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Income inequality, human capital, natural resource abundance, and ecological footprint in ECOWAS member countries

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ABSTRACT

The growing human demand for economic and social development is resulting in a state of ecological overshoot. This paper investigates the heterogeneous effect of income inequality, human capital, and natural resources on the ecological footprint for the Economic Community of West African States (ECOWAS) member countries. Having accounted for cross-sectional dependence and slope heterogeneity, the findings from the Augmented mean group (AMG) estimation reveal that income inequality improves the quality of the environment in Burkina Faso, Nigeria, and Senegal, but deteriorates the environment in Benin. Moreover, human capital accumulation is important for environmental sustainability by exerting a reducing effect on the level of the ecological footprint for Burkina Faso and The Gambia. We further observe that natural resource abundance is not environmentally friendly for Cameroon and Nigeria. Evidence from the Dumitrescu and Hurlin (D-H) panel causality test shows that LGINI, LHC, and LNR stimulate the ecological footprint. Some policy recommendations are offered based on these findings.

1. Introduction

The rapid increase in production, consumption, and the concomitant surge in the environmental deterioration are among the most pressing challenges of the post-2015 sustainable development agenda. The growing human demand for economic and social development has brought about (un)conscious consumption of different natural resources far beyond the earth's biocapacity (Jorgenson, 2003). Implicit in this argument is the resulting environmental impacts such as global warming, climate change, loss of biodiversity, land degradation, and pollution (Chen et al., 2010). Today, over 85 % of the world population lives in a state of ecological overshoot (Ahmed and Wang, 2019; Global Footprint Network, 2020). In this context, the ecological footprint of consumption discusses the rate of depletion regarding grazing land for animals for meat, cropland for growing crops for food, forest area for harvesting timber/wood fiber for timber, built-up for accommodation infrastructure for housing, water resources, mineral resources, and energy land for abating excess CO_2 emissions from fossil fuels (Rees and Wackernagel, 2008).

Another persistent cause for concern is income inequality within and among countries (United Nations, 2019). Income inequality suggests that there is a disproportionate distribution of economic resources between societies, regions, and individuals (Uzar and Eyuboglu, 2019). Prevalent empirical explanations on the effect of income inequality on the environment remain decidedly mixed – ranging from strongly positive to intensely negative and essentially everything in between (see Heerink et al., 2001; Hübler, 2017; Kasuga and Takaya, 2017; Knight et al., 2017; Jorgenson et al., 2017; Grunewald et al., 2017; Liu et al., 2019). The empirical findings do not only offer conflicting evidence, however, carbon dioxide (CO_2) emissions - which constitute only a fraction of the entire environmental damage triggered by large scale production and consumption activities, is used as a conventional metric of environmental quality (Uddin et al., 2017). Therefore, a critical empirical question remains when the "overall level of bioproductive land and other natural resources required to produce commodities consumed by humans" are not considered (Jorgenson, 2003, p. 376).

In recent times, scholars begin to raise legitimate questions about whether human capital suffocates or liberates the environment.

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Conventionally based on the average years of schooling and return to education, human capital defines the skills and knowledge required to enhance a person's productivity (Hassan et al., 2019). Education is critical for human welfare and more so in the context of economic and social transformation (World Development Report, 2018). In fact, some scholars claim that human capital facilitates countries' capacity to use renewable energy and other pro-environmental technologies in the industrial, household, and transport sectors (Zafar et al., 2019; Ahmed et al., 2020). This strand of the literature argues that human capital stimulates societies' enthusiasm to reduce emission by increasing energy efficiency (Kwon, 2009), conserve natural resources and improve the overall quality of the environment (Bano et al., 2018). Its enhancements not only promote energy security and efficiency, but also generates positive spillovers such as fidelity to environmental rules, less inequality, and the abatement of crime rates. On the contrary, evidence from other studies suggests that human-induced activities including mining, chain saw operations, bush fires, and deforestation are key drivers of water, soil, and air pollution (Balsalobre-Lorente et al., 2018). Therefore, the effect of human capital on the environment remains an empirical question.

Moreover, the nexus between natural resources including minerals, gas, oil, coal, and forest as the percentage of gross domestic product and the environment is also not a subject without controversy. Scholars have argued that the abundance of natural resources dampens fossil fuel consumption as well as the potential for its import into the country (Balsalobre-Lorente et al., 2018). Contrary to this hypothesis, Ahmadov and van der Borg (2019) argue specifically that coal and petroleum abundance deteriorate the quality of the environment. Furthermore, economic growth and associated urbanization and industrialization trends facilitate demand for natural resource extraction (Ahmed et al., 2020), and a large amount of natural resource consumption, mostly through agriculture, deforestation, mining, and industrialization is inextricably linked to the environmental (un)sustainability (Langnel and Amegavi, 2020). Indeed, the 2019 report by the International Resource Panel (IRP) on the global resource outlook suggests that natural resource extraction and processing account for nearly 50 % of the total greenhouse gas (GHG) emissions (International Resource Panel, 2019, p.7). The report further notes that resource-related impacts on water stress and biodiversity loss due to land use are more pernicious and significant at over 90 %. When this trend persists, the goals of Kyoto Protocol, Paris Agreement, and recent United Nations Sustainable Development Goals (SDGs) may be difficult to annex. Accordingly, the empirical literature on the nexus between natural resources and the environment is decidedly mixed (Baloch et al., 2019).

The paper thus attempts to supplement the empirical literature by fitting income inequality, human capital, natural resources, and the ecological footprint for ECOWAS member countries. It should be noted that natural resources are inextricably linked to an economy's income level since economic development drives the extraction and consumption of different natural resources with consequences on the environment (Ulucak and Bilgili, 2018). However, countries with high levels of educated and skilled human capital have the potential to avert resource-curse syndrome through sustainable use of natural resources (Hassan et al., 2019; Desha et al., 2015). Moreover, Zen et al. (2014) and Ahmed et al. (2019) have argued that people with high educational background and high income and those with low education and low income are likely to assume different posturing towards the environment. To the best of our knowledge, the heterogeneous effect of income inequality, human capital, natural resources, and the ecological footprint has not been analyzed together in the extant scholarship.

