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Environmental Performance and Economic Growth in the West African Economies

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CAMA Working Paper 75/2024
December 2024

Hammed Oluwaseyi Musibau
University of Tasmania

Maria Belen Yanotti
University of Tasmania

Joaquin Vespignani
University of Tasmania
Centre for Applied Macroeconomic Analysis, ANU

Rabindra Nepal
University of Wollongong
Centre for Applied Macroeconomic Analysis, ANU

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Keywords

economic growth, environmental performance, ECOWAS, environmental governance, GMM, oil-producing economies

JEL Classification

O47, F64, K32

Address for correspondence:

(E) cama.admin@anu.edu.au

ISSN 2206-0332

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Hammed Oluwaseyi Musibau
Tasmanian School of Business and Economics, University of Tasmania, Australia

Maria Yanotti
Tasmanian School of Business and Economics, University of Tasmania, Australia

Joaquin Vespignani
Tasmanian School of Business and Economics, University of Tasmania, Australia;
Australian National University (ANU) - Centre for Applied Macroeconomic Analysis (CAMA)

Rabindra Nepal
School of Accounting, Economics, and Finance, University of Wollongong
Australian National University (ANU) - Centre for Applied Macroeconomic Analysis (CAMA)

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The importance of sustainable economic growth has been emphasized by the United Nations Sustainable Development Goals (SDG). SDGs 8 and 11 suggest that a sustainable environment can improve economic growth, which has been the priority for some governments worldwide. This study incorporates the environmental performance index (EPI) into the neoclassical growth model to examine the impact of environmental performance on economic growth for the Economic Community of West African States (ECOWAS). Using the two-step generalized method of moments (GMM) model, the empirical investigation finds a positive relationship between environmental performance and economic growth. More specifically, we find that improved environmental performance is observed to accelerate economic growth in non-oil-producing ECOWAS countries, but diminishes growth in oil-producing ECOWAS countries. Based on the findings, we recommend policies that encourage improved environmental performance in non-oil-producing ECOWAS economies.

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1 Introduction

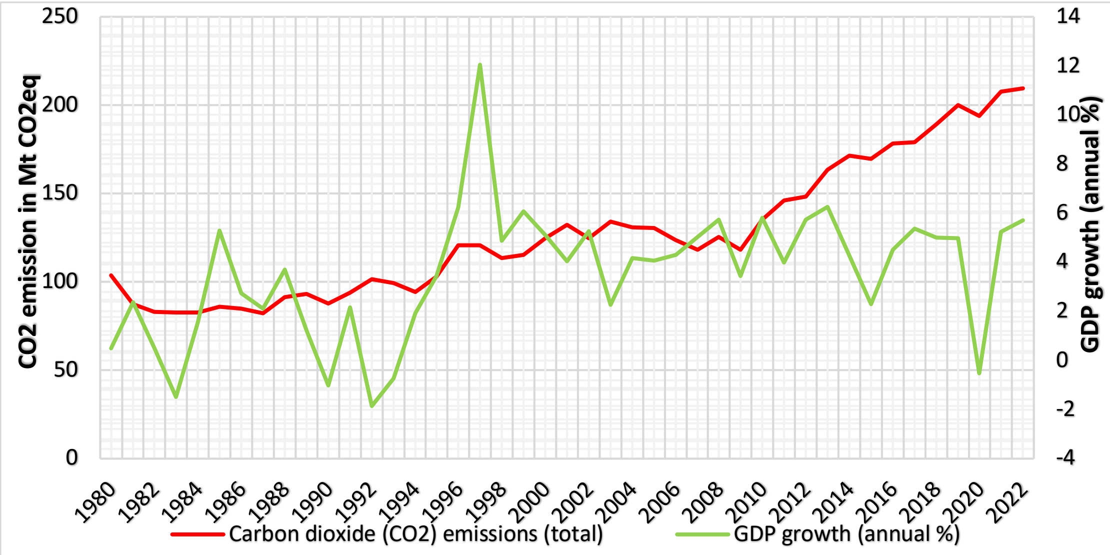
The causal link between environmental quality and economic growth is still debatable in the economic growth literature. Resource constraints theories argue that continuous economic growth may be unsustainable due to finite natural resources and environmental degradation (Islam et al., 2003). However, some scholars suggest that effective environmental policies and regulations, while crucial for environmental quality, may indirectly harm economic growth through intensive mitigation and abatement efforts, lowering the return to investment and growth incentives, particularly for developing economies (Brock & Taylor, 2005; Currie & Walker, 2019; Khan et al., 2020). Other scholars argue that environmental quality encourages cost savings and increased sales, increasing economic growth (Inglesi-Lotz, 2016; Chen et al., 2018; Rajbhandari & Zhang, 2018). The Environmental Kutznets Curve (EKC) hypothesis postulates that the relationship between economic growth and the environment is not linear; initially, environmental degradation increases with economic growth, but after reaching a certain income level, further growth leads to environmental improvements (Grossman & Krueger, 1995). The varying stages of economic development across countries, coupled with current extreme weather changes contributing to global warming and environmental degradation, prompts the need for further study, especially in developing economies like those in West Africa.

Sustainable Development Goals (SDGs) 8 and 11 suggest that a sustainable environment can enhance economic growth; a worldwide priority. The United Nations Framework Convention (UNFC) confirms that human activities from agriculture, fossil fuel combustion and industrial practices pose a serious threat to the realisation of environmentally friendly economies and achieving the SDGs, especially among the 15[1] member nations of the Economic Community of West African States (ECOWAS) (Antwi-Agyei et al., 2018; Nwaka, 2020; Ali et al., 2021). This study applyies the Yale Center for Environmental Law & Policy's Environmental Performance Index (EPI) to examines the role of environmental performance in economic growth in developing economies within ECOWAS.

[1] Nigeria, Ghana, Senegal, Cote d'Ivoire, Cabo Verde, Benin, Burkina Faso, Guinea, Gambia, Guinea-Bissau, Liberia, Niger, Mali, Sierra Leone and Togo.

West Africa contributes little to global emissions (approximately 2.03 percent of global greenhouse gas (GHG) emissions);[2] however, the region suffers significant effects of climate change (Abraham et al., 2021; Pickson & Boateng, 2022). USAID (2018) claims that ECOWAS is one of the world's most vulnerable regions to climate variability and change. Seveteen out of the twenty countries most threatened by climate change are located in Africa.[3] The region may lose up to 86 million workers in the coming years due to environmental problems, including rising temperatures, flooding, erratic rainfall and coastal erosion (World Bank, 2021). Zaman and Abd-el Moemen (2017) argue that economic development amid environmental degradation is unachievable.

