0	No cointegration		

Note: *** indicates statistical significance at 1%.

4.5 Estimated results

4.5.1 CS-ARDL output

Results in Table 9 reveals the short-run and long-run effect of human well-being on environmental degradation. Globalisation is shown to have both short and long term cushioning impacts on environmental degradation in the selected African countries. The result suggests that as these African countries continue to embrace political, social and economic integration, they are also able to adopt solid environmental policies that act as a guide against degrading the environment. Examples of such policies include the Earth summit of 1992 in Rio de Janeiro, the Kyoto protocol of 1997 in Japan, the Durban Platform for enhanced action of 2011 in South Africa, the Cancun agreement of 2010 in Mexico, and the more recent Paris agreement of 2015 in France. Policies from these environmental summits are possibly leading the way in the growth of green and efficient ecological friendly technologies in Africa, which can enhance environmental quality. This finding is consistent with Nathaniel (2021) and Aladejare (2022).

Similarly, life expectancy is adversely linked with environmental degradation both in the short and long term, suggesting that environmental degradation declines as life expectancy improves. Africans have a long history of engaging the life-threatening activities such as bush burning for farming and hunting, the use of crude energy sources from firewood and charcoal, harmful chemicals for fishing purposes, etc. These activities can inhibit longevity by aggravating respiratory diseases, blindness, kidney failures, etc. At the same time, they can harm the environment by increasing greenhouse gas emissions, loss of soil nutrients, deforestation, polluting water sources, etc. Hence, a reduction in these activities will promote longevity and reduce environmental degradation. This outcome aligns with extant studies such as Steinberger and Roberts (2010) and Charfeddine and Mrabet (2017). In contrast, income level is positively related to environmental degradation both in the short and long term. An indication that an increase in income tends to trigger ecological degradation in the same direction. The result shows that the quest for higher income through increased productivity in these countries is followed by higher environmental pollution. A plausible explanation for this outcome could be the use of less efficient income yielding assets in terms of their adverse impact on the environment. The result agrees with other literature dedicated to the income-environmental quality nexus, such as Gyamfi et al. (2022).

On the other hand, human capital development has negative short and long term impact on environmental degradation. Thus, implying that human capital development substantially reduces environmental degradation in African countries. This result underscores the role of human capital in Africa's environmental quality enhancement, suggesting that environmental awareness is strongly growing in African countries, possibly through media campaigns, community programmes and school curriculums. Having a well-informed population imbibing innovative and efficient environmental friendly measures will promote environmental quality in the continent. This result complements similar finds in extant studies such as Steinberger and Roberts (2010).

Urbanisation is positively associated with environmental degradation, but only in the long term. Indicating that growth in African urbanisation drive has no short-term effect but tends to enhance environmental degradation in the long-term. Urbanisation promotes humans' demands on environmental resources. The impact of such demand is known to diminish the biocapacity and worsen EF. Increase in urbanisation can stimulate higher economic activities, which increases energy demands, poor energy efficiency, and waste generation. African countries are heavily reliant on non-renewable energy sources (e.g., fossil fuels); therefore, when there is a rise in energy demand, ecological pressure is also likely to rise, and ultimately EF in the long term. Studies such as Nyangena et al. (2019) and Nathaniel (2021) have earlier reported the same effect.

The short and long term effect of natural resource rents on environmental degradation is positive. This, indicates that increases in resource rents deplete ecological quality in African countries. Hence, the extraction and exploitation of natural resources for revenue and domestic consumption have not been environmentally sustainable. The reason is that the excessive dependence on natural resources creates a depletion in biocapacity since resources are often not allowed to regenerate. This finding further compliments earlier submissions by Nathaniel (2021) and Aladejare (2022).

The error-correcting coefficient is rightly signed and significant. Its value of -0.28 shows that approximately 28% of short-term disequilibrium is corrected annually. Consequently, it would take 42 months to restore the long-term equilibrium path.