We focus on ECOWAS member countries for several reasons. The 2018 World Development Report suggests that millions of children in sub-Saharan Africa (SSA) are unable to read, write, and solve basic mathematical problems, invoking serious concern about the quality of human capital in the region. The 2019 human capital report by the World Economic Forum showed that while the global average human capital gap is 38 %, that of SSA is 47 %, which suggests that the region is leveraging less than half of its human capital. Scholars have attributed the inability to unlock the potential in the industrial sector of SSA countries to low human capital, poor infrastructure, and policy failures (Oyinlola et al., 2020, p. 88). Additionally, tertiary institutions in SSA including ECOWAS member countries have consistently been ranked poorly on Times Higher Education Index. Also, as inequality stands at about 0.58, sub-Saharan Africa is a home of ten out of nineteen most unequal countries in the world (UNDP, 2017). With respect to natural resource endowment, SSA hosts about 30 % of the world's mineral resources (Page, 2011; International Resource Panel, 2019). We focus on ECOWAS member countries because they are part of a single regional trade bloc and are thus more economically integrated than other countries in the region (Nwaka et al., 2020). Moreover, being predominantly primary sector driven economies, ECOWAS countries are replete with diverse natural resources including gold, diamond, timber, cocoa, uranium, oil, and gas in commercial quantities. For example, whereas Nigeria is the highest oil producer in Africa and among the top ten oil-exporting countries globally (Ike et al., 2020), Ghana, Cote D'Ivoire, Liberia, and Sierra Leone have recently been added to the league of oil-rich countries. Essentially, the emerging West African economies face challenges of the age-old "resource curse" syndrome that has bedeviled most African countries including Nigeria (Ayelazuno, 2014). Coupled with an increasing population growth rate within the sub-region, the scale, composition, and technique effects of pollutant emission are likely to be amplified through agriculture, industrialization, and mining activities (Nwaka et al., 2020) with its associated environmental concerns. Recently, land degradation, deforestation, lack of access to safe water, and loss of biodiversity compounded by climatic variability have been underscored as key hindrances to the realization of sustainable development goals in sub-Saharan Africa (United Nation, 2020).

By situating the paper in the context of natural resource-dependent emerging economies, the paper introduces distributional heterogeneity to explore the inequality-induced ecological destruction, by accounting for human capital, natural resource rent, economic growth, urbanization, and the institutional quality. The paper sheds light on the specific policy domains through which appropriate policies can be formulated to deal with environmental challenges threatening low and middle-income countries. The rest of the paper is structured as follows: previous literature is reviewed, the methodology, data sources, model specification, and the econometric techniques are discussed, empirical data and analysis are presented and discussed, conclusion and recommendations are provided.

2. Theoretical literature

2.1. Linking income inequality and the environment

The nexus between inequality and the environment is underpinned by two prevalent explanations. While one strand of the theoretical scholarship posits that increasing inequality chokes the environment (Boyce, 1994; Borghesi, 2006), the contrasting view maintains that high inequality liberates same (Ravallion et al., 2000; Heerink et al., 2001). From the political-economy perspective, Boyce (1994) contends that wealthy individuals tend to benefit from environmental deterioration. Implicit to the 'power-weighted decision rule', the environmental damages become much more pernicious when the winners or rich, who disproportionately benefit from the economic activities also wield much political influence (Boyce, 1994). This means that when the economic elites gain more political power, the consumption of ecological resources is intensified with its associated environmental consequences. The disproportionate allocation of political power and income in society means that environmental policies are likely to protect the interests of the ruling coalition to the detriment of the larger population (Wolde-Rufael and Idowu, 2017). In that regard, projects that exhibit worse implications on the ecological resources cannot be halted and the poor are likely to bear the most brunt of the environmental damages since they depend on the ecological resources for their fundamental survival. Downey (2015) argues that the poor bear the consequences because the rich tend to shun away from the polices that engender environmental protection partly due to the cost associated with it coupled with their capacity to insulate themselves from the environmental harm. On the contrary, Ravallion et al. (2000) and Heerink et al. (2001) argue that the broad picture of the extent to which inequality affects the environment can be made clearer if it is interrogated in the context of the marginal propensity to emit (MPE). The core thesis in this strand of the literature is that in a society where income distribution is more balanced, the poor enter the middle class and consume more of ecological resources as well as other carbon-intensive products (Heerink et al., 2001). Nevertheless, though the consumption demand is the locus in this opposing strand of the literature in determining MPE, the argument falls flat in the face of the Keynesian model, which asserts that poorer households have a higher marginal propensity to consume (MPC) than the richer households (Jorgenson et al., 2017). Consequently, the MPC thesis stands to insinuate that an increase in inequality means there is lower incomes for the poor which should have a likelihood of reducing excessive ecological resource consumption and CO_2 emissions.

