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Blue Bonds and Ocean Sustainability: Evidence from selected African countries

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Research Article

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Abstract

This study examines the nexus between blue bond issuance and ocean sustainability in selected African countries. Ocean sustainability is a major concern in Africa, as catalytic projects aimed at guaranteeing a blue economy are scarce and require substantial financing. The issue of blue bonds, a variation of blue finance, could be a plausible solution to finance ocean sustainability needs. Despite their importance, blue bonds face persistent barriers in the African context; therefore, they have been issued in only three countries to date: Seychelles, Gabon, and Cape Verde. Panel data from these countries for the years 2018–2023 were analysed using fixed-effects regressions. The study found that blue bond issuance is positively and significantly related to the ocean health index, implying that projects focused on ocean sustainability can be financed viably through blue bond proceeds. The growth rate of the gross domestic product was positive and significant, indicating that economic growth increases the sustainability of the oceans. Regulatory quality was significantly negative, indicating that ineffective regulatory enforcement stifles progress towards improving ocean sustainability. The proxies for carbon dioxide emissions and inflation were positively associated with ocean sustainability. There are several implications of these findings. Firstly, there is a need for the development of African capital markets to accommodate innovative financing through blue bonds to finance ocean sustainability-related projects. Secondly, African national governments must invest in financial infrastructure to support the development of the blue bond market and ensure robust institutional and capital market regulatory frameworks that align with international standards.

1 Introduction

The oceans cover over 70% of the world's surface area [1], and the ocean economy is huge, generating annual revenue of US$3 trillion [2]. 80% of global trade revolves around the oceans, where approximately 40% of the world's population resides [3]. Sustainable oceanic ecosystems drive economic development because they are economic hubs for coastal and maritime activities. Thus, ensuring ocean sustainability entails balancing economic growth with the sustainable use of ocean resources [4].

On a global scale, ocean health is under threat due to the deterioration of the sea as a result of climate change and a number of anthropogenic activities, such as sea pollution [2]. For example, African coastal areas are suffering due to rising sea levels, unsustainable fishing practices, marine pollution, global warming, coastal development, and other anthropogenic activities [1, 5]. Ensuring ocean sustainability is a concern in Africa, as projects aimed at a blue economy remain scarce on the continent [5]. This stifles progress towards the Great Blue Wall Initiative, focused on the Western Indian Ocean to protect ocean and marine ecosystems over a 2 million km2 range (United Nations Economic Commission for Africa [6]. Catalytic blue economy projects of this kind aimed at the protection and preservation of coastal and marine areas are scarce and require substantial funding [2, 5].

African countries are grappling with debt distress [7], including Small Island Developing States (SIDS) [8]. Proczek & Garbarczyk [9] reiterate that overwhelming debt burdens choke the national fiscus of many

developing countries in providing funding to support their coastal regions. Although Umar et al. [10] demonstrate that green taxes have a profound effect in financing oceanic and coastal requirements, March et al. [7] argue that blue bonds circumvent fiscal constraints. In the same vein, some researchers argue that blue bonds “may intensify fiscal dependence, create “blue debt”, and allow "bluewashing” when impact is weak [11]. The Ocean Panel, established in 2018, addresses ocean-related problems, including innovative financing solutions [11]. Therefore, innovative financial instruments customised to support the SDGs are in high demand [2].

The issuance of blue bonds, a variation of blue finance [11, 12], could be a plausible solution to fund ocean sustainability requirements [13]. Sustainable blue finance is a subset of climate finance [12, 3]; therefore, blue bonds are sometimes categorised as green bonds [12] and are structured in a way that replicates green bond issuances and regulation [14]. In the empirical literature, blue bonds are the widely recognised form of blue financing to support oceanic ecosystems and freshwater territories. According to the World Bank [15], “a blue bond is a debt instrument issued by governments, development banks, or others to raise capital from impact investors to finance marine and ocean-based projects that have positive environmental, economic and climate benefits”. Blue bonds are issued in large part in the major currencies: the United States Dollar (USD), the EURO (EUR), and the Japanese Yen (JPY) [16].