Figure 1 – CO_2 emission and GDP growth in ECOWAS, 1990- 2022



As depicted in Figure 1, CO_2 emissions have increased at a rapid rate while gross domestic product (GDP) growth has been more volatile in ECOWAS countries. CO_2 emissions contribute to climate change, which has severe economic effects on ECOWAS and broader. The natural disasters that affect this region (droughts, floods and desertification; Ani, 2022; Lenshie et al., 2022) have an adverse impact on the region's economy, particularly on agriculture, which employs a large proportion of the population (Omisore, 2018). United Nations Climate Change (UNCC) (2020) found that, on average,

[2] West Africa's total regional GHG emissions were 994.70 million metric tons of carbon dioxide equivalent (MtCO2e) in 2014. Approximately 31.5 percent of GHG emissions came from the land-use change and forestry sector, followed by the energy, agriculture, waste and the industrial processes sector. https://www.climatelinks.org/resources/greenhouse-gas-emissions-factsheet-west-africa-region . Accessed 26th November 2023.
[3] United Nations Climate Change https://unfccc.int/news/climate-change-is-an-increasing-threat-to-africa . Accessed 26th November 2023.

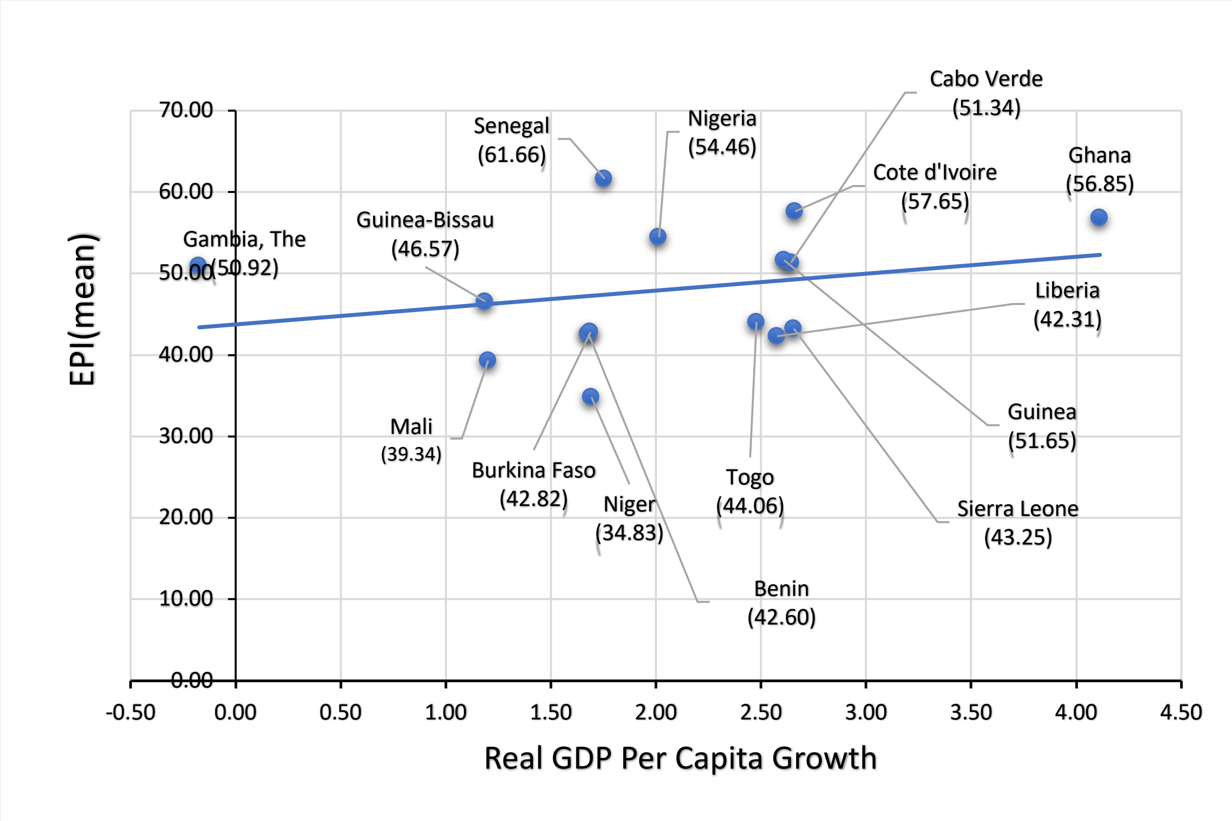
crop yields in WA have decreased by 20% over the past few decades due to changes in temperature and rainfall patterns caused by climate change and the net primary productivity is expected to decline by 42% by 2050. According to the Intergovernmental Panel on Climate Change (2022, p. 2) WA's temperatures will increase by 1.5–3°C by 2050. UNCC (2020) suggests that increasing temperature as a result of climate change is threatening human health and safety, productivity, food security and socio-economic development, especially in developing economies like West African countries (UNCC, 2022; Fotso-Nguemo et al., 2023).

Given these developments, ECOWAS countries will be further chanllenged to achieve sustainable economic growth. To investigate the effects of environmental performance on economic growth in ECOWAS countries, we propose to incorporate Yale Center for Environmental Law & Policy's Environmental Performance Index (EPI)[4] and a measure of environmental governance (motivated by Acemoglu, 2005 and Arrow et al., 1995) into the neoclassical growth model to measure the role environmental sustainability has on economic growth for ECOWAS countries.

Our environmental sustainability variable extends the scope of the variables used in existing studies on the environment and growth nexus, which focus on CO_2 emissions, energy consumption, ecological footprint and energy security (Le et al., 2020; Ozcan et al., 2020; Yao et al., 2020; Shittu et al., 2021; Ren et al., 2022; Wang et al., 2022). All these measure only one aspect of environmental sustainability and ignore other indicators of environmental degradation. The EPI was created because it is impossible to find a single variable that captures all aspects of environmental sustainability indicators (Das et al., 2017). The EPI, ranked on a scale of 1 to 100 with higher EPI indicating better environmental performance, provides a variable for a summary of 24 performance indicators and ranks 180 countries based on environmental health and ecosystem vitality. Figure 2 shows the pattern of real economic growth and EPI for ECOWAS countries. The scatter plot reveals a weak positive relationship between the two variables across the region, motivating further exploration.

[4] https://epi.yale.edu/ Accessed 20th August 2022.

Figure 2: Scatterplot of GDP Per Capital and EPI, West Africa (2006-2018)



Studies that use the EPI examine the effects of economic growth on the environment rather than the impact of the environment on economic growth (Al-Tuwaijri, Christensen & Hughes, 2004; Chowdhury & Islam, 2017; Shittu et al., 2021). As a result, the purpose of this study is to fill a gap in the literature on economic growth by presenting an analyses of the impact of the environment on economic growth for ECOWAS countries as measured by environmental performance and environmental governance, given the environmental challenges impeding the region's economic progress.