2.2. Linking human capital, natural resources and the environment

Under the popular notion of the Environmental Kuznets Curve (EKC) hypothesis as championed by Grossman and Krueger (1995), the interface between human capital, natural resources, and the environment resonates with the ostensible structural changes that occur through the developmental stages of the economy. Consistent with this hypothesis, Panayotou (2016) contends that the inverted U-shape of EKC is symptomatic of scale, composition, and technical effects. Thus, human capital and natural resources theoretically influence the quality of the environment through this channel of effects. Scholars have actively underscored that increasing income (economic growth) requires more input and thus more natural resources are used in the production process. Therefore, at the initial stages of economic development humans use more energy including natural resources - inefficient industrialization and neglect its environmental consequences, which leads to *scale effects* and lethal pollution (Zafar et al., 2019). However, as income grows, the structure of the economy tends to change – *composition effects* - and gradually increases cleaner activities that produce less pollution (Dinda, 2004) with the help of more educated and skilled human capital accumulation. At high-income levels, dirty and obsolete technologies are replaced with upgraded new and cleaner technology – *technique effects*, which may improve the quality of the environment (Bano et al., 2018). The rationale is that when the quality of life improves, people begin demanding a cleaner environment, energy-efficient products, and the protection of natural resources. However, Zafar et al. (2019) argue that the abundance of natural resources is consequential for a country's economic development, depending on the extraction procedure and use of such resources. It follows that as the economy grows with an increase in agrarian and other resource extraction activities, the rate of resource depletion is likely to be far more than the rate of resource regeneration, and the pollution of the ecosystem increases with much toxicity (Dinda, 2004; Balsalobre-Lorente et al., 2018). Nevertheless, a shift from the agricultural-based to a manufacturing-oriented economy, and subsequently to an information-intensive or knowledge society tends to lessen human demands on the environment and improves the quality of the environment as a consequence.

2.3. Empirical literature

Following the above theoretical arguments, an active body of empirical literature has evolved that attempts to explain the nexus between income inequality and the environment. From an autoregressive distributive lag (ARDL) approach, Baek and Gweisah (2013) observed that income inequality stimulates CO_2 emissions in US. Based on the Generalized method of moments (GMM), Hao et al. (2016) established a positive effect of inequality on CO_2 emissions in 23 provinces of China between 1995 and 2012. Using the income share of the top 10 % at the US state-level within fixed and random effect models, Jorgenson et al. (2017) established a positive relationship between inequality and the CO_2 emissions. Knight et al. (2017) adopted a two-way fixed effects longitudinal models and observed that the wealth share of the top decile stimulates CO_2 emissions in high-income countries. Kasuga and Takaya (2017) found that income inequality reduces air quality in residential areas and commercial areas and not in industrial areas. Zhu et al. (2018) found that income inequality increases CO_2 emissions in middle and high emission countries.

Contrary to these scholars, Grunewald et al. (2017) used a group fixed effect technique and reported that while higher income inequality reduces emission levels in low and middle-income countries, emission levels tend to surge in upper-middle-income and high-income societies under higher income inequality conditions. In Turkey, Demir et al. (2019) concluded that increasing income inequality reduces environmental deterioration. Employing a quantile regression model, Hübler (2017) noted that regressions with pooled data support a negative relationship between inequality and CO_2 emission levels, whereas regressions with fixed effect doubt that such relationship do exist. Employing both the ARDL and quantile regression to examine inequality-environment nexus in US states, Liu et al. (2019) observed that while higher income inequality stimulates CO_2 emissions in the short-term, it abates emission levels in the long-run. Employing quantile regression to track the heterogeneity, the authors further noted that inequality reduces CO_2 emissions in states with higher per capita carbon emission rate. However, in a comparative study between China and India within Bounds test and Cointegration regressions, Wolde-Rufael and Idowu (2017) recorded an insignificant relationship between inequality and CO_2 emissions. Within fixed-effect model in high income countries, Knight et al. (2017) also established no significant relationship.

Conversely, some studies have interrogated the relationship between human capital, natural resources, and pro-environmental practices in recent times. Zafar et al. (2019) observed in the US that natural resource and human capital abate ecological footprint. The authors further posit that effective management of ecological resources cannot be guaranteed without educated and skilled human capital formation. This is particularly important because human capital encourages the consumption of eco-friendly and other energy-efficient products. This is analogous to the view that education is crucial for the population to better appreciate the consequences of environmental deterioration (Ulucak and Bilgili, 2018). Whereas the work of Hassan et al. (2019) found in Pakistan that natural resources promote ecological footprint, and subsequently deteriorates the quality of the environment, that of Mahmood et al. (2019) established in the same setting that human capital reduces CO_2 emissions. Desha et al. (2015) put out that where skilled and educated people dominate, environmental policies are more likely to receive unflinching support. Ahmed and Wang (2019) found a negative relationship between human capital and ecological footprint in India. Employing an Augmented Mean Group (AMG) among BRICS countries, it is revealed that natural resource abundance abates CO_2 emissions in Russia but stimulates same in South Africa (Baloch et al., 2019). Ulucak and Khan (2020) used fully modified ordinary least squares (FMOLs) and dynamic ordinary least squares (DOLS). They established that natural resource rent, renewable energy, and urbanization reduce ecological footprint among BRICS economies, suggesting their ability to improve the environmental quality. Ahmed et al. (2020) engaged Bayer and Hack cointegration test and ARDL approach to investigate the determinants of ecological footprint in China. The authors observed that natural resources rent, urbanization and economic growth surge ecological footprint, however, human capital reduces same, and possibly improves environmental quality.

In sum, though there exist an active body of literature on the nexus between inequality and the environment, different findings proliferate as a result of differences in the methods used, various research traditions pursued, the geographical settings, and the variables used. Nevertheless, previous studies have paid insufficient attention to human capital and natural resource rent in the inequality-environment nexus.

3. Data and methodology

3.1. Data and model specification

To accomplish the objectives of this study, annual data from the Global Footprint Network (GFN), the Standardized World Income Inequality Database (SWIID), Penn World Table (PWT 9.1), the World Bank - World Development Indicators' databank (WDI), and the Polity IV project were obtained for the period 1984–2016, and created a panel for 11 ECOWAS member countries. The countries include Burkina Faso, Benin, Ivory Coast, Cameroon, The Gambia, Ghana, Niger, Nigeria, Senegal, Sierra Leone, and Togo (excluding Guinea, Guinea Bissau, Liberia, and Mali subject to data availability). We deem these countries as ideal for this study because their economies generally depend on primary export products such as crude oil and gas, gold, cocoa, and other minerals. To avoid possible emitted variable bias, some standard covariates as observed in the extant literature as key influencers of an environmental quality are added to the model: GDP capita (economic growth), urbanization, energy consumption, and institutional quality (see Bello et al., 2018). In this paper, democracy is used as a proxy for institutional quality because it offers an opportunity for citizens to exert control over the leaders and the officialdom to not only ensure equitable distribution of economic resources and political power (Huber et al., 2006) but to also be responsive to threatening environmental conditions. The detailed description of the data is shown in Table 1.

