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UNBUNDLING SOCIOECONOMIC LIVING CONDITION: ANALYZING ENVIRONMENTAL QUALITY IMPACT ON SUSTAINABLE DEVELOPMENT FOR NIGERIA

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Sustainable development is a development strategy that utilizes resources in a manner that ensures their availability for future generations. The study thus, investigates the impact of environmental quality (a component of socioeconomic living conditions) on sustainable development in Nigeria. The influence of biocapacity deficit per capita (measurement for environmental quality) and other macroeconomic variables on human development index (sustainable development's measurement) is examined using data which range from1999q1 to 2022q2. Having utilized the Autoregressive Distributed Lag framework to evaluate the short-term and the long-term equations, the result reveals that, apart from real per capita gross domestic product and capital investment, which are significant in the short run, biocapacity deficit per capita, urban population and labour force do not exhibit significant effects. However, in the long-run, biocapacity deficit per capita and labour force turned out negatively significant. Interestingly, biocapacity deficit per capita is observed to be sustainable development retarding. The key implication from the outcomes of this research is that the degraded environment retards long-term development sustainability in Nigeria. Therefore, the study recommends extensive reforestation and afforestation efforts to enhance the nation's degraded lands, restore biodiversity, and boost carbon sequestration. However, despite the insightful findings, key macroeconomic variables like technological innovation and institutional quality that would have explained sustainable development were not factored into the study analysis.

Keywords: **Sustainable Development; Environmental Quality; Biocapacity Deficit, Human Development Index, Autoregressive Distributed Lag, Macroeconomic Variables**

JEL Classification: **I31; O13, Q56, R11**

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1. Introduction

The Kuznets curve hypothesis, which explores the connection between environmental quality (that is, environmental degradation) and economic growth, has significantly transformed perspectives on the environment, and deepened insights about the impact of nature on humanity. However, extant studies have revealed some alternative environmental curves which signify different dynamics on nexus between the environment and economic growth. These alternative curves are the N-shaped, the S-shaped, the contrasting U-shaped and the monotonic increase or decrease curves (See Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. 2002; Panayiotou, 1993; Stern, 2004 & Arrow et al., 1995). These latter curves merely complement the former (Environmental Kuznets Curve [EKC]), indicating patterns of environmental effect varies across pollutants. But, EKC supremacy over the latter curves in literature stems from its conceptual and empirical clarity across board (Grossman & Krueger, 1995). Besides, EKC power to explain structural economic changes, technical innovations, and regulatory progresses in development is superb (Panayiotou, 1997).

Owing to these cited superiorities, numerous studies have scrutinized the theory's validity (refer to Panayotou, 1993; Stern, 2004; Orubu & Omotor, 2011; Solarin, Nathaniel, Bekun, Okunola & Alhassan, 2021 among others). Some scholars have utilized their grasp of environmental quality through the hypothesis to explain its effects on various aspects of life such as foreign direct investment, urbanization, financial development, government quality, and more (see Shahbaz et al, 2016; Baloch, Ozturk, Berkun & Khan, 2020; Iorember Goshit & Dabwor, 2020; Khan, Hou & Le, 2021; Aderinto, 2022; Mahmoodi & Dahmardeh, 2022). Despite the conflicting findings from these numerous studies, minimal consideration has been paid to the seemingly correlation between the quality of environment and sustainable development. Thus, this study focuses on environmental condition [i.e. degradation] impact on sustainable development in Nigeria.

Beside the environment being an integral part of the socioeconomic living condition, its condition (whether improved or degraded), is likely to influence human development. The socioeconomic living condition is synonymous with the quality of life, the standard of living, the economic well-being, and the living condition. Therefore, these terms are used interchangeably. The socioeconomic living condition can be unbundled (that is, disaggregated) into economic, social, and the environment. The three combine to provide a comprehensive understanding of man's quality of life, and offers valuable insights into the well-being of people (McGregor & Pouw, 2017). But the individual analysis of these three, could give an in-depth perception. The environment among the three stands out due to its significant global impact on human development. For example, the negative consequences

of environmental degradation have led to imbalanced ecosystems that affect human populations. Consequently, the implementation of stringent environmental policies and the enforcement of penalties are necessary to achieve sustainable development goals (Odutola, 2020). This necessitates the importance of quality environment. As a result, a high-level global body, Conference of Parties (COPs) has since been instituted to address the adverse effects of environmental degradation, and explore potential solutions.

Referring to sustainable development, the concept centres around human development (see Medarov & Petrova, 2021, Le Blanc, 2015). Various understandings about sustainable development have been advanced, with the Brundtland Commission's definition, the most popular. According to the commission's report, sustainable development is a global objective aimed at meeting the present generation's needs without compromising the ability of future generations to meet their own needs (Mensah, 2019). This definition simplifies sustainable development as a development strategy that utilizes resources in a manner that ensures their availability for future generations (Mohieldin, 2017). In other words, for development to be sustainable, it is required that natural resources are replenishable after consumption or depletion. When this is done in a way that benefits up-coming generations, it promotes continuity and ensures sustainability of resources replacement.

Sustainable development has the potential to stimulate positively social progress, balanced environment, and economic growth in nations (Gossling-Goidsmiths, 2018; Zhai & Chang, 2019). In other words, sustainable development can benefit countries socially, environmentally, and economically. These three possible benefits via development sustainability, could in turn stimulate the improving of people's living conditions. Interestingly, these three (the social component, the environmental component and the economic component) form the integral part of human socioeconomic well-being. Focusing on the significance of sustainable development, it can be described as a paradigm that promotes standard of living while safeguarding the natural environment from threats such as deforestation and pollution (Benaim & Raftis, 2008; Browning & Rigolon, 2019). In other words, the interconnectedness between sustained development and the state of the human environment is further revealed.

