Environmental Performance in the West African Economy: MM-Quantile and 2SLS Approach

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Highlights

- *Few studies explore the impact of environmental performance and economic growth globally.*
- *We examined the impact of environmental performance on West African economic growth using a novel MM quantile regression model.*
- *The relationship between economic growth and environmental performance is positive*
- *With a threshold value 48% obtained, the relationship between the EPI and economic growth returned negative at any point below the 48% level of optimal threshold.*
- *Government size, labour, and capital stock have a positive impact on West African Economic Growth, while trade openness decreases economic growth.*

[*] We thank Dr. Nguyen and Dr. Raghavan for useful comments and discussions on various versions of the paper, as well as feedback provided at the Australian Conference of Economists 2021, organised by the Economic Society of Australia. Corresponding author: hammed.musibau@utas.edu.au. Locked Bag 1317, Tasmanian School of Business and Economics, UTAS, Launceston, 7250, Tasmania, Australia; P: +61 3 6324 3659; F: +61 3 6324 3369.

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Abstract

The 2019 World Bank report on West Africa's coast indicates that over $3.8 billion is lost annually due to environmental issues, like erosion, flooding, and pollution. In this paper, the newly introduced environmental performance index (EPI) is incorporate into the neoclassical growth model to empirically address the impact of environmental performance on economic growth for the Economic Community of West African States (ECOWAS). Using the novel Method of Moments-Quantile Regression methodology and 2SLS models, the empirical investigation finds a positive relationship between environmental performance and economic growth across quantiles for ECOWAS. Empirical results provide evidence supporting bidirectional relationship running from environmental performance to economic growth; from government size to economic growth; and from trade openness to economic growth across all quantiles. Results show that environmental performance, government size, labour, and capital stock have a positive impact on West African Economic Growth, while trade openness decreases economic growth. We find a 48% optimal threshold of environmental performance index (EPI) on economic Growth for ECOWAS countries. Based on the findings, policies to encourage improved environmental performance above the threshold estimated will go a long way to enhance West African economies.

Keywords: economic growth, environmental performance, ECOWAS, Moment of Method-QR estimator

JEL classification: F43, F64, C31

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1.Introduction

The causal link between environmental quality, energy, and output growth is still debatable in the economic growth literature. Some scholars think that environmental quality and energy use indirectly harm economic growth through the additional costs they represent for firms, reducing their profit. Others argue that environmental quality and energy use encourage cost savings, increase sales, and improve economic growth. However, the divergence in scholars' opinions, alongside current extreme weather changes, global warming, and environmental degradation especially in developing African countries prompts the need for further study.

Of interest is the Economic Community of West African States (ECOWAS) in the early stage of finding a balance between economic development and the need to tackle severe environmental issues. As shown in Figure 1, ECOWAS countries experienced economic depression between 2007-2009, and then between 2014-2016. The region's desire to tackle widespread environmental degradation issues is borne from the rapid population growth it is experiencing and has led to more demand for energy and other related resources. Consequently, Africa has become one of the world's largest pollutants with extensive erosion, high population growth and poverty. As depicted in Figure 1, CO_2 emissions have increased at an increasing rate against GDP growth in ECOWAS countries. Amegah and Agyei-Mensah (2017) found that exposure to outdoor air pollution has led to 176,000 deaths and 626,000 disability-adjusted life years in Sub-Saharan Africa a year, and it is speculated that these numbers are higher in reality due to the limited data emanating from the region. The increase in death rate per year leads to loss of potential labour force in the sub-region, thus reducing the average productivity of ECOWAS residents and reducing economic growth. Zaman & Moemen (2017) argue that economic development amid environmental degradation is unachievable.

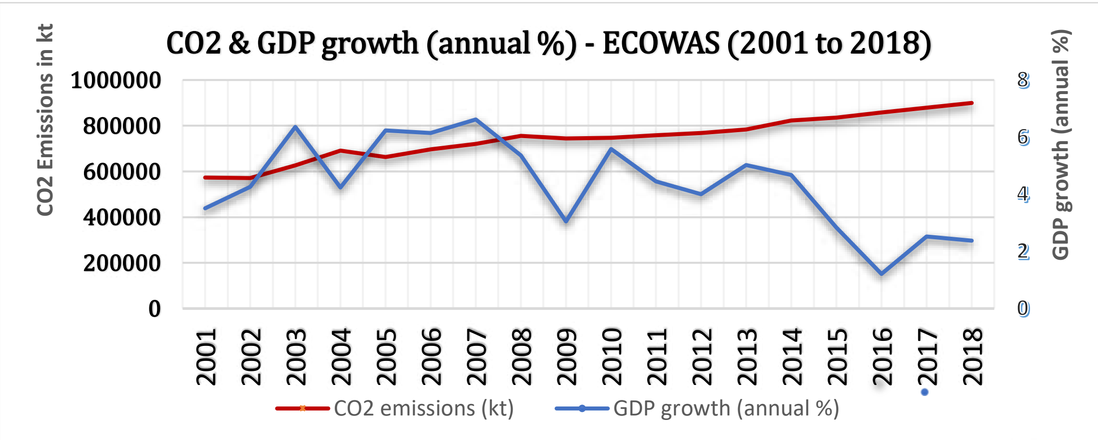

Figure 1: CO_2 emission (kt.) and GDP growth (annual %) in ECOWAS (2001-2018)

Source: World Bank (World Development Indicator 2019)

The demand for more energy as the ECOWAS population increases increased demand for generator plants, charcoal, and other alternative energy sources (Lambe et al., 2015; Hafner, Tagliapietra, & de Strasser, 2018). The International Energy Agency (2018) reports that two out of three sub-Saharan Africans (SSA) do not have access to electricity. These environmental factors can have adverse effects on the sub-regions' sustainable growth, as potential labourers are sick and dying due to environmental issues, and capital utilisation is inefficient.

Due to the growing concerns of global warming and its influence on sustainable development with regards to environmental performance, the majority of existing studies link economic growth with environmental quality using a single environmental indicator, such as CO2 emissions (Madu 2009), or energy consumption (Romero et al. 2017), or transport energy (Liddle and Lung, 2013). Al-Tuwaijri et al., (2004); Chowdhury & Islam, (2017); Ansari et al., (2019); Lee and Thiel, (2017); Halkos and Zisiadou, (2018) use the newly created index of environmental performance (EPI)[1], comprising ecological vitality and environmental health, which is more robust than other studies that employed other indexes to assess the linkage between economic growth and the environment in developing countries. These studies have introduced EPI into the neo-classical growth model to investigate the role environmental performance on economic growth. Our best of knowledge is that no comprehensive study has been conducted in ECOWAS nations on this nexus despite the sub-region's economic growth is challenged with an environmental issue.

This study's findings will contribute to the limited research on the complementarity between environmental performance index (EPI) in the neoclassical growth model in the context of ECOWAS. The study uses MM quantile regression and 2SLS methodologies to examine the causal link among capital, labour, environmental performance, and economic growth in ECOWAS. The choice of the ECOWAS sub-region as the research focus stems from the fact that it is the second most populous sub-region in Africa; this continent similarities in resources, economic integration, and environmental issues. The area is regarded as environmentally harsh and for years have been engaged in conflict in the region. Accordingly, the relationship between environmental performance on economic performance is understood poorly, which calls for a more systematic, comprehensive assessment of the issue.

The rest of the paper is organised as follows. Section 2 covers a literature review, while Section 3 describes the data and research methods. Results and discussion are presented in Section 4, and conclusions are provided in Section 5.

[1] EPI captured captures all effects of all environmental dimensions into one variable alone.

2.0 Literature Review

2.1 A Brief Review of the EPI

Environment 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 stated in EPI Report (2020) 'It is estimated using 24 indicators in ten categories. The EPI was first introduced in 2000 under a different name, the ESI. The environmental sustainability index (ESI) was initially developed by researchers at Columbia and Yale universities, collaborating with the World Economic Forum and the Joint Research Center of the European Commission to respond to growing environmental concerns and their future manageability'. The need for a comprehensive quantitative measure for environmental monitoring and management was after the mottos of "what gets measured gets done" and "if you cannot measure it, you cannot manage it." The ESI was renamed in 2006 to EPI, and the latest update of EPI is for 2018. The methods and underlying theory used to construct the EPI framework (EPI Report, 2020) are comprehensively discussed alongside its potential usage, as illustrated in Figure 2.