Blue bonds are a variation of a wide array of bond instruments [12, 17]. Blue bonds are used to raise funds to cover ocean funding requirements, such as mitigating ocean pollution, ensuring ocean health, preserving aquatic life, fishing governance, maintaining coastal infrastructure, and promoting maritime activities [18]. Blue bonds spearhead progress towards the development of a blue economy, as well as stimulating ‘blue recovery’ from global socio-economic shocks such as the COVID-19 pandemic [19].

Given the disconnect between finance, investments and the SDGs, thereby creating a funding gap [20], blue bonds are praised for accelerating efforts in achieving Sustainable Development Goal (SDG) 14, specifically ‘Life under Water’ [21, 19]. Their purpose distinguishes them from other environmental sustainability bonds, such as green bonds and sustainable bonds [22, 18]. Additionally, blue bonds differ from conventional bonds in that the proceeds of the former are used to support oceanic, coastal, and maritime sustainability, while the proceeds from the latter accrue to the issuer [22]. The issuance of blue bonds is still nascent, at approximately “0.5% of the sustainable debt market”, since the US$15 million Seychelles landmark issuance in 2018 [13]. Nonetheless, blue bonds are gaining momentum among various stakeholders, including national governments, philanthropists, and bilateral and multilateral organisations [23].

As thematic bonds [7, 11] have gained traction over the years, blue bond issuances are prevalent in North America and Europe [23], indicating their uneven distribution across regions, countries, and industries [20]. Thus, the issuance of blue bonds is inadequate to finance the vast majority of ocean-related requirements [1], hence the need to improve their attractiveness [11]. Although March et al. [7] outlined the necessary conditions for the issuance of blue bonds to finance the blue economy, the issuance of blue bonds is obscured by a lack of awareness among capital market investors [2]. Some authors argue

that there is a lack of transparency in cash flows in the blue economy [20]. Benzaken et al. [24:1] further add that the “blue economy is still a small percentage of global investment”.

22 blue bond transactions were recorded between 2018 and 2022, totalling US$5 billion [13], and the issuances increased significantly to 45 by May 2024, with total proceeds amounting to US$8,100 million [25]. Of this amount, the proceeds of the three African issuances (Seychelles 2018, Gabon 2023, and Cape Verde 2023) totalled $518 million, which represents only 6.4% of the aggregate proceeds [25]. Resultantly, a huge blue bonds funding gap exists on the African continent. Table 1 provides a summary of blue bonds issued in Africa between 2018 and 2023, while Appendix 1 provides additional details on the nature and structure of the issuances.

Table 1
Blue Bonds issued in Africa between 2018 and 2023

Debt Categorisation	**Number of issues**	**Amount in US$ millions**
Ocean-based Debt for Nature (DFN)	2	515
Blue Conservation (BC)	-	-
Blue Economy (BE)	1	3
	3	**518**
Source: Adapted from Liu et al. [25:5]		

The low uptake of blue bonds faces persistent barriers in the African context and is partly attributed to a lack of awareness [18]. Sarangi [4], supported by Bosmans & de Mariz [13], further states that the life below water SDG14 is the most underfunded sustainable development goal. Thus, examining the efficacy of blue bonds in funding oceanic sustainability requirements is significant because blue bonds are attractive to pro-environmental investors, offering financing resilience for the management of coastal ecosystems [22].

Extensive research on blue bond issuance has been carried out in different parts of the world, but little is known about the African continent, as shown in Appendix 2, which is a summary of the empirical framework for this study [1, 19, 13, 7, 25]. This lack of research does not attract blue investments and delays capital market development on the continent. Consequently, the study seeks to contribute to the existing literature in the following ways. Firstly, to the best of the researcher’s knowledge, this is the first study to empirically examine the blue bonds-ocean sustainability nexus in the African context, a niche area that has been understudied. Moreover, the study deviates from a related empirical study by Nefzi et al. [26] that investigated the interdependence and causality between the blue bond market and different financial assets over different time periods and frequencies. Secondly, the current study goes beyond the prevailing focus of existing African scholars who have focused on the African continent. For example, Nunoofio & Jugumath [27] focused on the impact of blue economy expenditure on the Mauritian tax