The current study builds on the extant literature on inequality-environment nexus by incorporating human capital, natural resources, economic growth, urbanization, energy consumption, and the institutional quality. Our initial model can be specified as:

$$\begin{aligned}\ln EFP_{it} &= \alpha_0 + \theta_1 \ln HC_{it} + \theta_2 \ln GINI_{it} + \theta_3 \ln GDPC_{it} + \theta_4 \ln NR_{it} \\ &+ \theta_5 \ln URB_{it} + \theta_6 \ln EC_{it} + \theta_7 \, Polity2_{it} + \mu_{it}\end{aligned} \tag{1}$$

Where EFP is ecological footprint in global hectares (gha), HC is human capital, GINI income inequality, GDPC stands for economic growth, NR is natural resource rent, URB is the urbanization, EC represents energy consumption, Polity2 is democracy index, and μ_t is the residual term. Descriptive statistics and correlation results are shown in Table 2.

Table 1
Data sources and description.

Data	Definition/measurement	Source
Ecological footprint (EFP)	The productive land and water required to support human consumption and waste absorption. Measured in global hectares.	GFN
Human capital (HC)	Average years of schooling and return to education.	PWT(9.1)
Gini index (GINI)	Gini coefficient of income inequality. The value of 0 (perfect equality) and 1 (maximum inequality.	SWIID
Natural resource rent (NR)	Total natural resource rent including oil, natural gas, coal, minerals, and forests.	WDI
Economic growth (GDPC)	GDP per capita (constant 2010 US$)	
Urbanization (URB)	Number of people living urban areas (% of total)	WDI
Energy consumption	Primary energy before transformation to other energy use fuel (kilogram of oil equivalent per capita).	WDI
Institutional quality (Polity2)	Polity2 Index measured from −10 (most autocratic) to + 10 (most democratic).	Polity IV dataset

Note: With the exception of institutional quality variable (s), all variables were transformed into natural logs for easy interpretation.

3.2. Panel unit roots and cointegration techniques

The ability to ascertain the stationarity level of variables is crucial to avert spurious regression syndrome. Cross-sectional dependence (CD) is due to unobserved mutual factors, common shocks, and spill-over effects (Wang and Dong, 2019). Therefore, any attempt to ignore CD can thus distort the true parameter values of coefficients and thereby diminish the efficiency gains of panel data estimates (Phillips and Sul, 2003). In that regard, Pesaran et al., 1999 has argued that an analysis of CD is crucial for the appropriate unit root and panel estimation techniques to be selected. Indeed, previous literature has established that first-generation panel unit root test such as LLC, IPS, and Hadri - is ineffective in the presence of CD in panel data series (Ulucak and Li, 2020). Therefore, the paper employs the second-generation panel unit root test - Breitung (2001) and cross-sectional augmented IPS (CADF and CIPS) as proposed by Pesaran (2007) to determine the extent to which cross-sectional dependence affects panel unit root tests. Breitung (2001) unit root test assumes a common autoregressive (AR) parameter for all individuals and deems to be superior to other traditional unit root tests with respect to its power for moderately sized panel datasets. Also, it is efficient in the presence of cross-sectional dependence. The CIPS, however, estimates heterogenous panels and effectively accounts for the presence of cross-sectional dependence by allowing for the heterogeneity in panel data (Im et al., 2003). CADF regression uses cross-sectional averages and their first difference to remove the influence of dependences across countries. Following Pesaran (2007), the CADF statistic can be operationalized as:

$$\Delta y_{it} = \phi_i + \beta_i y_{it} + \tau_i \bar{y}_{it-1} + d_i \bar{y} \Delta_t + \varepsilon_{it} \tag{1.1}$$

Where ϕ_i is the deterministic term and y_t is the mean of CD for time t. An average of CADF an individual ADF statistics are used for the calculation of CIPS statistics. The incorporation of one period lag will yield the following equation:

$$\Delta y_{it} = \phi_i + \beta_i y_{it-1} + \tau_i \bar{y}_{it-1} + \sum_{j=0}^{1} \tau_{it} \Delta \bar{y}_{it-1} + \sum_{j=0}^{1} \tau_{it} \Delta y_{it-1} + \varepsilon_{it} \tag{2}$$

After obtaining CADF statistic, the CIPS can be estimated as:

$$CIPS = \frac{1}{N} \sum_{j=i}^{N} t_i(N, T) \tag{3}$$

Where t_i (N, T) denotes the t-statistics in the CADF regression.

It should be noted that common techniques such as Predroni (2004) and Kao (1999) are usually used in testing for cointegration in panel data. However, these first-generation panel cointegration techniques might produce biased estimates in the presence of cross-sectional dependence because they assume the condition of cross-sectional independence (Westerlund, 2007). Therefore, Westerlund (2007) cointegration test was engaged in this paper. Westerlund cointegration test drives four statistics, which assume null hypothesis of zero error correction term and insinuates the condition of no cointegration among the variables. Contrary to Pedroni, Westerlund relaxes the imposition of common factor restrictions on tests based on residual dynamics, which are deemed to be structural in nature instead of residual. The bootstrap approach is able to handle the negative impact of cross-sectional dependence and yields more robust critical values (Westerlund, 2007). It estimates groups (G_t, G_a) and panels (P_t G_a) statistics. Whereas groups (G_t, G_a) offer test statistics to help ascertain cointegration in one or more cross-sectional units, the panels (P_t G_a) aid in discovering cointegration in the whole panel.

Table 2
Descriptive statistics and correlation results.