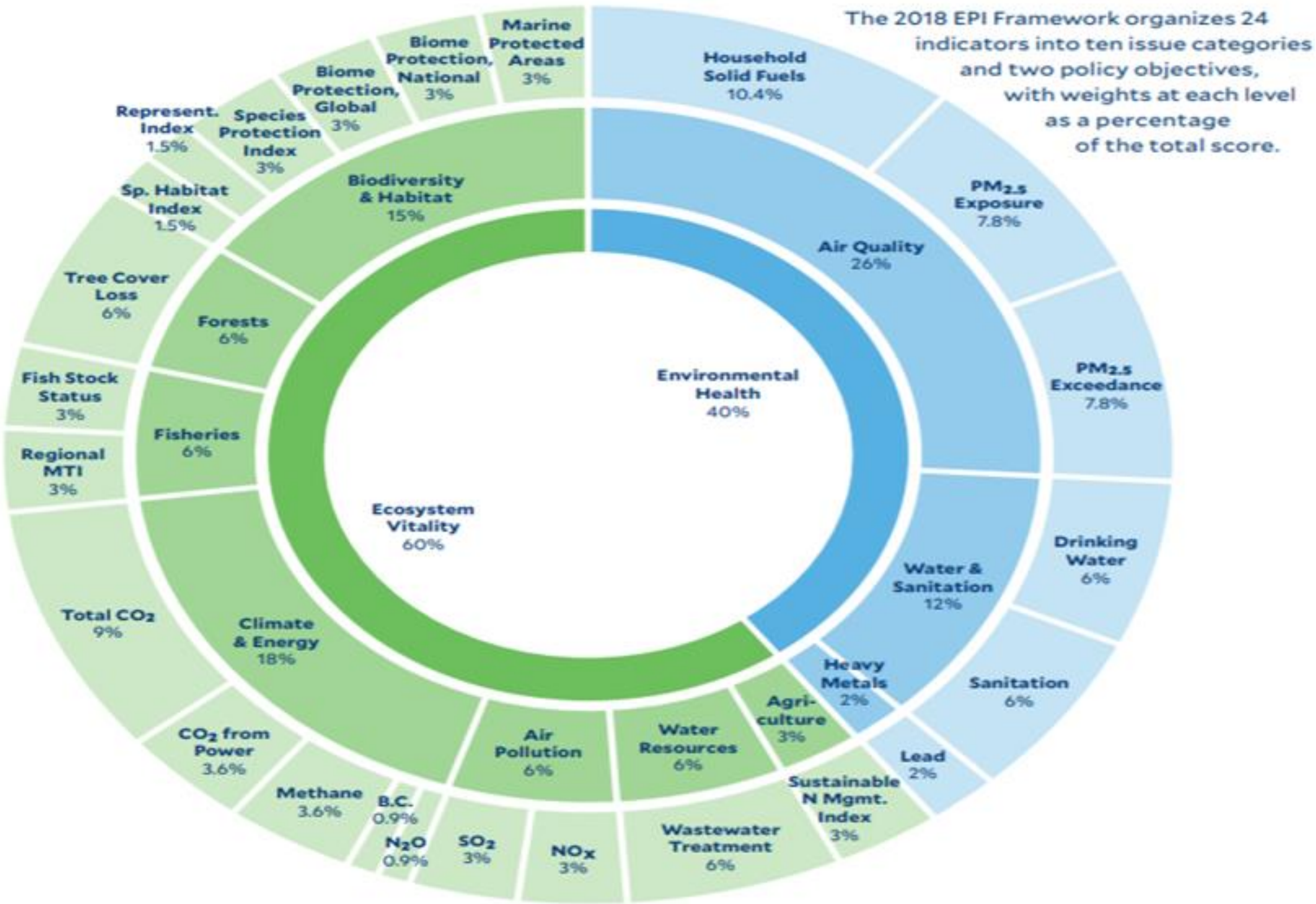

Figure. 2. The EPI 2018 framework.
Source: https://epi.envirocenter.yale

As an index, the EPI refers to measuring 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 the governments or policymakers; it also enables the comparison on a common basis. Conversely, it remains vital to comprehend the extent of disparity from the index directly ascribed to economic growth. The index was composed based on two measurement objectives: environmental health deviation due to the current environmental state, and ecosystem vitality – which includes agriculture, fisheries, habitat, biodiversity, forests, energy, etc. As shown Figure 2, it is notable that a potential "cyclical relationship" exists within the EPI design.

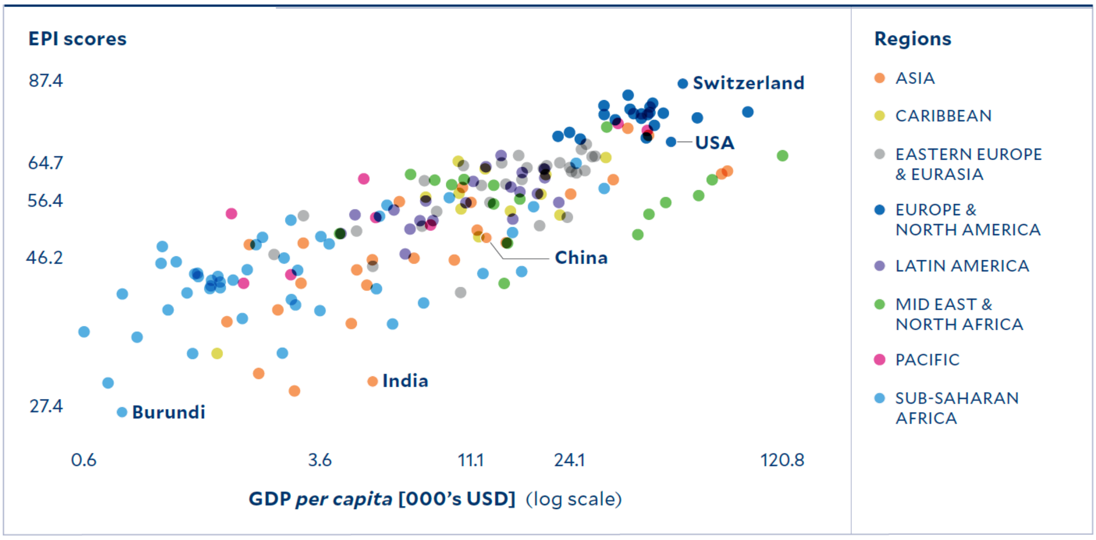

Figure 3. The relationship between 2018 EPI Scores and GDP per capita.
Source: EPI Report (2018).

The EPI Report 2018 provides a visual inspection for the relationship between EPI and economic growth, which positively correlates as depicted in Figure 3. Developing countries, particularly in sub-Saharan Africa, score lower than any other regions, occupying 30 of the bottom 40 positions (Wendling et al., 2018). Investments in clean water, sanitation, and energy infrastructure could help these countries significantly boost their scores. This supports the United Nations (2019) reporting that Africans are living on less than a dollar a day, with a huge number of people living in the slums, often without access to basic health facilities, electricity accessibility, and the region is expected to double its population due to low levels of education and poor family planning, putting even more pressure on the limited resource. African countries score poorly in the 2018 EPI, for instance, Benin (38.17), Burkina Faso (42.83), Cabo Verde (45.25), Cote d'Ivoire (45.25), The Gambia (42.42), Ghana (49.66), Guinea (49.66), Guinea-Bissau (44.67), Liberia (41.62), Mali (43.68), Niger (35.74), Senegal (49.52), Sierra Leone (42.54), and Togo (41.78) (Wendling et al., 2018). Figure 4 below illustrates the differences in EPI between ECOWAS and developed economies. The developed economy has higher EPI scores than ECOWAS. Low EPI scores in West African countries show the need for national sustainability efforts, especially on-air quality, protecting biodiversity, and reducing greenhouse gas emissions. Given these facts, we develop an econometric model to verify whether improved environmental performance would boost economic growth in developing economies like ECOWAS countries.

