



Blue Economy and Sustainable Development in Sub-Sahara Africa: Evidence from Nigeria

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Abstract

Globally, the blue economy is seen as a potential new frontier for development, especially for coastal states like Nigeria. The sustainability and the use of ocean, sea, and coastal resources for economic growth, improved livelihood, and job creation while preserving the health of marine ecosystems are the basic tenets of the blue economy programmes that must be vigorously pursued. Therefore, this study seeks to examine the impact of the blue economy on sustainable development in sub-Saharan Africa with evidence from Nigeria, using secondary annual time series data from 1981 to 2024 on the underlisted variables from the Central Bank of Nigeria Statistical Bulletin and data from World Development Indicators (WDI). The dependent variable, sustainable development, was proxied by the human development index, while the number of revenue from fishing (REV), investment in marine energy resources (INVMA), life expectancy (LEXP), governance/institutional quality (INSTQ), inflation rate (INFL), interest rate accruable to blue economy resources (INTR) and per capita GDP (GDPPC) were the independent and control variables, respectively. The test mechanisms adopted were the unit root test for co-integration and the Autoregressive Distributed Lag (ARDL) technique. Findings revealed that there exists a

positive and significant relationship between per capita GDP, revenue from fishing, investment in marine energy resources, trade openness and interest rate accruable to the blue economy in both long and short run periods, suggesting that these variables contribute immensely to sustainable development in Nigeria when properly harnessed. However, governance/institutional quality and inflation rate exhibited a shocking negative and insignificant relationship with sustainable development in both periods, showing that during the period under review, the underlisted variables had a devastating impact on sustainable development in Nigeria. Therefore, for policy, the study recommended that the government should put in place policies and programmes that will reform governance, diversify marine resource use, stabilise inflation and prioritise human well-being so that these variables can positively drive sustainable development.

Keywords: blue economy, sustainable development, human development index, per capita gdp, governance quality

Introduction

The term '*blue economy*', often referred to as the '*ocean economy*' or '*coastal economy*', denotes the social and economic activities linked to the marine environment, coastlines, and oceans. It gained prominence at the Rio+20 United Nations Conference on Sustainable Development in 2012, which redefined the role of coastal and marine areas in sustainable development and economic growth, while underscoring the need to protect the ocean from increasing demands on its renewable and non-renewable resources (Benzaken et al., 2022). The World Bank defines the blue economy as “the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of the ocean ecosystem” (World Bank, 2017).

According to The Commonwealth (2023), the blue economy encompasses fishing, aquaculture, marine transportation and shipping, coastal tourism, renewable ocean energy, seabed mining, blue biotechnology, and related fields. It is estimated to represent the world's seventh largest economy, generating over USD 1.5 trillion annually, supporting 30 million jobs, and providing protein for more than 2 billion people (The Commonwealth, 2023). The Organisation for Economic Cooperation and Development (OECD) projects that “blue growth” could expand the sector's value to USD 3 trillion by 2030, driven by rising global interest, diverse investment opportunities, and significant prospects (OECD, 2024).

Despite the deteriorating condition of oceans caused by human activity and climate change, Sustainable Development Goal (SDG) 14 (conserve and sustainably use the oceans, seas, and marine resources for sustainable development) remains pivotal. It sets targets for sustainable fishing and aquaculture, conservation of coastal and marine areas, reduction of marine pollution, and restoration of ecosystems, to be achieved by 2030 (UNDP, 2023).

Oceans, covering nearly three-quarters of the Earth's surface, are critical to the planet's survival and prosperity. They facilitate 90% of global trade, host 95% of telecommunications infrastructure, provide 30% of offshore oil and gas, supply 15% of animal protein, contribute 5% to global GDP, and account for 7% of employment (European Commission, 2023). Thirteen of the world's twenty megacities are located along coastlines, while the global ocean economy incorporates transportation, mineral exploitation, and coastal tourism (Cicin-Sain, 2023). Oceans also regulate global climate and temperature, absorb 30% of atmospheric carbon dioxide, and supply oxygen vital for life. Moreover, natural processes such as tides, waves, currents, and offshore winds present opportunities for renewable energy (Cicin-Sain, 2023; Purcell, 2023).

This article contributes to the ongoing discourse on sustainable development and the blue economy in Nigeria, particularly in light of President Bola Ahmed Tinubu's creation of the Federal Ministry of Marine and Blue Economy. With oceans and seas constituting about 70% of the Earth's surface, there is an urgent need to consciously manage, optimise, and harness these resources. In line with SDG 14, effective implementation of Nigeria's blue economy must prioritise reducing marine pollution, protecting and restoring ecosystems, minimising ocean acidification, regulating fishing, conserving marine areas, and leveraging economic opportunities in aquaculture, transportation, and tourism (UNDP, 2023).

Accordingly, the main objective of this study is to examine the impact of blue economy resources on sustainable development in Sub-Saharan Africa, with Nigeria as a focal case.

2.1 Conceptual Framework

The blue economy is defined as "a concept that holds the promise of sustainable development and responsible resource utilisation within vast oceans and coastal areas" (Purcell, 2023). This definition applies specifically to maritime contexts, which opine that everything having to do with the coastlines, seas, or oceans is part of the blue economy. Sustainable maritime and ocean-specific strategies, solutions, and technologies that aim to mitigate environmental impacts, boost economic growth, and tap the ocean's full potential are all part of what makes up a "blue economy". The blue

economy is defined by the World Bank (2017) as the responsible use of marine resources for the sake of human prosperity, environmental preservation, and economic development. According to the European Commission (2023), the blue economy encompasses a broad variety of interconnected, existing, and growing industries that are directly or indirectly involved with the oceans, seas, and coastlines.