	EFP	HC	GINI	GDPC	NR	URB	EC	Polity2
Panel A								
Mean	16.345	0.353	−0.864	6.691	1.998	15.327	6.014	−0.353
Minimum	12.947	0.02	−1.155	5.609	0.403	12.356	4.728	−9
Maximum	19.15	0.89	−0.42	7.849	3.982	18.321	8.048	8
Std. Dev.	1.169	0.201	0.136	0.543	0.647	1.258	.603	5.532
Panel B								
EFP	1.000							
HC	0.273	1.000						
GINI	−0.215	−0.194	1.000					
GDPC	0.440	0.460	−0.110	1.000				
NR	0.405	0.252	−0.012	−0.190	1.000			
URB	0.695	0.418	−0.010	0.353	0.515	1.000		
EC	−0.265	0.133	0.362	0.316	−0.005	−0.016	1.000	
Polity2	0.185	0.252	−0.318	0.042	0.059	0.220	−0.182	1.000

3.3. Augmented mean group (AMG)

The existence of heterogeneity and the CD requires a long-run estimator that can overcome such issues. Drawing insights from previous literature (see Baloch et al., 2019; Destek and Sarkodie, 2019), this paper employs AMG algorithm. The AMG estimator was proposed by Eberhardt and Teal, 2010), Eberhardt and Bond (2009) and Bond and Eberhardt (2013). It has several advantages. First, it is efficient due to its characteristics that avert the challenges of CD and heterogenous slopes. Second, the AMG estimator is flexible even in the presence of non-stationary variables or cointegrated or not (Eberhardt and Teal, 2010; Destek and Sarkodie, 2019). Thus, it is robust and unbiased for various combinations of cross-section and time dimension variables (Bond and Eberhardt, 2013). Third, it is efficient for moderately sized samples (Eberhardt and Teal, 2010) such us the one employed in this study. It estimates the CD as well as common dynamic effects where common dynamic impact of the unobserved parameters is examined by using two-stage approach as shown below:

$$\Delta y_{it} = \sigma_0 + \theta_1 \, \Delta \, X_{it} + \sum_{1-2}^{T} P_t \, (\Delta D_t) + \mu_{it} \tag{4}$$

Where ΔD denotes the first difference of T-1 period dummies and P_t is the parameters for period dummies. α_0 indicates the intercept. The estimated parameter P_t is thus replaced by τ variables leading to the following dynamic equations:

$$\Delta y_{it} = \sigma_0 + \theta_1 \Delta \, X_{it} + d_i \, (\lambda_t) + \mu_{it} \tag{5}$$

$$\Delta y_{it} - \lambda_t = \sigma_0 + \theta_1 \, \Delta X_{it} + \mu_{it} \tag{6}$$

After the adapted group-specific regression model with $\varnothing_t$, the mean values of the parameters are thus computed. The next step is to obtain the MG estimator for AMG by averaging the slope of each unit:

$$AMG = \frac{1}{N} \sum_{J=0}^{1} \widehat{\beta}_i \tag{7}$$

Where $\widehat{\beta}$ are the estimates of β_i.

4. Empirical results

4.1. Results of cross-sectional dependence and unit root

Before the unit root properties of our data series were ascertained, the existence of cross-sectional dependence was detected. Analogous to recent studies (Wang and Dong, 2019; Baloch et al., 2019), Breusch-Pagan LM, Pesaran Scaled LM, and Pesaran CD tests by Breusch and Pagan (1980) were performed in this paper to obtain reliable results. The three test results in Table 3 show that our quantitative variables exhibit significant cross-sectional dependence across countries. This implies that any shock in one ECOWAS member country may have a spill-over effect in other member countries.

Table 3
Cross-sectional dependence.

Test	Statistic	Probability
Breusch-Pagan LM	258.1395	0.0000
Pesaran Scaled LM	19.36859	0.0000
Pesaran CD	5.544929	0.0000

Source: Author's computation. Note: Significant at 1 %.

Having ascertained the CD properties of each variable, the paper implements econometric methods that can avert any potential problem due to CD. As can be seen in Table 4, with the exception of urbanization, the results obtained from the Breitung unit root test reject the null hypothesis of the presence of unit root properties not at levels but at first difference.

Table 5 presents the findings of CADF and CIPS. The null hypothesis of CADF assumes that all series are non-stationary. As can be seen in Table 5, with the exception of HC, all variables in CADF unit root test are stationary at first difference. With respect to CIPS, when the test statistics are greater than the critical values, we reject the null hypothesis and conclude the presence of stationary properties in the panel data series. As can be seen, the findings (Table 5) obtained from the CIPS

Table 4
Breitung (2001) unit root test.

Variables	Level		First Difference	
	Intercept	Intercept & trend	Intercept	Intercept & trend
EFP	2.32 (0.99234)	−0.36 (0.3634)	−8.33(0.0000)	−5.19 (0.0000)
GINI	2.22(0.9845)	7.33(1.0000)	−1.63(0.0545)	6.76 (1.0000)
HC	9.35 (1.0000)	6.42 (1.0000)	−0.04 (0.4839)	0.10 (0.5404)
GDPC	2.80 (0.9974)	3.31 (0.9995)	−5.34 (0.0000)	−2.23 (0.0128)
EC	−1.07 (0.1424)	1.12(0.8678)	−5.58(0.0000)	0.19(0.5780)
URB	18.89 (1.0000)	8.42(1.0000)	5.02(1.0000)	0.94(0.8264)
NR	−3.16 (0.0008)	−1.21(0.1139)	−8.08(0.0000)	−6.23(0.0000)
POLITY2	−0.12 (0.4511)	−1.25 (0.1060)	−10.79 (0.0000)	−9.59(0.0000)

Source: Authors' computation. Note: the p-value are in the parenthesis at 1 %, 5 % and 10 % significance levels.

Table 5
Unit root properties (Pesaran, 2003, 2007).