The condition of the natural environment can either deteriorate or improve, reflecting on its overall quality. However, due to continuous development activities, the natural environments have degraded over time (Aluko, 2004). This shows that resources have been depleted beyond a regeneration capacity, jeopardizing the sustainability of a healthy environment (Khan, Hou & Le, 2021). This is environmental degradation, and is attracting global concerns. Neglecting to take actions that would remedy this critical state of the environment, could

significantly impede social progress (Stern, 2007). The human environment plays a crucial role in human development. However, striking a balance between utilizing the environment and preserving humanity is a key concern (Stern, 2007). Consequently, there is growing concern about the management of degraded environments to promote sustainable development (Stern, 2007). This evidently reveals there is seemly nexus between the state of the human environment and sustainable development, which requires scientific validations.

The natural environment is comprised of air, water, land, biodiversity, and various ecosystems. These environmental essentials, can significantly ascertain the quality of the environment as a result of activities of the human elements within it. For instance, some countries are classified industrialized, which allows for industrial activities and waste that can act as pollutants to the natural environment. This however, may not be the case with nation that are not industrialized. Many Sub-Sahara African (SSA) countries are in this category, with significant portion of their ecosystems being forests. Lately, actions of humans in the environment, especially on the forest has led to deforestation, almost surpassed the global average rate. These human-induced actions, along with other environmental challenges, are causing evident severe environmental degradation and biodiversity unbalancing.

So, if the characteristics of an environment differ across nations and regions, there is likelihood of variation in the factors that degrade it too. It is thus crucial to note that, the assessment and measurement of environmental quality may equally differ in terms of value and methodology. Consequently, the evaluation of environmental degradation's impact on human development needs revisitation. Numerous studies conducted in Nigeria, and in other nations have measured environmental degradation using carbon emissions (CO2 or CO), while some have developed indices as proxy (Orubu & Omotor, 2011; Solarin et al., 2021; Mesagan & Nwachukwu, 2018; Mehmood, 2021). However, it is possible that these approaches have not fully captured the complexity of environmental degradation. Therefore, this research addresses this gap by utilizing 'biocapacity deficit per capita'. This will capture adequately the seemly complexity of a degraded environment, especially in Nigeria. The approach which is rarely employed, is derived from a well-established ecological footprint methodology. Thus, with this, the study empirically considers the theoretical proposition that there is a connection between the human environment and sustainable development.

Subsequently, to realize the set goal, the study is structured as follows: Section 2 presents stylized facts on sustainable development and environmental degradation. Section 3 provides a brief literature review. Section 4 summarizes the methodological framework. The empirical

results and discussions are in Section 5, while section 6 contains concluding remarks along with useful policy recommendations.

2. Sustainable Development and Environmental Quality: Stylized Facts

This study considered environment quality (that is, environmental degradation) and sustainable development in Nigeria. Nigeria has a biocapacity deficit (that is, her ecological footprint surpassing the biocapacity). It registered 77 percent, which placed it in the deficit region (Global Footprint Network [GFN], 2024), and is a signpost for a degraded environment. Expectedly, environmental conditions reflect on the inhabitant's development. This is why human development index (HDI) is used to proxy sustainable development.

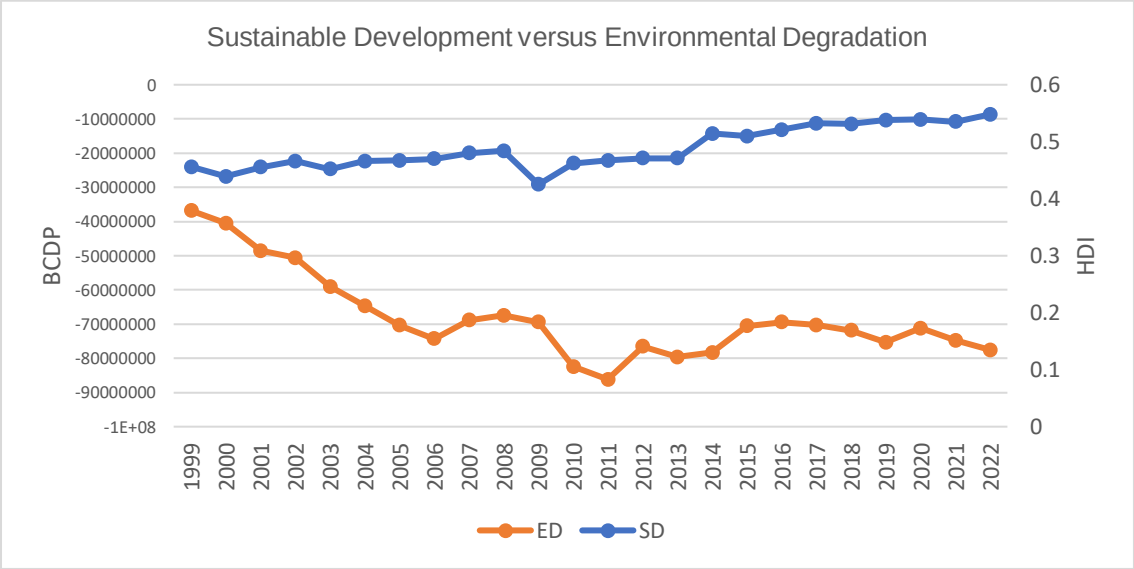

Figure 1: Sustainable Development and Environmental Degradation in Nigeria

Source: *Authors' computation (2024)*

In line with the graphs in figure 1, there has been a disturbing trend regarding sustainable development in Nigeria. This reveals a deficiency of noteworthy progress in sustainable development, likely to be associated with evident fluctuations in environmental

deterioration during the period. The trend of the graph between 1999 and 2022 shows an unstable environment where trends come and go without showing movement towards achieving the goals of sustainable development. This indicates the inability of development initiatives to ensure human development throughout these years due to this underlying instability, as is demonstrated by the variations displayed. Given this, it is evident that the fluctuation and instabilities that are currently present, and are depicted in the graph highlight the pressing requirement for thoughtful policy frameworks and proactive measures in order to tackle the fundamental causes of environmental degradation and open the door for Nigeria to follow a more resilient and environmentally friendly development path. The graph's evident volatility during the years, portends possible negative outcomes for Nigeria's sustainable development trajectories. The nation's short- and long-term sustainable development aspirations may be hampered by the graph's ongoing instability and insufficient progress in resolving environmental degradation challenges. Failure to address the destabilizing forces could endanger sustained growth, and significantly impact human development of the present as well as generations yet to come.