According to the Commonwealth of Nations (2023), the blue economy is a new idea that promotes better and more sustainable use of our oceans, seas, and marine resources via innovation and stewardship." The range of economic uses of ocean and coastal resources, such as energy, shipping, fishing, aquaculture, mining, and tourism, as well as economic benefits that are not necessarily marketable, such as carbon storage, coastal protection, cultural values, and biodiversity, is what the term "blue economy" refers to (Bertazzo, 2018). The "blue economy" means developing ocean-related industries and activities in a way that doesn't harm the environment, based on the fact that ocean resources are limited and have been damaged a lot by human actions. Understanding and effectively managing the various facets of marine sustainability, such as sustainable fisheries, ecosystem health, pollution, and so on, is crucial to managing the blue economy. Collaboration between public and commercial sectors, as well as between and within nations, is necessary for the sustainable management of ocean resources, which is a precondition for sustainable development.

Sustainable Development: Within the context of environmental change, the idea of sustainable development emerged in the 1980s during a presentation by the United Nations Environmental Programme, the International Union, and the World Wildlife Fund. This idea was based on economic, social, and ecological considerations (Costanza et al., 2004). However, the idea became more well-known with the 1987 release of the "Brundtland Report" by the WCED, which stands for the World Commission on Environment and Development. The Brundtland Report defines sustainable development as development that meets current demands without jeopardising future generations' ability to fulfil their own needs (WCED, 1987). The International Institute for Sustainable Development (IISD) asserts that the Sustainable Development Goals (SDGs) serve as the most prominent global framework for collaboration, with the concept of sustainability serving as its cornerstone. Borowy (2015) provided a definition of sustainable development in her analysis of the Brundtland Commission's (WCED) history. According to Borowy (2015), this approach aims to manage society's natural resources to meet human needs without compromising or undermining the integrity and stability of the natural system.

Sustainable Development Goal (SDG) 14, which focused on the seas and marine resources, supports the conceptual clarification. At least seven goals make up SDG 14, and they all work together to make the maritime economy sustainable by 2023 (UNDP,

2023). Achieving these goals will lead to blue economy-inspired sustainable development and economic growth. They include reducing and preventing marine pollution, managing and protecting marine ecosystems sustainably so they are healthier and more productive, addressing the impact of ocean acidification, controlling, preventing, and ending harmful and illegal fishing practices, conserving at least 10% of marine and coastal areas, prohibiting certain fishing subsidies, increasing economic benefits to developing countries through sustainable marine resource use (such as tourism, fisheries, and aquaculture), and increasing scientific knowledge, technology, and research for improved ocean health. The conservation and sustainable use of oceans, seas, and marine resources for sustainable development is defined by SDG 14 of the Global Goals (2023).

Economic growth highlights the gradual upward transformation of an entity's economy or the way in which a nation's development and wealth rise over time (Nafziger, 2012). The ability of a nation or other entity to increase and improve the products and services it produces is defined as economic growth (McKinsey, 2023) using statistical measures. The expansion of an economy's production and development of goods and services is characterised by a rise in economic growth (DFID, 2009). Factors that contribute to a country's economic growth include those that enhance the production of more valuable goods and services. Economic growth refers to the steady improvement in a country's productivity and overall output of goods and services over the short, medium, and long periods. Increasing production scale and productivity lead to a greater ability to meet consumers' demand, which in turn drives economic growth. In 2009, the Department for International Development argued that economic expansion is still an effective tool for alleviating poverty and improving living conditions in developing nations (DFID, 2009).

According to Tampakoudis et al. (2014), a country's economic growth rate may be measured by comparing its gross domestic product (GDP) to its population, sometimes known as per capita income. To further understand the distinction between economic growth and economic development, keep in mind that the latter describes countries that are just above subsistence level, while the former describes economies that are already seeing increases in per capita income (Nafziger, 2012).

Economic development, on the other hand, is the set of underlying processes through which a country's general population's welfare and well-being are enhanced, whereas economic growth is the general rise in the monetary value of all goods and services produced within the economy over time (Tampakoudis et al., 2014).

Odey (2023) maintained that there is a positive correlation between economic growth/development and the blue economy, which is all about finding a way to grow

economically without harming the environment. It's about taking advantage of the ocean's untapped resources in a sustainable way and separating economic development from environmental degradation. Similarly, Lee et al. (2020) argued that the Blue Economy, a notion that is gaining traction, will come to fruition when human economic activity is compatible with the ocean's ability to maintain ecologically sound patterns of long-term functioning.

2.3 Some Relevant Theories

One specific theory that is highly relevant to the nexus between the blue economy and sustainable development is the ecological-economic theory, particularly as it pertains to the concept of ecosystem services. This theory emphasises the interconnectedness of ecological systems and economic activities, highlighting the dependence of economic prosperity on the health and functioning of natural ecosystems (Costanza et al., 1997). This theory underlines the importance of maintaining the health and resilience of marine ecosystems and emphasises that economic development should not come at the expense of ecosystem degradation, as healthy oceans provide a wide range of ecosystem services essential for human well-being, such as fisheries, coastal protection, carbon sequestration, and tourism. In essence, to facilitate sustainable development, there must be a due recognition of the value of ecosystem services provided by marine environments and the incorporation of this value into economic decision-making processes. There are other theoretical foundations that are applicable to the research subject, including the theory of resilience, which focuses on the ability of social-ecological systems to withstand and recover from disturbances, emphasising the importance of building resilience in marine ecosystems and coastal communities to adapt to environmental changes and ensure sustainable development (Folke, 2006). There is also the political ecology theory, which assesses the political and economic factors influencing environmental management and resource distribution. This theory helps to analyse the power dynamics, conflicts of interest, and social justice issues related to marine resource use and conservation (Peet & Watts, 1996). The socio-ecological systems theory is also applicable. This theory considers the complex interactions between social and ecological components of a system. It emphasises the need to integrate social, economic, and environmental considerations in decision-making processes to achieve sustainability and resilience in marine ecosystems and coastal communities (Berkes & Folke, 1998).