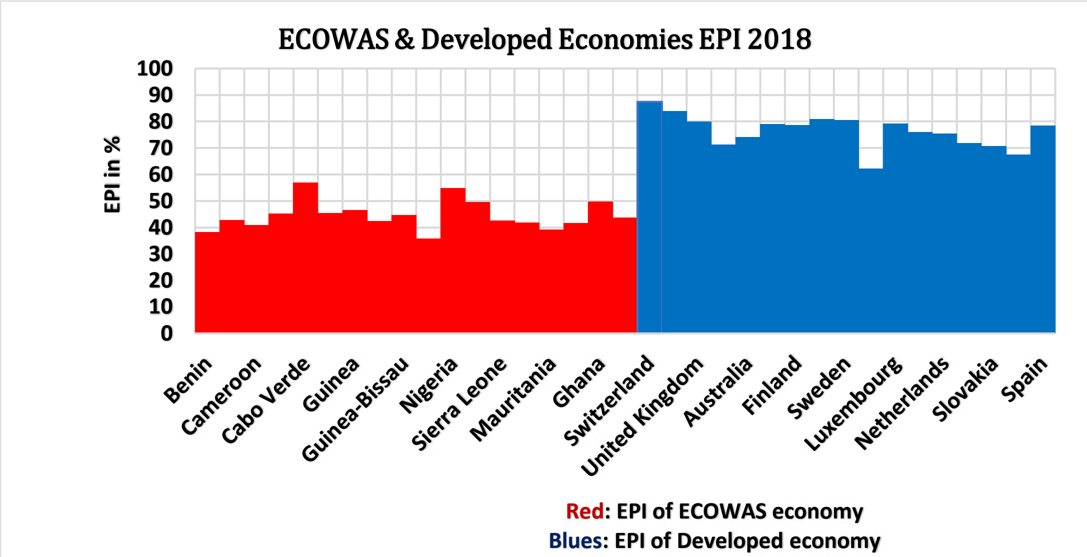

Figure.4: 2018 EPI for Developed Economies and ECOWAS
Source: https://epi.envirocenter.yale

2.2 Theoretical Framework

The augmented classical growth theory recognised that 'factors of production' and energy contribute to sustainable economic growth. However, the theory assumes that they contribute a little to growth because their national accounts' components are small. Economic theory submits that natural resources and their appreciation are salient factors of production. This is because; its abundance declines the costs of energy, thus induce substitution of machine-labour. This long-term substitution has been a key driver of economic growth (Mankiw, Romer, &Weil, 1992). A limited but growing number of studies recently in African (MENA), ECOWAS, and Sub-Sahara regions look at the relationship between labour, capital, and growth and produce mixed results (Agbloyor, Abor, Adjasi, & Yawson, 2014; Akinlo, 2004; Gui-Diby, 2014; Ogundari & Awokuse, 2018; Shittu, Yusuf, El Houssein, & Hassan, 2020; Wolde-Rufael, 2009). Studies like -- Gui-Diby (2014) and Wolde-Rufael (2009) suggest that labour and capital promote economic growth in Africa. However, Agbloyor, Abor, Adjasi, and Yawson (2014) and Shittu, Yusuf, El Houssein, and Hassan (2020) found that physical and human capital exhibit a negative relationship with economic growth.

The pioneering work of Freedman and Jaggi (1992) examined the long-term relationship between the percentage change in three pollution measures and various accounting ratios as empirical proxies for environmental performance and economic performance, respectively. Other work -- Cherniwchan

(2012), Fang and Chen (2017); Li and Li (2020); Lee and Yue (2017); Ozturk (2019) -- measured environmental performance using CO2 emissions. Grimaccia and Naccarato (2019), Nepal and Paija (2019), and Le and Nguyen (2019) measure environmental performance in terms of energy security. Dogan et. al. (2020) measure environmental performance using Ecological Footprint Per Capita. Chen et al. (2020) used renewable and non-renewable energy to measure environmental qualities. Baek and Kim (2013) used electricity consumption and nuclear energy, while Li and Li (2020) used energy Investment, and Nguyen et. al. (2020) used energy intensity. Other research measured environmental performance using proxies of environmental health such as air quality, water sanitation, land, etc.; see (Charfeddine, Al-Malk, & Al Korbi, 2018; Orubu & Omotor, 2011; Qu & Long, 2018; Song, Wang, & Wu, 2018; Sun, Luo, & Li, 2018). However, these studies are of mixed opinions regarding the interconnectivity between environmental performance and economic growth. Table 1 and Table 2 summarize the mixed empirical evidence on sustainable environment and output, and EPI and economic growth nexus.

Table 1
Literature for Environmental sustainability and Economic Growth

Author(s)	Countries	Period	Methodology	Dependent Variable	Other Variable	Findings
Al-Tuwaijri, Christensen, and Hughes Ii (2004)	USA	Compustat, data for year 1994 US "Standard & Poors 500" and 198 firms.	Structural Simultaneous equation model (2sls and 3sls).	Environmental Disclosure, EPI	Production Efficiency MARGIN Economic Profitability	1. Economic P + EPI 2. Economic P - Environmenta Disclosure 3. MARGIN +
Cherniwchan (2012)	157 countries	1970–2000	Two-sector model of neoclassical growth/A Least Squares with Dummy Variables (LSDV) estimator.	Emissions Per Capita	Industry's Share of Total Output	Industry's Shar Output + Emis Capita.
Baek and Kim (2013)	Korea	1. Nuclear Power 1971–2007 2. Others 1978–2007	Autoregressive distributed lag (ARDL) approach	Environmental Quality	Electricity Production, Energy Consumption, Nuclear Energy and Economic Growth	1. Econo + Environme Quality 2. Nuclea Environment 3. Electri Production ar Consumption Environment
Le (2016)	15 sub-Saharan African	1983–2010 (annual)	Panel cointegration test by Westerlund	EC, GDP	K, trade openness, financial	Middle-incor countries: GI

	Countries	3.	(2007) and panel-based ECM Granger causality		development	low-income c EC →GDP (S
Mohapatra, Adamowicz, and Boxall (2016)	Canada	1990–2010 (annual)	Generalized Method of Moments (GMM) estimator	GHG emissions	GDP per capita and GHG emissions	Economic Gro reducing pollu
Chowdhury and Islam (2017)	5 BRICS Countries	2002-2016	2SLS and 3SLS Models	EPI	GDPg, and EPI	1. Brazil: EPI, Russia:Y EPI,India:Y - China:Y +ive SA:Y +ive E
Lee and Yue (2017)	USA	1989–2015 Quarterly Country-Level Data	Structural Vector Autoregression (SVAR) model.	Real GDP and CO_2 Emissions.	Petroleum Consumption, Net Imports	2. Petrole Consumption emissions. 3. Net Im CO_2 emissio 4. Petrole Consumption growth 5. Net Im GDP growth
Chen and Fang (2018)	Chinese cities	2003–2012 (annual)	Bootstrap panel Granger non-causality test by Dumitrescu and Hurlin (2012)	Electricity, GDP	K, human capital	Central and we China: GDP → Electr Eastern China: 6. GDP⇐
Le and Nguyen (2019)	74 countries	2002-2013	Panel-Corrected Standard Errors (PCSE) and Feasible Generalized Least Squares (FGLS) techniques	GDPpc, ES	Capital Formation(L), Trade, Credit, Political Stability	7. ES →
Nepal and Paija (2019)	South Asia	1975-2014	ARDL bounds test/cointegration/Toda-Yamamoto Granger causality	GDP, Electricity consumption, Energy Security	Population, K(capital)	1.No link Elec consumption & 2.Energy Secu →Climate Cha growth
Chen et al. (2020)	103 countries	1995 to 2015	Threshold model	GDP	K, L, REC, NREC	All REC Y, N 2. OECD REC NREC ≠ Y, 3. OECD REC +i NREC ≠ Y, 4. REC ≠ Y, NR

						5.Dping Cs: R NREC ≠ Y
Dogan, Ulucak, Kocak, and Isik (2020)	BRICST Countries	(1980–2014) annual	The fully modified ordinary least squares (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	Energy Structu Population (-) Intensity (+) Policy Suggest technological p mitigate emissi Limitation: ene efficiency, and technologies.
Li and Li (2020)	China	2001 - 2016	Spatial Durbin model	Total Carbon Emissions	Consumption of Fuel, Standard Coal Coefficient, The Low Calorific Value Coefficient, Carbon Emission Coefficient and The Oxidation Rate of the Fuel.	Energy Investr Economic Gro Total Carbon E
Nguyen, Pham, and Tram (2020)	G-20 countries	2000 - 2014	Fully Modified OLS, Fixed Effects and Quantile Panel Regression	Carbon dioxide emissions	FDI, Trade Openness, GDPPC, Imported ICT goods, Exported ICT goods, Gross domestic spending on R&D (% GDP), and Energy intensity level of primary energy.	1.Economic Gr Information an Communicatio Technological Financial Deve (Increase)Envi degradation. 2. Energy Price Direct Investm Technology, S Innovation and Openness -(De Environmental degradation.