3. Literature Review

The Brundtland Commission Report has become famous for its conceptualization of ***'sustainable development'***. The report simply defines sustainable development as changes which guarantee the right of future generations, to improved environmental quality, and satisfactorily meeting the present generations' need (World Commission on Environment and Development [WCED], 1987). Giving further clarification to the Commission's definition, Mohieldin (2017) sees sustainable development as a development strategy which engages resources in a manner that allows the resources to be available for future generations' usage. In other words, Mohieldin views this developmental concept as a development strategy that dictates how nations' available resources should be utilized. *But Khan, Hou and Le (2021) had a very narrow perspective about the concept when its definition aligned with the environment only. That, in any environment, consumption of natural resources should be done in a way that their replenishment capacity is guaranteed. Put differently, renewable resources should be replaced to always make the human environment habitable. Besides Khan et al's definition, sustainable development encompasses seeking productive use of available renewable resources to alleviate poverty, improve welfare and quality of life (Aluko, 2004). Aluko's conceptualization has revealed that sustainable development is human development focused. Afterall, the millennium development goals, which were later increased*

to 17 goals, are geared towards improving human lives. But, opposing to viewing sustainable development from the angle of environmental quality only, Barbier (1987) cited in Odutolu (2020) submits that, sustainable development ensures long-time equilibrium amongst the three pillars (economic, social & the environment) which revolve round economic development. In other words, sustainability in one out of the three pillars cannot guarantee sustainable economic development.

The varied degree of suitability of an environment brings about environmental quality. The concept is coined from two words, 'environment' and 'quality'. While the former is physical setting which comprises tangible and intangible elemental components that accommodates living and non-living creatures, the latter implies value or worth of a thing. Merging the meanings of these two key words, ***environmental quality*** therefore, is a condition or status of tangible and intangible elemental components (air, water and biodiversity) in an environment, and the ecosystem health. In what seems similar to this definition, but with a slight variation, the United States Environmental Protection Agency (USEPA, n.d.) describes it as the state of the air, water, land, and natural resources which impact people's health and quality of life. But Odum (1989) in his study equated ecosystem health to environmental quality in terms of valuation, and thus submits that environmental quality is the capacity of the ecosystem to endure the processes of ecological system and maintains a balance in the face of distortions. This reveals the association amongst elements of environment and their toughness to oppose what brings about distortion.

Inferring from Odum's submission, the environment can be distorted. So, the essence of qualitative environment is its capability to maintain a balanced nature when distorted. However, whenever this balance is not achieved or sustained, the environment becomes degraded, and this leads to the loss of the ecosystem. Oyinbo, Ihugba and Egbon (2017) remarks that a degraded environment is harmful to living creatures, and eventually becomes a lost ecosystem. Hence, at that point, environmental quality turns a challenge into growth and development. Olawoyin and Edewor (2018) submits that the quality of environment could impact sustainable development, and a degraded one is capable of hampering socioeconomic progress.

Theoretically, Environmental Kuznets Curve (EKC) is a known theory associated with issues bordering on the quality of the environment. This theory was put forward by Simon Kuznets, however, the appellation 'EKC hypotheses' was coined by Panayotou (1993). Fundamentally, the theory links the state of the environment to growth. There is an inverted U-shaped connexion between economic growth and environmental degradation. Put differently, as increased income levels are observed, the state of elements such as water,

air, land and natural resources which constitute the environment becomes seriously distorted, but eventually falls once income crosses some threshold levels (Orubu & Omotor, 2011). Stern (2004) deepens the understanding about what EKC theory really means, when the investigation reveals that environmental degradation measures would initially increase, and later experience a drop as per capita income of a country's economy improves. In other words, Stern's study supported the U-shape preposition of Simon Kuznets.

But Rupasingha, Goetz, Debertin and Pagoulatos (2004) consider spatial association in the evaluation of EKC for toxic waste release. Engaging Bayesian spatial error Tobit model, the outcome indicated an N-shape EKC. That indeed was a drastic variation from the known U-shaped EKC. In all of these however, despite the numerous empirical investigations' inconclusiveness on EKC hypothesis, certain landmarks conclusions about the hypothesis are established. That, there is an association between environmental degradation and economic growth; as income level improves environmental degradation falls; and of course, there are factors supportive of improved quality of the environment (Orubu & Omotor, 2011).

But this study focus is on the ***sustainable development-environmental quality effect***. That is, environmental quality impact on sustainable development. Accordingly, there is need for a deviation from the theoretical norms (that is, the use of EKC hypothesis). Human improvement forms the core of sustainable development, and it can be attained through continuous growth in nations' gross domestic products. Thus, any growth theory can adequately explain the sustainable development-environmental quality impact. The new growth theory (endogenous model) is one theory that can best address sustainable development. According to Babasanya, Ogunleye and Ogunyomi (2019) the theory has become popular with the report on sustainable development championed by Brundtland in 1987. The new growth theory known as endogenous model was built on Solow and Swan's understanding of economic growth (now known as the Solow-Swan model). The model (the Solow-Swan growth model) advanced that national output besides capital and labour input, is exogenously ascertained via technical progress rate.