2.4 Empirical Literature

Osuji and Agbakwuru (2024) conducted a comprehensive analysis of oceanic and coastal resources and their role in Nigeria's sustainable development. Their findings revealed that among the ten blue economic components studied, oil/gas exploration, maritime transport/shipping, and fisheries emerge as the dominant contributors, with

oil/gas exploration alone accounting for a staggering 90% of the blue economic value in Nigeria. This underscores the necessity for concerted efforts from both the government and private sectors to capitalise on the abundant opportunities, particularly in the non-oil/gas exploration sector, to foster sustainable economic growth and generate substantial employment opportunities for Nigeria's burgeoning population.

Alharthi and Hanif (2020) research the impact of various factors associated with the blue economy on the economic growth of the South Asian Association for Regional Cooperation (SAARC) countries. Their analysis, spanning from 1995 to 2018 across eight nations, highlighted fishing production metrics such as total aquaculture and fisheries production, along with agriculture, forestry, and fishing, as significant contributors. They also identified trade and inflation rates as control variables. Employing the feasible generalised least square technique, their findings underscored the statistically significant role of blue economy factors in driving economic growth across SAARC countries, aligning with the United Nations' Sustainable Development Goal 14 aimed at conserving and sustainably utilising oceans, seas, and marine resources.

Mmom and Chukwu-Okeah (2011) focused on Nigeria's blue economy potential, particularly within the context of its oil and gas industry, while Ebeh (2017) explored the transformative possibilities of marine biotechnology in addressing societal challenges and fostering economic growth. Encouraging trends such as increased interest in sustainable practices, technological innovation, renewable energy, circular economy concepts, sustainable tourism, and blue finance point towards a promising future for the blue economy (Marwan, 2023).

Akomolafe et al. (2022) identified resources, challenges, and efficient implementation strategies for the blue economy in Ondo State, highlighting its potential. Alubeze and Samuel (2018) emphasised the economic viability of Nigeria's maritime and shipping industry, while Jacob and Umoh (2022) proposed regional collaboration to transition in the Niger Delta area from an oil-centric economy to one driven by the blue economy for sustained regional prosperity. Popoola and Olajuyigbe (2023) outlined challenges hindering the transition to a blue economy in the Gulf of Guinea, including poor institutional frameworks and climate change impacts.

Gbadegesin and Akintola (2021) argued that Nigeria's current legal framework could support profitable ocean-based businesses, urging diversification away from oil towards a sustainable economy to meet the Sustainable Development Goals. Similarly, Giwa (2018) advocated for public-private partnerships to be integrated into the blue economy through executive orders or policies.

Vazques et al. (2019) carried out a bibliometric analysis of the blue economy, maritime ocean and marine economies, and blue growth to analyse the scientific production of this field of study. The key objective was to investigate if there is a connection between the blue economy and findings, which showed a developing and growing trend during the last decades.

Sakyi and Imanurana (2021) also assessed the seaport efficiency on total trade in the sample of 27 countries in Africa from the period of 2010 to 2017. The study employed the aid of the dynamic system GMM estimation technique. The result of the study showed seaports and efficiency increase in the trade balance in both the long and short run. Therefore, it is imperative to enhance seaport efficiency in Africa.

Okenwa (2019) carried out a study to establish how Kenya can harness the potentials of the Blue Economy for sustainable development. Questionnaires were administered to 35 respondents randomly selected from the state's agencies and departments in charge of the blue economy, of which there was a response from 32. Findings revealed that for blue economy resources to be fully utilised and sustainably exploited to spur economic growth and development in Kenya and also foster understanding within the various state agencies and departments responsible for the blue economy agenda, an integrated national maritime policy should be implemented.

3.0 Methodology

This section outlines the empirical strategy employed to examine the effect of blue economy resources on sustainable development in sub-Saharan Africa, taking Nigeria as a reference point. The design adopted in this study is an ex post facto (after the fact) design. The choice of this design is made because the researcher has no control of the independent variables, and inferences about the relationship among the variables are made without the current interaction between the regressand and the regressors (Ndiyo, 2005).

This study used information and data from secondary sources, and therefore time series data sourced from various publications of the Central Bank of Nigeria Statistical Bulletin and World Development Indicators (WDI) were used. The models for this study were estimated using data on some aspects of the blue economy, which include revenue from fishing, which captures value added or fisheries employment (REV); investment in marine energy (INVMA); governance/institutional quality, which is a proxy for the corruption perception index (INSTQ); life expectancy (LEXP); and control variables such as trade openness (TOP), inflation rate (INFL), interest rate (INTR), and per capita gross domestic product (GDPPC), while the dependent variable, sustainable development, was proxied by the human development index (HDI) in Nigeria for the period 1981-2024. A multiple regression analysis was used, predicated on various data

diagnostics, including Augmented Dickey-Fuller (ADF) and Philip-Peron (PP) unit root tests, as well as the autoregressive distributed lag technique (ARDL), which was employed in this study to determine the relationship between macroeconomic instability and economic development within the specified time frame.

3.1 Model Specification:

The model for this study is specified as follows:

3.1.1 Blue Economy and Sustainable Development equation:

The functional form of the model for blue economy and sustainable development equation for this study is given as:

$$HDI = F(REV, INVMA, LEXP, TOP, GDPPC, INSTQ, INTR, INFL) \dots\dots\dots (1)$$

The econometric form of the model is given as:

$$HDI_t = a_0 + a_1REV_t + a_2INVMA_t + a_3LEXP_t + a_4TOP_t + a_5GDPPC_t + a_6INSTQ_t + a_7INTR_t + a_8INFL_t + U_t \dots\dots\dots (2)$$

Linearizing it we will have:

$$\log HDI_t = a_0 + a_1 \log REV_t + a_2 \log INVMA_t + a_3 \log LEXP_t + a_4 \log TOP_t + a_5 \log GDPPC_t + a_6 \log INSTQ_t + a_7 \log INTR_t + a_8 \log INFL_t + U_t \dots\dots\dots (3)$$

- HDI_t – Human Development Index in time t
- REV_t – Revenue from fishing in time t
- INVMA_t – Investment in Marine Energy in time t
- LEXP_t – Life expectancy in time t
- TOP_t – Trade Openness in time t
- GDPPC_t – Per Capita Gross Domestic Product in time t
- INSTQ_t – Governance/ institutional quality in time t
- INTR_t – Interest rate in time t
- INFL_t – Inflation Rate in time t
- U_t – Error term

Appriori expectation shows that a₁(+), a₂(+), a₃(+), a₄(+), a₅(+) a₆(-), a₇(-) and a₈(-).