Our study applies the two-step GMM model enabling us to control for endogeneity in the environment and economic growth relationship.[5]

We also make an important distinction across ECOWAS countries. We split our sample into oil-producing and non-oil producing countries. Khan et al., 2021 show that utilization of fossil fuels negatively influences the quality of the environment and increases the risk

[5] Most existing studies on the role of environmental quality in economic growth have used traditional models such as Panel Ordinary Least Square (POLS), Fully Modified Ordinary Least Square (FMOLS), Dynamic OLS (DOLS) and panel autoregressive distributed lag model (ARDL) (Dinda, Coondoo & Pal, 2000; Uddin et al., 2017; Rahman, 2020; Tenaw, 2022; Caglar et al., 2023). Further, very few studies have controlled for endogeneity, which is essential to avoid a biased estimate (Caglar et al., 2023).

of several diseases associated with the undernourishment and respiratory system, increasing the death ratio. Asafu-Adjaye et al. (2016) find a bi-derectional causality between real GDP and fossil fuel consumption for developing exporters of fossil fuels, and argue that efforts to conserve fossil fuels may harm economic growth, and Baek & Kim (2013) show that fossil fuels in electricity production and energy consumption have a detrimental effect on the environment. Therefore a distinction between oil producing and non-oil producing countries becomes relevant in our investigation.

Our empirical findings show that, on average, environmental performance has a positive and significant effect on economic growth for non-oil-producing West African countries, suggesting that higher environmental performance translates into better economic performance in non-oil producing ECOWAS countries. Results reveal that improved environmental performance reduces economic growth in oil-producing ECOWAS countries. Our findings have important implications for political incentives and social wellbeing, and they suggest policies to improve environmental performance in non-oil-producing West African economies, and a transition to non-fossil fuels for oil-producing ECOWAS countries. The findings of this study add to the limited research on the complementarity of EPI in the neoclassical growth model in the context of ECOWAS.

The remainder of this chapter is organised as follows; section 2 presents the EPI backgound. Section 3 describes the data and research methods for the study. Results and robustness exercises are presented in section 4, while discussion and conclusions are provided in section 5.

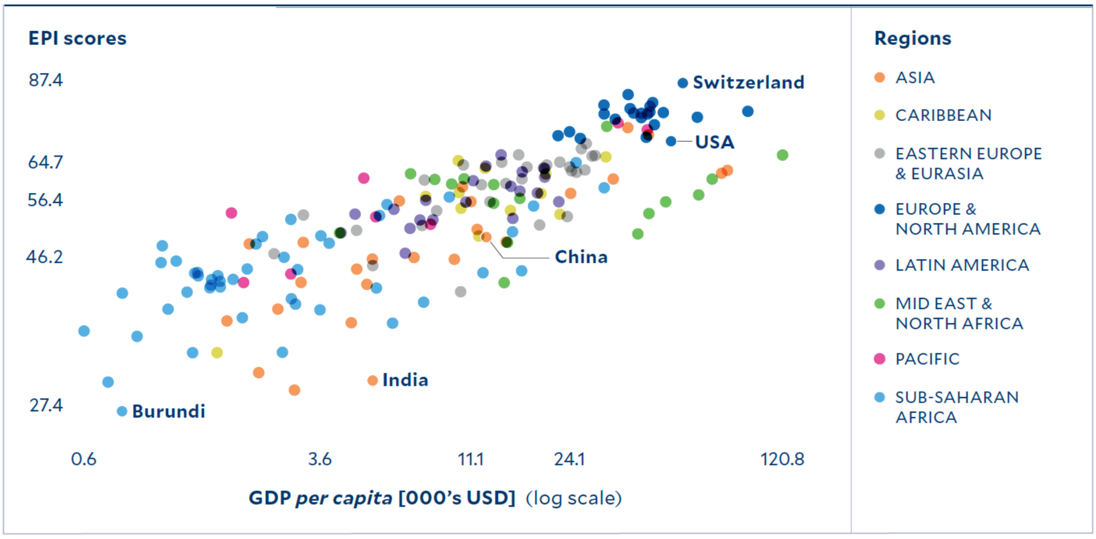
2 A Brief review of the EPI

We innovate in the use of the EPI to understand the effect the environment has on economic growth. Other studies measure one or few aspects of environmental performance: CO_2 emissions (Li et al., 2017; Sharif et al., 2019; Li et al., 2020; Khan & Ozturk, 2021; Li et al., 2022), energy security (Le & Nguyen, 2019; Huang et al., 2021; Nepal et al., 2021; Chu et al., 2023), renewable and non-renewable energy (Chen et al., 2022), electricity consumption and nuclear energy (Baek & Kim, 2013), energy investment (Shahbaz et al., 2020), energy intensity (Deichmann et al., 2018; Mahmood & Ahmad, 2018), ecological footprint per capita (Bigerna et al., 2022; Gorus & Karagol, 2022; Yilanci et al., 2022). Other researchers measured environmental performance using proxies of environmental health such as air quality, water sanitation and land (Orubu & Omotor, 2011; Charfeddine et al., 2018; Qu & Long, 2018; Usman et al., 2020; Shittu et al., 2020; Freedman & Jaggi, 1992).[6] However, they may be underestimating or overestimating the effect of the environment on economic growth by ignoring other indicators of environmental performance.

The environmental performance index (EPI) is one of the most robust sustainable development indicators. It covers two dimensions of sustainable development: environmental health and ecosystem vitality. As reflected in Figure A1, it is estimated using 24 indicators in 10 issue categories (Wendling et al., 2020).

As an index, the EPI measures the general qualitative influence of nature and the living environment by employing an aggregate of numerous policy measures, groups and indicators. The EPI represents a tool to assess the environmental performance of governments or policymakers; it also enables comparison on a common basis. The index was composed based on two measurement objectives: environmental health deviation and ecosystem vitality.

Figure 3: The Relationship between 2018 EPI Scores and GDP per Capita



Source: Wendling et al. (2018)

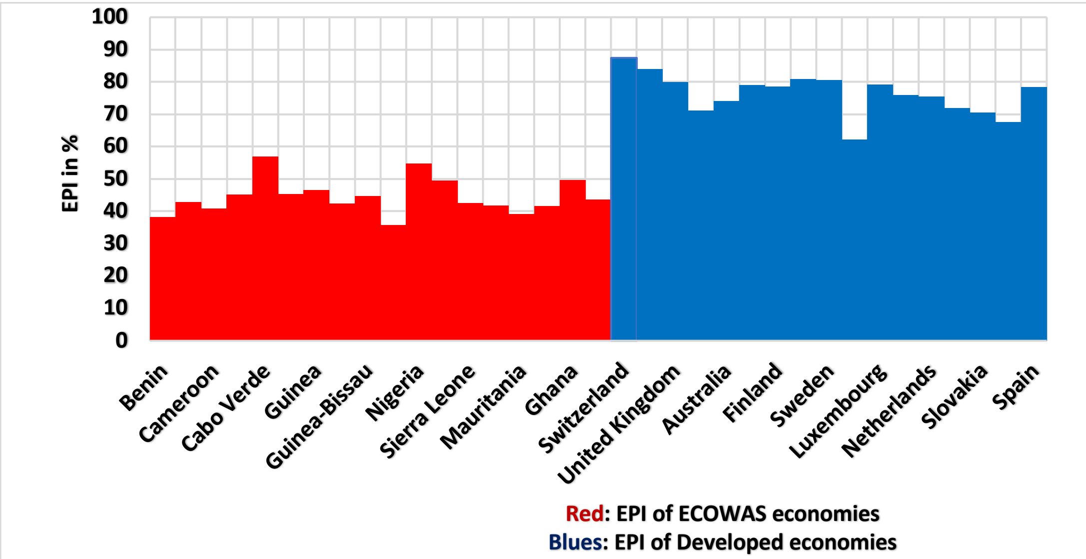
The EPI Report in 2018 provides a visual inspection of the positive correlation between EPI and economic growth, as depicted in Figure 3 above. Developing countries,