	CADF		CIPS	
Variables	Level	Δ	Level	Δ
EFP	−2.611 (0.154)	−5.325 (0.000)	−2.861	−5.600
GINI	−1.771 (0.984)	−2.962 (0.010)	−2.243	−3.824
HC	−1.737 (0.988)	−2.218 (0.678)	−1.752	−3.245
GDPC	−2.260 (0.619)	−3.505 (0.000)	−2.219	−4.931
EC	−2.233 (0.657)	−3.944 (0.000)	−2.681	−4.895
URB	−3.185 (0.001)	−3.518 (0.000)	−1.946	−3.888
NR	−3.009 (0.006)	−5.271 (0.000)	−3.638	−5.621
POLITY2	−2.035 (0.875)	−3.877 (0.000)	−2.087	−5.087
Critical values			−2.66 9 (10 %) −2.76 (5 %) −2.93 (1 %)	−2.66 (10 %) −2.76 (5 %) −2.93 (1 %)

Source: Authors' computation. Note: For CADF results, p-value are shown the parenthesis at 1 % significance level. Critical values for CIPS are: 2.66 9 (10 %), −2.76 (5 %), −2.93 (1 %).

suggest that the null hypothesis of non-stationarity can be rejected at levels at 1 % significance at first difference, implying that the variables employed in this paper are integrated of 1(1).

4.2. Panel cointegration results

The stationarity of the variables at first difference demands that long-run association among the variables should be ascertained. The traditional cointegration methods were ignored in that they fail to address the challenges of heterogeneity and cross-sectional dependence in the data series. Consequently, Bootstrapped panel cointegration test developed by Westerlund (2007) was employed since it is deemed to be robust amidst cross-sectional dependence and slope heterogeneity (Ulucak and Bilgili, 2018). Findings from Westerlund cointegration test (Table 6) evokes the condition of long run relationship among the variables.

4.3. Panel estimation results

For us to estimate the long-run parameters of the impacts of income inequality, human capital, and natural resources on the ecological footprint across West African countries, the AMG algorithm, which is robust to cross-sectional dependence and heterogeneity was employed. It should be noted that the AMG estimator provides efficient results even in the presence of non-stationary variables or under the condition of no integration. As illustrated in Table 7, the coefficient on income inequality is negative and statistically significant at 10 % level for Burkina Faso, Nigeria, and Senegal, but also, indicates an increasing effect for Benin. Thus, a percentage increase in income inequality is likely to decrease the ecological footprint level by 2.584 %, 0.544 %, 0.711 %, and 9.693 % respectively, for Burkina Faso, Nigeria, and

Table 6
Westerlund (2007) Bootstrap error correction-based cointegration test.

Statistic	Value	Z-value	Robust p value
G_t	−3.125	0.165	0.040
G_a	−0.695	7.031	0.000
P_t	−11.927	−2.141	0.080
P_a	−1.303	5.676	0.910

Authors' construction. Note: Gt and Ga denote the group mean tests. Pt and Pa are panel mean tests.

Senegal but worsens the quality of the environment by 9.693 % for Benin (see Table 7).

'However, it must be underscored that although income inequality exhibits no significant relationship for Cameroon, Cote D'Ivoire, The Gambia, Ghana, Niger, Sierra Leone, and Togo, the coefficients for most of them are negative, amplifying the environment quality-improvement role of income gap among ECOWAS member countries. Similarly, the overall estimation for all the 11 countries reveals that, on average, income inequality exerts a reducing effect but insignificant effect on the ecological footprint, meaning that the deepening of income inequality has the potential to improve the quality of the environment in West Africa. Similarly, the overall estimation for all the 11 countries reveals that, on average, income inequality appears to encourage cleaner environment in the sub-region. Although the negative impact of income inequality may seem unreasonable and defies policy logic, the underpinning reason is due to the law of marginal propensity to emit which holds that equal income distribution may lift a majority of the poor into the middle and powerful class, leading to the consumption of more ecological resources and other carbon-intensive products. This is, however, at variant to the popular notion of the EKC hypothesis that posits that people tends to be environmentally conscious when their income level increases. Another plausible reason is in the context of the law of diminishing marginal utility, where the rich have a smaller marginal utility of money compared to the poor especially in the long run. Hence, the rich will exhibit less consumption and carbon emissions behaviors in the long term due to their limited utility of money, at the same time, the poor also show less consumption ability triggered by more income moving from the poor to the rich. Eventually, this is likely to result in a less ecologically intensive lifestyle, and subsequently improves the quality of the environment. Notwithstanding this result, however, optimizing income distribution among the ECOWAS member countries remains a viable long-term policy domain.

Human capital, however, is negative and shows a statistically significant impact on ecological footprint for Burkina Faso and The Gambia at 5 % and 1 % levels respectively. This implies that a I% increase in human capital accumulation is likely to improve the sustainability of the environment by 14.162 % and 8.413 % by exerting a reducing impact on the level of the ecological footprint. However, it can be observed that human capital accumulation has no significant impact on the environment for Cameroon, Cote D'Ivoire, Niger, Senegal, Sierra Leone, Togo, and Benin. The panel group result suggests that, on average, human capital is negative and statistically insignificant in West Africa. This means that human capital accumulation has the potential to abate the level of the ecological footprint in West Africa if there is a practical commitment to consistently improve the standard of education in the sub-region. This result is analogous to the hypothesis that as more people get educated, they become aware of environmental issues and exhibit pro-environmental practices. This implies that ECOWAS member countries with a higher level of human capital accumulation are most likely to avert the age-old 'resource-curse' hypothesis, benefit from their natural resources, and generally achieve the environmental sustainability.