However, economists like Arrow, Lucas, Romer, and others were not comfortable with Solow and Swan's version of economic growth explanation, so, they came up with the endogenous growth model. In the model, hinging on the concept of sustainable development, the rate of technical progress, was internalized, instead of treating as an external variable in the model. (Babasanya, Ogunleye, & Ogunyomi, 2017). The endogenous version from the Solow-Swan model was indeed an ingenious innovation. According to Jhingan (2003) the endogenous version broadens the Solow-Swan model by internalizing technology

progression rate in the model. Babasanya, Ogunleye and Ogunyomi (2019) remarked that, the seemly inverse association between output (economy's GDP) and environmental quality is facilitated by technological rate via it influence on human capital. So, equating environmental quality/degradation to rate of technical progression in order to ascertain the former's impact on growth can either be multifaceted or cumbersome. Be that as it may, the endogenous growth model has revealed that technology via human capital and sound health determine growth vis-à-vis human quality improvement [that is, human development] (Yumashev, Ślusarczyk, Kondrashev & Mikhaylov, 2020).

The empirical literature on environmental quality and human development (that is, sustainable development) reveals varied focuses and methodologies across studies. A study examines the impact of energy consumption on human development in Organization for Economic Co-operation and Development (OECD) countries, the results show that human development index levels are influenced by factors such as urbanization, GDP, gross national income (GNI) per capita, energy consumption, and research and development (R&D) costs. Likewise, assessing the effect of renewable energy and education on environmental quality in Group of 11 economies, the study finds that renewable energy and education reduce carbon emissions, though foreign direct investment and natural resources exacerbate environmental degradation. In a related approach, another research considers the relationship between environmental degradation (using ecological footprint as a proxy) and economic growth, renewable and non-renewable energy, and governance quality in European and Asian emerging economies, and the findings indicate renewable energy lessens environmental degradation only in European countries, highlighting the complexity of these relationships (see Yumashev et al., 2020; Mehmood, 2021; Mahmoodi & Dahmardeh, 2022).

In the Nigerian context, the link between environmental quality and poverty reduction was examined, and the study concludes that improved environmental quality correlates with rising poverty due to the social and financial costs of accessing electricity and sanitation. Similarly, another assesses the impact of natural resources, energy consumption, and population growth on ecological footprint and carbon emissions, and finds that while renewable energy reduces degradation, non-renewable energy and population growth exacerbate it (see Owolabi, Aderounmu & Ogunbiyi, 2019; Khan et al., 2021).

Furthermore, in Nigeria, studies have examined the relationship between income and environmental degradation. While a certain study finds that increased income mitigates pollution, though organic water pollutants rise with income in the absence of stringent environmental measures, another explores the determinants of environmental quality, and

reveals that financial development positively impacts environmental quality. This contrasts a related study which finds that financial development degrades environmental quality. But, economic growth's impact on ecological footprint was examined, and the outcome showed GDP adversely impacts environmental quality in the short run but improves it over time, underscoring the nuanced effect of economic growth (see Oruba & Omotor, 2011; Mesagan & Nwachukwu, 2018; Solarin, Nathaniel, Bekun, Okunola, and Alhassan, 2021).

Although these studies creatively utilize ecological footprints and other indicators of environmental quality, very few directly assess the link between environmental degradation (using biocapacity deficit per capita) and sustainable development in Nigeria, highlighting a significant research gap. This study addresses this gap, advancing understanding of environmental quality's role in sustainable development in nation's unique socio-economic landscape.

4. Methodology

4.1 Theoretical Framework, Model and Data

This study is predicated on the new growth theory known as endogenous growth mode. The theory explains that; in addition to capital and labour inputs, other inputs referred to as 'residual' in the theory can also influence growth. Prior to this, the classical ideas about output production in any economy was a function of capital and labour. This ideology held sway for quite a while before the advent of the neo-classical's understanding about growth. Thus, this economic philosophy subjugated the economic space for about three decades. What the neo-classical hypothesised is represented in the equation below.

$$Y_t = R_t f\left(K_{t,} L_t\right) \tag{1}$$

The mathematical model as depicted in equation 1 relates output level (Yt) to amounts of capital (Kt), labour (Lt) and technological rate (Rt) in a nation's production process. In this case, (Rt) is externalized, and it is what Solow-Swan hypothesized.

Solow and Swan continued to externalize the residual factor, and believed in its constant returns. But Arrow, Lucas, Romer, and others felt otherwise, and extended the Solow-Swan

model by internalizing the formally exogenous factor as a result of the concept of sustainable development (Babasanya, Ogunleye, & Ogunyomi, 2019).

$$Y_t = f(K_t, L_t R_t) \tag{2}$$

It is pertinent to note that in equation 2, (Rt) is internalized, as against the case in model 1. What the originators of the new growth theory did was to make the model an increasing return to scale and reveal technological progress as long period input that can grows any economy. Thus, technological progress influence on the economy can be observed from three (3) fronts: (a) the rate of investment, (b) size of the capital stock, and (c) the stock of human capital (Babasanya, Ogunleye, & Ogunyomi, 2019).

In order to empirically demonstrate the effect of environmental quality (that is, environmental degradation) on sustainable development, the study adapts with modification the combination of the study's theoretical framework and a behavioural equation. The behavioural equation was developed by OECD and the United Nations (UN), and applied in Yumashev et al (2020). The equation relates data on an issue bordering on human development and carbon emissions, energy consumption and other macroeconomic variables.