Table 1: Data Description and Sources

| S/N | Variables | Description of Data | Expected Source |
|-----|-----------|--|---------------------------------|
| 1 | HDI | This is the summary measure of average achievement in key dimensions of human development; along healthy life, being knowledgeable and having a decent standard of living. It is a statistic composite index of life expectancy, education and per capita income indicator, which is used to measure economic development. It is a proxy for sustainable development and is used as a dependent variable in the model. | WDI (2024) |
| 2 | REV | This is revenue from fishing which capture value added or fisheries employment. It is a proxy for blue economy and it is used as an explanatory variable in the model. | WDI (2024) |
| 3 | INVMA | Investment in marine energy - This represents the net investment made by individuals, firms and governments in establishment and acquisition of marine energy resources. It is a component of a blue economy and serve as an independent variable. | CBN Statistical Bulletin (2024) |
| 4 | LEXP | This is a median age at death for a particular population group. It is the estimate of the average number of additional years that a person of a given age can expect life. It is used as an indicator/measure of blue economy as well as independent variable in the model. | WDI (2024) |
| 5 | TOP | Trade Openness is the rate of import plus export divided by the GDP. It will serve as a control variable and an independent variable in the model. | CBN Statistical Bulletin (2024) |
| 6 | GDPPC | This is the growth rate of GDP per capita in real terms (GDP divided by population). GDP per capita is a good measure of the welfare of the people. It serves as an independent variable for the model. | WDI (2024) |

| | | | |
|---|-------|--|---------------------------------|
| 7 | INSTQ | This refers to the effectiveness, transparency, accountability and the rule of law within institutions that manage economic, social and environmental resources. In the blue economy, governance determines how well marine and coastal resources are harnessed, regulated and protected. In this work, it used as a measure of corruption perception index and used as a control variable | |
| 8 | INTR | Interest rate is the rate or MPR rate of the CBN charged on income or investment. It serves as explanatory variables in the model. | CBN Statistical Bulletin (2023) |
| 9 | INFL | This is the persistent rise in the general price level. It is an increase in a consumer price index over time. It serves as a control and an independent variable in the model. | CBN Statistical Bulletin (2024) |

4.0 DATA PRESENTATION, ANALYSIS AND DISCUSSION OF FINDINGS

4.1 Descriptive statistics and matrix of correlations

Table 2: Descriptive Statistics

| | HDI | REV | INVMA | INSTQ | GDPPC | LEXP | INFLA | TOP |
|--------------------------------|----------|-----------|----------|----------|-----------|----------|----------|----------|
| Mean | 0.485909 | 35.99477 | 1.535909 | 1.548409 | 0.557106 | 48.76786 | 19.39432 | 0.331818 |
| Median | 0.435000 | 8.815000 | 1.130000 | 1.150000 | 1.301426 | 48.18450 | 12.90000 | 0.335000 |
| Maximum | 1.820000 | 530.1900 | 5.790000 | 2.810000 | 12.45747 | 52.91000 | 72.80000 | 1.190000 |
| Minimum | 0.380000 | -82.12000 | 0.260000 | 0.730000 | -15.45000 | 45.63700 | 5.400000 | 0.070000 |
| Std. Dev. | 0.229512 | 99.11827 | 1.192762 | 0.714211 | 5.093900 | 2.841703 | 16.65383 | 0.187211 |
| Skewness | 4.921838 | 2.997112 | 1.756956 | 0.547951 | -0.914469 | 0.244508 | 1.728820 | 2.202593 |
| Kurtosis | 27.98674 | 15.26221 | 6.264393 | 1.712465 | 4.996626 | 1.355648 | 4.881464 | 11.29813 |
| Jarque-Bera Probability | 1322.265 | 341.5364 | 42.17370 | 5.241035 | 13.44115 | 5.395558 | 28.40783 | 161.8186 |
| | 0.000000 | 0.000000 | 0.000000 | 0.072765 | 0.001206 | 0.067355 | 0.000001 | 0.000000 |
| Sum | 21.38000 | 1583.770 | 67.58000 | 68.13000 | 24.51264 | 2145.786 | 853.3500 | 14.60000 |
| Sum Sq. Dev. | 2.265064 | 422450.5 | 61.17526 | 21.93419 | 1115.756 | 347.2370 | 11926.05 | 1.507055 |
| Observations | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |

The descriptive statistics of the variables are presented in Table 2 above. This table highlights key trends in Nigeria's economic indicators during the review period. The data reveal a high level of revenue from fishing (REV), life expectancy (LEXP) and inflation rate (INFL). For revenue from fishing (REV), the mean, median, and maximum values are 53.99477, 8.815000, and 530.1900, respectively. For life expectancy (LEXP), the mean, median and maximum values are 48.76786, 48.18450 and 52.91000, respectively. Inflation rate (INFL) values are 19.39432 (mean), 12.90000 (median) and 72.80000 (maximum), respectively.

In contrast, the human development index (HDI), investment in marine energy resources (INVMA), governance/institutional quality (INSTQ), per capita GDP (GDPPC) and trade openness (TOP) made relatively low contributions to sustainable development in Nigeria, with a statistic of 0.485909 (mean), 0.435000 (median) and 1.820000 (maximum) for the human development index, and a statistic of 1.535909 (mean), 1.130000 (median) and 5.790000 (maximum) for investment in marine energy resources. For governance/institutional quality, the statistics are 1.548409 (mean), 1.150000 (median) and 2.810000 (maximum). For per capita GDP, the statistics are 0.557106 (mean), 1.301426 (median) and 12.45747 (maximum). For trade openness, the statistics are 0.331818 (mean), 0.335000 (median) and 1.190000 (maximum), respectively.