Table 9: Panel CS-ARDL output

	Coefficient	St. Error	Z-statistics	P-value
Long-run results				
GI	-0.011	0.004	-2.61	0.009***
LE	-0.115	0.058	-1.99	0.047**

YGP	0.017	0.008	2.05	0.041**
HC	-7.615	4.101	-1.86	0.063*
URB	0.038	0.022	1.75	0.081*
NRR	0.004	0.002	2.19	0.028**
Short-run results				
$l\Delta GI$	-0.012	0.005	-2.59	0.009***
ΔLE	-0.130	0.069	-1.88	0.060*
ΔYGP	0.010	0.005	2.01	0.044**
$l\Delta YGP$	0.016	0.008	1.96	0.051*
$l\Delta HC$	-10.618	5.540	-1.92	0.055*
ΔHC	1.439	3.054	0.47	0.637
ΔURB	0.029	0.028	1.02	0.309
$l\Delta URB$	0.012	0.030	0.39	0.697
$l\Delta NRR$	0.003	0.001	2.08	0.038**
ΔNRR	0.004	0.001	2.76	0.006***
$constant$	-0.782	0.217	-3.60	0.000***
$ECM(-1)$	-0.281	0.047	-6.00	0.000***

Note: *, **, *** indicates statistical significance at 10%, 5% and 1%, respectively. l is the lag operator.
Source: Author's Computation.

4.6 Panel D-H causality outcome

The D-H causality result in Table 10 reveals a significant feedback impact between most indicators of human well-being and environmental degradation. As human well-being indicators significantly affect environmental quality, the reverse is almost true for the selected African countries. Ecological resources are undoubtedly a prerequisite for humans' continuous survival on earth and advancing their well-being. We rely extensively on the environment for sourcing not just our primary needs (i.e., food, housing, clothing) but also income, means of transportation, healthcare facilities, infrastructure, etc. Likewise, the environment depends on us for friendly extractive and exploitative techniques that are imperative for ensuring sustainability. However, Table 10 also shows a unidirectional causal flow from environmental degradation to income; and no causality between urbanisation and environmental degradation.

Table 10: D-H causality output

Null Hypothesis: No homogenous causality			
	W-Stat.	Zbar-Stat.	Decision
$GI \rightarrow EF$ $EF \rightarrow GI$	5.885*** 1.627**	17.031 2.045	Bi-directional
$LE \rightarrow EF$ $EF \rightarrow LE$	4.567*** 7.964***	12.393 24.346	Bi-directional
$YGP \rightarrow EF$ $EF \rightarrow YGP$	1.468 1.812***	1.487 2.700	Uni-directional
$HC \rightarrow EF$ $EF \rightarrow HC$	5.969*** 13.229***	17.325 42.872	Bi-directional
$URB \rightarrow EF$ $EF \rightarrow URB$	1.343 0.908	1.048 -0.484	No causality
$NRR \rightarrow EF$ $EF \rightarrow NRR$	2.029*** 1.588*	3.461 1.910	Bi-directional

Note: *, **, *** indicates statistical significance at 10%, 5% and 1%, respectively.
Source: Author's Computation.

5. Concluding Remarks

Environmental degradation continues to attract interest from academics, policymakers, and other stakeholders. However, empirical studies have been limited particularly in the choice of human well-being indicators. Therefore, this study extends the literature by broadening the indicators of human well-being to include life expectancy, income, human capital development, urbanisation, and globalisation, and assessing their association with EF used to proxy for environmental degradation in 29 African countries from 1970 to 2019. Preliminary tests adaptable to the effects of CSD and heterogeneity in the panel dataset, alongside the CS-ARDL and the D-H causality approach, were adopted. Findings from the study showed that the adopted human well-being indicators have varying effects on environmental degradation in the short and long term. Specifically, globalisation, life expectancy and human capital development were found to be environmentally enhancing both in the short and long term. In contrast, income growth was environmentally degrading in the short and long term. At the same time, urbanisation was only environmentally detrimental in the long term with no significant short-term effect. Natural resource rent which served as a control variable was environmentally degrading both in the short and long term. Also, the existence of a bidirectional association between human well-being and environmental degradation was revealed through a D-H causality approach. Empirical findings from this study imply a win-win symbiotic nexus between the environment and human well-being in African countries.