The basic OECD-UN behavioural equation is stated thus:

$$HDI_t = \beta_0 Kpc_t^{\alpha 1} Pop_t^{\alpha 2} HC_t^{\alpha 3} LE_t^{\alpha 4} RNE_t^{\alpha 5} C0_{2_t}^{\alpha 6} E_t^{\alpha 7} \varepsilon_t \tag{3}$$

In the mode, *HDI* captures sustainable development, *Kpc* represents the main factor of capital production, *Pop* is population, *HC* is human capital, *LE* is life expectance, *RNE* is renewable energy, CO_2 is pollution and *E* means energy consumption. The *α's* are parameters estimates and *ε* is the error term. This study adapts the equation, and modifies using replacement, inclusion and exclusion principles. Therefore, since the research is basically about the sustainable development-environmental quality (degradation) effect, environmental degradation (*ED*) is proxied by biocapacity deficit per capita, and it replaces CO_2, GDP per capita, labour force (*LF*) and capital (*K*) are included in the model, while, UP is used in place of *Pop*, the rest variable in the behavioural equation are left out. Meanwhile, sustainable development measured by HDI is equally an output (Y_t) variable, following the endogenous growth philosophy (Babasanya, Ogunleye, & Ogunyomi, 2019). Thus, Y_t in

equation 2 is replaced by *HDI*. Hence, the empirical equation for the study, is an adaption of equation 3, and is as stated below:

$$HDI_t = f\left(\beta_0 K_t^{\alpha 1} LF_t^{\alpha 2} BCDP_t^{\alpha 3} RGDPP_t^{\alpha 4} UP_t^{\alpha 5} \varepsilon_t\right) \quad (4)$$

Taking the linear-log of equation 4, the linearized function becomes as shown below:

$$HDI_t = \alpha_0 + \alpha_1 lnK_t + \alpha_2 LF_t + \alpha_3 BCDP_t + \alpha_4 lnRGDPP_t + \alpha_5 UP_t + \varepsilon_t \quad (5)$$

Where HDI_t is human development index which captures sustainable development (see Yumashev et al., 2020; Medarov & Petrova, 2021, Le Blanc, 2015), lnK_t is capital investment (proxied by gross fixed capital formation, and is in billions of naira), LF_t is labour force (capture by labour force participation rate, and is expressed in millions of persons), $BCDP_t$ is biocapacity deficit per capita which measures environmental quality (that is, degradation), and is expressed global hectares (gha) per individual, $lnRGDPP_t$ is log of real GDP per capita (it reveals individual's share of total GDP, and is in millions of naira per citizen), UP_t signifies percentage of persons residing in a nation's cities or townships, is often expressed in millions of individuals and ε_t is the disturbance term.

The autoregressive distributed lag (ARDL) framework with its bounds test cointegration methodology is engaged to establish the presence or otherwise of long-run relationship amongst the macroeconomic variables. The ARDL framework became applicable after the unit root test outcomes reveal a mixed order of integration of the considered variables (that is, I [0] & I [1]). This is one of advantages the ARDL application. Besides this, the ARDL approach simultaneously evaluates both short-run and long-run periods. Hence equation 6 below depicts the ARDL model to be evaluated:

$$HDI_t = \alpha_0 + \sum_{k=1}^{n} \alpha_1 \Delta\, lnK_{t-1} + \sum_{k=1}^{n} \alpha_2 \Delta LF_{t-1} + \sum_{k=1}^{n} \alpha_3 \Delta BCDP_{t-1} + \sum_{k=1}^{n} \alpha_4\, \Delta lnRGDPP_{t-1} + \sum_{k=1}^{n} \alpha_5 \Delta UP_{t-1} + \gamma_1 lnK_{t-1} + \gamma_2 LF_{t-1} + \gamma_3 BCDP_{t-1} + \gamma_4 lnRGDPP_{t-1} + \gamma_5 UP_{t-1} + \varepsilon_t \quad (6)$$

where γ_1 to γ_5 are the long-run parameters and α_1 to α_5 are the short-run parameters of the variables. The possibility of any long-run association amongst the macroeconomic variables is ascertained using the ARDL bound test for cointegration. If cointegration is established at 5% significant level, the ARDL long-run and short-run models are evaluated in-line with the specified equations below:

$$HDI_t = \alpha_0 + \sum_{k=1}^{n} \alpha_1 \Delta\, lnK_{t-1} + \sum_{k=1}^{n} \alpha_2 \Delta LF_{t-1} + \sum_{k=1}^{n} \alpha_3 \Delta BCDP_{t-1} + \sum_{k=1}^{n} \alpha_4\, \Delta lnRGDPP_{t-1} + \sum_{k=1}^{n} \alpha_5 \Delta UP_{t-1} + \varphi ECM_{t-1} + \varepsilon_t \quad (7)$$

where φ is the parameter of the ECM_{t-1} and should be negatively signed, and the ECM_{t-1} is one lag error correction term that accounts for the speed of adjustment to the long-run equilibrium. All the coefficients (α's) of the explanatory variables with the exception of those of $BCDP_t$ and UP_t are expected to directly impact HDI_t in Nigeria.

The econometric function specified in 6 is evaluated utilizing quarterly data. Yearly data obtained from various issues of Central Bank of Nigeria Statistical Bulletins (2022), World Development Indicators (2022) and Global footprints network (2024) ranging from 1999 to 2022 of the engaged variables are converted to quarterly data using E-views. Aside *K* and R*GDPP* which are logged, the rest of the included variables are in their natural forms.

4.2 Data Analysis and Result Presentation

The findings presented in Table 1 are descriptive summary statistics of the variables used in the study.

Table 1. Estimation of Descriptive Statistics Test Result

Variables	Description	Mean	S.D.	Max	Min	Skew	Kurt	J-Bera	Obs.
HDI	**Human Development Index**	0.4864	0.0341	0.5480	0.4250	0.2314	1.9269	1.9917	92
UP	**Urban population**	43.780	5.7542	53.521	34.304	1.7057	4.7629	21.504	92
LF	**Labour force**	59.777	0.5387	60.422	58.437	1.7030	4.5476	20.412	92
K	**Gross fixed capital formation**	23.470	138.33	1298.0	1.0100	0.9511	5.1472	12.000	92
RGDPP	**RGDP per capita**	5.8389	3.1399	17.010	0.9900	-0.4065	2.2703	1.7404	92
BCDP	**Biocapacity deficit per capita**	-0.4189	0.0604	-0.3068	-0.5222	1.6424	7.1383	40.712	92

Note: SD=Standard Deviation, Max=Maximum, Min=Minimum, Obs.=Observations, Skew=Skewness, Kurt=Kurtosis & J-Bera =Jarque-Bera