revenue base. Omollo et al. [5] looked at the barriers and enablers of blue carbon projects in Africa through a horizon scan analysis. Pi et al. [28] examined the effect of climate finance on the protection of natural resources in Sub-Saharan Africa. None of these scant African studies have interrogated the relationship between blue bond issuance and ocean sustainability; therefore, this timely study aims to fill this void in the coastal and maritime literature. Blue bonds are an innovative financial instrument needed to accelerate the concept of the blue economy in Africa [29].

The theoretical foundations of the study are based on signalling and stakeholder theories, which are widely used in investment finance and have been applied to green bond issuances [30, 31]. Drawing on signalling theory [32], blue bond issuers signal their commitment to environmental objectives such as ocean sustainability through the issuance of thematic bonds aligned with SGD14. The sustainability signalling effect of blue bonds manifests itself through the credible use of the proceeds of the issuance and the increased demand for bonds by investors [31].

According to stakeholder theory [33], institutions have to meet the different requirements of internal and external stakeholders, including environmental protection and conservation. In so doing, institutions remain relevant in the societies in which they operate, and this guarantees their legitimacy, long-term value creation, and longevity [31]. Thus, the issuance of blue bonds enables the issuers to respond to societal needs such as ensuring ocean sustainability. Using the aforementioned theories and the findings of previous related studies [34, 12, 35, 28], the study hypothesised that there is a positive relationship between the issuance of blue bonds and ocean sustainability.

H_0: There is a positive relationship between the issuance of blue bonds and ocean sustainability.

Panel data for the years 2018–2023 were obtained for three African countries that have issued blue bonds to date: Cape Verde, Gabon, and Seychelles. Fixed effects regressions were employed in the estimations. The study found that the issuance of blue bonds has a positive and significant relationship with the ocean health index, implying that projects that focus on ensuring ocean sustainability can be financed viably through proceeds obtained from the issuance of blue bonds. As a result, there is a need to ensure the development of a robust blue bond market supported by sound institutional and governance frameworks.

The results on the control variables showed that the gross domestic product growth rate, CO_2 emissions and the inflation rate coefficients were positive and significant with ocean sustainability. The regulatory quality coefficient was negative and significant. Conclusions were drawn from these findings and recommendations for business practice, policy formulation, and social implications are provided in Section 4.

The study proceeds as follows: the materials and methods section is next, followed by the presentation and discussion of the research findings, and lastly, the conclusions and recommendations.

2 Materials and Methods

2.1 Data

The study utilised a panel dataset for 3 purposively sampled African countries that issued blue bonds between the years between 2018 and 2023. 2018 marked the year in which the Seychelles issued the landmark blue bond [16], and 2023 is the most recent year in which blue bond issuances were recorded in the African continent in Cape Verde and Gabon. Data on blue bond issuance were obtained from the database of Liu et al. [25]. Data on ocean sustainability were obtained from the Ocean Health Index Initiative following previous studies [36, 37]. Data on some control variables were obtained from the World Development Indicators (WDI) of the World Bank [38, 28], while some were obtained from the World Governance Indicators of the World Bank [37].

2.2 Model Specification and Variables

The fixed effects model was employed in the regressions to obtain the results. To obtain unbiased and consistent estimates, standard errors were clustered at the country level to accommodate within-country independence. Eq. (1*)* specifies the empirical model to be estimated.

$$lnOHI_{it} = \beta_0 + \beta_1 D_{it}^{BB} + \beta_2 lnRGDP_{it} + \beta_3 lnCO2_{it} + \beta_4 lnREGQ_{it} + \beta_5 lnINFL_{it} + \mu_{it} \quad (1)$$

where β_i represents the model coefficients to be estimated and μ_{it} represents the idiosyncratic term.

The dependent variable, ocean sustainability, was captured using the Ocean Health Index *(OHI)*, consistent with empirical studies [36, 37]. The OHI composite index measures the extent to which people benefit from ocean systems sustainably and the status of societal goals such as clean water, carbon storage, artisanal fishing opportunities, coastal livelihoods and economies, among others.