Proceeding further, the estimating coefficient of natural resources with respect to the ecological footprint of consumption is positive and significant for Cameroon and Nigeria, suggesting a stimulating effect of natural resources on the ecological footprint, and the consequent deterioration of the quality of the environment. Nevertheless, for countries such as Burkina Faso, Cote D'Ivoire, The Gambia, Ghana, Niger, Senegal, Sierra Leone, Togo, and Benin, the natural resources abundance seems to have no influence on the state of the environment. We further observe that the panel group result signals that the coefficient of natural resources is positive and statistically significant at 1 % level. This implies that a I% increase in natural resources is likely to stimulate the ecological footprint level by 0.063 %, all other things being equal, suggesting a collateral damage to the environment. This is particularly true because these countries have discovered natural resources

Table 7
Results of AMG panel data estimation.

	LGINI	LHC	LGDPC	LNR	LEC	LURB	POLITY2
Burkina Faso	**−2.584***	**−14.162****	1.115	0.108	**0.370****	−0.600	**0.032****
Cameroon	−0.898	0.715	0.346	**0.074***	0.271	−0.919	0.020
Cote D'Ivoire	−0.538	−2.953	**0.571****	0.063	0.148	2.672	0.023***
The Gambia	−0.716	**−8.413*****	−0.019	0.083	0.043	0.547	0.001
Ghana	0.103	−0.657	0.187	0.083	**0.410*****	1.321	**0.031*****
Niger	−0.442	−5.765	0.402	0.107	−0.222	5.251	0.008**
Nigeria	**−0.544***	−1.817	−0.714	**0.082***	1.116	−2.147	−0.003
Senegal	**−0.711***	−12.030	0.872	0.073	0.066	0.998	0.014
Sierra Leone	0.112	12.621	0–.300	0 .052	1.714	1.876	0.007
Togo	0.993	−1.321	0.302	0.0351	**0.640****	3.443	0.011
Benin	**9.693 ***	4.213	0.202	7.583	**−3.843***	0.293	−0.023
Panel (FULL)	−0.092**	−1.333*	0.288	**0.063*****	**0.287***	**1.661***	**0.012****

Source: Authors' computation.
Note: ***p < 0.01, **p < 0.05, *p < 0.1 indicate significance at 1 %, 5 %, and 10 % respectively.

including crude oil, gas and minerals such as gold and bauxite in commercial quantities. Therefore, overexploitation of natural resources mainly through unsustainable practices may contribute to the environmental deterioration.

Commenting on other variables, energy consumption deteriorates the quality of the environment in Burkina Faso, Ghana, and Togo, but also reduces the level of ecological footprint in Benin. More so, we further observe that economic growth shows an increasing effect on the ecological footprint for Cote D'Ivoire. Urbanization exhibits no significant relationship on the ecological footprint in individual countries, but on average, the group panel result points to the fact that an increasing level of urbanization is likely to exert a negative influence among the ECOWAS member countries. Also, the institutional quality (polity2) appears to drive the environmental degradation in Burkina Faso, Cote D'Ivoire, Ghana, and Niger.

Moreover, there are alternative panel estimators, which are known to produce robust results where CD is present: mean group (MG) (Pesaran & Smith, 1995) and common correlated effects mean group (CCMG) (Pesaran, 2006). Therefore, we engage MG and CCMG estimators (see Table 8) to ascertain the robustness of our findings. The results from the two regressions are analogous to the AMG estimator in Table 7. Thus, whereas the coefficient of HC is consistently negative and significant in CCMG estimator, that of GDPC and NR are positive. The LGINI is negative but insignificant. From the MG estimator, GINI, HC, and NR bear the consistent negative sign but insignificant.

We further examine the direction of causality by employing Dumitrescu and Hurlin (D-H) panel causality test. The D-H causality test as proposed by Dumitrescu and Hurlin (2012) deals with cross-sectional dependence in panel data series. It is based on the individual Wald statistic of Granger non-causality averaged across cross-sections. The findings from Table 9 show that LGINI, LHC, LNR, LGDPC, and LURB cause the ecological footprint. However, there is no evidence to suggest that LEC and POLITY2 drive the environmental deterioration.

Table 8
Robustness analysis.

Variables	MG	CCMG
LHC	−0.294(2.286)	−12.15*(7.317)
LGINI	−0.956(0.770)	−2.098(2.000)
LGDPC	0.219(0.304)	1.176*(0.614)
LNR	0.165(0.106)	0.115**(0.0492)
LURB	0.684(0.444)	0.758(1.097)
LEC	−0.260(0.269)	−0.603(0.702)
Polity2	−0.00260(0.003)	0.00258(0.0125)

Source: Authors' computation.
Note: ***p < 0.01, **p < 0.05, *p < 0.1 indicate significance at 1 %, 5 %, and 10 % respectively.

Table 9
Dumitrescu and Hurlin (2012) panel causality test.

Null hypothesis	W-stat	Z-bar-stat	Prob.
LGINI ≠LEFP	4.077	6.141	0.0810
LHC ≠ LEFP	8.971	16.293	0.0000
LGDPC ≠LEFP	2.337	2.601	0.0092
LNR ≠LEFP	2.580	3.107	0.0019
LEC ≠LEFP	0.304	−1.588	0.1123
LURB ≠LEFP	8.516	15.354	0.0000
POLITY2 ≠LEFP	1.504	0.884	0.377

Source: Authors' construction. ≠ stands for no causality. Lag order 2.