Note: GDP→EC means that the causality runs from growth to electricity consumption. ELEC→GDP means that the causality runs from electricity consumption to growth. ELEC↔GDP means that bi-directional causality exists between electricity consumption and growth. GDP+EC mean positive relationship and GDP-EC mean negative relationship.

2.4 Other empirical studies on environment and quantile on quantile technique

The causal relationship between environmental impact and economic growth has been extensively studied using different methodologies ranging from traditional estimation techniques like Ordinary least-squares (OLS), fixed and random effects, Fully Modified OLS (FMOLS), Dynamic OLS (DOLS), Canonical Cointegrating Regression (CCR), and Panel Auto-Regressive Distributed Lag (Panel ARDL) to mention a few. However, there is scant research on quantile-quantile techniques. Quantile regressions estimate a collection of numerous response variables and conditional median, which are subject to a particular value of the independent variables. The estimates from quantile regression are superior to those of normal regressions, particularly the minimum square type, as they produce outcomes of the conditional mean for the dependent variable subjected to values of other exogenous variables.

3. Methodology

3.1. Specification of the econometric model

The Solow-Swan Neo-Classical growth model introduced in 1956 explains long-run economic performance through a non-linear relationship between stock of capital, labour and technological progress between countries using a production function with constant returns to scale. The Solow-Swan growth model introduced labour as a production factor into the Harrod-Domar 1946 original model. They concluded that output can be produced using two factors of production, capital (K) and labour (L), and stated that the substitution elasticity must be asymptotically equal to one. Incorporating the environmental dimension to the neo-classical model, we follow Greiner (2004a), and specify the aggregate the production function as follows:

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

Where Y_{it} is total output, H_{it} is the stock of knowledge (human capital) i.e. aggregate investment's by-product, while L_{it} is labour input, and K_{it} is aggregate capital stock, t is the time-variant; $\alpha_1, \alpha_2, \alpha_3$ represent the elasticity of growth in relation to capital, human capital, labour, environmental factor and $\alpha_1 + \alpha_2, + \alpha_3 = 1$. E_{it} is the damage function incorporating the damage from the environment (industrial pressure). The effective units of labour stock are AL_{it}, and (e) is the error term. A_{it} represents a Hicks-neutral technological progress; the as an increasing variable, A_{it}, in $A_{it}\, F(K_{it}, H_{it}, L_{it}, E_{it})$. Note that, the total factor productivity A_{it} for each economic sector changes over time (t) at a constant rate i.e. $A_{it+1} = \left(1 + g_{A_i}\right) A_{it}$, for $i = 1, 2, \ldots\ldots n$.

This study creates a modified version of the Solow-Swam model by including environmental variable E, in a single model to estimate the role of environmental performance on economic Growth in ECOWAS member countries. We use data spanning from 2006 to 2018 to examine the link between environmental performance and economic growth for ECOWAS. A Method of Moments-Quantile Regression (MM-QR) is used for a long-term series where there is bidirectional causality between the environment and economic growth. A Cobb-Douglas production function type model is specified as follows.

$$Y_{it} = K_{it}{}^{\alpha} E_{it}{}^{\beta} (A_{it} L_{it})^{1-\alpha-\beta} \quad (2)$$

Where $E(t)$ is EPI. Simon, Smith & Kuznets (1971) hints that transition towards any sustainable growth path has environmental quality at first worsening with economic growth and then improving as we approach the balanced growth path. Transforming the model to a linear function with the inclusion of control variables derives our aggregate EPI model in Eq.3 and Eq.4 for the disaggregate model where EPI are disaggregated into Health Impact, Air Quality, Water & Sanitation, Biodiversity & Habitat, Forestry, Fisheries, Water Resources, Agriculture and, Climate & Energy.

$$InGDPG_{it} = \rho_0 + \rho_1 InK_{it} + \rho_2 InL_{it} + \rho_3 InEPI_{it} + \rho_4 SIZE_{it} + \rho_5 TOP_{it} + \varepsilon_{it} \quad (3)$$

$$InGDPG_{it} = \varphi_0 + \varphi_1 InK_{it} + \varphi_2 InL_{it} + \varphi_3 InQuaAir_{it} + \varphi_5 InWaterSan_{it} + \varphi_6 InBioDivHab_{it} + \varphi_7 InForestry_{it} + \varphi_8 InFisheries_{it} + \varphi_9 InWaterRes_{it} + \varphi_{10} InAgric_{it} + \varphi_{11} InClim \,\&\, Energy_{it} + \varphi_{12} SIZE_{it} + \varphi_{13} TOP_{it} + \varepsilon_{it} \quad (4)$$

GDPG is the GDP 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 (Human capital index) in country *i* at time t, EPI is environmental performance index in country *i* at time t. EPI is disaggregated into: Air Quality, the environmental risk exposure in term of air pollution to human health in country *i* at time t; Water and sanitation, the exposure to unsafe sanitation and unsafe water quality in country *i* at time t; Biodiversity and habitant, the average area of terrestrial biome area and species - bird, mammals, and amphibians - distributions in a country under protection in country *i* at time t; Forestry, the tree coverage loss in country *i* at time t; Fisheries, the percentage of fishing stocks overexploited and collapsed in country *i* at time t; Water Resource, the wastewater treatment level weighted by connection to wastewater treatment rate in country *i* at time t; Agriculture, the ratio of nitrogen inputs-to-outputs in country i at time t; Climate & Energy, performance in change in CO2 emissions per unit of GDP and percent of population with access to electricity in country *i* at time t. SIZE is the size of government(Government final consumption expenditure as a % of GDP) in country *i* at time t, and TOP is the trade openness (Net Trade as % of GDP) in country *i* at time t. The data for variables obtained from various sources is presented in Table 4.

Table 4: Description of the variables and data source

Variable	**Description**	**Measurement**	**Expected sign**	**Source**
GDPG	GDG Growth	GDP growth (annual %)		WDI(WorldBank)

K	Capital Stock	Gross Capital formation & Gross Capital formation percentage of GDP	+	WDI(WorldBank)
L	Labour Stock	Human capital index, based on years of schooling and returns to education	+	PennWorldTableVersion9.1
EPI	Environmental Performance Index	Environmental Health plus Ecosystem vitality.	+/-	https://epi.envirocenter.yale.edu/
QuaAir	Air Quality	Provision against environmental risk exposure in term of air pollution to human health in a country	+	https://epi.envirocenter.yale.edu/
WaterSan	Water and sanitation	Access to good sanitation and safe and drinkable water quality	+	https://epi.envirocenter.yale.edu/
BioDivHab	Biodiversity and habitant	The average area of terrestrial biome area and species - bird, mammals, and amphibians - distributions in a country under protection	+/-	https://epi.envirocenter.yale.edu/
Forest	Forest	The percent of tree cover loss in a country	+/-	https://epi.envirocenter.yale.edu/
Fisheries	Fish stocks	The Percentage of fishing stocks overexploited and collapsed	+/-	https://epi.envirocenter.yale.edu/
WaterRes	Water Resource	The wastewater treatment level weighted by connection to wastewater treatment rate in a country	+/-	https://epi.envirocenter.yale.edu/
Agric	Agriculture	The ratio of nitrogen inputs to outputs in a country	+/-	https://epi.envirocenter.yale.edu/
Clim&Energy	Climate & Energy	The performance in Change in CO2 emissions per unit GDP and percent of population with access to electricity in a country	+/-	https://epi.envirocenter.yale.edu/
SIZE	Size of Government	Government final consumption expenditure as a percentage of GDP	-	WGI(WorldBank)
TOP	Trade Openness	Net trade (Exports minus imports) as apercentage of GDP)	+	WDI(WorldBank)

[i] Note: *Gross Capital Formation as a percentage of GDP is used as a complete capital stock in the model.*

In the empirical literature, mixed results have been reported on the estimated coefficients for capital, labour, and environmental performance index. Therefore, the following hypotheses are tested:

H_1: There is a relationship between the environmental performance index and economic growth.

H_2: There is a relationship between the disaggregated components of environmental performance and economic growth.