[6] Table B1 summarises the mixed empirical evidence on sustainable environment and economics growth.

particularly in Sub-Saharan Africa, score lower than any other region, occupying 30 of the bottom 40 positions (Wendling et al., 2018). The United Nations (UN, 2019) report shows that a high percentage of West Africans are living on less than a dollar a day, with a huge number of this percentage living in the slums, often without access to basic health facilities, electricity and clean water. These areas also experience high population levels due to low levels of education and poor family planning, putting even more pressure on the limited available resources.

Figure 4 below illustrates the differences in EPI between ECOWAS and developed economies for the latest year of our study period. The developed economies have higher EPI scores (from 50 to 80) than ECOWAS (from 35.74 to 56.94). Low EPI scores in West African countries show the need for national sustainability efforts, especially in terms of air quality, protecting biodiversity and reducing GHG emissions (Ofoezie et al., 2022). Given these facts, we developed an econometric model to verify whether improved environmental performance boosts economic growth in developing economies like the ECOWAS countries.

Figure 4: 2018 EPI for ECOWAS and Developed Economies



Source: Wendling et al. (2018)

As shown in Table B1, Chowdhury & Islam (2017) is the only study applying the EPI, however, their examination studies the inverse relationship; that is the effect of economic growth on EPI.

Inspired by Acemoglu (2005) and Arrow et al. (1995), we complement the EPI index with the environmental governance index generated applying principal component analyses (PCA) to Environment Social and Governance (ESG) World Bank data on coastal protection and terrestrial and marine protected areas (as a proportion of total territorial area).[7]

3 Methodology and Data

This section discusses the model and estimation techniques employed in the study. The section starts with the specification of the Solow–Swan neoclassical growth function and continues with the description of the variables, data sources and estimation techniques applied and used in the study.

3.1 Theoretical background

The Solow–Swan neoclassical growth model (Solow, 1956) estimates long-run economic performance using a production function with constant returns to scale to explain the non-linear relationship between the stock of capital, labour and technological progress between countries. The growth model incorporates labour as a factor of production into the original Harrod–Domar (1946) model. They concluded that output can be produced using two factors of production, capital (K) and labour (L), and state that the elasticity of substitution must be asymptotically equal to one. The augmented classical growth theory recognises that factors of production and energy contribute to sustainable economic growth (Stern, 2019). The economic theory submits that natural resources and their appreciation are salient factors of production (Stiglitz, 1974). This is because their abundance decreases energy costs, inducing the substitution of capital labour. This long-term substitution has been a key driver of economic growth (Mankiw et al., 1992).

Incorporating the environmental dimension into the neoclassical model, we follow Greiner and Semmler (2008) and specify the aggregate production function as follows:

$$Y_{it} = A_{it}{K_{it}}^{\alpha_1}(H_{it}L_{it})^{\alpha_2}{E_{it}}^{\alpha_3}e^{\mu}, \tag{1}$$

[7] See https://databank.worldbank.org/metadataglossary/world-development-indicators/series/ER.PTD.TOTL.ZS . Accessed 18th November 2023.

Where Y_{it} is total output, H_{it} is the stock of knowledge (human capital), that is, aggregate investment's by-product, while L_{it} is labour input, and K_{it} is aggregate capital stock (gross capital formation) and E_{it} is the environmental damage function (industrial pressure). A_{it} represents Hicks-neutral technological progress; as an increasing variable, A_{it}, in $A_{it}\, f(K_{it}, H_{it}, L_{it}, E_{it})$. t is the time-variant; $\alpha_1, \alpha_2, \alpha_3$ represent the elasticity of growth to capital, human capital, environmental factor and $\alpha_1 + \alpha_2, + \alpha_3 = 1$. The effective units of labour stock are AL_{it}, and (e) is the error term.

Following the neoclassical growth model, the following hypothesis is tested:

H_1: There is a relationship between the environmental performance index and economic growth; $\alpha_3 \neq 0$.

3.2 Estimation Technique

Empirical evidence from previous studies has shown that there is most likely a bidirectional causality between environmental sustainability and economic growth. The meta-analysis on environment–income nexus in Li et al. (2007) finds two groups of literature; the first group (with 353 observations) suggests that environmental quality may help to promote economic growth while the second group (with 111 observations) claims that growth worsens environmental quality. Chang and Fang (2018) observe that economic growth induces environmental sustainability, while Le and Nguyen (2019) posit that environmental sustainability promotes economic growth. This points to the fact that the environmental performance is an endogenous regressor.

As shown in Table B1, the causal relationship between environmental impact and economic growth has been extensively studied using different methodologies ranging from traditional estimation techniques like POLS, FMOLS, DOLS, Canonical Cointegrating Regression, and panel ARDL to mention just a few (Wolde-Rufael, 2009; Le & Nguyen, 2019; Ozcan et al., 2020; Vural, 2020; Paija et al., 2021; Adedoyin et al., 2021). However, few studies have controlled for endogeneity (Al-Tuwaijri, Christensen & Hughes 2004; Mohapatra, Adamowicz, & Boxall, 2016; Caglar et al., 2023),[8] an important issue when modelling the relationship between environment and income. Estimating the effect of the environment on growth without controlling for endogeneity

[8] Baek & Kim (2013) mention the reserve causality between environment and growth.

may lead to bias (Cameron & Trivedi, 2009). This study contributes to the existing literature by using a two-step GMM to explore the role of environmental performance using the EPI in economic growth. The GMM estimator is considered as one of the most widely used estimators for estimating dynamic panel data, due to its suitability for short panel, that is, N > T, and its ability to control for endogeneity bias (see Nickell, 1981). Applying a two-step GMM model aloows for the inclusion of lags among the dependent variable to tackle potential heterogeneity in the estimated coefficients on the variables examined. Applying these models enables us to account for potential endogeneity in the environment and economic growth relationship. Given a dynamic panel data as presented below:

$$GDPpcG_{it} = \rho_0 + \rho_1 GDPpcG_{it-1} + \rho_2 K_{it} + \rho_3 L_{it} + \rho_4 EPI_{it} + \rho_5 TOP_{it} + \rho_6 ENVIGOV_{it} + \rho_7 ECONGOV_{it} + \eta_i + \varepsilon_{it}, \tag{2}$$

Where GDPpcG is the real GDP per capita growth in country *i* at time *t*, K is the capital stock (gross capital formation) in country *i* at time *t*, L is the labour (Labor force, total in millions) in country *i* at time *t*, EPI is the environmental performance index in country *i* at time *t*, TOP is the trade openness (net trade as % of GDP) in country *i* at time *t*. $ENVIGOV$ is the environmental governance in country *i* at time *t*, $ECONGOV$ is the economic governance in country *i* at time *t*. ρ is the vector of parameters associated with the independent variables, η_i represents the country-specific fixed effect while ε_{it} is the idiosyncratic disturbance term.