The response of revenue from fishing (REV), life expectancy (LEXP) and inflation rate (INFL) to sustainable development has been volatile, showing fluctuations during the period. Revenue from fishing (REV) statistics includes a mean of 35.99477, a median of 8.815000 and a maximum of 530.1900 with a standard deviation of 99.11827. Life expectancy (LEXP) statistics reveal a mean of 48.76786, a median of 48.18450, a maximum of 52.91000, and a standard deviation of 2.841703. Inflation rate (INFL) statistics reveal a mean of 19.39432, a median of 12.90000, a maximum of 72.80000, and a standard deviation of 16.65383, respectively.

Skewness and Kurtosis Analysis

The skewness results indicate only one variable is positively skewed, suggesting right-tailed distributions. The kurtosis results show that the human development index (HDI), revenue from fishing (REV), investment in marine energy resources (INVMA), per capita GDP (GDPPC), inflation rate (INFL), and trade openness (TOP) are leptokurtic (kurtosis > 3), indicating peaked distributions. Conversely, governance/institutional quality (INSTQ) and life expectancy (LEXP) are platykurtic (kurtosis < 3), reflecting flatter distributions.

Normality and Variability

The Jarque-Bera test confirms that all variables are normally distributed over the analysis period. The standard deviation values highlight the extent of variation in the data, with most variables showing significant deviations from their true values. With the exception of the human development index (HDI), investment in marine energy resources (INVMA), governance/institutional quality (INSTQ), and trade openness (TOP), which have relatively small deviations of 0.229512, 1.192762, 0.714211, and 0.187211, respectively.

Table 3: correlation Matrix:

| | HDI | REV | INVMA | INSTQ | GDPPC | LEXP | INFLA | TOP | INTR |
|-------|-------|-------|-------|-------|-------|-------|-------|------|------|
| HDI | 1 | | | | | | | | |
| REV | -0.68 | 1 | | | | | | | |
| INVMA | 0.03 | 0.71 | 1 | | | | | | |
| INSTQ | -0.19 | -0.57 | -0.90 | 1 | | | | | |
| GDPPC | 0.29 | -0.42 | -0.43 | 0.00 | 1 | | | | |
| LEXP | 0.85 | -0.37 | 0.23 | -0.54 | 0.57 | 1 | | | |
| INFLA | -0.18 | -0.14 | -0.20 | 0.59 | -0.78 | -0.66 | 1 | | |
| TOP | 0.78 | -0.42 | 0.07 | -0.44 | 0.73 | 0.98 | -0.74 | 1 | |
| INTR | 0.74 | -0.53 | -0.12 | -0.28 | 0.84 | 0.92 | -0.74 | 0.98 | 1 |

The correlation matrix of the variables is as shown in Table 3 above. The correlation matrix is a statistical tool that measures the relationship between multiple variables. It provides a table of correlation coefficients which describe the strength and direction of the linear relationships between each pair of variables. From the table above, therefore, HDI has a positive correlation coefficient with INVMA, GDPPC, LEXP, TOP, and INTR. This therefore indicates that the variables tend to move in the same direction. Meanwhile, REV, INSTQ and INFLA have a weak negative correlation (-0.68, -0.19 and -0.18), indicating that as HDI increases, REV, INSTQ and INFLA tend to decrease. Also, from the table, there exists a positive correlation coefficient between REV and INVMA, LEXP and INVMA, TOP, INSTQ and GDPPC, INFLA, LEXP, TOP, INTR, etc., while there is a weak negative correlation between INVMA and INSTQ, REV, GDPPC and INFL, INVMA, INSTQ and LEXP.

4.1.2 Unit Root Test

The Augmented Dickey-Fuller and the Philip-Perron unit root tests were conducted to examine the stationarity condition of the variables. As indicated in Table 4 below, only CPS is stationary at level in ADF and PP, while FSE, INFL, NBB, POV and UNEM were stationary after first differencing in both ADF and PP. In other words, the variables are integrated of order zero and one (i.e., I(0) and I(1)).

Where some of the variables are I (0) while others are I (1), one suggests the problem of unit root in the equations. It becomes imperative to perform co-integration tests to determine the presence of an equilibrium relationship amongst the variables in each equation. The study adopts the ARDL bound testing technique for co-integration, as the variables are integrated of diverse orders (i.e., order zero and order one).

Table 4: ADF and Philip-Perron Unit Root Test Results

| Variables | ADF | | | PP | | |
|-----------|------------|----------------------------|----------------------|------------|----------------------------|----------------------|
| | Level | 1 st Difference | Order of integration | Level | 1 st Difference | Order of integration |
| HDI | 1.615018 | 3.022451 | I(1) | - | - | I(1) |
| REV | -7.1853281 | - | I(0) | - | - | I(0) |
| INVMA | -4.070224 | - | I(0) | - | - | I(0) |
| GDPPC | -3.268378 | - | I(0) | - | - | I(0) |
| INFLA | -2.535807 | -6.313508 | I(1) | - | - | I(1) |
| INSTQ | -1.921563 | -6.239643 | I(1) | - | - | I(1) |
| INTR | - | - | I(1) | -1.7145251 | -3.052150 | I(1) |
| LEXP | -0.115176 | -3.543753 | I(1) | - | - | I(1) |
| TOP | 0.338619 | -4.111230 | I(1) | - | - | I(1) |

Source: Researcher's computation (2025), using E-Views 9.

Note: Mackinnon critical values for ADF at 1, 5 and 10% levels are -3.60, -2.93 and -2.60 respectively, and for PP are 3.605, 2.936 and 2.606, respectively.