The main independent variable is the issuance of blue bonds *(BB)*. Given the nascent nature of the blue bond market in Africa, the proxy for the issuance of blue bonds was a binary variable (1/0), taking the value of 1 in the year a blue bond was issued and 0 otherwise. This approach is in line with Corzo et al. [16], who used dummies to capture the issuance of blue bonds for a global sample of 74 issuers between 2018 and 2025. However, the study acknowledges that the binary measurement of blue bond issuance is a limitation, as it does not capture the variation in the volume of issuance and the allocation of the issuance proceeds. This approach is contrary to Nefzi et al. [26], who used data from the Solactive Blue Bond Index, and Jiang et al. [12], who used the total amount of blue bonds issued/total amount of all bonds issued.

On the control variables, economic growth *(RGDP)* reflects how economic development influences the sustainability of ocean ecosystems [36, 38, 37]. Rising temperatures due to high levels of carbon dioxide *(CO_2)* emissions lead to ocean acidification, which is detrimental to ocean sustainability [38]. Regulatory quality *(REGQ)* reflects how institutional frameworks are designed to enforce regulations that protect marine ecosystems, including oceanic activities [37]. Given the incubating nature of African institutional frameworks [39], it is expected that regulatory quality is negatively related to ocean sustainability. The

general price level *(INFL)* affects ocean health indirectly by influencing the cost of funds required to boost ocean health initiatives [36]. Year fixed effects were included in the regression model to account for global shocks [37]. Table 2 summarises the variables used in the study.

Table 2
Dependent, Independent and Control Variables

Variable and Notation	Variable Type	Description/ Measurement	Predicted Effect	Citations	Source
Ocean sustainability *(lnOHI)*	Dependent	Ocean Health Index (0-100)		[36, 37]	Ocean Health Index Initiative
Blue Bonds *(BB)*	Independent	Dummy variable taking the value of 1 in the year a blue bond was issued and 0 otherwise	+	[16]	Author-generated using data from Liu et al. [25]
Economic Growth *(lnRGDP)*	Control	Annual growth rate of the gross domestic product (%)	+	[38, 28]	WDI
Global Warming *(lnCO_2)*	Control	Carbon dioxide emissions (Mt/CO_2)	-	[38]	WDI
Regulatory Quality *(lnREGQ)*	Control	Composite governance score (0-100)	+	[37]	WGI
Inflation *(lnINFL)*	Control	Consumer Price Index (%)	-	[36]	WDI
Time Dummies	Year-fixed effects	Categorical variable		[37, 16]	Author-generated
Source: Author's compilation based on literature review					

3 Discussion of Results

3.1 Descriptive Statistics

Table 3 presents descriptive statistics for the study variables. The minimum value for the ocean health index is 5.41, while the maximum value is 88.68. On average, the mean value of the ocean health index for the sampled countries is 69.56, indicating moderate ocean sustainability. The minimum and maximum values of the blue bond issuance variable indicate the binary nature of the proxy used.

Table 3
Descriptive Statistics

Variables	Observations	Mean	Standard Deviation	Min	Max
OHI	24	69.55917	16.15085	5.41	88.68
BB	24	0.125	0.337832	0	1
RGDP	24	2.917116	6.975884	-20.8053	15.84368
CO_2	21	2.326852	2.237321	0.6283	5.6528
REGQ	21	-0.1581	-0.4884	-0.90	0.43
INFL	24	2.458942	2.414738	-1.035301	9.769099
Source: Author's compilation					

3.2 Correlation Analysis

Table 4 presents the correlation analysis for the variables used.

Table 4
Correlation Analysis

	OHI	BB	RGDP	CO_2	REGQ	INFL
OHI	1					
BB	0.0160	1				
RGDP	-0.1390	0.0631	1			
CO_2	-0.0231	-0.0127	-0.0679	1		
REGQ	0.0100	0.0200	0.0900	-0.9400	1	
INFL	0.2233	0.1961	0.2374	0.0167	0.0000	1
Source: Author's compilation						

In line with a priori expectations, the blue bond variable is positive with the ocean health index, while economic growth and carbon emissions have a negative association and the inflation rate has a positive association.