To overcome the problem of endogeneity, which is inherent in dynamic panel as noted by Nickel (1981), Arellano & Bond (1991) proposed a difference GMM estimator. The differenced GMM takes the first difference of Equation (2) to remove unobserved heterogeneity. The differenced GMM rests on the assumption that the error term is free from second-order autocorrelation. One of the shortcomings of differenced GMM is that differencing may reduce the variation in the explanatory variables, which might exacerbate measurement error (Beck, Levine & Loazya, 2000; Griliches & Huasman, 1986). To overcome the differenced GMM shortcoming, Arellano & Bover (1995) and Blundell & Bond (1998) propose the system GMM that, in addition to the differenced GMM, uses the lagged difference of the explanatory variables as an instrument.[9] The

[9] GMM estimators with two steps tend to be more efficient than those with one step (Windmeijer, 2005). However, one-step systems assume that error term variance is independent and homoscedastic across

validity of the instrument is assessed through the Hansen–Sargan test of over-identification as shown in Table B5, which confirms the validity of the instruments when the estimate fails to reject the null of instrument validity.

3.3 Data

Our main variable of interest is the EPI, expecting a positive relationship between environmental quality and real GDP per capita (Uddin et al., 2017). *ENVIGOV*, the environmental governance, and *ECONGOV*, the economic governance, are also variables of interest. We have estimated environmental and economic governance using principal component analysis (PCA). Indexes are created from coastal protection, terrestrial and marine protected areas (% of total territorial area) for environmental governance and using rule of law, control of corruption, economic and social rights performance score, and strength of legal rights index for economic governance. Tables B3 and B4 show the results of the PCA analysis. The 'grease the wheels' hypothesis, and studies such as Arrow et al. (1995), Acemoglu (2005), Burgess et al. (2015) and Thanh et al. (2020), argue that good governance increases economic growth, while Kim et al. (2018) suggest that governance negatively affects economic growth.

Control variables include capital, labour and trade openness. Capital, labour and trade openness are expected to have a positive relationship on economic growth (Helpman & Krugman, 1985; Grossman & Helpman, 1991). Akinlo (2004) and Wolde-Rufael (2009) find that labour and capital promote economic growth in Africa. The data for variables obtained from various sources are presented in Table B2.

Table B6 presents the summary statistics for the data. The correlation coefficient among the variables is low, which suggests low multicollinearity among the variables.[10]

We performed cross-section dependency tests. For instance, among the ECOWAS countries, some members like Nigeria, Ghana, Guinea and Senegal have more robust economies than other members, suggesting potential interdependence among these economies; that is, other ECOWAS member nations may be linked to these economies. Consequently, we present the average correlation coefficients and cross-dependence (CD)

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countries and times, while two-step GMM models use residuals of the first-step estimation for estimating variance–covariance matrix and iterative approach that allows more efficient parameter estimation, reducing potential biases and improving precision (Windmeijer, 2005; Hwang & Sun, 2018; Mittal & Garg, 2021).

[10] In addition, our variance inflation factor (VIF) result is less than 5, which confirms no potential multicollinearity among the variables.

tests in Table B7. The probabilities of CD tests are not significant, showing no evidence of cross-dependence among economic regions.

4 Empirical Findings

4.1 Environmental Performance in Economic Growth

Following Equation (2), Table 1 presents the empirical results of the role of environmental performance on economic growth using the two-step GMM model. The estimates are reported in column 2 of Table 1. $GDPpcG\_{t-1}$ is the lag of real GDP per capita growth, while EPI, L, OPEN, K, ENVIGOV and ECONGOV represent environmental performance, Labor force, total, trade openness, capital stock, environmental governance and economic governance, respectively. The lag of GDP per capita growth is statistically significant, which implies that economic growth is persistent.

The coefficient of environmental performance is positive, indicating that environmental performance significantly increases economic growth at the 5% level of significance. The estimated elasticity is 0.04 (see Table 1); that is, a 1% increase in EPI increases economic growth by 0.04 percentage points, ceteris paribus. While the magnitude of the result is weak, it still reflect statistical and economic significance. It intuitively implies that a sustainable environment will spur economic growth.

The coefficient for total labour force (L) is positive and statistically significant. Increased total labour force stimulates economic growth in developing ECOWAS economies, consistent with the neoclassical model. Capital stock significantly improves economic growth. This is in line with a priori expectation and with previous studies (Solow, 1962; Barro, 2016; Rahman & Velayutham, 2020). Trade openness significantly increases economic growth as well (Barro, 2016; Alam & Murad, 2020), particularly for small open economies such as ECOWAS.

The effect of environmental governance on growth is found to be positive and statistically significant at a 5% level. Environmental governance contributes significantly to economic growth; other things being equal, a 1% increase in environmental governance increases economic growth by 0.34 percentage points. Thus, encouraging good environmental governance may help promote resource efficiency and minimise risks, thereby generating higher economic growth. This finding contributes to the work of Li et al. (2018) and Li et al. (2020). On the other hand, economic governance is found to be negative and statistically significant at a 5% level. Other things being equal, a 1% increase in economic governance decreases economic growth by 0.40 percentage points. To achieve sustainable economic growth, governments must strike a balance between environmental governance and economic governance. Our results show that ECOWAS can achieve sustainable economic growth that is both environmentally friendly and beneficial.

Table 1: Main Analysis: The Role of EPI in real GDPpc growth

Model	One-step GMM Model	Two-step GMM Model
GDPpcG_lag1	0.162**	0.133***
	[0.07]	[0.04]
EPI	0.050**	0.044**
	[0.026]	[0.017]
Labour	0.017**	0.014**
	[0.008]	[0.007]
Capital	0.026**	0.026***
	[0.008]	[0.002]
TOP	0.026**	0.034***
	[0.014]	[0.007]
ENVGOV	0.355**	0.344**
	[0.188]	[0.154]
ECONGOV	–0.350**	–0.400**
	[0.143]	[0.093]
Constant	–3.15**	–3.13***
	[1.575]	[1.125]
F-stat.	17041	43.10
Prob	0.000	0.000
Observations	132	132

Note: GDP is real GDP per capita growth, Capital is gross capital formation (as a percentage of GDP), Labour is the Labor force, total, EPI is environmental performance, TOP is trade openness, ENVIGOV is environmental governance, ECONGOV is economic governance. Robust Huber-White standard errors are reported in parentheses. The *p*-values, ***, **, * significant at the 1%, 5% and 10% levels, respectively.