The mean value for HDI is calculated to be 0.4864, with a standard deviation of 0.0341. This signifies that the minimum observed value is 0.4250, while the maximum value is 0.5480,

based on a total of 92 observations. This metric serves as an indicator of the level of sustainable development within the Nigerian context. Furthermore, the average urban population recorded in the study is 43.780, with a corresponding standard deviation of 5.7542. The urban population variable exhibits a range from a minimum of 34.304 to a maximum of 53.521 million of persons, providing insights into the size and distribution of urban inhabitants in Nigeria. Additionally, the mean value of the labour force is calculated at 59.777 million, with a relatively low standard deviation of 0.5387 million. This metric ranges from 58.437 to 60.422 million of people, and represents the total number of individuals engaged in employment or seeking work opportunities within the country. Moreover, the average gross fixed capital formation is 23.470 billion naira, accompanied by a notable standard deviation of 138.33 billion naira. The substantial range of this variable spans from 1.0100 to 1298.0 billion naira, signifying the aggregated value of investments made in fixed assets within the Nigerian economy. Another critical macroeconomic variable is the real GDP per capita, and its mean is 5.8389 million per person, with a standard deviation of 3.1399. The real GDP per capita reveals a spectrum from 0.9900 to 17.010 million naira per citizen and reflects the economic output generated per individual in Nigeria. Then, there is biocapacity deficit per capita, and mean is -0.4189 million naira. The data show a standard deviation of 0.0604, which is rather minimal, and it ranges from -0.5222 to -0.3068. This variable (BCDP) represents the degree to which Nigerian's footprints' impact on the country's environment surpasses its per-person biocapacity.

More so, the biocapacity deficit per capita exhibits strong right skewness (1.6424) and extreme leptokurtosis (7.1383), with a sharp peak and outliers, as indicated by a high Jarque-Bera statistic (40.712), signalling significant deviation from normality. Overall, several variables, including urban population, labour force, and biocapacity deficit, display notable skewness and kurtosis, suggesting non-normal distributions and the presence of extreme values. In contrast, variables like real GDP per capita are closer to normal distribution. The Jarque-Bera test further confirms that non-normality may affect the validity of regression analyses where normality is required. Hence, the statistical analysis highlights environmental challenges in Nigeria, such as resource depletion and urban sprawl, driven by high urban populations and biocapacity deficits. Sustainable management of labour force participation and industrial capital formation is crucial to mitigating environmental harm. Balancing economic growth with environmental protection remains essential for long-term sustainability.

Table 2. Augmented Dickey-Fuller (ADF) Unit Root Test Result

Variables	@Levels	1st Difference	Integration Order	Prob*
HDI	-1.324929	-3.581842	I(1)	0.0000
UP	-7.313966	-1.234210	I(0)	0.0016
LF	-2.391939	-4.332020	I(1)	0.0006
K	-3.581883	-1.114538	I(0)	0.0008
RGDPP	-7.461822	-1.175442	I(0)	0.0002
BCDP	-2.862031	-4.995840	I(1)	0.0005
		Critical Values		
	1%	5%	10%	
	4.062	3.459	3.156	

Source: *Authors' computation (2024)*

The ADF test findings I (0) for stationary and I (1) for non-stationary, and their integration orders provide information on each variable's stationarity characteristics. The results are as depicted in Table 2. Initial analysis at levels for the variable HDI shows a test statistic of -1.324929, which denotes non-stationarity. However, at first difference and with test statistic of -3.581842, it is stationary at a 5% significance, and became integrated at order [I (1)]. In contrast, with test statistic of -7.313966 at level, variable UP was stationary. However, following a single differencing, test statistic -1.234210 indicates the non-stationarity of the variable. Thus, it makes UP to integrated at order of I (0). Similarly, variables K and RGDPP are stable at levels, as evidenced by test statistics of -3.581883 and -7.461822, respectively, resulting in integration orders of I (0). On the contrary, both variables LF and BCDP were initially non-stationary at level, but became stationary at first differencing, making the two variables having order of integration I (1).

The critical values listed in the table (1%, 5% & 10%) act as benchmarks for determining the statistical significance of the test outcomes. When the absolute value of the test statistic exceeds the corresponding critical value, the null hypothesis of a unit root is rejected. Consequently, the ADF Unit Root Test results play a pivotal role in unveiling the order of integration required for each variable, offering crucial insights into their stationarity and the necessity for differencing to attain stationarity within the time series data. From the table, the order of integration reveals what is known as mixed order of integration [I (0) & I (1)]. With this, the study proceeds to conduct the ARDL Bound test to assess long-run cointegration.

Table 3. ARDL Bound Test for Cointegration Results

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	5.09	10%	2.26	3.35
k	5	5%	2.62	3.79
		2.50%	2.96	4.18
		1%	3.41	4.68

Source: *Authors' computation (2024)*

The ARDL Bound's testing procedure is relevant owing to the mixed order of integration processes of the variables, as well as used of error correction mechanism. The result of the Bound cointegration test is presented in Table 3 where the computed F-statistic as well as the corresponding lower I (0) and upper I (1) bounds of the cointegration tests are equally depicted. The procedure for the Bounds test indicates that the computed F-values must be greater than both the lower and upper Bounds in order to establish cointegration in the combined variables. If, however, "the estimated F-value falls between the two Bounds values, then there is need to proceed with a lesser structure of the ECM analysis by applying the Josselus procedure" (Stock & Watson, 2020). From the result, the computed F value for the Bound cointegration test is greater than both the lower and upper Bounds values at the 5% significant level. This shows that the null hypothesis of no cointegration among the variables is rejected at the 5% level. Essentially, a long-run relation between sustainable development measurement and the independent variables is established. These results reveal presence of long run relation among the variables.