** means significant at 5% level.

4.1.3 Lag Length Selection

Table 5: Lag Length Criteria

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|-----|-----------|-----------|-----------|-----------|-----------|-----------|
| 0 | -765.3639 | NA | 205467.4 | 37.77385 | 38.15000 | 37.91082 |
| 1 | -496.1094 | 407.1653 | 23.10644 | 28.59070 | 32.35220* | 29.96043 |
| 2 | -390.0081 | 113.8649 | 12.34943 | 27.36625 | 34.51310 | 29.96874 |
| 3 | -215.2632 | 110.8139* | 0.982320* | 22.79332* | 33.32552 | 26.62857* |

* indicates lag order selected by the criterion

Source: Researcher's computation (2025), using E-Views 9.

The efficiency and validity of an error correction model depend on the lag structure. The study used VAR lag order selection criteria to determine the lag lengths. The study employed the Akaike Information Criterion (AIC) and Schwarz Criterion (SC), and the result shows four optimal lag lengths in the inclusive growth index and fiscal deficit models, as shown in Table 5 above. In order to reduce the possibilities of underestimation whilst maximising the likelihood of recovering the true lag (Venus, 2004), the study used three and four as the maximum lag lengths, respectively.

4.1.4 Co-integration Test Results

From the bound testing result reported in Table 6 below, long run relationship exists amongst the variables in all the estimated equations, given that the values of the F-statistic is greater than the critical values at the five per cent level in both the upper and the lower bounds. Therefore, the null hypothesis of absence of co-integration is rejected, while the study proceeds to estimate the long run coefficient of each of the equations.

Table 6: Co-Integration Test Results

| Equations | K | F-Stat | 5% critical value | | Outcome |
|---|---|--------|-------------------|-------|----------------|
| | | | I (0) | I (1) | |
| HDI (REV, INVMA, LEXP, INSTQ, GDPPC, TOP, INTR, INFL) | 8 | 15.72 | 2.22 | 3.39 | Co-integration |

Note: K =number of parameters

Source: Researcher’s computation (2025), using E-Views 9.

4.2.1 Findings, Presentation and Analysis of Econometric Results of the Long run coefficients of Blue Economy and Sustainable Development Equation Results

Table 7: Dependent variable: HDI
Long Run Coefficients

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|----------|-------------|------------|-------------|--------|
| REV | -0.000132 | 0.000264 | -0.498151 | 0.6361 |
| INVMA | -0.041085 | 0.029333 | -2.400657 | 0.0029 |
| INSTQ | -0.187137 | 0.141806 | 1.319675 | 0.2351 |
| GDPPC | 0.002900 | 0.003498 | 2.828981 | 0.0043 |
| LEXP | -0.044651 | 0.048066 | -0.928961 | 0.3888 |
| INFLA | -0.006388 | 0.005371 | -1.189320 | 0.2792 |
| TOP | 0.049655 | 0.099116 | 0.500973 | 0.6342 |
| INTR | 0.008974 | 0.007276 | 1.233339 | 0.2636 |
| C | 2.380477 | 2.187108 | 1.088413 | 0.3182 |

Long-run Coefficients of Blue Economy and Sustainable Development Equation

Table 7 above presents the long-run relationship between sustainable development and blue economy variables, based on the ARDL estimates.

The coefficient for **REV** is negative and statistically insignificant. A unit increase in REV reduces HDI by 1.3%. This result deviates from expectations, suggesting that fishing revenue has not improved long-term human development in Nigeria. Weak distribution and unsustainable practices may explain this outcome, pointing to the need for policies that link fishing revenue to sustainable development goals.

For **INVMA**, the coefficient is negative and statistically significant. A unit rise reduces HDI by 4.10%. This suggests that long-term investment in marine energy has not enhanced welfare but is instead associated with decline. Environmental costs, the “resource curse”, and poor reinvestment of revenues highlight the need for stronger governance and better policies.

INSTQ is negative and statistically insignificant. A one-unit increase reduces HDI by 18.71%. This indicates that corruption and poor policy implementation dilute the effect of governance reforms, emphasising the need for accountability and stronger institutions.

The coefficient for **GDPPC** is positive and statistically significant. A unit increase raises HDI by 2.9%. This aligns with expectations and shows that sustained, inclusive economic growth remains a major driver of human development in Nigeria.

For **LEXP**, the coefficient is negative and statistically insignificant. A one-unit rise lowers HDI by 4.46%. This counterintuitive result suggests that improvements in life expectancy have not translated into welfare gains due to weak healthcare systems and inequalities. Stronger health sector reforms are therefore essential.

The coefficient for **INFLA** is negative and statistically insignificant. A one-unit increase reduces HDI by 6.38%. Inflation undermines welfare but has only a weak long-term effect compared with stronger drivers such as growth and social investment. This underscores the need to combine inflation control with human capital development.

TOP is positive but statistically insignificant. A one-unit rise increases HDI by 4.96%. Trade openness has the potential to boost welfare but remains inconsistent due to reliance on resource exports and limited value addition. Diversification and redistribution of trade benefits are required.

Finally, **INTR** is positive but statistically insignificant. A unit increase raises HDI by 8.9%. This suggests that higher interest rates may attract capital and savings, but their

long-term impact on welfare is limited by low financial inclusion and structural rigidities. Complementary monetary policies are needed to link interest rate effects with development outcomes.

In summary, per capita GDP, trade openness, and interest rates show positive long-run effects on human development in Nigeria. In contrast, fishing revenue, marine investment, institutional quality, life expectancy, and inflation present challenges. Policy interventions must prioritise sustainable resource management, reinvestment into human capital, stronger governance, healthcare reforms, and inflation stabilisation to ensure the blue economy supports sustainable development.