We performed additional analysis by dividing West African countries into oil-producing WA and non-oil-producing West African countries.[11] The oil-producing economies are more likely to emit carbon emissions than the non-oil-producing economies, providing a rationale for the difference in the EPI impact on growth. As shown in Table 2, we find that environmental performance significantly increases economic growth in non-oil-producing WA countries; a 1% increase in EPI increases economic growth by 0.19 percentage points, ceteris paribus, for non-oil producing ECOWAS countries. This effect is stronger than the one found in Table 1 for the sample of all ECOWAS countries. However, we found that in oil-producing ECOWAS countries the coefficient for environmental performance is negative and not statistically significant, suggesting that higher environmental performance doesn't have a significant effect on economic growth.

The same findings apply to environmental governance.[12] Environmental governance contributes significantly to economic growth in non-oil producing ECOWAS countries; other things being equal, a 1% increase in the environmental governance index increases economic growth by 0.59 percentage points. For non-oil producing ECOWAS countries, encouraging good environmental governance may promote resource and generate higher economic growth. Meanwhile, economic governance is found have a negative and statistically significant effect at a 5% level on economic growth for both ECOWAS country sub-samples, following results in Table 1.

Trade openness appears also not statistically significant for oil-producing countries. All other control variables provide the expected sign and significance, coherent with results in Table 1.

[11] Oil producing ECOWAS countries include: Nigeria, Ghana, Cameroon, Cote d'Ivoire, and Niger. Non-oil producing ECOWAS countries include: Benin, Burkina Faso, Cameroon, Cabo Verde, Chad, Equatorial Guinea, The Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Senegal, Sierra Leone, and Togo.

[12] The oil-producing ECOWAS sub-sample is small, 5 countries with 39 observations. The low statistical significance of some of the coefficients may be due to the nature of the small sample.

Table 2: Role of EPI on real GDPpc growth – ECOWAS sub-samples

Group	Oil-production countries	Non-oil-production countries
GDPpcG_lag1	0.279***	0.200***
	[0.347]	[0.093]
EPI	–0.024	0.191**
	[0.208]	[0.093]
Labour	0.036	0.036*
	[0.0762]	[0.021]
Capital	0.038**	0.029***
	[0.0127]	[0.004]
TOP	0.023	0.051***
	[0.059]	[0.012]
ENVGOV	–6.057	0.590**
	[5.70]	[0.195]
ECONGOV	–2.906**	–0.331***
	[1.417]	[0.085]
Constant	1.201	–12.804**
	[16.61]	[5.65]
F-stat.	2.23	171.14
Prob	0.06	0.000
Obs	39	110

List of oil producing WA countries - Nigeria, Ghana, Cameroon, Cote d'Ivoire, and Niger; and non-oil producing WA countries - Benin, Burkina Faso, Cameroon, Cabo Verde, Chad, Equatorial Guinea, The Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Senegal, Sierra Leone, and Togo. Note: Robust Huber-White standard errors are reported in parentheses; the *p*-values are - ***, **, * significant at the 1%, 5% and 10% levels, respectively.

Our findings show that environmental performance affects economic growth in ECOWAS countries. Higher environmental performance indeces reflect higher real economic growth per capita. However when digging further, we find a strong positive effect of higher environmental performance on economic growth for non-oil producing ECOWAS countries. Our results may suggest that policies promoting environmental performance and economic growth necessitate to be different for oil-producing and non-oil producing countries in ECOWAS.

4.2 Diagnostic Tests

The validity of a model depends on the outcome of the diagnostic tests. We first carried out stationary tests for all our variables of interest. The results of the Fisher (1932) panel unit root tests are reported in Table A8. We also performed various diagnostic tests such as endogeneity, normality, stability, autocorrelation and heteroscedasticity. Table B5 confirms no evidence of endogeneity. The probability value for the Hansen J-statistics suggests that instruments are not over-identified, while the F-statistics also suggest the instruments are not weak. Also, indicate that the instruments are not correlated with error term. This confirms that the IVs do not pose any weak identification issues.

5 Summary and Conclusions

As important as environmental sustainability is to economic growth, this study empirically investigates the impact of environmental performance on economic growth among the ECOWAS countries, using annual data spanning from 2006 to 2018.

The study utilised a two-step GMM regression approach to address the potential endogeneity issue in growth modelling. This methodology is recognised for its robustness in handling endogeneity concerns. The primary aim of employing this regression framework was to comprehensively analyse the relationship between environmental performance and economic growth, specifically focusing on the Economic Community of West African States (ECOWAS).

Our findings reveal that higher environmental performance, proxied by the Yale's Environmental Performance Index (EPI), has a significant positive impact on economic growth in ECOWAS countries. This result intuitively implies that a sustainable environment promotes economic growth in West African countries.

When separating oil-producing from non-oil producing ECOWAS countries, we find that environmental performance is significant in explaining economic growth for non-oil-producing ECOWAS countries, and not significant in oil-producing countries.

Similar results were foung for environmental governance. Environmental governance has a statiscally significant positive effect on economic growth for the West African economy, specially for non-oil producing economies. However, economic governance is found to have a negative (non-statistcally significant) impact on economic growth for oil-producing ECOWAS countries.

These findings suggest that policies promoting higher environmental performance need to be different in nature, and differently applied in oil-producing and non-oil producing economies for ECOWAS. Non-oil-producing countries implementing robust environmental policies can foster economic growth and attract sustainable investment in the region. This can be achieved by implementing robust environmental regulations, fostering a culture of sustainable practices and technologies, and investing in environmental education and awareness.

Our findings also reveal that economic growth is persistent in ECOWAS. Additionally, capital, labour and trade openness have positive and statistically significance on determining economic growth as widely accepted.

We also found that economic governance in ECOWAS decreases economic growth in the region. This may be due to weak institutions in ECOWAS, which undermine the effective allocation of resources, distorts markets, hampers investment and discourages economic growth.

Our findings suggest that environmental governance policies rather than economic governance policies are promoting economic growth in ECOWAS. Governments must find a harmonious equilibrium between environmental protection and economic advancement to attain sustainable economic growth.