5. Discussion

This paper employs the AMG algorithm to interrogate the heterogenous effects of income inequality, human capital, and natural resources on the ecological footprint among ECOWAS member countries. The finding regarding the negative impact of income inequality on the ecological footprint echoes similar findings by Hübler (2017), Wolde-Rufael and Idowu (2017), Grunewald et al. (2017), and Liu et al. (2019). This means that redistribution of income to improve environmental quality may not be a viable policy instrument within the ECOWAS sub-region. This result generally validates the marginal propensity to emit (MPE) hypothesis as posited by Ravallion et al. (2000) and Heerink et al. (2001). Nevertheless, this result should be interpreted with caution, keeping in mind the nuances in low- and high-income countries. Thus, the potential for high income inequality to improve the quality of the environment may be pertinent in poor countries as the current paper and others by Wolde-Rufael and Idowu (2017) and Grunewald et al. (2017) have demonstrated. However, the finding rebuts the work of Baek and Gweisah (2013), Hao et al. (2016), Knight et al. (2017), Jorgenson et al. (2017), Kasuga and Takaya (2017), and Ridzuan (2019), which dominantly suggest a worsening impact of income inequality on the environment. Some reasons may account for the ostensible differences in findings. First, our evidence emanates from the poorest but natural resources dependent sub-region. Second, we used a measure of an environmental quality – ecological footprint – which is more comprehensive compared to CO_2 emissions, which is extensively used in the existing literature. Consequently, our finding refutes the political-economy hypothesis as desperately proposed in income inequality and the environment literature (Boyce, 1994; Borghesi, 2006). One plausible reason behind the differences may be that we used a measure of an environmental quality – ecological footprint – which is more comprehensive compared to CO_2 emissions. Moreover, the finding regarding the negative contribution of human capital to the ecological footprint, and the eventual improvement in the environmental quality corroborates with the recent work by Hassan et al. (2019), Mahmood et al. (2019), and Ahmed and Wang (2019), meaning that higher human capital accumulation, which is a function of an improved educational standard is crucial for maintaining environmental sustainability particularly in emerging and transitional economies. The evidence further signal that the natural resource rent exerts an increasing effect on the ecological footprint, and contradicts the work of Zafar et al. (2019) in the US, Baloch et al. (2019) in BRICS including Russia but not South Africa, and echoes that of Ahmed et al. (2020) in China and the 2019 global report (International Resource Panel, 2019). This implies that natural resource rent stimulates environmental deterioration in natural resource-rich countries. Proceeding to the other covariates, the paper finds that energy consumption appears to deteriorate the quality of the environment by stimulating ecological footprint levels of some West African countries. However, economic growth and urbanization were observed to significantly increase the ecological footprint, and subsequently worsen the environmental quality. This is consistent with the existing empirical studies (see Bello et al., 2018).

6. Conclusion and policy recommendations

Though an active body of literature exists on the relationship between inequality and the environment, the results have been decidedly mixed. In part, previous studies have paid insufficient attention to human capital and natural resource rent in inequality-environment nexus within natural resource-dependent low-and middle-income countries. Another palpable deficiency in the inequality and the environment literature is the use of CO_2 emissions as the conventional metric for environmental quality. The current paper attempts to fill these knowledge gaps by investigating the heterogeneous effect of income inequality, human capital, and natural resource rent, on the ecological footprint in ECOWAS member countries between the period of 1984–2016. Having accounted for cross-sectional dependence and slope heterogeneity, the findings from the AMG algorithm reveal that the impacts of income-inequality, human capital, and natural resource rent are heterogenous among ECOWAS member countries. We observe that income inequality improves the quality of the environment in Burkina Faso, Nigeria, and Senegal, but deteriorates the environment for Benin. The finding further reveals that human capital accumulation is important for environmental sustainability by exerting a reducing effect on the ecological footprint for Burkina Faso and The Gambia, but with no significant influence for Cameroon, Cote D'Ivoire, Niger, Ghana, Senegal, Sierra Leone, Togo, and Benin. Furthermore, natural resource abundance is not environmentally friendly for Cameroon and Nigeria, perhaps because of the current mode of unsustainable natural resource consumption patterns.

Based on the above findings, the following policy recommendations are proposed. Since rapid economic growth is always accompanied by income inequality and environmental deterioration, it presents problematic trade-offs. The governments in ECOWAS member countries need to pay critical attention to quality economic development while ensuring that income grows steadily. This demands the strengthening of environmental policies so that as efforts are made to increase the incomes of the population, people will be compelled to observe pro-environmental practices. Another plausible recommendation related to income inequality is that the responsibilities of the rich towards the protection of the environment should be increased. As such, environmental taxes that correlate positively with income status may provide a window of opportunity. Most critically, it is important to promote green and less resource-intensive lifestyles based on appropriate policy measures to invoke environmental consciousness and awareness. These policy measures should motivate and compel citizens to patronize green goods and services provided by the government and the private sector, and ultimately help decouple human well-being from resources use. Programs such as energy savings, recycling, the use of renewable energy sources, and less resource consumption come in handy. The use of cleaner technology will help create smart cities and subsequently mitigate the problem of urbanization and unsustainable economic activities on the environment. Since the economies of ECOWAS member countries largely depend on primary products such as crude oil and gas, cocoa, gold timber, and other minerals, it is important to implement resource value-addition policies. This will allow a gradual shift from the excessive consumption of natural resources to an industrial and knowledge-based society. This shift has the potential to reduce the rate at which the population depends on the natural resources and to ensure that the countries stay within their biocapacity.

Furthermore, it should be underscored that the progress of human capital formation hinges on a whole gamut of issues including education, knowledge, health, skills, and work experience. Considering that the human capital formation in SSA is the lowest, ECOWAS member countries must increase human capital development by investing in education, health, and technology. This will allow them to benefit from natural resources and to avert the resource-curse syndrome. Nevertheless, this study has some limitations. First, only education and its expected return is used to study the relationship between human capital and ecological footprint. It should be noted that

health aspect is an important part of human capital index and future studies should aim at a comprehensive measure of human capital index in such relationship. Second, future studies can improve on the extant scholarship by making regional comparison based on income and natural resource endowments such as oil-rich countries.

CRediT authorship contribution statement

Zechariah Langnel: Conceptualization, Investigation, Methodology, Formal analysis. **George Babington Amegavi:** Literature review, Writing – review & editing. **Prince Donkor:** Data curation, collection, Writing – review & editing. **James Kwame Mensah:** Introduction, Supervision.

Declaration of competing interest

No potential conflict of interest was reported by the authors.

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