3.2. Estimation techniques

In the existing literature, OLS, fixed and random effect, FMOLS, and Dynamics Ordinary Least Squares (DOLS) models are usually employed for panel data. However, these methodologies do not allow economic growth determinants to classify the conditional heterogeneous covariance effects by allowing for the influence of the individual effects on the whole distribution instead of simply changing means, based on Arias, Hallock, and Sosa-Escudero (2002) and Arellano and Bonhomme (2016). To address these issues, we use the " method of moments Quantile Regression" (MM-QR) by Machado and Santos Silva (2019), allowing for fixed effects. MM-QR approach is specifically applicable in situations where individual effects are embedded in the panel data setting. MM-QR approach is instinctive as well due to its ability to offer regression quantile non-crossing estimates. For a location-scale variant model, the equation follows this form to estimate the conditional quantiles $Q_Y(\tau \mid X)$:

$$Y_{it} = \alpha_i + X_{it}'\beta + (\delta_i + Z_{it}'\gamma)U_{it} \tag{5}$$

whereby probability, $P\{\delta_i + Z_{it}'\gamma > 0\} = 1.(\alpha, \beta', \delta, \gamma')'$ constitute the parameters for estimation. $(\alpha_i, \delta_i), i = 1, \ldots\ldots, n$ describes individual i fixed effects as Z is a k-vector of identified components of X which are differentiable transformations with the element that represents the differentiable transformations and the element l is given as

$$Z_i = Z_i(X), l = 1, \ldots\ldots, k \tag{6}$$

For any fixed effect, X_{it} is identically and independently distributed and is independent across time (t). U_{it} is identically and independently distributed over individuals (i) across time (t) and are orthogonal to X_{it} and normalized based on Machado and Silva (2019) to satisfy the moment conditions, indicating strict exogeneity. Then, Eq. (5) is further specified as follows;

$$Q_Y(\tau \mid X_{it}) = \alpha_i + \delta_i q(\tau)) + X_{it}'\beta + Z_{it}'\gamma q(\tau) \tag{7}$$

From Eq. (4), X_{it} signifies the vector of exogenous variables, which are the capital stock (K), labour stock (L), environmental performance index (EPI), size of government (SIZE), and trade openness (TOP). $Q_Y(\tau \mid X_{it}$ is the quantile distribution for $\mathrm{GDPG_{it}}$ and it is restricted based on the location of an exogenous variable. $X_{it}.\ \alpha_i + \delta_i q(\tau)$ represents the scalar coefficient indicating the symptomatic feature of quantile-τ fixed effect for individual cross-section i. Unlike the normal OLS-fixed effects that stand for an intercept shift, the individual effect of MM-QR is not implying an intercept shift. The individual effect is never changing as it is a time-invariant factor having heterogeneous impacts that differ across quantiles for the conditional distribution of the dependent variable (γ). $q(\tau)$ is the τ-th (i.e., sample quantile).

Using MM quantile regression allows for empirical insights provided into the distributional heterogeneity across the panel by incorporating fixed effects. Thus, the approach provides a heterogeneous relationship between the variables in different conditional quantiles of economic growth, which conventional regressions may not address. Moreover, examining the role of environmental performance in the West African economy at diverse quantiles is of interest for several reasons. First, the conditional quantiles' estimations are more robust and efficient to outliers from the dependent variable than traditional mean regression which is prone to outliers' distorting effects; ECOWAS has a large proportion of the population in poverty and with low income. Second, the conditional mean estimators failed to depict the entire distributional effect of environmental performance on economic growth on previous work. Quantile regression segregates the independent variables' distributional influence across a spectrum of different quantiles on the dependent variable. This makes it simpler for people to define the "heterogeneous effects of heterogeneous cross-sections". Hence, conditional quantile estimates encompass detailed data, which seems not to be possible using conditional mean estimates. The MM-QR model enables possible asymmetries under various gradations in the response of GDP growth to increases or decreases in environmental performance.

3.4 Panel Granger causality test

The application of granger causality test allows us to seek the direction of causality between the capital stock, labour stock, environmental performance, government size, trade openness and economic growth in West Africa. This approach has a desirable advantage as it allows for a separate analysis of short-run causality Nepal and Paija (2019). The estimation model can be explained as per the following:

$$\begin{bmatrix} \Delta GDPG_{i,t} \\ \Delta K_{i,t} \\ \Delta L_{i,t} \\ \Delta EPI_{i,t} \\ \Delta SIZE_{i,t} \\ \Delta TOP_{i,t} \end{bmatrix} = \sum_i \sum_t \left(\begin{bmatrix} \varphi_{i,t} \\ \varphi_{i,t} \\ \varphi_{i,t} \\ \varphi_{i,t} \\ \varphi_{i,t} \\ \varphi_{i,t} \end{bmatrix} + \begin{bmatrix} \rho_{11_{i,t}} & \rho_{12_{i,t}} & \rho_{13_{i,t}} & \rho_{14_{i,t}} \\ \rho_{21_{i,t}} & \rho_{22_{i,t}} & \rho_{23_{i,t}} & \rho_{24_{i,t}} \\ \rho_{31_{i,t}} & \rho_{32_{i,t}} & \rho_{33_{i,t}} & \rho_{34_{i,t}} \\ \rho_{41_{i,t}} & \rho_{42_{i,t}} & \rho_{43_{i,t}} & \rho_{44_{i,t}} \\ \rho_{51_{i,t}} & \rho_{52_{i,t}} & \rho_{53_{i,t}} & \rho_{54_{i,t}} \\ \rho_{61_{i,t}} & \rho_{62_{i,t}} & \rho_{63_{i,t}} & \rho_{64_{i,t}} \end{bmatrix} \begin{bmatrix} \Delta GDPG_{i,t-1} \\ \Delta K_{i,t-1} \\ \Delta L_{i,t-1} \\ \Delta EPI_{i,t-1} \\ \Delta SIZE_{i,t-1} \\ \Delta TOP_{i,t-1} \end{bmatrix} + \begin{bmatrix} \mu_{i,t} \\ \mu_{i,t} \\ \mu_{i,t} \\ \mu_{i,t} \\ \mu_{i,t} \\ \mu_{i,t} \end{bmatrix} \right) \quad (8)$$

where, *GDPG* represents *GDG* growth in country *i* at time *t*, *K* is the capital stock in country *i* at time *t*, *L* is the capital stock in country *i* at time *t*, *EPI* is the environmental performance index in country *i* at time *t*, *SIZE* is government size in country *i* at time *t*, *TOP* is trade openness in country *i* at time *t*, and μ is the error term. The null hypothesis assumes that $x_{i,t}$ does not granger cause $y_{i,t}$ which can be expressed as $\rho_{i,t} = 0$. However, the significance of coefficient is derived from Wald test statistics.

4. Empirical Findings

Table 5 presents the summary statistics for the data. The correlation coefficient among the variables is low, which suggests low multicollinearity among the variables.

Table 5
Descriptive statistics, and correlation Matrix.

Variable	Obs	Mean	Std. Dev.	Min	Max
GDPg	195	4.77	3.71	-20.5	20.7
L	132	1.580462	0.322729	1.12645	2.46482
K	187	10.93172	33.24039	-65.8272	239.83
EPI	180	48.01978	8.017424	25.7	64.58
Size	176	13.9303	5.427263	0.911235	25.1583
Top	195	71.08738	33.63296	20.7225	311.354

Pair-wise correlation	L	K	Epi	Size	top
L	1				
K	0.01	1			
EPI	0.52	-0.14	1		
Size	0.04	0.07	-0.09	1	
Top	0.28	0.14	-0.23	0.25	1

Note: GDPG is GDP Growth in percentage, Capital stock (Gross Capital Formation as a percentage of GDP) L is the labour Stock, EPI is environmental performance, SIZE is government size, and TOP is trade openness. Figure in [.] are the p-values, *,**,*** Significant at the 1, 5, and 10 percent levels, respectively.

We perform cross sections dependency tests. The first-generation unit root test may not be sufficient to determine the degree of integration of the variables Additionally, among the ECOWAS countries, some members, like Nigeria, Ghana, Guinea, and Senegal have more robust economies than other members, leading to interdependence among the economies; that is, other ECOWAS member-nations may depend on these countries. Considering this, the study presents the average correlation coefficients and cross-dependence (CD) tests (Friedman (1937) and Pesaran's (2015)) in Table 6. The probabilities of CD tests are not significant, showing no evidence of cross-dependence among economic regions.