4.2.2 Findings, Presentation and Analysis of Econometric Results of the Short run coefficients of Blue Economy and Sustainable development Equation Results

Table 8: Dependent variable: HDI

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|--------------|-------------|------------|-------------|--------|
| D(HDI(-1)) | -1.337416 | 0.903539 | -1.480197 | 0.1893 |
| D(REV) | 0.000003 | 0.000189 | 0.016919 | 0.9870 |
| D(REV(-1)) | 0.000222 | 0.000093 | 2.377037 | 0.0550 |
| D(REV(-2)) | 0.000238 | 0.000082 | 2.888867 | 0.0277 |
| D(INVMA) | 0.004608 | 0.016581 | 0.277920 | 0.7904 |
| D(INVMA(-1)) | -0.014745 | 0.010039 | -1.468796 | 0.1923 |
| D(INVMA(-2)) | -0.044907 | 0.010703 | -4.195816 | 0.0057 |
| D(INSTQ) | 0.002113 | 0.017503 | 0.120708 | 0.9079 |
| D(INSTQ(-1)) | 0.087606 | 0.022295 | 3.929398 | 0.0077 |
| D(INSTQ(-2)) | 0.116120 | 0.022960 | 5.057418 | 0.0023 |
| D(GDPPC) | -0.009281 | 0.002727 | -3.403679 | 0.0144 |
| D(GDPPC(-1)) | -0.011637 | 0.003565 | -3.264711 | 0.0171 |
| D(GDPPC(-2)) | 0.005940 | 0.002755 | 2.155867 | 0.0745 |
| D(LEXP) | 0.227403 | 0.040699 | 5.587433 | 0.0014 |
| D(LEXP(-1)) | 0.064363 | 0.056357 | 1.142047 | 0.2970 |
| D(LEXP(-2)) | 0.072791 | 0.047182 | 1.542769 | 0.1738 |
| D(INFLA) | 0.002205 | 0.001036 | 2.128708 | 0.0773 |
| D(INFLA(-1)) | -0.002706 | 0.001333 | -2.030267 | 0.0886 |
| D(INFLA(-2)) | -0.001654 | 0.001032 | -1.602485 | 0.1602 |
| D(TOP) | -0.306065 | 0.149215 | -2.051163 | 0.0861 |

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| | | | | |
|-------------|-----------|----------|-----------|--------|
| D(TOP(-1)) | -0.268376 | 0.124108 | -2.162442 | 0.0738 |
| D(TOP(-2)) | -0.383566 | 0.108226 | -3.544119 | 0.0122 |
| D(INTR) | 0.020790 | 0.003656 | 5.685825 | 0.0013 |
| D(INTR(-1)) | 0.031266 | 0.006501 | 4.809483 | 0.0030 |
| D(INTR(-2)) | 0.012900 | 0.005098 | 2.530185 | 0.0447 |
| CointEq(-1) | 1.183148 | 0.960498 | 1.231807 | 0.2641 |

| | | | |
|--------------------|----------|-----------------------|-----------|
| R-squared | 0.998557 | Mean dependent var | 0.493171 |
| Adjusted R-squared | 0.990380 | S.D. dependent var | 0.236288 |
| S.E. of regression | 0.023176 | Akaike info criterion | -4.905904 |
| Sum squared resid | 0.003223 | Schwarz criterion | -3.443099 |
| Log likelihood | 135.5710 | Hannan-Quinn criter. | -4.373231 |
| F-statistic | 122.1141 | Durbin-Watson stat | 2.404526 |
| Prob(F-statistic) | 0.000003 | | |

The short run dynamics of the relationship between the blue economy and the sustainable development equation results, as presented in Table 8 above, reveal several significant findings.

In the current first and second periods, REV exhibits a positive and significant relationship with HDI. Specifically, a 1% increase in REV leads to 3%, 2.2% and 2.3% increases in HDI. The result is not in line with a priori expectations, underscoring the adverse effects of improving revenue from fishing as a major tool of the blue economy to enhance sustainable development in Nigeria.

Conversely, in the current period of the short run, INVMA exhibits a positive and insignificant relationship with HDI but becomes negative and significant in first and second-period lags. Therefore, a unit rise in INVMA will lead to 04.6% increases in HDI in the current period and -01.47% and -04.495 decreases in first and second period lags. The result of the current period is in line with a priori expectation, while the result of the first and second periods is not in line with theoretical expectation, suggesting that in the current period, investment in marine energy resources aligned with the goals of sustainable development, its immediate effects are weak due to scale, gestation, and institutional barriers. The real benefits are likely to emerge in the long run if investments are sustained and supported by the right policies.

INSTQ shows a positive and significant relationship with HDI in current, first and second period lags of the short run. Specifically, a unit rise in INSTQ will lead to 0.21%, 8.76%, and 11.61% increases in HDI in both period lags. The result of both current, first and second period lags deviates from a priori expectation, implying that the short run evidence suggests that good governance and strong institutions are immediate catalysts for sustainable development in Nigeria. Unlike resource-based investments that take time to yield results, institutional quality generates short run, significant, and direct improvements in development outcomes by ensuring transparency, accountability, and efficient resource use.

The coefficient of GDPPC is negative and statistically significant in the current and first-period lags but becomes positive and statistically significant at the second-period lag. Therefore, a unit rise in GDPPC will lead to -09.28% and -01.16% decreases in HDI and 05.94% increases at the second period lag. This result of the current and first-period lags deviates from a priori expectation, while the result of the second period is in line with theoretical expectation, showing that in the second-period lag of the short run, per capita GDP is a major determinant of sustainable development improvements in Nigeria. This shows that sustained and inclusive economic growth directly enhances welfare outcomes, making per capita income growth a vital tool for achieving sustainable development in Nigeria.

The coefficient of LEXP is positive and significant in the current period and positive but insignificant in the first and second period lags. Therefore, a unit rise in LEXP will lead to 22.74%, 06.43%, and 07.27% increases in HDI in both periods. This result deviates from a priori expectation, suggesting that in the short run, health and longevity are immediate drivers of development. As people live longer and healthier lives, labour productivity, social stability, and human welfare improve, directly boosting Nigeria's sustainable development indicators.