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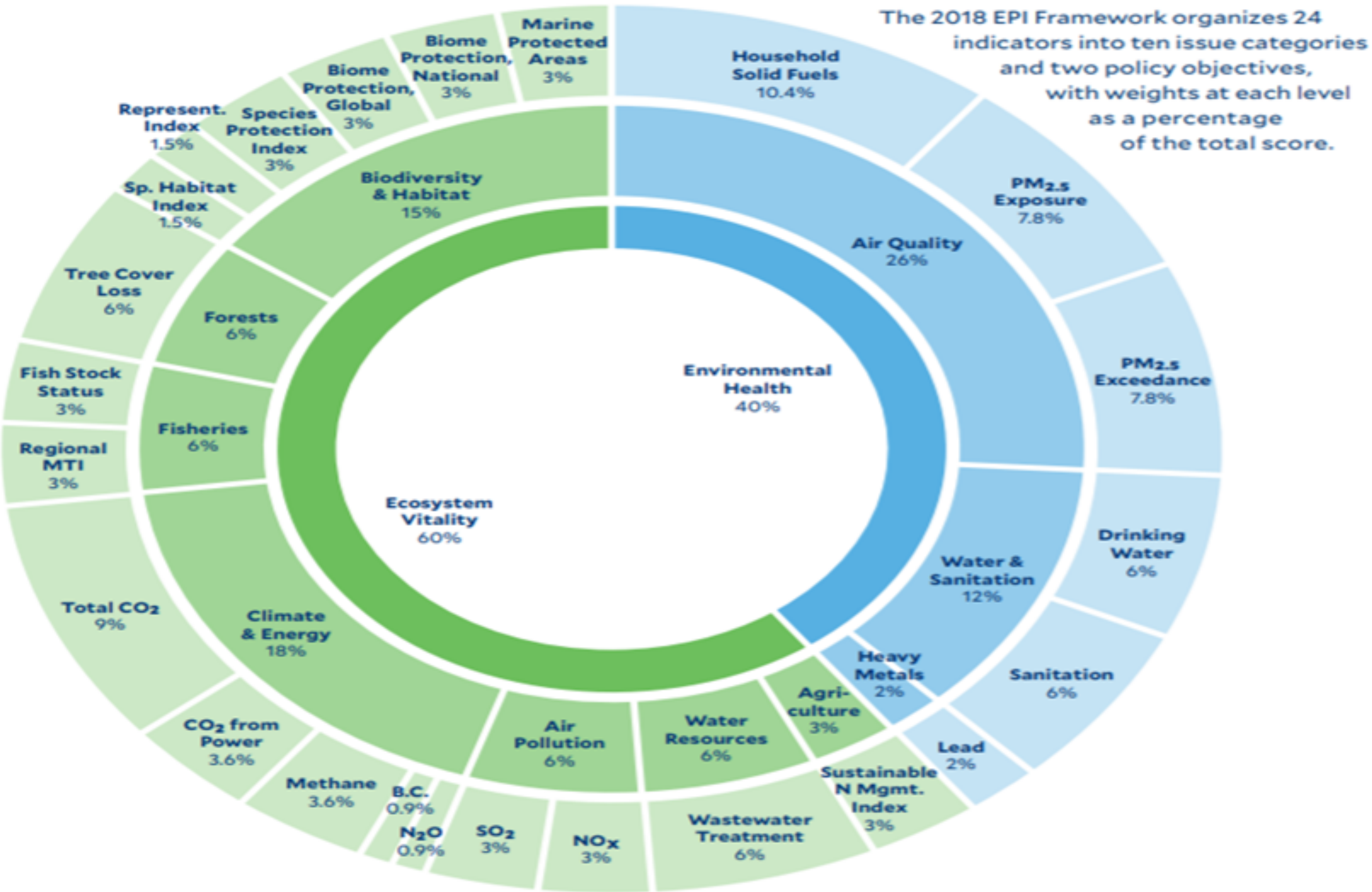
Appendices

Appendix A: Figures

The EPI was first introduced in 2000 under the name of Environmental Sustainability Index (ESI), developed by researchers at Columbia and Yale universities in (2006) in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission in response to growing environmental concerns and their future manageability.

As the need for a comprehensive quantitative measure for environmental monitoring and management was raised, the ESI was renamed in 2006 to EPI with the inclusion of additional indicators to extend the scope of ESI. The methods and underlying theory used to construct the EPI framework are comprehensively discussed alongside its potential usage, as illustrated in Figure A1.

Figure. A1: The 2018 EPI framework.



Source: https://epi.yale.edu/downloads/epi2018reportv06191901.pdf

Appendix B: Tables

Table B1: Literature on Environmental Sustainability and Economic Growth

Author(s)	Countries & Period	Methodology	Dependent Variable	Independent variables	Findings
Dinda, Coondoo, and Pal (2000)	33 countries separately for three time periods (i.e., 1979–82, 1983–86 and 1987–90)	POLS	GDP per capita	Environmental quality (measures as air quality)	Overall, air quality reduces GDP per capita
Orubu and Omotor (2011)	47 African (1990–2002)	POLS	Environmental quality (suspended particulate matter [SPM] and organic water pollutants [OWP])	GDP per capita, literacy rate	1. Per capita, GDP increases OWP and decreases SPM. 2. Literacy rate increases OWP and reduces SPM.
Mohapatra, Adamowicz and Boxall (2016)	Canada (1990–2010 [annual])	GMM estimator	GHG emissions	GDP per capita and GHG emissions	Economic growth reduces pollution
Chowdhury and Islam (2017)	5 BRICS Countries (2002–2016)	Descriptive statistical techniques	EPI	GDP growth (Y)	1. In India and China, a negative relationship between EPI and Y 2. Russia and Brazil: a positive relationship between EPI and Y 3. In the entire BRICS, found a negative relationship between EPI and Y
Uddin et al. (2017)	27 leading emitting countries (1991–2012)	Group DOLS and GM-FMOLS	Ecological footprint (EF)	Real income and trade openness	1. Ecological footprint per capita has significant long-run association with real income and trade openness. 2. Real income is found to increase EF.

					3. Openness found to reduce EF
Ozcan and Nguyen (2019)	74 countries (2002–2013)	Panel-corrected standard errors (PCSE) and feasible generalised least squares (FGLS) techniques	GDP per capita	Energy security, capital formation, trade, credit, political stability	Energy security → GDP per capita
Dogan, Ulucak, Kocak and Işik (2020)	BRICS Countries (1980–2014) annual	The FMOLS and the dynamic ordinary least squares (DOLS) estimators	Ecological footprint per capita	GDP per capita, the square of GDP per capita, energy structure, energy intensity and population growth	1. Energy structure is found to increase ecological footprint per capita. 2. Population reduces ecological footprint per capita. 3. Energy intensity is found to increase ecological footprint per capita.
Rahman (2019)	Top 10 electricity-consuming countries (1971–2013)	FMOLSs and DOLS	CO_2 emissions	Electricity consumption, economic growth and globalisation	1. Electricity consumption and economic growth are found to increase CO_2 emissions. 2. Globalisation found to decrease CO_2 emissions.
Tenaw (2022)	20 Sub-Saharan African (SSA) countries (2000–2017)	Dynamic common-correlated effects (DCCE) estimation approach	Real GDP	Share of modern renewable energy in total final energy consumption, average of mean years of schooling	1. Modern renewable energy is found to have a negative effect on economic growth. 2. Average of mean years of schooling promotes growth.
Caglar and Yavuz (2023)	EU countries (1995–2018)	CS-ARDL approach	Environmental quality (biocapacity/ecological footprint)	Environmental protection expenditure (% of GDP), economic growth (real per capita GDP, 2015 US$), renewable energy consumption (% of total energy consumption)	1. Real GDP Per capita reduces ecological footprint. 2. Renewable energy increases the ecological footprint. 3. The environmental protection expenditure on the ecological footprint is insignificant.