Having established the existence of long-run association amongst the engaged variables, it is necessary to first ascertain the lag length of the model. Thus, the result of the lag structure selection is as shown in Table 4. Essentially, this study adopts the Akaike information criterion (AIC) for determining the optimal lag length. AIC lag length of 4 is preferred to Schwarz Information Criterion (SIC) of 2 because, for time series data (especially for quarterly data), longer lag will improve forecasting by accommodating the latent influence that is likely not possible with a shorter lag selection. Hence, the lag length of 4 periods as the optimal lag length is chosen.

Table 4. Lag Length Selection Test Result

Lag	LogL	LR	FPE	AIC	SC	HQ
1	797.4626	NA	6.68e-16	-17.91677	-16.88223	-17.50065
2	1032.515	403.7367	6.24e-17	-22.60035	-20.53128*	-21.76811*
3	1043.483	17.29086	1.16e-17	-22.01136	-18.90776	-20.76300
4	1066.220	32.63468	1.67e-18*	-22.69930*	-17.56116	-20.03482
5	1109.956	56.60000*	1.53e-17	-21.88133	-16.70866	-19.80073
6	1153.766	50.50937	1.48e-17	-22.06507	-15.85787	-19.56836
7	1167.349	13.74350	3.15e-17	-21.53763	-14.29589	-18.62480
8	1190.469	20.12733	5.94e-17	-21.23455	-12.95828	-17.90560

Source: *Authors' computation (2024)*

In Table 5 is the outcomes of the ARDL estimates. Note that the short-run estimates are reported in the upper panel while the long-run estimates are in the lower panel. The adjusted R-squared value from the estimates is high at 0.646. This indicates that over 64 percent of the behaviour of HDI (that is, sustainable development) is explained in the model. Essentially, the model has strong explanatory or predictive capacity.

The evaluation of the short-run impacts of the independent variables on the sustainable development indicator (HDI) is performed by observing the individual coefficients of the explanatory variables for the upper panel of the Table 5. Meanwhile, HDI (that is, Constant) with coefficient (0.781) and p-value (0.00) is significant. It indicates other factors not included in the model have an influence on the dependent variable. In the estimates, the coefficients of current and lagged real GDP per capita are significant at the 1% level. This reveals that 1% rise in per capita real GDP leads to a 0.087 percent rise in the dependent variable (i.e., HDI). This suggests that income levels have both immediate and delayed impacts on sustainable development measurement in Nigeria in the short-run. However, the immediate impact is shown to be positive while the delayed impact is negative. For capital investment, it is also significant in the short-run, but negative. With the statistic (-0.119, p = 0.00), it means a percentage increase in capital investment leads to 0.119 percent drop in the dependent variable, suggesting investment may be directed towards less impactful or unsustainable sectors. The coefficient of the error correction term is significant at the 1% level and negatively signed as expected. This shows that any short-term deviation from its long-run equilibrium in sustainable development path will be restored in the long run. The coefficient of the error correction terms is however very low at -0.145, which shows that

adjustment to long-run equilibrium is slow in Nigeria. Only about 14.5 percent of long-run adjustment of dependent variable is completed in the first period.

Table 5. Short-run and Long-run Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short run				
Constant	0.781	0.14	5.72	0.00
DLOG(RGDPP)	0.508	0.12	4.13	0.00
DLOG(RGDPP(-1))	-0.511	0.13	-4.07	0.00
D(LF)	-0.022	0.01	-1.61	0.11
D(LF(-1))	0.024	0.02	1.36	0.18
D(LF(-2))	0.008	0.01	0.54	0.59
D(LF(-3))	0.022	0.01	1.81	0.07
DLOG(K)	-0.119	0.04	-3.31	0.00
DLOG(K(-1))	0.067	0.04	1.82	0.07
ECM (-1)	-0.145	0.03	-5.71	0.00
Long run				
BCDP	-0.276	0.10	-2.65	0.01
LOG(RGDPP)	0.087	0.09	1.02	0.31
UP	0.005	0.01	0.83	0.41
LF	-0.098	0.03	-3.87	0.00
LOGK	-0.107	0.06	-1.89	0.06
Adj. R-sq.	0.646			
F-statistic	17.09			

Source: *Authors' computation (2024)*

Recall that the long-run outcomes are in the lower panel of Table 5. This aspect of the result is more stable and reliable. It shows steady state impacts of the independent variables. In this case, only the coefficients of biocapacity deficit per capita (BCDP) and labour force (LF) pass the significance test at the 1% level; other explanatory variables coefficients fail the significance test even at the 5 percent. With parameter outputs (-0.276, p = 0.01), BCDP is negative as expected. It thus follows that a unit rise in biocapacity deficit will decrease the dependent variable by 0.276 unit. This means that larger biocapacity deficit (higher environmental degradation) undermines sustainable development. Thus, it shows that in

Nigeria, environmental degradation seriously influences sustainable development. This finding is line with (Yumashev et al, 2020). This aligns with the notion that sustained improve environment is crucial for long-term sustainable development. For labour force, parameter outcome is (-0.098, p = 0.00), and it statistically significant. It indicates a unit increase in labour force participation rate leads to 0.098 adverse effect on the dependent variable. Which economically means that, labour force growth, without adequate capital or skill development, can strain sustainable development.

These findings follow past studies like those of Pearce (1991) and Stern (2004), which signpost the need for the sustainable use of natural resources in order to attain long-term sustainable development. Also, outcomes by Akinlo (2008) on the role of labour in development propose that unskilled labour force expansion can strain economic systems, echoing the negative impact of labour observed in this study.

On the whole, the economic implication is that, the significant negative effect of biocapacity deficit highlights the critical importance of environmental sustainability for long-term sustainable development. Capital investment and labour appear to have adverse influence in the long run, signifying that without sustainable investment practices and skilled labour, sustainable development may worsen despite economic growth. Policies must, therefore, be focused on reducing environmental degradation and ensuring that growth is inclusive and sustainable.

The study provides for robustness checks by testing the stability of the estimated models' interrelationships presented in the empirical analysis. This allows for the elimination of doubt about the likely outlier regression for any of the groups in the sample. The post diagnostic test employs normality test, serial correlation and heteroskedasticity.