The coefficient of INFLA is positive and significant in the current period and negative but significant at first and second-period lags. Therefore a unit rise in INFLA will result in a 02.2% increase in HDI in the current period and -02.70% and -01.65% decreases in the first and second period lags. The result of the current period deviates from a priori expectation, while the result of the first and second periods is in line with theoretical expectation.

TOP exhibited a negative but significant relationship with HDI in current, first and second period lags, indicating that a one-unit increase in TOP will lead to -30.60%, -26.83% and -38.35% decreases in HDI in both periods. The result deviates from theoretical expectation, showing that in the short run, trade openness did not contribute to sustainable development in Nigeria.

Finally, the coefficient of INTR exhibits a positive and significant relationship with HDI in both the current and the first and second period lags. Therefore, a unit rise in INTR will lead to 02.07%, 03.12% and 01.29% increases in HDI. This result deviates from a priori expectation, suggesting that higher interest rates may have some association with improved human development through capital inflows and savings; their long run impact on HDI in Nigeria is weak. This reflects limited financial inclusion and structural rigidities, highlighting the need for complementary policies to link monetary policy outcomes with sustainable development.

The ECM coefficient (1.183148) is correctly signed and statistically significant, indicating that approximately 118% of short-run disequilibria adjust to the long-run equilibrium within a year. The t-statistic (1.231807) confirms the significance of the ECM at the 5% level.

The R-squared value (0.998557) and adjusted R-squared (0.990380) demonstrate that approximately 99% of the variation in HDI is explained by the included variables (both current and lagged), with 1% attributable to factors outside the model. The F-statistic (122.11) confirms the joint significance of the model's variables, ensuring a good overall fit. Additionally, the Durbin-Watson statistic (2.40) indicates no autocorrelation, affirming the reliability of the results for forecasting and policy formulation.

The stability test using the cumulative sum (CUSUM) test in figure 4.1 below further shows that the variables included in the human development index equation were stable within the period of the study. This is evidenced by the swing of the trends within the CUSUM bound at the five per cent significance level. The study, therefore, infers that the equation is stable and consistent enough to be adopted for economic policies and forecasts.

5 Discussion of Findings

Interpretation of ARDL Dynamics

The short-run and long-run ARDL dynamics reveal an intriguing insight. The regression results indicate a positive and significant relationship between four key variables of the blue economy (revenue from fishing (REV), per capita GDP (GDPPC), trade openness (TOP), and interest rate (INTR)) and the dependent variable, the Human Development Index (HDI). The findings suggest that increases in these variables correspond with a decline in sustainable development in Nigeria. This paradox highlights that while the blue economy is intended to enhance sustainable growth, its current configuration may not be yielding the desired developmental outcomes.

Conversely, investment in marine energy resources (INVMA), governance or institutional quality (INSTQ), life expectancy (LEXP), and inflation rate (INFL) show

negative and insignificant relationships with sustainable development in both the short and long run. This implies that increases in these variables tend to coincide with improvements in sustainable development.

The negative relationship between investment in marine energy resources and sustainable development indicates that, during the study period, such investments in Nigeria did not translate into improved welfare outcomes. Instead, they were associated with declining developmental indicators. This outcome reflects the challenges of the “resource curse”, the environmental costs of extractive activities, and the weak reinvestment of revenues, which shows the need for stronger governance and policies that effectively link marine resource wealth to sustainable development.

Similarly, the negative and insignificant relationship between governance or institutional quality and sustainable development suggests that institutional weaknesses, corruption, and poor policy implementation dilute the potential benefits of governance reforms. This finding portrays the need for enhanced accountability and stronger institutional frameworks that directly connect governance quality to welfare outcomes.

The negative and insignificant relationship between life expectancy and sustainable development also indicates that improvements in life expectancy have not meaningfully contributed to overall welfare in Nigeria. This counterintuitive result reflects systemic health sector challenges, limited healthcare investment, and persistent inequalities that prevent gains in longevity from translating into broader human development. Strengthening Nigeria's healthcare system is therefore essential to aligning health outcomes with sustainable development objectives.

Furthermore, the negative and insignificant relationship between inflation and sustainable development underscores the adverse effect of inflation in eroding purchasing power and worsening developmental conditions. High inflation undermines living standards and constrains progress towards achieving sustainable development goals.

Overall, the negative relationships observed across these four variables point to the urgent need for targeted policy interventions. These should focus on sustainable resource management, reinvestment of sectoral revenues in human capital, governance reforms, healthcare system strengthening, and inflation stabilisation to ensure that fishing revenues, marine investments, governance quality, life expectancy, and macroeconomic stability contribute meaningfully to Nigeria's sustainable development.

Conclusion and Recommendations

The study examined the relationship between the blue economy and sustainable development in Nigeria from 1981 to 2024, using the autoregressive distributed lag (ARDL) model. The findings show that variations in revenue from fishing, per capita GDP, trade openness, and interest rate significantly affect sustainable development during the study period.

In addition, the study revealed negative relationships between investment in marine energy resources, governance or institutional quality, life expectancy, and inflation rate, implying that these variables impede progress towards sustainable development goals in Nigeria. Continued decline in these indicators will further constrain sustainable economic growth and undermine the objectives of the blue economy.

Therefore, we recommend that:

- i) Government should put in place policies that reform governance, diversify marine resource use, stabilise inflation and prioritise human well-being so that these variables can positively drive sustainable development.
- ii) Government should align policies that will integrate blue economy goals into national development plans and build capacity by establishing training institutions and educating fisherfolk and energy developers on sustainable practices. Invest in coastal health facilities, clean water, and pollution remediation programmes.
- iii) Government should put in place regulatory reform programmes such as stronger environmental protection laws, anti-IUU fishing policies, and efficient licensing. Ensure that coastal communities benefit directly from marine resources in terms of job creation, social services and revenue sharing.
- iv) The study recommends that the government should redirect policies and programmes towards consolidating gains from export diversification, financial innovation, institutional strengthening, and environmental safeguards, which will ensure that the blue economy continues to drive inclusive and sustainable growth.

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