Note: ‘Energy Security → GDP per capita’ means the causality runs from Energy Security to GDP per capita. BRICS: Brazil, Russia, India, China and South Africa.

Table B2: Description of the Variables and Data Sources

Variable	Description	Measurement	Source
GDP	GDP per capita growth	GDP per capita (at constant 2010USD$ [annual growth])	WDI (World Bank)
K	Capital stock	Gross capital formation (percentage of GDP)	WDI (World Bank)
L	Labour stock	Labour force, total in millions	WDI (World Bank)
EPI	Environmental performance index	Environmental health plus ecosystem vitality. Index from 0 to 100.	https://epi.envirocenter.yale.edu/
TOP	Trade openness	Net trade (Exports minus imports) as a percentage of GDP	WDI (World Bank)
ENVIGOV	Environmental governance	Principal component analyses (PCA) index from coastal protection and terrestrial and marine protected areas (% of total territorial area)	Environment Social and Governance (ESG), World Bank DataBank
ECONGOV	Economic governance	This is derived using principal component analyses from rule of law, control of corruption, economic and social rights performance score, and strength of legal rights index	ESG, World Bank DataBank

Note: GDP is GDP per capita growth. Gross Capital Formation as a percentage of GDP is used as a complete capital stock in the model.

Table B3: Environmental governance index.

Principal components/correlation

Rotation:	unrotated	= principal		
Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	1.358	0.716	0.679	0.679
Comp2	.641		0.320	1.00
Number of obs	195			
Number of comp	2			

Trace	2
Rho	1.00
Predict envigov:	

Principal components (eigenvectors)			
Variable	Comp1	Comp2	Unexplained
CP	0.7071	0.7071	**0**
TMPA	0.7071	-0.7071	**0**

Note: CP Coastal protection, TMPA Terrestrial marine protected areas (% of total territorial area)

Table B4: Economic governance index.

Principal components/correlation				
Rotation:	Unrotated	= principal		
Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	2.986	2.451	0.746	0.746
Comp2	0.535	0.117	0.13	0.88
Comp3	0.41	0.35	0.10	0.98
Comp4	0.059		0.014	1.00
Number of obs	180			
Number of comp	4			
Trace	4			
Rho	1.00			
Predict econgov:				

Variable:	Comp1	Comp2	Comp3	Comp4
ROL	0.5290	-0.2157	0.5259	-0.6301
COC	0.5534	-0.1794	0.2833	0.7625
EC	0.4371	0.8863	-0.1428	-0.0556
SLRI.	-0.4722	0.3685	0.7891	0.1361

Note: ROL rule of law, COC control of corruption, ESRPS economic and social rights performance score, and SLRL strength of legal rights index. Both Control of Corruption and Voice and Accountability index scores lie between –2.5 and 2.5, with higher scores corresponding to better institutions (outcomes).

Table B5: Diagnostic Tests: Endogeneity and Instrument Validation

Tests	**Coefficient**
Ramsey RESET test (power of fitted)	2.01
Cragg-Donald (weak identification test)	1491.13
LM Test (under-identification test)	11.81
Hansen J statistic (over-identification)	5.50
Pagan – Hall (IV heteroskedasticity test)	15.594
Sargan (score) and Basman chi2 (1)	0.23/0.25
Observations	132

Note: *p*-values, ***, **, * significant at the 1%, 5% and 10% levels, respectively.

Table B6: Descriptive Statistics, Correlation Matrix and VIF from 2006 to 2018

Variable	Obs	Mean	Std. Dev.	Min	Max
$GDPpcG_{it}$	195	2.05	3.65	–22.31	18.05
L_{it}	195	7581474	1.33e+07	189912	6.49e+07
K_{it}	187	10.93	33.24	–65.82	239.83
EPI_{it}	180	48.98	8.02	25.07	64.58
TOP_{it}	195	71.09	33.63	20.72	311.35
$ENVIGOV_{it}$	195	–3.44e–09	1.17	–1.96	3.61
ECONGOVit	180	–2.38e–09	1.73	–2.49	5.36

e(V)	GDPPPG_lag1	L	K	EPI	TOP	ENVIGOV	ECONGOV
GDP_{it}	1						
L_{it}	–0.13	1					
K_{it}	–0.06	–0.01	1				
EPI_{it}	0.02	–0.03	0.41	1			
TOP_{it}	0.12	0.07	–0.07	0.04	1		
$ENVIGOV_{it}$	0.03	–0.05	0.11	–0.12	–0.29	1	
$ECONGOV_{it}$	–0.09	–0.09	0.03	0.07	0.13	–0.11	1

VIF: multicollinearity test

Variable	VIF	1/VIF
GDP_{it-1}	1.06	0.946
L_{it}	1.04	0.950
K_{it}	1.30	0.768
EPI_{it}	1.29	0.775
TOP_{it}	1.23	0.810
$ENVIGOV_{it}$	1.13	0.884
$ECONGOV_{it}$	1.07	0.934
Mean VIF	1.16	

Note: *P*-values ***, **, * significant at the 1%, 5% and 10% levels, respectively. The VIF analysis certifies that our model is not subject to any possible multicollinearity issues, given that both the largest individual VIF and the mean VIF are less than 5.

Table B7: Friedman and Pesaran Cross-Sectional Independence (CD) Tests

Test	Friedman		Pesaran abs	
CD-test	Prob.	CD-test	Prob.	Av. Abs. Value
	8.307	0.8727	1.366,	0.1719
Sample Size (N*T)	15 < 195	15 < 195	15 < 195	15 < 195

Note: *P*-values ***, **, * significant at the 1%, 5% and 10% levels, respectively.

Table A8: Panel unit root test

Fisher 1932		
Variable	Lags	chi_sq
GDP	1	159.99***
		(0.000)
Labour	1	61.21**
		(0.007)
Capital	1	56.33**
		(0.035)
EPI	1	148.7***
		(0.000)
TOP	1	58.538**
		(0.0014)
ENVGOV	1	5.307***
		(0.000)
ECONGOV	1	2.835**
		(0.002)

Note: GDP is real GDP per capita growth in percentage, Capital is gross capital formation (as a percentage of GDP), L is the Labour force, total, EPI is environmental performance, ENVIGOV is environmental governance, ECONGOV is economic governance and TOP is trade openness. are the p-values, ***, **, * significant at the 1, 5, and 10 percent levels, respectively.