Table 6
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	0.283
Sample Size (N*T)	15 < 195	15 < 195	15 < 195	15 < 195	15 < 195

Note: GDPG is GDP Growth in percentage, Capital stock (Gross Capital Formation as a percentage of GDP) L is the labour Stock, EPI is environmental performance, SIZE is government size, and TOP is trade openness. Figure in [.] are the p-values, *, **, *** Significant at the 1, 5, and 10 percent levels, respectively.

The MM-QR estimation results are presented following Eq. (7). Table 7 presents the empirical results of the aggregate model, the impact of EPI on economic growth, comparing MM-QR results with other estimation models. The disaggregated EPI model is presented in Table 8. The last row 9 in both Tables presents our threshold estimates.

Table 7
Results of MM Quantile Regression Model (MM-QR) for Aggregate Model

Quantiles (τ)	**Location**	**OLS Without Cluster**	**With Cluster**	**2SLS**	**MMQ25**	**MMQ50**	**MMQ75**
$\rho_*(\tau)$	1.940	1.940	1.940	3.568	-1.893	2.226	5.530*
	[2.176]	[2.050]	[3.220]	[2.432]	[2.599]	[2.230]	[2.325]
$B_L(\tau)$	1.015	0.014	1.015	0.555	0.750	1.035	1.264
	[1.061]	[0.033]	[1.307]	[1.217]	[1.262]	[1.057]	[1.134]
$B_K(\tau)$	0.014	1.015	0.014	0.007	0.037	0.012	-0.008
	[0.029]	[1.091]	[0.047]	[0.035]	[0.035]	[0.029]	[0.031]
$B_{EPI}(\tau)$	0.016	0.016	0.016	0.007	0.042	0.014	-0.008
	[0.036]	[0.039]	[0.042]	[0.045]	[0.043]	[0.036]	[0.039]
$B_{SIZE}(\tau)$	0.054	0.054	0.054	0.046	0.101	0.05	0.009
	[0.054]	[0.051]	[0.066]	[0.056]	[0.064]	[0.054]	[0.057]
$B_{TOP}(\tau)$	-0.010	-0.010	-0.010	-0.011	-0.014	-0.01	-0.007
	1.940	[0.008]	[0.010]	[0.009]	[0.013]	[0.011]	[0.011]
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Threshold							
Thres-α	-2.404						
Turning Point	48.27(0.035)						

Note: $\rho_*(\tau)$ is the lag of GDP growth, GDPG is GDP Growth in percentage, Capital stock (Gross Capital Formation as a percentage of GDP), **$B_K(\tau)$** is Capital Stock, **$B_L(\tau)$** is the Labour Stock, **$B_{EPI}(\tau)$** is environmental performance, **$B_{SIZE}(\tau)$** is government size, and **$B_{TOP}(\tau)$** is trade openness. Figure in [.] are the p-values, *, **, *** Significant at the 1, 5, and 10 percent levels, respectively.

Table 8
Results of MM Quantile Regression Model for Disaggregate EPI

Quantiles (τ)	**Location**	**OLS Without Cluster**	**With Cluster**	**2SLS**	**MMQ25**	**MMQ50**	**MMQ75**
$\rho_*(\tau)$	8.276	8.276	8.276	6.264	6.606	8.249	9.87
	[6.077]	[6.724]	[8.650]	[8.294]	[7.442]	[6.092]	[6.229]
$B_L(\tau)$	0.030	0.03	0.03	0.024	0.05	0.03	0.011
	[0.052]	[0.058]	[0.054]	[0.061]	[0.064]	[0.052]	[0.053]

$B_{K}(\tau)$	0.882 [2.074]	0.882 [2.321]	0.882 [2.672]	1.507 [2.925]	1.229 [2.537]	0.888 [2.078]	0.552 [2.126]
$B_{QualityAir}(\tau)$	-0.013 [0.027]	-0.013 [0.045]	-0.013 [0.010]	-0.012 [0.047]	-0.046 [0.035]	-0.013 [0.028]	0.019 [0.028]
$B_{Water San}(\tau)$	-0.124 [0.065]	-0.124 [0.069]	-0.124 [0.076]	-0.115 [0.072]	-0.12 [0.079]	-0.124 [0.065]	-0.128 [0.066]
$B_{WaterRes}(\tau)$	0.052 [0.031]	0.052 [0.033]	0.052 [0.033]	0.056 [0.036]	0.059 [0.038]	0.052 [0.031]	0.045 [0.032]
$B_{BioDiv}(\tau)$	-0.082* [0.036]	-0.082* [0.038]	-0.082* [0.039]	-0.078 [0.044]	-0.07 [0.044]	-0.081* [0.036]	-0.093* [0.037]
$B_{Agric}(\tau)$	0.057 [0.029]	0.057 [0.034]	0.057 [0.047]	0.057 [0.035]	0.055 [0.036]	0.057 [0.030]	0.059* [0.030]
$B_{Forests}(\tau)$	.00015 [00019]	.0002 [.00023]	.0002 [.00016]	.00021 [.0003]	0.007 .00013 [0.045] [.0002]	. 00029 00016]	0.014 .0030 [0.036] [.0015]
$B_{Fisheries}(\tau)$	-.00027 [.0003]	-.00032 [.0003]	-.0003 [.0003]	-0.003 [0.540] [.0001]	0.007 -.0002 [0.045] [.0004]	.00023 [.0003]	0.0003 0.014 . 00027 [0.036]
$B_{Clim.Eng}(\tau)$	-0.002 [0.032]	-0.002 [0.037]	-0.002 [0.025]	0.003 [0.039]	0.040 -.0011 [0.094] [.0010]	-0.002 [0.032]	0.007 [0.033]
$B_{SIZE}(\tau)$	0.043 [0.083]	0.043 [0.084]	0.043 [0.092]	0.038 [0.091]	0.054 [0.102]	0.043 [0.084]	0.033 [0.085]
$B_{TOP}(\tau)$	8.276 [6.077]	-0.012 [0.012]	-0.012 [0.008]	-0.011 [0.013]	-0.011 [0.015]	-0.012 [0.013]	-0.013 [0.013]
Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Threshold

Thres-α	-2.404	
GMM C statistic chi2(1)		-129.97
Prob.		1.000
Wald chi2(4)		2.40
Prob > chi2		0.663
Residual Diagnostics		
F-Statistics		2.8893(0.000)
Breusch-Pagan / Cook-Weisberg Test		0.17(0.6836)
Skewness and Kurtosis		0.41064(0.522)
Lagrange Multi. Test		0.48444(0.486)
Ramsey's RESET Test		0.8907(0.641)
Squared Residuals		1.3455(0.246)
DW-Statistic		2.08(0.00)

Note: $\rho_*(\tau)$ is the lag of GDP growth, GDPG is GDP Growth in percentage, Capital stock (Gross Capital Formation as a percentage of GDP), $\mathbf{B_K(\tau)}$ is Capital Stock, $\mathbf{B_L(\tau)}$ is the Labour Stock, $\mathbf{B_{EPI}(\tau)}$ is environmental performance, $\mathbf{B_{QualityAir}(\tau)}$ is Air Quality (Provision against environmental risk exposure in term of air pollution to human health), $\mathbf{B_{WaterSan}(\tau)}$ **is** water and sanitation (exposure to unsafe sanitation and unsafe water quality), $\mathbf{B_{WaterRes}(\tau)}$ is Water Resource (wastewater treatment level), $\mathbf{B_{BioDiv}(\tau)}$ is Biodiversity and habitant (the average area of terrestrial biome area and species - under protection), $\mathbf{B_{Agric}(\tau)}$ is Agriculture (ratio of nitrogen inputs to outputs), $B_{Forests}(\tau)$ is Forest (the tree cover loss in the country), $\mathbf{B_{Fisheries}(\tau)}$ **is** Fisheries (fishing stocks overexploited), $\mathbf{B_{Clim.Eng}(\tau)}$ is Climate & Energy(performance in Change in CO2 emissions per unit GDP and % of population with access to electricity), is $\mathbf{B_{SIZE}(\tau)}$ is government size, and $\mathbf{B_{TOP}(\tau)}$ is trade openness. Figure in [.] are the p-values, *, **, *** Significant at the 1, 5, and 10 percent levels, respectively.