Therefore, this study highlights essential policy measures that could simultaneously enhance human well-being and environmental quality in African countries based on the aforementioned. First, since globalisation serves as the vehicle for transferring eco-friendly technologies between countries, environmental policies promoting clean business strategies and allowing African governments to find a path towards deriving environmental sustainability should be adopted. Furthermore, African governments should consider investing robustly in modern environmental-friendly technologies. Investment in efficient green technologies should also be scaled-up. African countries should adopt legal and regulatory approaches to dissuade detrimental environmental FDI inflows; while offering eco-friendly investment incentives by utilising tax relieves and joint partnerships. This move will encourage the growth of efficient environmental friendly technologies. Determining and administering appropriate sanctions on erring economic agents engaging in degrading environmental activities will help strengthen adherence to environmental laws by all stakeholders. The effect of such measures will critically reduce emissions and assure environmental conservation. In promoting international trade, there is the need to regulate the exchange of goods and services and enforce only multi and bilateral trade agreements that have a potential lower adverse impact on the environment.

African governments will also have to demonstrate more commitment to tackling issues of poor income in the continent. Poor income level is responsible for cheap sourcing of energy from charcoal and firewood, bush burning for farming and hunting, illegal mining, and harmful fishing techniques. These activities culminate in greenhouse gas emissions, deforestation, pollution of water bodies, and soil erosion, reducing human longevity and eroding environmental sustainability. Hence, it is crucial to stress that the continent's income growth should be anchored on having an investor-friendly economy, which is a prerequisite for the massive development of small, medium and large enterprises. An economy overwhelmed with volatile macroeconomic policies, insecurity, corruption, political instability, etc., will undoubtedly impact poorly on life expectancy, as individuals would have to embark on the aforementioned crude survival means, which are detrimental to environmental sustainability.

African countries should strive more in developing green urban cities. Smart cities should be replicated importantly in densely populated communities. Similarly, more awareness of the need to embrace energy-saving approaches should be encouraged and the use of energy-efficient and environmentally friendly means of transportation and appliances. Consequently, improvement in human capital development is crucial to achieving environmental sustainability. A significant level of investment in human capital development, especially in developing curriculums that emphasise the two-way relationship between humans and the environment, is required. Such curriculum should, from early learning to advance schooling, robustly cover the beneficial impact of a symbiotic nexus between humans and their environment.

Lastly, policymakers and governments in the continent should also begin to fashion out strategies to lower their reliance on the extraction and utilisation of natural gas, fossil fuel, and minerals for income and energy sources with high adverse environmental impact. Thus, research and investment in renewables such as solar, geothermal, wind, tidal, hydropower, etc., should be intensified. By adopting these renewable energy sources, detrimental environmental effects from conventional means can be reduced, and sustainable economic growth and eco-friendly development can be guaranteed. However, an efficient conservative approach to resource exploration should be imbibed in the interim. Innovative technologies that have been proven efficient in natural resources exploration should be considered above their purchasing cost, so long as they have a minimal adverse environmental impact.

Compliance with Ethical Standards

Authors' contributions

The corresponding author conceived the idea, wrote the introduction, collected and analysed the data, and interpreted the results, reviewed the required literature and edited the manuscript, wrote the methodology section, provided the relevant policy directions, read and approved the final manuscript.

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Research involving human participants and or animals

This study article does not contain any study with human participants or animals performed by the author.

Data Availability Statement

The data that support the findings of the study are available from the corresponding author upon reasonable request.

Consent to participate

Not applicable.

Consent to publish

Not applicable.

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