To aid in the correlation analysis, Table 5 presents the Variance Inflation Factor (VIF) scores to detect multicollinearity.

Table 5
VIF scores

Variable	N	VIF	1/VIF	Comment
BB	24	1.035324	0.965881	Acceptable
RGDP	24	1.089801	0.917599	Acceptable
CO_2	21	9.372116	0.106699	Acceptable
REGQ	21	9.410988	0.106259	Acceptable
INFL	24	1.106361	0.903864	Acceptable
Source: Author's compilation				

The VIF scores ranged from 1.03 to 9.41 and were all less than 10, the cutoff point, indicating that multicollinearity was not a concern during estimation.

3.3 Empirical Results

Table 6 presents the estimated results using the fixed effects model.

Table 6
Fixed Effects Results

Blue Bonds *(BB)*	**Dependent Variable: *(OHI)***	**95% Confidence Interval**
	0.0945387* [2.08e-07]**	**(0.094536, 0.0945413)**
Economic Growth *(lnRGDP)*	0.0016277*** [6.45e-07]	(0.0016195, 0.0016359)
Global Warming *($lnCO_2$)*	3.950999*** [0.0000221]	(3.950718, 3.951281)
Inflation *(lnINFL)*	0.0828697*** [2.92e-07]	(0.082866,0.0828734)
Regulatory Quality *(lnREGQ)*	-0.2995222*** [6.29e-07]	(-0.2995302, 0.2995302)
Year-specific fixed effects		
***1%, **5% and 10* significance levels		

Figures in square brackets [ ] are robust standard errors clustered at the country level.

In line with the hypothesis and a priori expectations of the study, the dummy variable of blue bonds is positive and statistically significant with the ocean health index at 1% level of significance. This indicates that projects focused on ensuring ocean sustainability can be financed viably through the issuance of blue bonds. The results support the theoretical framework of the study that encompasses the signalling and stakeholder theories. Accordingly, the results support the notion that the blue bond issuance structure must be fit for the purpose [7, 8, 25]. The study's findings align with those of Jiang et al. [12], who found that blue financing supports environmental quality in the marine fishery ecosystem. However, Nefzi et al. [26] found that blue bonds help investors to diversify their investment alternatives, but their effectiveness is limited by the nascent development of the blue bond market. In the same vein, Corzo et al. [16] further found that the capital markets are still incomplete and non-standardised for thematic investing using blue bonds to address sustainability-linked commitments because they address themes selectively, with a stronger focus on environmental issues.

The real GDP growth coefficient is positive and significant with the ocean health index at the 1% level of significance, indicating that economic growth boosts ocean sustainability. The result is consistent with Camkaya et al. [38], who found a positive relationship for the world's 10 largest blue economies. Contradictory evidence comes from Ha [36], who found a negative relationship between economic growth and ocean sustainability in a global sample of 35 countries, and Pi et al. [28], who reported that high levels of economic growth are detrimental to natural resources in Sub-Saharan Africa.

The parameter for CO2 emissions is positive and significant with the ocean health index of 1% level of significance, suggesting that rising CO2 emissions improve ocean sustainability. This result is counterintuitive and must be interpreted with caution. As CO2 emissions are from broader economic activities, this finding may indicate that there are positive results for environmental sustainability in ocean ecosystems with an increase in economic growth. Nonetheless, this finding is contrary to the prior expectation of a negative coefficient and the study of Camkaya et al. [38], as high levels of carbon emissions are associated with ocean warming, acidification and deoxygenation.