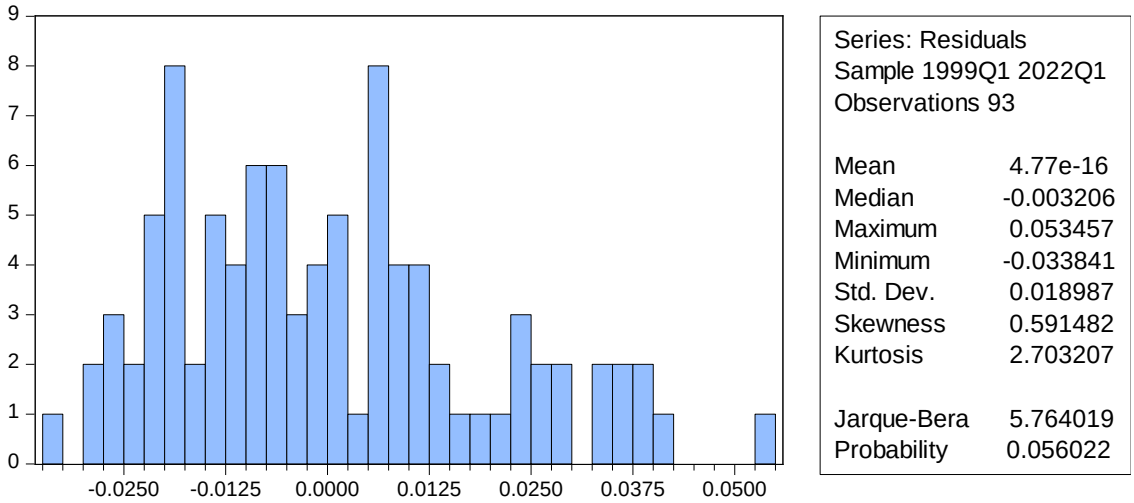

Figure 2. Normality Test

In figure 2, the histogram shows the distribution of the residuals from the model over the sample period (1999q1 to 2022q1), providing a visual representation of how the errors are spread around the mean. The Jarque-Bera statistic (5.764019) and its accompanying probability (0.056022) are used to ascertain normality. Since the probability value (p-value) of 0.056 is slightly above the common threshold of 0.05, we conclude that the residuals are not significantly different from a normal distribution at the 5% significance level. This suggests that the residuals are approximately normally distributed.

Table 6. Heteroskedasticity and Serial Correlation Test

F-statistic	200.8265	Prob. F (2,85)	0.1204
Obs*R-squared	76.75640	Prob.Chi-Square (2)	0.0617
F-statistic	1.901072	Prob. F (5,87)	0.1023
Obs*R-squared	9.160095	Prob.Chi-Square (5)	0.1028
Scaled explained SS	6.826689	Prob.Chi-Square (5)	0.2339

As seen in Table 6, the correlation result is not significant. This suggests that, the null hypothesis of no link between the variables is accepted. This reveals that the data used are reliable and well-suited for estimation. It is crucial that there be no correlation in the data used for the analysis. If there exist any correlation, the outcome could be erroneous. On the

other hand, the results of the heteroskedasticity test for the variables in the same table, show no evidence of heteroskedasticity. This, indicates that the variance of the errors is constant at all levels of the independent variables. This lack of heteroskedasticity is important since it implies that the model's estimations are true and dependable, guaranteeing that the findings are precise and appropriate for the analysis.

Since the post diagnostic findings are revealed as excepted, we therefore proceed to document a reliable conclusions and policy recommendations.

5. Conclusion and Policy Recommendation

The study examines the nation's environmental quality on sustainable development. Environmental condition/quality is a key pillar of any country's socioeconomic living condition. The study utilized quarterly data, and having engaged in pre-estimation, detailed estimation and post estimation analyses, the stationarity, the nature of integration of the variables, regression results and stability of the results were ascertained. In both long-run and short-run outputs, some macroeconomic independent variables like biocapacity deficit per capita (BCDP), labour force (LF), real GDP per capita (RGDPP) and capital investment (K) at 1% are found to significantly influenced human development index (HDI) and indicator for sustainable development. However, the long-run results are considered more stable and reliable, giving insights into the steady-state influence of the explanatory variables on sustainable development.

Thus, relying on the study's empirical output, it is discovered that aside BCDP and LF, other explanatory variables coefficients failed the significance test even at 5% level in the long-run (an indication of not statistically significant in the context of this investigation). The coefficient of BCDP as stated was significant at the 1% level and negatively signed as expected. It is indication of a degraded environment seriously hindering sustainable development in Nigeria. This is in tandem with Yumashev et al (2020) findings. This reinforces the belief of a rapid debased environment relating with poorer human development. By implication, environmental restoration and sustainable practises to improve human development should be prioritized. Also, policy makers should ensure plans to incorporate policies on sustainable environment to reduce the impact of degradation on development. So, the study recommends the need to decisively check-mate environmental degradation. This calls for massive

reforestation and afforestation policies to improve the already debased lands, restore biodiversity, and enhance carbon seizure.

Also, the coefficient of LF passed the significance test at the 1% level, but not rightly signed. This is an indication of labour force adversely associating with improved sustainable development in Nigeria. By implication, labour force growth, without required skills development, is poorly draining human improvement. It is hence recommended that the need for pragmatic and enduring policies to reposition the labour force via compulsory skills acquisition. Equally, policy makers should introduce good condition of work/work environment, living wages/salaries to employment security, to guarantee good quality of living and improvement in human development.

In spite of the insightful results of this study, its limitations must be recognized. First, the utilization of the ARDL framework, suitable for capturing short-run and long-run nexus, is possibly limited in handling structural breaks or non-linearity in the data. Also, the study main focus is on the nation's environmental quality, potentially overlooking other critical macroeconomic variables impacting sustainable development, such as technological innovation or institutional quality. These identified limitations can be suggested as areas of focus to be addressed in future studies

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