Following Table 7 on the relationship between capital, labour, and GDP growth, the MM-QR model confirms that both capital and labour increase economic growth in ECOWAS at the first quantiles (0.25), middle quantiles (0.50) and higher quantiles (0.75), as further suggested by OLS and 2SLS techniques. Environmental performance has a positive effect on economic growth across all quantiles, including the OLS and 2SLS models. This indicates that environmental performance improves economic growth in West Africa. This outcome is in line with available literature (e.g. Awodumi & Adewuyi, 2020), which suggest that an adequate policy should be formulated to enhance economic growth through a sustainable environment.

As displayed on row 9, the threshold estimate suggests that as long as environmental performance in ECOWAS is above the threshold level of 48.27 percent (the threshold level below which the environment may constitute developmental challenges), the sub-region should be sufficient to enhance economic growth. This explains that even though the level differs across countries, at any level below the threshold level, environment may harm the sub-region's economic growth.

On the disaggregated EPI, the coefficient of air quality on economic growth is negative across quantiles (0.25 - 0.75), OLS, and 2SLS models. The results show that increasing air pollution reduces productivity (economic growth) in West Africa. This leads to the conclusion that air pollution harms economic growth in ECOWAS, as expected. Our result is consistent with Jiang and Chen (2020) who suggest that quality air is essential for sustaining economic growth in China, and positive air quality has a greater impact on output.

The relationship is negative across different quantiles between access to clean water and sanitation and economic growth. A possible reason may be attributed on the fact that most West African water and sanitation supply system comes from the borehole and the latrine system which is not safe for people. This is because boreholes contain disease-causing microorganisms that can cause illness. Also, pit latrine excreta may potentially leach into the groundwater, thereby threatening human health. That is a loss of economic potential which negatively affects economic growth; it notably indicates that unsafe water and poor sanitation contribute negatively to economic growth in ECOWAS countries. The United Nations (2014) reports that Africans are living on less than a dollar a day, with a huge number of her people living in the slums, without access to basic necessities of life, including health facilities, drinkable water, and sanitation, thus exposing the region to environmental hazard, with adverse effect on economic growth.

However, the corresponding coefficients for Water resource and economic growth were observed to be positive in all models and across the quantiles. The result indicates that water resource promotes economic growth across the quantiles. Our result is consistent with Zhang et al (2016) suggest that abundant water resources is essential for sustaining economic growth.

Likewise, the relationship between biodiversity and habitat and economic growth is observed to be negative across all quantiles, since increasing evidence in the literature shows that loss of biodiversity and habitat as a result of greater resource consumption and higher emissions negatively affect economic growth. Fuentes (2011) suggests that protection of wild biodiversity is very valuable for present and future human welfare and adds to the size and growth of an economy while biodiversity loss harms output. Land cover is not regulated, and it is over-exploited in West Africa causing loss and decline in biodiversity of the subregion. Our results support Otero et al. (2020) which suggest improvements in resource use efficiency for policymakers to reduce global air pollution and prevent biodiversity loss in order to achieve sustainable growth.

Forest stocks and agriculture have a positive effect on economic growth from 25th quantile to 75th quantile. Additionally, at a higher level of economic growth (75 quantiles), Agriculture exerts a significant positive effect on economic growth in West Africa. This indicates that increase in forestry and agriculture productivity (in term of sustainable nitrogen management) promotes economic growth in the region. Our finding is consistent with the work of Amirnejad, Mehrjo, and Yuzbashkandi (2021) that suggest that MENA countries should protect forest resources by diversifying economic activities such as agroforestry instead of forest depletion. Also, Sarwar et al (2021) confirm that expansion of sustainable nitrogen management increases agricultural productivity, which will increase economic growth.

Fisheries (fish stock) exert a negative impact on economic growth from 25th quantile to 75th quantile, which is consistent with Sugiawan et al. (2017). One of the possible reasons is that West Africa fisheries is under pressure from gas, oil spillage, and chemicals which have affected the stock of fish over time. Lam et al. (2020) suggest that substantial tropical fisheries contribute to the well-being of societies thus promote economic growth. Healthy oceans support the well-being of coastal communities, provide jobs and food, and thus promote sustainable economic growth.Climate and energy negatively affect economic growth of the region. International Energy Agency (2018) reports that the demand for more energy as the ECOWAS population grows has increased demand for generator plants, charcoal, and other alternative energy sources which increase CO2 emission in the region and exposed the life of the people in danger and reducing economic resources.

The coefficient for government size is negatively associated with economic growth for the sub-region in most of the quantiles, OLS, and 2SLS models except quantiles 50. This leads to the conclusion that expenditure on government size harms economic growth in ECOWAS. This is consistent with (Whajah, Bokpin, & Kuttu, 2019), and with Armey (1995) hypothesis that when expenditure on government size is above a certain threshold, it harms economic growth.

The relationship between trade openness and economic growth is negative for ECOWAS in all the quantiles (0.05 t- 0.95), OLS, and 2SLS models. A possible justification of this relationship is developing/underdeveloped economies find their imports beyond their exports, creating trade imbalances that retard the region's economic growth.

Table 9 presents the p values of the quantile granger causality test among the GDP per capita growth, and the explanatory variables for the ECOWAS economy. The work suggests bidirectional causality running from capital stock to GDP growth as both variables' granger cause each other. Also, labour stock and GDP growth in Table 8 showed evidence of bi-directional causality running at (0.05 to 0.95), with no evidence of feedback between labour stock and GDP growth at median quantiles (0.50) and upper quantile (0.95). This supports Benhamou and Cassin, (2021) which confirms that economies are driven by the amount of capital and labour stock in the economy. A bidirectional causality is also obtained from environmental performance to GDP growth, government size, and GDP growth, and bidirectional causality between trade openness and economic growth. Wang (2013) confirmed a bidirectional causality between the environment and the global economy.

Table 9
Results of Quantile Causality for ECOWAS

Quantiles (τ)	GDPG ↓ K	K ↓ GDPG	GDPG ↓ L	L ↓ GDPG	GDPG ↓ EPI	EPI ↓ GDPG	GDPG ↓ SIZE	SIZE ↓ GDPG	GDPG ↓ TOP	TOP ↓ GDPG
0.05-0.95	0.013	0.007	0.007	0.007	0.007	0.007	0.013	0.007	0.013	0.007
0.05	0.007	0.007	0.171	0.007	0.007	0.007	0.007	0.007	0.013	0.007
0.10	0.007	0.007	0.230	0.007	0.007	0.007	0.007	0.007	0.013	0.007
0.20	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.013	0.007
0.30	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.013	0.007
0.40	0.013	0.007	0.007	0.007	0.007	0.007	0.013	0.007	0.013	0.007
0.50	0.013	0.007	0.296	0.007	0.007	0.007	0.013	0.007	0.013	0.007
0.60	0.013	0.007	0.007	0.007	0.007	0.007	0.013	0.007	0.013	0.007
0.70	0.013	0.007	0.007	0.007	0.007	0.007	0.013	0.007	0.013	0.007
0.80	0.013	0.007	0.007	0.007	0.007	0.007	0.013	0.007	0.013	0.007
0.90	0.013	0.007	0.007	0.007	0.007	0.007	0.013	0.007	0.013	0.007
0.95	0.013	0.007	0.382	0.007	0.007	0.007	0.013	0.007	0.013	0.007

Notes: GDPG is Gross Domestic Product Growth in each country; the K is Capital Stock; L is Labour Stock, EPI is environmental performance index; SIZE is government size and TOP is trade openness. Figure in [.] are the p-values, *,**,*** Significant at the 1, 5, and 10 percent levels, respectively.

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The validity of a model depends on the outcome of the diagnostic tests. In the light of this, we performed various diagnostic tests such as endogeneity, normality, stability, autocorrelation, and heteroskedasticity. In Table 7, row 16 confirms no evidence of endogeneity. Table 7, row 17, and the Squared Residuals and Breusch-Pagan / Cook-Weisberg Test confirm no heteroskedasticity in the estimated model. Also, Skewness and Kurtosis confirm no non-normality issues. Ramsey's RESET Test confirms no specification error, and Lagrange Multiplier Test confirms no serial correlation. Finally, our DW-Statistic confirms no autocorrelation in the estimated model.