The coefficient of regulatory quality is negative and significant with the ocean health index of 1% significance level. This indicates regulatory loopholes stifle progress towards improving ocean sustainability. This finding aligns with the a priori expectation given the weak African institutional frameworks to enforce regulations [39]. The inflation rate coefficient is positive and significant with the ocean health index at the 1% level of significance. This indicates that the inflation rate influences ocean sustainability through indirect effects as national governments readjust their fiscal positions to accommodate the rise in the general price level. Thus, a rise in the inflation rate leads to an upward review of government expenditure allocated to marine protection and conservation, thereby boosting investment in ocean ecosystems. Mixed evidence is reported in the study of Ha [36], which found different results for the inflation rate coefficient using different estimation techniques.

4 Conclusions and Recommendations

This study examined the relationship between the issuance of blue bonds and ocean sustainability for selected African countries utilising panel data for the years 2008 to 2023. The fixed effects estimation technique was employed, and the main results showed that blue bonds have a positive and significant relationship with the ocean health index. The intuition is that financing marine-related projects with blue bond proceeds improves the sustainability of oceans.

Concerning the control variables, the results are twofold. On the one hand, the study found that an increase in the real GDP growth rate spurs ocean sustainability, as the estimated coefficient was positive and statistically significant. Furthermore, the inflation rate supports ocean sustainability through indirect effects, as the coefficient was positive and significant. However, the results show that the coefficient for regulatory quality was negative and statistically significant, suggesting that ineffective regulatory frameworks reduce ocean sustainability. In addition, the study found a positive relationship between carbon emissions and ocean sustainability.

These findings have several implications. Firstly, the positive result between blue bonds and ocean sustainability implies that there is a need for the development of African capital markets to accommodate innovative and thematic bonds to finance sustainability-related projects.

Secondly, African national governments must invest in financial infrastructure to support the development of the blue bond market by ensuring that there are robust institutional and capital market regulatory frameworks that align with international standards. Once these fundamentals are in place, potential impact investors, individual or institutional, can channel their surplus cash resources to SDG14-related projects through the blue bond market. Third, there is a need to raise public awareness of innovative financial instruments such as blue bonds to encourage the general public to invest their savings in blue bonds. In return, members of the public will earn periodic coupon payments and improve their livelihoods. Fourth, tracking and monitoring the proceeds of blue bonds is essential to ensure transparency in disbursements and evaluating their effectiveness in funding ocean sustainability projects. This will help blue finance practitioners identify specific projects to be funded [7] and then customise blue bond issuances based on funding requirements, case by case, as project needs vary [3].

The positive result between economic growth and ocean sustainability implies that there is a positive contribution of economic activities in general and ocean business environments to ocean sustainability. This means that sustainable marine-related economic activities in the formal and informal sectors exert a positive influence on the sustainability of oceans in African economies. The negative coefficient for regulatory quality implies that there is a need to strengthen regulatory measures to protect and sustain the health of oceans in Africa by increasing institutional capacity supported by an enabling regulatory environment in ocean ecosystems. The positive parameter for the inflation rate implies that the African monetary authorities need to keep the general price level within tolerable levels to minimise the indirect effects of the inflation rate on ocean sustainability. However, an increase in the general price level affects the required rate of return on blue bonds, leading to an increase in the cost of the funds available.

The study has limitations. As noted in the materials and methods section, blue bonds were captured as a dummy variable, and this does not capture variation in the volume of issuance and the allocation of the issuance proceeds. Inference of results to wider contexts was limited by sample size, as only 3 out of 54 countries were included in the sample.

More studies that analyse the impact metrics of blue bond financing are encouraged. This will help to track progress, identify areas of improvement, and map the way forward in developing robust blue bond markets.

Declarations

Author Contributions

Corresponding author: conceptualisation, writing, reviewing, and editing.

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Data Availability Statement

The dataset used is available upon request.

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Institutional Ethics Review

Institutional ethical clearance was obtained for the study Ref No. 16638. No human participants or animals were involved in the study.

Disclosure of AI use

ChatGPT Classic (GPT-5.6 Luna version) was used to obtain some STATA19 software commands during the estimation process. Grammarly and Writefull were used for language editing.

Declaration of Competing Interest

The author declares no conflict of interest.

Consent to Publish

Not applicable.

Consent to Participate

Not applicable.

Declaration of Clinical Registration

Not applicable.

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