5. Summary and Conclusions

Theoretically, the accumulation of capital, labour, and technological progress is expected to enhance economic growth. To bolster the theoretical justification for labour and capital (technology inclusive), scholars have included energy as a part of modern technological progress in the exogenous growth model for environmental sustainability. However, as important as environmental sustainability is to economic growth, this study empirically investigates the impact of environmental performance on economic growth among ECOWAS countries, using data spanning from the 2006–2018 period. The study used the novel Method of Moment Quantile regression (MM-QR) methodology to provide an in-depth understanding of the complementarity between the environmental performance indicator (EPI) and economic growth in the neoclassical growth model for ECOWAS. MM-QR is useful since environmental performance's effect on economic growth may differ from one ECOWAS country to another due to each country's specific individual circumstances.

Our results confirm that environmental performance improves economic growth. Based on the findings, a policy to encourage improved environmental performance above the threshold estimated to improve the ECOWAS economy is suggested. This policy is essential for governments/policymakers to determine the optimal level of environmental performance required for sustainable economic growth in their respective countries. Our study also extended the existing literature by examining the impact of disaggregated EPI on economic growth and the following findings are presented below:

1. There is a negative relationship between air quality and economic growth. The provision against environmental risk exposure in terms of air pollution to human health is negative in most of the West African countries. Indicating that exposure to PM2.5 and ozone exposure is very high in the sub-region. The increase in air pollution in this region reduces labour productivity and agricultural crop yield, increases health expenditures, and thus negatively affects economic growth.

2. The coefficient of access to clean water and sanitation on economic growth is negative in West Africa. Access to clean water and sanitation does not mean the water and sanitation are safe for the public because the West African water and sanitation supply system comes from the borehole and

the latrine system. We argue that boreholes contain disease-causing microorganisms that can cause illness. Most boreholes contain high levels of chemical contaminants, such as arsenic, which can cause disease in people who drink the water. Similarly, pit latrine excreta may potentially leach into groundwater, thereby threatening human health through the borehole. Therefore, this is likely to affect labour productivity and economic growth. Hence, economic growth can be promoted if health-threatening illnesses are averted through the provision of treated water and a sanitary system.

3. The result shows a negative relationship between biodiversity and habitat and economic growth in West Africa. This is due to unregulated land coverage and over-exploitation, which result in loss or decline in West Africa's biodiversity. However, safeguarding biodiversity and habitat is essential for human welfare improving labour productivity.

4. Forestry and agriculture positively stimulate economic growth. Increase in forestry and agriculture productivity (in term of sustainable nitrogen management) promote economic growth. Hence, policy to protect the forest and sustainable nitrogen management should be encouraged in West Africa.

5. The fisheries coefficient shows a negative impact on economic growth. A possible reason is that West Africa fisheries are under pressure from gas, oil spillage, over-exploitation, and trawling by other countries, which have affected the fish stocks in the region. Hence, the preservation of fish stock and protection of the marine environment is important for economic growth in West Africa and other third-world countries.

6. The relationship between climate protection & access to energy and economic growth is found to be negative in West Africa. The shortage of access to reliable and affordable modern energy has severely hinder economic development in the region.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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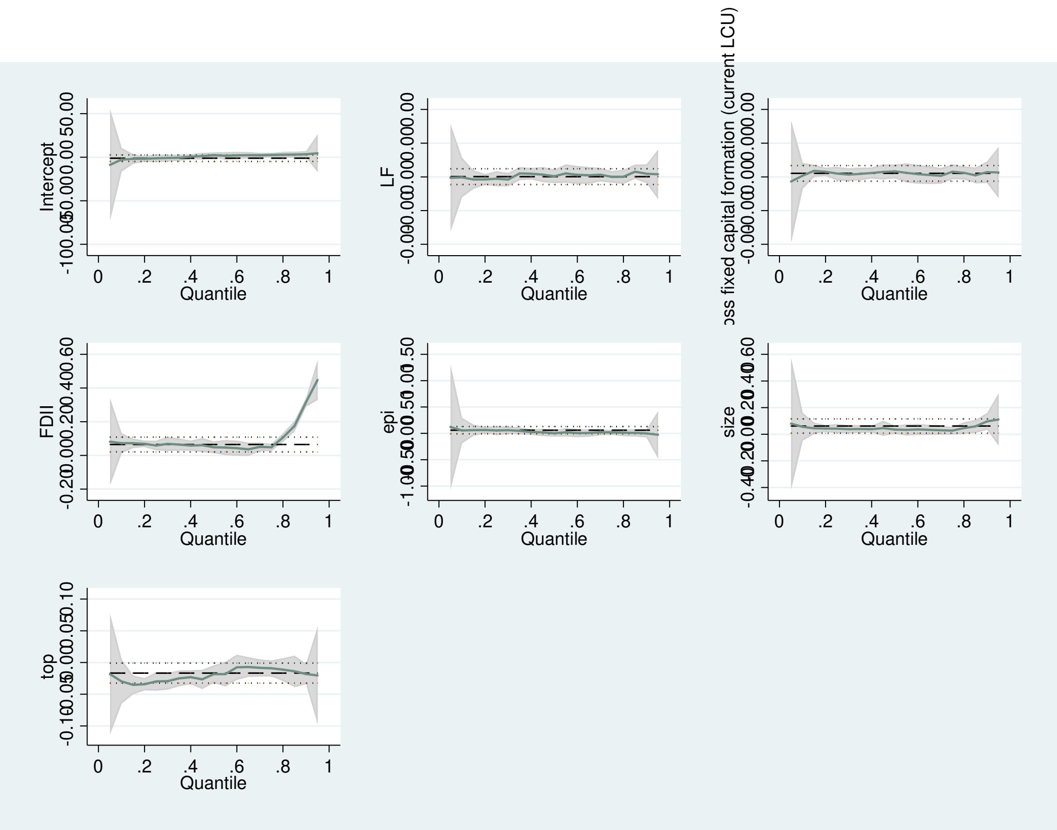
Appendix

The Q-plots



II Endogeneity Test

Table 3
Test of endogeneity

Instrumented: epi				
Instruments: GDPG L K size top				
gdpg	**Coef.**	**Robust Std. Err.**	**z**	**P>z**
epi	-0.2944	0.3811	-0.77	0.44
gdp	4.62E-13	2.75E-12	0.17	0.866
L	4.1353	3.872	1.07	0.286
K	-0.0145	0.0385	-0.38	0.706
_cons	12.860	13.165	0.98	0.329
GMM C statistic chi2(1)		-129.97		
Prob		1.000		
Wald chi2(4)		2.40		
Prob > chi2		0.663		
Number of obs		195		

Notes: GDPG is Gross Domestic Product Growth in each country; the K is Capital Stock; L is Labour Stock, EPI is environmental performance index; SIZE is government size and TOP is trade openness. Figure in [.] are the p-values, *,**,*** Significant at the 1, 5, and 10 percent levels, respectively.

Stationary Test

The results of the Fisher (1932) panel unit root tests are reported in Table 10. The results show that labour stock (L) contains a panel unit root and after the first difference of Labour is stationary; thus, the labour stock is integrated of order one [i.e., I (1)]. However, GDP growth (GDPG), GDP per Capita (GDPPC), Capital Stock (K), Environmental Performance Index (EPI), Trade Openness (TOP) and Government size (SIZE) are stationary at level. The stationary test confirms a mixed order of integration which support our Quantile Autoregressive Distributed Lag (ARDL) (QARDL) approach.

Table 10
Panel unit root test

		Fisher 1932	
Variable	lags	chi_sq	Order of Integration
Specification without trend			
GDPG		159.99***	0
		(0.000)	
		89.93	
GDPPC		(0.000)	0
L		61.21**	1
		(0.007)	
K		56.33**	0
		(0.035)	
EPI		148.7***	0
		(0.000)	
SIZE		62.65**	0
		(0.0004)	
TOP		58.538**	0

	(0.0014)	
Specification with trend		
GDPG	131.05***	0
	(0.000)	
	103.23	
GDPPC	(0.000)	
L	52.01**	1
	(0.013)	
K	44.87**	0
	(0.04)	
EPI	151.99***	0
	(0.000)	
SIZE	63.9**	0
	(0.0003)	
TOP	64.7**	0
	(0.0002)	

Note: GDPG is GDP Growth in percentage, Capital stock (Gross Capital Formation as percentage of GDP) L is the labour Stock, EPI is environmental performance, SIZE is government size and TOP is trade openness. Figure in [.] are the p-values, *,**,*** Significant at the 1, 5, and 10 percent levels, respectively.

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